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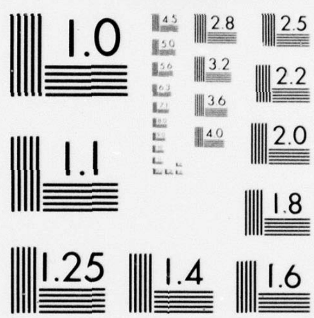

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

REPORT NO. CG-D-75-78

BIOLOGICAL EFFECTS OF OIL POLLUTION - A COMPREHENSIVE BIBLIOGRAPHY WITH ABSTRACTS

Melvin Light and Joseph J. Lanier
U. S. Coast Guard Research and Development Center
Avery Point, Groton, Connecticut 06340

October 1978

Final Report

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U.S. DEPARTMENT OF TRANSPORTATION
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WASHINGTON, D.C. 20590

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16. Abstract

This bibliography is a compilation of abstracts of literature on the biological effects of oil pollution. Comprehensive coverage is provided on oil spill incidents, toxicity, tainting, behavioral effects, physiological effects, biodegradation, effects of cleaning agents, analyses for petroleum hydrocarbons in tissues and other related topics.

Over 1200 references with abstracts are included. Rapid access to and cross-referencing of any given abstract is provided by use of a permuted index that lists alphabetically the keywords and corresponding citation number assigned to each abstract.

The bibliography should be a valuable reference tool for oil pollution researchers, environmental scientists, federal, state and municipal planners, administrators and other decision makers.

17. Key Words	18. Distribution Statement
Bibliography; Oil Pollution; Petroleum Hydrocarbons (PHC's); Biological Effects; Biodegradation; Analyses for PHC's in Tissues	

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Unclassified	Unclassified		

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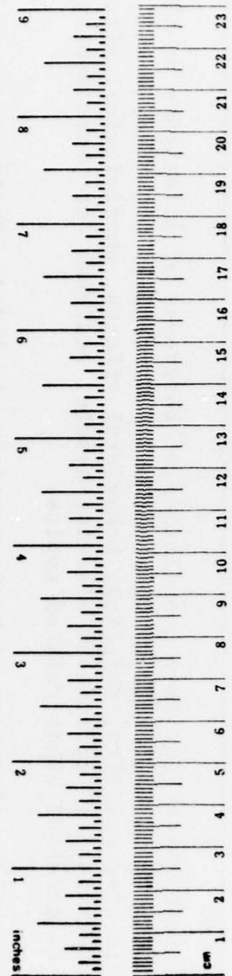
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

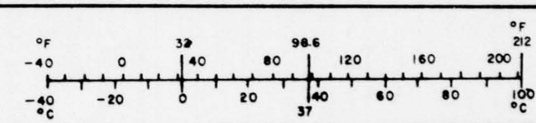
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in ≡ 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



ACKNOWLEDGEMENTS

The authors acknowledge the assistance of Dr. Lewis R. BROWN, Microbiology Department, and of Dr. Charles D. MINCHEW, Zoology Department, Mississippi State University for providing us with a large number of abstracts on various aspects of oil pollution and for encouraging us to publish this bibliography. We also wish to thank MST2 Robert W. FORTIN, USCG for his assistance with proofreading the abstract section of the manuscript and for performing the formidable task of entering the vast number of keywords for the abstracts into the computer. Thanks are also due to MSTC David D. LOCKHART, USCG for his significant contribution of preparing a computer program for sorting the groups of keywords into the permuted index. We also wish to thank Mrs. Lori WATROUS and YN3 Becky LAMBERT of the Word Processing Center, Coast Guard Research and Development Center, whose expert typing skills made this publication possible.

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INTRODUCTION

The supertanker AMOCO CADIZ grounded on the coast of Brittany, France in March 1978, spilling 220,000 tons of crude oil over some 200 kilometers of coastline. This was the largest oil pollution incident ever recorded, and the resulting eco-catastrophe forceably brought attention to the need for information to assess accurately the environmental damage wrought by such a massive spill. The AMOCO CADIZ spill was only one of a series of major oil spills in recent years, such as the ARGO MERCHANT, METULA, and TORREY CANYON supertanker groundings and the Santa Barbara blowout.

During the Conference on Assessment of Ecological Impacts of Oil Spills held in June 1978 at Keystone, Colorado, much attention was given to the impending "Oil Spill Liability Fund and Compensation Act of 1978" (S.2900, 95th Congress, 2d Session), also known as the "superfund" legislation. This Act is a Bill to provide for compensation for damages and cleanup costs caused by discharges of oil and hazardous substances, to establish a liability fund, and for other purposes. Use of the liability fund includes provisions for: (a) the costs of assessing both short-term and long-term injury to, destruction of, or loss of any natural resources resulting from a discharge of oil or a hazardous substance; and (b) the costs of Federal or State efforts in the restoration, rehabilitation, or replacement or acquiring the equivalent of any natural resources injured, destroyed, or lost as a result of any discharge of oil or a hazardous substance. In order to obtain an accurate monetary estaimate of the resulting ecological damage, it will be necessary to know which organisms in an impacted area have been affected adversely.

There is an enormous and constantly increasing volume of literature relating to field and laboratory studies on the effects of petroleum on organisms, as well as on the ecological impacts of specific oil spills. In view of the recent rash of oil spill incidents, the Coast Guard deems it very timely to publish this current and comprehensive bibliography with abstracts on the biological effects of oil pollution. This publication provides rapid assess to the maze of information available, and should be a valuable reference tool for oil pollution researchers, environmental scientists, federal, state and municipal planners, administrators and other decision makers.

The nucleus of this bibliography was a collection of literature accumulated by researchers of Mississippi State University for one task of a research contract for the U.S. Coast Guard (Contract title: "A Scientific Study to Develop One or More Practical Methods for the Accurate Assessment of an Oil Spill Cleanup", DOT-CG-81-76-1476). The objective of their task was to derive an estimate of the maximum level of oil which can be considered harmless to the marine biological community as determined through review and interpretation of the literature (see Abstract No. 187 in this volume, Brown, L.R., 1977). In the course of collecting and screening the available literature for pertinent material, many relevant and non-relevant papers were accumulated on the consequences of oil spills. These papers covered many aspects of oil spills including physical and chemical processes, biological effects, identification of oil samples, and economic and legal factors.

The Coast Guard Research and Development Center decided to update and widen the search for the bibliography. It soon became apparent, however, that the scope of the references would have to be limited to publications only relating to biological effects of oil spills, because of the overwhelming amount of literature available on all aspects of oil pollution. References on identification of spilled oils by chemical analytical techniques are not included, because these techniques have already been thoroughly reviewed.[1,2] However, references on analyses for petroleum hydrocarbons in biological tissues are reported.

Publications screened during the course of the search included scientific journals; reference books; government, university and private institution reports; conference proceedings; bibliographies, and other literature pertaining to environmental pollution. The 1226 references on the biological effects of oil pollution included in this volume, span a period of time from the late 19th century to mid-1978. In most cases, the author's own abstract is reproduced where available. Because of limitations on time and on access to libraries, this bibliography is by no means complete, however, the vast majority of pertinent references are included. In a number of instances where a publication was not readily available, the reference data are cited without abstracts.

Section B of this volume presents 1120 references, most with abstracts, acquired prior to January 1978 and listed alphabetically by author. Section C includes 106 references with abstracts which were acquired since January 1978 after Section B was completed. References presented in Section C are also listed alphabetically by author.

Section D is a subject index. This is a permuted index which lists alphabetically the keywords and the corresponding serial number assigned to each abstract. Thus, each group of keywords for the abstracts is listed for all combinations in which they can be arranged. This type of index enables rapid access to, and provides for cross-referencing of, any given abstract.

Several keywords are assigned to each abstract and the keywords relate to the following general categories:

1. Effects on Ecosystems - spill incidents; effects of cleaning; recolonization; productivity; food chain magnification.

2. Effects on Organisms - toxicity; tainting; behavioral effects; physiological effects.

3. Biodegradation.

4. Taxonomy.

---

1. BENTZ, A.P. "Oil Spill Identification" Analytical Chemistry, Vol. 48, No. 6, May 1976.
2. BENTZ, A.P. "Oil Spill Identification and Remote Sensing" Advances in Chemistry Series. In press.

5. Habitat types.

6. Geographic areas.

7. Effects of specific crude oils, petroleum fractions, cleaning agents and dispersants.

8. Analyses for petroleum hydrocarbons in tissues.

The authors hope that this bibliography will be helpful to other researchers by providing a convenient and rapid method for searching through the vast quantity of literature relating to the biological effects of oil pollution. Because of the rapid proliferation of literature in this field, we recommend that the bibliography be updated on an annual or biennial basis.

1. Abbott, B. J., and W. E. Gledhill (1971)

THE EXTRACELLULAR ACCUMULATION OF METABOLIC PRODUCTS BY HYDROCARBON DEGRADING MICROORGANISMS.

Advances in Applied Microbiology, D. Perlman (ed.), pp. 249-388

A review of the products excreted by hydrocarbon degrading microorganisms.

2. Ackman, R. G. and D. Noble (1973)

STEAM DISTILLATION: A SIMPLE TECHNIQUE FOR RECOVERY OF PETROLEUM HYDROCARBONS FROM TAINTED FISH.

J. Fish. Res. Bd. Can. 30 711-714

Simple steam distillation was found to be efficacious for isolation of hydrocarbons from contaminated whitefish. Gas-liquid chromatography on support coated open-tubular Apiezon-L columns demonstrated that hydrocarbons recovered from the tainted fish had a composition pattern qualitatively similar in detail to that from a sample of diesel oil suspected as the source of contamination.

3. Adams, H. K. (1936)

THE POLLUTION OF THE SEA AND SHORE BY OIL

Rep. Coun. Roy. Soc. Land., p.27

4. Ages, A. (1971)

OIL RECONNAISSANCE IN THE MAGDALEN ISLANDS - 1970.

Bedford Institute of Oceanography, Canada, Report No. AOL 1971-8. 23pp.

The sinking of an oil barge in the Gulf of St. Lawrence in Sept. 1970 resulted in an oil slick approximately 20 miles long and 10 miles wide. Before reaching the shores of Prince Edward Island, the oil slick was driven away and subsequently broken up by a favorable shift in the wind. However, part of the emulsified oil landed on the western beaches of the Magdalen Islands two weeks after the accident. Shore reconnaissance of the Magdelens indicated minor pollution damage, the oil did not affect the eastern shores and lagoons where scallop fisheries are an important source of income. The high pour point of the oil is believed to have been responsible for the sudden dispersal of the slick when it was disturbed by the wind and waves. The pour point also facilitated beach cleaning because the oil did not penetrate into the sand during warm weather.

5. Ahearn, D. G. (1974).

THE SOURCES, FATES AND EFFECTS OF OIL IN THE SEAS.

In: Pollution and Physiology of Marine Organisms. F.J. Vernberg and W. B. Vernberg (eds.). Academic Press, New York pp. 247-251.

An overview of the fate and effect of oil pollution in the marine environment.

6. Ahearn, D. G. and S. P. Meyers (1972).

THE ROLE OF FUNGI IN THE DECOMPOSITION OF HYDROCARBONS IN THE MARINE ENVIRONMENT.

In: Biodegredation of Materials Volume 2, H. A. Walters and H. Vande Plas (eds.). pp. 12-18.

Mixed cultures of hydrocarbonoclastic yeasts have been seeded on the estuarine control plots and plots enriched with crude oil. The survival and growth of the seeded yeasts and the development of hydrocarbon utilizing indigenous strains is being monitored. Direct predator species are being identified and their rate of food intake ad multiplication are being investigated. Laboratory studies have examined the effects of crude oils and crude oils seeded with fungi on the survival of the common Guppy, Lebistes reticulatus. High asphalt oil proved less toxic than a less viscous Louisiana crude. Future plans call for 1) the continuation of field evaluation of use of hydrocarbonoclastic yeasts to remove oil pollutants, 2) examination of effects of varying cultural conditions on the oil-dispersant qualities of yeasts, and 3) expansion of studies on the impact of oil on the ecology of micro bial communities.

7. Ahearn, D. G. and S. P. Meyers (eds.) (1973).

THE MICROBIAL DEGREDATION OF OIL POLLUTANTS.

Louisiana State University and Agricultural and Mechanical College Center for Wetland Resources. Sea Grant Program. Publication LSU-SG-73-01. 314 pp. Conference Proceedings.

Papers are presented on the status of knowledge concerning the use of microorganisms in facilitating oil biodegredation. Topics cover hydrocarbon utilization by specific microbes, distribution and abundance of those microbes and the pollution control and ecological impacts of the microbial degredation in various marine environments.

8. Ahearn, D. G. and S. P. Meyers (1976)

FUNGAL DEGREDATION OF OIL IN THE MARINE ENVIRONMENT

In: Recent Advances in Aquatic Mycology, E.B.G. James, (ed.). John Wiley and Sons, Halsted Press, New York, pp. 125-133

The effects of hydrocarbons on fungal ecology in aquatic regions are reviewed. Topics discussed include the breakdown of oil in seawater, the assimilation of petroleum fractions by fungi, and hydrocarbons and fungal ecology. Hydrocarbonoclastic yeasts are widespread in the neritic environment and may occur in high densities in surface slicks. However, the rate of degradation and emulsification of crude oil by commonly marine occurring yeasts mainly strains of Rhodotorula, Debaryomyces, and members of the Candida lipolytica complex, is relatively slow compared with yeasts from aquatic sites chronically polluted with oil. In oil-enriched water certain indigenous yeasts are selectively stimulated, but a sustained increase in biomass does not occur. Hydrocarbonoclastic molds, mainly species of Cladosporium and Cephalosporium, also occur in marine habitats, but their relationship to natural slicks as cultural oil pollution is unknown. Evidence indicates comparatively low oil-assimilating capacities by cladosporia from oil-enriched sediments and water.

9. Ahearn, D. G., and S. P. Meyers, and P. G. Standard (1971)

THE ROLE OF YEASTS IN THE DECOMPOSITION OF OILS IN MARINE ENVIRONMENTS.

Devs. Ind. Microbiol. 12 126-134.

Yeasts from various marine freshwater and terrestrial environments were examined for their capacity to assimilate hydrocarbons. Hydrocarbonoclastic yeasts are wide-spread; however, strains able to assimilate hydrocarbons at levels 2% (v/v) generally are concentrated in oil-polluted habitats. Louisiana crude oil plus refinery and laboratory fractions and vapors of a number of aromatic hydrocarbon globules, but certain strains, mainly marine isolates of Trichosporon sp., penetrated and developed within the globule. Field and laboratory data suggest that yeasts play a role in microbial decomposition of surface oil depositions in the marine environment.

10. Ahokas, J. T., Pelkonen, O. and Karki, N. T. (1975)

METABOLISM OF POLYCYCLIC HYDROCARBONS BY A HIGHLY ACTIVE AKYL HYDROCARBON HYDROXYLASE SYSTEM IN THE LIVER OF A TROUT SPECIES.

Biochem. Biophys, Res. Commun. 63. 635-641.

11. Aksenova, Ye. I. and A. S. Trufanova (1971)

EFFECT OF CHLOROPHOS AND PETROLEUM PRODUCTS ON PROTOCOCCACEAE AND BLUE-GREEN ALGAE.

Hydrobiol. J. 7,74-76.

A series of experiments were run to determine the effect of a pesticide (chlorophos) and industrial effluent containing petroleum products on some protococcal and blue-green algae.

The test organisms were protococcal [culture of Scenedesmus obliquus (Turp.) Kutz] and blue-green [Aphanizomenon flos-aquae (L.) Ralfs.] algae. The former were grown in the laboratory while the latter were taken from Don water during its "blooming". Two series of experiments were performed with each culture (in 3 replications) in 0.5-liter flasks under natural light and at a water temperature of 20 to 25^{o}. The staff of the hydrochemical laboratory monitored changes in the hydrochemical properties.

Chlorophos was used at concentration of .05, .1, .5, and 1.0 mg/liter and petroleum products at concentrations of .05, .1, .5, 1.0, and 5.0 mg/liter. The control algae were observed at the same time. The effect of these substances was judged from change in the algal abundance and biomass and from their morphology.

Change in density of the algae in the course of a day under the influence of the various concentrations was computed from the difference between the number of algae in the control, experimental vessels, and expressed in percentage of control.

12. Aldrich, E. C. (1938)

A RECENT OIL POLLUTION AND ITS EFFECT ON THE WATER BIRDS IN THE SAN FRANCISCO BAY AREA.

Bird Lore 40,
110-114

On March 6, 1937, the oil tanker FRANK BUCK spilled its cargo of oil in The Golden Gate, San Francisco Bay. Oil was washed up on beaches for several miles north and south of the Golden Gate. This article reports the results of a beach survey for oiled birds made shortly after the incident.

13. Alkire, G. C., C.O. Becker, M. W. Cook, D. Davis and C. E. Leach (1967)

OIL SPILLAGE STUDY, LITERATURE SEARCH, AND CRITICAL EVALUATION FOR SELECTION OF PROMISING TECHNIQUES TO CONTROL AND PREVENT DAMAGE

Battelle Memorial Institute Pacific Northwest Labs., Richland, Washington. 281 pp.

A review and evaluation of 761 references to the literature on the state of technology of prevention and control of major oil spillage on water, the restoration of the shoreface and fowl. Operational practices in shipping, offshore oil production practices, and transmission line safety codes are encompassed. Note is taken that oil spills are studied by aerial surveys including spectrophotometric, ultraviolet, infrared, radar and microwave imaging. In regard to chemical treatments, it is indicated that all dispersants and emulsifiers are more or less toxic. Oil may be confined by booms and then either burned or recovered. Technology for reclamation of recovered oils though available is not in general use. (Sinha-OEIS)

14. Allen, H. (1971).

EFFECTS OF PETROLEUM FRACTIONS ON THE EARLY DEVELOPMENT OF A SEA URCHIN.

Mar. Pollut. Bull. 2. 138-140

This report indicates that the water-soluble extracts of a number of crude and refined oil products have little harmful effect on fertilization but are highly toxic to developing sea-urgin eggs.

15. Alpine Geophysical Union (1971)

OIL POLLUTION INCIDENT PLATFORM CHARLIE MAIN PASS BLOCK 41 FIELD LOUISIANA

U.S. Environmental Protection Agency, Water Quality Office, Washington, D.C. Water Pollution Control Research Series No. 15080 FTN. 136 pages.

For roughly eight weeks, wells on the Chevron Oil Co. Platform Charlie in the Main Pass Oil Field in the Gulf of Mexico were out of control, spewing crude oil and natural gas into the air from the platform level. Pollution effects and control measures taken are discussed.

16. Alyakrinskaya, I. O. (1966)

BEHAVIOR AND FILTERING ABILITY OF THE BLACK SEA MYTILUS GALLOPROVINCIALIS ON OIL POLLUTED WATER.

Zool, Zh. 45. 998-1003; also in Biol. Abstr. 48(14):6494.

M. galloprovincialis can tolerate high concentrations of oil. Addition of oil to water in the amounts of 1, 2, 5 and 10 ml/l does not affect behavior. Concentrations exceeding 20 ml/l do affect the mollusc. During filtration of oil-polluted water, the mollusc forms pseudofaeces (oil drops connected by muscus) thereby purifying the water to a degree. The ability of this mollusc to filter oil-polluted water through its body cavity is due to the extreme pollution resistance of the ciliated epithelium of gills and mantle.

17. Alyakrinskaya, I. O. (1966)

EXPERIMENTAL DATA ON THE CONSUMPTION OF OXYGEN IN SEA WATER POLLUTED WITH PETROLEUM.

Oceanology. 6 (1), 71-78

Reports extensive contamination by petroleum in Novorossiysk Bay. The film on the water surface acts as a barrier to exchange between the water and the atmosphere. Large concentrations reduce the content of dissolved oxygen and increase bio-chemical oxygen demand and oxydizability. In the summer clams catastrophically high concentrations of pollution occur. Experimental data are tabulated. (Sinha-OEIS)

18. American Institute of Biological Science (1976)

SOURCES, EFFECTS AND SINKS OF HYDROCARBONS IN THE AQUATIC ENVIRONMENT. PROCEEDINGS OF THE SYMPOSIUM, AMERICAN UNIVERSITY WASHINGTON, D.C. 9-11 AUGUST 1976.

American Institute of Biological Sciences. 578 pp

This volume is a collection of papers presented at the symposium. The articles on biological effects are entered separately in this bibliography.

19. American Petroleum Institute and Federal Water Pollution Control Administration (1969)

PROCEEDINGS JOINT CONFERENCE ON PREVENTION AND CONTROL OF OIL SPILL.

American Petroleum Institute, New York. 345 pp.

This volume contains 41 papers presented at the 1969 Joint Conference on Prevention and Control of Oil Spills. Many of these deal with biological effects of oil pollution.

20. American Petroleum Institute, Environmental Protection Agency, United States Coast Guard (1973)

PROCEEDINGS OF JOINT CONFERENCE ON PREVENTION AND CONTROL OF OIL SPILLS. MARCH 13-15 1973, WASHINGTON, D.C.

American Petroleum Institute, Washington, D.C. 834 pp.

This volume contains 87 papers presented at the 1973 Joint Conference for the Prevention and Control of Oil Spills. Seventeen of these papers deal directly with biological effects of oil pollution.

21. American Petroleum Institute, Environmental Protection Agency and United States Coast Guard (1975)

1975 CONFERENCE ON PREVENTION AND CONTROL OF OIL POLLUTION. PROCEEDINGS. MARCH 25-27, 1975, SAN FRANCISCO, CALIFORNIA.

American Petroleum Institute, Washington, D.C.

This volume contains 92 papers presented at the 1975 Joint Conference for the Prevention and Control of Oil Pollution Twenty-two of these papers deal with biological effects of oil pollution.

22. American Petroleum Institute, Environmental Protection Agency, and United States Coast Guard (1977)

PROCEEDINGS 1977 OIL SPILL CONFERENCE (PREVENTION, BEHAVIOR, CONTROL, CLEANUP) MARCH 8-10, 1977. NEW ORLEANS LOUISIANA.

American Petroleum Institute, Washington, D.C.

This volume contains 123 papers presented at the 1975 Oil Spill Conference. Thirty-eight of these papers deal with spill behavior and effects.

23. American Petroleum Institute (1977).

OIL SPILL STUDIES: STRATEGIES AND TECHNIQUES

Proceedings of a Workshop at Gurney's Inn, Montauk, L.I. February 24-26, 1976. American Petroleum Institute publication number 4286

The Oil Spill Studies: Strategies and Techniques Workshop was convened to organize a summary of current techniques and suggest sampling strategies to study the effects of oil spills on marine and estuarine biota. It provides the marine scientist with the collective field and analytical experience of researchers who participated in this effort. The workshop addressed massive petroleum releases to the marine environment.

24. American Society for the Testing of Materials (in press)

PROCEEDINGS OF CONFERENCE: CHEMICAL DISPERSANTS FOR THE CONTROL OF OIL SPILLS

American Soeicty for the Testing of Materials, 4-5 October 1977, Williamsburg, Virgina

Twenty papers were presented at this conference covering a wide range of topics relating to dispersant toxicity deployment, and their ecological effects.

25. Amphlett, M. J. (1968)

PETROLEUM MICROBIOLOGY ANNUAL REPORT.

Progr. appl. Chem., 51, 486

26. Andelman, J. B. and Michael J. Suess (1970)

POLYNUCLEAR AROMATIC HYDROCARBONS IN THE WATER ENVIRONMENT.

Bull. Wld. Hlth. Org. 43/479-508.

Many polynuclear aromatic hydrocarbons (PAH) are known to be carcinogenic to animals and probably to man. This review is concerned with carcinogenic and non-carcinogenic PAH in the water environ-

ment, with emphasis on 3,4-benzpyrene (BP). Because it is ubiquitous, BP is one of the most potent of the carcinogenic PAH and has been widely studied. Although PAH are formed in combustion and other high-temperature processes, there is also evidence for their endogenous formation in plants, which may explain their ubiquity therein. Although the solubility of these compounds in pure water is very low, they may be solubilized by such materials as detergents, or they may otherwise occur in aqueous solution associated with or adsorbed on to a variety of colloidal materials or biota, and thereby be transported through the water environment. A notable characteristic of PAH is their sensitivity to light.

PAH have been found in industrial and municipal waste effluents, and occur in soils, ground waters and surface waters, and their sediments and biota. With the exception of filtration or sorption by activated carbon, conventional water treatment processes do not effeciently remove them, and they have been found in domestic water supplies. Because of the ubiquity of PAH in the environment, it is impossible to prevent completely man's exposure to them; nevertheless their surveillance should be continued and their concentrations in the environment should be reduced where practicable.

27. Anderson, A. W. (1976)

NATIONAL AND INTERNATIONAL EFFORTS TO PREVENT TRAUMATIC VESSEL SOURCE OIL POLLUTION.

University of Miami Law Review, 30 (4), 985-1051.

Traumatic vessel source oil pollution is defined as oil spillage resulting from unexpected damage to the physical container of the oil. Oil pollution is extremely destructive to the marine environment since it disrupts the food chain by poisoning and smothering algae, plankton and intertidal organisms. It also interferes with phytoplankton photosynthesis, reduces dissolved water oxygen, impairs recreational facilities, and has been linked with genetic/carcinogenic changes in marine life and higher animals including man. The problem is magnified by the lack of uniform cleanup systems, the mobility of oil slicks, the increase of supertankers in maritime oil transportation, and conflicting construction and equipment requirements in different countries, as well as conflicting laws in international and coastal water. The intergovernmental Maritime Consultative Organization has attempted uniform regulation of technical and economic aspects of maritime commerce. Efforts underway to regulate sea traffic include training and certification programs. Navigation technology exists to prevent groundings and collisions including the use of offshore deepwater ports to reduce traffic density in coastal zones. More international cooperation is necessary. The author concludes that methods already exist to prevent traumatic oil pollution without awaiting a technological break through.

28. Anderson, J. W. (1973)

EFFECTS OF PETROLEUM HYDROCARBONS ON THE GROWTH OF MARINE ORGANISMS.

In: Petroleum Hydrocarbons in the Marine Environment, A.D. McIntyre and R. J. Whittle (eds.) Rapp. P.-v. Reun. Cons. int. Explor. Mer p. 17

29. Anderson, J. W. (1973)

UPTAKE AND DEPURATION OF SPECIFIC HYDROCARBONS FROM OIL BY THE BIVALVES RANGIA CUNEATA AND CRASSOSTREA VIRGINICA.

In: BACKGROUND PAPERS FOR A WORKSHOP ON INPUTS, FATES, AND EFFECTS OF PETROLEUM IN THE MARINE ENVIRONMENT. NSF OCEAN AFFAIRS BOARD, AIRLIE, VIRGINIA, 21-25 MAY 1973.

Groups of clams and oysters were exposed to oil-water ennulsions of four test oils for various lengths of time. Detailed analyses of specific hydrocarbons were conducted on control animals. those exposed to the test oils, and those allowed to cleanse themselves after exposure. The report concludes that oil hydrocarbons are taken up by clam and oyster tissue and that both aromatic and saturated hydrocarbons are released from the tissues relatively rapidly in clean water.

30. Anderson, J. W. (1975)

LABORATORY STUDIES ON THE EFFECT OF OIL ON MARINE ORGANISMS: AN OVERVIEW.

American Petroleum Institute Publication No. 4299, Washington, D.C.

31. Anderson, J. W., R. C. Clark, Jr., and J. J. Stegeman (1974)

CONTAMINATION OF MARINE ORGANISMS BY PETROLEUM HYDROCARBONS.

In: Marine Bioassays, B. Cox (ed.). Marine Technology Society, Washington, D.C. p. 36-75.

This article reviews the contamination of marine organisms by petroleum hydrocarbons including the subjects of the characteristics of hydrocarbons, analytical methods, sources of contamination, routes of entry into the organism, levels of contamination, uptake and release, localization in tissues and metabolism. Conclusions as to needs and recommendations are also presented.

32. Anderson, J. W., D. B. Disit, G. S. Ward and R. S. Foster. (in press)

EFFECTS OF PETROLEUM HYDROCARBONS ON THE RATE OF HEART BEAT AND HATCHING SUCCESS OF ESTUARINE FISH EMBRYOS.

In: Pollution and Physiology of Marine Organisms, A. Calabrese, F.P. Thruberg and F.J. Vernberg (eds.), Academic Press, New York.

33. Anderson, J. W. and J. M. Neff (1975)

ACCUMULATION AND RELEASE OF PETROLEUM HYDROCARBONS BY EDIBLE MARINE ANIMALS.

In: Recent Advances in the Assessment of Health Effects of Environmental Pollution. Vol. III. Commission of the European Communities, Directorate General Scientific and Technical Information and Information Management. Luxembourg. pp. 1461-1469.

Oysters were exposed to concentrations reaching 400 ppm of dispersed fuel oil in a flow-through tank for 8 hr. Oysters rapidly accumulated a wide spectrum of different hydrocarbons. The mono-, di-, and tri-methylnapthalenes were accumulated to higher concentrations than were the other di- and tri-aromatic hydrocarbons or individual paraffins. When returned to oil-free seawater, oysters released 90% of the paraffins in 24 hr; naphthalenes were released to background levels in 28 d. When exposed to water-soluble fractions of No. 2 fuel oil, clams, shrimp, and fish rapidly accumulated napthalenes in their tissues to levels 1 magnitude higher than the exposure concentrations. Returned to oil-free seawater, they released the napthalenes to low or undetectable levels in 6-14d.

34. Anderson, J. W., J. M. Neff, B. A. Cos, H. E. Tatum, and G. M. Hightower (1974)

CHARACTERISTICS OF DISPERSIONS AND WATER-SOLUBLE EXTRACTS OF CRUDE AND REFINED OILS AND THEIR TOXICITY TO ESTUARINE CRUSTACEANS AND FISH.

Mar. Biol. 27/75-88.

The quantitative hydrocarbon composition and behavior in seawater of water-soluble fractions (WSF) and oil-in-water dispersions (OWD) of 4 oils was investigated. Two crude oils, South Louisiana crude and Kuwait crude, and two refined oils, No. 2 fuel oil and bunker C residual oil, were used in these investigations. The WSFs of the crude oils had higher total oil-hydrocarbon concentrations and were richer in light aliphatics and single-ring aromatics than were the WSFs of the refined oils. The WSFs of the refined oils contained significantly higher concentrations of naphthalenes than did those of the crudes. The hydrocarbon composition of the aqueous phase of OWDs closely resembled that of the parent oils. Gentle aeration of the OWDs resulted in a loss of 80 to 90% of the aqueous hydrocarbons in 24 h. Alkanes disappeared from the dispersions more rapidly than aromatics. The WSFs and OWDs of the refined oils were considerably more toxic to the 6 test species than were those of the crude oils. The test species can be ranked according to increasing sensitivity to oil as follows: *Cyprinodon variegatus*, *Menidia beryllina*, *Fundulus similus*, *Penaeus aztecus* post larvae, *Palaemonetes pugio* and *Mysidopsis almyra*. The results of this investigation are discussed in relation to the potential impacts of oil spills on the marine estuarine environments.

35. Anderson, J.W., Neff, J.M., Cox, B.A., Tatem, H.E. and Hightower,G.M. (1974)

THE EFFECT OF OIL ON ESTUARINE ANIMALS:TOXICITY, UPTAKE AND DEPARATION, RESPIRATION.

In: Pollution and Physidogy of Marine Organisms, F.J. Vernberg and W.B. Vernberg, (eds.) Academic Press, New York pp. 285-310.

Short-term toxicity studies, uptake and depuration studies and physiolgical effect studies were conducted on three estuarine species (sheeps-head minnow, Cyprinodon variegatus; grass shrimp, Palaemonetes pugio; and brown shrimp, Panaeus aztecus) using several petroleum crudes and distillates (South La Crude, Kuwait Crude, #2 fuel oil and bunker C). Water soluable fractions of the refined oils were more toxic than the WSF's of the crude oils. The majority of toxicity is associated with naphthahenes. Petroleum hydrocarbons are rapidly accumulated with aromatics being more rapidly accumulated and retained longer than alkanes. The patterns of uptake & depuration are species specific. Respiratory rate is affected by hydrocarbon concentration. The response is species dependent.

36. Anderson, R.D. (1975)

PETROLEUM HYDROCARBONS AND OYSTER RESOURCES OF GALVESTON BAY, TEXAS.

In: EPA Conf. on Prev. & Contrl. of Oil Poll. pp. 541-548.

Field and laboratory studies of petroleum hydrocarbons in the tissues of the American oyster, Crassostrea virginica, a primary shellfish resource in the Galveston Bay system, were conducted from 1971-1974. Initial ultraviolet spectrophotometric and gas chromatographic analyses of tissues revealed significant amounts of oil-derived petroleum hydrocarbons from oysters collected at Morgan's Point Reef at the lower end of the Houston Ship Channel. Lower values, when detectable, were found in oyster meats collected at natural and artificial reefs scattered throughout the lower bay system. Laboratory and field studies were conducted to determine uptake and depuration of petroleum hydrocarbons by oysters. Rapid depuration of petroleum hydrocarbons accumulated in field and experimental exposures was found. In oil-free seawater, oysters released saturated chains and most aromatic fractions rapidly with depuration to below detectable levels (0.1 ppm) taking place within 52 days. Transfer of oysters for depuration purposes shows promise of improving the overall quality of this shellfish resource.

37. Anderson, R.D. and J.W. Anderson (1973)

UPTAKE AND DEPURATION OF PETROLEUM HYDROCARBONS BY THE AMERICAN OYSTER, CRASSOSTREA VIRGINICA GMELIN.

Proc. Natl. Shellfish. Assoc 64/1-2

American oysters, Crassostrea virginica Gmelin, were exposed to oil-water emulsions of selected crude oils and petroleum fractions. The rate of uptake and depuration of petroleum hydrocarbons was determined by gas chromatographic and ultraviolet spectrophotometric methods.

Oysters rapidly accumulated saturated and aromatic hydrocarbons from oil-water mixtures. Aromatic hydrocarbons were accumulated to a greater extent than n-paraffins relative to their respective concentrations in the exposure water. Saturated hydrocarbons were accumulated in higher amounts from crude versus petroleum fractions. Accumulation of oil-derived petroleum hydrocarbons was not consistent when uptake of oil by oysters was measured over a period of several days. Following return to oil-free seawater, oysters depurated the saturated chains and most aromatic fractions rapidly. Depuration was nearly completed within 21 days.

Groups of oysters were exposed to oil-water mixtures then returned to bay waters for shell growth studies. Daily average growth of experimental and control populations revealed nearly uniform results. Growth of oyster control groups averaged slightly below most of the experimentals except for a slight difference in one test group.

38. Anderson, R.D. and J.W. Anderson (1976)

OIL BIOASSAYS WITH THE AMERICAN OYSTER, CRASSOSTREA VIRGINICA (GMELIN).

Proc. Nat. Shellfish Assoc. 65 38-42.

Oyster bioassays were conducted to determine the relative toxicity of four test oils and a reference toxin. The oysters (Crassostrea virginica) were exposed to oil-water dispersion of two crude and two partially refined petroleum hydrocarbons. The partially refined oils 2 fuel and Venezuela bunker C were found to be more toxic than the two crude oils tested, South Louisiana and Kuwait. Oysters demonstrated greater resistance to test oils than to the reference toxin, dodecyl sodium sulfate. Valve closure by oysters made it difficult to determine percent mortality data in 96-hour or extended studies. Composition of test solutions is compared to calculated values of oil in water and referenced to the relative toxicity demonstrated. Behavior and conditions of test animals is discussed in relation to bioassay results.

39. Anderson, J.W., R.C. Clark. and J.J. Stegeman (1974)

PETROLEUM HYDROCARBONS

In: MARINE BIOASSAYS WORKSHOP PROCEEDINGS, sponsored by API, EPA, and Marine Technology Society. Marine Technology Society, Washington, D.C. pp. 36-75.

This paper is a review of the levels of hydrocarbons found in the marine environment and the techniques used to determine these levels.

40. Andrews, A.R. and G.D. Floodgate (1974)

SOME OBSERVATIONS ON THE INTERACTIONS OF MARINE PROTOZOA AND CRUDE OIL RESIDUES. (1974)

Mar. Biol. 25, 7-12

Marine protozoa were observed to take up Kuwait crude-oil residues in the laboratory and the field. The results suggest that the injestion occurs only while the organisms are feeding on normal food sources or on bacteria adhering to partially degraded oil globules.

41. Anon. (1930)

ROAD TARS AND FISH LIFE - REPORT OF THE JOINT COMMITTEES ON DAMAGE TO FISHERIES.

Surveyor, 78, 625-626.

42. Anon. (1955)

PACIFIC SALMON INVESTIGATIONS.

Comm. Fish Rev. 17/35-36.

The possibility of polluted waters at Lutak Inlet near Haines, Alaska, has prompted the Service's biological laboratory at Seattle, Wash., to begin a limited investigation to determine the toxicity of petroleum products to fish life. The source of the possible pollution is a group of jet-fuel and Diesel-fuel storage tanks at the Inlet. When these tanks are flushed out some of the petroleum products enter Inlet waters, giving rise to a need for definite knowledge on the effect of these products on salmon and other marine resources in the area.

Using silver salmon fingerlings as test fish, the laboratory has tested automobile gasoline, jet-aviation fuel, Diesel-truck oik and sludge oil. Automobile gasoline and het-aviation fuel have proved more lethal to the fingerlings than the other two products: surface films of automobile gasoline and jet-aviation fuel were lethal at 5,000 and 10,000 parts per million, respectively, and agitated solutions of the two products at 100 and 500 parts per million. Tests with surface films of Diesel oil and sludge oil proved lethal at 20,000 and 100,000 parts per million, respectively, and agitated solutions of Diesel oil at 5,000 parts per million. Fingerlings testing with agitated solutions of sludge oil were greatly distressed but not killed.

43. Anon. (1968)

EXPLOITING AND POLLUTING OCEANS.

Nature 219, 840-842

A massive attack on floating oil was launched by the British Government after the Torrey Canyon sinking, primarily using detergents to disperse the oil. Unfortunately, the detergent was the cause of most of the damage to life along the coast; the oil itself had little effect apart from the destruction of sea birds. But there was less damage than originally expected, for detergents in the sea lose their toxicity rapidly. The toxicity is almost entirely within the organic solvent fraction, which evaporates within two to five days. The actual effectiveness of the detergent in emulsifying and dispersing the oil is doubtful. A more effective method would seem to be the sprinkling of powdered natural chalk (or better still, a heavier, unwettable material such as silicone-treated sand) on top of the oil to sink it. But sunken oil may foul fishing lines or be washed ashore later; much depends on how quickly bacteria destroy the sunken oil. Only in extreme cases should the use of detergents be considered, and only then, after mechanical removal has been attempted.

44. Anon. (1968)

LAST WORD ON TORREY CANYON.

Nature. <u>217</u>, 303-304.

A report on the Torrey Canyon disaster has been prepared by the committee of scientists convened by the Chief Scientific Adviser to the British Government. The object is to collect the lessons learned during the aftermath of the Torrey Canyon incident and to examine the measures to be taken in the future. As outlined in the report, the incident was tackled in six parts: how to deal with the oil remaining in the ship, how to dispose of the oil on the sea, how to prevent oil reaching the coastline, how to treat beaches which might become contaminated, how to reduce dangers to marine life, and how to coordinate the efforts of other bodies dealing with the threat to wildlife.

45. Anon. (1969)

OIL LEAK IN CALIFORNIA.

Nature, <u>221</u>/902

The offshore well in the Santa Barbara channel became uncontrollable on January 28, 1969, and was brought under control on February 8. The oil released, estimated at about 1000 tons, subsequently polluted around 30 miles of coastline. Great efforts were made by the oil company to limit the pollution by setting booms around the drilling platform and by spraying the slick with water-soluble dispersant, but poor weather hampered the operations and much oil reached the shore. Harbors and small estuaries had been boomed, however, and only at Santa Barbara was oil driven into the harbor by an offshore wind. The main method of cleaning up the oil from the harbor and beaches was by spreading straw on the oil slicks and beaches at low tide. The oil-soaked straw was then cleared by bulldozing and raking, but there were problems with disposal of the straw. Except for the water-soluble dispersant, utilized by the oil company, no chemical cleansing or dispersant materials were used.

The group of plants and animals most affected was the seabirds, thousands of which were rescued and taken to cleaning stations. Much of the fauna of the rocky areas were coasted with oil, but did not seem greatly affected. These included limpets (Acmaea spp, Lottia), barnacles (Pollicepes, Balanus glandula and Cthalamus fissus), mussels (Mytilus spp) and chitons (Macrocystis) became coated with oil, also, but since the rocky areas were not treated with toxic chemicals, cleansing was eventually accomplished by natural processes of oil weathering and bacterial degradation.

46. Anon. (1969)

OIL SPILL DAMAGE TO MARINE LIFE.

Oil and Gas J., March 17, 1969, pp. 65-68.

Dr. Wheeler J. North and assistants conducted a 1-week study of marine life in the Santa Barbara Channel, three weeks after the oil spill of 1969. The great kelp beds in the channel, which are the prime source of fish food there, were unharmed, even though they were blackened by the oil. The small sea life living on the kelp was also unharmed. The only observed damage was the death of several scallops around the offshore platform where the spill originated, and of about 500 birds. About 30% of the marine life around the platform had been adversely affected, but the remaining 70% was feeding normally in the current.

47. Anon. (1970)

OIL POLLUTION IN THE TAY.

Mar Poll. Bull. 2(1):4-5

About 88 tons of tapped Venezuelan crude oil were spilled into the River Tay in February of 1968. Damaging effects were chiefly the loss of seabirds and fouling of amenity beaches. This paper includes recommendations made by a conference of local authorities and by the Technical Advisory Committee on oil pollution in the Tay on how to handle such matters in the future.

48. Anon. (1970)

THE LONG AND SHORT OF THE OIL SPILLS.

Science News 97(11):263-264

Research conducted at Woods Hole Oceanographic Institution shows that effects of various petroleum fractions on marine life are deadly and highly residual. The most toxic components are the aromatic hydrocarbons, which are the most soluble in water and are not biodegradable. Hydrocarbons in general tend to concentrate in fatty tissues, where they remain essentially unchanged, and are passed up the food chain.

49. Anon. (1971)

MICROBES ARE ONE WAY TO CLEAN UP OIL SPILLS

Environ. Sci. and Technol. 5 389.

Certain naturally occurring mixed microbial cultures will devour some fractions of crude oil in the presence of nutrients, according to scientists at Florida State University at Tallahassee. Bacteria innoculated into test oil slicks, to which nutrient phosphate and nitrate have been added, degrade the oil and enulsify it. The bugs show a preference for paraffinic hydrocarbons, but some degradation of higher aromatics occurs also. The cultures can be mass-prepared, much the same as penicillin cultures, and freeze-dried for storage where they can be dropped by air onto oil slicks.

50. Anon. (1972)

A GUIDE TO MARINE POLLUTION

Gordon and Breach Science Publishers, London, 173 pp.

This book is a collection of papers presented at a seminar in Rome, 4-10 December 1970.

Papers presented deal with methods of detection, measurement and monitoring of pollutants. Halogenated hydrocarbons, petroleum, inorganic chemicals, organic chemicals, nutrient chemicals, suspended solids and turbidity, radioactivity, and the use of biological indicator organisms are specifically discussed and analytical techniques are described. The concept and design of a world monitoring system is proposed for the protection and management of the marine environment.

51. Anon. (1972)

HYDROCARBONS ARE FOUND IN CLAMS DURING ONGOING STUDIES IN NARRAGANSETT BAY.

Maritimes, 16(1): 1-2

Hydrocarbons, possibly derived from petroleum products, have been found in sediments and clams in what were considered unpolluted parts of Narragansett Bay. The concentration of hydrocarbons, varied from 94 ppm of dry weight near the sewaga outfalls to 11 ppm near the mouth of the Bay. Clams from Charlestown Pond, a coastal salt marsh generally isolated from pollution, contained no detectable levels of petroleum hydrocarbons.

52. Anon. (1974)

MARINE POLLUTION MONITORING (PETROLEUM)

U.S. National Bureau of Standards, Gaithersburg, MD.

Abstracts are presented of papers on sampling methods and techniques for oil slicks, tar balls, and particulates; analytical methods for the determination of oil in water; standards and intercomparison criteria; sampling and analytical methods for oil in marine organisms and sediments; and biological assessment of oil pollution.

53. Anon. (1975)

BUG THAT GOBBLES SPILLS.

Tanker and Bulker International, 1(6): p. 16

A General Electric Company has created in the laboratory a man-made organism designed to attack oil spills on waterways, digesting the petroleum and converting it into a form that can be eaten by marine life. Petroleum is a mixture of many different types of hydrocarbons, and any individual strain of oil-digesting bacteria can digest only a few of them. Attacking oil spills with mixed strains of bacteria also has proved unsatisfactory--because the competition between strains of bacteria also has proved unsatisfactory--because the competition between strains hampers their growth. This problem has been solved by combining the genes from four different strains of cil-digesting bacteria into a single "super-strain." In laboratory tests, it has grown at a much faster rate on crude oil than have any of the individual strains.

54. Anon. (1976)

COUNTING THE BIRDS.

Mar. Pollut. Bull. 7, 221

This article reports the results of the Beached Bird Survey run by the Royal Society for the Protection of Birds. The mortality rate is highest during January and February. Fewer birds are now dying as a result of oil pollution than in the late 1960's.

55. Arcos, J.C., et al (1976)

DIMETHYLNITROSAMINE-DEMETHYLASE: MOLECULAR SIZE-DEPENDENCE OF REPRESSION BY POLYNUCLEAR HYDROCARBONS. NONHYDROCARBON REPRESSORS.

J. Toxicology and Environ. Health. 1 395-408.

Studies with 58 polynuclear aromatic hydrocarbons have shown that to repress demethylation of dimethylnitrosamine (DMN) in rat liver, the hydrocarbons must satisfy specific requirements of molecular goemetry regarding size, shape, and coplanarity. Expressing the molecular size of these planar compounds by the two-dimensional area occurpied, the size for maximal repressor activitiy ranges between about 85 and 150 A^2. In addition to being within the correct molecular size range the hydrocarbons must have an elongated-rather than compact-molecular shape; circularly shaped and/or highly symetrical hydrocarbons, such as coronene, triphenylene, ovalene and tetrabenzonaphthalene; have very low activity or are inactive, in spite of being in the optimum size range. Coplanarity of the molecule is a critical requirement; thus, the potent carcinogen, 9, 10-dimethyl-1,2-benzanthracene, is inactive as repressor of DMN-demethylase synthesis. Two exceptions, fluoranthene and benzo-(ghi)fluoranthese, showed significant induction of DMN-demethylase. The molecular size distribution of hydrocarbons that repress the DMN-demethylase shows a mirror-image relationship with respect to the earlier reported molecular size requirement for induction of azo dye N-demethylase. Compounds other than hydrocarbons also show the mirror-image relationship in the sense that pregnenolone-16-carbonitrile, α- and β-naphthoflavone and Aroclor 12524 (known to be inducers of various mixed-function oxidases) are strong repressors of DMN-demethylase. Aminoacetonitrile, a strong inhibitor of carcinogenesis by DMN, is also a potent repressor of DMN-demethylase. The enzyme is inhibited by pretreatment of the animals with cobaltous chloride, an inhibitor of the synthesis of cytochrome P-450. Pregnenolone-16α2-carbonitrile and 3-methyl-cholanthrene, despite their similarity of action on DMN-demethylase, have different effects on azo reductase, which is repressed by the former and induced by the latter compound.

56. Arthur, D.R. (1968).

THE BIOLOGICAL PROBLEMS OF LITTORAL POLLUTION BY OIL AND EMULSIFIERS - A SUMMING UP.

In: Biological Effects of Oil Pollution On The Littoral Environment. J.D. Carthy and D.R. Arthur (eds.) Supplement to Volume 2 of Field Studies. Field Studies Council, Great Britian.

This paper summarizes the results of a symposium on the biological effect of oil pollution in the littoral environment. The author concludes that there are many problems posed by oil and emulsifier/solvents that require immediate investigation and lists the most urgent problems.

57. Atema, J. (1975)

SUBLETHAL EFFECTS OF PETROLEUM FRACTIONS ON THE BEHAVIOR OF THE LOBSTER, HOMORUS AMERICANUS, AND THE MUD SNAIL, NASSARIUS OBSOLETUS.

Proc. of Estuarine Research Federation Meetings. 24 pp., 11 ref.

Studies on sublethal effects of petroleum fractions on behavior of H. americanus and N. obsoletus are summarized in an attempt to clarify contradictory results and to gain an understanding of the underlying principles. There appear to be a surprising number of similarities in the way specific petroleum fractions affect the behavior of a curstacean arthropod and a gastropod mollusc. The hypothesis is advanced that (1) specific hydrocarbon fractions is specific amounts are responsible for distinct behavioral changes; (2) these fractions are present in varying quantities in different oils; (3) the changes in behavior are general enough to affect a large number of marine invertebrates in a similar manner.

58. Atema, J, D.B. Boylan and J.H. Todd (1971).

IMPORTANCE OF CHEMICAL SIGNALS IN STIMULATION OF MARINE ORGANISM BEHAVIOR.

Amer. Chem. Soc. Abstr. 162nd Natl. Meeting.

Recent results of the chemotaxis research group at Woods Hole Oceanographic Institution demonstrate the importance of chemical signals in stimulating certain behaviors of marine organisms. It is our belief that man's pollution may exert a subtle but dangerous effect on this important communication system. Such interference could lead to the inability of anadromous fish to find spawning grounds, to the lack of sex stimulation of natural communities through blockage of social recognition and to the disturbance of other aspects of behavior in aquatic organisms. Bioassays have been developed in order to study the effects of natural communicants on behavior of marine organisms and the effects of specific pollutants on chemical communication systems. The results (*Homarus americanus*) and other crustacea, the classification of chemical markers important in homestream recognition by alewives (*Alosa pseudoharengus*) and the identity of host specific substances in the symbiotic relation between the horseshoe crab (*Limulus polyhemus*) and the flatworm *Bdelloura candida*) are discussed. The effects of altered chemical environment on these systems are considered.

59. Atema, J., S. Jacobson, J. Todd and D. Boylan (1973).

THE IMPORTANCE OF CHEMICAL SIGNALS IN STIMULATING BEHAVIOR OF MARINE ORGANISMS: EFFECTS OF ALTERED ENVIRONMENTAL CHEMISTRY ON ANIMAL COMMUNICATION.

In: *Bioassay Techniques and Environmental Chemistry*. Ann Arbor Science Publishers, Inc. pp. 177-197.

Kerosene and the branched chain-cyclic fraction of kerosene were found to stimulate feeding behavior in *Homarus americanus*. A dilute sea water extract of kerosene consisting primarily of benzenes and napthalenes was found to inhibit attraction of the mud snail *Nassarius obsoletus* to food extract.

60. Atema, J. and L. Stein (1972).

SUBLETHAL EFFECTS OF CRUDE OIL ON THE BEHAVIOR OF THE AMERICAN LOBSTER.

Technical Report, Woods Hale Oceanographic Institution, No. 72-74.

61. Atema, Jelle and Lauren S. Stein. (1974).

EFFECTS OF CRUDE OIL ON THE FEEDING BEHAVIOUR OF THE LOBSTER HOMARUS AMERICANUS.

Environ. Pollut. (6). pp. 77-86.

Small quantities of crude oil (oil seawater ratio of 1:100,000) interfered with graphic, possibly chemosensory, behaviour of the lobster, Homarus americanus in their feeding behaviour. The period between noticing food and going after it doubled following the addition of oil. In contrast, the water-soluble fraction of this same amount of crude oil did not have noticeable effects on chemosensory and feeding behaviour. No morphological changes in odor receptors after oil exposure were detected by light and electron microscopy.

Chemical analyses showed that when water was brought in contact with an oil slick, the original lipid concentration of the water dropped considerably. Over a five-day period the oil degraded in seawater, but this could not be correlated with behavioural changes.

The results suggest that small quantities of whole oil mixed into seawater contain a noxious smell to the lobster, depressing appetite and chemical excitability, and increasing the time taken to find food.

62. Atlas, R.M. (1974).

FATE AND EFFECTS OF OIL POLLUTANTS IN EXTREMELY COLD MARINE ENVIRONMENTS.

Office of Naval Research Reference No. AD-769 895/4GA.

The discovery and plans for the use of Alaska's north slope petroleum fields have raised the question of what effects any accidential spillages would have on the indigenous biological populations and what the fate of the oil would be. Interactions of microorganisms and Prudhoe crude oil in Alaskan coastal waters were assessed. The main study site was Prudhoe Bay in Arctic Alaska. Some work was done at Valdez, the proposed southern terminus for the trans-Alaskan pipeline. Other experiments were conducted at Umiat and Cape Simpson, where there are large natural oil seepages.

63. Atlas, R.M., et, al. (1974).

INTERACTIONS OF MICROORGANISMS AND PETROLEUM POLLUTANTS IN THE ARCTIC.

Abstr. Ann. Meet. Am. Soc. Microbiol., 74:64.

Microorganisms encounter oil in the Arctic from natural seepages and accidental spillages. The effects of such petroleum pollutants on the natural microbial communities were determined. Incubation of Prudhoe crude oil with water from coastal ponds along Prudhoe Bay resulted in several changes in the microbial communities. Bacterial populations increased by several orders of magnitude. Addition of 1.0 ml. oil/100 ml. water resulted in a complete disappearance of coccoid green algae and a qualitative change from amoeboid to flagellated protozoans. Other algae, including blue-green and diatoms, appeared to be unaffected by the oil. The microbial populations associated with a natural oil seepage at Cape Simpson were markedly different from those of the adjacent area. The seep was almost devoid of bacteria but did contain large numbers of viable fungi, about 10^6/g. This fungal population was composed of yeasts and one imperfect filamentous fungus, tentatively identified as Rhodotorula, Candida and Mucor species. Miniature oil slicks floating in Prudhoe Bay were subject to extensive microbial degradation under ambient conditions. The microbial populations underlying the slicks greatly increased especially under nutrient-enriched slicks. Pseudomonads showed the greatest increase, but species diversity was unaffected.

64. Atlas, R.M. (1975).

EFFECTS OF TEMPERATURE AND CRUDE OIL COMPOSITION ON PETROLEUM BIODEGREDATION.

Applied Microbiology, 30(3):396-403.

The biodegradability of 7 different crude oils was highly dependent on their composition and on incubation temperature. At $20^{o}C$ lighter oils had greater abiotic losses and were more susceptible to biodegradation than heavier oils. These light crude oils, however, possessed toxic volatile components which evaporated slowly and inhibited microbial degradation of these oils at $10^{o}C$. Rates of oil mineralization for the heavier oils were significantly lower at $20^{o}C$ than for the lighter ones. Similar relative degradation rates were found with a mixed microbial community, using CO_2 evolution as the measure, and with a Pseudomonas isolate from the Arctic, using O_2 consumption as the measure. Paraffinic, aromatic and asphaltic fractions were subject to biodegradation. Some preference was shown for paraffins, especially at low temperatures. Oil residues generally had a lower relative percentage of paraffins and higher percentage of asphaltics than fresh or weathered oil.

65. Atlas, R.M., et al. (1975).

EFFECTS OF PETROLEUM AND RELATED POLLUTANTS ON ARCTIC MICROORGANISMS.

Abstr. Annu. Meet. Am. Soc. Microbiol. 75 208.

Arctic microorganisms were exposed to various concentrations of crude oil, natural gas and the combustion product SO_2. Selected bacteria, algae, fungi and lichens and also mixed communities were examined for effects on nitrogen fixation, photosynthesis and respiration. Sulfur dioxide and crude oil reduced photosynthetic activity, as measured by $14CO_2$ fixation, up to 90%, but natural gas had no similar effect. Respiration of mixed communities, aquatic and terrestrial, and of isolated organisms capable of hydrocarbon metabolism increased when exposed to petroleum hydrocarbons. Sulfur dioxide had no effect on the respiratory activity of any tested microorganism. Using the acetylene-ethylene method greater than 90% inhibition of nitrogen fixation of algae and lichens was observed when crude oil was applied, less than 20% inhibition followed SO_2 exposure and no inhibition was observed.

66. Atlas, R.M., et al (1976)

EFFECTS OF PETROLEUM POLLUTANTS ON ARCTIC MICROBIAL POPULATIONS.

Environ. Pollut., 10(1):35-43.

Microorganisms encounter oil in the Arctic from natural seepages and accidental spillages. Incubation of Prudhoe crude oil with water from coastal ponds along Prudhoe Bay resulted in several changes in the microbial communities. Bacterial populations increased by several orders of magnitude; ameoboid protozoa were replaced by flagellated protozoa; coccoid green algae completely disappeared; diatoms increased and blue-green and green filamentous algae appeared to be unaffected. The microbial populations associated with a natural oil seepage at Cape Simpson were markedly different from those of the adjacent areas. The seep was devoid of vascular plant cover and, in some areas, of bacteria. Fungi were found to be abundant in the bacteria-free regions. Lichens flourished in the older sections. Underlying oil slicks experimentally flated in Prudhoe Bay, the baceterial population increased, in large part attributable to oil degrading Pseudomonads, but species diversity appeared to be unaffected.

67. Atlas, R.M., and R. Bartha (1972)

DEGRADATION AND MINERALIZATION OF PETROLEUM IN SEA WATER.

Biotech Bioeng. 14/297-308

Within the framework of a study on the oil biodegradation potential of the sea, the ability of a Flavobacterium sp. and Brevibacterium sp. to metabolize a parraffinic crude oil and a chemically defined hydrocarbon mixture was investigated. Major components of the crude oil were identified by combination gas chromatography and mass spectrometry. The rate and extent of total hydrocarbon biodegradation was measured. In addition, CO_2 evolution from the crude oil was continuously monitored in a shaker-mounted gas train arrangement. Degradation started after a 2 to 4 day lag period, and reached its maximum within two weeks. At this time up to 60% of the crude oil and 75% of artificial seawater, were degraded. Mineralization (conversion to CO_2) was slightly lower due to formation of products and bacterial cell material. N-Paraffins were preferentially degraded as compared to branched chain hydrocarbons. Biodegradation of n-paraffins in the range of C_{12} to C_{20} was simultaneous; no diauxie effects were observed.

68. Atlas, R.M. and R. Bartha (1973)

ABUNDANCE, DISTRIBUTION AND OIL BIODEGRADATION POTENTIAL OF MICROORGANISMS IN RARITAN BAY.

Environ. Pollut. 4/291-300

Using an improved enumeration technique, the abundance of oil degrading microorganisms was monitored in Raritan Bay during a 1-year period. The determined numbers varied from a low of 20/1 to a high of 3400/1 of surface sea water. The abundance of oil-degrading microorganisms was positively correlated with existing patterns of low-level oil pollution and with the water temperature, but was independent of total microbial counts. All tested sea water samples contained an adequate microbial population to cause the extensive biodegradation of added Sweden crude oil within 18 days. The number of oil-degrading microorganisms in sea water samples was found to be a useful and sensitive indicator of low-level oil pollution that escaped routine gas chromatographic detection.

69. Atlas, R.M. and R. Bartha (1973)

FATE AND EFFECTS OF POLLUTING PETROLEUM IN THE MARINE ENVIRONMENT.

Residue Reviews; Residues of Pesticides and Other Contaminants in the Total Encironment, 49 49-85.

An estimated 5 million metric tons of oil is spilled into the ocean yearly during normal operations. The effects of chronic low-level oil pollution on ecological equilibriums, marine food chains, and seafood consumed by man are also of concern. The composition of crude oil is discussed. The fate of spilled oil is determined by forces such as evaporation, dissolution, emulsification, autoxidation and biodegradation. The crucial role of biodegradation is described. The relative biodegradability of various petroleum components is discussed. Methods of oil pollution control include preventive measures, physical containment, collection, ignition, sinking, dispersion and stimulated biodegradation.

70. Atlas, R.M. and R. Bartha (1973)

STIMMULATED BIODEGREDATION OF OIL SLICKS USING OLEOPHILIC FERTILIZERS.

Environmental Science and Technology, 7(6): 538-541

Biodegradation of polluting oil at sea is seriously limited by the scarcity of N and P. Since water-soluble sources of these elements would be ineffective in the ocean, oleophilic compounds were screened to serve as fertilizers for oil slicks. A combination of paraffinized urea and octy'phosphate promoted oil biodegradation, in laboratory experiments and in field trials, to an extent that the practical application of this principle to oil cleanup appears feasible. The tested oleophilic fertilizer supplies nutrients to hydrocarbon degrading microorganisms selectively and, in contrast to nitrate and phosphate salts, it does not trigger algal blooms.

71. Atlas, R.M. and E. Schofield (1976)

RESPONSES OF THE LICHENS PELTIGENA APTHOSA AND CETARIA NIVALIS AND THE ALGA NOSTOC COMMUNE TO SULFUR DIOXIDE, NATURAL GAS, AND CRUDE OIL IN ARCTIC ALASKA.

Astarte 8, 53-60

The sensitivity of the Arctic populations of the lichens Peltigena aphthosa and Cetaria nivalis and the alga Nostoc commune to three pollutants was determined by measuring rates of nitrogen fixation, CO_2 fixation and O_2 consumption. Sulfur dioxide was most inhibitory to carbon dioxide fixation, but did not inhibit oxygen consumption. Prudhoe crude oil severely inhibited both nitrogen and carbon dioxide fixation. Normal gas has a much lesser effect on the test organisms. Lichens appeared to be less sensitive to the pollutants than were free algae.

72. Aubert, M. and E. Miquelis (1965)

TECHNIQUES FOR STUDYING AND RESULTS OF USING A DESTRUCTIVE PRODUCT (P.A.M.6) ON LAYERS OF FUEL OIL FLOATING ON THE SEA.

Water Pollution Control Federation Journal 1965 pp. 319-322.

After discussing the cuases and characteristics of pollution of sea water by fuel oil, the effects of such pollution on coastal regions and beaches, and the impossibility of chemical treatment to produce a harmless substance, the authors describe extensive studies using various artificial and natural absorbant powders to precipitate the surface layer of hydrocarbon on to the sea bed, thus avoiding carriage of pollution onshore. Exceptionally satisfactory results were obtained only with natural marine deposits of the type containing quartz crystals, hyaline quartz, mica, mica schist, hornblende, and amphibole; the process of adsorption and precipitation of hydrocarbon was accelerated by mixing the adsorbent material with activated silica which serves as a wetting agent. The method introduces no toxic materials into the sea, and the precipitated material has no harmful effects on the benthic flora, but, the products of the gradual degradation are taken up by the benthic flora and may even provide certain growth factors. The natural precipitant used, known as P.A.M.6 was applied satisfactorily on a large scale when water contaminated with hydrocarbons had to be pumped out of a boat wrecked in Cannes Harbor in 1962. (Sinha-OEIS)

73. Avolizi, R.J. and M. Nuwayhid (1974)

EFFECTS OF CRUDE OIL AND DISPERSANTS ON BIVALVES.

Mar. Pollut. Bull, 5 149-152

74. Badger, G.M. (1948).

THE CARCINOGENIC HYDROCARBONS: CHEMICAL CONSTITUTION AND CARCINOGENIC ACTIVITY.

British Journal of Cancer. 2 310-350.

This article reviews the chemical constitution and carcinogenic activity of hydrocarbons.

75. Bailey, N.J.L., H.R. Krouse, C.R. Evans and M.A. Rogers (1973).

ALTERATION OF CRUDE OIL BY WATERS AND BACTERIA.

Bull. Am. Assn. Petrol. Geol., 5(7), 1276-90.

76. Baily, H.C. and R.W. Brocksen (1974)

GROWTH OF JUVENILE CHINOOK SALMAN EXPOSED TO BENZENE, A WATER SOLUBLE COMPONENT OF CRUDE OIL.

J. Fish Res. Bd. Canada

77. Bak, R.P.M. and J.H.B.W. Elgershuizen (1976)

PATTERNS OF OIL-SEDIMENT REJECTION IN CORALS.

Marine Biology, 37 (2): 105-113

The patterns of oil-sediment rejection of 19 Carribean hermatypic corals are identical to their patterns of rejection of clean sediments. The rejection pattern is typical for coral species and displays maximum and minimum rates dependent on the size and density of the oil-sediment particles. A coral's efficienty of rejection of sediment depends on the size and amount of the sediment particles. Oil drops 0.06 mm are removed by the coral's tissues. Physical contact with oil-sediment particles apparently is less harmful to corals than the toxic effects of oils. Three types of sediment were used in the sediment-shedding experiments: sand, sand-oil combinations, and carborundum powder.

78. Baker, J.M. (1970)

COMPARATIVE TOXICITIES OF OILS, OIL FRACTIONS, AND EMULSIFIERS.

In: The Ecological Effects of Oil Pollution on Littoral Communities. E.B. Cowell (ed.). Inst. of Petroleum. pp. 78-87. Great Britian

Work on salt-marsh plants has shown that the low-boiling fractions of crude oil are the most toxic. Fresh crude oil is more toxic than weathered oil. Further evidence from the literature is reviewed: oils vary in their toxicity according to the content of low-boiling compounds, unsaturated compounds, aromatics, and acids. The higher the concentration of these constituents, the more toxic the oil.

All undiluted emulsifiers tested were more toxic to plants than fresh Kuwait crude oil, but none caused permanent damage at concentrations of less than 10 percent.

79. Baker, J.M. (1970)

GROWTH STIMULATION FOLLOWING OIL POLLUTION.

In: The Effects of Oil Pollution on Littoral Communities. E.B. Cowell (ed) Inst. of Petroleum. pp. 72-77

Apparent growth stimulation of plants following oil pollution has been observed by several people. Experimental evidence is presented showing that in some cases there are statistically significant increases in shoot lengths and dry weights of the salt-march grasses Puccinellia maritima and Festuca rubra following oil treatment. Investigation into the reasons for this effect are described: possibilities are nutrients released from other oil-killed organisms; growth regulating compounds in the oil; and an increase of nitrogen fixation. Not enough evidence is yet available for any definite conclusions.

80. Baker, J.M. (1970)

OIL POLLUTION IN SALT MARSH COMMUNITIES.

Mar. Poll. Bull., 1(2):27-28.

This report outlines research carried out between February and December 1969 on the effects of oil pollution and cleansing methods on salt marsh communities in the area near Milford Haven, Pembrokeshire, U.K.

81. Baker, J.M. (1970)

SEASONAL EFFECTS OF OIL POLLUTION ON SALT MARSH VEGETATION.

Oikos, 22(1):106-110.

Salt marsh transects near Pembroke, S.W. Wales, were experimentally sprayed with fresh Kuwait crude oil at different times of year, and recovery measured using a points frame. There was little long term vegetative damage to most perennial species, but in the case of the annual Suaeda maritima damage was severe, and was further investigated using density and dry weight measurements. Flower density measurements for Juncus gerardii, Festuca rubra, Plantago maritima, and Spartina x townsendii, showed that marked reduction of flowering can occur if plants are oiled when the flower buds are developing. Flowers, if oiled, rarely produce seeds. Oiling of seeds during winter may reduce germination in the spring.

82. Baker, J.M. 1970

THE EFFECTS OF OILS ON PLANT PHYSIOLOGY.

In: The Ecological Effects of Oil Pollution on Littoral Communities. E.B. Cowell, (ed.) Inst. of Petroleum, pp. 88-101. Great Britan

Oils can penetrate into plants, where they travel in the intercellular spaces and possibly also in the vascular system. Cell membranes are damaged by penetration of hydrocarbon molecules leading to leakage of cell contents and oil may enter the cells.

Oils reduce transpiration rate, probably by blocking stomata and intercellular spaces. This may also be the reason for the reduction of photosynthesis which occurs, though there are other possible explanations, such as disruption of chloroplast membranes and inhibition caused by accumulation of end-products. The effects of oils on respiration are variable, but an increase of respiration rate often occurs, possibly due to mitochondrial damage resulting in an uncoupling effect. Oils inhibit translocation, probably by physical interference. The severity of the above effects depends upon constituents and amount of the oil, environmental conditions, and species of plant.

83. Baker, J.M. (1970)

THE EFFECTS OF OILS ON PLANTS.

Environ. Poll. 1, 27-44.

Oils vary in their toxicity according to the content of low-boiling compounds, unsaturated compounds, aromatics, and acids. The higher the concentration of these constituents, the more toxic the oil. After penetrating into a plant, the oil may travel in the intercellular spaces and possibly also in the vascular system. Cell membranes are damaged by penetration of hydrocarbon molecules, leading to leakage of cell contents, and oil may enter the cells. Oils reduce transpiration rate, probably by blocking stomata and intercellular spaces. This may also be the reason for the reduction of photosynthesis which occurs, though there are other possible explanations of this--such as disruption of chloroplast membranes and inhibition caused by accumulation of end-products. The effects of oils on respiration are variable, but an increase of respiration rate often occurs, possibly due to mitochondrial damage resulting in an "uncoupling" effect. Oils inhibit translocation probably by physical interference. The severity of the above effects depends on the constituents and amount of the oil, on the environmental conditions, and on the species of plant involved.

84. Baker, J.M. (1971)

COMPARITIVE TOXICITIES OF OILS, OIL FRACTIONS AND EMULSIFIERS.

In: The Ecological Efforts of Oil Pollution on Litteral Communities. E.B. Cowell, (Ed.) p. 78-87. Inst. of Petroleum, Great Britian

Work on salt-marsh plants has shown that the low-boiling fractions of crude oil are the most toxic. Fresh crude oil is more toxic than the weathered oil. Further evidence from literature has been reviewed. Oils vary in their toxicity according to the content of low boiling compounds, unsaturated compounds, aromatics, and acids. The higher the fraction of these constituents, the more toxic the oil. All undiluted emulsifiers tested were more toxic to plants than fresh Kuwait Crude oil but none caused permanent damage at concentrations of less than 10 percent.

85. Baker, J.M. (1971)

EFFECTS OF CLEANING

In: The Ecological Effects of Oil Pollution on Littoral Communities. E.B. Cowell (Ed.) Inst. of Petroleum, pp. 52-57 Great Britian

Emulsifier treatment, burning, and cutting have been experimentally investigated as possible cleaning methods for oiled salt-marsh vegetation. The results given show that none of these methods decrease the damage due to the oil, and they may increase it. In general it is, therefore, best to leave oiled salt marsh to recover naturally.

86. Baker, J.M. (1971)

OIL AND SALT MARSH SOIL.

In: Ecological Effects of Oil Pollution on Littoral Communities, Institute of Petroleum, London. E.B. Cowell (ed.) p. 62-71.

Salt-marsh soil may be affected by oil either directly, when oil penetrates the soil, or indirectly, when oil covers Spartina shoots and, therefore, prevents oxygen diffusion down the plants into the mud. Oil in the soil may have a harmful, a beneficial, or little effect, depending on a number of factors such as volume and type of oil. Concerning oil on Spartina shoots, experimental evidence is presented which indicates that oxygen diffusion down the plants into the mud is normally important in maintaining an oxidized rhizosphere, and that oil on the shoots reduces this diffusion and may, therefore, give rise to an increase of roxic reduced ions.

87. Baker, J.M. (1971)

REFINERY EFFLUENT.

In: The Ecological Effects of Oil Pollution on Littoral Communities, E.B. Cowell (ed.) Institute of Petroleum, London. pp. 33-43.

The effects of a continuous refinery discharge have been studied in Southampton Water. An area of Spartina anglica which has died over the period 1951-70 has been mapped and reasons for death investigated. Soil pH, soil oil content, sulphides, outfall water temperature, and pH in general do not reach damaging levels. Death has probably been caused by thin oil films which become stranded on the plants during high spring tides, and these oil films likewise prevent re-colonization. Soil over most of the marsh surface is not markedly toxic and re-colonization could probably eventually occur if the plants were not subjected to frequent oil films. Oil content was built up mainly in the creeks, where the vegetation, if any is present, now consists mainly of blue green algae.

88. Baker, J.M. (1971).

SUCCESSIVE SPILLAGE.

In: Ecological Effects of Oil Pollution on Littoral Communities E.B. Cowell, (ed.) Institute of Petroleum, London. pp 21-32.

Experimental plots in three plant communities on the N Gower coast, Glamorgan, have been subjected to two, four, eight, or twelve successive monthly oil sprayings. In general, recovery from up to four oilings is good, but more than this results in a rapid decline of the vegetation. Species vary considerably in their tolerance of successive spillages and a tentative grouping is given. This ranges from the very susceptible annuals *Suaeda maritima* and *Salicornia* spp., through grasses and rosette perennials, to the very tolerant Umbellifer *Oenanthe lachenalli*.

89. Baker, J.M. (1971)

THE EFFECTS OF A SINGLE OIL SPILLAGE.

In: The Ecological Effects of Oil Pollution on Littoral Communities E.B. Cowell (ed.) Institute of Petroleum, London pp 16-20

The effects of oil spillages in Milford Haven during 1968 and 1969 are described. These observations, together with evidence from experimental oil spraying and previously published reports on oiled salt marshes, indicate that a single oil spillage does not cause long-term damage to marsh vegetation. Short-term effects are death of oiled shoots, followed by new growth from plant bases. During the recovery period there may be reduced germination and flowering, a reduced population of annuals, and growth stimulation of some species.

90. Baker. J.M. (1973)

BIOLOGICAL EFFECTS OF REFINERY EFFLUENTS

In: Proceedings 1973 Conference on Prevention and Control of Oil Pollution API, USCG, EPA. pp. 715-724. Amer. Petrol Inst. Wash. D.C.

Field and laboratory techniques were used to study the effect of effluents on organisms and communities near discharge sites. Generally, ecosystems differ in their capacity to receive and degrade effluents. Speed of dispersion oil dilution are the major factors determining the amount of biological damage. Changes in distribution and abundance of species are often very localized and in some cases result from behaviorial responses rather than direct toxic effects.

91. Baker, J.M. and G.B. Crapp (1974).

TOXICITY TESTS FOR PREDICTING THE ECOLOGICAL EFFECTS OF OIL AND EMULSIFIER POLLUTION ON LITTERAL COMMUNITIES

In: Ecological Aspects of Toxicity Testing of Oils and Dispersants
L.R. Bengen and E.B. Cowell (eds.) John Wiley & Sons, New York. pp. 23-40

In this paper an attempt is made to correlate the results of final tests with laboratory toxicity tests in order to be able to predict the ecological impact of oil and emmulsifiers on salt marshes and rocky shores.

92. Baker, J.M., J. Jelly, and S. Reynard (1973)

THE "DONA MARIKA" OIL SPILL

Marine Pollution Bulletin, 4 (12) : 181-182.

In Aug. 1973, 3,000 tons of gasoline was spilled in Milford Haven (Wales) when the tanker DONA MARIKA ran aground. Since most documented oil spills in British waters have been of crude oil, there was considerable interest in the damage cuased by this spillage of a refined oil product. Information is provided on behavior of gasoline in water, biological examination of the shore, and sublittoral effects. Pb analyses and reports from the general public. The leakage, which lasted for several days, severely affected the fauna of Lindsway Bay. Death of mollusks, particularly of limpets, resulted from prolonged anesthesia, or more usually from predation by gulls. There does not seem to have been a significant accumulation of Pb, and no obvious traces of gasoline remained on the rocks 1 wk after the accident. A large growth of seaweed is to be expected following the death of large numbers of limpets, and within 4 wk of the accident Enteromorpha was growing rapidly and giving the whole bay a green appearance.

93. Baldwin, I.L. 1922.

MODIFICATION OF THE SOIL FLORA INDUCED BY APPLICATIONS OF CRUDE PETROLEUM.

Soil Science, 14:465-475

The soil flora is changed remarkably by applications of crude petroleum. Most types of bacteria are inhibited by the action of the crude petroleum, but some few types are very greatly stimulated by its action. Mold growth is not inhibited by the action of the crude petroleum.

Ammonia production in the soil is lowered slightly by applications of crude petroleum. The ammonia produced in the soil is probably the result of mold growth and not bacterial action as the bacterial types favored by the crude petroleum are not able to form ammonia from organic material.

When first applied, nitrate production in the soil is completely inhibited by the crude petroleum. The inhibitory action lasts over a varying period of time, depending upon the size of the application, and is followed by a period of rather slow nitrification, which gradually becomes more intense.

The data in regard to crop growth are not conclusive, but the indications are that small applications of curde petroleum to the soil do not injure its crop-procuding power. Larger applications have a detrimental indluence partly because of their effect on the physical condition of the soil.

It seems that crude petroleum when incorporated in soil is gradually broken down into simpler products and the effect of its presence is no longer apparent.

94. Barbier, M.D. Joly, A. Saliot and D. Tourres. 1973

HYDROCARBONS FROM SEA WATER.

Deep Sea Res. 20:305-314

Dissolved hydrocarbons have been extracted by means of chloroform, from coastal and open sea waters; after isolcation of the unsaponifiable fraction and prepatative thin-layer chromatography, they were analysed by gas liquid chromatorgraphy and mass spectrometry.

Hydrocarbons represent ca 20% of the total extracts; concentrations mg= micrograms may vary from 10 to 140 mg/l. N-Paraffins occur to an extent of ca. 12% from n-C_{14} to n-C_{37}, with a maximum at n-C_{27} to n-C_{30}; odd carbon paraffins are not predominant. Sea waters of different origins (collected at depths of as much as 4500 metres) show a similar composition in dissolved hydrocarbons; this composition does not differ much from the hydrocarbons usually found in algae. A probable hypothesis is that sea-water hydrocarbons originate from the micro or macro phytoplankton. Coastal waters clearly indicate pollution by hydrocarbons of lower molecular weight or chlorinated hydrocarbons.

95. Barclay-Smith, P. (1956)

OIL POLLUTION

Bird notes, 27, 81-83

96. Bergmann, G. 1971

BIOBLIOGRAPHY OF EFFECTS OF OIL POLLUTION ON AQUATIC ORGANISMS.

Publ. College Fisheries, University of Washington, Seattle.

97. Barnett, C.J. and J.E. Kontogiannis. 1975

THE EFFECT OF CRUDE OIL FRACTIONS ON THE SURVIVAL OF A TIDEPOOL COPEPOD, TIGRIOPUS CALIFORNICUS.

Environ. Pollut., 8:45-54.

The effect of four common crude oil fractions on the survival of a tidepool copepod, Tigriopus californicus, were studied. Four concentrations each of diesel oil, kerosene, gasoline and benzene were used. Diesel oil was the most detrimental; a concentration of 0.10 ml/l caused total mortality within five days. The three highest concentrations of kerosene resulted in less than 15% survival at the end of eight days. Gasoline showed the highest mortality within the first 24 h while benzene was most lethal between the first and second days. We conclude that the more slowly evaporating crude oil fractions present the greatest hazard and that the survival of T. californicus is inversely proportional to the concentration of the crude oil fraction in the environment.

98. Barry, M.M., P.P. Yevich, and H.H. Thayer, (1971)

AYPICAL HYPERPLASIA IN THE SOFT-SHELLED CLAM MYA ARENARIA.

J. Inverte. Pathol. 17, 17-27

Nine hundred and forty Mya arenaria were collected from four geographic locations (Maine, Rhode Island, Maryland and California). Histological examination of these animals showed that 354 contained areas of hyperplasia. Studies are currently underway to identify causitive factors, among which may be pollutants such as petroleum hydrocarbons.

99. Barry, M.M. and P.P. Yevich (1972)

INCIDENCE OF GONADAL CANCER IN THE QUAHOG MERCENARIA MERCENARIA.

Oncology, 26 87-96.

100. Barry, M. and P.P. Yevich (1975)

THE ECOLOGICAL, CHEMICAL AND HISTOPATHOLOGICAL EVALUATION OF AN OIL SPILL SITE, PART III: HISTOPATHOLOGICAL STUDIES.

Mar. Poll. Bull. 6, 171-173.

In July 1971 when approximately 25% of the clams in Long Cove, Searsport, Maine had been killed by the March 1971 oil spill, collections of surviving clams were made for histological examination. These studies were continued through 1974 and revealed a high incidence of gonadal tumors in clams contaminated by oil. The area of highest oil impact correlated with the highest percent of tumors. The tumors were found to be maligant neoplasms.

101. Barsdate, R.J. 1972

ECOLOGIC CHANGES IN AN ARCTIC TUNDRA POND FOLLOWING EXPOSURE TO CRUDE OIL.

Sci. Alaska. Proc., Alaskan Sci. Conf., Vol. 23:52.

The Application of Prudhoe Bay crude oil to a small tundra pond at Barrow, Alaska, in July of 1970 was followed by a number of physical, chemical, and biological changes. Physical effects of the spill were minor for the most part of short duration. Immediately following the spill the pond water temperatures increased 4°C due to reduced evaporative cooling, but normal temperatures were reestablished within three days. Low oxygen occurred in the water under the floating oil, but neither major ionic constituents nor dissolved nutrient compounds were influenced greatly. During the 1970 season, phytoplankton and emergent vascular plant production appeared unaffected, although there was massive zooplankton mortality. During the second year (1971), the production of phytoplankton, benthic algae, and vascular plants was low. Numbers of benthic animals and the biomass of chironomid larvae were low, as was the survival of crustacea presumably introduced as resting or early active stages during spring breakup. Based on preliminary information the pond system appears in 1972 to be very similar to the previous year.

102. Barsdate, R., *et al*. 1972

NATURAL OIL SEEPS AT CAPE SIMPSON, ALASKA: AQUATIC EFFECTS.

Sci. Alaska Proc. Alaskan Sci. Conf., Vol, 23:91-95.

In ponds at the natural oil seeps of Cape Simpson, Alaska, phytoplankton productivity and abundance, as well as numbers of bacteria, were high in waters in contact with old tars and asphalts. Both oil-free ponds and ponds containing much fresh, low viscosity oil were substantially less productive. The ionic composition of the water was little influenced by the seeps. Phytotoxicity may limit primary productivity in waters in contact with relatively fresh oil, but at lower levels of hydrocarbon stress productivity is high, possibly because of reduced grazing pressure.

103. Bartha, R. (1976)

BIODEGREDATION OF OIL SLICKS IN THE MARINE ENVIRONMENT.

Office of Naval Research Report N00014-67-A-0115-0005. Distributed by Defense Documentation Center, Defense Supply Agency, Cameron Station, Alexandria, Virginia. 14 pp.

The degradation of petroleum hydrocarbons by marine bacteria was studied with the ultimate aim of using this process in the cleanup of polluting oil. Hydrocarbon-utilizing marine bacteria were isolated and their growth requirements and metabolic pathways were studied. Enzymatic and regulatory mechanisms responsible for the recalcitrance or delayed utilization of certain hydrocarbons, e.g. polynuclear aromatics and highly branched iso-alkanes were identified. The abundance and distribution of hydrocarbon degrading bacteria was measured in New Jersey coastal waters. The limiting factors of oil biodegradation in the marine environment were studied. Apart of the nature of the oil itself, water temperature and mineral nutrients (N, P, Fe) were found to be the most important limiting factors. Given favorable water tempoeratures, the rate of oil biodegradation can be increased by an order of magnitude of more by supplying the above mineral nutrients to a floating oil slick in oil-soluble (oleophilic) form. This method of application prevents nutrient loss by dilution and does not trigger algal blooms. The patented procedure is considered to be a new cost-effective way to cleanup oceanic oil spills.

104. Bartha, R., and R.M. Atlas. (1973)

BIODEGRADATION OF OIL IN SEAWATER: LIMITING FACTORS AND ARTIFICIAL STIMULATION, PP.147-152.

In: The Microbial Degradation of Oil Pollutants, Ahearn and Meyers, (eds) Center for Wetland Resources, LSU, Baton Rouge, La., Publ. No. LSU-SG-73-01.

The limiting factors of petroleum biodegradation in seawater were systematically evaluated. In the surveyed coastal waters, hydrocarbon oxidizers were found to be abundant, but their substrate ranges relatively restricted. Besides lowering the biodegradation rates, low water temperatures caused long lag periods due to retention of volatile inhibitors in curde oil. Nitrogen and phosphorus were found to be severely limiting. Addition of these nutrients dramatically increased oil biodegradation both in laboratory and in field experiments. An oleophilic fertilizer formula for use on flating oil slicks is described.

105. Bascom, W.N. (1975)

INSTRUMENTATION FOR MEASURING POLLUTION IN THE SEA.

In: Marine Municipal and Industrial Watewater Disposal: Third International Congress: Preprints pp. IX-1-IX-30.

The most useful and cost-effective instruments for measuring, sampling, and making observations at sea are presented and described. The selected instruments are designed to make measurements of the physical characteristics of the sea, water chemistry, soft bottom sampling fish populations, and direct observation of undersea environments. The instruments or samplers used to quantify various pollutants in the sea are current meters, bathythermograph, turbidity meter, floatable sampler, sediment collector, multiple measurements, microbe sampler, mussel buoy, television and 35-mm cameras, trawls, baited movie cameras, grab sampler, interstitial water sampler, geological corer, and biological box corer.

106. Battelle Memorial Institute, Richland Washington (1967)

OIL SPILLAGE STUDY LITERATURE SEARCH AND CRITICAL EVALUATION FOR SELECTION OF PROMISING TECHNIQUES TO CONTROL AND PREVENT DAMAGE. Distributed by NTIS.

One section of this report covers biological and ecological effects of oil pollution on fish and shellfish, waterfowl, aquatic plants, and other life forms. A section on bioassay of detergents is included.

107. Battelle Memorial Institute (1969).

REVIEW OF THE SANTA BARBARA CHANNEL OIL POLLUTION INCIDENT:

Report to Federal Water Pollution Control Administration and U.S. Coast Guard, Water Pollution Control Research Series DAST 20,100 pp.

108. Battelle Memorial Institute (1972).

OIL SPILL THREATY AGENTS: A COMPENDIUM.

American Petroleum Institute, Publication 4150. 238 pp. Washington, D.C.

Agents for treating oil spills on water are categorized, and the mechanisms by which they function are classified. General identification information is given for all agents, along with data on chemical and physical properties, cost, availability, application, effectiveness, toxicity and spill experience. Agents are listed by manufacturer, trade name and type.

109. Battelle Memorial Institute (1974).

SUMMARY REPORT ON THE EFFECTS OF OIL DISCHARGES, DOMESTIC AND INDUSTRIAL WASTEWATERS ON THE FISHERIES OF LAKE MARACAIBO, VENEZUELA TO CREOLE PETROLEUM CORPORATION CARACAS, VENEZUELA.

Battelle, Pacific Northwest Laboratories, Richland, Washington.

Samples of lakewater, sediments and biota were subjected to laboratory experiment and analysis over a period of three years, 1971-1974. The study concludes that oil enters the lake ecosystem both by natural seeps and incidental to oil production but that these hydrocarbons have not caused discerable damage.

110. Bayne, Brian (1976)

WATCH ON MUSSELS

Mar. Pollut. Bull. 7 217-218

This article argues for an international effort to use Mytilus as a monitor of the levels of pollutants in the marine environment.

111. Bechtel, T.J. and B.J. Copeland (1970)

FISH SPECIES DIVERSITY INDICES AS INDICATORS OF POLLUTION IN GALVESTON BAY, TEXAS.

Mar. Sci. Univer. Tex. 15: 103-132

Fish species diversity indices calculated from both fish weights and numbers were found to be indicators of environmental and pollution stress in Galveston Bay, Texas. Correlation of diversity with percent waste water indicates that those areas receiving the greatest amounts of effluents and toxic materials have the lowest diversity. Sampling throughout the system indicated that the fish populations could be divided into somewhat separated communities, each structured as a response to environmental and pollution stress.

112. Beer, J.V. (1968)

POST-MORTUM FINDINGS IN VILED ANKS DYING DURING ATTEMPTED REHABILITATION.

In: The Biological Effects of Oil Pollution on Littoral Communities, J.D. Carthy and D.R. Arthur, (eds.) Supplement to Vol. 2 of Field Studies. Field Studies Council

This paper describes the motality and pathology of birds damaged in the Torry Canyon oil spill and whose rehabilitation was being attempted. The pattern of mortality and pathological changes were strongly suggestive of severe stress and the presence of powerful irritants or poisons in the gut. Mortality followed a roughly exponential path, with chances of survival decreasing with this.

113. Beer, J.V. (1968)

THE ATTEMPTED REHABILITATION OF OILED SEA BIRDS.

Wildfowl, 19, 120-124

114. Beery, J.V. 1970

TREATING OILED BIRDS

Mar. Poll. Bull. 1(6): 84-85

Large numbers of oiled birds, mostly guillemots, were brought in to the RSPCA Wild Birds' Hospital at Mousehole in Cornwall. Oiled plumage was cleaned with "Tremalon B" or "Euirly Liquid" followed by rinsing in warm water and drying in a stream of hot air. "Larodan 127" proved to be an efficient cleanser but lethal to the birds. Internal treatment consisted of dosing with a medicinal paraffin-bismuth mixture to a meliorate the condition of the gull. Vitamin B complex was also administered to weakened birds. They were fed sprat and herring. Waterproof of the plummage is slow to return. The birds need individual attention and the success rate is inversely related to the number of birds that have to be handled simultaneously.

115. Bellamy, D.J. 1968

THE KELP PROJECT

Triton, <u>12</u>, 16-17

116. Bellamy, D.J., P.H. Clarke, D.M. John, D. Jones, A. Whittick, and T. Darke. 1967

EFFECTS OF POLLUTION FROM THE TORREY CANYON ON LITTORAL AND SUBLITTORAL ECOSYSTEMS.

Nature, <u>216</u>: 1170-1173

Pollution from oil and detergent deposited on the beaches of Devon and Cornwall after the grounding of the Torrey Canyon on March 18, 1967, has altered the balance of littoral and sublittoral ecosystems at two sites. This effect is most marked on the littoral zone, and falls off below the low water mark.

117. Bellamy, D.J. and A. Whittick (1968)

PROBLEMS IN THE ASSESSMENT OF THE EFFECTS OF POLLUTION ON INSHORE MARINE ECOSYSTEMS DOMINATED BY ATTACHED MACROPHYTES.

In: <u>The Biological Affects of Oil Pollution on Littoral Communities</u> J.D. Carthy and D.R. Arthur (eds.) Supplement to Volume 2 of Field Studies, Field Studies Council.

This paper describes methods developed for the study of the effects of chronic and acute pollution by use of phytosocialogical oil phytometric comparison of an area before and after pollution oil comparison of polluted against non-polluted areas. The macrophyte chosen as a phytometer was <u>lamminaria</u> <u>hyperborea</u>.

118. Bellan, G.L. (1974)

TOXICITY TESTING AT THE STATION MARINE D'ENDOUME

In: <u>Ecological Aspects of Toxicity Testing of Oils and Dispersants</u> L.R. Beynon and E.B. Cowell (eds.) John Wiley & Sons New York

This presentation is a description of the short-term and long-term toxicity tests developed by the Station Marine d'Endoume.

119. Bender, M.F. (1974)

EVALUATION AND INTERPRETATION OF DIVERSITY MEASURES AS BIOLOGICAL INDICES OF POLLUTION AND/OR ENVIRONMENTAL CHANGE IN AQUATIC SYSTEMS, PP. 474-481.

In: Proceedings of the International Seminar and Exposition on Water Resources Instrumentation, Vol. 2, Data Acquisition and Analysis. Krizek, R.J. and E.F. Mosonyi (eds.) Ann Arbor Science Publishers.

This paper presents the evaluation and interpretation of two diversity measures, the Shannon and evenness measures, that can be employed as biological indices of changes in the quality of an aquatic system. The use and misuse of such measures are also discussed.

120. Bender, M.E., J.L. Hyland, and T.K. Duncan (1974)

EFFECT OF AN OIL SPILL ON BENTHIC ANIMALS IN THE LOWER YORK RIVER, VIRGINIA.

In: NBS Special Publication 409, Marine Pollution Monitoring (Petroleum), Proceedings of a Symposium and Workshop held at NBS, Gaithersburg, Maryland, May 13-17, 1974.

This article reports the findings of field and laboratory experiments designed to determine the effect of a spill of number 6 fuel oil on intertidal benthic communities of the lower York River, Va. The field study consisted of a series of transects in the spill and control areas, which were sampled quarterly after the spill by use of plexiglass corers. The effect of the spill was most evident when comparing numbers of species. Recovery in terms of both species richness and faunal similarity was shown two years after the spill. The laboratory studies tested the toxicity of water soluble fractions of Bunker C oil to seven members of the benthic intertidal community. The four species which were not affected by accommodated oil in the laboratory also did not reveal population depressions following the oil spill in the rivers.

121. Bender, M.E., E.A. Shearls, R.P. Ayres, C.H. Hershner, and R.J. Huggett (1977)

ECOLOGICAL EFFECTS OF EXPERIMENTAL OIL SPILLS ON EASTERN COASTAL PLAIN ESTUARINE ECOSYSTEMS.

In: Proceedings 1977 Oil Spill Conference. p. 505-Amer. Petrol. Inst. Wash. D.C.

Five segments of a mesohaline marsh located off the York River in Virginia were physically isolated from the surrounding area, except for allowing subtidal flow and dosed with fresh and artificially weathered South Louisiana crude oil. The experimental design and field site utilized in this study are described. The mini-ecosystems each contained about 695 m^2 of marsh. 100 m^2 of open water and 15 m^2 of intertidal mud flat. In September 1975, three barrels (5701) of each of the experimental oils were spilled into replicate systems.

Overall, the artifically weathered oil was shown to have as great an ecological impact on the communities as the fresh crude. Phytoplankton and fish populations all showed greater declines following the spills in the weathered oil systems. Phytoplankton production declined immediately after both oil spills but had recovered to control values within seven days. Species composition was not affected by the oils, while periphyton biomass, as measured by adenosine triphosphate (ATP), increased after both treatments. Marsh grass production was reduced in both spill units. Benthic animals, showing population declines after both oil spills, included nereid polychaetes, insect larvae and amphipods. Oligochaete populations decreased shortly after the fresh crude spill, returned to normal within 30 days, and then declined again relative to the control in both treatments 11 weeks after the spill. Mortalities of fish. Fundulus herteroclitus, held in live boxes were noted only in the weathered treatment systems.

122. L.R. and E.B. Cowell (eds.) (1974)

Ecological Aspects of Toxicity Testing of Oils and Dispersants.

John Wiley & Sons New York 149 p.

This volume contains the proceedings of a workshop on the toxicity testing of oils and dispersants held at the Institute of Petroleum, London. Papers are presented in this volumn together with discussions. The papers deal with both laboratory and field investigations. A final article giving a European view, written by the editors and K.W. Wilson was produced after the workshop meeting and summarizes some of the general conclusions.

123. Berdugo, V., R.P. Harris and S.C. O'Hara (1977)

THE EFFECT OF PETROLEUM HYDROCARBONS ON REPRODUCTION OF AN ESTUARINE PLANKTONIC COPEPOD IN LABORATORY CULTURES.

Mar. Pollut. Bull. 8:6 138-143

The effect of short-term exposure to high concentrations (mg/l) of water soluble fraction of aromatic heating oil on subsequent egg production by the estuarine copepod Eurytemora affinis was studied in laboratory cultures to investigate possible sublethal biological effects following exposure to hydrocarbon under an oil spill. Significant reduction in subsequent length of life, total number of eggs produced, mean brood size, and rate of egg production was observed. Exposure to naphthalene alone at 1 mg/l for 24 h produced a significant effect on total fecundity of the females. Ingestion rates were significantly lowered. Exposure to low levels (10 and 50 mg/l) of ^{14}C-naphthalene alone over 10 days produced no significant effect on feeding or reproduction despite the high concentrations of hydrocarbon accumulated.

124. Berridge, S.A., R.A. Dean, and others (1968)

PROPERTIES OF PERSISTANT OILS AT SEA.

Institute of Petroleum Journal, London, 54 (539), 300-309.

This paper discusses the physical, chemical and biological processes which may operate on crude oil after it has been spilled at sea. It is suggested that evaporation is the major process, that biological degradation is insignificant, and that the formation of water-in-oil emulsions will markedly affect the rates of these processes, and extent and ease of removal of pollution. Research into the rates of these processes, particularly biological ones, is urgently needed but the design of the experiments poses many problems. (Sinha-OEIS)

125. Berry, W.O. and J.D. Brammer (1977)

TOXICITY OF WATER-SOLUBLE GASOLINE FRACTIONS TO FOURTH-INSTAR LARVAE OF THE MOSQUITO AEDES AEGYPTI L.

Environ. Pollut. 13, 229-234

The toxicity of water-soluble components of gasline to laboratory-reared fourth-instar larvae of the mosquito *Aedes aegypti* (L.) was investigated. A median lethal dose (LD_{50}) and a non-lethal dose (NLD) were established for these larvae following a 24 hour exposure to water-soluble fractions of benzene, toluene, and xylenes. Based on the actual amount of each component in solution, static toxicity bioassays showed that acute toxicity of these monoaromatics increased in the sequence benzene, toluence, xylene. However, toxicity increased in the sequence xylene, benzene, toluene when the results were examined with respect to the amount of aromatic added to water to produce the LD_{50}. The importance of determining the concentrations of compounds dissolved in water is stressed.

126. Berwald, Y. and L. Sachs. (1965)

IN VITRO TRANSFORMATION OF NORMAL CELLS TO TUMOR CELLS BY CARCINOGENIC HYDROCARBONS.

J. Nat. Cancer. Inst. 35:641-661

The application of benzo[a]pyrene (BP) to normal hamster-embryo cells in culture produced transformed cells. These cells showed: 1) a hereditary random pattern of growth,

2) the ability to grow continuously in culture, 3) progressive growth as tumors after subcutaneous inoculation into adult hamsters, 4) a resistance to the toxic action of BP when tested at a later stage of growth in culture. Transformed cells in culture were obtained with the in vivo carcinogenic hydrocarbons BP, 3-methylcholanthrene (MCA), 7, 12-dimethylbenz(a)anthracene, and 10-methylbenz(a)anthracene, but not in untreated hanster-embryo cultures or with the in vivo noncarcinogenic hydrocarbons 8-methylbenz(a)anthracene, chrysene and pyrene. It was shown that carcinogenic hydrocarbons can directly induce in vitro the transformation of normal cells to tumor cells.

127. Bieri, R.H., V.C. Stamoudis, M.K. Cueman. (1977)

CHEMICAL INVESTIGATIONS OF TWO EXPERIMENTAL OIL SPILLS IN AN ESTUARINE ECOSYSTEM

In: Proceedings 1977 Oil Spill Conference p. 511-515. Amer. Petrol. Inst, Wash. D.C.

The fate of fresh and artifically weathered South Louisiana crude oil was investigated in large-scale experimental oil spills. The oil, originally introduced to the surface of a creek bounded by walls of transite (but open at subtidal level to allow communication with surrounding waters), was distributed by tidal action over a marsh of *Spartina alterniflora*. Samples of surface film, water, organic detritus, sediment, fish (*Fundulus heteroclitus*) oyster (*Crassostrea Virginica*), and clam (*Mercenaria mercenaria*) were collected over long periods and subjected to detailed chemical analysis by gas chromatography and computerized low resolution GC-MS techniques. Results are presented for water and *Fundulus*.

Maximum concentration of individual aromatic compounds found in fish were similar for both oils. This maximum occurred six hours after the spill for weathered crude and 76 hours after the spill for fresh crude for all aromatic compounds except naphthalene and the methylnaphthalenes. Uptake appeared to be non-specific. In all cases investigated, hydrocarbon concentrations in animal tissue reached a maximum and then decreased to levels below measurability (<10 ppb). In the interpretation of the data, a distinction is made between environmental residence times observed in natural systems and the biological residence times measured in laboratory experiments.

128. Bingham, E., A.W. Horton, and R. Tye (1965)

THE CARCINOGENIC POTENCY OF CERTAIN OILS.

Arch. Environ. Health, 10, 449-451

129. Blackman. R.A.A. and Mackie, P.R. (1973)

PRELIMINARY RESULTS OF AN EXPERIMENT TO MEASURE THE UPTAKE OF N-ALKANE HYDROCARBONS BY FISH.

ICES, CM 1973/E:23 Fisheries Improvement Committee, Lisbon.

130. Blaylock, J.W., P.W. O'Keefe, J.N. Roehm and R.E. Wildung. (1973)

DETERMINATION OF N-ALKANE AND METHYLANAPHTHALENE COMPOUNDS IN SHELLFISH.

In: Proc. Joint Conf. Prevent. Contr. Oil Spills, API, Washington, D.C. pp. 173-177.

During the course of investigations to determine the possible toxicity of petroleum to marine biota, it became evident that quantitative estimates of the petroleum components in water and biota would assist in meaningful interpretation of the results of bioassays. However, published procedures for estimation of n-alkanes in marine biota were largely qualitative, and even less effort had been afforded the measurement of aromatic petroleum residues. A method originally utilized for determination of ploycyclic aromatic hydrocarbons in foods was therefore adapted for the digestion of tissue and extraction of hydrocarbons from shellfish exposed to petroleum during bioassays. Tissue extracts were partitioned into saturate and aromatic fractions by column chromatography. Using gas-liquid chromatography, the n-alkanes of carbon numbers 12 to 19, and the methyl substituted naphthalenes were identified in the saturate and aromatic fractions, respectively. Both groups of compounds were quantitated by reference to an internal standard.

The procedure allowed recovery of over 70% of n-alkanes and methylnaphthalenes applied to the tissues prior to digestion. Minimum detectable levels for n-alkanes and methylnaphthalenes were approximately .08 to .15 and .03 to .04Mg/g of wet tissue, respectively.

131. Bleakley, R.J. and P.J.S. Boaden (1974)

EFFECTS OF AN OIL SPILL REMOVER ON BEACH MEIOFAUNA.

Institute Oceanographique, Paris. Annales, 50(1): 51-58

The effects of an oil spill remover (80% nonyl-octyl phenol ethylene oxide condensate; 20% methyl cyclohexanol), and of the surfactant alone, on the meiofauna of intertidal sand were examined. The meiofauna apparently survives the effects of diluted detergent because of molecular adsorption by the sand grains, but concentrations >100 ppm are toxic. Spraying of beaches contaminated by oil spills probably produces such concentrations. The meiofauna recovers very slowly because of the persistence of detergent in the sand. The long-term effects on the meiofauna are not influenced by the state of the tide at the time when the detergent is applied.

132. Blumer, M. (1967)

HYDROCARBONS IN DIGESTIVE TRACT AND LIVER OF A BASKING SHARK.

Science, N.Y., 156 390-1

Hydrocarbons of zooplankton pass through the digestive tract of the basking shark without fractionation or structural modification. They are resorbed in the spiral valve and deposited in the liver. In contrast to unsaturated fatty acids, the olefinic hydrocarbons are not decreased in concentration. The hydrocarbon assemblage in the digestive tract and in the liver is indicative of the food sources and feeding grounds of the shark. Sgnalene, abundant in shark liver, occurs only in traces in zooplankton; phytane, if present at all, constitutes less than 0.005 percent of the hydrocarbons of zooplankton and of shark liver.

133. Blumer, M. (1969)

OIL POLLUTION OF THE OCEAN

Oil on the Sea. D.P. Hoult (ed.) Plenum Press, New York pp. 5-13

Also In: WHOI Contrib. # 2336

A review of oil pollution in the marine environment including the extent of marine oil pollution, oil composition and biological effects; oil analysis and law enforcement; long term effects of oil pollution; countermeasures against large oil spills; and a long-term outlook. 10 refs.

134. Blumer, M. 1970

OIL CONTAMINATION AND THE LIVING RESOURCES OF THE SEA.

In: FAO Techn. Conf. Mar. Pollut., paper R-1, Rome, 1-11.

Review article on the affects of oil on the biota with recommendations on the handling of spills and observations on the probable impact of pollution on the ocean as a whole. Several references.

135. Blumer, M. (1971)

SCIENTIFIC ASPECTS OF THE OIL SPILL PROBLEM.

Environmental Affairs, 1(1):54-73

This article reviews the input and ecological impact of petroleum hydrocarbons in the marine environment. Topics covered include toxicity, carcinogenesis, biodegredation, and persistence of oil.

136. Blumer, M. Et.al (1971)

PANEL 2: PETROLEUM.

FAO Fish Rep. Suppl. 1(99) 17-36

A review of petroleum pollution in the marine environment including: a description of petroleum; its concentration in the environment; the use of petroleum and the extent of marine pollution's monitoring systems; hydrocarbon analysis of water, sediments, and organisms; correlation of spilled oil and its source; choice of analytical techniques; isolation of hydrocarbons; gas chromathography; gel permention deromatagraphy; spectral analysis of 6C eluates; contamination problems; interlaboratory calibration; automation of techniques; methods of obtaining oil samples; hydrocarbon analysis of biological samples; biological monitoring; detection and monitoring; environmental fate of oil; determination of polycyclie aromatic compounds; interaction between oil pollution and other pollutants; and a registory of laboratories active in oil pollution research.

137. Blumer, Max (1972)

SUBMARINE SEEPS: ARE THEY A MAJOR SOURCE OF OPEN OCEAN OIL POLLUTION?

Science, 176, 1257-1258

This article argues that submarine seepage is several orders of magnitude less than man's action in fouling the high seas and beaches. If annual submarine seepage since the early tertiary had averaged the present rate of oil pollution from human activity, then the average offshore oil field would have lost to the oceans 2500 times the free flowing oil, or more than 1500 times the total oil existing in situ before commercial offshore oil production started.

138. Blumer, M., Ehrhardt, M. and Jones, J.H. (1973)

THE ENVIRONMENTAL FATE OF STRANDED CRUDE OIL.

Deep Sea Res. 20 239-60

The weathering history of 2 light paraffinic crude oils which stranded on Martha's Vineyard, Massachusetts, and on Bermuda was studied over periods of 13 1/2 and 16 mo. respectively. The evaporative history of the oils, the microbial utilization of the normal alkanes, and other physical and chemical changes involved in the weathering process are described. At both locations a considerable and environmentally important fraction of the oil persisted throughout the survey period. The residues are far from being inert asphalts, they remain crude oils, modified by evaporation of the lower boiling components and by partial microbial degradation. The environmental impact of spilled oil depends directly on the magnitude of the standing crop of fossil fuels and on the retention during weathering of specific biologically active oil components. An unanticipated degree of persistence of oil and of its high boiling components, even under conditions favorable to weathering, was indicated. Wax aggregates in one of the oils suggest that it was derived from tank washings. A survey for wax in open ocean tar should give insight into its sources and the effectiveness of measures to control oil pollution.

139. Blumer, M., R.R.L. Guillard and T. Chase. (1971)

HYDROCARBONS OF MARINE PHYTOPLANKTON.

Marine Biology 8, 183-189

The hydrocarbon contents of 23 species of algae (22 marine planktonic), belonging to 9 algal classes, were analyzed. The highly unsaturated 3, 6, 9, 12, 15, 18-heneieosahexaene predominates in the Bacillariophyceae, Dinophyceae, Cryptophyceae, Haptophyceae and Euglenophyceae. Rhizosolenia setigera contains n-heneicosane, presumably derived from the hexaolefin by hydrogenation. Two isomeric heptadecenes have been isolated: the double bond is located in 5-position in the bluegreen alga Synechococcus bacillaris and in 7-position in 2 green algae. Our complete analyses are discussed in the context of earlier data; some generalizations appear no longer valid. Hydrocarbon analysis of marine algae should provide a tool for the investigation of the dynamics of the marine food chain. Knowledge now available provides the background needed for distinguishing between hydrocarbons of recent biogenic origin and hydrocarbon pollutants from fossil fuels.

140. Blumer, J., J.M. Hunt, J. Atema, and L. Stein (1973)

INTERACTION BETWEEN MARINE ORGANISMS AND OIL POLLUTION.

Office of Research and Monitoring, U.S. Environmental Protection Agency Report No. EPA-R3-73-042.

141. Blumer, M., J.C. Robertson, J.E. Gordon, and J. Sass, (1969)

PHYTOL-DERIVED C_{19} DI- AND TRIOLEFINIC HYDROCARBONS IN MARINE ZOOPLANKTON AND FISHES.

Biochemistry 8:4067-4074

Three phytol-derived olefinic hydrocarbons have been isolated from marine zooplankton and fishes. Their structures have been determined by ultraviolet, infrared, nuclear magnetic resonance, and mass spectometry and by combined gas chromatography and mass spectomatry of their ozonolysis products. They are the 2, 10- and 5, 10-diene and the 2, 6, 10-triene analogs of pristane (2, 6, 10, 14-tetramethylpentadecane). The presumed mode of formation of these and related olefins and their fate in the marine food chain and in marine sediments is discussed. Because of their relative stability, these and related olefins and their fate in the marine food chain and in marine sediments is discussed. Because of their relative stability, these and related hydrocarbons provide tracers for the study of dynamic processes in the marine food chain. These olefins are not present in ancient sediments and in petroleum; therefore, they are valuable markers for the distinction between hydrocarbons derived from organisms and from oil pollution.

142. Blumer, M., H.L. Sanders, J.F. Grassle, and G.R. Hampson. (1971)

A SMALL OIL SPILL.

Environment, 13(2):2-12.

On September 16, 1969, an oil barge ran aground off Fassets Point, West Falmouth, in Buzzards Bay. Between 650 and 700 tons of #2 fuel oil was spilled into the coastal waters. Analysis of the aftermath of this suggests that oil is much more persistent and destructive to marine organisms and to man's marine food resources than scientists had thought. A wide range of fish and invertebrates was killed immediately and washed up onshore. Ninety-five precent of the animals recovered by trawling were dead or dying. Almost no animals were alive on bottom sediment and tidal marsh samples. All visual effects of the spill were gone within a few days, but oil remained essentially unaltered within sediments eight months after the spill. Oysters removed from polluted areas and placed in clean, running water for six months still contained fuel oil at essentially the same concentration and of the same composition.

143. Blumer, J. and Sass, J. (1972)

INDIGEINOUS AND PETROLEUM DERIVED HYDROCARBONS IN A POLLUTED SEDIMENT.

Mar. Pollut. Bull., _3_, 92-94

144. Blumer, Max and J. Sass. (1972)

OIL POLLUTION: PERSISTENCE AND DEGRADATION OF SPILLED OIL.

Science. 176:1120-1122.

In September 1969, approximately 600 metric tons of number 2 fuel oil were spilled in Buzzards Bay, Massachusetts. Two years later, fuel oil hydrocarbons still persisted in the marsh and in offshore sediments. Hydrocarbon degradation is slow, especially below the immediate sediment surface and appears to proceed principally through microbial utilization of alkanes and through partial dissolution of the lower-boiling aromatic hydrocarbons. The boiling range of the spilled oil and the relative abundances of homologous hydrocarbons (for example, phytane and pristane) have been well preserved. The findings are in agreement with the known geochemical stability of hydrocarbons. Fuel oil is an appreciable fraction of whole crude oil. This fact suggests that oil products and crude oils have a considerable environmental persistence.

145. Blumer, J. and J. Sass (1972)

THE WEST FALMOUTH OIL SPILL.

Data available in 1971. II. Chemistry. Woods Hole Oceanographic Institution. Woods Hole, Mass. Ref. No. 72-19. 127pp.

A spill of 650,000 to 700,000 l. of No. 2 fuel oil on September 16. 1969, contaminated the coastal areas of Buzzards Bay, Massachusetts. A chemical study aimed at a documentation of the effects, the persistance and the eventual disappearance of the pollutant hydrocarbons in this area was undertaken. Chemical data available in November 1971 is summarized.

146. Blumer, M., J. Sass, G. Souza, H. Sanders, F. Grassle, and G. Hampson. (1970)

THE WEST FALMOUTH OIL SPILL.

Woods Hole Oceanographic Institution. Reference 70-44, pp. 1-32

A spill of 650,000-700,000 liters of #2 fuel oil has contaminated the coastal areas of Buzzards Bay, Mass. The present report summarizes the results of our continuing chemical and biological study which were available at the end of May 1970, more than eight months after the accident.

The effects of environmental exposure on the composition of the oil are discussed; many analytical parameters are sufficiently stable to permit continued correlation of the oil remaining in sediments and organisms with the fuel oil involved in the spill.

Oil from the spill is still present in the sediments, inshore and offshore and in the shellfish. A further spread of the pollution to more distant offshore regions has occurred during mid-winter; as a result, the pollution now covers a much larger area than immediately after the accident. The first stages of biological (presumably bacterial) degradation of the oil are now evident especially in the least polluted regions; however, it has depleted predominantly the straight and branched chain alkanes. The more toxic aromatic hydrocarbons are resistant; as a result the toxicity of the oil has not been diminished.

Where oil can be detected in the sediments there has been a kill of animals; in the most polluted areas the kill has been almost total. Shellfish that survived the accident have taken up the fuel oil. The 1970 crop of shellfish is as heavily polluted as was last year's crop. Oysters transplanted to unpolluted water for as long as 6 months retained the oil without change in composition of concentration.

147. Blumer, J., Sanders, H.L., Grassle, J.F. and Hampson, G.R. (1971)

AN OCEAN OF OIL

Environment, 13 2-12

148. Blumer, M., G. Souza and J. Sass. (1970)

HYDROCARBON POLLUTION OF EDIBLE SHELLFISH BY AN OIL SPILL.

Marine Biology, 5:195-202.

A spill of 650,000 to 700,000 l. of No. 2 fuel oil contaminated the coastal areas of Buzzards Bay, Massachusetts. Gas chromatography demonstrates the presence of this oil in the sediments of the affected area. Two months after the accident, essentially unchanged oil is still being released from the sediments. The presence of the same pollutant is demonstrated in whole oysters Crassostrea virginica and in the adductor muscle of the scallop Aequipecten irradians. A presumably biochemical modification leads to a gradual depletion of the straight chain and, to a lesser extent, of branched chain hydrocarbons. This does not result in detoxification, as the more toxic aromatic hydrocarbons are retained in the organisms several months after the accident. Scallops from an uncontaminated area contain hydrocarbons in lesser amounts and of very different molecular weight and type distribution; they are accountable entirely from biological sources.

149. Boating Industry Association

ANALYSIS OF POLLUTION FROM MARINE ENGINES AND EFFECTS ON ENVIRONMENT.

U.S. Environmental Protection Agency. Grant: 1EPA R-801799. 71 pp.

Four ponds were subjected to outboard engine emissions at a rate calculated to be 3 times greater than that from saturation boating levels. Small changes in phytoplankton species variation, phytoplankton productivity as measured by ^{14}C fixation, chlorophyll$_a$ measurements, zooplankton population dynamics, the benthic microinvertebrate community, and water quality, in general, could not be ascribed to emissions effects to the exclusion of natural stress. Gasoline hydrocarbon fractions remain in the water column <1 d before being removed by evaporation, absorption, or biological oxidation processes.

150. Boehm, P.D. and J.G. Quinn. (1976)

THE EFFECT OF DISSOLVED ORGANIC MATTER IN SEA WATER ON THE UPTAKE OF MIXED INDIVIDUAL HYDROCARBONS AND NUMBER 2 FUEL OIL BY A MARINE FILTER-FEEDING BIVALVE (MERCENARIA MERCENARIA).

Est. & Coast. Mar. Sci., 4:93-105.

Laboratory studies, using the marine bivalve *Mercenaria mercenaria*, were performed to examine the role that naturally occurring surfactant dissolved organic matter (DOM) plays in mediating the process of hydrocarbon uptake. The uptake of a simple hydrocarbon mixture consisting of an n-alkane, hexadecane and an aromatic hydrocarbon, phenanthrene was studied as was the uptake of charcoal, results in: (1) a statistically significant increase in the uptake of hexadecane; (2) no change in the amount of phenanthrene taken up; and (3) a sevenfold increase in the quantity of No. 2 fuel oil taken up by the clam. The uptake of the "saturated" fraction of the fuel oil increased 17 times when DOM was removed and the "aromatic" fraction increased five times. The findings indicate that solubilization of saturated hydrocarbons by the DOM results in their being taken up less readily by the filter-feeding bivalve. When this DOM is removed, these hydrocarbons are retained more readily by the animal's gill due to changes in the hydrocarbons' physical state in seawater. The increase in the uptake of the "aromatic" fraction of fuel oil in the absence of DOM may reflect a co-solubilization of aromatic and saturated hydrocarbon components.

151. Boesch, D. (1973)

BIOLOGICAL EFFECTS OF CHRONIC OIL POLLUTION ON COASTAL ECOSYSTEMS.

In: Inputs, Fates and Effects of Petroleum in the Marine Environment. Background Information for Workshop, Ocean Affairs Board, NSF, Airlie, Va. 21-25 May 1973

This paper is a review including sublethal effects on metabolism, sublethal effects on behavior, food chain magnification, and biological effects of petroleum on wetlands and estuaries.

152. Boesch, D.F. (1974)

POTENTIAL EFFECTS OF OIL AND GAS DEVELOPMENT ON BENTHIC ORGANISMS.

In: Marine Environmental Implications of Offshore Oil and Gas Development in the Baltimore Canyon Region of the mid-Atlantic Coast. Proceedings of the Estuarine Research Federation Conference and Workshop. Estuarine Research Federation, p. 421-430

This paper briefly reviews the literature on the effects of activities associated with oil and gas development on benthic organisms and offers suggestions on the design of baseline studies. The effects of both chronic leakage oil acute spillage are discussed.

153. Boesch, D.F., C.H. Harshner and J.H. Milgram (1974)

OIL SPILLS AND THE MARINE ENVIRONMENT.

Ballinger Publishing Company, Cambridge, Mass. pp 114

This volume is divided into two sections, the first being an assessment of the ecological effects of oil pollution and the second on technological aspects of the prevention, control and cleanup of oil spills.

The first section attempts to evaluate the available information on the ecological impact of oil and to draw conclusions from this information. It is a review intended for decision makers. Included are a review of available research on biological effects, ordered by biological community type; a summary of information concerning long term effects; a discussion of methods and how they influence results and conclusions; and an appraisal of the present direction of research dealing with oil.

154. Boiko, E.V. (1975)

ROLE OF MYTILUS EDULIS LINNE IN THE PURIFICATION OF SEA WATER OF PETROLEUM PRODUCTS (IN EXPERIMENT).

Gidrobiologicheskii Zhurnal, 11 (2): 28-33.

Water is purified twice as fast in aquariums with M. Edulis as in the control (without animals). About 7% of the initial amount of the petroleum products remained in the aquariums 3 wk. after M. edulis was put into it; 1.4% of the products is settled by hydrobionts onto the bottom of the vessels, 5.6% remains in the surface film, and about 2% remains in the dissolved state in the water layer.

155. Boney, A.D. (1968)

EXPERIMENTS WITH SOME DETERGENTS AND CERTAIN INTERTIDAL ALGAE, FIELD STUDIES, 2 (SUPPL.)

In: The Biological Effects of Oil Pollution on Littoral Communities
J.D. Carthy and D.R. Arthur (eds.) 55-72

The effect of several brands of emulsifiers was ascertained on several species of algae. The experiments were designed to determine the direct effect of very concentrated solutions of detergent in sea water and the larger term effects of very low concentrations.

156. Boney, A.D. 1970.

TOXICITY STUDIES WITH AN OIL-SPILL EMULSIFIER AND THE GREEN ALGA, PRASINOCLADUS MARINUS.

J. Mar. Biol. Assn. U.K., 50:461-473

Cyst phases of the green alga Prasinocladus marinus were used in an investigation of the toxic properties of an oil-spill emulsifier BP 1002, and of its solvent and surfactant fractions. Various aspects of a rejuvenation process (e.g. reappearance of chloroplast and pigments; formation of pyrenoids and starch sheath; onset of cell division and liberation of motile cells) were utilized as a means of assay in addition to observations on cell viability. The "aged" cysts were more tolerant of all types of toxic agents than were the young non-motile cells. The surfactant fractions were more toxic when used alone, and the solvent fraction alone more toxic than the compounded BP 1002. The application of any of the toxic agents at low temperature ($4^{o}C$) resulted in a marked reduction in their effects at high concentrations (e.g.500ppm) although rapid changes in cell condition (chloroplasts, pryenoids) were observed. The toxic effect was appreciably increased with both "aged" and "young" cells when accompanied by a lowering in salinity. Aeration of the toxic solutions caused a significant lowering of toxicity with both BP 1002 and the solvent fraction. Chloroplast pigment regeneration in "recovering" cysts was a sensitive means of assaying toxic effects.

157. Boney, A.D. (1974)

AROMATIC HYDROCARBONS AND THE GROWTH OF MARINE ALGAE.

Marine Pollution Bulletin, 5(12) 185-186.

Aromatic compounds isolated from marine muds cause cancerous growths in certain seaweeds. In this study a number of aromatic hydrocarbons, including some which are not yet reported as having carcinogenic activity have been found to stimulate growth of algae.

158. Boney, A.D. and E.D.S. Corner (1962)

ON THE EFFECTS OF SOME CARCINOGENIC HYDROCARBONS ON THE GROWTH OF SPORLINGS OF MARINE RED ALGAE.

Journal of the Mar. Biol. Assoc. U.K. 42 579-85

Low concentration of various carcinogenic polycyclic aromatic hydrocarbons cause a considerable reverse in cell production when applied to sporlings of certain marine red algae.

Whereas law concentrations of carcinogenic derivitives of benzathracene stimulate cell production, similar concentrations of structually released non-carcinogenics inhibit it.

The applicability of the method as a rapid screening test for carcinogens is discussed.

159. Boos, G. (1974).

OIL ON THE SEAS

Bird Notes, 31, 185-188.

160. Boswell, J.L. (1950)

THE EFFECT OF CRUDE OIL ON OYSTERS.

Texas A&M Res. Found., Project 9 (mimeo pp. 28)

161. Bott, T.L., K. Rogenmuser and P. Thorne (1976)

EFFECT OF NO. 2 FUEL OIL, NIGERIAN CRUDE OIL AND USED CRANKCASE OIL ON THE METABOLISM OF BENTHIC ALGAL COMMUNITIES

In: Sources, Effects and Sinks of Hydrocarbons on the Aquatic Environment. Proceedings of the Sumposium, American University, Washington, D.C. 9-11 August 1976.

No. 2 Fuel Oil, Nigerian Crude Oil, and used crankcase oil were studied for effects on the metabolism of benthic algal communities. Exposure depressed net community primary productivity but degree of effect was dependent on the kind of oil and concentration of exposure. Used crankcase oil became associated with the algae in greatest amounts but No. 2 Fuel Oil exerted greatest toxicity. Recovery of community function took place in all instances. Blue green algal development was fostered to varying degrees.

162. Bourne, E. (1968)

THE EFFECTS OF THREE HYDROCARBONS ON FISH CELLS IN VITRO.

Ph.D. thesis, Oklahoma State University.

163. Bourne, W.R.P. (1965)

THE WEATHER, OIL AND SEABIRDS CAST ASHORE.

Seabird Bull., 1:42-45.

Proposals have been made by the RSBP and ISBP to organize a Seabird Group for the purpose of beachcombing both to obtain evidence for the present incidence of oiling, and as a source of general ornitholo-

gical information. The following objects would be suitable for the Group: 1) comprehensive breeding censuses; 2) surveys of distribution away from the breeding places; and 3) recording stranded birds.

164. Bourne, W.R.P. (1967)

THE TORREY CANYON DISASTER.

Seabird Bulletin, 3, 4-11

165. Bourne, W.R.P. (1968)

OBSERVATIONS OF AN ENCOUNTER BETWEEN BIRDS AND FLOATING OIL

Nature 219, 632

A short note on the authors observations of the interactions of guillemots, gulls and kittiwakes to a small oil slick. The birds took no particular notice of the oil except when it was thick and they came in contact with it, when they took avoiding action. The guillemots avoiding action consisted of diving, which the gulls flew off.

166. Bourne, W.R.P. (1968)

OIL POLLUTION AND BIRD POPULATIONS

In: The Biological Effects of Oil Pollution on Litteral Communities J.D. Carthy and D.R. Arthur (Eds.)Supplement to Volume 2 of Field Studies, Field Studies Council, Great Britian

A review article on the impact of oil pollution on the populations of shore and sea birds, including the results of the Seabird Groups measurement of the effect of oil pollution, and a description of the impact of oil on birds adaptations for the marine environment.

167. Bourne, W.R.P. (1969)

CHRONOLOGICAL LIST OF ORNITHOLOGICAL OIL-POLLUTION INCIDENTS

Seabird Bull., 7:3-8

This paper is composed mainly of general statements taken from current notes in Bird Notes and News (subsequently Bird Notes and then Birds), and later Reports of the British Section, International Council for Bird Preservation, in Europe, and from Bird Lore (subsequently Audobon Magazine, then Audubon) in North America.

168. Bourne, W. R. P. (1970)

OIL POLLUTION AND BIRD CONSERVATION.

Biol. Conserv., 2(4):300-302

Oil pollution has been causing damage to bird populations for half-a-centruy. Owing to increasing precautions that are being taken, it is not clear that despite a vast increase in traffic the position is any worse now than it was before World War II. Information on the full scale and character of the damage is still inadequate, however, and the first need is for many more data. Meanwhile it seems very doubtful whether any bird species in northern Europe is threatened with reduction in numbers on more than a local scale, although locally the damage may be severe. It is argued that the most effective way of combating such reduction is by the further control of pollution and by conservation of the breeding stock to enable it to repair the damage--rather than by the rehabilitation of oiled birds, as it seems doubtful whether this can ever be carried out on a sufficient scale to influence the outcome markedly. The main argument for rehabilitation appears to be a humanitarian one, for the relief of suffering and to avoid the unnecessary slaughter of birds that could be saved. It is suggested that if birds are rehabilitated, it is unsatisfactory to release them immediately, when they have become tame and accustomed to be fed, and that the best method of disposal for them may be not to attempt to return them directly to the wild state but to try to establish breeding populations of tame semi-captive birds in protected situations, where they might provide useful objects for study and an ornament to the countryside.

169. Bourne, W.R.P. (1970)

SPECIAL REVIEW - AFTER THE "TORREY CANYON" DISASTER.

Ibis, 112 120-125.

170. Bourne, W.R.P. (1971)

THE THREAT OF OIL POLLUTION TO NORTH SCOTTISH SEABIRD COLONIES.

Mar. Poll. Bull., Bol. 2:117-119

A report of the recent oil pollution incident in northern Scotland in which 12,000 dead birds, mainly guillemots, were found and up to 10,000 may have died. It emphasizes that, with the increasing likelihood of oil pollution in this area, the seabird communities will need to be watched and protected not only during the breeding season but all the year round.

171. Bourne, W.R.P. (1974)

GUILLEMOTS WITH DAMAGED PRIMARY FEATHERS.

Mar. Poll. Bull., Vol. 5:88-90

Increasingly since the first World War, there have been observations of abnormal wearing of plumage in auks. Various reasons for this have been advanced, the most likely being the after-effects of oil pollution.

172. Bourne, W.R.P., J.D. Parrack, and G.R. Potts (1967)

BIRDS KILLED IN THE TORREY CANYON DISASTER.

Nature, 215:1123-1125.

The Torrey Canyon disaster probably killed more than 30,000 seabirds. In a sample of 1,223 dead birds of eight different species 97 percent were guillemots and razorbills.

173. Bourne, W.R.P. and T.R.E. Devlin, (1969)

BIRDS AND OIL

Birds, 2, 176-178

174. Bowman, R.E. (1978)

FOOD HABITS OF FISH AND SQUID FOUND IN THE VICINITY OF THE ARGO MERCHANT OIL SPILL, AUGUST 1977.

In: In the Wake of the Argo Merchant. Proceedings of a Conference and Workshop held at the University of Rhode Island, January 11-13, 1978 Center for Ocean Management Studies, University of Rhode Island.

The stomach contents of 21 species of fish and squid were analyzed to determine the potential impact of Argo Merchant oil on the fish stocks in the Northwest Atlantic. Important prey groups found in the stomachs of predators sampled in the region of the oil spill included gammaridean amphipods, polychaete worms, rock crabs, and American sand lance. The quantities and types of foods eaten by each predator were similar to data previously collected. Gammaridean amphipods covered with the same type of oil which was carried by the Argo Merchant had previously been found in the stomachs of Atlantic cod and little skate. Although no oil was found in their stomachs, American sand lance were found to feed on the same genera of copepods previously noted to be contaminated with Argo Merchant oil. Predator prey relationships found in this study showed that 81 percent of the predators represented ate gammaridean amphipods and 38 percent of the predators species fed on American sand lance, thus establishing two potential pathways for the oil to have been passed on to the higher trophic levels.

175. Boyd, H. (1970)

OIL POSES URGENT PROBLEMS IN CANADA.

Mar. Poll. Bull., 1 69-71

The stranding of the tanker Arrow in Chedabucto Bay, Nova Scotia, 4 February 1970 occasioned the largest oil spill in Canadian waters so far. By 14 February an estimated 1.5 million gallons of oil had escaped.

Ascertained losses of wildlife have not been very heavy, if only because the bay is much less frequented by wintering birds than many other parts of the Nova Scotia coast. The best estimate of birds killed by 14 February was 2,300, principally sea ducks, grebes, and awks. An aerial survey on 15 February found almost 2,000 birds in the Bay.

176. Boyland, E. (1964)

POLYCYCLIC HYDROCARBONS.

Brit. Med. Bull. 21:121-126

The target material in which the precancerous biochemical lession occurs may be nucleic acid or protein or even some other type of molecule. It might be the DNA of the nucleus or a suppressor in the cytoplasm.

Three hypotheses of the mechanism of action of carcinogenic polycyclic compounds have been discussed. All need further investigation but they are not necessarily mutually exclusive. Carcinogenic compounds may form complexes with nucleic acid and then be oxidized so that the oxidation products react chemically with the bases or other part of the melecule. Like many hypotheses these will be difficult to prove correct, but it might be possible to show one or other to be false.

177. Boyle, C.L. (1969)

OIL POLLUTION OF THE SEA: IS THE END IN SIGHT?

Biol. Conserv. 1(4):319-327

After a brief historical statement, the chief cause of deliberate oil pollution of the seas--the cleaning out of oil tanks--is examined, and means of abolishing it are discussed. Examples of oil discharge following accidents are also given, and means of cleaning up the resulting oil-slicks are considered. The effect of oiling on marine fauna is dealth with--especially the effect on individual birds. Methods of cleaning oil from birds are looked at, and the possibilities of the birds rehabilitation are discussed. Finally, the prospects of the termination of oil pollution are considered. Special references are made to the Interactional Conference on Oil Pollution of the Sea, held in Rome in October 1968.

178. Branten, B. et al (1972)

TISSUE-SWELLING IN MYTILUS EDULIS L. INDUCED BY EXPOSURE TO A NONIAONIC SURFACE ACTIVE AGENT.

Norwegian J. Zool, 20:137-140

Mytilus edulis L. collected in Gullman Fjord during the course of one year were exposed to the surface-active agent nonylphenol ethoxylate. The water content of the large adductor muscle increased as a result of this exposure. The size of the tissue-swelling varied as a function of the exposure-time and to concentration of the surfactant. The susceptibility of the common mussed to the surfactant, measured as tissue-swelling, varied during the year. It was less in the spawning period than in other parts of the year. It is concluded that the swelling of the tissue is due to some non-specific damage to the cell membranes.

179. Brenniman, G., et all (1976)

A CONTINUOUS FLOW BIOASSAY METHOD TO EVALUATE THE EFFECTS OF OUTBOARD MOTOR EXHAUSTS AND SELECTED AROMATIC TOXICANTS ON FISH.

Water Res., 10(2):165-169.

A continuous flow bioassay system was designed to measure the effects of outboard motor exhaust (OME) emissions and selected volatile and evaporative aromatic toxicants on goldfish (Carassius auratus). Continuous flow bioassays were run for 24, 48, 72, 96 and 720h to determine lethal concentrations for 50% of individuals (LC-50's) for leaded OME, non-leaded OME, toluene, xylene, and 1,3,5-trimethylbenzene, the three individual compounds having been identified as significant aromatic components of OME. The 96 h LC-50's for these substances were found to be 171, 168, 23, 17 and 13 ppm, respectively. The values of 171 and 168 ppm for the two OME's are given in terms of gallons of fuel burned per million gallons of water. The continuous flow bioassay method was demonstrated to be a more reliable indicator of the effects of OME pollutants on aquatic organisms than is the static bioassay method.

180. Bridie, A.L. and J. Bos. (1971)

BIOLOGICAL DEGRADATION OF MINERAL OIL IN SEA WATER.

J. Inst. Petrol. 57:270-277.

There are still many opinions concerning the degradation of mineral oil in sea water and experimental evidence to test various hypotheses is needed. Therefore the bacterial oxidation of oil has been investigated in a marine environment. To this end, the rate of oxidation of oil in actual sea water samples was measured at the laboratory and the results were compared with those obtained on model substrates. It was found that mineral oil is equally well degraded biologically in sea water and in fresh water and that the rate of degradation depends mainly on the availability of nitrogen and phosphorus-containing compounds, which elements control the growth of a bacterial population. As these compounds are indeed present in sea water, but in extremely low concentrations only, it must be expected that the natural purification process, in the case of oil, will take a relatively long time, probably many months.

181. Brisby, W.L. (1969)

OIL SLICK EFFECTS ON RINCAN ISLAND

In: AMERICAN PETROLEUM INSTITUTE, DIVISION OF PRODUCTION, SPRING MEETING, PACIFIC COAST DISTRICT, LOS ANGELES, MAY 1969, pp. 147-150

Oil leakage occured in the vicinity of the Atlantic Richfield Oil Company's offshore drilling island 0.5 miles off Point Gordo, Mussel Shoals, Ventura County. When the oil slick reached Rincon Island there was some destruction to the biota, but it was said to be minimal. The writer's opinion is that while the oil seepage did kill some of the intertidal organisms on Rincon Island, the destruction was not as great as anticipated. The greatest damage to life was found to be the result of silting and pollution from recent storms. (Sinha-OEIS)

182. Brockson, R.W. and H.T. Bailey. (1973)

RESPIRATORY RESPONSE OF JUVENILE CHINNOK SALMON AND STRIPED BASS EXPOSED TO BENZENE, A WATER-WOLUBLE COMPONENT OF CRUDE OIL.

In: Conference on Prevention and Control of Oil Spills. pp. 783-792.

Experiments were conducted using juvenile chinnok salmon, Oncorhynchus tshawytscha, and striped bass, Morone saxatilis. The fish were exposed to sublethal concentrations of the aromatic hydrocarbon benzene, for periods ranging from 1-96 hours. Prior to exposure, and after exposure to the benzene, respiration rates of individual fish were measured. Results show increases in respiratory rate up to 115 percent above that of control fish after exposure periods of 24 hours for striped bass and 48 hours for chinnok salmon. Fish exposed to benzene concentrations of 10 ppm for periods longer than those listed exhibited a narcosis that caused a decrease in respiratory rate. The narcotic state induced by exposure to benzene was shown to be reversible when the fish were placed in freshwater and kept for periods longer than 6 days. Possible biochemical mechanisms leading to this response are hypothesized.

183. Brodersen, C.C., S.D. Rive, J.W. Short, T.A. Mecklenburg and J.F. Karinen (1977)

SENSITIVITY OF LARVAL AND ADULT ALASKAN SHRIMP AND CRABS TO ACUTE EXPOSURES OF THE WATER-SOLUBLE FRACTION OF COOK INLET CRUDE OIL

In: Proceedings 1977 Oil Spills Conference p. 575-578. Amer. Petrol Inst., Wash., D.C.

The sensitivity of adult and larval Alaskan shrimp and crabs to the water-soluble fraction (WSF) of Cook Inlet crude oil was measured by tests using 96-hour static bioassays at the water temperatures that these animals normally encounter. Larval crustaceans were found to die more slowly than adults, making it necessary to measure sensitivity in terms of concentrations causing moribundity (death imminent) insetad of in terms of concentrations causing death during exposure. The cessations of all motion and reaction was found to indicate moribundity in adults, and the cessation of swimming was found to indicate morbundity in larvae exposed for 96 hr. Ninety-six-hour LC_{50}'s for moribundity for stage 1 larvae ranged from 0.95 to 1.8 ppm depending on species, while 96-hr LC_{50}'s for adults ranged from 1.9 to 4.2 ppm oil. Sensitivities for stage 1-V1 larvae of coonstripe shrimp ranged between 0.24 ppm and 1.9 ppm.

Larvae were more sensitive to oil than adults. The sensitivity of larvae depended on species and developmental stage. Larvae are probably more vulnerable than adults to oil exposure because of greater sensitivity to oil and greater susceptibility to predation. Cold-water species may be particularly vulnerable because of increased time spent as developing larvae.

184. Brooks, M. (1975)

SOURCES, SINKS, CONCENTRATIONS AND SUB-LETHAL EFFECTS OF LIGHT ALIPHATIC AND AROMATIC HYDROCARBONS IN THE GULF OF MEXICO.

Tech. Rep. College Station, Texas A&M University, Ref. 75-3-T.

185. Brown, D.H. 1972.

THE EFFECT OF KUWAIT CRUDE OIL AND A SOLVENT EMULSIFIER ON THE METABOLISM OF THE MARINE LICHERS LICHINA PYGMAEA.

Mar. Biol. 12(4):309-315

This article reports the effect of Kuwait crude oil and BP 1002 on the ^{14}C fixation of a marine lichers Lichina pygmaea. The emulsifier was more inhibitory than the oil. The inhibitory component in the emulsifier was concluded to be the surfactant.

186. Brown, J.E. (1975)

DOES OIL AFFECT THE MARINE ENVIRONMENT?

Exxon USA, 14(3), 26-31.

This popular article summarizes the results of the two-year, multidisciplinary Offshore Ecology Investigation conducted by the Gulf Universities Research Consortium in Timbalier Bay, Louisiana. The research effort was directed at determining the effect of long-term offshore oil exploration and production on the marine environment. No adverse effect was found.

187. Brown. L.R. (1977)

ESTIMATE OF MAXIMUM LEVEL OF OIL INNOCUOUS TO MARINE BIOTA AS INFERRED FROM LITERATURE REVIEW.

Final Task Report to U.S. Coast Guard. Report No. CG-D-43-77. Available through National Technical Information Service.

A review of the literature determined that Acartia tonsae is the most oil-sensitive of the organisms for which toxiicity data are available. Nigeria crude is the most toxic of the five crude oils tested. The TLM value is .55 mg/l. 1% of this value, or 5.5 ug/l should be safe for Acartia, and therefore for all other members of the marine ecosystem. Nearly 2000 articles were examined for this review. 135 of the most germaine are listed as references.

188. Brown, L.R., and G.S. Pabst. (1969)

MICROBIAL DEGRADATION OF PETROLEUM IN AQUATIC AND MARINE ENVIRONMENTS.

Bacteriological Proc., 1969.

It is an established fact that oil pollutants in our natural waters are decomposed by microorganisms, but little is known about the products formed or their effect on aquatic or marine life. The aerobic and anaerobic microbial degradation of an asphaltic crude, a naphthenic crude, and a refined motor oil in both fresh and salt water by mixed cultures was studied. The disappearance of oil was more rapid under aerobic conditions and resulted in RQ values of 0.4 to 0.6. Changes in physical characteristics differed for each oil and were recorded photographically. Chemical changes accompanying the microbial utilization of the oil included the production of waxy materials in addition to water-soluble compounds. The growth of the microorganisms on the oils rendered the water unfit for fish life.

189. Brown, L.R. and R.G. Tischer (1969)

DECOMPOSITION OF PETROLEUM PRODUCTS IN OUR NATURAL WATERS.

Mississippi State University Water Resources Research Institute. Completion Report. 41 pp.

Experimental data suggest that water-soluble products formed during microbial decomposition of petroleum products are harmful to fish. Microflora caused marked physical changes in the oil under both aerobic and anaerobic conditions. The disappearance of oil was more rapid under aerobic conditions. A thin layer chromatographic technique was developed and used to demonstrate chemical changes that occured in the oil during microbial decomposition. Addition of a nitrogen source and supplemental inorganic phosphate enhanced microbial activity. The waters were toxic for fish even after separation and removal of bacteria and oil.
(Sinha-OEIS)

190. Brown, P.E. (1959)

DESTRUCTION OF SEA BIRDS

In: Proc. Intern. Conf. Oil Poll. Sea, Copenhagen, 71-73

191. Brown, R.G.B., D.I. Gillespie, A.R. Lock, P.A. Pearce, and G.H. Watson. (1973)

BIRD MORTALITY FROM OIL SLICKS OFF EASTERN CANADA. FEBRUARY-APRIL 1970.

Canadian Field-naturalist 87:225-234.

Oil slicks resulting from the "Arrow" and "Irving Whale" spills in February 1970 resulted in the known deaths of 1,500 ducks and seabirds, and an estimated total kill of at least 12,000 birds. The species principally affected were Oldsquaws, Red-brested Mergansers, grebes, and murres in Chedabucto Bay, Nova Sotia; murres, Dovekies, and Fulmars between the Nova Scotian coast and Sable Island; and Common Eiders (subspecies borealis), murres, and Black Guillemots off southeast Newfoundland. The breeding populations to which some of these birds belonged are identified, and the overall effect of this mortality on the species as a whole is assessed. Only the kill of borealis eiders approached significance to the population of this subspecies. It is emphasized that the hazard presented by an oil spill depends on its position and timing as much as on its size.

191.A. Brown, R.S. and K.R. Cooper (1978)

HOSTOPATHOLOGIC ANALYSIS OF ZOOPLANKTON AND BENTHIC ORGANISMS FROM THE VICINITY OF THE ARGO MERCHANT.

In: In the Wake of the Argo Merchant, Proceedings of a Conference and Workshop held at the University of Rhole Island, Jan 11-13 1978. Center for Ocean Management Studies, University of Rhode Island, Kingston, Rhode Island.

A variety of zooplankton and benthic species were collected on two cruises to the Argo Merchant and examined histo pathologically. On the first cruise, made two months after the spill, some zooplankton showed signs of external and internal fouling with oil; a Cancer crab was found dead with a thick deposit of Argo oil coating the remmant of the gut; a hermit crab was found moribund; several Modidus had mantle lesians reminicent of pearl formation. One mussel had these lesions adjacent to Argo oil on the internal shell surface. One starfish had tarballs in the buccal cavity. In contrast speciments collected on the second cruise, seven months after the spill, showed no signs of oil contamination.

192. Brown, S.O., and V. Van Horn. (1950)

AEROBIC AND ANAEROBIC OXIDATION OF CRUDE OILS BY MICROORGANISMS FROM LOUISIANA BAY-BOTTOM MUDS.

Texas A&M Res. Found., Project 9.

Anaerobic microorganisms capable of oxidizing crude oil were found to be present in every one-gram sample nine out of ten 0.1-gram samples, eight out of ten 0.01-gram samples, and one of ten 0.001-

gram samples. This indicated that the number of anaerobic oil-oxidizing microorganisms was on the order of 100 per gram of mud. It was found that all of five samples of curde oil, each representing a different oil field, were susceptible to degradation by these microorganisms.

193. Brown, S.O., et. al. (1951)

DECOMPOSITION OF ORGANIC COMPOUNDS BY MARINE MICROORGANISMS.

Texas A&M Res. Found., Project 9, 11 pp.

Sixty-six organic compounds representing alcohols, hydroxyorganic acids, aliphatic hydrocarbons, cylco-alkanes, heterocyclic compounds, aromatic carboxylic acids, phenols, aromatic amines, mercaptans, and other related compounds were shown to be oxidized by marine micro-organisms of the waters of Southern Louisiana. The procedure was to determine by the Winkler method the oxygen consumed by bacteria in a solution of the pure compound of sterile aged sea water when innoculated with fresh sea water of Southern Louisiana. The results demonstrate that bacteria are present which will destroy a very diverse group of organic compounds. In all probability, the presence of these microorganisms would prevent the acumulation of toxic by-products due to bacterial action on hydrocarbons in the salty or brackish waters of Southern Louisiana.

194. Brownell, R. (1971).

WHALES, DOLPHINS AND OIL POLLUTION.

In: Biological and Oceanographic Survey of the Santa Barbara Oil Spill. 1969-1970. Vol. 1, p. 255. Allan Hancock Found. Sea Grant Publ. 2, D. Straughan (ed.).

The number of gray whale strandings in 1969 did not differ significantly from that of previous years. Six dolphins were stranded between February and May of 1969, but only one was reported by the news media. Cause of death was reported to be massive lung hemorrhage as a result of the animals's blowhole being clogged with oil, but there was no evidence to support this statement. The remaining five dolphins showed no external oil contamination.

195. Brownell, R. and B. LeBoauf. (1971)

CALIFORNIA SEA LION MORTALITY: NATURAL OR ARTIFACT.

In: Biological and Oceanographical Survey of the Santa Barbara Oil Spill, 1969-1970. Vol. 1. p. 287. Allan Hancock Foundation Sea Grant Publ. 2. D. Straughan (ed.).

The population of California Sea Lion (Zalophus californianus) pups was censused on June 16, 1969. In spite of the fact that 46% of the living pups and 68% of the dead pups were oily, the mortality rate was only

13%, a figure well within the normal limits. If oil contamination had a deleterious effect on pup health, and in some way increased the probability of death, the effect was unquestionably, very small.

196. Bruce, H.E. (1974)

SAMPLING MARINE ORGANISMS AND SEDIMENTS FOR HIGH PRECISION GAS CHROMATOGRAPHIC ANALYSIS OF AROMATIC HYDROCARBONS.

In: NBS Spec. Publ. 409, Marine Pollution Monitoring (Petroleum), Proceedings of a Symposium and Workshop held at NBS, Gaithersburg, Maryland, May 13-17, 1974.

This paper describes hand collection methods used to collect sediment samples and inner-tidal tidal organisms for analysis of aromatic hydrocarbons in the pasts per billing range. The methods minimize contamination and sample handling errors.

197. Bryan, G.W. (1969)

THE EFFECT OF OIL-SPILL REMOVERS (DETERGENTS) ON THE GASTEROPOD NUCELLA LAPILLUS ON A ROCKY SHORE AND IN THE LABORATORY.

Jour. Mar. Biol. Assn. U.K., 49:1067.

The effects of oil-spill removers (detergents) on a population of the dogwhelk *Nucella lapillus* have been studied at Porthleven in South Cornwall, where heavy oil pollution occurred following the "Torrey Canyon" incident in March 1967. *Nucella* is one of the shore animals which are most resistant to "detergent" treatment, but at Porthleven the species was wiped out in the harbor and the majority of animals were killed on the reef nearby.

Growing animals which recovered from the effects of the "detergent" were later found to have developed growth disturbances in the shell. These effects on growth were studied in the field and in the laboratory and appear to be an indirect effect of "detergent" resulting from its interference with the ability of the animal to feed and with the availability of food.

Recolonization of the reef was more rapid than expected and depended largely on the survival of some very young animals in the sublittoral zone. Probably because most of the potential predators had been wiped out by the "detergent" these animals were able to invade the reef in large numbers late in 1967. In fact, 2 years after the "detergent" treatment, there was some evidence that the reef may have become overopoulated with *Nucella*.

In contrast, recolonization of the outer harbour, where the species was wiped out, was slow during the first 2 years and dependent on lateral movements of animsls from the reef. It is concluded that if the "detergent" treatment of the reef had been slightly heavier, then the species would have been wiped out there as well and would have been slow to recover.

198. Buck, W.F.A. and J.G. Harrison (1967).

SOME PROLONGED EFFECTS OF OIL POLLUTION ON THE MEDWAY ESTUARY.

WAGBI Teurboah 1966-7, 32-33

199. Bugbee, S.L. and C.M. Wattes, (1973)

THE RESPONSE OF MACROINVERTEBRATES TO GASOLINE POLLUTION IN A MOUNTAIN STREAM.

In: Conference on Prevention and Control of Oil Spills. pp. 725-732. Amer. Petrol. Inst., Wash. D.C.

The effect of the accidental spillage of 5000 gallons of aviation fuel into a mountain stream was monitored for a year and re-examined after three years. Immediately after the accident a survey indicated that the majority of aquatic invertebrates and about 2,500 fish were killed for at least two miles (3.2 kilometers) downstream from the spill. Gasoline residues in the sediments prohibited recolonization of mayflies, stoneflies and certain caddisflies for at least six months. The midge Orthocladius was the most resistent organism. The reappearance of mayfly and stonefly nymphs 12 months after the spill indicated a significant degree of recovery in the maeroinvertebrate community within three years after the spill there was complete recovery as indicated by an average diversity value of 4.00.

200. Burnett, F.L., and Synder, D.W. (1954)

BLUE CRAB AS STARVATION FOOD OF OILED AMERICAN EIDER.

Ank. 71, 315-316

This note describes briefly the effect of the breaking up of two tankers off Monomoy Island had on the large flock of American Eiders. More particularly described is the finding of two eiders, each with a bluecrab stuck in the throat.

201. Burns, K.A. (1976)

HYDROCARBON METABOLISM IN THE INTERTIDAL FIDDLER CRAB UCA PUGNAX

Marine Biology 36:5-11.

The fiddler crab Uca pugnax was examined for its ability to metabolize foreign hydrocarbons. The microsomal mixed function oxidase system was identified in U.pugnax tissues using Aldrin epoxidation rates as the assay. Rates were slow: 96 pM Dieldrin per mg microsomal protein per hour in the hepatopancreas, 438 pM mg^{-1} h^{-1} in the gill, and 228 pM mg^{-1} h^{-1} in claw-muscle microsomes. Using standard methods, no difference in rates could be detected between crabs living in clean areas and those living in environments highly contaminated with foreign hydrocarbons. In vivo rates of naphthalene oxidation were measured and used to calculate a clearance time for U. pugnax body tissues based on the aromatic hydrocarbon content of crabs collected from an oil-polluted salt marsh. Calculated clearance time was beyond the life span of the crab. It is concluded that this minimal ability of U. pugnax to metabolize foreign hydrocarbons partially accounts for its sensitivity to oil pollution in the environment.

202. Burns, K.A. and J.M. Teal (1971)

HYDROCARBON INCORPORATION INTO THE SALT MARSH ECOSYSTEM FROM THE WEST FALMOUTH OIL SPILL.

Woods Hole Oceanographic Institute, Technical Report, Reference No. 71-69, p. 1-24. (Unpublished manuscript).

The oil barge "Florida" ran aground just off Little Island, West Falmouth, Massachusetts on September 16, 1969. About 175,000 gallons of Number Two fuel oil leaked into Buzzards Bay and the adjacent Wild Harbor Marsh.

This report presents the results of analyses done on marsh muds and organisms collected nearly a year after the spill. We studied the incorporation of polluting hydrocarbons into, and their movement through the marsh ecosystem.

Analyses of surface muds agreed well with observations on plant growth. The dead areas were the most heavily polluted. A deep mud core in the dead area showed oil has penetrated to at least 70 cm.

Virtually all the marsh organisms living in the contaminated area were affected by the oil at least to the extent that they accumulated oil hydrocarbons in their tissues. Our data suggests that two processes may occur as the oil passes through the marsh ecosystem. There may be a progressive loss in the straight chain hydrocarbons in relation to branched chain, cyclic and aromatic hydrocarbons. There also appears to be a selection for the higher boiling fractions of the contaminants higher up in the food chain.

203. Burns, K.A. and J.M. Teal. (1973).

HYDROCARBONS IN THE PELAGIC SARGASSUM COMMUNITY.

Deep Sea Res., 20:207-211.

Pelagic Sargassum weed and associated macrofauna were analyzed for their hydrocarbon content. All the organisms appeared contaminated with petroleum hydrocarbons. There was no relation between the amount of natural, recently biosynthesized hydrocarbons in an organism and the amount of petroleum contamination. Animals had a larger ratio of petroleum to natural compounds than the Sargassum. There was no relation between the hydrocarbon content and the animals' supposed positions in the food chain.

204. Butler, M. and F. Borkes (1972)

BIOLOGICAL ASPECTS OF OIL POLLUTION IN THE MARINE ENVIRONMENT: A REVIEW.

McGill University, Montreal Marine Sciences Centre, Manuscript Report No. 22. 121 pp.

Origins, classifications and sources of petroleum hydrocarbons and solvent emulsifiers are described, along with their physico-chemical properties, behavior, toxicity and fate in the marine environment. The effects of oil pollution on marine birds, mammals, fish, sediments, shellfish, benthic invertebrates, algae and plankton are reviewed and several oil spill incidents are summarized, including TORREY CANYON, Santa Barbara, Buzzards Bay and ARROW. The geography and pollution of the Baltic and North seas, Gulf of St. Lawrence and Arctic Ocean are also considered.

205. Button, D.K. (1971)

BIOLOGICAL EFFECTS OF PETROLEUM IN THE MARINE ENVIRONMENT.

In: Impingement of Man on the Oceans, D.W. Hood (ed.) New York: Wiley, pp 421-29.

Microbial oxidation of oil is probably at a steady-state with oil input to the oceans. The oil oxidizing microorganisms operate in the oil phase of oil in water emulsions. Efficied oxidation requires an impact of mixing and thermal energy. Thus arctic spills may persist.

The lower moleculer weight hydrocarbons are hazardous to organisms in high concentrations. The cause of the toxicity is probably the fact that freely diffusible hydropliopic species alter the high-liquid-centered membranes functional in active transport and nerve impulse transmissions. These species too, however, can be acted upon microbially when not at saturation.

206. Button, D.K. (1974)

ARCTIC OIL BIODEGREDATION.

Final Report USCG-D-114-75. NITS Ad-A014 096/26A. 43pp.

The abundance of microbial hydrocarbon oxidizers is reported from measurements in three widely distributed marine systems in the far north. Concomitant in situ organic substrate oxidation rates measured by $^{14}CO_2$ collection were 0.2 to 1.6 ng/l hr from an initial added concentration of 1.4 micrograms/L mixed amino acids and 2 to 50 ng/hr from added dodecane solution. The solubility of dodecane in saline medium was determined and the predictability of high molecular weight alkane solubility confirmed. This true solution was used to show that a relatively high molecular weight hydrocarbon can be co-metabolized along with another substrate (arginine) from the dissolved phase. Dodecane derived CO_2, arginine and flutamic acid were recovered from the ^{14}C-dodecane, ^{12}C-arginine medium after having been supplied to a continuous culture of a marine hydrocarbon oxidizing isolate. Clay sorption experiments were conducted which showed that the catalytic role of suspended sediments was negligible. No dodecane sorption by bentonite could be detected in a 20% saturated hydrocarbon solution. These and other data presented support the assumption that direct dissolved phase organic material metabolism is a normal ubiquitous marine process having characteristics compatible with submicrogram per liter steady state hydrocarbon concentrations.

207. Byrne, C.J. and J.A. Calder (1977).

EFFECT OF WATER-SOLUBLE FRACTIONS OF CRUDE, REFINED AND WASTE OIL ON THE EMBRYONIC AND LARVAL STAGES OF THE QUAHOG CLAM MERCENARIA SP.

Mar. Biol. (Berl.) 40(3):225-232.

The embryonic and larval stages of the quahog clam Mercenaria sp were exposed to the water-soluble fractions of 6 oils and the effects on survival and growth rate of the various stages were noted.

208. Byrom, Jane A., S. Beastall, and S. Scotland (1970).

BACTERIAL DEGREDATION OF CRUDE OIL.

Mar. Pollut. Bull., 1, 25-26

209. Cabinet Office, London (1967)

"THE TORREY CANYON" REPORT OF THE COMMITTEE OF SCIENTISTS ON THE SCIENTIFIC AND TECHNOLOGICAL ASPECTS OF THE TORREY CANYON DISASTER.

London, Cabinet Office, H.M. Stationery Office. 56 p.

The course of events following the grounding of the Torrey Canyon off the coast of Cornwall is reviewed, with an account of measures taken to reduce and remove contamination of the beaches and harbors by the spilled oil, and the effects of the oil, and the detergents used to remove it, on fish, shellfish, intertidal plants and animals, and sea birds. Based on the experience gained, recommendations are made for dealing with similar disasters in future to minimize pollution effects. (Sinha-OEIS)

210. Cahnmann, H.H. and M. Kuratsune, (1957)

DETERMINATION OF POLYCYCLIC AROMATIC HYDROCARBONS IN OYSTERS COLLECTED IN POLLUTED WATER.

Anal. Chem. 29:1312-1317.

As barnacles take up polycyclic aromatic hydrocarbons from polluted surroundings, it was of interest to know whether other marine animals living in water polluted with petroleum oils or tars also contain such hydrocarbons. As an investigation of edible marine animals is of particular practical interest, oysters collected in a moderately polluted harbor area were chosen for the present investigation. The nonsaponifiable matter obtained from an oyster extract was fractionated in a series of chromatographic separations, and the fractions thus obtained were investigated spectrophotometrically. The analytical procedures used are also applicable to other complex mixtures. The spectrophotometric investigation of the chromatographic fractions led to the detection of a number of polycyclic aromatic hydrocarbons. They amounted to about 1 mg. per 1 kg. of shucked oysters.

211. Cahnmann, H.H. and M. Kuratsune. (1956).

PAH IN OYSTERS COLLECTED IN POLLUTED WATER.

Proc. Amer. Ass. Cancer Res..2:99

Oysters were collected in a harbor area where the water is polluted with ship fuel oil and industrial sewage. A methanol extract of the oysters was fractionated by solvent partition between aqueons methanol and cyclohexane. The material in the epiphase was saponified and the nonsaponifiable material fractionated in a series of chromatographic separations.

Spectrophotometric investigations of the chromatographic fractions revealed the presence of a number of polynuclear aromatic hydrocarbons, among them naphthalenes, phenanthrenes, pyrene, fluroauthene and chrysene. The amount of polynuclear aromatic hydrocarbons found was considerably less than the amount present in certain batches of barnacles. Nevertheless, the presence of even small amounts of these hydrocarbons may pose a health problem under conditions of severe pollution.

212. Cairns, John, Jr. and Arthus Scheier. (1962).

THE EFFECTS OF TEMPERATURE AND WATER HARDNESS UPON THE TOXICITY OF NAPTHENIC ACIDS TO THE COMMON BLUEGILL SUNFISH, <u>LEPOMIS MACHROCHIRUS</u> RAF., AND THE POND SNAIL <u>PHYSA HETEROSTROPHA</u> SAY.

Nat. Acad. Nat. Sci. Phila., <u>353</u> 1-12

Literature dealing with the toxicity of naphtenic acids is briefly discussed. For fish, the concentration of naphthenic acids which resulted in 50% survival in 96 hours was 5.79 p.p.m. in soft water at 18°C., and 5.60 p.p.m. in soft water; 7.15 ppm in hard water at 18°C., 7.10 ppm in hard water at 30°C. For snails, the concentration of naphthenic acids which resulted in 50% survival in 96 hours was 6.60 p.p.m. in soft water at 20°C., and 15.6 p.p.m. in soft water at 30°C.; 12.6 p.p.m. in hard water at 20°C., and 12.2 p.p.m. in hard water at 30°C.

213. Caldwell, R.S. (1976)

ACUTE AND CHRONIC TOXICITY OF SEAWATER EXTRACTS OF ALASKAN CRUDE OIL TO ZOEAE OF THE DUNGENESS CRAB, CANCER MAGISTER DANA.

In: Environmental Assessment of the Alaskan Continental Shelf. Principal Investigators Reports for the Year Ending March 1976, Vol. 8. Effects of Contaminants, p. 345-375.

The full strength seawater soluble fraction of Cook Inlet crude oil is acutely toxic to first instar C. magister larvae but no lethal or sublethal effects were found of an approximately 1/10 dilution of this fraction during a 28-day continuous exposure period. In similar long-term exposures, 0.16 ppm naphthalene, the highest concentration tested, is also without effect on the larvae but 7.2 ppm benzene and possibly also 1.4 ppm benzene result in reduced larval survival. The effects of benzene appear to be manifested at the time of the first zoeal molt in these longterm exposures. A comparison of the lethal concentration of benzene with the estimated concentration of this aromatic compound in the full strength seawater soluble fraction of crude oil suggests that benzene may account for a major portion of the toxicity of this fraction. Since the concentrations of many of the seawater extractable components of crude oil may be expected to decline rapidly under natural environmental conditions as a result of dilution, evaporation, and metabolism by microorganisms, these studies suggest that crude oil contaminations of seawater may not seriously affect decapod larvae as long as the larvae do not contact the oil/water interface.

214. California Fish and Game Department (1969)

PROGRESS REPORT ON WILDLIFE AFFECTED BY THE SANTA BARBARA CHANNEL OIL SPILL.

January 28 - March 31, 1969, 8 pp.

Seven ocean aerial and four beach transects were established to determine the effect of the 1969 Santa Barbara oil spill on wildlife. Results of the aerial surveys indicated that bird numbers in the affected area remained relatively stable. On the basis of the transect data, bird losses for the 75.5 miles of beach from Pt.

Conception to the Ventura River were estimated to be 1603 birds. Additional data from bird treatment centers raises the estimated loss of birds to 3600.

215. Campbell, B., E. Kern, D. Horn (1977)

IMPACT OF OIL SPILLAGE FROM WORLD WAR II TANKER SINKINGS.

Report No. MITSG-77-4 Department of Ocean Engineering, Massachusetts Institute of Technology Cambridge, Mass.

The available data on tanker sinkings was accumulated. A computer model was developed to estimate the tragectory of oil released from each ship sunk in the vicinity of Cape Hatteras. Asbury Park, New Jersey was also investigated on the merit of substantial documentation of spills in that area. Interviews were conducted to obtain first-hand information on visible effects of the oil. Newspapers and records of marine activities were analyzed to determine environmental and other oil related effects. Results indicated that effects of the oil spills as observed by residents of the area under investigation, were negligible. In both cases, regional wildlife and economy survived with minimal difficulty.

216. Canadian Scientific Pollution and Environmental Control Society. (1971)

Oil Problems Investigation. Report of Canadian Scientific Pollution and Environmental Control Society, Vancover, B.C. 356pp.

Various aspects of the oil pollution problem were studied. Individual papers are concenred with a legal analysis of oil pollution incidents off Canada's west coast, the effects of oceanic and meteorological conditions on oil spill dispersal and effects of oil and dispersants on the marine environment. The examinations deal particularly with meteorological and oceanic aspects of the Pacific Northwest and the Alaskan coast.

217. Canevari, G.P. (1969)

THE ROLE OF CHEMICAL DISPERSANTS IN OIL CLEANUP.

In: Oil on the Sea, D.P. Hoult (ed.) Plenum Press, New York. pp. 29-51.

This article discusses the use of dispersants including arguments for and against their use from a biological point of view. The arguments for the use of dispersants include the fact that it destroys slicks which foul birds and block oxygen transport, and increases the rate of biodegredation. The argument against their use is the fact that they contain toxic components and also cause toxic petroleum components to enter the water column.

218. Canevari, G.P. and G.P. Lindblom (1976)

SOME DISSENTING REMARKS ON "DELETERIOUS EFFECTS OF COREXIT 9527 ON FERTILIZATION. AND DEVELOPMENT.

Mar. Pol. Bull. 7 127-128

This article discusses the relevance of laboratory toxicity studies of a chemical oil dispersant. While Lönning and Hagström use a sensitive means to determine the more subtle, sublethal effects of chemicals on marine life, two major aspects of their work should be clarified. First, a concentration of 1-10 ppm of chemical dispersant, wherein fertilization of the sea urchin egg was affected in their work, does not occur in the usual marine environment with proper use of the dispersant. Second, there is no evidence to support the conclusion that the specific chemical dispersants studied by Lönning and Hagström preferentially release "toxic substances" from the crude oil.

219. Caparella, D.M. and P.A. LaRock (1975)

A RADIOISOTOPE ASSAY FOR THE QUANTIFICATION OF HYDROCARBON BIODEGRADATION POTENTIAL IN ENVIRONMENTAL SAMPLES.

Microbial. Ecol. 62 28-42.

220. Carlberg, S.R. (1976)

OIL AND OIL DISPERSANTS.

In: Second FAO/SIDA Training Course on Marine Pollution in Relation to Protection of Living Resources: Methods for Detection, Measurement and Monitoring of Pollutants in the Aquatic Environment. United Nations Food and Agriculture Organization, UNIPUB, New York. p. 328-35.

Topics discussed include oil pollution from ships, effects and fate of oil pollution at sea, possible ways of dealing with released oil, and biological aspects of oil pollution. About 95% of the crude oil tonnage is now equipped with the load-on-top system (LoT) to eliminate the discharge of oily water from the emptied tanks. The LoT prevents an estimated 1.6 million tons of oil from reaching the sea. Some calculations suggest that 0.7 million tons of oil are released into the marine environment annually from crude oil carriers. When oil is released into the sea, a thin homogeneous slick is formed; 25%-30% of the substance evaporates. The remaining nonvolatile components are converted into oil-in-water or water-in-oil emulsions. Most of the water-in-oil "mousse" washes ashore and forms tarry lumps. Parts of the oil-in-water emulsions are distributed as fine suspensions, consumed by plankton, settle on heavy particles, dissolve, or undergo chemical reactions or bacterial degradation. Possibly ways of dealing with released oil include taking no action at all in the open ocean, suction and skimming, absorbing and gelling, burning, oil sinking and dispersion. Substances in mineral oil taken up by marine organisms often cannot be excreted and thus may be regarded as risks for higher trophic levels in the food chain. Oil and its aromatic compounds may completely hide the identifying smell of a certain area for migrating fish. Dispensing agents have a deleterious effect on larval hatching and larval chemoreceptors of fish. Oil is also able to concentrate DDT and other nonpolar hydrocarbons (whether chlorinated or not) which are insoluble in water.

221. Carr, R.H. (1919)

VEGETATIVE GROWTH IN SOILS CONTAINING CRUDE PETROLEUM.

Soil Sci., 8:67-68.

Several soybean plants were grown in pots containing soil with varying concentrations of crude oil. Growth of plants was actually improved with small amounts of oil (0.75%), and rather large amounts may be mixed with the soil (4.00%) before the soybean plant succumbs to the oil treatment. This damage seems to be due in part to the plant's inability to secure water rapidly enough to meet its needs.

A small amount of oil is even desirable in nodule development, and where the amount of oil was increased to the extent of damaging the plant, there was still some nodule formation.

222. Carvell, F. and M. Tadlock (1971)

Its Not Too Late. Macmillan Company, Glencoe Press, Beverly Hills, California 327 pp.

The historical roots, nature, and scope of the current ecological crisis are examined, and changes that have occurred in the environment are considered. The economics of pollution is discussed along with the need for establishing ecological priorities. Specific instances of environmental deterioration, such as the Santa Barbara oil spill, are analyzed, along with the population explosion, land conservation, and the exploitation of water resources. The ways in which environmental problems can be attacked are examined.

223. Center for Ocean Management Studies (1978)

In: IN THE WAKE OF ARGO MERCHANT CONFERENCE AND WORKSHOP HELD AT UNIVERSITY OF RHODE ISLAND JAN 11-13, 1978, PROCEEDINGS.

Center for Ocean Management Studies, University of Rhode Island, Kinsgtown, Rhode Island.

In: These proceedings combine 23 papers and the results of three workshops on physical, chemical and biological aspects of the effects of the Argo Merchant spill.

224. Cerame-Vivas, M. (1969)

THE WRECK OF THE OCEAN EAGLE.

Sea Frontier, 15(4): 224-231.

Background information, an ecological damage report, and a review of cleanup procedures involved in the wreck of the tanker Ocean Eagle near San Juan. No data are included.

225. Cerniglia, C.E. (1975)

OXIDATION AND ASSIMILATION OF HYDROCARBONS BY MICROORGANISMS ISOLATED FROM THE MARINE ENVIRONMENT.

North Car. State Univ., Raleigh, Ph.D. Thesis, 65.

Results suggest that the major group of organisms that grew on paraffinic hydrocarbons in the littoral areas of North Carolina were the mycobacteria and related organisms. Fewer fungi were isolated but these were more effective in mineralizing hydrocarbons and crude oil. Isolates that grew well on hydrocarbons were of the genera Cunninghamella, Penicillium, Aspergillus, Cephalasporium, and ans Penicillium. Growth rates were affected by incubation temperature, and growth was better on NH_4Cl than on $NaNO_3$, with 0.25 mg/ml N being sufficient for mineralization of crude oil.

226. Cerniglia, C.E. and J.J. Perry. (1973)

CRUDE OIL DEGRADATION BY MICROORGANISMS ISOLATED FROM THE MARINE ENVIRONMENT.

Z. allg. Mikrobiol. 13:299-306.

The utilization of crude oil by microorganisms isolated from marine environments was investigated. Enrichment procedures for isolating crude oil degrading organisms were carried out using samples of mud collected among the estuaries and along the coast of North Carolina. The basal medium was seawater supplemented with nitrogen and phosphate. The fungi isolated under these conditions utilized crude oil more effectively than did the bacteria and several oil utilizing fungi were isolated in pure culture. Among the fungi selected were strains of Cunninghamella eleguns; Aspergillus versicolor, Cephalosporium acremonium and a Pencillium sp. These fungi utilized a wide variety of hydrocarbon substrates as a source of carbon and energy. All grew on a mineral salts medium with no requirement for seawater.

The amount of crude oil utilized by growing fungi was determined. The results suggested that of the fungi isolated C. elegans and the Penicillium sp. were most effective in degrading crude oil. When paraffin base crude oil was added to the seawater basal salts medium (0.2% v/v) and innoculated with C. elegans ver 90% of the oil was assimilated after 5 days growth. Less than one-half of this amount of asphalt base crude oil was assimilated after 5 days growth. Less than one-half of this amount of asphalt base crude oil was utilized. The optimum temperature for growth of fungi that utilized crude oil differed but all grew at temperatures between 15 and 24°C. Significant growth of the fungi on crude oil did not occur unless the seawater was supplemented with a source of nitrogen and phosphorus. The results of this study suggested that fungi can effectively assimilate crude oil and that paraffin base crude is more readily degraded than the asphalt base crude oil.

227. Chadwick, H.K. (1960).

TOXICITY OF TRICON OIL SPILL ERADICATOR TO STRIPED BASS (ROCCUS SAXATILLIS).

California Fish and Game, 46:371-372.

Tricon Oil Spill Eradicator is a commercial product designed to emulsify oil spilled on water. The manufacturer lists the composition as 20 percent petroleum sulfonate, 5 percent fatty acid esters, 10 percent polyethylene glycol ether, 63 percent petroleum solvents, and 2 percent alcohol.

The use of Tricon Oil Spill Eradicator has been proposed in water of the San Francisco Bay area. Since these waters are inhabited by striped bass, the California Department of Fish and Game conducted bioassays in early 1957, in order to determine this eradicator's toxicity to this species.

Five striped bass were placed in each of eight aquaria containing 7,500 ml of a mixture of water taken from the San Joaquin River at Antioch and various amounts of oil spill eradicator. For a control, five bass were placed in a ninth aquarium with 7,500 ml. of river water. The bass used ranged from 2.7 to 4.3 inches and averaged 3.4 inches in fork length. Air was bubbled slowly through the water in all aquaria; water temperature was maintained at approximately 65 degrees F.

These results show clearly that Tricon Oil Spill Eradicator is is toxic to striped bass at low concentrations. It is probable that lethal concentrations would occur at least locally, if the eradicator were used to treat oil spills.

228. Chan, E.L. (1977)

OIL POLLUTION AND TROPICAL LITTORAL COMMUNITIES: BIOLOGICAL EFFECTS OF THE 1975 FLORIDA KEYS OIL SPILL.

In: Proceedings 1977 Oil Spill Conference. p. 539-542. Amer. Petrol. Inst. Wash., D.C.

This study reports biological effects of the July 1975 oil spill in the Florida Keys for a one-year period. Floating seagrass served as a natural sorbent for oil and stranded in the intertidal zone. A soluble component of oil, or possibly an organic cleaning solvent, leaching from this debris, was probably responsible for a mass mortality of subtidal echinoderms on the rocky platform. Several crab species were eliminated from the rocky shores, mangrove fringes, and *Batis* marsh communities for several months. Subtidal pearl oysters (*Pinctada radiata*) from the grass flat community suffered extensive mortalities, also attributable to a soluble component of oil. Red mangrove (*Rhizophora mangle*) seedlings on the fringe and in the mangrove swamp, sustaining greater than 50% oiling of their leaves were killed. Dwarf black mangroves (*Avicennia nitida*) with greater than 50% oiling of pneumatophores also died, as did some where the substrate remained oiled one year later. Elevated temperatures, exceeding lethal limits for many intertidal organisms were observed in oil-covered substrates. Oil persisted in the substrate of rocky shores and mangrove-marsh areas for at least one year after the spill.

229. Chan, G. (1972)

A STUDY OF THE EFFECTS OF THE SAN FRANCISCO OIL SPILL ON MARINE ORGANISMS. PART I.

College of Marin, Kentfield, California 94904.

The San Francisco oil spill occured on January 18, 1971, when two Standard Oil vessels collided under the Golden Gate Bridge, releasing 840,000 gallons of Bunker C fuel. This oil was washed up on intertidal shores of the area. This report describes the impact of this oil on Duxberry Reef as determined by transects made before and after the spill. Recovery of the area since the spill is also debated.

230. Chan, G.L. (1973)

A STUDY OF THE EFFECTS OF THE SAN FRANCISCO OIL SPILL ON MARINE ORGANISMS. PP 741-782.

In: Proceedings, Joint Conferences on Prevention and Control of Oil Spills, American Petroleum Institute, Washington, D.C.

The San Francisco oil spill of 18 January 1971 covered areas that which had been extensively studied by transects. Comparative transects and laboratory observations determined that marine organisms died from being smothered by the oil, with certain species such as acorn barnacles and limpets suffering the highest mortalities. Comparison of pre-oil and post-oil transect counts showed there was a significant decrease in marine life after the oil spill on the reef. Marine snails suffered less mortality than sessile organisms. The normally large populations of striped shore crabs was missing from the rocky crevices. Marine algal blooms were observed in certain localities. By December 1971, the condition of the area is one of apparent good health; the recruitment of some marine animals appear to be approaching normal levels. The oil has mostly disappeared.

231. Chan, G.L. (1975)

A STUDY OF THE EFFECTS OF THE SAN FRANCISCO OIL SPILL ON MARINE LIFE. PART II: RECRUITMENT.

In: Conference on Prevention and Control of Oil Pollution. pp. 457-462. Amer. Petrol Inst., Wash., D.C.

A study of marine organisms on intertidal transects encompassed the central theme of observing the effects of the San Francisco Bunker C oil spill of January 18, 1971. From a comparison of pre-oil and post-oil transect data with computation of 95% confidence intervals for population means, it was estimated that 4.2 to 7.5 million marine invertebrates, chiefly barnacles, were smothered by the oil. In subsequent observations from 1972 to 1974, the sample counts of invertebrates had returned to, and in some cases surpassed, pre-oil transect levels. No lingering effects of the oil spill have been noted in any of the marine species.

232. Chan, G.L. (1977)

THE FIVE-YEAR RECRUITMENT OF MARINE LIFE AFTER THE 1971 (SAN FRANCISCO OIL SPILL).

In: Proceedings 1977 Oil Spill Conference. pp. 543-545. Amer. Petrol. Inst., Wash. D.C.

On January 18, 1971, two Standard Oil tankers collided underneath the Golden Gate Bridge, releasing about 840,000 gallons of Bunker C fuel. An estimated 4.2 million to 7.5 million intertidal invertebrates, chiefly barnacles, were smothered by the oil. Five-year observations of marine life recruitment following the spill indicate that population densities of some marine species have significantly increased in the San Francisco Bay area intertidal zones at Sausalito and Duxbury Reef. With some fluctuations, the barnacles Balanus glandula and Chthamalus dalli have increased from July 1971 to May 1976 - from 93 to 189 barnacles per dm^2 at Sausalito and from nine to 34 per dm^2 at Dusbury Reef. The large bed of mussels., Mytilus californianus, showed a steady rise from $5.9/m^2$ in April 1971 to $14.01dm^2$ in July 1976. The density of mobile organisms, such as limpets, snails, crabs, and starfish, all show cyclical variations; some show an overall increase. The limpets, Collisella spp., which suffered high mortality during the spill have increased threefold over pre-oil counts.

In 1975, some significantly low sample means were recorded for barnacles in Sausalito and for 18 composite species at Duxbury Reef, probably due to natural ecological forces. The five-year recruitment (1971-76), however, shows no evidence of lasting detrimental effects of Bunker C oil on the populations of marine life within the transect sites.

233. Chasse, C., M.T.H. Halos and Y. Perrot (1967).

OUTLINE OF A BALANCE OF BIOLOGICAL LOSSES CAUSED BY THE FUEL OIL FROM THE TORREY CANYON ON THE TREGOR SEABOARD.

Penn Ar Bed 6 (50), 107-112.

The effect of oil pollution from the Torrey Canyon on fisheries along the coast of Brittany was estimated. For a 50-km stretch of coast, and a depth down to 15 m, it was estimated that 100,000 tons of algae and 35,000 tons of fish were destroyed, representing a loss of 10 mil, kcal with a potential value of 5.4 mil. francs. (Sinha-Oeis)

234. Chia, F. (1970).

REPRODUCTION OF ARCTIC MARINE INVERTEBRATES.

Mar. Poll. Bull., 1(5):78-79.

In temperate waters, biological damage caused by even a major oil spill seems to be relatively short-lived. Although the consequences of a spill may be locally catastrophic, the oil is eventually eroded, dispersed and biologically degraded, and the area recolonized by a flora and fauna. For the most part this recolonization is by the settlement of planktonic larvae and other dispersive phases in the life histories of marine organisms. Several features of the reproductive biology of Arctic marine invertebrates suggests that recovery of an area from oil pollution is likely to be a much lengthier process in high latitudes.

235. Chia, F.S. (1971).

DIESEL OIL SPILL AT ANACORTES.

Mar. Poll. Bull., 2(7): 105-106.

A preliminary report on a study of the damage to intertidal invertebrates. Of the forty eight species collected, most were severely affected by the oil.

236. Chia, Fu-Shiang (1973).

KILLING OF MARINE LARVAE BY DIESEL OIL.

Marine Pollution Bulletin 4(2):29-30

Laboratory observations are given on the effect of Texaco No. 2 diesel oil on 14 species of 5 phyla of pelagic larvae: Echinodermata (Pisaster ochraceous, Luidia foliata, Crossaster papposus, Dendraster exercutricus), Mollusca (Acmaea scutum, Haminoea virescens, Melibe leonina, Katharina tunicata, Crassostrea gigas), Annelida (Nereis vexillosa, N. branti, Serpula vermicularis), Arthroposa (Balanus cariosus), and Urochordata (Boltenia velosa). All larvae died at different durations (from 3 to 72 hr) after being placed in 0.5% oiled seawater, except Crossaster which survived 8 d. Symptoms of contact with oil are acute contractions of the gut, asynchronization and sluggish beat of cilia or setae, and occasional violent movement of the body. Species specificity in terms of survival may be related to larval size.

237. Chipman, W.A. and P.S. Galstoff. (1949)

EFFECTS OF OIL MIXED WITH CARBONIZED SAND ON AQUATIC ANIMALS.

U.S. Fish and Wildlife Service, Special Scientific Rept. No. 1, 50.

Crude oil, Diesel oil, and Navy Grade Special fuel oil added to sea water are toxic to the hydrozoan Tubularia crocea; barnacle, Balanus balanoides; embryos of the toadfish, Opsanus tau; and the eastern oyster, Ostrea virginica. The one experiment performed with the hard shell clam, Venus mercenaria, failed to show toxicity, probably from insufficient concentration of oil used. The toxicity of these oils is apparent whether they are present as oil slicks on the surface of the water or are held on the bottom bound to carbonized sand. Strongly toxic fractions obtained by shaking crude oil and Diesel oil with sea water and separating the two phases show that the toxic effect is due to a substance or substances leached by water.

The toxicity of crude oil to toadfish embryos was found to increase with concentration; the relationship may be approximately expressed by an equation $y = ax^c$, where y is survival time, x is concentration, and a and c are constants. The presence in water of crude oil and Diesel oil mixed with carbonized sand and of extracts of these oils interferes with the pumping mechanisms of the gills of oysters and reduces the rate of filtration of water. Continued exposure of oysters to sea water flowing at a slow rate over a mixture of crude oil and carbonized sand results in a marked reduction in the amount of water pumped by oysters and in a decrease in the number of hours that the oysters remain open.

238. Cimberg, R., S. Mann, D. Straughan (1973).

A REINVESTIGATION OF SOUTHERN CALIFORNIA ROCKY INTERTIDAL BEACHES THREE AND ONE-HALF YEARS AFTER THE 1969 SANTA BARBARA OIL SPILL: A PRELIMINARY REPORT. PP. 697-702.

In: Proceedings, Joint Conference on Prevention and Control of Oil Spills. American Petroleum Institute, Washington, DC.

Ten rocky intertidal beaches in southern California, which were surveyed for a 12-month period following the 1969 Santa Barbara oil spill, were reinvestigated in June and July of 1972. Data from this 1972 survey as well as data collected during the same months on the same beaches in 1969 and 1970 were analyzed by forming beach groupings using cluster analysis. This analysis indicates that sand movement and substrate stability are the two most important factors affecting the presence of marine organisms on these beaches during this period. Overall, the effect of the 1969 Santa Barbara oil spill on the presence and abundance of rocky intertidal organisms was less important than other environmental factors. Most mortalities reported were localized in tide pools and high intertidal areas.

239. Clark. R.B. (1968).

OIL POLLUTION AND THE CONSERVATION OF SEABIRDS.

In: Proceedings of the International Conference on Oil Pollution of the Sea, Rome, pp. 76-112.

240. Clark, R.B. (1970).

OILED SEABIRD RESEARCH UNIT.

Mar. Poll. Bull., 1(2):22.-24.

Following the wreck of the Torrey Canyon, the (UK) Advisory Committees on Oil Pollution of the Sea established a small research unit in the department of zoology of the University of Newcastle. Research has been carried out on the waterproofing abilities of bird plumage. A second research unit was established in Newcastle upon Tyne on 1 January 1970. The most urgent task is to devise suitable methods of cleaning oiled birds without destroying the water-repellency of the plumage. Also studied, will be treatment of oiled birds with enriched foods and drugs, threatment of acute enteritis following the ingestion of oil, and fate of rehabilitated birds in breeding colonies in the Farne Islands and elsewhere.

241. Clark, R.B. (1971).

OIL POLLUTION AND ITS BIOLOGICAL CONSEQUENCES. A REVIEW OF CURRENT SCIENTIFIC LITERATURE.

Prepared for Great Barrier Reef Petroleum Drilling Royal Commissions, 111 p.

242. Clark, R.B. (1971).

THE BIOLOGICAL CONSEQUENCES OF OIL POLLUTION OF THE SEA, PP. 53-73.

In: Water Pollution as a World Problem. The Legal, Scientific and Political Aspects.

A review covering the effects of oil pollution on sea-birds, commercial fisheries and coastal flora and fauna. Topics also covered are: treatment of oil pollution; special problems of the arctic, oil pollution as a public health hazzard, and international conventions and control measures.

243. Clark, R.B. (1971).

CHANGING SUCCESS OF COASTAL SPORT FISHING.

Mar. Pollut. Bull., 2 153-156.

244. Clark, R.B. (1973).

IMPACT OF ACUTE AND CHRONIC OIL POLLUTION ON SEABIRDS.

In: Inputs, Fates and Effects of Petroleum in the Marine Environment. Background Information for the Workshop, Ocean Affairs Board, NSF, Airlie, Va. 21-25 May 1973.

This paper is a review of the mortality of seabirds as based on beach surveys. It discusses both chronic spillage and large spill incidents. Estimates of the impact of these mortalities is the bird populations have made. The use of dispersants is discussed as a favorable method of reducing bird losses. Treatment of oiled birds and methods of seabird conservation are also covered.

245. Clark, R.B. and K.G. Gregory. (1971).

FEATHER-WETTING IN CLEANED BIRDS.

Mar. Poll. Bull., 2(5):78-79.

At present, the limiting factor in the rehabilitation of oiled seabirds is the immediate loss of water-repellancy from the plumage following cleaning, and so far no cleaning method is generally accepted as overcoming this problem. The characteristic watertight plumage of seabirds is dependent on the water-repellency of constituent feathers, and this is a function of structural and surface properties.

Oiling and cleaning may reduce the apparent contact angle or impair directional water-shedding by individual feathers or render the normally hydrophobic porous structure water-wettable. Plumage-wetting in cleaned birds may therefore be caused by the absorption of water by individual hydrophilic feathers, or it may be the result of penetration by water between hydrophobic feathers exhibiting an impaired water-shedding ability or a lowered apparent contact angle.

246. Clark, R.C. (1973).

BIOLOGICAL FATES OF PETROLEUM HYDROCARBONS IN AQUATIC MACROORGANISMS.

In: Inputs, Fates, and Effects of Petroleum in the Marine Environment. Background information for the Workshop, Ocean Affairs Board, Airlie, Virginia 21-25 May 1973. VOL. I & II..

The major objectives of the workshop were to provide an opportunity for experts from the national and international academic, industrial, and governmental communities working with petroleum in the ocean to accomplish the following goals:

Quantify more precisely the inputs of petroleum to the marine environment.

Compare different analytical techniques, both chemical and biological, and establish reliability criteria for these techniques.

Develop more specific knowledge about the fates of petroleum in the ocean, caused by such processes as weathering, dispersion, biodegradation, and biological uptake.

Evaluate effects of high-level, catastrophic spills on coastlines and coastal biota, low-level effects on marine resources and effects on human health.

Forty-four papers are included in the 2 volumes. A report of the findings of the workshop was prepared and published separately by the National Academy of Sciences. (See entry no. in the bibliography.)

Revia.

247. Clark, R.C. (1974).

METHODS FOR ESTABLISHING LEVELS OF PETROLEUM CONTAMINATION IN ORGANISMS AND SEDIMENT AS RELATED TO MARINE POLLUTION MONITORING.

In: Marine Pollution Monitoring (Petroleum) Proceedings of a Symposium. National Bureau of Standards Special Publication No. 409 p. 189-194

A concise review and comparison of techniques for extraction, identification and quantification of hydrocarbons in organisms and sediment.

248. Clark, R.C. Jr. (1976).

IMPACT OF THE TRANSPORTATION OF PETROLEUM ON THE WATERS OF THE NORTHEASTERN PACIFIC OCEAN.

U.S. Natl. Mar. Fish. Serv. Mar. Fish. Rev. 38 20-26.

249. Clark, R.C., Jr., *et al*. (1973).

INTERAGENCY INVESTIGATIONS OF A PERSISTENT OIL SPILL ON THE WASHINGTON COAST, PP. 793-808.

In: Proceedings, Joint Conference on the Prevention and Control of Oil Spills. American Petroleum Institute, Washington, DC.

An interagency team of biologists, chemists, oceanographers and engineers has been investigating the long-term effects of oil spilled by the grounding of the troopship GENERAL M.C. MEIGS January 6, 1972, on an ocean coast intertidal community of plants and animals. Oil has continuously been released from the 440,000 liters of Navy Special Fuel Oil carried by the vessel. The team assessed biological damage by making (1) surveys of abundance and physiological condition of animals, (2) qualitative evaluation of obvious damage to plants, and (3) measurements of the hydrocarbon uptake in both plants and animals. A series of sites, forming a vertical profile of the rocky shelf area from the upper intertidal zone to the lowest low tide level in Wreck Cove, have been studied.

This report describes the preliminary findings of the first ten months (January-October, 1972) of the investigation. Abnormal and dead sea urchins (*Strongylocentrotus purpuratus*) indicated that this species was affected. Loss of fronds and bleached thalli not evident in control areas were observed in the plant community in the immediate vicinity of the hulk. Petroleum hydrocarbons were taken up in the intertidal community. The normal paraffin hydrocarbon patterns and content over the range $n\text{-}C_{14}H_{30}$ to $n\text{-}C_{37}H_{76}$ of healthy-appearing goose barnacles (*Mitella polymerus*), crabs (*Hemigrapsus nudus*) and an alga (*Fucus gardneri*) display the same basic characteristics as the fuel which had been lost from the GENERAL M.C. MEIGS.

250. Clark, R.C., and M. Blumer. (1967).

DISTRIBUTION OF N-PARAFFINS IN MARINE ORGANISMS AND SEDIMENTS.

Limnol. Oceanogr. 12-79-87.

Twelve species of benthic algae from the northeast coast of the United States, three species of planktonic algae grown in the labortory, a pelagic alga, a sample of mixed phytoplankton and zooplankton, and a recent marine sediment were analyzed for their normal paraffin distribution from $C_{14}H_{30}$ to $C_{32}H_{66}$.

Normal paraffins occurred in all samples. Benthic and planktonic algae and the mixed plankton sample exhibited only a slight odd-carbon predominance. All algae showed a major maximum at $n\text{-}C_{15}H_{32}$

or $n\text{-}C_{30}H_{62}$. In all these features, the algae and the plankton differed from recent marine sediments. This suggests that the normal paraffins of recent marine sediments are largely derived from sources other than the organisms studied.

Differences in the hydrocarbon distribution patters of various classes of benthic algae may be of taxonomic value. Pristane occurs in several benthic and planktonic algae; phytane, if present, occurs at a concentration too low to be detected by the method used.

251. Clark, R.C. and J.S. Finley (1973).

TECHNIQUES FOR ANALYSIS OF PARAFFIN HYDROCARBONS AND FOR INTERPRETATION OF DATA TO ASSESS OIL SPILL EFFECTS IN AQUATIC ORGANISMS.

In: Prevention and Control of Oil Spills, Proceedings of Joint Conference, Washington, D.C. March 13-15, 1973. p. 161-172.

Normal paraffin hydrocarbons are one of the major groups of compounds in crude oil and petroleum products. Since these compounds can be readily separated from aquatic organisms using solvent extraction and liquid-solid chromatography and identified by gas-liquid chromatography, the normal paraffins can serve as indicators of petroleum pollution in the aquatic environment. It is necessary, however, to differentiate between natural (or biogenic) hydrocarbons and those assimilated by the organisms from pollution sources by comparing the natural hydrocarbon content and pattern of organisms from areas of pollution with those of organisms from pollution sources by comparing the natural hydrocarbon content and pattern of organisms from areas of pollution with those or organisms from relatively "unpolluted" areas. The paper suggests techniques for obtaining and analyzing petroleum hydrocarbon data which can lead to a standard method for detecting and following the biological uptake of oil by living organisms from the aquatic environment.

252. Clark, R.C. and Finley, S. (1973).

PARAFFIN HYDROCARBON PATTERNS IN PETROLEUM-POLLUTED MUSSELS.

Mar. Pollut. Bull., 4 172-176

By applying modern analytical chemistry techniques to the problem of oil pollution in the marine environment, it is possible to detect very low levels (5ppb) individual n-paraffins $n\text{-}C_{14}H_{30}$ to $n\text{-}C_{37}H_{76}$) of paraffin hydrocarbons in intertidal marine organisms and to use these compounds with suitable baseline information for estimating the quantity of petroleum pollution uptake in the organisms. Under conditions of moderate to major oil pollution, this technique provides a calculation of residual paraffin hydrocarbon pattern in exposed organisms which can be compared to the pollutant hydrocarbon pattern. For low-level persistent pollution, the use of paraffin hydrocarbon patterns and content can often provide an indication of petroleum uptake but, in cases where the pollutant is low in paraffin hydrocarbons (lubricating oils, some crude oils, etc.) or where the rate of bacterial degradation is equivalent to the pollutant input, different techniques of analysis are required.

253. Clark, R.C., Jr., and J.S. Finley (1974)

ANALYTICAL TECHNIQUES FOR ISOLATING AND QUANTIFYING PETROLEUM PARAFFIN HAZARDOUS IN MARINE ORGANISMS.

In: NBS Special Publication 409,, Marine Pollution Monitoring (Petroleum), Proceedings of a Symposium and Workshop hold at NBS, Gaithersburg, Maryland, May 13-17, 1974. National Bureau of Standards. pp. 209-212.

This paper describes anylitical techniques to quantify n-paraffins in marine organisms and argues for the technique as a monitoring procedure. The method involves benzene-methanol solvent extraction, silical gen-alumina column chromatography, and linear programmed-temperature gas chromatography. The procedure can isolate and identify individual n-paraffin hydrocarbons at the nanogram (10-9g) lead over the molecular range from 14 to 37 carbon atoms will approximately 75% reproductibility.

254. Clark, R.C., Jr. and J.S. Finley. (1975).

UPTAKE AND LOSS OF PETROLEUM HYDROCARBONS BY THE MUSSEL, MYTILUS EDULIS, IN LABORATORY EXPERIMENTS.

U.S. National Marine Fish Serv. Fish. Serv. Fish. Bull. Vol. 73:508-515.

Petroleum paraffin hydrocarbons from No. 2 and No. 5 fuel oils were rapidly incorporated into the mussel, Mytilus edulis, in a laboratory system that simulated tides. The mussels were exposed to levels of petroleum hydrocarbons from a surface slick similar to those encountered in the environment after an oil spill. After 14 days in clean seawater, the mussels had lost most of the hydrocarbons from the fuel oils, however, detectable traces of the No. 2 fuel oil still remained after 35 days. Preliminary results from these laboratory studies confirm previous studies of pollutant uptake and loss following actual oil spills.

255. Clark, R.C. Jr., J.S. Finley and B.G. Patton. (1975).

Long-term chemical and biological effects of a persistent oil spill following the grounding of the Genral M.C. Meigs.

In: Conference on Prevention and Control of Oil Pollution. pp. 479-488. Amer. Petrol. Inst., Wash., D.C.

Petroleum hydrocarbon uptake patterns and observations of plant and animal populations of an intertidal community exposed continually since January 1972 to small quantities of a Navy Special Fuel Oil residue from the grounded unmanned troopship General M.C. Meigs were obtained by an interagency team of oceanographers, biologists, chemists and engineers. Although the tar-ball-like character of the released oil served to limit its coverage, specific members of the intertidal community showed effects of the persistence of the spill. This report describes the long-term observations and analyses made since the grounding of the 622-foot military transport on a rich and productive intertidal regime.

256. Clendonming, K.A. (1959).

THE EFFECTS OF WASTE DISCHARGE ON KELP, FUEL OIL.

Univ. Calif. Inst. Mar. Resources, 59 4-12.

257. Clendenning, K.A. and North, W.J. (1960).

THE EFFECTS OF WASTES ON THE GIANT KELP MACROCYSTICS PYRIFERA. pp. 82-91

In: Waste Disposal in the Marina Environment. Pergamon, N.Y.

258. Clarke, C.H.D., Gabrielson, H., Kessel, B., Robertson, W.B., Wallace, G.J. and Cahalabe, V.H. (1965).

REPORT OF THE COMMITTEE ON BIRD PROTECTION, 1964.

Auk, 82, 477-491.

This general report includes a paragraph on "Oil and Sea Birds." Most of this paragraph is devoted to the description of a large spill in the Dry Tortugas and the active feather to protect colonies of sooty and noddy terns.

259. Cobet, A.B. and H.E. Guard. (1973).

EFFECTS OF A BUNKER FUEL ON THE BEACH BACTERIAL FLORA.

In: Conference on Prevention and Control of Oil Spills., pp. 815-820. Amer. Petrol. Inst.

Studies at four sampling locations on three beaches in the San Francisco area affected by oil from an 840,00 gallon spill of Chevron bunker fuel have shown that the size of the bacterial population and distribution of bacterial genera within the beach was unaffected by the petroleum hydrocarbons remaining in the beach sand after completion of the cleanup operation. Only 15 percent of the beach bacteria were affected by a variety of petroleum components including the pentane soluble fraction of the bunker fuel.

260. Cohen, Y.A. Nissenbann, and R. Eisher (1977).

EFFECTS OF IRANIAN CRUDE OIL ON THE RED SEA OCTOCORAL HETEROXENIA fuscebcens.

Enciron. Pollut. 12 173-185

Acute toxicity and sublethal effects of Iranian crude oil on colonies of the Red Sea octocoral Heteroxenia fuscescens were studied under continuous flow assay conditions. Static toxicity bioassays conducted in 31. jars at 41% salinity and 22 degrees C showed that 12 vol/1 crude oil to seawater was toxic to 50% of the test colonies in 96 hours. Surviving colonies were adversely

affected. Tank tests in large, deep containers and flowing seawater demonstrated a depth protection effect. Gas chromatographic analysis of hydrocarbon composition of coral exposal to high sub-lethal levels of crude oil showed that petroleum derived hydrocarbons were incorporated into the tissues.

261. Cole, H.A., editor (1975).

Petroleum and the Continental Shelf of North-West Europe, Vol. 2. Environmental Protection. Applied Science Publishers, London. 126pp.

This volume consists of thirteen papers presented at a conference organized jointly by the Geological Society of London, the Institute of Geological Sciences, the Institute of Petroleum and the Petroleum Exploration Society of Great Britian. The papers are mainly reviews, including general reviews of the biological effects of oil pollution.

262. RR. Colwell (1974).

MICROORGANISMS OF THE OUTER CONTINENTAL SHELF.

In: Marine Environmental Implications of Offshore Oil and Gas Development in the Baltimore Canyon Region of the Mid-Atlantic Coast. Proceedings of Estuarine Research Foundation Federation Outer Continental Shelf Conference and Workshop. Estuarins Research Federation. p. 259-264.

This article discusses the effect of pollutants on microbial populations particularly with reguard to biodegredation of hydrocarbon pollutants. The work cited was primarily done in Chesapeake Bay.

263. Colwell, R.R., J.D. Walker, and J.D. Nelson. (1972).

MICROBIAL ECOLOGY AND THE PROBLEM OF PETROLEUM DEGRADATION IN CHESAPEAKE BAY.

In: The Microbial Degradation of Oil Pollutants. pp. 185-197.

Petroleum degradation in the marine environment is one of the many processes effected by microorganisms. Control of this process will be achieved only through an understanding of microbial ecology. Information obtained on the ecology of mercury-metabolizing bacteria in Chesapeake Bay has provided interesting comparisons with the petroleum-degrading microbial populations. Petroleum degradation studies are being done to obtain a seasonal incidence, as well as species distribution of petroleum-degrading microorganisms in Chesapeake Bay. From analysis of water and sediments collected at two stations in Chesapeake Bay it was found that the concentration of petroleum in an oil polluted site in Baltimore Harbor was ca five times greater than in Eastern Bay. The numbers of petroleum-degrading microorganisms, measured by direct and replica plating, in the water and sediment samples were related to the concentration of oil in each sample. Total yields of petroleum-degrading microorganisms grown on an oil substrate were greater for those organisms exposed to oil in the natural environment. Microorganisms isolated from water and sediment samples collected in Baltimore Harbor grew on substrates representative of the aliphatic, aromatic and refractory hydrocarbons. From analyses of species distribution, it was observed that a hydrocarbon-utilizing fungus, Cladoeporium resinae, and actinomycetes were predominant among the hydrocarbon-utilizing isolates. Microbial degradation of petroleum in Chesapeake Bay appears to be mediated by the autochthonous microbial flora. The objective of work in process is to determine whether a seasonal fluctuation in the petroleum-degrading microflora occurs in the Bay.

264. Conder, P.J. (1968).

TO CLEAN OR KILL.

Birds, 2 56.

265. Connel, P.W. (1971).

KEROSENE TAINTING IN AUSTRALIAN MULLET.

Mar. Poll. Bull., 2:188-190.

This article is a preliminary report on the chemical composition of substances causing a kerosene-like taint in mullet. These substances are kerosene-like in composition and may originate from similar substances isolated from river sediments.

266. Conney, A.H., et al. ([illegible]8).

SUBSTRATE-INDUCED SYNTHESIS AND OTHER PROPERTIES OF BENZPYRENE HYDROXYLASE IN RAT LIVER.

J. Biol. Chem., [illegible]28:753-766.

The enzymatic hydroxylation of 3,4-benzpyrene (BP) by fortified rat liver homogenates has been described. This benzpyrene hydroxylase is heat- and trypsin-labile, is localized in the microsomes, and requires reduced tri- and diphosphopyridine nucleotide (TPNH and DPNH) and oxygen are 8-hydroxy-BP, 10-hydroxy-BP, an unidentified compound which is probably the metabolite designated as [illegible] by Weigert and Mottram. and more polar unidentified metabolites. Small quantities of BP-5, 8-quinone, BP-5, 19-quinone, and 5, [illegible] dihydroxy-BP were also formed.

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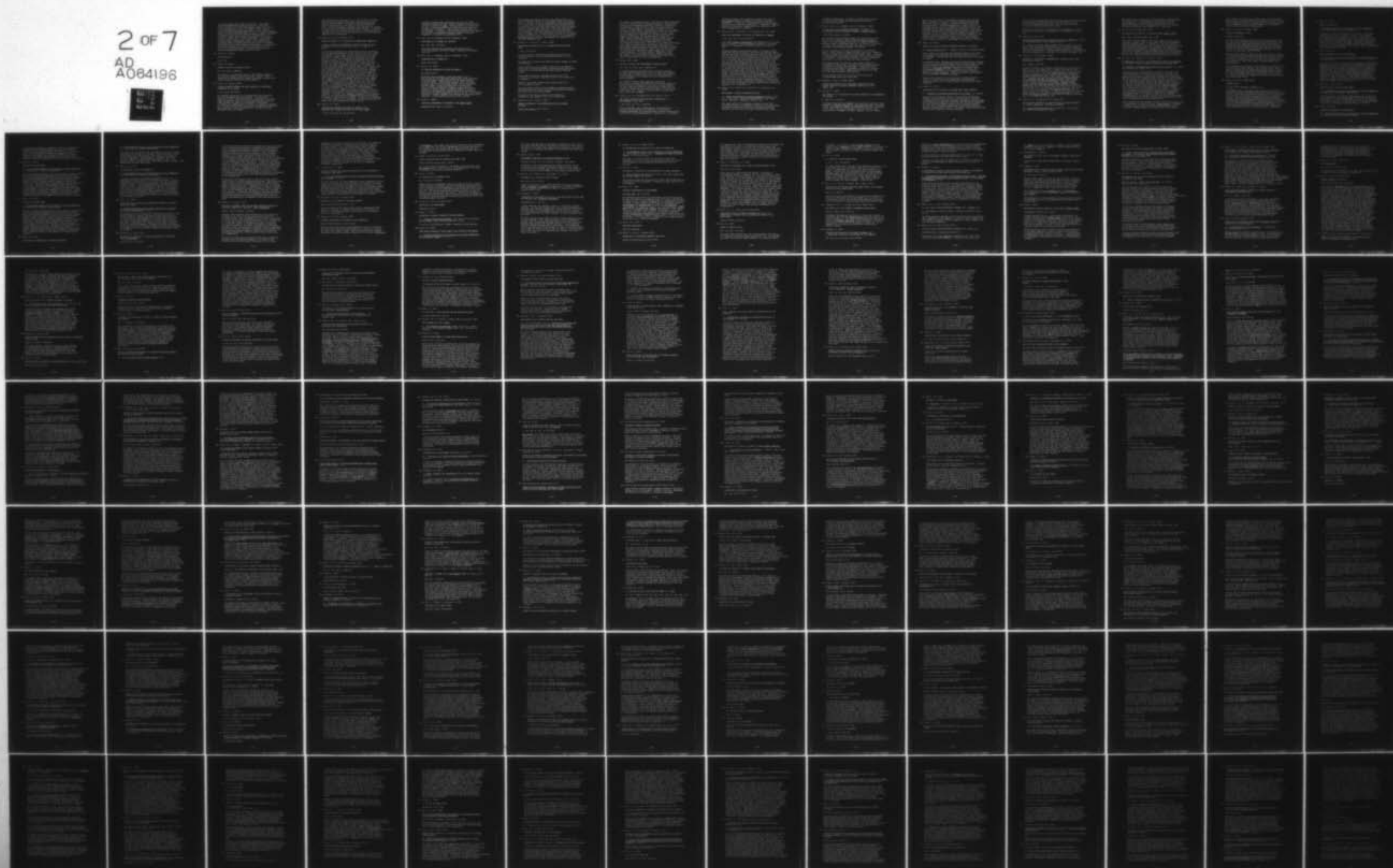

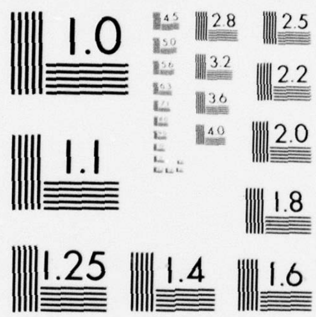

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was ca five times greater than in Eastern Bay. The numbers of petroleum-degrading microorganisms, measured by direct and replica plating, in the water and sediment samples were related to the concentration of oil in each sample. Total yields of petroleum-degrading microorganisms grown on an oil substrate were greater for those organisms exposed to oil in the natural environment. Microorganisms isolated from water and sediment samples collected in Baltimore Harbor grew on substrates representative of the aliphatic, aromatic and refractory hydrocarbons. From analyses of species distribution, it was observed that a hydrocarbon-utilizing fungus, Cladoeporium resinae, and actinomycetes were predominant among the hydrocarbon-utilizing isolates. Microbial degradation of petroleum in Chesapeake Bay appears to be mediated by the autochthonous microbial flora. The objective of work in process is to determine whether a seasonal fluctuation in the petroleum-degrading microflora occurs in the Bay.

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Mar. Poll. Bull., 2:188-190.

This article is a preliminary report on the chemical composition of substances causing a kerosene-like taint in mullet. These substances are kerosene-like in composition and may originate from similar substances isolated from river sediments.

266. Conney, A.H., et al. (1958).

SUBSTRATE-INDUCED SYNTHESIS AND OTHER PROPERTIES OF BENZPYRENE HYDROXYLASE IN RAT LIVER.

J. Biol. Chem. 228:753-766.

The enzymatic hydroxylation of 3,4-benzpyrene (BP) by fortified rat liver homogenates has been described. This benzpyrene hydroxylase is heat- and trypsin-labile, is localized in the microsomes, and requires reduced tri- and diphosphopyridine nucleotide (TPNH and DPNH) and oxygen are 8-hydroxy-BP, 10-hydroxy-BP, and unidentified compound which is probably the metabolite designated as F by Weigert and Mottram, and more polar unidentified metabolites. Small quantities of BP-5, 8-quinone, BP-5, 19-quinone, and 5,8-dihydroxy-BP were also formed.

The intraperitoneal injection of .1 to . mg. of BP or of certain other polycyclic aromatic hydrocarbons into weanling male rats caused a rapid increase in the hepatic benzpyrene hydroxylase activity to about five to ten times the control value by 24 hours. Several experimental approaches indicated that the increase in activity was the result of induced enzyme synthesis. In particular, the response to the BP could be prevented by the administration of ethinine. The effect of ethionine was nullified by the simultaneous administration of methionine.

267. Connor, M.S. and R.W. Howarth (1977).

POTENTIAL EFFECTS OF OIL PRODUCTION ON GEORGES BANK COMMUNITIES:

A Review of the Draft Environmental Impact Statement for Outer Continental Shelf Oil and Gas Lease Sale No. 42. WHOI-77-1. 50 pp.

The biological communities of Georges Bank and their interaction with the proposed development of oil resources there were studied in fall 1976. Several major failings were found with the draft environment statement (DES) for Outer Continental Shelf lease sale no. 42, and it was considered an insufficient and overly optimistic analysis of the possible environmental effects of offshore oil exploitation. Oil from spills - small and large - and oil from chronic discharges may have a serious impact on the fish and other organisms of Georges Bank. The DES lacks a view of the integrative nature of biological communities. Chronic oil pollution associated with oil exploitation on Georges Bank may affect benthic communities in more subtle ways, e.g., changing the relative composition of the species in a given community. This has important ramifications for the fisheries. Most of the commercially important fish of Georges Bank are bottom feeders, and a change in the bottom community structure may well change the abundances of the different species of fish. Fish larvae are not distributed evenly in a body of water, but rather in patches. Low sublethal concentrations of oil shift the composition of the phytoplankton from larger forms such as diatoms to tiny microflagellates. The Bureau of Land Management's analysis of the time needed for recovery - weeks or months - following a spill is considered excessively optimistic. Recovery apparently is considered to coincide with any repopulation by organisms. There were also inadequate assessments of the possible impacts of oil exploitation on endangered species and on coastal environments, particularly the wetlands. For most of the discussion on oil spill impacts on the environment, the DES uses pipeline, not tanker, data for frequencies and sizes of spills.

268. Conover, R.J. (1971).

SOME RELATIONS BETWEEN ZOOPLANKTON AND BUNKER C OIL IN CHEDABUCTO BAY FOLLOWING THE WRECK OF THE TANKER ARROW.

J. Fish. Res. Board Can. 28:1327-1330.

Zooplankton ingested small particles of oil that were found dispersed throughout the water column in Chedabucto Bay following the wreck of the tanker Arrow. As much as 10% of the bunker C in the water column was associated with zooplankton and their feces contained up to 7% bunker C. The oil had no apparent effect on the organiams. In addition to the particulate oil which was exported from the bay by hydrodynamic processes, perhaps 20% more was sedimented to the bottom as zooplankton feces.

269. Cook, J.W., W. Carruthers and D.L. Woodhouse. (1958).

CARCINOGENICITY OF MINERAL OIL FRACTION.

Brit. Med. Bull. 14:132-135.

This report discussed the separation and characterization of the carcinogenic fractions of Kuwait, Lagunillas and Oklahome crude oils.

270. Cook, J.W., W. Carruthers, and D.L. Woodhouse. (1958).

CARCENOGENICITY OF MINERAL OIL.

Nature 213: 691-92.

271. Cooley, J.F. (1977)

OIL INHIBITS REPRODUCTION IN TESTS ON MUSSELS.

Maritimes 21 12-14.

Experiments were performed to study the effects of No. 2 home heating oil on a simplified predator-prey system consisting of the blue mussel (Mytilus edulis) and the common starfish (asterias forbesi). Observations were made of the individual species as well as the two-species system. These observations included: amount of time the mussel spent filtering food, time of reaction of mechanical stimulus, sexual conditions, production of byssal threads by mussels, movement of starfish, weight loss, and predation. Several functions of mussels were affected by the water-accomodated fraction of the No. 2 oil including respiration, feeding, response time, reproduction and byssal thread production. Little effectual was noted on the starfish.

272. Cooper, L. (1968).

SCIENTIFIC CONSEQUENCES OF THE WRECK OF THE TORREY CANYON.

Helgolander Wiss. Meer., 17:340-355.

Field studies were made at sea and on the polluted shores, as well as laboratory studies of the detergents employed to disperse the oil. The drift of the oil established by direct observation at sea, was found to be directly ahead of the area where the oil was predicted to be would have been of more value than the blanket survey of a limited area close to the coast, and strong surface currents should be added vectorially to the calculated wind-drift when known. The French treated the oil with 3,000 tons of craie de Champagne with 1% sodium stearate, and most of the treated patches observed were pink. This color was due to the flagellate Noctiluca miliaris, which may have engulfed the dispersed oil on the chalk phagotrophically.

273. Copeland, B.J. and Troy C. Dorris. (1962).

PHOTOSYNTHETIC PRODUCTIVITY IN OIL REFINERY EFFLUENT HOLDING PONDS.

J. WPCF. 34:1104-1111.

A study was made to estimate the primary productivity due to algal photosynthesis in the effluent holding ponds of two oil refineries.

The productivity estimates were made from diurnal changes in oxygen concentrations.

Linear regression of gross primary producitivity and community respiration on holding time showed a progressive decrease in both productivity and respiration as the water traveled from pond to pond.

Gross primary productivity decreased from 23.38 to 14.20 g o^2/day/sq m at refinery A and from 21.66 to 7.50 g o^2/day sq m at refinery B.

Community respiration exceeded gross primary productivity at every sampling station.

The gross primary productivity and community respiration values approached each other near the end of the pond system, indicating that stabilization was being attained.

Efficiency of the algae to convert solar radiation to carbohydrates was estimated to be 1.0 to 3.60 percent.

274. Copeland, B. and T. Dorris. (1964).

COMMUNITY METABOLISM IN ECOSYSTEMS RECEIVING OIL REFINERY EFFLUENTS.

Limnol. and Oceanog., 9(3): 431-447

The diurnal curve method was used to investigate community metabolism in two oil refinery effluent holding pond systems. Photosynthetic productivity and community respiration, addition of oxygen from the atmosphere, and the effects of light and temperature were studied. Average community respiration was highest in late fall and lowest in early spring. Photosynthetic productivity was higher in spring and fall than in summer and lowest in winter. There was no photosynthetic productivity at Refinery A during Winter Community metabolism in the holding ponds was higher than in most natural communities and lower than in sewage oxidation ponds. Diffusion of oxygen from the atmosphere was a major contributor of oxygen to the system during winter and in the first few ponds of the series. Efficiency of the algae in converting solar energy to chemical energy was greatest during fall and spring when sunlight was more nearly optimal, and lowest in winter when sunlight was below optimal. Algae in oil refinery effluent are less efficient than algae in sewage communities or natural climax communities. The direct effect of temperature on the bioactivity of the oil refinery effluent community was small. The community was moving forward a production respiration (P/R) ratio of about unity at the end of holding time.

275. Corner, E.D.S. (1975).

THE FATE OF FOSSIL FUEL HYDROCARBONS IN MARINE ANIMALS.

Proc. Roy. Soc. Land. Ser. B. 189 391-413.

Certain hydrocarbons presenting crude oil have been detected in several marine animal species as well as algae and sediments. The importance of pollution as a source of these hydrocarbons is briefly considered, as is evidence for their biosynthesis in marine organisms.

The problem of whether these compounds, particularly the polycyclic aromatic hydrocarbons are transferred through the marine food web is considered in the light of recent evidence for their uptake and release by various marine animals; and the question of whether they are excretal unclugal or as metabolites is discussed in the context of the many studies that have been made of their fate in mammals.

276. Corner, E.D.S., CC. Kilvinaton and S.C.M. O'Hara. (1973).

QUALITATIVE STUDIES ON THE MATABOLISM OF NAPHTHALENE IN MAIA SQUINADO (SPIDER CRAB).

J. Mar. Biol. Ass. U.K., 53:819-832.

Extraction methods, paper chromatography, enzyme hydrolysis and spectrophotofluorometry have been used in identifying unchanged naphthalene, an acid-decomposable precursor of naphthalene, 1,2-dihydro-1,2-dihydroxynaphthalene, a glucoside of this compound, l-naphthyl sulphate, and l-naphthyl glucoside in the urine of Maia squinado (Herbst) dosed with the aromatic hydrocarbon naphthalene. In addition, l-naphthylmercapturic acid has been detected in the urine after acidification. l-Naphthol, l-naphthyl glucoside and l-naphthyl sulphate have been identified in the urine of Maiadosed with l-naphthol.

277. Corner, E.D.S., R.D. Harris, C.C. Kilungton and S.C.M. O'Hara

SHORT-TERM EXPERIMENTS ON THE FATE OF NAPHTALENE IN CALANUS.

J. Mar. Biol. Ass. U.K., 56:121-133.

Adult female Calanus helgolandicus Claus immersed for 24 h in sea-water solutions of (1-^{14}C) naphthalene accumulated a detectable quantity (3.6 pg/animal) from concentrations as low as 0.10 yg/1.

Feeding experiments using barnacle nauplii or diatoms as foods showed that the dietary route of entry was more important quantitatively than direct uptake from solution in that in order to ensure that the same quantity of radioactivity in the animals was attained by the two routes the level of hydrocarbon in solution had always to be far greater than that present as particulate food. Relevant to these observations was the further finding that after napthalene had been accumulated directly from solution in sea water depuration was rapid and only a small fraction, less than 5% of the original radioactivity could be detected after 10 days: by contrast, when the hydrocarbon was taken up by way of the food depuration was much slower, so that at the end of 10 days about a third of the original level or radioactivity still remained in the animals. Short-term experiments in which Calanus were fed on labelled diets for 24 h under bacteria-free conditions showed that at the end of this period over 90% of the radioactivity in the animals was present as unchanged naphthalene. However, more than two thirds of that released by the animals was in some form other than the hydrocarbon, a finding consistent with the view that Calanus is able to metabolize it.

278. Corner, E.D.S., Harris, R.P., Whittle, K.J. and Mackie, P.R. (1976)

HYDROCARBONS IN MARINE ZOOPLANKTON AND FISH:

In: Effects of Pollutants on Aquatic Organisms Lockwood, A.P.M. Vol. 2, pp. 71-105. Society for Experimental Biology Seminar Series, Cambridge: Cambridge University Press.

This paper reviews the background to studies in short-term and long-term effects of petroleum hydrocarbons, the former being principally concerned with toxicity, tainting and behavioral responses, and the latter with uptake, metabolism and release or possible accumulation. The paper is divided into two parts, the first section being mainly concerned with zooplankton, and the second with fish.

279. Corner, E.D.S., A.J. Southward, and E.C. Southward. (1968).

TOXICITY OF OIL-SPILL REMOVERS (DETERGENTS) TO MARINE LIFE: AN ASSESSMENT USING THE INTERTIDAL BARNACLE, ELMINIUS MODESTUS.

J. Mar. Biol. Assn. U.K., 48:29.

The oil-spill removers BP 1002, Gamlen, Slipclean and Dasic have been tested for toxicity using the barnacle Elminius modestus Darwin. All four substances were more toxic than the laboratory detergent Teepol-L, and Kuwait crude oil. BP 1002 was the most toxic of the oil-spill removers, and Dasic the least, but all were poisonous at concentrations between 2 and 10 ppm.

Most of the toxicity of BP 1002 was provided by the "Kerosene extract" ("Kex") used as an organic solvent; the solvent "Shelsol R" used in the preparation of Dasic, was also highly toxic. Suspensions of these solvents in sea water soon lose toxicity, however, because of evaporation. The surfactant component of BP 1002, although of lower toxicity (25 ppm) is likely to be more persistent.

Low concentrations of BP 1002 (0.5 and 1.0 ppm) inhibit the development of larvae while 3 ppm slows down the swimming activity of cyprids and prevents their settlement. Sensitivity to the poison varies with stage of development; the adults are far more resistant than the nauplii, being killed by 100 ppm of BP 1002, but 5 and 10 ppm slow down cirral activity.

Possible modes of action of the poisons are discussed and conclusions made about their future use.

280. Coughlan, J. and J.F. Spencer (1967).

MILFORD HAVEN:EFFECTS OF OIL SPILLAGES ON ECOLOGICAL SURVEY. CENTRAL ELECTRICITY RESEARCH LABORATORY, REPORT RD/L/N 23/67 (mimeo, pp8.)

281. Cowell, E.B. (1969).

THE EFFECTS OF OIL POLLUTION ON SALT MARSH COMMUNITIES IN PEMBROKESHIRE AND CORNWALL.

J. Appl. Ecol. 6:133-142.

Salt-marsh associations are damaged by oil pollution, especially those dominated by Spartina townsendii and Puccinellia maritima. The damage is most severe when oil reaches the shore soon after it is spilled and is less severe when the oil has been at sea for some days. The lesser severity of damage in Cornwall, compared to that in Milford

Haven, may be due partly to the length of time the oil was at sea before stranding. The time of year when spillage occurs possibly affects the severity of damage. Surfactants severely affect some salt-marsh plants. Repeated contamination is likely to have increasingly serious effects if changes in the microflora of the salt-marsh muds lead to increasingly anaerobic conditions. Chronic oil pollution has been shown to cause the death of plants in salt marshes at Fawley. The effects could cause major changes in erosion and deposition patterns, leading to serious conservation problems. Even though no cleaning had been done, no oil or effects of pollution could be seen in te marshes in Cornwall except in small isolated areas, 3 months after the oil was brought in by the tide on 26 March.

282. Cowell, E.B. (1971).

CHRONIC OIL POLLUTION CAUSED BY REFINERY EFFLUENTS, PP. 380-381.

In: Water Pollution by Oil. P. Hepple, Institute of Petroleum, London.

Chronic damage can result from the continued presence of low levels of pollutant in the environment where refinery effluent waters are discharged. Reocvery will not occur unless the source of pollution is removed.

At Southampton Water, Spartina contaminated by effluent water has been killed out and there has been almost total ecosystem collapse. Twelve successive monthly sprayings of Kuwait crude oil have killed all plants in a Puccinellia maritima dominated turf at Weobley Castle and Spartina townsendii at Crofty. Sprayings in the upper salt marsh turf at Llanrhidian have eliminated all species except the Umbellifer Oenanthe lachenalii. Oysters were killed by "bleed-water" from the Lake Barre oilfield in Louisiana.

Present results suggest that if oil levels in outfalls cannot be lowered to 10 ppm or less, then damage could be minimized by resiting discharge pipes in areas of deeper water and greater tidal dispersion.

283. Cowell, E.B. (1971).

SOME EFFECTS OF OIL POLLUTION IN MILFORD HAVE, UNITED KINGDOM.

In: Conference on Prevention and Control of Oil Spills. pp. 429-436.

Research on the biological effects of oil pollution and detergent cleaning operations within the port of Milford Haven is described. Observations made on accidental spillages, experimental field spillages and laboratory investigations confirm that both salt marsh communities and rocky shores do normally recover from oil pollution accidents but that shore cleaning with emulsifiers can do serious damage if misused, although recovery follows. The effects of some new emulsifiers which are up to 1000X less toxic are discussed.

Chronic pollution damage from refinery discharges has been identified both in Milford Haven and elsewhere, but it has been shown that these effects are eliminated if the outfall pipes are located offshore in locations of good dispersion and currents.

Long-term surveys reveal no widespread long-term damage to the fauna and flora of Milford Haven attributable to the development of the oil port.

284. Cowell, E.B. (ed.) (1971)

The Ecological Effects of Oil Pollution on Litteral Communities. Applied Science publishers Ltd. Essex, England, 248 pp.

This collection of papers deals primarily with the impact of several spills along the English and Welsh coast on the littoral communities. Papers cover the effects on several hufitabs including the saltmarsh, rocky shore and mud flats. The papers were presented at an international conference organized by the Institute of Petroleum, 30 November 1970.

285. Cowell, E.B. and J.M. Baker. (1969).

RECOVERY OF A SALT MARSH IN PEMBROKESHIRE, SOUTH-WEST WALES, FROM POLLUTION BY CRUDE OIL.

Biol. Conserv. 1:291-295.

Bentlass Salt Marsh, near Pembroke, south-west Wales, was polluted by Kuwait crude oil in January 1967. Frequency data taken in June 1966, and June 1968, show that some species were more affected than others by the oil. In June 1967, Suaeda maritima, Salicornia spp., Halimione portulacoides, and filamentous green algae, showed the greatest reduction of frequency, while Aster tripolium, Cochlearia spp., Triglochin maritima, Puccinellia maritima, Juncus gerardi, Limonium humile, and Spartina townsendii, showed some reduction. At this time frequencies of Festuca rubra, Plantago maritima, Armeria maritima, Aetemisia maritima, Glaux maritima, and Spergularia spp., were not significantly lower than the pre-spill levels. By June 1968 most of the species which were affected in 1967 showed some recovery, the exception being Triglochin maritima, the ill-effect of which had increased. The species with the greatest coverage, Festuca rubra in the upper marsh, Puccinellia maritima in the mid-marsh, and Spartina townsendii in the lower marsh, had all recovered more or less completely by June 1968.

286. Cowell, E.B., J.M. Baker, and G.B. Crapp (1972).

THE BIOLOGICAL EFFECTS OF OIL POLLUTION AND OIL-CLEANING MATERIALS ON LITTORAL COMMUNITIES, INCLUDING SALT MARSHES.

In: Marine Pollution and Sea Life, M. Ruive (ed.). FAO, Fishing News (Books) Ltd. London. pp. 359-364.

This paper reports research done at Milford Haven, south-west Wales, on the effects of oil and dispersants on salt-marsh and rocky shore communities. In addition to accidental spills, oil was sprayed on selected site to determine the effect of both one-time and chronic spillage on these communities. 23 references.

287. Cox, B.A. and J.W. Anderson. (1973).

SOME EFFECTS OF #2 FUEL OIL ON THE BROWN SHRIMP PENAENS AZTECUS.

Amer. Aool. 13:abstract number 262, p 1308

Sensitivity of brown shrimp of three sizes groups to water soluble fractions of Number 2 fuel oil was tested. WSF's were determined by infrared spectrophotometry. Postlarvae were the least sensitive. Uptake and depuration of WSF by two size groups of shrimp were tested. Tissue and water concentrations of diaromatics were measured by ultraviolet spectrophotometry. Maximum uptake occurred within the first hour of exposure. Deparation began during the 20 hour exposure period. The larger shrimp absorbed more hydrocarbon but depurated it more rapidly. Moulting frequency and growth rate were not affected.

288. Cox, B.A., J.W. Anderson, J.C. Parker. (1975).

AN EXPERIMENTAL OIL SPILL: THE DISTRIBUTION OF AROMATIC HYDROCARBONS IN THE WATER, SEDIMENT, AND ANIMAL TISSUES WITHIN A SHRIMP POND.

In: Conference on Prevention and Control of Oil Pollution. pp. 607-612. Amer. Petrol. Inst., Wash., D.C.

A common practice in the mariculture of shrimp on the Texas coast is the application of fuel oil on the surface of the pond. This thin oil layer serves to eliminate large aquatic insects which are predators of the small juvenile shrimp. Ordinarily, a common diesel fuel is used and it is removed from the pond after one day's treatment. In this experimental spill study, a high aromatic (38%) #2 fuel oil was utilized in higher quantity than normal and the residue was not removed. Mortalities of juvenile shrimp (Penaeus setiferus) and other invertebrates associated with the pond were recorded over a period of 96 hours following the oil treatment. A peak in the level of mortality occurred 48 hours after the spill, coinciding with the peak in the concentration of naphthalenes (naphthalene, methylnaphthalenes in the tissues of caged and free swimming organisms occurred at the point (48 hours) at which the concentration of naphthalenes in the sedimdnt reached a peak approximately 12 days after the maximum peak in the tissues and water.

While the pond water and sediments studied contained measureable levels of naphthalenes, the shrimp and clams (Rangia cuneata) were shown to release a major portion of accumulated naphthalenes by day 96. Oysters and sediment measured at this same time interval showed levels between 3 and 6 parts per million (ppm) total naphthalenes. Shrimp, clams, and oysters taken to the laboratory 38 days after the spill released naphthalene to background or near background levels. The data compiled in this study were compared to the findings of various field and laboratory investigations.

289. Crafts, A.S., and H.G. Reiber. (1948).

HERBICIDAL PROPERTIES OF OILS.

Hilgardia. 18:77-156.

The tests on the relation of toxicity to boiling range have shown that two types of toxicity--acute and chronic--are caused by oils. Starting with the light fractions, acute toxicity increases with increased boiling temperature through the three light fractions of gasoline and reaches a maximum in the fourth fraction that boils between 330° and 420°F, but is practically equaled by the second fraction, boiling between 390° and 425°F.

Chronic toxicity begins to show up in the third stove-oil fraction and increases with increasing boiling temperature through fractions 2, 3, and 4 of Diesel oil. U.S. no. 1 fuel oil is high in chronic toxicity; but its high viscosity interferes with penetration, so that a mixture of 1 part with 3 parts of kerosene makes a more toxic material.

The refined fractions kerosene, odorless kerosene, and mineral seal oil are devoid of acute toxicity. All, however, show a certain degree of chronic toxicity, particularly against grasses. Mineral seal oil, the heaviest, was toxic to mixed weeds, grass, corrots, and flax by the seventh day of the test and more so as time went on. None of the natural or synthetic fractions tested was entirely free of phytocidal effect.

290. Craig, R.E. and J.A. Adams (1967).

CROMARTY FIRTH.

Scotland Marine Laboratory, Aberdeen. 20 p.

The Cromarty Firth, a deep-water harbor between the Tay and the Orkneys, was surveyed to determine the degree of pollution and circulation of fresh and tidal waters within the estuary. A large grain distillery and an oil depot are the main sources of pollution. Salinity, oxygen and BOD were determined and water movement was measured with a direct-reading current meter and with a fluorimeter after discharge of Rhodamine B dye. Biological samples were collected and lists of organisms found are presented in appendices. The present degree of pollution, although causing some nuisance from smell and discoloration, is not a hazard to fish. (Sinha-OB15)

291. Crapp, G.B. (1971)

CHRONIC OIL POLLUTION.

In: Ecological Effects of Oil Pollution on Littoral Communities, Inst. of Petroleum, London, E.B. Cowell, ed.

Populations of limpets and barnacles were studied at an effluent discharge pipe of an oil refinery. A series of six transects were established around a particular outfall. These transects were surveyed using an abundance scale. Some deleterions influence was affecting these populations during the period of study and the normal refinery effluent is implicated. Persistant discharge of oil in very low concentrations appears to have damaged the fauna and flora of the shore adjacent to the outfall. Very young individuals are the most severely affected.

292. Crapp, G.B. (1971).

FIELD EXPERIMENTS WITH OIL AND EMULSIFIERS.

In: The Ecological Effects of Oil Pollution on Littoral Communities E.B. Cowell (ed.)

A description is given of two empirical investigations undertaken to determine the relative effects of oil and emulsifiers, in the field. Experimental oiling of rocky shores was found not to damage the flora and fauna, except where the application of thick atmospheric residue brought about a physical dislodgement of periwinkles and topshells. The application of emulsifier caused substantial mortalities in many species, but its most damaging consequences stemmed from the development of an algal forest following the destruction of limpets and mussels. The ultimate effects of the emulsifier treatment were, therefore, much greater than is apparent from an assessment of mortalities alone.

293. Crapp, G.B., et. al (1971).

INVESTIGATIONS ON SANDY AND MUDDY SHORES.

In: The Ecological Effects of Oil Pollution on Littoral Communities, E.B. Cowell, Ed. pp. 208-216. Great Britian.

This paper describes preliminary investigations into the effects of oil pollution on the flora and fauna of intertidal sediments in Milford Have. The report is confined to a survey of the macrofauna of the intertidal and to reported incidents of tainting of seafoods in the area. Description of planned research are included.

294. Crapp, G.B. (1971).

LABORATORY EXPERIMENTS WITH EMULSIFIERS.

In: The Ecological Effects of Oil Pollution on Litteral Communities. E.B. Cowell (ed). pp. 129-149, Great Britian.

A description is given of a comparative test of the tolerances of various species to different emulsifiers. Batches of 50 were exposed to various concentrations of BP 1002 in sea water for one hour. This was followed by washing and placing in sea water. This water was changed after one hour and thereafter at 12-hour intervals. The recovery was assessed on a "three-value" scale. Results of statistical analysis of recovery rates have been presented.

295. Crapp, G.B. (1971).

MONITORING THE ROCKY SHORE.

In: The Ecological Effects of Oil Pollution on Littoral Communities
G.B. Cowell (ed.) p. 102-113. Great Britian.

Studies of Milford Haven during the earliest stages of industrialization have proved valuable in giving a basic account of marine ecology and in providing pre-pollution data in the event of an oil spillage. Description has been given of a re-survey of 22 of Milford Haven transects covered in earlier studies to determine whether any changes can be detected which are attributable to the industrialization of the Haven. The results show no general impoverishment of the littoral fauna and flora of Milford Haven in the first decade of its development as an oil port. The methods used have demonstrated a marked change in the barnacle population, attributable to climatic deterioration; a decline in the abundance of the top-shell Mondonta lineata, possibly attributable to climatic deterioration; and an inexplicable decline in the numbers of Littorina saxatilis tenebrosa.

295. Crapp, G.B. (1971).

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In: The Ecological Effects of Oil Pollution on Littoral Communities
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296. Crapp, G.B. (1971).

THE BIOLOGICAL CONSEQUENCES OF EMULSIFIER CLEANSING.

In: <u>The Ecological Effects of Oil Pollution on Littoral Communities</u>. E.B. Cowell (ed.) pp. 150-168. Great Britian.

A discussion has been given of the consequences of the use of solvent emulsifiers after certain oil spillages. Observations made on these polluted shores have been related ot the results of the laboratory and field experiments. The following oil spillages, have been discussed: CHRYSSI P. GOULANDRIS spillage (January, 1967). Gulf refinery spillage (November, 1968). FINA NOVEGE spillage (November, 1967). TORREY CANYON spillage (March, 1967).

297. Crapp, G.B. (1971).

THE ECOLOGICAL EFFECTS OF STRANDED OIL.

In: <u>The Ecological Effects of Oil Pollution on Littoral Communities</u>, E.B. Cowell (eds). pp. 181-186. Great Britian.

A description is given of laboratory experiments with oil to investigate the ways in which oil could affect the shore. Littoral organisms may be affected by oil in two ways: They may be poisoned (chemical effects), or they may be smothered or impeded mechanically (physical effects). Only the lighter fractions of crude oil were found to be toxic to inter-tidal animals. The shore is only likely to be extensively damaged by spillage of light oils, and perhaps crude oils, which are stranded in large quantities very soon after being released. The presistent fractions of oil are not chemically toxic, but can affect the animals by adhering to them and disturbing their behavioral activities.

298. Crapp, G.B. (1971).

THE EFFECTS OF OIL POLLUTION AND EMULSIFIER CLEANSING ON LITTORAL ANIMALS AND PLANTS.

In: <u>Field Studies Council, Oil Pollution Research Unit, Orielton Field Centre, annual report</u>. pp. 7-13.

The ecological effects of emulsifier cleansing and standard oil were studied Attempts to produce less toxic oil dispersants have so far only produced 1 compound suitable for beach cleaning, BP 1100. It is still sufficiently damaging to kill large numbers of more susceptible species when used heavily. Crude and fuel oils are not very toxic to organisms of the rocky shore, but lighter fractions can be very much more damaging. Effluents containing a low concentration of oils may cause ecological damage if persistently discharged at the same point, and this should be considered when outfall pipes are designed.

299. Crocker, A.S., <u>et al</u>. (1974).

THE EFFECT OF A CRUDE OIL ON INTESTINAL ABSORPTION IN DUCKLINGS (<u>ANAS PLATYRHYNCHOS</u>).

Environ. Pollut., 7:165-177.

The rates at which water and Na^+ are transported across the intestinal mucosa increase when ducklings are transferred from freshwater to a diet contaning hypertonic saline drinking water (60% standard seawater equivalent; 264 mM NaCl, 6 mM KCl). These increments in mucosal transfer rates seem to be essential for the successful adaptation of ducklings to hypertonic saline drinking solution. Ducklings given a single oral dose of a crude oil (0.2 ml) at the start of maintenance on hypertonic saline did not develop the characteristic increases in mucosal water and Na^+ transfer rates observed in control ducklings 1 and 4 days later. In addition, high mucosal transfer rates which had been developed in ducklings fed hypertonic saline for 3 days were abolished 24 h after the oral administration of 0.2 ml crude oil. Although concentrations of 5 ppm and 20 ppm commercial dispersant in drinking water had no effect on either freshwater- or saline-maintained ducklings, the presence of 12.5-50.0 ppm dispersed crude oil in this solution prevented the development of high mucosal transfer rates in the ducklings given hypertonic saline drinking water.

Neither whole nor dispersed crude oil affected the basal musocal transfer rates of freshwater-maintained ducklings. High mucosal water and Na transfer rates are considered necessary to sustain the net uptake of ingested water and electrolytes from the gut of ducklings adapted to hypertonic saline. A diminution of the mucosal transfer rates in seawater-adapated ducklings, through the action of ingested crude oil, may therefore limit the amount of free water available to the organism. Although the high mortality among oil-contaminated seabirds may be due to a variety of pathological conditions, it is postulated that dehydration resulting from impairment of mucosal transfer mechanisms may be an important factor contributing to their death.

300. Crocker, A.D., et al. (1975).

THE EFFECT OF SEVERAL CRUDE OILS AND SOME PETROLEUM FRACTIONS ON INTESTINAL ABSORPTION IN DUCKLINGS (ANAS PLATYRHYNCHOS).

Environ. Physiol. Biochem., 5:92-106.

Ducklings given hypertonic saline drinking water show significant increases in the rates of Na^+ and water transfer across the intestinal mucosa. These increased rates of transfer are maintained as long as the birds are fed hypertonic saline. Oral administration of a single small dose of crude oil had no effect on the basal rate of mucosal transfer in freshwater-maintained ducklings but the adaptive response of the mucosa is suppressed in birds given hypertonic saline. When crude oils from eight different geographical locations were tested, the degree of inhibition varied between them; the greatest and smallest degrees of inhibition being observed following administration of Kuwait and North Slope, Alaska, crude oils, respectively.

The effects of distillation fractions derived from two chemically different crude oils were also examined. The volume of each distillation fraction administered corresponded to its relative abundance in the crude oil from which it was derived. The inhibitory effect was not associated exclusively with the same distillation fractions from each oil. A highly naphthenic crude oil from the San Joaquin Valley, California, showed the greatest inhibitory activity in the least abundant (2%), low boiling point (245^{o}C) fraction and the least inhibitory activity in the highest boiling point (4820C) most abundant (47%) fraction. In contrast, a highly paraffinic crude oil from Paradox Basin, Utah, showed the greatest inhibitory effect with the highest boiling point fraction and a minimal effect with the lowest boiling point fraction; the relative abundances of these two fractions; the relative abundances of these two fractions in the crude oil represented 27 and 28%, respectively.

301. Crutchfield, J.A. (1968).

EFFECTS OF MINERAL AND PETROLEUM EXTRACTION ON LIVING RESOURCES OF CONTINENTAL SHELF WATER.

In: <u>Proc. 21st Annual Session, Gulf and Carribbean Fisheries Institute, Univ. of Miami</u>, pp. 20-36.

The first section of this paper summarizes current information on actual and potential production of fish and shellfish from each of the major segments of the continental shelf adjacent to the United States. The second deals with the types of conflict that may arise between fishermen and those exploring for or producing oil or minerals from the shelf. The final section evaluates in qualitative terms some of the indirect effects stemming from expanded petroleum and mineral activity in offshore waters that may be of real benefit to the producers of seafood.

302. Cullinane, J.P. and P.M. Whelan (1976).

EFFECTS OF OIL ON BEACHES IN WEST CORK, IRELAND.

Marine Pollution Bulletin <u>7</u>(4): 72-73.

This note describes the effects of the influx of approximately 6000 gallons of congealed oil, probably ballast, onto three beaches in West Cork. The damage described is due primarily to the mechanical effects of encrusting oil.

303. Cundell, A.M. and R.W. Traxler (1973).

MICROBIAL DEGREDATION OF PETROLEUM AT LOW TEMPERATURE.

Marine Pollution Bulletin, <u>4</u>(8): 125-127.

Bacteria were isolated from littoral sediments collected in Chadabucto Bay, Nova Scotia, and from oil-contaminated soil adjacent to a natural oil seep at Cape Simpson, Alaska. Data are presented on the range of hydrocarbon utilization and growth temperature of 2 bacteria (<u>Arthrobacter</u>

and Psedomonas), which suggest that bacteria existing in these environments play a significant role in the biodegradation of pollutant hydrocarbons. The combination of high pressure and low temperatures may mean that petroleum hydrocarbons reaching deep-sea sediments will remain essentially unchanged.

304. Cundell, A.M. and R.R. Young (1975).

HINDGUT MICROFLORA FROM OIL-POLLUTED SOFT-SHELL CLAMS.

Marine Pollution Bulletin 6(9): 134-135.

The natural microflora resident in the hindgut of the soft-shell clam Mya arenaria appear to have no role in the biodegradation of petroleum hydrocarbons in oil-polluted estuarine sediments.

305. Currie, A. (1974).

OIL POLLUTION IN THE CROMARTY FIRTH.

Mar. Poll. Bull. 5:118-119.

Cromarty Firth on the northeast coast of Scotland is an area of international importance to wildfowl, and the whole area has been designated a "Site of Special Scientific importance" by the Nature Conservancy Council. There are proposals to establish National Nature Reserves in two bays in the Firth. The area has also become a centre of activity for the oil industry exploiting the North Sea oilfield. Repeated oil spillages are threatening the conservation value of the area and unless strong measures are taken to reduce and treat oil pollution from all sources, there could be enormous damage to wildlife.

306. Currier, H.B. and S.A. Peoples (1954).

PHYTOTOXICITY OF HYDROCARBONS.

Hilgardia 23 155-73.

307. Dagley, S. (1971).

CATABOLISM OF AROMATIC COMPOUNDS BY MICRO-ORGANISMS.

In: Advances in Microbial Physiology. A.H. Rose and J.F. Wilkinson, (eds.) Academic Press, London and New York. 6:1-46.

A review of the metabolism of aromatic compounds by microorganisms.

308. Dalby, D.H. (1968).

SOME FACTORS CONTROLLING PLANT GROWTH IN THE INTERTIDAL ENVIRONMENT.

In: The Biological Effects of Oil Pollution on Littoral Communities, Field Studies, 2 (Suppl.), p. 31-37.

This study concludes that the biological consequences of an oil spill must vary vastly according to the position in the annual tide cycle and the nature of the shore, quite apart from such matters as the quantity and type of oil involved, and whether or not emulsifier was used in its removal.

309. Dames and Moore (1975).

ENVIRONMENTAL ANALYSIS OF A LOUISIANA OFFSHORE OIL PORT.

Prepared for LOOP, Inc., New Orleans, Louisiana. Two volumes.

Volume One of this report describes the proposed offshore oil port installation and the present environmental baseline, while Volume Two deals with the probable impact of the construction and operation of the oil port on the environment of the Louisiana Contintal Shelf.

310. Davavin, I.A., Mironov, G.O. and Tsimbal, I.M. (1975).

INFLUENCE OF OIL ON NUCLEIC ACIDS OF ALGAE.

Mar. Pollut. Bull. 6,13-15.

Studies on the effect of oil on DNA and RNA of some Black Sea algae (Ulva, Grateloupia, Polysiphonia) suggest that it inhibits biosynthesis of these compounds and modifies the degree of polymerization of deoxyribonucleic acids.

311. Davenport, J. (1973).

A COMPARISON OF THE EFFECTS OF OIL, B.P. 1100 AND OLEOPHILIC FLUFF UPON THE PORCELAIN CRAB, PORCELLANA PLATYCHELES.

Chemosphere No. 1. pp. 3-6.

It would seem that the oleophilic 'fluff' is a relatively innocuous substance. For any given concentration, it is no more detrimental to porcelain crabs than the detergent B.P. 1100 which itself is much less toxic than many of the detergents used upon oil spills in the past. At high concentrations the 'fluff' appears to be less detrimental than B.P. 1100.

Much more important is the cause of death in 'fluff'/seawater mixtures. It would seem that 'fluff' killed the crabs by strictly mechanical effects, either by blocking the nephropores so that urine release was impaired, thus producing the observed swelling, or by blocking the branchial chambers and producing the suffocation. These mechanical effects were potentiated by the presence of crude oil, probably because the oil made the 'fluff' sticky so that the chances of the crabs being able to repel the 'fluff' by producing water currents in the oral region were reduced.

312. Davies, J.A. and D.E. Hughes (1968).

THE BIOCHEMISTRY AND MICROBIOLOGY OF CRUDE OIL DEGREDATION.

In: The Biological Effects of Oil Pollution on Littoral Communities J.D. Carthy and D.R. Arthur, (eds). Supplement to Volume 2 of Field Studies. Field Studies Council.

This paper is a short review of (1) the action of bacteria on components of oil, (2) the action of bacteria on crude oil, and (3) the environmental factors affecting the metabolism of oil by bacteria.

313. Davis, C.C. (1972).

THE EFFECTS OF POLLUTANTS ON THE REPRODUCTION OF MARINE ORGANISMS.

In: Marine Pollution and Sea Life, M. Ruivo, (ed), FAO, Fishing News (Books) Ltd. London, pp. 305-311.

This article reviews the known effects of several marine pollutants on reproduction of marine organisms. Included is a short section on oil and detergent.

314. Davis, J.B. (1956).

MICROBIAL DECOMPOSITION OF HYDROCARBONS.

Ind. Eng. Chem., 48, 1444-1448.

Microbiologists have found that hydrocarbons are utilized by certain bacteria, actinomycetes, filamentous fungi, and yeasts, although they are generally not so readily decomposed as are carbohydrates, proteins, or lipids. Gaseous aliphatic-hydrocarbons are decomposed by bacteria (*Methanomonas* and *Mycohacterium*) actinomycetes (*Streptomycetes* and *Nocardia*), and filamentous fungi of the class Phycomycetes. *Pseudomonas* species, *Micobacterium*, *Nocardia*, and filamentous fungi degrade liquid and particularly solid aliphatic hydrocarbons. Cyclic hydrocarbons are apparently less susceptible to microbial degradation. Although *Desulfovibrio desulfuricans* seems capable of both cyclic and paraffinic hydrocarbons. However, definite proof of this has yet to be established. In all probability, decomposition of a crude oil cannot be carried out by a single microorganism.

315. Davis, J.B., (1967).

PETROLEUM MICROBIOLOGY.

Elsevier, Amsterdam.

316. Davis, J.E. and S.S. Anderson (1976).

EFFECTS OF OIL POLLUTION ON BREEDING GREY SEALS.

Marine Pollution Bulletin, 7(6):115-118.

Oil stranded on the shore in Pembrokeshire, West Wales in September 1974 coincided with the start of the Grey Seal breeding season there Observations were made on the effect the oil had on newborn pups and their mothers. Behavior of oiled seals did not appear to differ from that of normal seals. Peak weights of oiled pups were significantly lower than those for unoiled pups, but this may have been due to cleaning observations, veterinary inspection and visiting observers. There was no difference between the mortality of oiled and unoiled pups on the beaches.

317. Davis, S.J. and Gibbs, C.F. (1975).

THE EFFECT OF WEATHERING ON A CRUDE OIL RESIDUE EXPOSED AT SEA.

Water Res. 9(3):275-286.

Kuwait crude oil residues have been exposed to weathering at sea (Langstone Harbour, Portsmouth) for 2 yr. in the form of a water-in-oil emulsion ("chocolate mousse") in a floating layer about 1.4 cm thick. One batch of oil was exposed in a tank open to tidal flushing below the water line and a second batch was exposed in a closed tank. A number of chemical and physical properties of the oil were measured at intervals as were the concentrations of mineral nutrients and bacterial numbers in the sea water. Asphaltenes, specific gravity and viscosity all increased, as did the "polar" fraction from liquid chromatography. The n-alkanes decreased to about half the original levels in the open tank but were little altered in the closed tank. The constancy of vanadium and nickel concentrations suggest that no net loss of oil occurred, the substantial changes in properties deriving from chemical modification (probably oxidation and polymerization) of oil components rather than mineralization (conversion to carbon dioxide and water) of some components leaving a residue of altered composition. It was not determined which of several processes predominated in causing these changes, but it is thought likely that in this thick layer of mousse auto-oxidation predominated over biodegradation.

318. Davis, S.J., C.F. Gibbs, and K.B. Pugh (1977).

QUANTITATIVE STUDIES ON MARINE BIODEGREDATION OF OIL, III. COMPARISON OF DIFFERENT CRUDE OIL RESIDUES AND EFFECTS OF SEA WATER SOURCE.

Environ. Pollut. 13 203-216.

319. Day, J.H. (1972).

EFFECT OF WAFRA OIL SPILL.

Mar. Poll. Bull. 3:164-165.

The tanker WAFRA grounded 8 km, east of Cape Agulhas, South Africa, on 27 February 1972 and lost about 15,000 tons of oil. At high water the limpets and barnacles seemed unaffected, but crabs were nearly eliminated. At low tide the limpet _Patella cochlear_ was badly affected but _P. longicosta_ was only slightly affected. In general, sea urchins, octopus, alikreukels, perelemoen, and rock lobsters were badly affected, but mussels, red baits, and barnacles showed little damage.

320. Day, J.H. (1972).

OIL POLLUTION IN SOUTH AFRICAN SEAS.

S. Afr. J. Sci., 68:130-131.

The WAFRA grounded about 8 km east of Cape Agulhas on February 7, 1971. Large tanks ripped open, and about 15,000 tons of crude oil were spilled. Animals which could close their shells (mussels, etc.) seemed little affected, but soft-bodied animals such as _Octopus_, _Haliotus_, _Turbo_, and echinoderms were killed. The effect on fish was not investigated, but some fish catches reportedly had to be dumped due to tainted flesh. The oil slicks did not reach the penguin colonies and these were saved. There was no study of mortality among birds, marine mammals, or marine flora.

321. Day, J.H., P. Cook, P. Zoutendyk, and R. Simons. (1971).

THE EFFECT OF OIL POLLUTION FROM THE TANKER "WAFRA" ON THE MARINE FAUNA OF THE CAPE AGULHAS AREA.

Zool. Afr. 6:209-210.

This review covers a description of the wreck and an overview of the ecology of rocky shores in the Cape Agulhas area. The effect of oil pollution on these rocky shores is then described, with brief notes on the effect of oiling on sandy beaches and offshore fishes.

322. Dennington, V.N., J.J. George, and C.H.E. Wyborn (1975).

THE EFFECTS OF OILS ON GROWTH OF FRESHWATER PHYTOPLANKTON.

Environ. Pollut., Vol. 8:233-237.

Experiments investigating the effects of oils on pure cultures of freshwater algae show that _Euglena gracilis_ Klebs will grow in cultures containing up to 10% diesel and lubricating oils, whereas the growth of _Scenedesmus quadricauda_ (Turpin) Brebisson is reduced by lubricating oil and halted by the presence of diesel oil. It is suggested that oils may affect photosynthetic metabolism in sensitive species.

323. Deshimaru, O. (1971).

STUDIES ON THE POLLUTION OF FISH MEAT BY MINERAL OILS.
I. DEPOSITION OF CRUDE OIL IN FISH MEAT AND ITS DETECTION.

Bull. Jap. Soc. Sci. Fish., 37(4):297-301.

Yellow tail, Seriola quinqueradiata was reared in sea water experimentally polluted with crude oil and its deposition in the meat was studied. Testing a piece of meat in the mouth an obvious or slight oily smell was perceived in fish reared in sea water with crude oil in the range of 50 ppm for 5 days or 10 ppm for 13 days.

By feeding fish with a diet containing crude oil of about 1%, a slight smell was perceived in the meat after 8 days' culture.

Collecting the vapor from the sample meat by the Head Space method, the resulting Gas-chromatogram was almost identical with the crude oil assayed.

324. DeVries, A.L. (1976).

THE PHYSIOLOGICAL EFFECT OF ACUTE AND CHRONIC EXPOSURE TO HYDROCARBONS OF PETROLEUM ON THE NEAR SHORE FISHES OF THE BERING SEA.

In: Environmental Assessment of the Alaskan Continental Shelf. Principal Investigators' Reports for the Year Ending March 1976. Vol 8. Effects of Contaminants, p. 1-14.

Toxicity data for exposure to water soluble hydrocarbons on a few Bering Sea fishes are presented. The temperature of exposure appears to have profound effect. At low temperatures the hydrocarbons appear to be less toxic. Baseline measurements of oxygen consumption both at the orgainsmal and tissue level reveal that the Bering Sea fishes are similar to other cold water fished in regards to their physiology. Studies of the levels of freezing resistance in sculpin indicated that it is a seasonal phenomonen. The time course of the appearance and disappearance of freezing resistance indicate that this system will be a good model for studying the effect of naphthalene on antifreeze synthesis.

325. DeWitt, F.A., Jr. and P. Melvin (1975).

OIL SPILL AND OIL POLLUTION REPORTS, NOVEMBER 1974 - FEBRUARY 1975.

U.S. Environmental Protection Agency. Publication EPA/670/2-75-044, 271 pp.

The second quarterly compilation of oil spill events and oil pollution report summaries includes summaries of oil spill events, summaries and bibliographic literature citations, summaries of current research projects, and patent summaries.

326. DeWitt, F.A., Jr, and P. Melvin (1975).

OIL SPILL AND OIL POLLUTION REPORTS, FEBRUARY 1975 - APRIL 1975.

EPA/670/2-75/059. Available from GPO 246 p.

This report is the third quarterly compilation of oil spill events and oil pollution report summaries. Presented in the report are:

(a) summaries of oil spill events; (b) summaries and bibliographic literature citations; (c) summaries of current research projects; and (d) patent summaries.

327. Diaz-Piferrer, M. (1962).

THE EFFECTS OF AN OIL SPILL ON THE SHORE OF GUAMICA, PUERTO RICO. (ABSTRACT)

Association of Island Marine Laboratories, 4th meeting, Curacao, 12-13.

328. Dickman, M. (1971).

PRELIMINARY NOTES IN CHANGES IN ALGAL PRIMARY PRODUCTIVITY FOLLOWING EXPOSURE TO CRUDE OIL IN THE CANADIAN ARCTIC.

Can. Field-nat. 85:249-251.

Mackenzie Valley Crude oil which had been exposed for 2 months to natural arctic summer conditions was added to bottles containing algae taken from a marsh near Inuvik, N.W.T. Carbon 14 primary productivity was ten times lower in the oil treated samples (0.59 ± 0.30 mgC/m^3/hr.) than in the untreated control samples (5.12 ± 1.2 mgC/m^3/hr.) after a four hour incubation period.

Small flagellates such as Cryptomonas spp. and Chlamydomanas spp. comprised nearly 80% of the primary producers in the Inuvik marsh samples.

Some implications of the significance of these preliminary findings are discussed in view of the proposed 800 mile Mackenzie Valley Pipeline route.

329. Dicks, B. (1973).

SOME EFFECTS OF KUWAIT CRUDE OIL IN THE LIMPET, PATELLA VULGATA.

Environmental Pollution, 5, 219-229.

A simple toxicity test for pollutants associated with the oil industry using the limpet, Patella vulgata, is described. This test with an organism of considerable importance to the ecological balance of the rocky shore takes into account some of the criteria likely to be of importance to mortality in natural populations after an oil spillage. As such, it allows some prediction of the ecological effects of an oil spill on the shore.

Natural rhythm in activity is shown to affect the susceptibility of the limpet population to crude oil, greatest toxic effects occurring during times of greatest activity. A circadian rhythm is demonstrated in the activity of the limpet. There appears to be no difference in the toxicity of crude oil to large and small specimens.

330. Dieter, M.P. (1976).

THE EFFECTS OF PETROLEUM HYDROCARBONS ON AQUATIC BIRDS.

In: Sources, Effects and Sinks of Hydrocarbons in the Aquatic Environment. Proceedings of the Symposium, American University Washington, D.C. 9-11 August 1976.

Petroleum hydrocarbons have been positively identified in avion tissue and their structures confirmed using gas chromatography/ mass spectrometry. Crude oil in microliter amounts cause close-related mortatlities in incubating eggs. Future research will examine the effects of sublethal amounts of oil ingested by mallards. Food chain studies with invertebrates and mallards are also being conducted.

331. DiSalvo, L.H. and H.E. Guard (1975).

HYDROCARBONS ASSOCIATED WITH SUSPENDED PARTICULATE MATTER IN SAN FRANCISCO BAY WATERS.

EPA Conf. on Prev. & Contr. of Oil Pollution. pp. 169-173. Amer. Petrol. Inst., Wash., D.C.

Suspended sediments were obtained at seven stations in San Francisco Bay during the summer of 1974 using a double settling tube device termed the "bio-sampler." One tube of the device passively collected suspended sediments which settled from ambient waters at the sampling sites. The top of the second tube contained bay mussels (Mytilus edulis) as biological agents for the active entrapment and deposition of suspended particulates occurring in the water. Presence of the mussels in the sampler was, in most cases, indispensable for collection of sufficient amounts of material for analysis over one-week sampling periods.

A thin-layer chromatographic method was employed for analysis of total alkane and total aromatic hydrocarbons in recovered sediments. The sediments were found to contain 190-6188 ppm dry weight of total hydrocarbons, with alkane-aromatic ratios varying from 1.1 to 5.1. Water separated from recovered sediments after shaking contained from 15 to 450 ug per liter total hydrocarbons. Filtration of these water samples through 0.45 Millipore filters had little or no effect on their hydrocarbon concentration.

Calculations based on minimum possible values suggested that 13.5 or more metric tons of presumably pollutant hydrocarbons were present in association with suspended particulate matter in the bay system at any given time during the sampling period.

Previously published information on bay circulation suggested that suspended particulates, and thus pollutant hydrocarbons, may be accumulated in ths shoal areas of the eastern bay margins.

332. DiSalvo, L.H., H.E. Guard, L. Hunter, and A.B. Cobet (1973).

HYDROCARBONS OF SUSPECTED POLLUTANT ORIGIN IN AQUATIC ORGANISMS OF SAN FRANCISCO BAY: METHODS AND PRELIMINARY RESULTS.

In: The Microbial Degredation of Oil Pollutants. Louisiana State University Center for Wetland Resources, LSU-SG-73-01.

Investigation into fate and effects of petroleum-derived hydrocarbons was initiated by analyzing the hydrocarbon content of selected Bay animals to determine if this served as an indicator of chronic hydrocarbon pollution in Bay food chains. Initial results have been obtained using solvent extracts of sponge, mussel, and crab tissues. Closely related animals were obtained from relatively clean waters along the northern California coast to provide "unpolluted" control extracts for comparison. To date, it has been shown that Bay organisms have a significantly higher content of hydrocarbons than the clean water organisms. Methods tested included gas chromatography (GC), thin layer chromatography (TLC), fluorescence spectrometry, and high pressure liquid chromatography (HPLC). Comparative results between the different methods suggest thin hayer chromatography to be the method of choice.

333. DiSalvo, L.H. Guard, H.E. and Hunter, L. (1975).

TISSUE HYDROCARBON BURDEN OF MUSSELS AS POTENTIAL MONITOR OF ENVIRONMENTAL HYDROCARBON INSULT.

Env. Sci. Technol., 9, 247-251.

A simplified method for the analysis of total tissue hydrocarbon burden was used to measure hydrocarbon concentration in the mussels Mytilus edulis al M. Californicas as an indicator of chronic hydrocarbon insult. Mussels transfered from clean water to polluted water stations took up hydrocarbons. When replaced in clean water their hydrocarbon content approaches clean-water baselines. Mussels transfered from polluted water to clean water lost a minor fraction of their hydrocarbon burden over a 10 week period. When replaced in polluted waters of origin, the mussels showed a tendency to return to their original hydrocarbon content.

334. Dixit, D. and J.W. Anderson (1977).

DISTRIBUTION OF NAPHTHALENES WITHIN EXPOSED FUNDULUS SIMILUS AND CORRELATIONS WITH STRESS BEHAVIOR.

In: Proceedings 1977 Oil Spill Conference. p. 633-636.Amer. Petrol. Inst., Wash., D.C.

Fundulus similus was exposed to naphthalene via oral administration, and naphthalene plus alkylnaphthalenes in water. The distribution of these compounds within the organs and tissues of the fish was monitored with time. Turn-over times for these compounds were relatively rapid, particularly in the case of naphthalene administered orally. Accumulation within detoxification (liver) and storage (gall bladder) was expected, but accumulation and retention in the brain were higher than anticipated. Stress-produced behavioral abnormalities may correspond to the content of naphthalenes in the brain and other tissues of the nervous system.

335. Dixon, T.J. and T.R. Dixon (1971).

THE PANTHER AFFAIR.

Mar. Poll. Bull., 2(7):107-108.

An explanation is put forward for the light seabird casualties that occurred after the severe shore oil pollution.

336. Dixon, T.J. and T.R. Dixon (1976).

OLYMPIC ALLIANCE OIL SPILLAGE.

Marine Pollution Bulletin, 7(5):86-90.

The collision of HMS Achilles and the Olympic Alliance in the Dover Straits in Nov. 1975 produced an oil spill of 2,000-3,000 tons of light crude oil which formed a slick 11.3 km long and 1.6 km wide; 10,000 additional tons of oil were lost while the tanker was en route to port. Offshore and inshore oil dispersing activities were conducted by 10 vessels. Despite considerable success in dispersing large quantities of the oil with the emulsifier BP 1100X, the English coastline was heavily polluted. Sandy, low-energy beaches with shallow profiles near Folkestone were extensively covered by a wide band of oil ranging from 100 to 250 m in width whereas narrow bands <3 m in width but 15-30 cm deep were characteristic of high-energy shingle beaches with steeper profiles near Dover and Deal. The rocky foreshores between Dover and Folkestone were severely polluted; many of the larger rock pools were filled with oil. The cost for oil clearance operations was £65,000. Precise numbers of beached birds are unknown, but auks were most frequently recorded. The cormorant population was particularly affected. Most of the diving birds and the floating debris were completely covered with a uniform layer of oil. Many birds apparently cleaned themselves and were not harmed. There was also oil damage to local inshore fishery equipment. The risk for further coastal pollution remains high, as there are several faults with the traffic separation scheme. The scheme is advisory, not compulsory, and the size draft, and number of ships using the Dover Strait have exceeded design estimates.

337. Donahue, W.H., R.T. Wang, M. Welch, and J.A.C. Nicol (1977).

EFFECTS OF WATER-SOLUBLE COMPONENTS OF PETROLEUM OILS AND AROMATIC HYDROCARBONS ON BARNACLE LARVAE.

Environron. Pollut. 13 187-202.

The effects of the water-soluble fractions of petroleum oils and of solutions of aromatics on embryos and nauplii of barnacles were investigated. Observations were made on development, and hatching of embryos, and the activity, phototaxis, and survival of larvae. Acute experiments (1 h duration) were carried out in glass tubes illuminated from above, and larvae remaining on the bottom were separated from those actively swimming. Concentrations at which half the larvae occurred in the bottom fraction were determined. Relative toxicities are given. Embryonic development and larval activity were adversely affected by No. 2 fuel oil at a concentration of 3 ppm and larval activity by naphthalene at the same level.

338. Dorris, T.C., W. Gould, and C.R. Jenkins (1959).

TOXICITY BIOASSAY OF OIL REFINERY EFFLUENTS IN OKLAHOMA.

In: Trans. 2nd Sem. Biol. Prob. Water Poll., R.A. Taft San. Eng. Center, Cincinnati, Ohio, Tech. Rep. W60-3:276-285.

A series of toxicity bioassays were performed upon refinery effluents throughout Oklahoma, utilizing fathead minnows (Pimephales promelas) as the test animals. It was found that toxicity rather than oxygen demand was the most important effect of oil refinery effluent on receiving streams. All untreated final effluents and most process effluents tested were found to be toxic, with TL_m48 values of about 15%. The only nontoxic process effluents found were those from cooling towers, and these were toxic if the towers had been treated with chlorine. Even with dilution from cooling tower blow-down, final effluents before treatment were always toxic. Several cases were observed wherein the immediate oxygen demand was satisfied, yet the effluents were still toxic.

339. Doudoroff, P., et al. (1951).

BIOASSAY METHODS FOR THE EVALUATION OF ACUTE TOXICITY OF INDUSTRIAL WASTES TO FISH.

Sewage Ind. Waste. 23:1380-1397.

This paper completely outlines the various bioassay methods for determining acute toxicity of industrial wastes to fish by describing all steps in choice and preparation of test animals, selection and preparation of test water (diluent), experimental conditions and procedures, and reporting, interpreting, and use of bioassay results.

340. Dow, R.L. (1975).

REDUCED GROWTH AND SURVIVAL OF CLAMS TRANSPLANTED TO AN OIL SPILL SITE.

Mar. Pollut. Bull., 6 124.

341. Dow, R.L. and J.W. Hurst Jr. (1975).

THE ECOLOGIAL, CHEMICAL AND HISTOPATHOLOGICAL EVALUATION OF AN OIL SPILL SITE, PART I: ECOLOGICAL STUDIES.

Mar. Poll. Bull. 6 164-166.

An oil spill into Long Cove, Searsport Maine, began on 16 March and lasted until at least 30 June 1971. It resulted in immediate and continuing soft clam mortalities which, based on before and after biological surveys, had by August 1974 exceeded 85% of the estimated 50 million market size clams occupying the area.

342. Dugan, P.R. (1972).

BIOCHEMICAL ECOLOGY OF WATER POLLUTION.

Plenum Press, New York. 155 pp.

Chapter 8 of this volume discusses biodegredation of hydrocarbons including substrate selection by bacteria, metabolic pathways, enzyme systems, oil breakdown products.

343. Dunn, B.P. (1976).

TECHNIQUES FOR DETERMINATION OF BENZO (A) PYRENE IN MARINE ORGANISMS AND SEDIMENTS.

Env. Sci. Technol. 10 1018-1021.

Rapid, economical, and reliable procedures are developed for the measurement of the carcinogen benzo(a)pyrene in small marine tissue and sediment samples. These involve alkaline digestion of samples, column chromatography on Florisil, DMSO extraction, separation of polycyclic aromatic hydrocarbons by thin layer chromatography, and measurement of benze(a)pyrene by fluorimetry. Recoveries of compound are measured for each sample by use of radioactive benzo (a)pyrene as an internal standard. The procedures, which have a sensitivity of 0.1 ug/kg and a precision of 6% appear more than adequate for application in routine monitoring programs for polycyclic aromatic hydrocarbons carcinogens in the marine environment.

344. Dunn, B.P. and A.F. Stich (1975).

THE USE OF ACCUMULATOR ORGANISMS IN A MONITORING SYSTEM FOR CHEMICAL CARCINOGENS IN COASTAL WATERS.

In: Proc. Thirteenth Pacific Science Congress, 1 20.

The extent of contamination of marine organisms and sediments by carcinogenic and mutagenic polycyclic aromatic hydrocarbons (PAH) was examined by isotope dilution and gas chromatographic techniques. The degree of contamination of mussels (Mytilus edulis and M. californianus) by benzo(a)pyrene (B(a)P) is correlated closely with the degree of human activity near the sampling site. Mussels from uninhabited areas show contamination ranging from 0.0 to 0.2 μg/kg wet wt; from the outer Vancouver harbor, 2-4 μg/kg; from a poorly flushed inlet with light industry, 30-60 μg/kg; and from marinas and wharf areas <60 μg/kg. Comparable levels were found in other organisms. Elevated levels of B(a)P were present in sediments near a sewage outfall. Motorboat marinas and creosoted wharf structures appear to represent major sources of PAH in the marine environment. Edible mussels growing on creosoted pilings show B(a)P levels ≤214 μg/kg, far in excess of the standard for smoked foods of 1 μg/kg recently adopted by the Federal Republic of Germany. The measurement of B(a)P in mussels, which are ubiquitous and easy to sample, may be useful in a large-scale screening program for carcinogens in the marine environment. The feasibility of applying this procedure on a global basis is discussed.

345. Dunn, B.P. and H.F. Stich (1975).

THE USE OF MUSSELS IN ESTIMATING BENZO(A)PYRENE CONTAMINATION OF THE MARINE ENVIRONMENT.

Proc. Soc. Exptl. Biol. Med. 150 49-51.

Mussels from various parts of the coast, inlet, and harbor were analyzed for Benzo(a)pyrene. The mussels from the coast were lowest in B(a)P while those near a marina were highest. These results argue against biogenic origin of the B(a)P. Mussels may represent a simple indicator for the degree of contamination of the marine environment by polycyclic aromatic hydrocarbons.

346. Dunn, B.P. and H.F. Stich (1976).

MONITORING PROCEDURES FOR CHEMICAL CARCINOGENS IN COASTAL WATERS.

J. Fish. Res. Bd. Can 33 2040-2046.

Sampling proceedures and analytical techniques have been developed for evaluating the contamination of coastal waters by polycyclic aromatic hydrocarbon carcinogens. The procedures involve extraction and purification of hydrocarbon fractions from marine sediments or organisms, and determination of compounds by thin-layer chromatography and fluorimetry, or gas chromatography. Initial results from mussels in Vancouver harbor indicate a seasonal variation of benzopyrene, a high incidence of this carcinogen in mussels near sewage outfalls and near cresoted pilings.

347. Dunn, B.P. and H.F. Stich (1976).

RELEASE OF THE CARCINOGEN BENZO(A)PYRENE FROM ENVIRONMENTALLY CONTAMINATED MUSSELS.

Bull. Env. Contam. Toxicol., 15 398-401.

348. Dunn, Bruce P. and David R. Young (1976).

BASELINE LEVELS OF BENZO(A)PYRENE IN SOUTHERN CALIFORNIA MUSSELS.

Mar. Pollut. Bull 7 231-734.

Marine mussels accumulate the carcinogen benzo(a)pyrene from contaminated environments. Baseline studies in California indicate that levels of the carcinogen in mussles are at or near zero, except in areas of human activity. This finding runs counter to previous suggestions that benzo(a)pyrene is widely distributed in marine organisms.

349. Dunning, A. and Major, C.W. (1974).

THE EFFECTS OF COLD SEAWATER EXTRACTS OF OIL FRACTIONS UPON THE BLUE MUSSEL, MYTILUS EDULIS.

In: Pollution and Physiology of Marine Organisms. (F.J. Vernberg and W.B. Vernberg, eds.) pp. 349-366, New York: Academic Press.

350. Dunstan, W.M., L.P. Atkinson, and J. Natoli (1975).

STIMULATION AND INHIBITION OF PHYTOPLANKTON GROWTH BY LOW MOLECULAR WEIGHT HYDROCARBONS.

Marine Biology, 31(4):305-310.

Experiments on 4 phylogentically different phytoplankton species exposed in culture to a range of concentration of benzene, toluene, and xylene showed a variety of growth responses for marine microalgae. The phytoplankton studied were Amphidinium carterae, Skeletonema costatum, Cricosphaera carterae, and Dunaliella tertiolecta. The degree of influence of the aromatic hydrocarbons, all components of fuel oils and crude oils, varied with concentration, compound, and species. Stimulation of growth in D. tertiolecta resulted from low microgram per liter concentrations of all 3 compounds. S. costatum showed no growth enhancement, whereas C. carterae and A. carterae had intermediate reactions. Closed culture vessels were necessary to retain the volatile hydrocarbons. The species-specific stimulation of low concentrations was shown further in experiments with mixtures of No. 2 fuel oil. The volatile fraction was most biologically reactive, being the source of growth enhancement at low levels and a major growth inhibitor at high concentrations. A significant environmental effect of oil on marine primary production could be the growth stimulation of particular species by low molecular wt aromatic compounds, producing an alteration of the natural phytoplankton community strucutre and its trophic relationships.

351. Duursma, E.K. and M. Marchand (1974).

ASPECTS OF ORGANIC MARINE POLLUTION.

Oceanography and Marine Biology; An Annual Review, No. 12:315-431.

World production and quantities of organic pollution, and organic chemistry and seawater are discussed. Specific classes of pollutants covered separately and in detail include pesticides, particularly organochlorine insecticides; herbicides; polychlorinated biphenyls; oil and hydrocarbons; sewage; detergents; wastes from wood processing industries; cyanides; and other organic pollutants. Each class of pollutant is discussed from the standpoints of chemical analysis, including preferred sampling, extractive, concentrative, instrumental, and classical wet methods; world distribution; associated biogeochemical phenomena; and the effects on phytoplankton, zooplankton, other invertebrates, fish, and birds. An extensive bibliography is given.

352. Eagles, D. (1964).

OIL POLLUTION - A NEAR DISASTER FOR THE GREATER SNOW GOOSE.

Canadian Audubon Mag., 1964 (2).

353. Ebeling, A.W., F.A. DeWitt, W. Werner, and G.M. Cailliet (1970).

SANTA BARBARA OIL SPILL: FISHES.

In: Santa Barbara Oil Symposium, Holmes, R.W. and F.A. DeWitt (editors). Santa Barbara, December 16-18, 1970. University of California.

354. Ehrhardt, M. (1972).

PETROLEUM HYDROCARBONS IN OYSTERS FROM GALVESTON BAY.

Environ. Poll., 3 257-271.

Oysters from a location in Galveston Bay, Texas, were analyzed for petroleum-derrived hydrocarbons. The lipids and hydrocarbons were Soxhlet-extracted with benzene/methanol and then partitioned into n-pentane. Hydrocarbons were separated from the lipids by column chromatography on a bed of silica gel covered by alumina; both absorbents were deactivated to prevent the formation of artifacts from sensitive components of the lipid fraction. Preparative TLC on activated silica gel then resolved the column effluent into aliphatic, mono-, di-, and tri-aromatic hydrocarbons. Individual compounds and compound types were identified from their gas chromatographic retention indices, mass spectra and UV spectra. The severe oil contamination of the oysters is evident, the concentration distribution of the aliphatic hydrocarbons is similar to the distribution found in a crude oil, and alicyclic and aromatic hydrocarbons are encountered at higher concentrations than in uncontaminated oysters.

355. Ehrhardt, Manfred, and Jurgen Heinemann (1974).

HYDROCARBONS IN BLUE MUSSELS FROM THE KIEL BIGHT.

In: Contributed Papers, Marine Pollution Monitoring Symposium and Workshop. National Bureau of Standards, Gaithersburg, MD. May 13-17, 1974, pp. 221-225.

Mussels exchange hydrocarbons with the surrounding water which contains a relatively constant if not rising concentration of fossil hydrocarbons in addition to recent biogenic hydrocarbons whose concentrations vary seasonally.

Mussels are able to degrade recent biogenic hydrocarbons which they ingest with their food and take up from the water, but are much less efficient in degrading cyclic saturated and aromatic hydrocarbons originating from fossil fuels.

Some time near the start of the experiment the mussels were exposed to oil pollution. Subsequently, they exchange saturated and olefinic hydrocarbons much more rapidly with the water than cyclic and aromatic hydrocarbons.

356. Ehrhardt, M. and J. Heinemann (1975).

HYDROCARBONS IN BLUE MUSSELS FROM THE KIEL BIGHT.

Env. Poll. 9(4):263-282. Also in: NBS Special Publication 409 Marine Pollution Monitoring (Petroleum), Proceedings of a Symposium and Workship held at NBS, Gaithersburg, Maryland, May 13-17, 1974.

Blue mussels (Mytilus Edulis) from a location east of the entrance to the Kiel Fjord have been analyzed for recent biogenic and petroleum-derived hydrocarbons. The freeze-dried animals were Soxhlet-extracted with n-pentane. Hydrocarbon fractions were obtained by column chromatography on a bed of silica gel covered by alumina. In addition, this procedure separated the hydrocarbon fractions from the lipids. Both adsorbants were deactivated to prevent the formation of artifacts from sensitive components of the lipid fraction. IR- and UV-spectroscopy were used to monitor the composition of fractions eluted from the column. Preparative TLC on activated silica gel resolved the column effluents into aliphatic, olefinic, mono- and di- + tri-aromatic hydrocarbons. Some individual components and compound types were identified from their gas chromatographic retention indices, UV-spectra, and mass-spectra.

The composition of hydrocarbons extracted from the mussels depended upon the time of sampling. Mussels sampled after the spring phytoplankton bloom contained hydrocarbons presumably derived from phytoplankton over a background of hydrocarbons whose composition is indicative of fossil origin. Mussels sampled in January, before the spring phytoplankton bloom, contained very little recent biogenic hydrocarbons. The altered composition of extracted hydrocarbons may be explained by the following assumption:

(i) aliphatic and olefinic hydrocarbons are metabolised within the mussels, but the animals lack the ability to degrade aromatics; and/or

(ii) the blue mussels exchange hydrocarbons with the surrounding water which carries a permanent burden of aromatics, but whose content of aliphatic and olefinic hydrocarbons varies.

357. Eisler, R. (1973).

LATENT EFFECTS OF IRANIAN CRUDE OIL AND A CHEMICAL OIL DISPERSANT ON RED SEA MOLLUSCS.

Israel Journal of Zoology, 22:97-105.

Predation rate of the gastropod drill, <u>Drupa granulata</u>, on the mussel, <u>Mytilus variabilis</u>, was measured over a period of 28 days after adults from both species had been immersed for 168 h in seawater solutions containing high sub-lethal concentrations (10 ml/liter) of Iranian crude oil. Predation rate was three times higher in controls than in the group where both predator and prey had been exposed initially; intermediate values were determined among groups where only one species had been treated initially. Fecundity of drills, as evidenced by number of egg cases deposited, was directly related to mussel consumption. In a similar study with a chemical oil dispersant, exposure to high (0.003 ml/liter) sublethal levels for 168 h did not affect markedly the rate at which mussels were destroyed and consumed during post-treatment. However, the fecundity of untreated drills feeding on untreated mussels (controls) was 3 to 10 times greater than among groups in which one or both species had been exposed initially to dispersant. Except for mussels consumed by drills, there were no deaths during the post-treatment period in either study, and all organisms appeared normal.

358. Eisler, R. (1975).

ACUTE TOXICITIES OF CRUDE OILS AND OIL-DISPERSANT MIXTURES TO RED SEA FISHES AND INVERTEBRATES.

Israel J. of Zool. 24(1-2):16-27.

Crude oil from fields in the Persian Gulf and in the Sinai plus a chemical oil dispersant were tested, using static bioassay procedures, for toxicity to adults or juveniles of ten marine species: Heteroxenia fuscescens, a soft coral; Nerita forskali and Drupa granulata, gastropod mulluscs; Mytilus variabilis, a mussel; Acanthopleura haddoni, a chiton (mollusc); Echinometra mathaei, sea urchin; Calcinus latens, a hermit crab; Palaemon pacificus, a shrimp; Parupeneus barberinus, goatfish; and Siganus rivulatus, rabbitfish. Concentrations fatal to 50% of individual test species in 168 hours, LC-50 (168 h), ranged from 0.74 to more than 30.0 ml/liter for Persian Gulf crude, from 14.5 to more than 30.0 ml/liter for Sinai crude, and from 0.006 to 0.064 ml/liter for the dispersant. In general, fishes and crustaceans were the most sensitive groups assayed and molluscs the most resistant. LC-50 (168 h) values for oil-dispersant mixtures of 10 parts oil to 1 part dispersant (v/v) for selected species ranged from 0.047 to 0.152 ml/liter which appears to reflect the biocidal properties of the dispersant. Some individuals that survived immersion in high concentrations of the test compounds for 168 h were adversely affected during treatment and afterwards.

359. Eisler, R. (1975).

TOXIC, SUBLETHAL, AND LATENT EFFECTS OF PETROLEUM ON RED SEA MACROFAUNA.

In: Proceedings of Conference on Prevention and Control of Oil Pollution. pp. 535-540.

This report studies the effects of crudes and a chemical oil counteractant on survival, metabolism, and behavior of representative species of Red Sea macrofauna under controlled environmental conditions. Specifically, it examines the action of crude oil from fields in Iran and in the Sinai, a chemical oil dispersant, and oil dispersant mixtures on juveniles or Adults of octocorals, crustaceans, molluscs, echinoderms, and teleosts. The choice of bioassay methodology on response parameters, especially survival, is significant. A comparison of toxicity values derived from tests in large (1,500 l), deep (2.0 m) tanks under conditions on continuous flow with those performed in small (3 l) jars under static conditions demonstrated that most assay species were up to 30 times more resistant to almost all toxicants in large tanks. Tank tests also demonstrated a protective effect with increasing depth: organisms confined 110 to 1.8 m from the surface exhibited higher survival than those held at shallower depths. Sublethal and latent effects of oils and dispersants on Red Sea biota were reviewed and included reduction in feeding rate and egg case deposition of predatory gastropods, interference with substrate attachment by mussels, liver enlargement and lowered blood hematocrit values in fishes, and bioaccumulation of crude oils in octocorals. These and other data presented herein suggest that introduction of petroleum into Red Sea ecosystems may disrupt established feeding-predator patterns, reproductive processes, defense mechanisms, and conceivably other systems, and it would constitute a potential threat to population stability.

360. Eisler, R. and G.W. Kissil (1975).

TOXICITIES OF CRUDE OILS AND OIL-DISPERSANT TEXTURES TO JUVENILE RABBITFISH, SIGAHUS RIVULATUS.

Trans. Am. Fish. Soc. 104(3):571-578.

Toxicities were determined for two crude oils, one from the Persian Gulf (Iran) and one from the Sinai Peninsula (Gulf of Suez), to rabbitfish, Siganus rivulatus, an economically important species of teleost from the Red Sea. Also tested for toxicity were ST 5, a chemical oil dispersant, and oil-ST 5 mixutres in the ratio 10:1 vol/vol. Static tests conducted in small (3-liter) jars at 41% salinity and 23^{o}C produced LC_{50} (168 h) values of 0.74 ml/liter for Iranian crude, 14.5 ml/liter for Sinai crude, and 0.010 ml/liter for ST-5; LC_{50} values for oil-ST 5 mixtures reflected biocidal properties of ST 5 alone. Iranian oil became less toxic with increasing time in seawater over a period of 168 hours; the reverse was observed for Sinai crude. ST 5 exhibited a dramatic reduction in lethality after 2 hours in the assay medium. The most toxic component tested of Iranian crude was the lowest-boiling fraction; with Sinai crude it was the highest-boiling fraction; with ST 5 the volatile surfactant component accounted for almost all deaths. Liver enlargement in rabbitfish was linked with exposure to oil as was lowered blood hemotocrit. Rabbitfish survival at a given petrochemical concentration was highest at intermediate salinities of 30-50% in the salinity range tested of 20 to 60%. Rabbitfish were more resistant to crudes and oil-dispersant mixtures in continuous flow bioassays conducted in large tanks than in static jar bioassays. Tank tests also suggested that mortalities were higher among toxicant-stressed fish confined 0.2 to 1.0 meters from the surface than among fish held 1.0 to 1.8 meters from the surface.

361. Eisler, E., G.W. Kissil, and Y. Cohen (1974).

RECENT STUDIES ON BIOLOGICAL EFFECTS OF CRUDE OILS AND OIL-DISPERSANT MIXTURES TO RED SEA MACROFAUNA.

Environ. Monitor. Ser. No. EPA-600/4-74-004, 156-179.

Because virtually nothing was known regarding the influence of crude oil or chemical oil counteractants on local coral reef ecosystems, the Hebrew University in 1972 initiated a continuing series of investigations in this subject area. This account summarizes progress during the first year of laboratory studies. Specifically, we report on acute toxicity to representative species of marine macrofauna of two common grades of crude oils (which together comprise more than 80% of all crude oil unloaded at Elat), a chemical oil dispersant used extensively in Northern Israel, and mixtures of oil and dispersant at realistic application levels. Bioassays were conducted under static as well as continuous flow conditions. Depth-toxicity interactions were evaluated using deep (2.0 m) tanks. Sublethal and latent effects of crudes and oil-dispesant mixtures of physiology, metabolism, and behavior were investigated as were short-term degradation and bioaccumulation of oil.

362. Elgershuizen, J. and H. DeKruijf (1976).

TOXICITY OF CRUDE OILS AND DISPERSANT TO THE STONY CORAL MADRACIS MIRABILIS.

Marine Pollution Bulletin 7(2):22-25.

The toxicity of various crude oils to Madracis mirabilis was tested by exposing colonies to various concentrations of oils. Practically all colonies exposed to solutions obtained from oil on the surface recovered. Oils mixed with seawater are more toxic than solutions from oils put on top of seawater. A dispersant mixed with seawater was initially slightly more toxic than the oils but recovery was poor, indicating more permanent damage.

363. Elmhurst, R. (1922).

INVESTIGATION ON THE EFFECTS OF OIL-TANKER DISCHARGES.

Ann. Rep. Scottish. Mar. Biol. Assoc., 1922, 8-9.

364. Engelhardt, F.R., J.R. Geraci, and T.G. Smith (1977).

UPTAKE AND CLEARANCE OF PETROLEUM HYDROCARBON IN THE RINGED SEAL, PHOCA HISPIDA.

Journal of the Fisheries Research Board of Canada, 34 1143-1147.

Ringed seals, Phoca hispida, showed rapid absorption of hydrocarbons from Norman Wells crude oil into body tissues and fluids when exposed by both immersion and injestion. Relatively low but significant levels were found in tissue, blood, and plasma. Levels in bile and urine were high, indicating these to be routes of excretion.

365. English, J.N., et. al. (1963).

POLLUTIONAL EFFECTS OF OUTBOARD MOTOR EXHAUST - FIELD STUDIES.

J. Water Poll. Contr. Fed. 35:1121-1132.

A preliminary study, conducted in the laboratory with tanks of water, showed that outboard motor exhausts damage the quality of water in a variety of ways. The most noticeable damaging effects were unpleasant taste and odor in the water and offflavoring of fish flesh.

Polluting effects after a short intense period of motor operation were determined in the laboratory investigation. The effects of natural purification by biological degradation or loss of volatile pollutional materials to the atmosphere such as would occur to some degree in an actual situation were not studied. The findings of a field study in which these factors were considered are presented here.

366. Environmental Protection Agency (1973).

OIL SPILL, LONG ISLAND SOUND MARCH 21, 1972, ENVIRONMENTAL EFFECTS.

Final Report U.S. Government Printing Office, Washington, D.C., Order No. 001. Contract No. 68-01-0044.

This study examines the effect of a spill of number 2 fuel oil on the benthic communities of Niantic Bay on the northern shore of Long Island Sound. Stations were analyzed for density and diversity of species. Sediments and selected biota were analyzed for fuel oil by gas chromatography. Only the mid-bay station was contaminated, which may have caused the loss of amphipods. The hermit crab, Pagurus may also be senitive to the oil. Concentration of the pollutant in its tissues appears to make it a good indicator for low levels of residual oil.

367. Environmental Protection Agency, Washington, D.C. (1973).

WASTE OIL STUDY (PRELIMINARY REPORT TO THE CONGRESS).

Available from the National Technical Information Service as PB-253-332.

The Federal Water Pollution Control Act Amendments of 1972 required that within six months after the enactment of the Amendments the Administrator of the Environmental Protection Agency deliver to Congress a preliminary report on the problem of the disposal of waste oils and their effect on the environment. Due to the limited time available for preparation of the report, and the relative lack of existing data at the time of the report, long-term ecological effects were not included. The report deals with

the quantities of waste oil generated in the United States and its routes of entry into the environment; the present methods of collection and disposal; the short-term biological effects of waste oil; and the economic and legal aspects of a waste oil policy. Topics for further study are identified, and a framework for research established, based on a number of working principles, which include studying waste oil disposal as a component of a total environmental policy; changing the mix of environmental disposal modes; studying the effects of federal regulations such as depletion allowances which discourage waste oil recovery operations; and forcing those who create the problem to bear the cost of reducing environmental damage. 26 ref.

368. Erickson, R.C. (1962).

EFFECTS OF OIL POLLUTION ON MIGRATORY BIRDS.

In: Trans. of Seminar on Biol. Problems Water Pollution, 3, 177-181.

369. Erickson, R.C. (1963).

OIL POLLUTION AND MIGRATORY BIRDS.

Atlantic Naturalist, 18, 5-14.

370. Ernst, V.V., J.M. Neff and J.W. Anderson (1977).

THE EFFECTS OF THE WATER-SOLUBLE FRACTIONS OF NO. 2 FUEL OIL ON THE EARLY DEVELOPMENT OF THE ESTUARINE FISH, FUNDULUS GRANDIS BAIRD AND GIRARD.

Environmental Pollution 14 25-35.

Embryos of Fundulus Grandis were exposed continuously to 12.5, 25 and 50% dilutions of the water-soluble fraction (WSF) of No. 2 fuel oil, corresponding to aqueous petroleum hydrocarbon concentrations of 1·1, 2·2 and 4·4 ppm, respectively, and aqueous naphthalenes concentrations of 0.56, 1.07 and 1.26 ppm, respectively. At different times during development, embryos were examined histologically and compared with unexposed controls. Embryos exposed to 12.5% WSF generally hatched earlier than the controls and most were normal. Some of those exposed to 25% WSF had pathological liver, kidney, lens and epithelial tissues while others appeared normal. None of the embryos exposed to 50% WSF hatched and all had pathological tissues.

371. Estuarine Research Foundation (1974).

MARINE ENVIRONMENTAL IMPLICATIONS OF OFFSHORE OIL AND GAS DEVELOPMENT IN THE BALTIMORE CANYON REGION OF THE MID-ATLANTIC COAST. PROCEEDINGS OF ESTUARINE RESEARCH FEDREATION OUTER CONTINENTAL SHELF CONFERENCE AND WORKSHOP.

Estuarine Research Foundation. 504 pp.

This volume contains, among other presentations, twenty papers on physical, chemical, geological, and biological oceanography with an

emphasis on the effects of oil pollution.

372. Evans, D.R. and S.D. Rice (1974).

EFFECTS OF OIL ON MARINE ECOSYSTEMS: A REVIEW FOR ADMINISTRATORS AND POLICY MAKERS.

Fishery Bull., U.S., 72(3):625-638.

A broad selection of recent literature on the effects of oil on marine ecosystems is reviewed. The focus is on studies on crude oil, and the results are discussed with the purpose of providing a summary of findings that will be a useful reference for administrators and policy makers involved in decisions concerning petroleum developments and related activities. The characteristics of crude oil and factors modifying its impact on the marine environment are discussed. Most research on the toxicity of oil has dealt with acute effects and data on long-term impacts at the community level are inconclusive. It is concluded that chronic low-level pollution is potentially more damaging to ecosystems than isolated catastrophic spills. Decision makers are forced to rely on interpretative judgments rather than conclusive data.

373. Evans, W. (1970).

<u>THALASSOTRECHUS</u> <u>BARBARAE</u> (HORN) AND THE SANTA BARBARA OIL SPILL (COLEOPTERA: CARABIDAE).

Pan-Pac *Entomol.*, 46(4):233-237.

A distinct animal association of the high littoral zones, the crevice fauna, is probably more susceptible to oil than any other animal association of the marine littoral. The crevices harbor a wide variety of animals, many of which use the crevices as protection against wave action, predation, or dessication; whereas others feed on detritus and plankton stranded when the tide recedes. Still others emerge at night at low tide and scavenge or prey on crustaceans and insects associated with the algae of this zone. To this last group belongs <u>Thalassotrechus</u> <u>barbarae</u> (Horn), a carabid beetle distributed on the Pacific coast from northern California to central Baya California. Because of these beetles' feeding habits, they are more likely to come into contact with oil. They could receive a dose by walking through it or through contamination of their food supply, but the oil would probably be fatal in either case.

A survey of <u>T</u>. <u>barbarae</u> populations was made from June 1969 through mid-August 1969, along that part of the California coast affected by the Santa Barbara oil spill. <u>Thalassotrechus</u> <u>barbarae</u> was not found in Refugio Beach, El Capitan Beach, Carpinteria, or Ventura. Since all of these localities were subject to heavy or moderate deposits of oil it is very probable that populations of <u>T</u>. <u>barbarae</u> which quite likely existed in these areas before, were killed by the oil along with other members of the high littoral crevice community.

374. Gentry, R. and W.B. McAllister (1976).

PHYSIOLOGICAL IMPACT OF OIL ON PINNEPEDS.

In: Environmental Assessment of the Alaskan Continental Shelf. Principal Investigators' Reports for the Year Ending March 1976. Vol. 8 Effects of Contaminants, p. 15-23.

Laboratory physiological measurements (metabolic rates and heat flux) are applied to the field problem of pinnipeds and otters encountering an oil spill. Direct measurements of diving behavior in unrestrained animals at sea are also made. The rationale for these two approaches is that for fur bearers oil fouling is likely to directly effect the insulative properties of the fur which will result in altered metabolic costs and impaired diving performance. In non-fur bearers different effects are anticipated.

375. Farrington, John W. (1973).

ANALYTICAL TECHNIQUES FOR THE DETERMINATION OF PETROLEUM IN MARINE ORGANISMS.

Woods Hole Oceanographic Inst. AD-766 792 NTIS. pp. 1-24.

The composition of hydrocarbons in petroleum and the composition of hydrocarbons isolated from marine organisms are discussed with the purpose of selecting the best analytical techniques for the quantification of petroleum contamination in marine organisms. Analytical techniques discussed include column, thin layer, and high pressure liquid chromatography; I.R., U.V. and U.V.-fluorescence spectrometry; gas chromatography; mass spectrometry; and combinations of the preceeding.

375A. Farrington, J.W. (1974).

SOME PROBLEMS ASSOCIATED WITH THE COLLECTION OF MARINE SAMPLES AND ANALYSIS OF HYDROCARBONS.

In: Proceedings of Marine Environmental Implications of Offshore Drilling in the Eastern Gulf Mexico. R.E. Smith (ed.) State University System of Florida, Institute of Oceanography.

The collection of marine samples for the purpose of hydrocarbon analysis must be undertaken with extreme care to avoid contamination during the sampling operation. Similarly, appropriate controls should be carried through the extraction and analysis procedures to insure that hydrocarbons are not introduced into the samples from the ship's atmosphere, the laboratory atmosphere, or from solvents and reagents. Intercalibration procedures are essential. Detection of petroleum hydrocarbons in the presence of recently biosynthesized hydrocarbons is discussed. The need for closely spaced sampling stations in some areas to provide baseline data is illustrated by results of analyses of saturated hydrocarbons in surface sediments from the New York Bight area and the continental shelf to the E.

376. Farrington, J.W. and G.C. Medeiros (1975).

EVALUATION OF SOME METHODS OF ANLYSIS FOR PETROLEUM HYDROCARBONS IN MARINE ORGANISMS.

In: 1975 Conference on Prevention and Control of Oil Pollution Proceedings. Sponsored by American Petroleum Institute, Environmental Protection Agency, and U.S. Coast Guard, American Petroleum Institute, Washington, D.C. pp. 115-121.

Soxhlet extraction, homogenization with Na_2So_4 in a Virtis homogenizer, and KOH-methanol digestion methods of extracting hydrocarbons from marine organisms have been tested and compared using subsamples of a clam (Mercenaria mercenaria) homogenate. The amounts of hydrocarbons were determined gravimetrically and the composition was partially characterized by gas chromatography. There was a statistically significant difference between the results of the Virtis vs. Soxhlet and Soxhlet vs. digestion methods. However, in practice the difference is small and would be apparent only if large numbers of replicate measurements were made.

The concentration of hydrocarbons in clams from three locations, a polluted harbor area, a less polluted bay area, and a relatively clean bay have been determined. The composition was partially characterized by gas chromatography.

Subsamples of clam homogenate spiked with 10 ppm API No. 2 fuel oil have been analyzed. Only 5 to 6 ppm of the spike were detected. Gas chromatographic analysis indicated that the lower molecular weight components of the spike were lost. The gas chromatographic passive tagging parameters were altered from those of the API No. 2 fuel oil by interference from hydrocarbons already present in the clams prior to spiking.

377. Farrington, J.W. and J.G. Quinn (1973).

PETROLEUM HYDROCARBONS IN NARRAGANSETT BAY.

I. Survey of Hydrocarbons in Sediments and Clams (Mercenaria mercenaria). Estuarine Coastal Mar. Sci. 1:71-79.

Analyses of hydrocarbons in surface sediments from eight stations and in clams (M. mercenaria) from three stations in Narrangansett Bay show that both contain a very complex mixture of hydrocarbons which is not present in clams from Charlestown Pond, a relatively unpolluted coastal pond. This complex mixture of hydrocarbons is present in crude oils and fuel oils, and it is not a likely product of recent biosynthesis by marine orgainsms. This suggests that the sediments and clams from the areas sampled in Narrangansett Bay are contaminated by petroleum hydrocarbons. Sewage effluents and small oil spills are the most probable sources of the petroleum hydrocarbons.

378. Farrington, J.W., J.M. Teal, J.G. Quinn, P.L. Parker, J.K. Winters, T.L. Wade, and K. Burns (1974).

ANALYSIS OF HYDROCARBONS IN MARINE ORGANISMS: RESULTS OF IDOE INTER-CALIBRATION EXERCISES.

In: NBS Special Publication 409, Marine Pollution Monitoring (Petroleum), Proceedings of a Symposium and Workshop held at NBS, Gaithersburg, Maryland, May 13-17, 1974. National Bureau of Standards. pp. 163-166.

Four participating laboratories analyzed a tuna meal sample provided as a work intercaribration standard by the National Bureau of Standards. The methods of analysis were not specified. The results are given and show fair agreement between laboratories. The authors argue for further intercalibration exercises.

379. Farrington, J.W., J.M. Teal, J.B. Quinn, T. Wade, and K. Burns (1973).

INTERCALIBRATION OF ANALYSES OF RECENTLY BIOSYNTHESIZED HYDROCARBONS AND PETROLEUM HYDROCARBONS IN MARINE LIPIDS.

Bull. Environ, Contam. Toxicol. 10:129-136.

GC columns do not completely resolve all of the hydrocarbons present in petroleum. The result is that the elution from the GC column of many overlapping and/or superimposed peaks with a wide boiling range which collectively produce a detector signal designated as an unresolved complex signal. Since this unresolved complex mixture signal is a characteristic of GC's of crude oils, fuel oils, and lubricating oils, the authors use the presence or absence of this signal in the hydrocarbon gas chromatograms as an initial screening criterion for the presence or absence of petroleum contamination in marine samples. The presence of a homologous series with peaks in the GC's is used as supplemental evidence for the presence of petroleum contamination only when reliable information is available concerning the recently biosynthesized hydrocarbons normally present in the sample type in question. The presence of petroleum contamination would be confirmed by further analyses.

380. Fasoli, U. (1973).

A PROPOSAL FOR THE APPLICATIONS OF MONOD'S MATHEMATICAL MODEL TO BIODEGREDATION OF MINERAL OIL IN NATURAL WATERS.

Water Research; 7(3):409-418.

A number of processes are responsible for the gradual lowering of the concentration of mineral oil in an oil and water mixture. Two mechanisms are primarily involved, usually in association with each other: evaporation and biodegradation. Monod's model was considered in the interpretation of mineral oil biodegradation. The role of evaporation and reoxygenation in the overall process of oil removal was examined by comparison with the biological process. The effect of the possible onset of anaerobic phenomena was also considered. Evaporation is of great importance even in the case of perfectly still water. When mixing takes place, it may be the primary factor. Biodegradation is always involved in the natural elimination of mineral oil. Monod's model gives a good approximation for the forecasting of its course, provided it is recognized that certain oil components, which are in fact oxidized much more slowly, must be treated as nonbiodegradable. As far as O_2 levels are concerned, anaerobic conditions arise when initial hydrocarbon levels are around 20 ppm, except when the water is already markedly O_2-deficient and all forms of aeration are excluded.

381. Fauchald, K. (1971).

THE BENTHIC FAUNA IN THE SANTA BARBARA CHANNEL FOLLOWING THE JANUARY 1969 OIL SPILL.

In: Biological and Oceanographic Survey of The Santa Barbara Oil Spill 1969-1970. Vol 1, compiled by D. Straughan, pp. 61-116. Allan Hancock Foundation, University of Southern California.

382. Feder, H.M., M. Cheek, P. Flanagan, S.C. Jewitt, and M.H. Johnson (1976).

THE SEDIMENT ENVIRONMENT OF PORT VALDEZ, ALASKA: THE EFFECT OF OIL ON THIS ECOSYSTEM.

Environmental Protection Agency, Ecological Research Series, Report EPA 600/3-76-086. Available from National Technical Information Service, Springfield, VA. 322 pp.

The Port Valdez intertidal sediment system was studied for three years. Physical, geological, geochemical, hydrocarbon, and biological features were examined. Sediments were poorly sorted gravels to plastic clays, and had low amounts of organic matter. Bacterial numbers varied from site to site, and decreased in numbers with depth. Meiofauna consisted primarily of nematodes and harpacticoid copepods. Most meiofaunal species were restricted to the upper three centimeters throughout the year. Meiofaunal densities were typically highest in summer and lowest in winter. Reproductive activities of copepods tended to be seasonal with only one species reproducing throughout the year. Bacterial populations were unaffected by single applications. It is concluded that oil is removed rapidly by tidal action. Three species of copepods exposed to oil in the field significantly increased in density in experimentally oiled plots. Uptake and release of added oil by intertidal sediments and the clam (*Macoma balthica*) were examined in the field. Petroleum was not detectable two months after application to sediments.

383. Federal Water Pollution Controll Administration (1968).

OIL AND HAZARDOUS MATERIALS-EMERGENCY PROCEDURES IN THE WATER ENVIRONMENT.

FWPCA Report. CWR-10-1. 137 pp.

Basic information is provided on the characteristics and effects of pollutants, and procedures to be followed in the event of significant releases to water of oil or other hazardous materials. Some general information is given on the effects of spills on aquatic life and important water uses. Pollution control measures, health hazard data, and first aid procedures are listed for each pollutant. (Sinha-OEIS)

384. Feldman, M.H. (1970).

THE 50-MILE BALLAST-OIL DUMPING PROHIBITED ZONE OFF ALASKA, RECONSIDERED IN THE LIGHT OF AVAILABLE DATA GLEANED FROM SIGNIFICANT INCIDENTS.

Pacific Northwest Water Laboratory Working Paper 77. Seattle, Washington.

A review of oil spill incidents in temperate, tropical, and arctic zones with a discussion of their relevance to potential incidents in Alaskan waters.

385. Feldman, M.H. (1973).

PETROLEUM WEATHERING: SOME PATHWAYS, FATE, AND DISPOSITION ON MARINE WATERS.

Ecological Research Series EPA 660/3-73-013. 27 pp.

Three mechanisms of oil pollution weathering on marine waters are discussed. Photolysis, interactions with trace materials, and sedimentation with particulate materials are considered competitive to other fates-of-petroleum mechanisms, and have possible ecological importance. Generation of carcinogenics from close molecular precursors is probable.

386. Field Studies Council (1971).

FIELD STUDIES COUNCIL, OIL POLLUTION RESEARCH UNIT, ORIELTON FIELD CENTRE, ANNUAL REPORT. pp 46.

The effects of oil pollution and oil-spill emulsifiers on littoral organisms are discussed. Toxicity of the emulsifiers BP 1002 and BP 1100 to cockles (*Cerastoderma edule*) and polychaetes (*Arenicola marina* and *Nerine* spp.), and the effects of BP 1002 on the metabolism of crabs (*Carcinus maenas* and *Cancer pagurus*) are reported. Biological observations made after the *Thuntank 6* oil spill are outlined. Effects of crude oil, oil fractions and products on the prawn *Leander squilla* are also discussed.

387. Finnerty, W.R., et. al. (1973).

MICROBES AND PETROLEUM: PERSPECTIVES AND IMPLICATIONS, pp. 105-126.

In: The Microbial Degradation of Oil Pollutants, Ahearn and Meyers, (eds.) Center for Wetland Resources, LSU, Baton Rouge, La., Publ. No. LSU-SG-73-01.

An ultra-structure study of Acinetobacter sp. grown on paraffinic and olefinic hydrocarbons demonstrated cytoplasmic sequestering of hydrocarbons. Induced membrane synthesis was additionally demonstrated as a result of hydrocarbon metabolism. Increased cellular and extracellular lipid synthesis was qualitatively and quantitatively documented during hydrocarbon metabolism. These studies serve to emphasize our lack of detailed knowledge concerning the consequences which may arise from this relationship.

388. Floodgate, G.D. (1971).

THE BIODEGRADATION OF OIL.

Marine Pollution Bulletin 2:143

A laboratory model of the marine environment is being constructed to investigate and assess the importance of the biodegradation of oil on the beach and at sea. Effect of water content of various crude oils in contact with sea water, as well as the bacteriology, biochemistry, and chemistry of the degradation process, is being investigated.

389. Floodgate, G.D. (1972).

BIODEGRADATION OF HYDROCARBONS IN THE SEA, pp. 153-172.

In: R. Mitchell, (ed.) Water Pollution Microbiology. Wiley-Interscience, New York.

A reveiw of the subject covering the origin of oil and hydrocarbons in the sea; the breakdown of oils and hydrocarbons including nonbiological microbiological, and biochemical factors, growth requirements, and the extent of breakdown.

390. Floodgate, G.D. (1973).

A THRENODY CONCERNING THE BIODEGRADATION OF OIL IN NATURAL WATERS pp. 17-24.

In: Ahearn and Meyers, (eds.) The Microbial Degradation of Oil Pollutants. Center for Wetland Resources, LSU, Baton Rouge, La., Publ. No. LSU-SG-73-01.

The term "microbial degradation of oil in the marine environment" means the degradation of a complex and variable mixture of hundreds of substrates by unknown mixed populations of microorganisms in an erratically changing medium. Biodegradation is not the only means whereby the oil is changed chemically. Other processes, such as evaporation, solubilization, photo-oxidation and possibly other abiological mechanisms, operate at the same time. The task of untangling the skein of events is formidable and bold generalizations are clearly ill advised. An attempt is made in this paper to examine the limitations of some of the methods in use to study this problem, and the difficulties of interpreting the data once they have benn obtained.

391. Fong, W.C. (1976).

UPTAKE AND RETENTION OF KUWAIT CRUDE OIL AND ITS EFFECTS ON OXYGEN UPTAKE BY THE SOFT-SHELL CLAM, MYA ARENARIA.

J. Fish. Res. Bd. Can. 33 2774-2780.

Mya arenaria were exposed to sea water to which crude oil had been added. The gills of this clam are capable of removing finely dispersal oil globules of 1-30 micrometer diameter. Clams exposed to seawater concentrations of 90-350 ppm for 10 days at 18°C accumulated oil in their tissues. Concentrations incorporated are directly related to the lipid content of the tissues. The respiratory rate was increased in small clams after prolonged exposure to relatively high oil concentrations and high temperatures.

392. Food and Agriculture Organization of the U.N., Department of Fishery Resources Div (1970).

REPORT OF THE SEMINAR ON METHODS OF DETECTION, MEASUREMENT AND MONITORING OF POLLUTANTS IN THE MARINE ENVIRONMENT.

In: FAO Fisheries Report No. 99. Suppl. 1,126 pp.

A special session of the FAO Technical Conference on Marine Pollution was conducted on Methods of Detection, Measurement and Monitoring of Pollutants. This seminar was orgainzed into panels dealing with specific groups of pollutants: Halongenated hydrocarbons, petroleum, inorganic chemicals, organic chemicals, nutrient chemicals, suspended solids and turbidity, and radioactivity. Another panel was concerned with the use of marine organisms to assess contamination levels; and the final group discussed the establishment of baseline and monitoring systems. The revised and amended version of the seminar report is set forth.

393. Food and Agriculture Organization (1971).

REPORT OF THE FAO TECHNICAL CONFERENCE ON MARINE POLLUTION AND ITS EFFECTS ON LIVING RESOURCES AND FISHING FISHERY.

Fishery Resources Division, Department of Fisheries, Food and Agrigulture Organization, United Nations. 191 pp.

The scope of the FAO Technical Conference on Marine Pollution and its Effects was broad and included, in principle, the consideration of all types of pollutants, from whatever source, in all sea areas, including estuaries. The Conference was organized in sections covering the following subjects: Marine pollution today; behavior and fate of pollutants; effects on the biology and life cycle of marine organisms; ecosystem modifications; technical aspects of pollution control; pollution effects on quality of marine products and fishing; and scientific basis for international legislative controls. The revised and amended version of the draft report and general conclusions of the Conference, as well as abstracts of papers are included.

394. Food and Agriculture Organization, U.N. (1973).

DIRECTORY OF EXPERTS ON MARINE POLLUTION.

FAO Fisheries Technical Paper 99 (Rev. 1) Research Information Section, Fishery Resources Division, Department of Fisheries, Food and Agriculture Organizations, United Nations.

Names of experts in activities throughout the world in the field of marine and brackish water pollution are presented. Contents include an alphabetical list of scientists in which each name is preceded by a 4-digit number designating the affiliation; a list of institutions and their addresses, in geographic order and classified by FAO area code, each followed by the names of staff engaged in pollution work; and a subject index listing staff by their field of experience.

395. Food and Agriculture Organization, U.N. (1974).

DIRECTORY OF INSTITUTIONS ENGAGED IN POLLUTION INVESTIGATIONS: CONTAMINANTS IN AQUATIC ORGANISMS.

FAO Fisheries Circular 325. 49 pp.

The addresses of 233 institutions in 48 countries are presented. Institutions are classifeid according to their activity with marine species, with freshwater species, or with both; the application of these activities to research programs, to monitoring programs, or to both is indicated. The geographical areas of interest to each institution are given; the communities or species of organisms being investigated are classified in each case as plankton, benthos, interstitial fauna, microorganisms, marine mammals, pelagic, demersal, or aquatic species of commercial interest; and categories of contaminants being analyzed are classified.

396. Food and Agriculture Organization, United Nations (1976).

SECOND FAO/SIDA TRAINING COURSE ON MARINE POLLUTION IN RELATION TO PROTECTION OF LIVING RESOURCES: METHODS OF DETECTION, MEASUREMENT AND MONITORING OF POLLUTANTS IN THE AQUATIC ENVIRONMENT.

United Nations Food and AGriculture Organization, UNIPUB, New York. 113 p.

Topics discussed include primary production and nutrients in seawater, redox measurements in natural waters and sediments, methods for chemical analysis of water, oil and oil dispersants, chemical analyses of a sea area polluted by mineral oil, ecological effects of marine pollutants, acute pollution problems affecting fisheries in estuaries and coastal waters, toxicity testing at Kristineberg Zoological Station, toxicity testing in a continuous flow system, monitoring of aquatic pollution, and bioassay methods used by the research laboratory at the Swedish National Environmental Protection Board.

397. Forns. J.M. (1974).

MID-ATLANTIC ZOOPLANKTON: AN OVERVIEW WITH CONSIDERATION OF POTENTIAL IMPACTS BY OFFSHORE OIL EXPLOITATION.

In: Marine Environmental Implications of Offshore Oil and Gas Development in the Baltimore Canyon Region of the Mid-Atlantic Coast. Proceedings of the Estuarine Research Federation Conference and Workshop. Estuarine Research Federation p. 277-290.

This article briefly reviews research on the abundance and composition of 300 plankton in the Mid-Atlantic Bight and reported effects of petroleum on marine zooplankton.

398. Forns, J.M. (1977).

THE EFFECTS OF CRUDE OIL ON LARVAE OF LOBSTER HOMARUS AMERICANS.

In: Proceedings 1977 Oil Spill Conference. p. 596-573. Amer. Petrol. Inst., Wash., D.C.

The effects of API reference South Louisiana crude oil upon four larval stages of American lobster (Homarus americanus) were determined in a flow-through system. Tests were conducted with naturally hatched animals in individual test chambers as well as in mass culture systems in an operating state lobster hatchery. Experimental flow-through crude oil exposure concentrations were 0.1 and 1.0 ppm, administered as a strongly-agitated emulsion-like mix to ambient temperature seawater ranging from 15^{o} - 20^{o}C. Oil exposure residence times ranged from 0.8-5.6 minutes depending on the test. Exposed animals were monitored six times daily for feeding behavioral characteristics, mobility, molting success, growth and development times to reach the fourth larval stage. Pigmentation analysis was performed on individual larvae by photomicroscopy, and hydrocarbon analyses were also conducted thereon. Post-larval development through the eighth stage was investigated. Statistical comparisons were made among different control animals and between control and oil-exposed larvae.

399. Fossato, V.U. (1975).

ELIMINATION OF HYDROCARBONS BY MUSSELS.

Mar. Poll. Bull. 6:7-10.

Mussels collected from hydrocarbon polluted areas of the Lagoon of Venice were transferred to the relatively unpolluted port entrance of Malamocco. Hydrocarbon elimination was quite rapid in the first 10-15 days but then slow and incomplete: 12% of the initial content persisted in the tissues for 8 weeks. Elimination of hydrocarbons was almost independent of water temperature between 7.5-26.0°C but virtually ceased in one lot when the temperature abruptly dropped from about 11°C to 4.5-6.0°C. The biological half-life of hydrocarbons in the mussels was calculated to be a little over 3 1/2 days, but this relates only to the initial rapid phase of elimination.

400. Fossato, V.U., et al. (1976).

HYDROCARBON UPTAKE AND LOSS BY THE MUSSEL MYTILUS EDULIS.

Mar. Biol. 36(3):243-251.

The dynamics of accumulation and elimination of hydrocarbons by the blue mussel Mytilus edulis were studied in a continuous-flow system. Mussels were exposed for as long as 41 days to 200-400 μ g/l of diesel fuel absorbed on kaolin particles. Hydrocarbons were accumulated in the tissues in excess of 1000 times the exposure levels. Upon termination of dosing, the mussels exhibited a rather rapid loss of hydrocarbons for the first 15 to 20 days (biological half-life = 2.7 to 3.5 days). Subsequently, however, elimination was reduced to a minimum and a considerable fraction of the hydrocarbons could be recovered from the tissues after as long as 32 days of depuration. The mussels exhibited definite signs of physiological stress due to chronic exposure to diesel fuel, although recovery was rapid upon termination of dosing. It is concluded that mussels could be utilized as a test organism for monitoring long-term hydrocarbon pollution in marine waters. The implications for the mussel culture industry are discussed.

401. Fossato, V.U. and E. Siviero (1974).

OIL POLLUTION MONITORING IN THE LAGOON OF VENICE USING THE MUSSEL MYTILUS GALLOPROVINCIALIS.

Marine Biology, 25(1):1-6.

Gas chromatographic analyses of M. galloprovincialis from different areas of the Lagoon of Venice show that these organisms contain a complex mixture of hydrocarbons attributable to fuel oil contamination. The measured amounts normally range from 0.8 to 8.7 mg/100 g wet wt, but values up to 22.0 mg/100 g have been recorded. The level of aliphatic hydrocarbons in mussels is related to the distance from pollution sources and to the degree of exchange between the sea and the area sampled. On the basis of this relationship between overall hydrocarbon pollution load and the level of contamination of M. galloprovincialis this bivalve might be effectively utilized as a self-integrating monitoring index of oil pollution in the waters of the lagoon.

402. Foster, J.W. (1962).

BACTERIAL OXIDATION OF HYDROCARBONS.

In: Oxygenases, O. Hayaish, O. (ed.), Academic Press, NY. 241-271.

A review of the oxidation of various classes of hydrocarbons by bacteria under aerobic and anaerobic conditions.

403. Foster, J.W. (1962).

HYDROCARBONS AS SUBSTRATES FOR MICROORGANISMS.

Ant. V. Leewenhoek 28 241-274.

404. Foster, M., M. Neushul and R. Zingmark. (1971).

THE SANTA BARBARA OIL SPILL. PART 2. INITIAL EFFECTS ON INTERTIDAL AND KELP BED ORGANISMS.

Environ. Pollut. 2:115-134.

The initial effects of the Santa Barbara oil spill on intertidal and kelp bed organisms were studied. Based on earlier surveys, the greatest negative biological change at a sample station after the spill was the loss of 16 plant species. However, losses in species were correlated in most cases with sand movement, and may have been related to the severe storms which occurred between and during the oil spill. Although gross species changes were not correlated with oil dosage, severe damage occurred in intertidal surf grass and barnacle populations as a result of the oil pollution. Potential long-term biological effects of the continuing pollution are discussed.

405. Frakenfeld, J.W., J.J. Elliott, R.E. Bentley and B.H. Sleight, III (1975).

TOXIC EFFECTS OF OIL DISCHARGED FROM SHIPS.

Final Report to U.S. Coast Guard, Report No. CG-D-16-76. Available through National Technical Information Service.

This study was conducted to determine the proportions of six petroleum products which are dispersed and dissolved in water under specified conditions and the toxic effects of both the dissolved and the dispersed-plus-dissolved fractions on selected test organisms. The oils employed included Kuwait crude, West Texas crude, Marine diesel, Navy distillate and Navy Special fuel oils, and a 9250 lubricating oil. The test organisms employed were the fathead minnow (Pimephales), mimmichog (Fundulus) and the brine shrimp (Artemia). Effects of time, temperature and salinity were investigated. The observed toxicity of each oil depended on (1) its inherent toxicity (ppm oil), (2) the solubility of the oil, and (3) its dispersability. LC_{50}'s ranged from a few ppm to a few hundred ppm.

406. Friede, J., P. Guire, R.K. Gholson, E. Gandy and A.F. Gandy, Jr. (1972)

ASSESSMENT OF BIODEGREDATION POTENTIAL FOR CONTROLLING OIL SPILLS.

Final Report to U.S. Coast Guard. Report No. 4110.1/3.1.

This report reviews past and current research work on biodegredation of marine oil spills to determine the practical feasibility of controlling oil spills and residues by biodegredation. The review has been confined to scientific books and periodicals. The literature review extends to June 1, 1972.

407. Friendly, A. (1970).

SPECIAL DANGER SEEN IN ARCTIC POLLUTION.

Washington Post, 64, June 6, 1970.

The Arctic fauna are far more susceptible to oil pollution than creatures of more temperate zones, because arctic marine invertebrates are inclined to have late sexual maturity and slow rate of growth. Most significant, however, is the pattern of the small Arctic organisms to produce a small number of eggs, and for these to be brooded by the parents rather than, as with other types, left to drift by the millions in the chance that enough will survive to perpetuate the species. Thus, reconstitution of a colony that has suffered loss must be from what remains of the breeding stock, and a major pollution incident which destroys a community of this kind eliminates not only the adults but also the stock of larvae. Replacement from adjacent areas will be slow, and re-establishment of the community will require many more years than in communities in temperate waters. Also, the microbial degradation of oil proceeds very slowly at low temperatures (of water) so that the toxic effects of spilled oil may persist for a very long time.

408. Fromm, P.O. (1965).

PHYSIOLOGICAL CONSIDERATIONS IN STUDIES OF THE ACTION OF POLLUTANTS ON AQUATIC ANIMALS, PP 316-319.

In: Biological Problems in Water Pollution, C.M. Tarzwell, (ed.) U.S. Public Health Service, Cincinnati.

409. Frye, J. (1974).

OIL SUPERSHIPS AND THE OCEANS.

Oceans, Nov. 1, 1974.

This article reviews the literature on the potential impact of superships and superports on the marine ecosystem.

410. Fucik, K.W., H.W. Armstrong, and J.M. Neff (1977).

UPTAKE OF NAPHTHALENES BY THE CLAM RANGIA CUNEATA IN THE VICINITY OF AN OIL SEPARATOR PLATFORM IN TRINITY BAY, TEXAS.

In: Proceedings 1977 Oil Spill Conference. p. 637-640 Amer. Petrol. Inst., Wash., D.C.

In three separate experiments, the clam, Rangia cuneata was exposed under and near an oil separator platform in Trinity Bay, Texas for periods of approximately 100 days. The greatest naphthalenes uptake was in those clams exposed beneath the platform. Clams exposed at distances of 150-1,000 m from the platform showed little or no uptake of naphthalenes. In clams returned to the lab and allowed to depurate, most of the accumulated naphthalenes were released, though detectable levels remained in some of the clams after 47 days. There was good correlation between the rates of naphthalenes uptake by the clams and naphthalenes levels in the sediments at the different stations. However, clams analyzed by gas chromatographic techniques showed high levels of weathered hydrocarbons suggesting that the sediments are a source of hydrocarbons accumulated by the clams. The results are discussed in relation to the physical features of Trinity Bay which is a very shallow, semi-enclosed body of water with a high suspended sediment load.

411. Galstoff, P.S. 1936).

OIL POLLUTION IN COASTAL WATERS.

In: North American Wildlife Conference Proc., 1:550-555.

Oil placed on a clean-water surface has a tendency to spread out until it forms a monomolecular layer. The presence of other contaminating substances which lower the surface tension may interfere with this process, resulting in stoppage of the spreading and formation of floating thicker films, recognizable by bright bands of color. There exists a definite relation between the thickness of the film and the amount of oil dumped. A conclusion has been drawn that oil may be discharged into surface waters at the rate of 10 gallons per hour per square mile without causing visible pollution, providing the distribution is uniform over the entire area; but the disappearance of oil from the surface does not mean that the pollutant has been eliminated. Its effects may still persist, even when no traces of oil are visible on the surface.

Oil may affect marine life in various ways--by forming film that inhibits gaseous exchange; by coating the bodies of animals; by direct toxic action of water-soluble fractions; by repelling migratory animals, and by interfering with the natural food chain of the sea. The water-soluble fractions affect the feeding mechanisms of mollusks, attack the nervous system and respiratory system of fish, and interfere with the normal food cycles, as well as imparting an oily flavor to seafood. Furthermore, oil coming from offshore

wells is usually complexed with brine or "bleed waters" loaded with poisonous hydrogen sulfide. Experiments on oysters and Nitzschia show that even though this bleed water is less toxic than oil, it exerts similar effects on marine life.

412. Galtsoff, P.S., H.F. Prytherch, R.O. Smith and V. Koehring, (1935).

EFFECTS OF CRUDE OIL POLLUTION ON OYSTERS IN LOUISANA WATERS.

Bull. Bureau Fish., Wash., 18, 143-210.

413. Ganning, B. and U. Billing (1974).

EFFECTS ON COMMUNITY METABOLISM OF OIL AND CHEMICALLY DISPERSED OIL ON BALTIC BLADDER WRACK, FUCUS VESICULOSUS.

In: Ecological Aspects of Toxicity Testing of Oils and Dispersants
L.R. Benyon and B.B. Cowelt (eds.) John Wiley & Sons New York pp. 53-67

In this study, the algal metabolism was monitored by analyses of dissolved oxygen. The results are correlated with concentrations of oils and dispersed oil. Fucus reacts with oily and emulsifiers by increasing its respiration. Emulsified oil reduces net productivity much more drastically than oil alone.

414. Gardiner, A.C. (1927).

THE EFFECT OF AGUEOUS EXTRACTS OF TAR ON DEVELOPING TROUT OVA AND ON ALEVINS.

Fish. Invest., Land., ser. I, 3 p. 14

415. Gardner, G.R. (1972).

CHEMICALLY INDUCED LESIONS IN ESTUARINE OR MARINE TELEOSTS.

In: Proceedings, Symposium on Fish Pathology.
Armed Forces Institute of Pathology, Washington, DC, p. 657-693.

It was found that the Texas-Louisiana crude oil and the saltwater soluble and insoluble fractions induced lesions in the olfactory organs of the marine teleost Menidia menidia. Whole crude oil promoted hyperplasia of the olfactory systenacular, or supporting epithelium.

416. Gardner, G., et al. (1974).

THE MICROSCOPIC PERILS OF MARINE POLLUTION.

Underwater Naturalist, 8:15-19.

A description of pathological effects of petroleum HC's and heavy metals in histophysiology.

417. Gardner, G.R., et al. (1975).

MORPHOLOGICAL ANOMALIES IN ADULT OYSTER, SCALLOP AND ATLANTIC SILVERSIDES EXPOSED TO WASTE MOTOR OIL.

In: Conference on Prevention and Control of Oil Pollution, pp. 473-477. Amer. Petrol. Inst., Wash. D.C.

Waste motor oil concentrations of 20 ppm and higher induced lesions in the vascular systems of Atlantic silversides and oyster. These lesions were associated with the pseudobranch, the heart, and the arterial system of the Atlantic silversides, and the branchial efferent vein of the oyster. Lesions occurred in the gastro-intestinal tract of oyster, the gill and kidney of scallop, and the mantle of both species. Based on these preliminary exposures, the scallop, of the three species tested, demonstrated the highest sensitivity to the toxic effects of 20 ppm waste motor oil, or higher, for periods up to 60 days. The LC_{50} (96 hr) value for waste motor oil and adult Atlantic silversides was 1,7000 ppm. Acute toxicity values were not determined for the oyster or scallop.

418. Gatellier, C.R., et. al. (1973).

EXPERIMENTAL ECOSYSTEMS TO MEASURE FATE OF OIL SPILLS DISPERSED BY SURFACE ACTIVE PRODUCTS

In: Proceedings, Joint Conference on Prevention and Control of Oil Spills. American Petroleum Institute, Washington, D.C. 497-504.

Using small "ecosystems" isolated by plastic bags, the degredation of oil was followed using various combination of dispersants and additives. It was found that dispersant plus sources of P and H greatly increased the rate of degredation of crude oil.

419. Gelboin, H.V. (1969).

A MICROSOME-DEPENDENT BILDING OF BENZ(A)PYRENE TO DNA.

Cancer Res. 29:1272-1276.

Benzo(a)pyrene- H incubated in the presence of rat liver microsomes with calf thymus DNA binds covalently to the DNA. The reaction requires reduced nicotinamide adenine dinucleotide phosphate and is greater when the microsomes are obtained from rats pretreated with polycyclic hydrocarbons. The binding is due to the formation of unknown metabolite(s) which then may bind to the DNA in the absence of microsomes.

420. George, J.D. (1970).

MORTALITY AT SOUTHEND.

Mar. Poll. Bull, 1(9):131

This article reports the biological effects of the oil pollution resulting from the 27 July 1970 spillage of 400,000 kg of oil into the Thames Estuary and from the ensuing cleanup operation. The oil was treated with dispersing fluids at the scene of the spillage. Beaches onto which the oil drifted were treated either with dispersant or fresh water and dispersant.

Two days after the spill the clean-up areas were examined. Where oil had been left untreated it had hardened to a tar-like consistency. Seaweeds such as Ulva lactuca, Enteromorpha intestimalis, and Fucus vesiculosus on the portions of the seawall spayed with dispersant had been damaged. Many dead Balanus balanoides, Litorina sp and Carcinas maenas were found among the weed.

Muddy sand flats in the immediate vicinity of the beaches were severely affected by freshwater/dispersant run-off. Drifts of dead and dying animals were apparent. Polychaetes form most of the biomass in this region and thousands of adult and juvenile Arenicola marina, Neanthos virens and Nerine foliosa were found on the surface of the sand. Smaller number of Nephtys hombergi and Eteone longa were discovered. Molluscan casualities in this region included Cerastoderma edule, Mytilus edulis and winkles. Dead specimens of Carcinus maenas were evident everywhere.

The influence of the cleaning fluids did not extend more than 100 m. seaward.

421. George, J.D. (1970).

SUB-LETHAL EFFECTS ON LIVING ORGANISMS.

Mar. Poll. Bull., 1:107-109.

In September, 1960, a spillage of approximately 200,000 kg of fuel oil occurred from the marine terminal at the Esso refinery at Fawley, Southampton, England. Some of this oil floated across Southampton Water and heavily polluted mud flats at the entrance to the River Hamble. Large populations of two common intertidal polychaetes Cirratulus cirratus (Muller) and Cirriformia tentaculata (Montagu) were under investigation on the mud flats at this time, and it was thus possible to observe at first hand the effects of the oil on these populations. It became apparent that the sub-lethal effects of pollutants merit further investigation.

422. Geraci, J.R. and T.G. Smith (1976).

DIRECT AND INDIRECT EFFECTS OF OIL ON RINGED SEALS (PHOCA HISPIDA) OF THE BEAUFORT SEA.

J. Fish. Res. Bd., Can. 33 1976-1984.

Six seals immersed in Norman Wells crude oil in pens in the Arctic for 24 hours suffered only transient eye problems and minor kidney and possibly liver lesions; no permanent damage was observed. In laboratory experiments three seals died within 71 minutes after oil was introduced into their pool. Hematologic and blood chemical studies indicate that death was caused by oil superimposed on the stress of captivity. Six 3-4 week old wild white coat harp seal pups were coated with crude oil. No deleterious effects were observed. Five captive ringed-seals were subjected to a commulative dosage of crude oil fed with their fish food. No significant lesions or behavioral changes were noted.

423. George, M. (1971).

OIL POLLUTION OF MARINE ORGANISMS.

Nature, 192(4808):1209.

The surrounding flora and fauna were examined and observed after the oil spill in Milford Haven. It was found that even when the surface of the water is covered by a thick layer of oil, only a very thin film of oil is deposited on littoral communities (animals and plant) as it recedes. It was later observed that the amount of oil in the area occupied by the limpets (Patella vulgata) was much reduced and that residual patches of oil in the area bore the characteristic marks of limpet radulas. It appeared likely that these mollusks were continuing to browse over the nearby barnacles and rocks, inadvertently taking in oil in the process. Since there was no decrease in the limpet population, it seemed probable that the oil was non-toxic, and was being passed through the alimentary canal and voided with the normal fecal material. Six months later, all traces of oil had been removed from the area inhabited by the limpets.

During recent years, industrial emulsifiers have been used to clean up such rocky areas after oil spills, but their use has been followed by a severe mortality among intertidal organisms. It is suggested that in view of the fact that oil films are removed fairly quickly from rockly shores by natural means, it is both wasteful and unnecessary to use emulsifiers on such shores.

424. George, J.D. (1971).

THE EFFECTS OF POLLUTION BY OIL AND OIL-DISPERSANTS ON THE COMMON INTERTIDAL POLYCHAETES CIRRIFORMIA TENTACULATA AND CIRRATULUS CIRRATUS.

J. Appl. Ecol., 8:411-420.

Observations were made in the field and in the laboratory on the effects of the 1960 oil spill at Fawley, England on two species of intertidal cirratulid polychaetes. Spawning, growth, and mortality of Cirratulus cirratus, and Cirriformia tentaculata were unaffected by the oil. Both species were killed by relatively low levels of Essolvene and BP 1002 dispersants, although C. cirratus was more tolerant.

The dispersant Corexit 7664 was much less toxic to both species, but all three dispersants prevented gamete formation in C. cirratus at concentrations approaching the lethal level.

425. Geraci, J.R. and T.G. Smith (1976).

BEHAVIOR AND PATHOPHYSIOLOGY OF SEALS EXPOSED TO CRUDE OIL.

In: Sources, Effects, and Sinks of Hydrocarbons in the Aquatic Environment: Proceedings of the symposium, America University, Washington D.C. 9-11 August 1976. p. 448.

Ringed seals, Phoca hispida and harp seals, Phoca groenlandica were exposed to oil both in the field and in the laboratory. They were either placed into crude-oil-covered water, brush-coated with oil, or given oil by mouth. Twenty-four hour surface exposure to light crude oil was damaging only to the eyes of healthy seals, whereas stressed seals died within 71 minutes of exposure. Oil in quantities reasonably expected to be ingested during an oil spill was not irreversibly harmful. Evidence is presented to show that the consequences of an oil spill ultimately depend on the season of spill, productivity of the area, and the variable health status of a seal population.

426. Giam, C-S, H.S. Chan and G.S. Neff (1976).

DISTRIBUTION OF N-Parrafins IN SELECTED MARINE BENTHIC ORGANISMS.

Bulletin of Enviornmental Contamination and Toxicology, 16(1), 37-43.

Gas chromatography was used to quantitate the hydrocarbons present in organisms (squid, shrimp, and fish) collected from various sites. All of the organisms had high concentrations of the C-15 and C-17 N-parrafins of the C-31 compound or both. Shrimp and wenchmen samples appeared to exhibit the least intraspecies and seasonal variation relative to their distribution of n-parrafins. The rise of overall distirbution in addition to the odd/even rations of hydrocarbons for baseline monitoring of hydrocarbon content was recommended.

427. Gibbs, C.F. (1972).

A NEW APPROACH TO THE MEASUREMENT OF RATE OF OXIDATION OF CRUDE OIL IN SEAWATER SYSTEMS.

Chemosphere, Pergamon Press. 3:119-124.

The apparatus described, in conjunction with Winkler titration, allows measurement of bio-oxidation of crude oil in seawater. Using unenriched seawater the rate observed is very low, nitrogen and/or phosphorus nutrients are shown to be important. The next problem to be approached is the maintenance of nutrient levels approximately representative of those in the natural environment.

428. Gibbs, C.F. (1975).

QUANTITATIVE STUDIES ON MARINE BIODEGRADATION OF OIL I. NUTRIENT LIMITATION AT 14° C.

Proc. R. Soc. Lond. B. 188:61-82.

A method for measuring oxygen uptake due to oil biodegradation for a long period, in a semi-closed system, with continuous nutrient replenishment is described. The rate and extend of degradation of Kuwait crude residues in the absence of high nutrient concentrations at 14°C was measured, and related to the supply and uptake of inorganic nutrients. The rate controlling factor was the rate of replenishment of nitrogen as nitrate or ammonia. Approximately 26% (based on oxygen uptake) or 44% (based on oil recovery) of the oil was degraded, the difference probably being due to the production of soluble organic compounds. Some properties of the recovered oil were measured. The residues after partial degradation were of sufficient density to sink in seawater. It appears that at 14° C, approximately 4 μmolavailable nitrogen is required per milligram of oil oxidized (based on oxygen consumption). The capacity of sea water to degrade oil in the natural environment is tentatively discussed.

429. Gibbs, C.F., K.B. Pugh & A.R. Andrews (1975).

QUANTITATIVE STUDIES ON MARINE BIODEGREDATION OF OIL II. EFFECT OF TEMPERATURE.

Proc. R. Sec. Lond., B, 188 83-94.

430. Gibson, R. (1966).

OIL POLLUTION AND ITS EFFECT ON BIRDS IN SOUTH-EAST KENT.

Seabird Bulletin, 2, 66-69

431. Giles, L.A. and Livingston, J. (1960).

OIL POLLUTION OF THE SEAS.

Trans. No. Amer. Wildl. Conf., 25 297-303.

432. Gilfillan, E.S. (1973).

EFFECTS OF SEAWATER EXTRACTS OF CRUDE OIL ON CARBON BUDGETS IN TWO SPECIES OF MUSSELS, PP. 691-695.

In: Proceedings, Joint Conference on Prevention and Control of Oil Spills. American Petroleum Institute, Washington, D.C.

Effects of crude oil and salinity stress on the metabolism of 2 common filter feeding animals (Mytilus edulis and Modiolus demissus) have been investigated. Carbon budgets have been calculated for each species under a variety of combinations of oil content and salinity. Both reduced salinity and crude oil tend to decrease the net carbon balance for each species; stresses from each source were additive in their effects on experimental animals. Although similar responses to oil were shown by each species, Mytilus appeared to be somewhat more resistant to oil than Modiolus.

433. Gilfillan, E.S. (1975).

DECREASE OF NET CARBON FLUX IN TWO SPECIES OF MUSSELS CAUSED BY EXTRACTS OF CRUDE OIL.

Mar. Biol. (Berl.), 29:53-57.

Effects of crude oil and salinity stress on the metabolism of two common filter-feeding animals (Mytilus edulis and Modiolus demissus) have been investigated. Carbon budgets have been calculated for each species under a variety of combinations of oil content and salinity. Both reduced salinity and the presence of crude oil tend to decrease the net carbon flux for each species; stresses from each source interacted in their effects on experimental animals. Although similar responses to oil were shown by each species, Mytilus edulis appeared to be slightly more resistant to oil than Modiolus demissus.

434. Gilfillian, E.S., D. Mayo, S. Hanson, D. Donovan, and L.C. Jiang, (1976).

REDUCTION IN CARBON FLUX IN MYA ARENARIA CAUSED BY A SPILL OF NO. 6 FUEL OIL.

Mar. Biol. 37:115-123.

Rates of respiratory assimilation and filtration have been determined on a monthly basis for two populations of Mya arenaria in Casco Bay, Maine, one of which was heavily oiled by a spill of No. 6 fuel oil. Monthly estimates of carbon flow have been calculated from these data. The same general trends were seen in each population; small negative carbon flow in winter, large negative carbon flow in the spring; large positive carbon flow during summer. However, the oiled population gained carbon at only 50% of the rate seen in the unoiled population. This difference results from the uptake of hydrocarbons by the oiled population.

435. Gill, C., Booker, F., and Soper, T. (1967).

THE WRECK OF THE TORREY CANYON.

David and Charles, Newton Abbot.

436. Glude, J.B. (1972).

INFORMATION REQUIREMENTS FOR RATIONAL DECISION IN CONTROL OF COASTAL AND ESTUARINE OIL POLLUTION.

In: Marine Pollution and Sea Life, M. Ruivo (ed.), Food and Agriculture Organization, United Nations, Fishing News (Books) Ltd. pp. 622-624.

This article proposes the preparation of a resource atlas of the coastline of the United States with charts and tables describing water movements and the results of research on the biological effects of various petroleum products and chemical and physical oil control materials upon important aquatic species and their environment.

437. Goethe, F. (1968).

THE EFFECTS OF OIL POLLUTION ON POPULATIONS OF MARINE AND COASTAL BIRDS.

Helgolander wiss. Meeresunters., 17:370-374.

Oil pollution of the sea, especially damage of oil tankers, may cause severe effects on populations of sea and coastal birds, especially as far as bird aggregations in winter quarters or breeding places are concerned.

Examples of oil pollution effects on birds are given and the most severely affected species of European waters quoted.

438. Goldacre, R.J. (1968).

EFFECTS OF DETERGENTS AND OILS ON THE CELL MEMBRANE.

In: The Biological Effects of Oil Pollution on Littoral Communities Supplement to Volume 2, Field Studies. J.D. Carthy and D.R. Arthur, (eds.) Field Studies Council.

This paper reports the effects of various pure substances found in crude oil and in emmulsifiers on the plasma membrane of the amoeba (*Amoeba proteus*). The method used was microscopic observations of *Amoeba* in hanging drop preparations while the chemicals were administered. Volatile substances at first increased, then decreased the sensitivity of the *Amoeba*, then, at high concentrations, carried the rapid increase in area of the cell membrane. A continuous series of these films peeled off the inner surfaces. Non-volatile, insoluble oils had little effect. Anionic detergents caused removal of the cell membrane while cationic detergents caused "toughening" of the membrane and eventual coagulation of the cytoplasm.

439. Goldberg, E. (ed.) (1972)

MARINE POLLUTION MONITORING STRATEGIES FOR A NATIONAL PROGRAM.

In: Deliberations of a Workshop Held At Santa Catalina Marine Biological Laboratory of the University of Southern California, Allan Hancock Foundation, October 25-28, 1972. Sponsored by the National Oceanic and Atmospheric Administration of the U.S. Department of Commerce.

This volume outlines procedures of sampling and analysis that could be used to monitor the levels of pollutants, including petroleum, in the marine environment.

440. Goldberg, E.D. (1975).

THE MUSSEL WATCH. A FIRST STEP IN GLOBAL MARINE MONITORING.

Mar. Pollut. Bull., 6 111.

This short article proposes a monitoring system using mussels (Mytilus). Speciments from 100 coastal and open ocean sites would be analyzed annually for concentrations of halogenated hydrocarbons, transuranics, heavy metals, and petroleum. Mussels appear valuable as monitors of hydrocarbon pollution since they rapidly take up both saturates and aromatics from their environs and store them with little breakdown.

441. Goldberg, E.D. (1976).

The Health of the Oceans.

Unesco Press, UNIPUB, New York. 172 pp.

Various aspects of marine pollution are explored. Oceanic and societal time scales and marine pollution dynamics are described. The role of halogenated hydrocarbons, radioactivity, heavy metals, petroleum hydrocarbons, and litter in ocean pollution is discussed. Predictive modes and monitoring strategies are presented. Short time-scale problems of the coastal ocean, long time-scale problems of the open ocean, strategies of diagnosis and treatment, and the use of mussels and barnacles as sentinel organisms for measuring pollution also are described.

442. Gooding, R.M. (1971).

OIL POLLUTION ON WAKE ISLAND FROM THE TANKER R.C. STONER.

U.S. Dept. Commerce, Natl. Mar. Fish. Serv., Spec. Sci. Rep. Fish., 636.

On September 6, 1967, the tanker R.C. Stoner foundered on the reef off the harbor entrance at Wake Island. During the following 10 days the vessel's cargo of over 22,000 kliters (6 million gal) of high octane aviation gasoline, aviation jet fuel, aviation turbine fuel, diesel oil, and bunker C black oil was spilled along the southern coast of the island.

A shore and underwater survey of the contaminated coastline showed that an estimated 2,500 kg of inshore reef fishes were killed and stranded on the shore. Numerous other fish and invertebrates were probably killed. Evidence is cited which indicates that most of the kill occurred on the shallow reef flat and the author speculates on the lethal effect of the various fuels.

443. Gordon, D.C, et al. (1976).

FATE OF CRUDE OIL SPILLED ON SEAWATER CONTAINED IN OUTDOOR TANKS.

Environ. Sci. Technol. 10(6):580-585.

The fate of crude oil spilled on seawater was studied in outdoor tanks. Concentrations of oil in the surface film, water column, and sediment were monitored for as long as three months by fluorescence spectroscopy. About half of the spilled oil formed tar balls or was stranded on the walls of the tank. It is estimated that less than 5% of the oil entered the water column and sediments. The concentration of oil in the water column was as high as 2-3 mg/l during the first few days. Oil could still be detected in the seawater (about 30 ug/l) and sediment (about 10 ug/g wet sediment) after three months. The concentrations observed were in the same range as reported in polluted environments and are potentially deleterious to some marine organisms.

444. Gordon, D.C. & N.J. Prouse (1973).

THE EFFECTS OF THREE OILS ON MARINE PHYTOPLANKTON PHOTOSYNTHESIS.

Mar. Biol. 22, 329-333.

The effect of three oils (Venezuelan crude, No. 2 fuel, and No. 6 fuel) on the photosynthesis of natural phytoplankton communities from Bedford Basin, Nova Scotia (Canada) and the Northwest Atlantic Ocean between Halifax and Bermuda were examined using a radiocarbon method. The 3 oils can inhibit photosynthesis, and the degree of inhibition depends upon oil type and concentration. The No. 2 fuel oil was the most toxic. Under certain conditions, low concentrations of Venezuelan crude oil can stimulate photosynthesis. On the basis of these results, it is concluded that present levels of oil contamination in Bedford Basin could be inhibiting photosynthesis by a few percent, while present levels in open ocean water have no apparent deleterious effect on photosynthesis.

445. Gowanloch, J.N. (1935).

POLLUTION BY OIL IN RELATION TO OYSTERS.

Trans. Amer. Fish. Soc., 65:293-296.

Oysters were dying in great numbers near recently drilled oil wells. No spatial relationship existed between the intensity of damage to an oyster bed and the distance of that bed from an oil development. It was determined that the mortalities occurred as a result of the discharge of "salt brine" from the drilling platforms into the sea. This salt water comes to the surface from "salt dome" oil wells under the sea, and is in intimate contact with the crude oil. Separation procedures were carried out in the surface between ejecting the brine, but oil remained complexed with it in amounts sufficient to induce oyster mortality.

446. Graham, R.J. (1963).

LONG-TERM TOXICITY OF OIL REFINERY EFFLUENTS.

PhD. Thesis, State Univ. Oklahoma.

447. Granmo, A. and G. Joergenson (1975).

EFFECTS ON FERTILIZATION AND DEVELOPMENT OF THE COMMON MUSSEL MYTILUS EDULIS AFTER LONG-TERM EXPOSURE TO A NONIONIC SURFACTANT.

Marine Biology 33(1):17-20.

Mussels were exposed to low-level concentrations (0.5-1.5 ppm) of tallow alcohol decaethyleneglycolether for 5 mo. Upon maturation at the end of this period, spawning ability was examined. Fertilization occurred at low-level concentrations (0.1-2.0 ppm) of the surfactant and was most successful for gametes from the long-term controls and the highest long-term concentration (1.5 ppm). Inhibited or delayed larval development was observed, related to the concentration gradient of the short-term exposures. Gametes from mussels exposed long-term to the surfactant were more sensitive than those from the long-term control.

448. Granmo, A. and S. Kollberg, (1976).

UPTAKE PATHWAYS AND ELIMINATION OF A NONIONIC SURFACTANT IN COD (GADUS MORRHUA L.)

Water Research, 10 (3): 189-194.

Cod were caught in the Gullmar Fjord, Sweden, acclimated at laboratory conditions, and starved for 1 wk preceding the experiment. After exposure to nonylphenol ethoxylate (NP 10 EO) in stagnant water, the fish were dissected and samples taken of gill filaments, blood from the dorsal aorta, liver, kidney, gall bladder and urine for analysis. The 5-part investigation revealed that rapid uptake occurs after exposure to 5 ppm at 11^{o} C and within 5 min all tissues except the gall baldder contain appreciable amounts of NP 10 EO. The highest concentration within 5 min (10 times that of the ambient water) was in the gills. After 30-min exposure, NP 10 EO starts to show up in the gall bladder, and, after 8 hr. stable conditions are reached with a concentration level of 4,000 ppm. The total surfactant accumulates in the gall bladder, and the lack of elimination and high concentration present indicate that no further transport or turnover takes place. If the samples from the different tissues are compared, the uptake of NP 10 EO between 5 min and 8 hr of exposure shows a 1,000-fold increase in the gall baldder, a 10-fold increase in the liver, and a 2-fold increase in the gills. Temperature increases cause a faster rate of uptake in all tissues. The gills and blood show the highest elimination rate after transfer to clear seawater.

449. Grant, C.W. and C.E. ZoBell, (1942).

"Oxidation of hydrocarbons by marine bacteria."

Proc. Soc. Exper. Biol. and Med. 51:266-267.

Bacteria in a raw sea water extract were found to attack a broad range of hydrocarbons, including crude oil and gasoline. It appears that aliphatic hydrocarbons are attacked more readily than cyclic or aromatic hydrocarbons, and long chains are more susceptible to bacterial oxidation than hydrocarbons of small molecular weight. Several species of Proatrinomyces, Pseudomonas and Mycobacterium were isolated by enrichment culture from the sea water medium.

450. Grant, E.M. (1970).

NOTES ON AN EXPERIMENT UPON THE EFFECT OF CRUDE OIL ON LIVE CORALS.

Fish. Notes Dept. Prim. Ind., Brisbane, 1 1-13.

451. Green, D.R., C. Bawden, W.J. Cretney, C.S. Wong (1974).

THE ALERT BAY OIL SPILL: A ONE-YEAR STUDY OF THE RECOVERY OF A CONTAMINATED BAY.

Pacific Marine Science Report, 74-9. 46 pp.

In Jan. 1973, the freighter Irish Stardust spilled roughly 200 tons of heavy fuel oil into Broughton Strait. One of the more contaminated bays, code-named Reserved Bay, was sufficiently isolated so that it could be left undisturbed for scientific study. Natural degradation of heavy fuel oil was studied on 5 visits during the year to obtain chemical samples, observe the physical fate of the oil, and follow its ecological effects. Only those species in direct contact with oil were harmfully affected, particularly limpets and periwinkles, and perhaps isopods, rockweed, and marshgrass. No species was completely eliminated and indications are that recolonization is occurring. No permanent effects are apparent on the biological community. The physical action of the wind, waves, and tide appeared to have little effect on the oil in the semiexposed location. The major mechanism for altering the chemistry of the oil was the action of bacteria, which took 1 yr to degrade the paraffin portion of the oil, leaving a thin asphaltlike covering on the rock and gravel of the beach. The coating, appearing more susceptible to physical weathering than the oil, was gradually disappearing. The beach was still polluted 1 yr after spillage, with 90%-95% of the oil removed by natural processes.

452. Green, Katherine A. (1974).

THE EFFECTS OF PETROLEUM HYDROCARBONS ON ORGANISMS OF THE CONTINENTAL SHELF.

The Biologist. Vol. 56, No. 4. pp. 165-179.

This article gives an overview of the effects of petroleum hydrocarbons on organisms in the continental shelf.

453. Greenwood, J.J.D. (1970).

OILED SEABIRDS IN EAST SCOTLAND.

Mar. Poll. Bull., 1(3):35-36.

Slightly more than 8000 birds were destroyed or found dead as a result of oil pollution from 6 January to 4 February, 1970. More than 30 species were affected to some degree. Among some 2000 accurately identified from the Tay region, the most common were eider (36%), guillemot (23%) razorbills (15%), and common scoter (11%).

454. Greenwood, J.J.D., R.J. Donally, C.J. Feare, H.J. Gordon and G. Waterston. (1971).

A MASSIVE WRECK OF OILED BIRDS: NORTHEAST BRITIAN, WINTER 1970.

Scottish Birds 6:235-250.

Counts of beached birds in northeast England and east Scotland in the period 1 January to 15 February 1970 were collated. Of the 12,856 birds, 12,400 were probably killed by oil. Oil was obvious on nearly all the swimming seabirds, on most of the other wildfowl and on half of the aerial seabirds but on few of the waders. It was found in the gut of many apparently unoiled birds. Ducks tended to have fresher oil on them than auks. We conclude that heavy fuel oil, perhaps from more than one source, was discharged off the east coast, probably late in December. It was brought ashore by southeasterly winds, along with the seabirds it had affected.

455. Greenwood, J.J.D. and J.P.F. Keddie. (1968).

BIRDS KILLED BY OIL IN THE TAY ESTUARY, MARCH AND APRIL, 1968.

Scot. Birds, 5:189-196.

An account is given of the methods used to count affected birds during the oil pollution of the Tay Estuary that occurred at the end of February 1968.

The total of birds found dead, destroyed, or taken into care was 1368, most of them being Eiders. The diving birds were affected to an extent out of proportion to their numbers.

The total mortality of the Eiders was probably about 2000--though it may have been up to four times as high. This represents approximately 7% of the British population and repetition of the incident could have serious effects on the size of that population.

456. Gregory, K.G. (1970).

OILED BIRDS IN HOLLAND.

Mar. Poll. Bull. 2(2):23

On 29 December 1970 12,000 tons of oil polluted the waterways of the Biesbosds, Netherlands, oiling considerable numbers of wildfowl. Many of these were treated at a local bird-cleaning organization. Here a new mixture containing a biologically "soft" non-ionic detergent was used to remove part of the oil. Any remaining on the feathers could be rinsed away later as a stable emulsion in water. While it is to be hoped that non-ionic detergents will leave the plumage in a non-wettable condition, preliminary tests with single feathers indicate that this will not be the case. Water-soluble ionic detergents may be neutralized by certain organic amines, and the possibility of rendering feathers hydrophobic in this way is being investigated.

457. Grice, G.D., G.R. Harvey, V.T. Bewen (1972).

THE COLLECTION AND PRESERVATION OF OPEN OCEAN MARINE ORGANISMS FOR POLLUTANT ANALYSIS.

Bull. Environ. Contam. Tox. 7 125-132

This paper describes the sources of contamination that beset sampling for pollutants and the procedures adopted to avoid contamination. Data are also presented that we believe confirm that the procedures described are successful solutions to the problems posed.

458. Griffin, Lynn and J.A. Calder (1977).

TOXIC EFFECT OF WATER-SOLUBLE FRACTIONS OF CRUDE, REFINED, AND WEATHERED OILS ON THE GROWTH OF A MARINE BACTERIUM.

Appl. Environ. Microbiol. 33(5):1092-1096

The water-soluble fractions of 3 crude and 2 refined oils reduced the growth rate and maximum cell density of the marine bacterium Serratia marinorubra grown in batch culture. The weathering of a crude and a refined oil was simulated in the laboratory. The water-soluble fractions remaining from this process were more toxic to S. marinorubra than were the parent unweathered oils. Increases in the magnitude of toxic effect of 3-30 times were observed as a function of increasing the concentration in the cultures. Toxicity did not correlate with the concentration of total water-soluble fraction or of aromatic hydrocarbons in the water-soluble fraction. Affected cultures did not exhibit a residual toxicity after being back-innoculated into control media.

459. Griffith, D. de G. (1970).

TOXICITY OF CRUDE OIL AND DETERGENTS TO TWO SPECIES OF EDIBLE MOLLUSCS UNDER ARTIFICIAL TEST CONDITIONS.

FAO Tech. Conf. Mar. Pollut., Rome, pap. E-16. Also In: Marine Pollution and Sea Life, M. Ruive (ed.) FHO Fishing News (Books) Ltd. London p. 224-229.

Littorina and Mytilus were exposed to a controlled tidal regime with a slick of oil or oil and dispersant. Arabin Light crude oil was used with a wide variety of dispersants. Experiments were done at three temperatures and mortality over time was measured. No toxic effects were seen among the animals exposed to crude oil without dispersants. Toxic effects were seen with dispersants.

460. Griner, L.A. And R. Herdman. (1970).

EFFECTS OF OIL POLLUTION ON WATERFOWL: A STUDY OF SALVAGE METHODS.

Water Pollution Control Research Series 15080 EBZ, 12/70, December 1970. 35 p. EPA-WQO Program 15080 EBZ 12/70.

A study was made of salvage methods for waterfowl subjected to oil pollution. Mallard ducks were the primary test species used. Aspects of the pathology of some of the waterfowl species involved in the Santa Barbara oil slicks were also investigated.

Although some refined petroleum products contain toxic compounds, the Santa Barbara crude used as a test oil in this study produced no apparent ill effects.

Polycomplex A-11 was found to be a rapid and effective cleansing agent for the removal of oil from bird plumage. Oil on bird plumage alters feathers structures by replacing the small air pockets between barbules of the feathers, thereby decreasing buoyancy and insulation. Removal of oil from down feathers is more difficult than from the contour feathers.

Ducks and geese are more amenable to treatment and post-treatment care than are the more aquatic fowls, such as grebes, loons, auks and murres. Confinement times should be as brief as possible, as the incidence of mycotic and other infectious diseases increases under long periods of close confinement.

461. Gritz, R.L. and D.G. Shaw (1977)

A COMPARISON OF METHODS FOR HYDROCARBON ANALYSIS OF MARINE BIOTA.

Bull. Environ. Contam. & Tox. 17 408-415.

As a preliminary to measurements of hydrocarbons in marine biota of Alaska waters, we carried out a comparison of several procedures of hydrocarbon analysis. Various methods are described and compared. We judge that 24 hour saponification and column chromatography on partially deactivated columns constitute the best procedure tested.

462. Grose, P.L. and J.S. Mattson (eds.) (1977).

THE ARGO MERCHANT OIL SPILL: A PRELIMINARY SCIENTIFIC REPORT.

National Oceanic and Atmospheric Administration.

This volume represents available results from the investigations carried out by the many groups involved in the initial assessment of the impact of the "Argo Merchant" spill. Included are fisheries investigations, particularly of plankton, seabird observations, observations of marine mammals, littoral zone and near coastal zone survey, and preliminary surveys of the impact of the spill on fishing activities. Appendix VIII is published separately as a Summary Fact Sheet.

463. Gruger, E.H. Jr., M.M. Wekell, P.T. Numoto, and D.R. Craddock (1977)

INDUCTION OF HEPATIC-ARYL HYDROCARBON HYDROXYLASE IN SALMON EXPOSED TO PETROLEUM DISSOLVED IN SEAWATER AND TO PETROLEUM AND POLYCHLORINATED BIPHENYLS SEPARATE AND TOGETHER IN FOOD.

Bull. Environ. Contam. and Toxical. Vol. 17 p. 512-520.

Hepatic Aryl Hydrocarbon Hydroxylase (AHH) is induced in coho salmon exposed to 1 ppm PCB's in the diet; however, comparable experiments with 1 ppm of Prudhoe Bay crude oil did not significantly alter the AHH activities. These findings suggest that in aquatic food-chains containing both petroleum hydrocarbons and PCB's, the latter compounds may exert a predominant influence on the induction of the hepatic AHH enzyme system. Despite the lack of induction of hepatic AHH with 1 ppm Prudhoe Bay crude oil in the diet, young coho salmon exposed to 150 ppb (0.15ppm) of a seawater-soluble fraction for 6 days exhibited a significant induction of this enzyme system. Thus, crude oil components of relatively high water solubility (e.g. methylated naphthalenes and polyakylated benzenes) may be more effective than high molecular weight insoluble components in inducing AHH.

464. Guard, H.E. and A.B. Cobet. (1973).

THE FATE OF A BUNKER FUEL IN BEACH SAND, pp. 827-834.

In: Proceedings, Joint Conference on Prevention and Control of Oil Spills. American Petroleum Institute, Washington, DC.

The dispersed oil concentrations in sand from 3 San Francisco area beaches have been measured over a 143 day period following an 840,000 gallon bunker fuel spill in San Francisco Bay. The dispersed oil remaining within the beaches after cleanup was extensively weathered while visible oil globules exhibited only minor weathering. Elevated levels of chloroform-extractable material were observed at 2 sampling locations following the spill. The background levels of chloroform-extractable materials determined from log-normal distribution analysis were tenfold higher on bay beaches than on ocean beaches. Laboratory experiments indicated that in a beach system evaporation, dissolution, and microbial degradation combine to remove the lower molecular weight fractions of bunker fuel. A major effect of the beach is to disperse the oil. This dispersal has been shown to greatly enhance the effect of dissolution on the composition of bunker fuel. While the effect of exposure to water on the composition of a bunker fuel slick is minimal, significant amounts of the lower ends of bunker fuel (which is highly dispersed) in a sand column are removed by dissolution.

465. Guard, H.E., L. Hunter and L.H.D. Salvo (1975).

IDENTIFICATION AND POTENTIAL BIOLOGICAL EFFECTS OF THE MAJOR COMPONENTS IN THE SEA WATER EXTRACT OF A BUNKER FUEL.

Bull. Environ. Contamination and Toxicology. 14(4):395-400.

Report on the composition of the seawater extract of a bunker fuel similar to that spilled in San Francisco Bay, 1971, including some observations on its effect upon a crab species, *Pachygrapsus crassipes*.

466. Gudin, C. and K.W.A. Chater (1977).

ISOLATION OF *TRICHODERMA HARZIANUM* (RIFAI) GROWING ON FERRIC HYDROXIDE MUD IMPREGNATED WITH GAS OIL.

Environmental Pollution 14 1-4.

In northern France, gas oil-impregnated ferric hydroxide mud was found to support fungal frowth. The fungus was identified by the

Commonwealth Mycological Institute, Kew, with whom a reference culture has been registered.

Experiments indicated that its growth resulted from the biodegradation of the gas oil.

It is believed that, in this unusual situation, contaminating hydrocarbons may be removed from the environment by microbial activity.

467. Guertin, D.L. and H.W. Gerarde. (1959).

TOXICOLOGICAL STUDIES ON HYDROCARBONS.

Arch. Ind. Health, A.M.A. 20:262-265.

An ultraviolet spectrophotometric method has been described for the quantitative determination of benzene and alkylbenzenes in blood. The procedure involves hemolysis of the sample and subsequent extraction of the hydrocarbon with cyclohexane. The ultraviolet absorption spectrum of the cyclohexane solution is recorded, and the concentration of aromatic is determined by reference to previously prepared calibration curves. The method has been applied to the determination of a number of alkylbenzenes and kerosene, used in a systematic study of the rates of absorption and elimination of these types of hydrocarbons from the blood stream of experimental animals. This work will be described in a future publication.

468. Gunkel, W. (1968).

BACTERIOLOGICAL INVESTIGATIONS OF OIL-POLLUTED SEDIMENTS FROM THE CORNISH COAST FOLLOWING THE TORREY CANYON DISASTER.

In: Biological Effects of Oil Pollution on Littoral Communities, Supplement to Volume 2 Field Studies, J.D. Carthy and D.R. Arthur, (eds.) Field Studies Council.

Samples were taken from oiled beaches three months after the Torrey Canyon accident. The samples were analyzed for oil-decomposing bacteria by placement on hydrocarbon substrates and observing the bacterial populations by turbidity. All twenty three samples taken proved to contain high numbers of oil decomposing bacteria and proteolytic bacteria, even those taken in areas where there was extensive use of emulsifiers.

469. Gunkel, W. 1973.

DISTRIBUTION AND ABUNDANCE OF OIL-OXIDIZING BACTERIA IN THE NORTH SEA. PP. 127-140.

In: The Microbial Degradation of Oil Pollutants. Ahearn and Meyers, (eds.) Center for Wetland Resources, LSU, Baton Rouge, La., Publ. No. LSU-SG-73-01.

Investigations include distribution of oil-oxidizing (and total heterotrophic bacteria) in the waters, surface films, sediments and beach sands of the North Sea in the vicinity of Helgoland and in the River Elbe estuary. Microbial concentrations in unpolluted samples, as great as 10^9 per liter of sediment, are reported.

470. Gunkel, W. (1973).

SOME REFLECTIONS ON THE BIODEGREDATION OF MINERAL OILS IN THE MARINE ENVIRONMENT.

Inputs, Fates, and Effects of Petroleum in the Marine Environment. Background information for the Workshop, Ocean Affairs Board, NSF, 21-25 May 1973 Airlie, Va. National Science Foundation.

Discussion of the difficulties in studying microbial degredation of oil.

471. Gunnerson, C.G. and G. Peter (1976).

THE "METULA" OIL SPILL. U.S. DEPT. OF COMMERCE, NOAA SPECIAL REPORT. 42 p.

Available from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402

In August 1974 the supertanker "Metula" ran aground in the Strait of Magellan and spilled over 50,000 tons of light Arabian crude oil. The spill was not contained and the oil was carried over large segments of beaches and tidal marshes of Tierra del Fuego and deep into the estuaries of the area. This report summarizes the findings of a team of scientists from the United States and Chile who investigated the environmental damage in August 1974 and January 1975. Future research needs are also described. Appendix B contains abstracts of the reports on the "Metula" oil spill. Complete texts of these reports are on microfiche and are included with this report.

472. Gutsell, J.S. (1921).

DANGER TO FISHERIES FROM OIL AND TAR POLLUTION OF WATERS.

Rep. U.S. Commiss. Fish. (1921) App. 7, 8 p.

473. Hadley, A.H. (1930).

OIL POLLUTION AND SEABIRD FATALITIES.

Bird Lore, 32, 241-243.

474. Hadley, D. (1977).

INTRA- AND INTER-SPECIFIC VARIABILITY IN TOLERANCE OF SOUTHERN CALIFORNIA LITTORINA PLANAXIS AND LITTORINA SCUTULATA TO PETROLEUM.

Environmental Research.

475. Hagstrom, Berndt E. and Sunniva Lonning (1977)

THE EFFECTS OF ESSO COREXIT 9527 ON THE FERTILIZING CAPACITY OF SPERMATAZOA.

Marine Pollution Bulletin 8:6 136-138

The water-soluble oil dispersant Esso Corexit 9527 has earlier been found to interfere, even in low concentrations, with fertilization and development. Further studies of the effect on sea urchin spermatozoa demonstrate that Corexit 9527 exhibits detrimental biological effects in concentrations down to 0.0003 ppm.

476. Halstead, B.W. (1972).

TOXICITY OF MARINE ORGANISMS CAUSED BY POLLUTANTS.

In: Marine Pollution and Sea Life, M. Ruiva (ed.) Food and Agriculture Organization, United Nations, Fishing News (Books) Ltd. pp. 584-594

This paper discusses how chemicals affect the quality of marine products and possibly thereby human health. Several pollutants are discussed with a short section on petroleum.

477. Hann, R.W. Jr. (1974).

VLCC "METULA" OIL SPILL.

Report to U.S. Coast Guard, Texas A&M University. (NTIS).

This report summarizes the history and environmental impact of the grounding of the VLCC "Metula", August 1974, on Satellite Patch Shoal in the Strait of Magellan, Chile.

478. Hann, R.W. Jr. (1975).

FOLLOW-UP FIELD SURVEY OF THE OIL POLLUTION FROM THE TANKER "METULA".

Final Report USCG-D-166-75. 59 pp. NTIS AD-A017 100/9GA.

The team found that over 128 kilometers or 80 miles of beach have evidence of METULA oil impact. It is the author's judgement that a majority of the oil which came ashore in August and September is still ashore. This would amount to some 20,000 tons of oil. This oil will continue to erode, leach into the water or be flushed from the estuaries and will be a chronic source of pollution for a long time to come. There appears to be substantial biological impact of the intertidal marine life, but the effect on other marine organisms is hard to determine. The oil spill is still having a detrimental effect on marine waterfowl and will continue to do so as long as unstablized oil or mousse is located at the top of the beach zone and in estuarine areas and as long as contaminated mussels are used as a food source.

479. Hann, R.W. Jr. (1977).

FATE OF OIL FROM THE SUPERTANKER METULA.

In: 1977 Oil Spill Conference Proceedings p. 465-468, API Pub. 4284, Amer. Petrol. Inst., Wash. D.C.

The supertanker Metula ran aground August 9, 1974 in the Strait of Magellan spilling a total of 51,500 tons of light Arabian crude oil and 2,000 tons of Bunker C fuel oil. This article reports the observation of the author on the fate of the oil 5 months and 17 months after the spill with regard to the marine life in the beach and intertidal zone and the weathering of the oil and physical changes in the impacted ecological systems.

The magnitude of the Metula spill coupled with the absence of any cleanup activity has made the spill serve a valuble role as a test system for observing recovery from a major spill in a cool climate.

480. Hann, R.W., Jr., and W.P. James (1974).

A SURVEY OF THE ECONOMIC AND ENVIRONMENTAL ASPECTS OF AN ONSHORE DEEPWATER PORT AT GALVESTON, TEXAS, PART II: ENVIRONMENTAL CONSIDERATIONS.

Texas A&M University Sea Grant Publication TAMU-SG-74-214.. 51pp.

The development of a deep draft port for the Galveston area is a project with broad implications for the environment. A framework was established for a comprehensive environmental study which should be undertaken in the early stages of planning for the proposed port. An environmental assessment matrix was followed which identified the project activities such as construction, operation, and maintenance for the offshore, Galveston Bay entrance, and terminal areas, as compared with environmental elements such as physical, chemical, geological, biological, and cultural features. Major environmental issues included effects on the Galveston Bay - Gulf interchange, removal of the established bottom in the offshore area, dredged material disposal, sediment transport changes, better oil spill control and containment in the harbor area, and the exponential increase in environmental change with the increasing depth of the project.

481. Hardy, J.P.L. (1967).

SEA POLLUTIONS BY HYDROCARBONS AND ITS BIOLOGICAL CONSEQUENCES.

Penn Ar Bed, 6(50), 123-128.

Reviews the sources of oil pollution of the sea and indicates the extent of such pollution throughout the world, including certain European coasts which suffer from chronic pollution. The effects of oil pollution are discussed, including lowering of the surface tension of the water, inhibition of gas exchange, and toxicity to algae, marine organisms, and sea birds. (Sinha-OEIS)

482. Hardy, R., P.R. Mackie, K.J. Whittle and A.D. McIntyre (1974).

DISCRIMINATION IN THE ASSIMILATION OF N-ALKANES IN FISH.

Nature, London, 252 577-8.

Kuwait crude oil was fed to cod (Gadus). After six months feeding, the tissues were analyzed for hydrocarbon control. There were marked differences between oiled and control groups though the hydrocarbon pattern in the oiled group did not resemble that of Kuwait crude. The apparent discrimination indicated by the liver analyses in the presence of a specific alkane array in the diet demonstrates that it is unlikely that a simple comparison of tissue analyses with those of extraneous hydrocarbon source will suffice to identify the source of the tissue alkanes.

483. Harger, J.R.E. and D. Straughan. (1972).

BIOLOGY OF SEA MUSSELS (MYTILUS CALIFORNIANUS (CONRAD) AND M. EDULIS (LINN.)) BEFORE AND AFTER THE SANTA BARBARA OIL SPILL (1969).

Water, Air, and Soil Pollut. Vol. 1:381-388.

Effects of the 1969 Santa Barbara oil spill on sea mussels were investigated by comparing biomass characteristics of mussel populations in polluted and clean areas before, during, and after the discharge. Animals in exposed areas were not significantly lighter in body weight than those in clean areas. Likewise no deleterious effect in the form of lowered body weights could be detected in mussels from polluted areas in three successive years subsequent to the oil spill. It is noted that the spill in question occurred at a time of minimal growth on the part of the sea mussels involved and that an adverse response might have resulted if the oil had washed ashore during a period of heightened growth. The technique employed makes reference only to living organisms, therefore no comment is made with respect to incurred mortality patterns.

484. Hargrave, B.T. and C.P. Newcombe. (1973).

CRAWLING AND RESPIRATION AS INDICES OF SUBLETHAL EFFECTS OF OIL AND A DISPERSANT ON AN INTERTIDAL SNAIL LITTORINA LITTOREA.

J. Fish. Res. Bd. Can., 30:1789-1792.

Crawling and respiration rates of the snail Littorina littorea are increased in the presence of Bunker C oil and decreased with brief exposure to a low toxicity dispersant (Corexit 8666) in sea water at 20C. The addition of the dispersant to an oil:seawater mixture also decreases both crawling and respiration. Behavioral traits, such as crawling, and physiological indices, such as respiration, may be sensitive measures of sublethal effects of pollutants on organisms.

486. Harris, R.P., V. Berdugo, E.D.S. Corner, C.C. Kilvington, and S.C.M. O'Hara (1977)

FACTORS AFFECTING THE RETENTION OF A PETROLEUM HYDROCARBON BY MARINE COPEPODS.

In: Fate and Effects of Petroleum Hydrocarbons and Organisms In Marine Ecosystems and Organisms. New York: Pergamon Press

^{14}C-1-Naphthalene was used as a model compound to study the retention of an aromatic hydrocarbon by marine planktonic copepods during 24-hour exposure experiments. Seven species were investigated, including representative estuarine, neritic and oceanic forms. Naphthalene concentrations varied from 0.2 to 1000 μg/l, a range including those that might occur temporarily under an oil spill.

Significant positive correlations were demonstrated between naphthalene retention and copepod size measured as dry weight and total lipid content; but a negative correlation was observed with temperature, and retention was diminished in animals starved for progressively longer periods. Amounts of the hydrocarbon absorbed on the surfaces of the animals appeared to be only a small fraction of the totals accumulated.

Supplementing the quantity of ^{14}C-1-naphthalene in solution with a relatively small amount as suspended food led to a marked increase in radioactivity in the animals. In addition, studies on the fate of naphthalene ingested by male and female Calanus helgolandicus during feeding for 24 hr on a plant diet showed that, compared with bulk constituents of normal foodstuffs, the hydrocarbon was more readily assimilated. About half the assimilated fraction was released in soluble form during feeding, either as unchanged hydrocarbon or metabolites, and the other half retained. There was no evidence that the size of the portion retained varied with the sex of the animal.

Upon transfer of the animals to clean seawater following exposure exponential depuration was observed, but in the case of Eurytemora affinis radioactivity accumulated by nauplius I was still detectable in the resultant adults 34 days later.

487. Harris, R.P., V. Berdugo, S.C.M. O'Hara, and E.D.S. Corner, (1977)

ACCUMULATION OF ^{14}C-1-NAPHTHALENE BY AN ESTUARINE AND AN OCEANIC COPEPOD DURING LONG-TERM EXPOSURE TO LOW-LEVEL CONCENTRATIONS.

Mar. Biol. 42 187-195.

Accumulation of the bi-cyclic aromatic hydrocarbon ^{14}C-1-naphthalene in adult female Calanus helgolandicus and adult female Eurytemora affinis in sea water concentrations of hydrocarbon ranging from .2 to 992 ug/l was studied during exposure periods of up to 15 days as part of an investigation of the possible effects on marine zooplankton of persistant exposure to low levels of petroleum hydrocarbons.

488. Harrison, E.H. (ed.) (1975).

BIOINDICATORS OF POLLUTION (A BIBLIOGRAPHY WITH ABSTRACTS).

National Technical Service, Springfield, Va. 124 pp. NTIS/PS-75/796.

The bibliography includes reports that discuss the use of microorganisms, animals, plants, and fishes to detect air and water pollution. It includes 119 references.

489. Harrison, E.A. (1976).

THE BIOLOGICAL EFFECTS OF OIL SPILLS (A BIBLIOGRAPHY WITH ABSTRACTS).

NTIS/PS-76-0033/1, 147 pp.

This bibliography contains 142 selected abstracts of Government-sponsored research reports on all aspects of biological and ecological effects of oil spills in salt and fresh water. The effects on microorganisms, plants, and animals are covered along with research on the residues and metabolic products of various oil components. (This updated bibliography contains supersedes NTIS/PS-75/118 and contains 35 new entries.)

See also entry #488

490. Harrison, J.G. (1967).

OIL POLLUTION FIASCO ON THE MEDWAY ESTUARY.

Birds, 1 134-131

491. Hartung, R. (1963).

INGESTION OF OIL BY WATERFOWL.

Papers of the Michigan Academy of Science, Arts, and Letters. 48:49-55.

When ducks come into contact with polluting oils, in all probability some of this oil is ingested. It has been determined that the ingestion of a sufficiently high dose of a certain cutting oil will result in reduction of mobility. The available evidence indicates that some oils can have toxic effects upon waterfowl, and may under certain circumstances be a definite factor in waterfowl mortalities. The toxicological effects of ingested oils on waterfowl, however, definitely bear further investigation.

492. Hartung, R. (1965).

SOME EFFECTS OF OILING ON REPRODUCTION OF DUCKS.

J. Wildl. Mgmt. 24:872-874.

After ingestion of 2 gm/kg of a relatively nontoxic lubricating oil, one mallard (Anas platyrhynchos) and two Pekins stopped laying for about 2 weeks. Very small quantities of oil coated on mallard eggs reduced their hatchability to 21 percent compared to 80 percent found for unoiled mallard eggs. Experimentally oiled mallards continued incubating their clutches, but their eggs did not hatch even though they continued incubation for longer than normal periods.

493. Hartung, R. (1965).

SOME EFFECTS OF OILS ON WATERFOWL.

Diss. Abstr., 25, 6866.

494. Hartung, R. (1967).

ENERGY METABOLISM IN OIL COVERED DUCKS.

J. Wildl. Mgmt. 31:798-804.

The metabolic rates of ducks covered with known quantities of oils were measured indirectly by determining total quantities of exhaled carbon dioxide. Metabolic rates increased linearly with decreasing ambient temperatures. Regression analyses of the metabolic rate--temperature plots made it possible to assess the heat conductivities of normal and oiled duck plumages. A dose-response curve could be established for the effects of oiling on the estimated heat conductivity. The lower lethal temperature for oiled and normal ducks could not be determined and was less than -26°C. Mortalities at those temperatures appear to be delayed until fat reserves are used up. The usual reduction in food intake by oiled ducks in conjunction with sharply increased metabolic rates can result in an "accelerated starvation". Recovery toward normal metabolic rates after oiling was observed.

495. Hartung, R. and G.S. Hunt. (1966).

TOXICITY OF SOME OILS TO WATERFOWL.

J. Wildl. Mgmt., 30:564-570.

A number of industrial oils were tested for their toxic effects on waterfowl. All oils were able to cause lipid pneumonia, gastrointestinal irritation, fatty livers, and adrenal cortical hyperplasia when fed to ducks in single doses by stomach tube. Feeding of a cutting oil and a diesel oil also resulted in acinar atrophy of the pancreas. The diesel oil and a fuel oil produced toxic nephrosis in a number of animals. Feeding the cutting oil produced a definite inhibition of cholinesterase activity while the diesel oil depressed cholinesterase activity only slightly. Approximate LD_{50} values were determined for a number of oils under different environmental conditions. Gross examination of a series of 41 ducks which had been killed by oil pollution in the wild showed, at autopsy, changes similar to those encountered in the experimentally fed ducks. It was concluded that the toxicity of polluting oils is a definite factor in the observed mortalities due to oil pollution.

496. Harvey, G.R. and J.M. Teal. (1970).

PCB AND HYDROCARBON CONTAMINATION OF PLANKTON BY NETS.

Bull. Environ. Contam. Toxicol. 9:287-290.

Report on the contribution of nylon plankton tow-nets to the level of hydrocarbon and PCB in the samples taken.

497. Hay, K.G. (1974).

OIL AND THE SEA. THE ECOLOGICAL IMPLICATIONS OF A CONTROVERSIAL INVASION.

Marine Technology Society. Journal, 8(1):19-20.

An in-depth study by the API on the fate and effects of oil spills determined that biological damage to an ecosystem depends on the type of oil spilled, biota of the area, the dose of oil, the physiography of the area, the season, weather conditions, previous exposure to other pollutants, and treatment of the spill. Oil may be assimilated by marine organisms, such as shellfish, shrimp and fin fish with the effects dependent on the particular species, its stage of growth and amount and kind of oil. Brine shrimp absorbed and purged aromatic hydrocarbons in a matter of hours. No metabolization of the oil fractions occurred. Fish metabolized these hydrocarbons and excreted the by-products in their urine. Oysters depurated the hydrocarbons within a few days when returned to an oil-free environment. No oil spill has resulted in any permanent damage to the environment. In most spills, biological recovery is achieved within a few generations involving 1 yr.

498. Hawkes, A.L. (1961).

A REVIEW OF THE NATURE AND EXTENT OF DAMAGE CAUSED BY OIL POLLUTION AT SEA.

Trans. North Am. Wildl. Conf. 26:343-355.

The principal source of oil pollution of the sea is shipping. Oil is spread from ships when taking on fuel, pumping bilges, and washing tanks. Much oil is also lost through leaking hulls. Ship casualties such as groundings cause the most damaging spills of oil. Oil drilling and natural seepage are two less significant causes of oil pollution of the sea.

Some of the potential hazards and consequences of oil pollution are fire, poisoning of animal life, upsetting of oceanic food chains, mechanical fouling of animals, pollution of beach and resort areas, fouling of boats, tainting of fin fish and shellfish, interference with navigation, damage from some removal techniques, degradation of oceanic waters as a source of industrial and domestic water supply, and repellent effects on marine fauna.

Financial losses as a consequence of marine oil pollution stem from loss of valuable natural resources, loss of revenue to resort areas, loss of time and revenue for cleaning operations on commercial fishing gear, loss to sources responsible for the pollution, costs to local and state governments for cleaning shorelines and property, costs of investigations, costs of prosecution. Intangible losses may be even greater than those mentioned.

499. Heidelberger, Charles. (1970).

STUDIES ON THE CELLULAR AND MOLECULAR MECHANISM OF HYDROCARBON CARCINOGENESIS.

Europ. J. Cancer. 6:161-172.

The author has reviewed his research carried out over the past 20 years concerned with the cellular mechanisms of hydrocarbon carcinogenesis. The interaction of labeled carciongenic hydrocarbons with the DNA, RNA, and protein of mouse skin has been studied at various times after topical application, and the results correlated with the carcinogenic process. A quantitative system, employing cells derived from C3H mouse ventral prostate, has been developed for obtaining malignant transformation in vitro with carcinogenic hydrocarbons. A mechanism involving the selection of preexisting malignant cells by the carcinogen has been ruled out with this system.

500. Heitz, James R., et al. (1974).

THE ACUTE EFFECTS OF EMPIRE MIX CRUDE OIL ON ENZYMES IN OYSTERS, SHRIMP AND MULLET.

In: Pollution and Physiology of Marine Organisms. pp. 311-328.

This study indicates that acute oil exposures to aquatic animals have few effects on the enzymes studied. The enzyme changes seen in the oyster may represent a compensation response which often occurs when animals are exposed to toxicants. Based on this study, other enzymes might serve as more sensitive indicators of oil exposure, such as those involved in fatty acid metabolism and/or detoxification. With information from an expanded study a more complete understanding of the impact of oil on marine organisms will be possible.

501. Hellebust, J.A., B. Hanna, R.G. Shenth, M. Gergis, and T.C. Hutchinson (1975).

EXPERIMENTAL CRUDE OIL SPILLS ON A SMALL SUBARCTIC LAKE IN THE MACKENZIE VALLEY, N.W.T.: EFFECTS ON PHYTOPLANKTON, PERIPHYTON, AND ATTACHED AQUATIC VEGETATION.

In: Conference on Prevention and Control of Oil Pollution. pp. 509-516., Amer. Petrol. Inst.

Experimental crude oil spills were made in 3-m^2 cylinders in open water, and in submerged moss, horsetail, and sedge communities of a small subarctic lake in the Mackenzie Valley, near Norman Wells, N.W.T. Studies were made of the effects of crude oil on phytoplankton, periphyton, and attached macrophytes in terms of population composition, seasonal succession, and biomass. The presence of crude oil (15 liters m^{-2}) had no significant effects on phytoplankton composition or abundance throughout the growth season but had a marked inhibitory effect on most members of the periphyton. One notable exception to this observation was a considerable growth stimulation of the blue-green alga *Oscillatoria angustissima*.

Laboratory studies on the effects of aqueous crude oil extracts on growth and photosynthesis of algal cultures isolated from the lake showed strong inhibition under most combinations of light and temperature. The inhibition of both growth and photosynthesis appeared minimal when the algae were grown under optimal conditions of light and temperature. The effects decreased with time in open culture systems, i.e. when evaporation was freely allowed.

Crude oil caused an immediate reduction in chlorophyll content of macrophytes upon contact, and significant decreases in biomass were evident in follow-up studies of experimental oil spills in macrophyte communities.

502. Hepple, P. (ed.) (1971).

WATER POLLUTION BY OIL.

Proceedings of a Seminar Sponsored by Institute of Water Pollution Control. Institute of Petroleum, and World Health Organization. Institute of Petroleum Engineers. 399 pp.

Problems of petroleum and water pollution control are discussed at length. Various major oil spills at sea, their effects and clean-up methods utilized are included. Oil pollution control for inland waters, refineries, pipelines, storage units, industry, sewers and treatment plants is also discussed.

503\. Hershner, C. and K. Moore (1977)

EFFECTS OF THE CHESAPEAKE BAY OIL ON SALT MARSHES OF THE LOWER BAY.

In: Proceedings 1977 Oil Spill Conference. p. 529-533. Amer. Petrol. Inst., Wash., D.C.

A study to determine the effects of the Chesapeake Bay oil spill of February 1976, and of the subsequent cleanup operations was conducted on the eastern shore of the Bay. The primary objective was to assess the biological impact on the marshes at the population level. Populations of intertidal mussels, *Modiolus demissus*, and oysters, *Crassostrea virginica*, showed no significant short-term effects. The popoulation of the snail, *Littorina irrorata*, was significantly reduced, but appears to be recovering well. The dominant marsh grass *Spartina alterniflora* showed increased net productivity as measured by standing crop, increased density, decreased mean height, and increased flowering success. Hypotheses to explain these observations are discussed. The impact of the spill on the marshes is thought to have been minimized by virtue of the relatively low toxicity of the oil, the time of year the spill occurred, and the comparatively high energy environment of the shoreline. (VIMS contribution number 718)

504\. Hertz, H.S., S.N. Chester, W.E. May, B.H. Gump, D.P. Enagonio, and S.P. Cram (1974).

METHODS FOR TRACE ORGANIC ANALYSIS IN SEDIMENTS AND MARINE ORGANISMS.

In: *NBS Special Publication 409, Marine Pollution Monitoring (Petroleum). Proceedings of a Symposium and Workshop Held at NBS, Gaithersburg, Maryland, May 13-17, 1974*. National Bureau of Standards. pp. 197-199.

Analytical methods are described for the determination in the parts per billion range, of aromatic hydrocarbons in sediment and organism samples from Prince William Sound, Alaska. The method involves headspace sampling by a stream of purified nitrogen and trapping on a TENAX pre-column in preparation for gas chromatography. This outgassing and trapping technique has the advantages of minimal sample handling; being a closed system; efficient separation and concentration of constituents; the fact that only water is added to the sample; the sample ending up in a form free of solvents, and the fact that even reasonably non-volatile hydrocarbons can be outgassed.

505\. Hertz, H.S., W.E. May, S.N. Chester, and B.H. Gump (1976).

PETROLEUM ANALYSIS: METHODOLOGY FOR QUANTITATIVE AND QUALITATIVE ASSESSMENT OF OIL SPILL.

Environmental Science and Technology, *10*(9):900-913.

An integrated chromatographic technique for petroleum analysis compatible with long-term studies of oil spills was presented. Dynamic headspace sampling and the complementary analytical techniques of gas chromatography and coupled-column liquid chromatography were utilized for quantitation of petroleum-containing samples. Gas chromatography-mass spectrometry was employed for identification of individual components in these samples. Analytical data obtained from a major oil spill were presented and discussed.

506. Hester, F.J. (1976).

LABORATORY BIOLOGICAL STUDIES: MAKING THEM APPROPRIATE FOR PREDICTING THE EFFECTS OF OFFSHORE OIL AND GAS PRODUCTION.

In: Eighth Annual Offshore Technology Conference: 1976 Proceedings: Bol 2. pp. 37-44.

The worldwide problem of assessing the environmental impact of oil and gas exploration by laboratory studies is examined. Widely referenced papers used in environmental impact reports are reviewed in light of more recent studies for applicability to the oceanic environment. Conclusions based on the older methods and studies should be revised. Some potential effects may be less likely to occur than previously indicated. Acute toxicity studies and sublethal effects studies are discussed. The responsibilities of laboratory scientists to make their work appropriate for predicting environmental effects are discussed with respect to proper methodology, study design, objectivity, peer review, and accessibility. Researchers should avoid second-hand references, use review papers cautiously, report objectively, identify speculation, and use recent references.

507. Heyerdahl. T.

ATLANTIC OCEAN POLLUTION AND BIOTA OBSERVED BY THE "RA" EXPEDITIONS.

Biol. Conserv., 3(3):164-167.

On two voyages virtually across the Atlantic Ocean in papyrus raft-ships in 1969 and 1970, surface pollution was observed from very close quarters. Visible pollution was recorded during six days of the eight weeks' sailing in 1969 and on forty of the first forty-three days of sailing in 1970, although the remainder of that voyage was in relatively clean water. The pollution was mainly in the form of floating asphalt-like material, mostly in tiny lumps but sometimes up to fist size, though other forms were also observed. The older lumps were often beset with living barnacles and algae, while quantities of dead coelenterates were in some places observed floating among them. Continued indiscriminate use of the world's oceans as a dumping ground for durable human waste seems likely to have very serious and perhaps irreversible effects on their productivity.

508. Hidu, H. (1965).

EFFECTS OF SYNTHETIC SURFACTANTS ON THE LARVAE OF CLAMS (_M. MERCENARIA_) AND OYSTERS (_C. VIRGINICA_).

J. Wat. Poll. Control Fed., 37: 262-270.

The results of these experiments on the effect of eight synthetic surfactive agents on clam and oyster larvae indicate the following:

1. Development of fertilized eggs and growth and survival of fully-formed veliger larvae of clams and oysters was reduced by concentrations of surfactants between 0.01 and 5.00 mg/l of active ingredient, depending on the surfactant used. The mean concentration producing such a reduction was 1.23 mg/l;

2. The cationic surfactants, lauryl pyridinium chloride (C-2) and a quarternary ammonium compound (C-1), were the most toxic. The mean of the minimum concentrations causing a significant reduction in development of fertilized eggs and survival and growth of veliger larvae was 0.30 mg/l. The range of minimum test concentrations causing these reductions was 0.01 to 1.00 mg/l;

3. The anionic surfactants, three alkyl aryl sulfonates (AAS-1, AAS-2, and AAS-3) and one alkyl sulfate (AS-1), were intermediate in toxicity. The mean minimum concentration causing a reduction in growth and survival was 1.15 mg/l and the range was 0.14 to 3.00 mg/l;

4. The nonionic surfactants, two alkyl polyether alcohols (N-1 and N-2), were least toxic. The mean minimum concentration causing a reduction in growth and survival was 2.33 mg/l and the range was 1.00 to 5.00 mg/l;

5. Clam larvae were less sensitive to surfactants than were oyster larvae. The mean minimum concentration for all detergents required to reduce significantly growth and survival of clam larvae was 1.44 mg/l, while that for oyster larvae was 1.02 mg/l;

6. Reduction in the rate of growth of larvae of clams and oysters occurred at lower concentrations, in most cases, than those required to produce mortality. In acute toxicity tests development of fertilized eggs was always halted at lower surfactant concentrations than those producing mortality of fully-formed veliger larvae within 48 hr; and

7. Concentrations of surfactant detrimental to clam and oyster larvae may be reached in certain commercial shellfish habitats. This study should be augmented by determination of surfactant levels encountered over shellfish beds. Bioassay methods could be used to determine possible modification of the effect of these compounds by the widely variant ecological factors found in nature.

509. Hnatiuk, J. (1976).

RESULTS OF AN ENVIRONMENTAL RESEARCH PROGRAM IN THE CANADIAN BEAUFORT SEA.

In: Eighth Annual Offshore Technology Conference: 1976 Proceedings: Vol. 1: Offshore Technology Conference, 1976. pp. 221-234.

The results of a multi-million dollar environmental research program consisting of 33 wildlife, biological, oceanographic, meteorological, sea ice, and oil clean-up studies related to the southern Beaufort Sea are presented. The studies were designed to provide ecological baselines, a better understanding of the physical environment, knowledge related to the consequences of a possible oil spill, and means of oil clean-up in ice-infested water. Seasonal offshore drilling in the sea from a floating vessel was approved in principle and scheduled to begin during the open water period of 1976. The results of the studies will be used to recommend operating constraints to safeguard the environment and minimize any adverse impact. A unique feature of the program was its joint government-industry nature. Government agencies coordinated the program with funding, management, and scientific input from oil industry personnel. The 2-yr program was completed by the end of 1975, and reports become available in early 1976. The hostile environment, research scope, research methods, and study results are provided. An important phase of the program is public interface to inform northern natives, government, and those with environmental concerns about the program and study results.

510. Hodson, R.E., F. Azom, and R.F. Lee (1977).

EFFECTS OF FOUR OILS ON MARINE BACTERIAL POPULATIONS: CONTROLLED ECOSYSTEM POLLUTION EXPERIMENT.

Bull. Mar. Sci. 27 119-126. Also available from National Technical Information Service. PB-270 146/45L.

The effects of four oils (Louisiana crude, Kuwait crude, No 2, and Bunker C) on heterotrophic uptake and mineralization of D-glucose-14C by 1 microgram - filterable microbial populations were examined in a controlled ecosystem pollution experiment in Saanich Inlet, British Columbia, Canada. The four oils inhibited D-glucose uptake and mineralization; the degree of inhibition was dependent on oil type and concentration. The two processed oils were more toxic than the crude oils tested. Low concentrations of Bunker C stimulated bacterial metabolism. Oil tolerance acquisition was not observed. Data suggest that concentrations of these oils in seawater above 300 micrograms/l can significantly inhibit marine bacterial activity.

511. Hoehn, R.C., J.R. Stauffer, M.T. Masnik and C.H. Hocutt. (1974).

RELATIONSHIPS BETWEEN SEDIMENT OIL CONCENTRATIONS AND THE MACROINVERTEBRATES PRESENT IN SMALL STREAM FOLLOWING AN OIL SPILL.

Environmental Letters. 7(4):345-352.

A study was conducted to assess the effects of an oil spill on the macro-invertebrate popoulations in a small creek in Virginia. Sediments were extracted with hexane, and the residue concentrations were correlated with the numbers and diversities of macroinvertebrates collected downstream of the spill. Based on the available data, it was concluded that the effect of the oil spill was a toxic one rather than one of rendering the sediments unsuitable for colonization.

512. Holcomb, R.W. (1969).

OIL IN THE ECOSYSTEM.

Science 166:204-206.

Review article discussing inputs and fates of oil, primarily in the marine environment, and describing the effects of oil on the Biota.

513. Holme, N.A. 1969.

EFFECTS OF "TORREY CANYON" POLLUTION ON MARINE LIFE, PP. 1-3.

In: Oil on the Sea
D.P. Hoult (ed.). Plenum Press., 3 p.

The "Torrey Canyon" stranded on the Seven Stones Reef off of Lands End on March 18, 1967. Initially, about 30,000 tons of oil escaped and drifted up the English Channel to Guernsey and the north coast of France. During the next week, some 20,000 tons escaped and polluted the west Cornish coast. On March 26, the ship broke her back and released 50,000 tons which drifted south into Biscay. The wreck was bombed on March 28-30, the remaining 20,000 tons being either burned or released into the sea.

Off the Cornish coast, the oil was sprayed with detergents, chiefly BP 1002. Emulsification was for the most part incomplete, and the toxic detergent killed many limpets, resulting in a great increase of the green weed on which the limpets browse. There were no effects on plankton or fisheries. The oil itself was lethal to seabirds, but killed shore animals and plants only when thick enough to smother them.

Because of the important shore shellfisheries, the French did not use detergents, but relied instead upon mechanical methods of cleaning up using straw. Natural chalk ($CaCO_3$) with an additive of stearic acid to make it oleophilic and hydrophobic, was used to disperse or sink the oil. There was no evidence that the sunken oil later fouled fishing gear, or was washed up on the beach.

514. Holmes, R.W. 1969.

THE SANTA BARBARA OIL SPILL, PP. 15-27.

In: D.P. Hoult, Ed. Oil on the Sea, Plenum Press, New York.

A description if given of the blowout at Union Oil Platform A starting January 28, 1969, including a review of the actions taken to clean the spill and an overview of the damage caused to the biota.

The animals suffering the most were the birds, particularly the diving species. The survival rate of treated birds was only 10 to 12%. A number of large mammals and their young were reported dead, but causes of death could not be positively established in most cases. Surveys of zooplankton, fish eggs, and fish larvae indicated little damage to these populations. In Goleta Bay, which was not as heavily contaminated as many local areas, entire plant and animal communities were killed by a layer of encrusting oil some 2 cm thick. No recolonization of either plants or animals in these particular areas was observed by the author. Although oil was trapped in massive quantities in the kelp beds, it did not seem to cause appreciable damage.

Floating oil affects the coupling between the winds and the sea surface, prevents evaporation, inhibits gaseous exchange between the atmosphere and the sea, changes the albedo of the sea surface, and modifies the quality and amount of solar radiation penetrating the sea surface.

515. Horn, M.H., J. Teal, and R. Backus. (1970).

PETROLEUM LUMPS ON THE SURFACE OF THE SEA.

Science, 168;245-246.

Lumps of crude oil residue floating on the sea surface have been observed widely. Samples were taken with surface-skimming nets in the Mediterranean Sea and eastern North Atlantic Ocean; their displacement volumes were as large as 0.5 ml/m^2. An isopod, *Idotea metallica*, appears to be associated with the lumps, and a barnacle, *Lepas pectinata*, grows upon them. Lumps were found in stomachs of *Scomberesox saurus*, a surface-feeding fish important in ocean food webs. Films on the lumps, presumably consisting mostly of bacteria, consumed oxygen at the rate of 4 $mm^3/hr/cm^2$ of lump surface. Chemical analysis suggested that certain lumps had been at large for only a few weeks; data from barnacle size and growth rate suggested that other lumps were at least 2 months old.

516. Horowitz, A., D. Gutnick, and E. Rosenberg (1975).

SEQUENTIAL GROWTH OF BACTERIA ON CRUDE OIL.

Applied Microbiology, 30(1):10-19.

Using a sequential enrichment culture technique, 3 bacterial strains capable of degrading crude oil in seawater were isolated in pure culture, UP-2, UP-3 and UP-4. Strain UP-2 had a strong preference for oil and oil degradation products as substrates for growth, converted 66% of the oil into a form no longer extractable by organic solvents, quantitatively degraded the paraffinic fraction, (gas chromatographic analysis), emulsified the oil during exponential growth, and produced $1.6x10^3$ cells/mb of oil. After exhausitve growth of UP-2 on crude oil, the residual oil supported the growth of UP-3 and UP-4 but not a previously isolated oil-degrading bacterium, RAG-1. Strainns UP-2, UP-3 and UP-4 grew on RAG-1 degraded oil (specifically depleted of n-alkanes). The growth of UP-3 and UP-4 on UP-2 and RAG-1 degraded oil produced new paraffinic compounds. When the 4 strains were grown together in a mixed culture or sequentially, there was >75% oil conversion. By plating on selective media, growth of the individual strains was measured kinetically in the reconstituted mixed culture, revealing competition for common growth substances (UP-2 and RAG-1), enhanced die-off (UP-2), and stabilization (UP-4) during the stationary phase.

517. Houldson, F. (1952).

OIL AND THE CALIFORNIA MURRE.

Audubon Mag., 54, 118-121.

518. Hoult, D.P. (ed.) (1969).

Oil on the Sea: Symposium on the Scientific and Engineering Aspects of Oil Pollution of the Sea, Proceedings.

MIT and WHOI, co-sponsors. Plenum Press. 114 pages.

These proceedings are composed of nine articles on the control and effects of oil pollution. Four of these deal with biological effects and are listed separately in this bibliography.

519. Howe, C. and S. Ottway (1971).

SOME EFFECTS OF CRUDE OIL, OIL FRACTIONS, AND PRODUCTS ON THE PROWN LEANDER SQUILLA.

In: Field Studies Council, Oil Pollution Research Unit, Orielton Field Centre, Annual Report. pp. 22-28.

The effects of oil films on *L. squilla* were investigated, in particular the factors of oil type, thickness of oil film, and the relative importance of direct toxicity and physical effects, such as interference with O_2 diffusions. Mortality of prawns kept in water under oil films is attributable to both physical effects, including reduction of gas exchange and subsequent O_2 depletion, and chemical toxic effects. The order of toxicity of different oil fractions varies considerably, gasoline being the most toxic. A variation in physical smothering effects of different oils and a variation in the amount of toxic water soluble fractions was noted.

520. Hufford, G.L. (1971).

THE BIOLOGICAL RESPONSE TO OIL IN THE MARINE ENVIRONMENT, A REVIEW.

Coast Guard Project No. 714141/003 Background Report. pp. 1-23.

A review of the literature indicates little is known about the short and long term fate and behavior of oil in the marine environment. Studies on the biological responses to oil have yielded ambiguous results. A recommended study to investigate biological responses to oil and its fractions in the marine environment is developed.

521. Hunnefeld, G.B. (1966).

OIL POLLUTION IN SURFACE WATERS CAUSED BY THE OPERATION OF OUTBOARD MOTORS.

Deutsche Gewaesserkundliche Mitteilungen 10, 57-59. (in German)

The contents including the results of investigations carried out at the Federal Institute of Hydrology, in Koblenz, Germany, have been published and were also presented at the 21st International Congress for Navigation in Stockholm, in 1965. The factors affecting water quality in rivers, lakes, and streams caused by oil, petroleum products, and water-soluble substances from outboard motors are discussed and measures introduced to prevent and control oil pollution of surface waters are summarized. (Sinha-OEIS)

522. Hunt, G.S. (1961).

WATERFOWL LOSSES ON THE LOWER DETROIT RIVER DUE TO OIL POLLUTION.

Gt. Lakes Res. Divn., Inst. Sci. Tech. Univ. Michigan, Publ. No. 7.

523. Hunt, G.S. and Ewing, H.E. (1953).

INDUSTRIAL POLLUTION AND MICHIGAN WATERFOWL.

Trans. No. Amer. Wildl. Conf. 18 360-368.

524. Hunt, P.G., F.J. Deneke, F.R. Koutz, and R.P. Murrman (1973).

TERRESTRIAL OIL SPILLS IN ALASKA: ENVIRONMENTAL EFFECTS AND RECOVERY.

Conference on Prevention and Control of Oil Spills. pp. 733-740.

Damage and natural recovery of terrestrial ecosystems affected by refined petroleum spills along the Haines to Fairbanks military pipeline in Alaska were investigated. Since the 20 cm-diameter, 1007-km-long pipeline was opened in 1956, there have been 40 reported ruptures along it. Mosses and trees were completely killed, and vegetation is now sparse in the drier portions of the spill areas.

Some new vegetation is growing in drainage pethways. Through laboratory studies on the rates of microbial respiration in Fairbanks silt containing 15 percent Prudhoe crude, it has been determined that microbial activity is increased by inoculation with mixed-culture oil-degrading microorganisms, increased pH, and phosphorus additions. Microbial activity also responds positively to nitrogen addition after an initial negative response. The negative response varied with treatments, and was not caused by either ammonia or nitrite toxicity. These observations were tested in the field along the pipeline where nitrogen and phosphorus fertilizers were applied in several rate combinations to small plots in a selected automotive gasoline spill area. In addition, the plots were seeded with a commercial grass mixture. The objective of this experiment was to determine if microbial degradation of the fuel and revegetation could be enhanced by the addition of fertilizer. There was a positive response in terms of microbial activity and plant growth in the treated plots. It has not been determined at this point if the increase in vegetation response was solely a fertilizer response or related to the increased rate of petroleum degradation.

525. Hunt, P.G., F.R. Koutz, R.P. Murrmann and T.G. Martin (1973).

MICROBIAL DEGREDATION OF PETROLEUM IN CONTINENTAL SHELF SEDIMENTS.

U.S. Cold Regions Research and Engineering Laboratory, Hanover, H.H. Special Report 196. 20 pp.

Degradation of petroleum wastes in surficial sediments under aerobic conditions was verified. It is estimated that under low O_2 conditions several hundred years would be required for complete degradation. The rate of degradation of petroleum wastes in continental shelf sediments would be very slow under the low O_2 conditions created by the high O_2 demand of the wastes.

526. Hunter, L., H.E. Guard and L.H. DiSalvo. (1974).

DETERMINATION OF HYDROCARBONS IN MARINE ORGANISMS AND SEDIMENTS BY THIN LAYER CHROMATOGRAPHY.

In: NBS Spec. Publ. 409, Marine Pollution Monitoring (Petroleum), Proceedings of a Symposium and Workshop held at NBS, Gaithersburg, Maryland. pp. 213-216.

Article details a TLC method used to determine the total hydrocarbon burden of organisms and sediments.

527. Hurst, J.W. (1955).

OIL POLLUTION OF SHELLFISH.

Maine Dept. Sea and Shore Fisheries.

528. Hutchinson, T.C. and W. Freedman. (1975).

EFFECTS OF EXPERIMENTAL CRUDE OIL SPILLS ON TAIGA AND TUNDRA VEGETATION OF THE CANADIAN ARCTIC.

In: Conference on Prevention and Control of Oil Pollution. pp. 517-526. Amer. Petrol. Inst. Wash., D.C.

Summer and winter crude oil spills were made on tundra and taiga sites in arctic Canada. The short- and long-term effects of these spills were recorded over a 3-year period. Spills were made by even surface spraying and by high intensity point spills. The vegetation present prior to such spills was carefully recorded. All surface spills had a devastating effect on above-ground vegetation. Species did, however, differ markedly in both their ability to survive an oil spill and their ability to recover. Many species, especially linchens, mosses and liverworts, were killed outright. Some woody and dwarf shrubs were able to produce new, healthy shoots within a few weeks of initial defoliation. The reduced production of storage material, as a result of foliage (and photosynthetic) loss, caused markedly increased plant losses by winter-killing factors. Flowering and reproduction were severely reduced, even in the third summer following a spill. Winter spills had significally less effect than summer spills. Permafrost was little affected, despite changes in the site energy budgets. Damage appeared greater in exposed taiga sites than on the tundra. Some species, such as black spruce, died throughout a 3-year period, emphasizing the necessity for long-term studies for accurate assessment.

529. Hyland, J.L., P.F. Rogerson, and G.R. Gardner (1977).

A CONTINUOUS FLOW BIOASSAY SYSTEM FOR THE EXPOSURE OF MARINE ORGANISMS TO OIL.

In: Proceedings 1977 Oil Spill Conference p. 547-550, Amer. Petrol. Inst., Wash., D.C.

A continuous flow-through bioassay system is described for exposing marine test organisms and their various life stages to oil. The apparatus consists of two principal stages - one for administering the water-accommodated fractions of oil (WAF) and the second for administering "whole" oil fractions (WF), including the soluble as well as nonsoluble fractions. The oil-contaminated effluent from the system first passes through a chamber to skim off separated oil and finally through a filter which lowers the oil concentration to below one part per million (1 ppm). Short-term lethal and chronic sublethal bioassays of several months duration were conducted in the system and are summarized briefly herein. Biological effects observed during bioassays have ranged from lethal toxicity at oil concentrations of approximately 10 parts per million (ppm) to sublethal behavioral modifications at approximately 10 parts per billion (ppb).

530. Hyland, J.L. and E.D. Schneider (1976).

PETROLEUM HYDROCARBONS AND THEIR EFFECTS ON MARINE ORGANISMS, POPULATIONS, COMMUNITIES AND ECOSYSTEMS.

In: Sources, Effects and Sinks of Hydrocarbons in the Aquatic Environment. Proceedings of the Symposium, American University, Washington D.C., 9-11 August 1976.

Analysis of available data from bioassays conducted on adult stages of a wide variety of marine organisms reveals lethal effects from soluble fractions of petroleum and petroleum products in the 1 to 100 part per million range. However, for the more sensitive larval and juvenile life stages lethal effects from oil may occur at lower levels, 0.1 to 1 ppm. Sublethal responses, regardless of life stage, indicate that oil will adversely impact certain ecologically and commercially important species in the low part per billion range, i.e., 1 to 10 ppb.

531. Idler, D.R. (1972)

EFFECTS OF POLLUTANTS ON QUALITY OF MARINE PRODUCTS AND EFFECTS ON FISHING.

Mar. Poll. and Sea Life. Fac. pp. 535-541.

This review paper is primarily concerned with tainting, undesirable modification of texture or colour, induced infestation of microbiological organisms, parasites and toxicity of fish, and their by-products, such as FPC, due to pollutants. The topics discussed may be divided into three major categories: (1) intoxicants; (2) microbiological contaminants; and (3) substances altering the flavour, odour, texture, or colour of fisheries products.

532. Idoniboye-Obu. B. (1977).

RECORDING BIOELECTRIC ACTION POTENTIALS OF MARINE DECAPOD CRUSTACEA BY REMOTE ELECTRODES: A BIOASSAY PROCEDURE FOR MONITORING HYDROCARBON POLLUTION.

Environ. Pollut. 12 159-166.

A method using electrodes on aquatic animals without injury to the animals for purposes of yielding bioelectric action potentials was developed. The method was applied to record gross muscle action poetntials in crustaceans in fresh water and distilled water, where obliterating effects of ions in seawater were not interferring. However, it was found that, provided the bioelectric generator on experimental animal was active and powerful enough, readable action potentials could be picked up by suitable non-polarizing electrodes, even in seawater. Motor behavior of mechanically unimpeded animals was suggested for use as a bioindicator to determine lethal concentrations of water-soluble hydrocarbons and oil pollutants.

533. Idoniboye-Obu, B. (1977).

BIOELECTRIC ACTION POTENTIALS OF PROCAMBARUS ACUTUS ACUTUS (GIRRARD) IN SERIALLY DILUTED SOLUTIONS OF SELECTED C_6 HYDROCARBONS IN WATER.

Environmental Pollution, 14 (1), pp 1-24.

Gross muscle action potentials and spontaneous nerve action potentials from moving animals inside experimental chambers or aquaria containing a sufficient depth of water can be recorded by means of remote electrodes. The myogenic biopotentials generally overshadow the neurogenic ones, particularly when the muscles contract vigorously as in voluntary movements and during escape activities. Both neurogenic and myogenic biopotentials diminish progressively under the influence of metabolically deleterious stresses (such as the effects of some water-soluble petroleum hydrocarbons) or vary spontaneously and directly according to the degree of normal activity or quiescence of the test organism.

The principle of recording the complex action potentials from both neurogenic and myogenic sources by remote electrodes in water is explored in a bioassay assessing the external concentrations of selected water-soluble poetroleum hydrocarbons. These petroleum hydrocarbons could bring about the ultimate cessation of impulse generation and propagation in short term exposures. Long before the harsh threshold of the "death response" itself is reached, a progressive diminution or irregularity of the biopotentials can indicate proximity to the point of no return. This is particularly so in the locomotor system, which begins to function less and less effectively in decapod Crustacea, commonly known as very active animals.

It is suggested that lethal thresholds of water pollution can be established in a systematic manner using selected test organisms, especially those of commercial importance, by such electrophysiological methods, with minimum destruction of experimental animals. The technique can be adapted or refined for use in regulatory laboratories and similar establishments, particularly in developing countries with few environmental indices or water quality criteria, to build up data that would justify at least interim regulatory limits for selected water-soluble pollutants.

534. Ignatiades, L. and T. Bacacos-Kontos. (1970).

ECOLOGY OF FOULING ORGANISMS IN A POLLUTED AREA.

Nature, 225:293-294.

Large numbers of oysters and cockles have been killed by crude or fuel oil in certain beds along the French and English Coasts. But it has been demonstrated that oysters are very tolerant of crude oil overlayering the water or periodically sprayed on the oysters. The work reported here was carried out to study the attachment and growth of fouling organisms in a very polluted area of Pireus Port. The most important fouling organisms were Bugula simplex, Hydroides norvegica, Ciona intestenalis, Ralanus amphitrite, and Mytilus edulis.

Results indicate that the fouling organisms can resist the toxicity of the oil-polluted water. The existence of a great amount of suspended mud also did not seem to affect the filtering mechanism of the filter-feeding organisms. Measurement of underwater light pentration showed that the green and blue lights were absorbed much more strongly in the area under study than in the non-polluted area outside the port. Because the strong light repels the attachment of certain fouling organisms, it seems reasonable to assume that the poor light conditions caused largely by the suspended mud were favorable for the attachment and development of the fouling organisms.

535. Ignatiades, L. and N. Mimicos (1977)

ECOLOGICAL RESPONSES OF PHYTOPLANKTON ON CHRONIC OIL POLLUTION.

Environ. Pollut. 13 p109-117.

The composition of phytoplankton in an inshore environment constantly polluted by petroleum hydrocarbons was followed over an annual cycle. The diatoms, dinoflagellates, micro flagellates, coccolithophores, silicoflagellates, blue-greens and others seemed to resist the toxicity of oil at the recorded concentrations. Special attention was paid to species composition, dominance, diversity and succession of diatoms and dinoflagellates. The results are compared with data obtained from onn-polluted environments and the relationships are discussed.

536. Interstate Electronics Corp. (1973).

DIRECTORY OF PERSONNEL IN OCEAN WASTE DISPOSAL AND RELATED ENVIRONMENTAL SCIENCE FIELDS.

Interstate Electronics Corporation, Oceanics Division. Report 4460C1543. 70 pp.

Names, addresses and affiliations are presented for personnel involved in ocean waste disposal and related environmental fields.

537. Irwin. W.H. 1965.

FIFTY-SEVEN SPECIES OF FISH IN OIL-REFINERY WASTE BIOASSAY.

In: Trans. 135th N. Amer. Wildl. & Natl. Resources Conf., 89-99.

Fifty-seven kinds of fish were studied to determine their use as bioassay animals and their relative resistance to oil refinery effluents. Seven papers, published and in press, derived from the study are summarized. Accepted bioassay methods were used; the effluent was taken directly at active refineries; and the fish were gathered from sixteen states. Variations in resistance and adaptability existed between both the kinds of fish and the individuals of a species.

The metabolic rates of individuals and species concerning oxygen, temperature and/or food requirements are limiting factors for some. Resistance rankings of fish; statistical treatments, quality items needed in specimens; behavior and life history; and suggestions for bioassay procedure are presented. The 24-hour median tolerance limits appeared to be as accurate as longer tests for the acute toxicity bioassay measurements when using oil refinery effluents.

538. Isakson, J.S., J.M. Storie, J. Vagners, G.A. Erickson, J.F. Kruger, and R.F. Corbett (1975).

COMPARISON OF ECOLOGICAL IMPACTS OF POSTULATED OIL SPILLS AT SELECTED ALASKAN LOCATIONS. VOLUMES I and II.

Final Report to U.S. Coast Guard Report No. CG-D-155-75.

A ranking of potential environmental impact for spills of crude oil, diesel-2, bunker C, and gasoline in amounts ranging from 100 to 50,000 barrels was made for 17 sites in Alaska. Spills were assumed to disperse from inertial, viscous, surface tension, wind, and current forces. Most probable wind and current conditions were utilized. Sites were characterized in terms of eight species habitats. Most probable cases were evaluated. A rating system was devised to characterize the impact based upon estimated species abundance, importance of species, and the impact of oil on such species over short and long term. Data gaps are noted and future studies recommended. Vol. I contains introduction, summary methodology, evaluation, and appendices. Vol. II contains detailed results.

539. Jackivicz, T.P., Jr. and L.N. Kuzminski. (1973).

THE EFFECTS OF THE INTERACTION OF OUTBOARD MOTORES WITH THE AQUATIC ENVIRONMENT--A REVIEW.

Environ. Res. 6:436-454.

The effects of the compounds associated with outboard motor subsurface exhausts on water quality and aquatic biota are reviewed. The problems affiliated with water quality may include the formation of undesirable tastes and odors and the appearance of oily substances. It has been demostrated that outboard motor exhaust water can exhibit a toxic effect in sufficiently high concentrations to fathead minnows and bluegills, taints the flesh of various fish, and may affect the reproduction of fish.

A discussion of the current research related to the effects of outboard motors on the aquatic environment is presented. Recommendations are given for future research to broaden the understanding of the interaction of outboard motors with the aquatic environment.

540. Jacobson, S. and D. Boylan (1971).

INTERFERENCE WITH CHEMOTAXIS IN A MARINE SNAIL, NASSARIUS OBSOLETUS, BY SEAWATER SOLUBLE COMPONENTS OF KEROSENE.

American Zoologist 11(4):694.

N. obsoletus exhibits positive rheotaxis in the presence of dilute extracts of oysters or scallops. In a Y-choice chamber the majority in a group of 10 snails entered the arm containing food extracts. In the presence of 0.1 ppb of the seawater soluble part of kerosene the attraction to oyster extract was reduced to a level not significantly different from the seaawater control group ($p<0.5$). Kerosene seawater extract at 0.2 but not 0.4 ppb also significantly reduced attraction to scallop homogenate ($p<0.5$). There was no difference in behavior between snails exposed to kerosene extract or seawater only. Components similar to those in kerosene extract mostly benzenes and naphthalenes, are found in seawater extracts of light and crude oils. Dilute oil pollutants may affect populations of marine organisms through disruption of chemically mediated behavior patterns.

541. Jacobson, S.M. and D.B. Boylan. (1973).

EFFECT OF SEAWATER SOLUBLE FRACTION OF KEROSENE ON CHEMOTAXIS IN A MARINE SNAIL, NASSARIUS OBSOLETUS.

Nature 241: 213-215.

Specimens of the marine snail Nassarius obsoletus were exposed to kerosene extracts in two experiments, each with a different attractant, in order to observe the effect of these extracts on the response of the snails to stimuli. The attractant used in experiment I was extract of the oyster Crassostrea virginica, and the behavior of the snails exposed to the kerosene extracts did not differ significantly from the behavior of those in the control group. Experiment II utilized homogenized adductor muscle from the scallop Aequipecten irridians as the attractant, and the response of the snails was signficantly lessened.

542. James, M.C. (1926).

REPORT OF U.S. BUREAU OF FISHERIES: PRELIMINARY INVESTIGATION ON THE EFFECT OF OIL POLLUTION ON MARINE PELAGIC EGGS.

In: Oil Pollution of Navigable Waters (Inter-departmental Committee, Washington). App. 6, pp 85-92.

543. Jamison, D.W. (1975).

A REGIONAL OIL IMPACT STUDY IN PUGET SOUND STATE OF WASHINGTON.

In: Pacific Science Association: Thirteenth Pacific Science Congress: Record of proceedings, vol. 1Vancouver, B.C., Can.: University of British Columbia. p. 38. (abstract only).

Since June 1974, the Washington Department of Ecology has been conducting a multidisciplinary regional analysis of the impact of oil contamination on Washington's Significant Biological Resources. Economists and marine biologists are working together to develop monitary values for commercially and recreationally important organisms and their food items (Significant Biological Resources). These data will be used to evaluate oil import routes, terminals, and sites for oil refineries and will permit reasonable assessment of damage resulting from an oil spill. Field studies are presently centered in the North Puget Sound region just S of the Canadian-U.S. border. Generalized habitat types have been inventoried in the area. Representative examples of each habitat type have been chosen to study in detail. The seasonal distribution and abundance of the Significant Biological Resources as well as other sampled organisms are documented. Standardized sampling methods are employed to ensure comparability of data between investigators. A unique computer based literature review system has been employed to develop species, habitat and oil impact fact sheets. The program design is such that the data can be used for analysis of any type of marine oriented man-nature impact assessment.

544. Jenkins, C.R. (1965).

A STUDY OF SOME TOXIC COMPONENTS IN OIL REFINERY EFFLUENT.

Diss. Abstr. 26, 1837.

545. Jensen, A.C. (1974).

SPORT FISHERIES AND OFFSHORE OIL.

New York. Fish. Game J. 21(2):105-116.

The possibility of exploratory and production drilling for petroleum on the Continental Shelf off the Northeast Coast of the United States has aroused the concern of sportfishermen from New York and neighboring states. This paper discusses the marine sportfishery resources in the area in relation to the suspected petroleum reserves.

546. Jigami, Y. *et al*. (1975).

THE DEGRADATION OF ISOPROPYLBENZENE AND ISOBUTYLBENZENE BY PSEUDOMONAS SP.

Agricultural and Biological chemistry. 39(9):1781-1788.

To clarify biodegradation pathways of isoalkyl substituted aromatic hydrocarbons, oxidation products of isopropylbenzene and isobutylbenzene by *Ps. desmolytica* S449B1 and *Ps. convexa* S107B1 were examined.

Oxidation products from isopropylbenzene were determined to be 3-isopropyl-catechol and (+)-2-hydroxy-7-methyl-6-oxoctanoic acid. Isobutylbenzene was also oxidized to 3-isobutylacatechol and (+)-2-hydroxy-8-methyl-6-oxononanoic acid by the same strains.

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BIOLOGICAL EFFECTS OF OIL POLLUTION - A OMPREHENSIVE BIBLIOGRAP--ETC(U)
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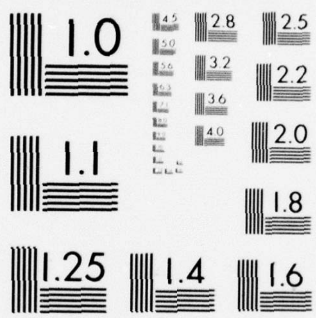

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From these results, the existence of an unknown reductive step in the degradation of these isoalkyl substituted aromatic hydrocarbons and the initial oxidation of these aromatic hydrocarbons by the strains were made clear. The degradation pathways of isopropylbenzene and isobutylbenzene by these strains were discussed.

547. Jobson, A., F.D. Cook and D.W.S. Westlake. (1972).

MICROBIAL UTILIZATION OF CRUDE OIL.

Applied Microbiology, Vol. 23, No. 6. pp. 1082-1089.

The utilization of two crude oil samples of different quality at 4 and 30° C has been studied by using pure and mixed bacterial cultures obtained by enrichment procedures. Growth, emulsification, and utilization occurred readily at both temperatures. The crude oil residue is increased in specific gravity and readily sediments out os solution. A comparison of the chemical analysis of the oils by liquid and gas-liquid chromatographic procedures before and after growth showed that the n-saturate fraction had been preferentially used. Some utilization of the aromatic fraction also occurred. Enrichments obtained with a high-quality crude oil were not as effective in utilizing a lower quality crude oil as sole carbon source as a population enriched on the low-quality crude oil.

548. Joensen, A.H. (1973).

DANISH SEABIRD DISASTERS IN 1972.

Mar. Poll. Bull., Vol. 4:117-118.

In recent years the Danish Game Biology Station has studied casualties to seabirds from oil pollution. 1972 was a particularly disastrous year and preliminary information on the events are given here. Very large losses of seabirds have been caused by quite small spillages of oil.

549. Johannes, R.E. (1972).

CORAL REEFS AND POLLUTION.

In: Marine Poliution and Sea Life, M. Ruive (ed.). FHO, Fishing News (Books) Ltd. London. pp. 364-375.

This paper reviews the known effects of various marine pollutants, including oil, on coral reef communities.

550. Johannes, R.E., J. Maragos, and S.L. Coles. (1972).

OIL DAMAGES CORALS EXPOSED TO AIR.

Mar. Poll. Bull., 3:29-30.

It was often assumed that the tropical marine environments with its rich diversity of species is difficult to harm by pollution. Corals provide an important habitat for many creatures and are now exposed to oil pollution as never before. Experimental evidence that some reef-building corals can be seriously damaged if coated with oil is presented. Corals of Eniwetok Atoll were studied. Floating oil killed coral tissue if it adhered when the corals were exposed to air.

551. Johnson, C.S. and A.R. Halliwell (1976).

ENVIRONMENTAL CONSIDERATION IN THE DESIGN OF BALLAST WATER OUTFALLS.

In: Eighth Annual Offshore Technology Conference: 1976 Proceedings Vol I,, pp. 235-245. Houston, Tx.

The development of the Occidental Group's North Sea Piper Field involves the operation of an oil-loading terminal, with associated tanker deballasting problems, in the environmentally upspoiled Orkney Islands, Scotland. The nature of the effluent and receiving waters were thoroughly studied to achieve minimal upset to a finely balanced marine ecosystem. The multidisciplinary approach which led to system design, environmental appraisal, and the comprehensive monitoring program are described.

552. Johnson, T.C. (1971).

NATURAL OIL SEEPS IN OR NEAR THE MARINE ENVIRONMENT: A LITERATURE SURVEY.

USCG Background Report. 35 pp.

A literature survey was conducted to determine where naturally occurring oil seeps have been reported to be injecting oil into the sea. The purpose of this was to locate natural laboratories where fate and behavior studies on oil in the marine environment might be conducted. Emphasis was placed upon seeps in the northern half of the Western Hemisphere. Results of these studies will contribute to the establishment of a logical marine pollution monitoring program by the U.S. Coast Guard. Of the locations determined, those which are most likely to be useful for planned Coast Guard studies are: Near Barter Island. Alaska; southern California; western Newfoundland and in the Gulf of Paria west of Trinidad.

553. Johnston, R. (1970).

DECOMPOSITION OF CRUDE OIL RESIDUES IN SAND COLUMNS.

J. Mar. Biol. Assn. U.K., 50(40):925-937.

Rates of oxygen uptake have been measured at a range of depths in sand columns (a) without oil, (b) heavily oiled, and (c) lightly oiled. Oxygen change in presence of oil indicates the response of the microbial population and provides an estimate of the rate of biological degradation of the crude oil. Breakdown is dominated by oxygen availability but nutrients contribute as auxiliary oxygen sources. Oxygen removal indicates initial rates of oxidation of oil at $10^{o}C$ ranging from 0.09 g oil m^{-2} day -1 for heavily dosed sand to 0.04 g oil m^{-2} day -1 for lightly dosed sand. These rates are applicable over periods of several months, thereafter the remaining oil, about 90%. decays immeasurably slowly.

554. Jones, D.F. and R. Howe. (1968).

MICROBIOLOGICAL OXIDATION OF LONG-CHAIN ALIPHATIC COMPOUNDS.

J. Chem. Soc. (c)2801-2808.

The yeast Torulopsis gropengiesseri converts long-chain alkanes into glycolipids which incorporate oxidised derivatives of the alkanes. Comparison of the lipid constituents of glycolipids derived from C_{12}-C_{24} alkanes, a variety of oxygenated alkane derivatives and a series of methylbeta -alkoxypropionates has indicated that the major pathway of alkane metabolism involves the formation of alkan-1-ols which are subsequently dehydrogenated to the corresponding alkanoic acids. These acids are metabolised, either by Beta-oxidation, or by hydroxylation to give omega-hydroxy-acids (and subsequently omegadicarboxylic acids) and by a stereospecific hydroxylation, omega-1-hydroxyacids. The oxidised alkanoic acids are protected from further degradation by incorporation into glycolipids. The chain-length of an alkanoic acid determines (i) whether Beta oxidation or hydroxylation is the predominant reaction, and (ii) whether hydroxylation takes place mainly at the omega- or the omega-1 position. Both omega- and omega-1 hydroxylations of alkanoic acids are most efficient when the site of hydroxylation and the carboxy-group are separated by a chain of fourteen methylene groups. It is proposed that these hydroxylations may be brought about by a single enzyme. A minor pathway of alkane metabolism involves the formation of alkan-2-oils which are incorporated into glycolipids and not oxidatively metabolised. Fermentations of long chain alk-1-enes yield glycolipids which incorporate omega-1-hydroxy-acids, omega-hydroxy-acids, and omega-dicarboxylic acids which are derived from the alk-1-enes both with and without loss of a carbon atom.

555. Jones, J.G. (1968).

METHODS OF STUDYING THE EFFECTS AND METABOLISM OF HYDROCARBONS IN NATURAL ENVIRONMENTS.

In: Biological Effects of Oil Pollution on Littoral Communities, Supplement to Volume 2, D. Carthy and D.R. Arthur, (eds.) Field Studies. Field Studies Council.

This paper is a summary of the results of a study to determine the modes of biosynthesis of naturally accuring hydrocarbons and the rates at which these hydrocarbons are metabolized by the indigenous microflora. The work was carried out in the terrestrial environment and concludes that it is possible to determine small differences in the microflora of a sample which has a higher level of naturally occurring hydrocarbons. It should therefore be possible to follow the effects of crude oil on certain ecosystems. Possible methods to accomplish this source of crude oil through an ecosystem are offered.

556. Jones, J.G. and M.A. Edington, (1968).

AN ECOLOGICAL SURVEY OF HYDROCARBON OXIDIZING MICROORGANISMS.

J. Gen. Microbiol. 52:381-390.

An ecological survey of the microflora of an upland moorland soil and the underlying shale was made over a 2-year period. Samples were taken at different depths of about 5, 20 and 40 cm in the soil, and from the underlying shale band in a cave system nearby, and the average total counts of bacteria and fungi were 35×10^6, 3×10^6 and 1×10^6 per g dry wt respectively. Hydrocarbon-oxidizing organisms occurre in all the samples. The numbers and activity of these organisms were determined in a variety of ways and finally expressed as a function of the total population of each sample. A significantly higher proportion of the population of the 20 CM. soil sample was able to utilize hydrocarbons as sole energy and carbon source, than of any of the other samples. When hydrocarbons were added there was a stimulation in respiration of all samples. Maximum stimulation of respiration occurred in the 20 cm. soil sample. The E_h of the 20 cm. soil sample was lower than in any other sample, it also contained a higher level of lipid and hydrocarbons. It is suggested that the higher level of hydrocarbon oxidation in the 20 cm. soil sample is due to the accumulation of hydrocarbons with a resulting adaptation of the microbial populations. More organisms were able to oxidize the longer chain n-aliphatic hydrocarbons than the short chain n-aliphatics, aromatic and alicyclic hydrocarbons. A list of the genera, including fungi, responsible for the oxidation of each hydrocarbon is given: the fungi play an important role in the hydrocarbon-oxidizing activity of each sample.

557. Jones, L.G., C.T. Mitchell, E.K. Anderson and W.J. North. (1969).

JUST HOW SERIOUS WAS THE SANTA BARBARA OIL SPILL?

Ocean Industry, June 53-56.

On January 28, the fourth well being drilled by Peter Bawden Drilling Co. for the Union oil group (Union, Gulf, Mobil and Texaco) from Platform A in Block 402 of California's Santa Barbara Channel started kicking as the drill pipe was being tripped out of the hole. With the blowout preventers closed around the drill pipe, the crew attempted to stab the Kelly into the drill pipe, and when this failed--because of danger to the crew--2,300 ft. of drill pipe was dropped into the hol the preventers closed off the well.

Soon it became apparent that the lower zone was pressuring a shallow sand that apparently outcropped or in some other way communicated directly with the ocean bottom. Oil started seeping to the surface.

Knowledgable enginners estimated the leakage at 500 barrels per day and over the 10-day period of the leak this amounted to approximately 236,000 gallons or about 5600 bbb.

This event received a great deal of publicity (some accurate--some inaccurate) and emotions were stirred deeply. The claims of damage to marine life and property varied so greatly that Ocean Industry delayed publication of related details until a more scientific assessment could be made.

Here is the first such report.

558. Jones, P.H. (1970).

EFFECT OF "HAMILTON TRADER" OIL ON BIRDS IN THE IRISH SEA IN MAY 1969.

British Birds. 63:97-110.

Just before dawn on 30th April 1969 the tanker Hamilton Trader was damaged in a collision with a German coaster near the Bar light vessel in Liverpool Bay. About 700 tons of heavy fuel oil were spilled into the sea. This incident provided an opportunity to trace the fate of the oil, and birds which encountered it, as it drifted in the Irish Sea for two weeks before coming ashore in Cumberland. Liaison was maintained between a wide range of institutions and individuals, and this report collates the ornithological information to present a fairly full picture of the course of the incident.

559. Juge, S. (1971).

A STUDY OF THE BACTERIAL POPULATIONS OF BOTTOM SEDIMENTS IN THE SANTA BARBARA CHANNEL AFTER THE OIL SPILL.

In: Biological and Oceanographical Survey of the Santa Barbara Oil Spill 1969 - 1970. Vol. 1, p. 179. Allan Hancock Found. Sea Grant Publ. #2. D. Straughan (ed.).

Box core samples were taken monthly from nine stations which extended from an area 1.1 miles off Rincon Point (Station 1) to Station 9 situated in the Santa Barbara Basin. Ten grams of sediment was removed from each sample for bacteriological examination, and the remainder of each sample was frozen for future chromatographic analysis for the presence of oil.

Results of plate counts for Stations 1 and 2 differ from those obtained in an earlier study by the author (Juge, unpubl. diss.) in that higher counts obtained at 60°C were present on distilled water medium, and at 18°C significantly higher counts were obtained on sea water medium. Results for Station 3 agreed with those of the earlier study, with plates of sea water medium incubated at $60^{o}C$ producing the highest counts. Plate counts from samples taken at Stations 4,5,6,7 and 9 were in the same range and varied very little. Only one sample was taken at Station 8. The tabulated report of the results obtained by gas-liquid chromatography analysis of the samples supports the suitability of this method for the determination of small quantities of hydrocarbons in marine bottom sediments.

560. Kalsi, S.S. (1974).

OIL IN NEPTUNE's KINGDOM: PROBLEMS AND RESPONSES TO CONTAIN ENVIRONMENTAL DEGREDATION OF THE OCEANS BY OIL POLLUTION.

Environmental Affairs, 3(1):79-108.

The international framework for limiting and preventing oil pollution is inadequate. The dire consequences of upsetting the marine ecosystem through gradual pollution urgently demand action. At the present level of organization in international society, threats to the ocean environment can be reduced by expanding contiguous zone jurisdictions for a temporary transitional period during which international agreements can be negotiated. Expanding contiguous zones for pollution control would hasten international concern on the issue. In the long run, all deliberate discharges of oil should be prohibited. Coastal states will have to accelerate the construction of waste oil and ballast water reception facilities and press for segregated ballast tankers.

561. Kanter, R. (1974).

SUSCEPTIBILITY TO CRUDE OIL WITH RESPECT TO SIZE, SEASON AND GEOGRAPHIC LOCATION IN MYTILUS CALIFORNICUS (BIVALVIA).

University of Southern California Sea Grant Program. USC-356-4-74.

Mussels from Pismo Beach, Coal Oil Point, Pales Verdes, and Santa Cataline Island, California were exposed to Santa Barbara Crude oil under laboratory conditions. Mussels died faster and in higher numbers at higher concentrations of oil in water. Larger animals showed higher mortalities than smaller ones. The two most susceptible populations were from Pismo Beach and South Catalina Island. Each population had different months of highest mortalities.

562. Kanter, R. and D. Straughan. (1971).

EFFECTS OF EXPOSURE TO OIL ON MYTILUS CALIFORNIANUS from different localities.

In: Proceedings, Joint Conference on the Prevention and Control of Oil Spills, pp. 485-488. API/EPA/USCG.

The results of the first two of a series of experiments in a study to determine if organisms exposed to natural oil seepage have a higher tolerance to a spill of similar crude oil than organisms that have not been exposed to natural oil seepage are presented. Mytilus californianus from different localities along the California coast were exposed to varying crude oil concentrations in the laboratory. The data shows a higher tolerance to oil in M. californianus from a natural oil seep area than in M. californianus from non-oil seep areas. There is also a different tolerance to oil between M. californianus from different non-oil seep areas.

563. Kantor, H. and R. Herwig (1977).

MICROBIAL RESPONSES AFTER TWO EXPERIMENTAL OIL SPILLS IN AN EASTERN COASTAL PLAIN ESTUARINE ECOSYSTEM.

Proceedings 1977 Oil Spill Conference. p. 517-522. Amer. Petrol. Inst. Wash., D.C.

Three large transite-sided enclosures, constructed in a tidal salt marsh in southeastern Virginia, were utilized to evaluate the effects of crude oil spillage on selected microbial populations. Unweathered Louisiana crude oil was spilled in one enclosure, artifically weathered South Louisiana crude in another, and the third served as a control. Each enclosure was constructed so as to allow unhampered exchange with tidal flow on the tidal creek side.

Heterotrophic bacteria and fungi, chitinolytic, cellulytic and petroleum-degrading bacterial populations from the tidal creek, and sediments in intertidal, mid- and back-marsh zones were enumerated at selected intervals following the oil spills. Dominant petroleum-degrading and heterotrophic bacterial isolates were selected for taxonomic grouping.

Within several days following the spills, the levels of petroleum-degrading bacteria rose by several orders of magnitude relative to the control enclosure. This differential has been maintained for approximately one year. Plots of the ratio of oil-degrading to heterotrophic bacteria reveal enhancement of the petroleum degrading component of the heterotrophic population. Mean levels of chitinolytic, cellulytic, heterotrophic bacteria and fungi were not statistically different in the oil and control enclosures. The potential significance of these observations is discussed.

564. Karimen, J.F. and Rice, S.D. (1974).

EFFECTS OF PRUDHOE BAY CRUDE ON MOLTING TANNER CRABS CHIONOECETES BAIRDI.

Mar. Fish. Rev. 36(7):31_37.

Premolt and postmolt juvenile male crabs from Alaska waters were exposed to Prudhoe Bay crude oil in static bioassays in the laboratory. Crabs in both stages were susceptible to crude oil. The estimated

48-hr median tolerance limits values were 0.56 ml oil/l. High doses of oil caused mortality. Molting success decreased with increasing exposure of crabs to oil, and newly-molted crabs autotomized limbs during exposure to oil. Oil spilled in Alaskan waters would harm the Tanner Carb resources.

565. Karrick, N.L., R.C. Clark, Jr. and R.R. Mitsuoka (1972).

Sumposium on Oil Pollution, The Environment, and Puget Sound, 23-24 February 1972, Olympic Hotel, Seattle, Washington.

Sponsored by EPA, NOAA, and Washington State Department of Ecology. 36 pp.

The proceedings of this symposium contain nine papers and three panel discussions.

566. Kasymov, A.G. (1970).

INDUSTRY AND THE PRODUCTIVITY OF THE CASPIAN SEA.

Mar. Poll. Bull., 1(7):100-103.

The growing problem of the pollution of the Caspian Sea has recently aroused much conern in the USSR for it seems to be leading to a catastrophe. A chain reaction is being set up which will have consequences that are difficult to predict. Poisonous industrial waste has a disastrous effect on fish spawn and young; it ruins spawning and fattening grounds, restricts migration, causes sickness in fish and hinders fishing. It also reduces the reserves of the fishing industry and lowers the quality of the fish. In polluted waters the biological equilibrium is destroyed, and with it the self-purification processes which rely on the activities of bacteria, algae and protozoa.

If pollution of the western part of the middle and southern Caspian Sea continues as it is now, the sea can be expected to be transformed into a dead sea, not only unsuitable for habitation by fish and other food animals, but also for the needs of technology.

567. Kasymov, A.G. and A.D. Aliev (1973).

EXPERIMENTAL STUDY OF THE EFFECT OF OIL ON SOME REPRESENTATIVES OF BENTHOS IN THE CASPIAN SEA.

Water, Air and Soil Pollution, 2(2):235-245.

Experimental studies of the influence of crude oil on the bottom fauna of the Caspian Sea were carried out in 1970-71 at Artern Island 86 km from Baku, USSR. The species were, in the order of decreasing sensitivity, Chironomus albidusCerastoderna Iamarcki and Nais elinguis > Neresis diversicolor, Prygohydrobia dubia, and Abra ovata. Under high concentrations of oil 3-5 mg/l the animals initially did not change weight and then they lost weight and perished. In a weak solution of oil (1 mg/l) a speed up in normal evolution, growth, and reproduction took place.

568. Kasymov, A.G. and S.I. Granovskiy. (1972).

THE EFFECT OF PETROLEUM ON BOTTOM ANIMALS IN THE CASPIAN SEA.

Hydrobiol., 8:85-88.

Five species of marine invertebrates were exposed to concentrations of oil varying from 0.1 to 20.0 mg/l in seawater. These organisms, which are important food sources for commercial fish in the Caspian Sea, were Nereis diversicolor (comb.), Cerastoderma lemarcki Reeve Mytilaster lineatus Gm., Abra Ovata Phil, and Pontogammarus maeoticus Sow. The petroleum came from the oil fields of Neftyanyee Kammi, Artemovskoye and Bulla-Duvaninskoye.

Oil from the Bulla-Duvaninskoye appeared to be the most toxic. The most sensitive and most resistant organisms were Nereis Diversicolor and Mytilaster lineatus respectively.

569. Katz, L.M. (1973).

THE EFFECTS OF WATER SOLUBLE FRACTIONS OF CRUDE OIL ON LARVAE OF THE DECAPOD CRUSTACEAN NEOPANOPE TEXANA (SAYI).

Environ. Pollut. 5 199-204.

The effect of a water-extract, made from artificial seawater polluted with crude oil at a concentration of 10 ml/litre, was tested on the survival of larvae of the decapod crustacean Neopanope texana to the megalopal stage, under laboratory conditions. High mortality occurred in zoea exposed from the day of hatching. There were indications that the pollutant had a retarding effect on the moulting process. It is suggested that more rigorous studies be conducted to determine fully the effects of oil pollution on these organisms.

570. Kauss, P.B. and T.C. Hutchinson. (1975).

THE EFFECTS OF WATER-SOLUBLE PETROLEUM COMPONENTS ON THE GROWTH OF CHLORELLA VULGARIS BEIJERINCK.

Environ. Pollut. (9):157-173.

The effects of the water-soluble components of petroleum on a selected algal test species. Chlorella vulgarishave been investigated under controlled laboratory conditions. Aqueous extracts of seven different crude oils and one refined product exhibited marked differences in toxicity to Chlorella, resulting in a 5% to 41% reduction of cell numbers during the first 48 h. However, this toxicity was only of a short-term nature, apparently resulting in a lag phase prior to the onset of growth. Work with oil extracts allowed to evaporate for 0, 24, 48 or 120 h prior to their inoculation with algae, suggests that the observed toxicity of oil extracts is due to highly volatile compounds which are largely lost from the culture flasks during the first 24 h. Lower concentrations of benzene, toluene, o-xylene and naphthalene resulted in a growth inhibition similar to that cuased by crude oil. Higher concentrations caused total inhibition of growth. The growth rate of cells was normal once the lag phase had ended.

A significant stimulation of growth was observed with three of the oil extracts after their toxic compounds had evaporated. It is not known at present if this stimulation is a reflection of an actual ability to utilize certain hydrocarbons heterotrophically from the extract. Other possible interpretations are discussed.

571. Kauss, P.B., T.C. Hutchinson and M. Griffiths. (1972).

FIELD AND LABORATORY STUDIES ON THE EFFECTS OF CRUDE OIL SPILLS ON PHYTOPLANKTON.

Proc. Inst. Environ. Sci., 18:22-26.

In the field species differ quite markedly in their response to an oil spill. Some were inhibited but others were actually stimulated, whilst a third group showed no effect. In the laboratory, aqueous extracts of 7 crude oils showed inhibitory effects to a test species but differed amongst themselves in degree of toxicity. This toxicity appeared to be reduced by volatilization of the toxic components. Marked decreases in pH were noted in dilute media in the presence of oil extracts. These pH changes were themselves sufficient to cause a considerable suppression of algal growth. However, when pH changes were artificially eliminated the aqueous extracts of oil still had toxic properties. Tests with benzene, toluene and xylene showed these three water-soluble crude oil components to have toxic properties and that toxicity increased along this methylation series. Cells were generally able to resume growth when the toxic factor was removed. Possible reasons for these results are discussed.

572. Kauss, P., T.C. Hutchinson, C. Sota, J. Hellebust, and M. Griffiths (1973).

THE TOXICITY OF CRUDE OIL AND ITS COMPONENTS TO FRESHWATER ALGAE.

In: Conference on Prevention and Control of Oil Spills. pp. 703-714. Amer. Petrol. Inst., Wash., D.C.

Field and laboratory experiments were conducted to determine the toxicity of crude oil to freshwater algae. In the field, experiments were continued for a two year period and changes in the abundance and species composition of phytoplankton tabulated. Species were found to differ markedly in their response to an oil spill - varying from considerable suppression of growth to stimulation.

In the laboratory, the effects of aqueous extracts of seven crude oils on a selected test species, Chlorella vulgaris, were determined. Marked differences in toxicity, as indicated by reduced growth, were found to exist between oils. Work with oils extracts of different ages suggests that the short-term toxicity of oils is due to the rapid loss of volatile compounds. Differences in the toxicity is selected aromatic components of crude oils--benzene, toluene, o-xylene and naphthalene--were observed and are believed to relate to an increase in methylation. Aqueous crude oil and naphthalene depressed the ^{14}C-$NaHCO_3$ uptake (i.e. photosynthesis) of Chlamydomanas angulosa. ^{14}C-naphthalene was rapidly taken up by Chlamydomonas cells. However, release of this compound was much slower, and, in unwashed cells seemingly dependent upon cell division.

Possible mechanisms of crude oil toxicity are discussed.

573. Keizer, P.D. (1975).

THE EFFECTIVENESS AND TOXICITY OF THE OIL DISPERSANT, OILSPERSE 43, IN LARGE OUTDOOR TANKS.

Surveillance Report EPA-5-AR-75-8.

One L of Venezuelan Guanipa crude oil was added to a holding tank containing surface water from Bedford Basin, Nova Scotia, and 1L of oil plus 1L of Oilspere 43 dispersant were added simultaneously to a 2nd tank. Use of the dispersant increased the dispersion of the crude oil. The resulting mixture was more homogeneous and the oil slick was less viscous than in the oil tank. The dispersant retarded formation of a surface crust. A weathered crude oil plus dispersant mixture with an oil concentration of 250 u/L was lethal to 50% of the bioassay test organisms, green sea urchins, within 4 d. No mortalities occurred among urchins exposed to the crude oil treatment. Use of "low-toxicity" dispersants on crude oil spilled in an inshore marine area could produce oil and dispersant concentrations lethal to the green sea urchin population.

574. Kempf, T., D. Ludemann and W. Pflaum (1967).

POLLUTION OF WATERS BY MOTORIZED OPERATIONS, ESPECIALLY BY OUTBOARD MOTORS.

Wasser, Boden, and Lufthygien Schr. Reihe, Ver. 20 48.

Details are given of extensive investigations into the polluting effects of underwater exhausts from outboard motors and mineral oils, carried out under the auspices of the Bundesministerium fur Gesundheitswesen, Germany. Tabulated and graphical data from field and laboratory experiments show the damage to fish and other aquatic organisms caused by motor and diesel oils, petrol and other organic solvents and their immiscibility with water. The ecological differentiation of microorganisms, such as diatoms and rotatoria, showed that oil-tanker accidents, liberating diesel oil, resulted in either total destruction of aquatic organisms or reduction of some species, but in certain favorable locations some species survived while others were able to tolerate the oil-water emulsion, resulting in only a small reduction in numbers, considered over the period of the annual cycle. (Sinha-OEIS)

575. Ketchum, Bostwick (1973).

OIL IN THE MARINE ENVIRONMENT.

In: Input, Fates and Effects of Petroleum in the Marine Environment. Background Information for the Workshop, Ocean Affairs Board, NSF, Airlie, Va. 21-25 May 1973.

This review paper covers sources of oil pollution, biological effects of petroleum hydrocarbons, persistance of oil in the ocean, the toxicity of oil, corrective measures and recommendations.

576. Kator, H. (1973).

THE UTILIZATION OF CRUDE OIL HYDROCARBONS BY MIXED CULTURES OF MARINE BACTERIA.

In: The Microbial Degradation of Oil Pollutants. Louisiana State University Publication No. LUS-56-73-01, Baton Rouge. pp. 47-65.

Marine bacteria degraded hydrocarbons in crude oils in an enriched seawater medium. Normal and branched paraffins were preferentially utilized. Utilization rates were inversely related to chain length.

577. Kinsey, D.W. (1973).

SMALL-SCALE EXPERIMENTS TO DETERMINE THE EFFECTS OF CRUDE OIL FILMS ON GAS EXCHANGE OVER THE CORAL BACK-REEF AT HERON ISLAND.

Environ. Pollut., 4:167-182.

A field fencing technique has proved satisfactory in maintaining an isolated, but biologically-acceptable, environment around natural reef outcrops. A single fenced outcrop with negligible surface exposure was used for four nighttime experiments. One of these was a control and the others used surface-floating films of Moonie crude oil. The control experiment was on a night of almost complete calm, but the others were on nights of varying temperature and wind conditions. Various parameters of community respiration were monitored, both inside and outside the fence over the 4-5 hr period of slack water occurring with the low-tide. The following points were indicated: (1) Films as thin as 0.1 mm caused considerable calming of the water surface; (2) under conditions of light wind, films of 0.1 mm and 0.7 mm nominal thickness caused no significant interference with oxygen and carbon dioxide transfer through the water surface other than that associated directly with the calming effect. Respiration of the reef community remained normal; (3) a 0.1 mm film of the heavier residual oil left after prolonged exposure of the "fresh" crude may have given some slight interference with gas transfer but it is more probable that this effect was an artefact of temperature; (4) no toxicity effects or abnormal behavior patterns were observed over the time periods used; (5) more information is required on the effects of dead calm weather, higher temperatures, thicker and more viscous oil films, and longer periods of exposure.

578. Kinney, P.J., D.K. Button, D.M. Schell (1969).

KINETICS OF DISSIPATION AND BIODEGREDATION OF CRUDE OIL IN ALASKA'S COOK INLET.

In: Proceedings Joint Conference on Prevention and Control of Oil Spills. API., FWPCA, Amer. Petrol. Inst., Wash., D.C.

The results of a study to quantitatively define the magnitude of oil pollution problems in Alaska's Cook Inlet are reported. Physical dissipation and biodegration rates were determined and combined with estimates of hydrocarbon input rates to assess the fate of oil in Cook Inlet. The question of accumulation of crude oil components within the Inlet is considered from the above results and by direct analysis. Results indicate that hydrocarbon accumulation is less than our present limits of detection. Cook Inlet flushing is 90 per cent complete in 10 months. Experimental results show that unsupplemented Cook Inlet water effectively degrades Cook Inlet crude, that this biodegradation is essentially complete in the order of a few months, and that the biodegration capacity of Cook Inlet is large. Thus biodegration is more important than physical flushing in removing hydrocarbon pollutants from Cook Inlet. The methods and results are discussed in terms of their applicability to other areas.

579. Kittredge, James S. (1973).

THE EFFECTS OF CRUDE OIL POLLUTION ON THE BEHAVIOR OF MARINE INVERTEBRATES.

National Technical Information Service. U.S. Dept. of Commerce. AD-762 047. pp. 1-12.

A study of oil pollution has revealed that the water soluble component of the oil is potentially the most dangerous to the marine biota. This water soluble material apparently destroys the sensitive neuronal dendrites of the chemoreceptor organs. Since most marine organisms depend primarily on chemoreception for the location of food, a suitable niche or sexual partners, disruption of this function would limit severely the survival of the species.

Supplementary observations on "cryptic odors" suggests that this natural mechanism of protection may provide a model for insect repellents.

580. Kittredge, J.S. (1975).

EFFECTS OF CRUDE OIL ON MARINE INVERTEBRATES.

NTIS AD-A017-921/8WO

Laboratory studies indicate that the aliphatic hydrocarbon compounds are not harmful to adult crabs. The monoaromatic hydrocarbons can inhibit behavior that is dependent on chemoreception, but the effect is transient. The polyaromatic hydrocarbon compounds are the potentially dangerous component of oil pollution. Since crustacea and many other species of marine organisms depend on chemoreception not only for locating food sources, but also for detecting predators, finding sexual partners and for locating a suitable niche, inhibition of chemoreception by sublethal amounts of hydrocarbon pollution may drastically limit the productivity of a marine habitat.

581. Kittredge, J.F., F.T. Takahaski, and F.O. Sarinana. (1974).

BIOASSAYS INDICATIVE OF SOME SUBLETHAL EFFECTS OF OIL POLLUTION.

In: Proceedings, Marine Technological Society, Washington D.C., Sept. 23-25 1974. pp. 891-897.

This article reports an investigation of the effects of the water-soluble components of crude oils on chemically triggered behavior responses of crabs. The two bioassays consisted of (1) the behavior of male crabs when exposed to the sex pheronone and (2) the typical rapid lateral movements of the mouth parts when presented with 2o ul of 3 mM taurine. Both responses are inhibited by water-soluble components of crude oi. Sensitivity was not recovered for 3 to 11 days. Monoaromatics act as anesthetics while naphthalenes and alkylnapthalenes produce persistent inhibition. Naphathalene at 1 ppb was inhibitory. The effects of naphthalene on oyster gill cilia was also studied. 1 ppm has irritant activity accelerating cilia that sweep mucous across the surface of the gills and decreasing the activity of the cilia that pump water through the gills. This system is being developed into a bioassay technique for hydrocarbon pollution.

582. Klein, S., R. Cooper, and D. Jenkins (1976).

JP-4 AND JP-9 FUEL TOXICITY STUDIES USING FRESH WATER FISH AND AUFWUCHS, ANNUAL REPORT.

Aerospace Medical Research Laboratory, Wright-Patterson Air Force Base, Ohio, Report AMRL TR-76-50. Available through National Technical Information Service, Springfield, Virginia. 60 pp.

This report contains the results of research efforts concerned with defining the effects of potential environmental contamination resulting from the use of certain Air Force materials on fresh water fish and aufwuchs. Materials evaluated include RJ-4, RJ-5, Methylcyclohexane, JP-9 and JP-4. Techniques for exposing organisms to those substances are discussed and the results of such exposures are presented.

583. Knieper, L.H. and D.D. Culley, Jr. (1975).

THE EFFECTS OF CRUDE OIL ON THE PALATABILITY OF MARINE CRUSTACEANS.

Prog. Fish-Culturist. 37(1):9-14.

Brown shrimp (*Penaeus aztecus*), white shrimp (*P. setiferus*), and crabs (*Callinectes sapidus*) were maintained in water to which was added varying concentrations of crude oil from 2 offshore Louisiana wells. Threshold concentrations, at which an oily taste in cooked specimens was detected, were 49-160 ppm for the shrimp; differences were noted between species and between oil sources. Shrimp exposed to oil and then maintained in clean water had an oily taste after 1 wk. Threshold values for the crabs were 620-1,250 ppm.

584. Knowles, R. and C. Wishart (1977).

NITROGEN FIXATION IN ARCTIC MARINE SEDIMENTS: EFFECTS OF OIL AND HYDROCARBON FRACTIONS.

Environ. Pollut. 13 p. 133-149.

Nitrogen fixation (acetylene reduction) was measured in grab and core samples of sediments from the Beaufort Sea and Eskimo Lakes, Northwest Territories, Canada. Very low rates (about mg N/square meter/year) were detected in untreated sediments. Activity was stimulated by the addition of glucose, sucrose, lactose, mannitol, and malate but much less so by acetate; negligible activity was supported by N-acetyglucosamine. There was no consistent effect of the presence or absence of oxygen. Nitrogen fixation potentials in glucose-supplemented sediment samples showed large variation between stations, between samples from the same station and between depths within single cores down to 18 cm. Weathered Norman Wells crude oil, hexance, decane, dodecane, and hexadecane had no effect on nitrogen fixation or carbon dioxide evolution. There was no evidence of the utilization of any of the hydrocarbons tested during periods of over 30 days under experimental conditions.

585. Koe, B.K. and L. Zechmeister. (1952.)

ISOLATION OF CARCINOGENIC AND OTHER POLYCYCLIC HYDROCARBONS FROM BARNACLES.

Arch. Biochem. Biophys., 41:396-403.

From the fleshy peduncle of the goose barnacle (Mitella polymerus), collected on the Southern California coast, small amounts of the following compounds were isolated in crystalline form: chrysene; fluoranthene; 1,2-benzperylene; coronene; and a mixture of 3,4- and 1,2-benzpyrenes. This indicates that the previously reported occurrence of polycyclic aromatic hydrocarbons in the thatched barnacle (Shimkin, et al, 1951) does not represent an exceptional instance. The habitat of the goose barnacles was about 40 miles from that of the thatched barnacles. It is probable that other similar marine materials occurring along the California coast would yield analogous results. Since anthracene and phenanthrene were isolated from the thatched barnacles, but were absent in the goose barnacles, either the composition of the marine detritus ingested by the two batches of animals was different, or identical supplies were subjected to different alterations by the two species of barnacles.

586. Komagata, K., T. Nakase, and N. Katsuya. (1964).

ASSIMILATION OF HYDROCARBONS BY YEASTS II. DETERMINATION OF HYDROCARBON-ASSIMILATING YEASTS.

J. Gen Appl. Microbiol. 10(4):323-331.

Of 56 strains of hydrocarbon-utilizers, 49 were isolated from various sources and the remaining 7 supplied from type culture collections. The present paper describes the taxonomical studies on these yeasts.

587. Kontogiannis, J.E. and C.J. Barnett. (1973).

THE EFFECT OF OIL POLLUTION ON SURVIVAL OF THE TIDAL POOL COPEPOD, TIGRIOPUS CALIFORNICUS. Environ. Pollut., 4:69-79.

A study of the effect of simulated oil pollution on Tigriopus californicus indicated that a 1.5 mm thick layer of crude oil on the water surface caused the death of all animals within three days, while a similar layer of mineral oil resulted in complete mortality in five days. When oxygen was added to the water containing crude oil, total mortality was delayed by two days. Approximately 100% mortality was extended to seven days when crude oil was enclosed in a dialysis membrane bag immersed in the water and oxygen was supplied. When mineral oil was used and air provided, the animals survived as well as the controls. It was concluded that death resulted because the oil acts as a barrier to oxygen transfer between air and water, and because it contains substances toxic to Tigriopus.

588. Koons, C.B., C.D. McAuliffe and F.T. Weiss (1976).

ENVIRONMENTAL ASPECTS OF PRODUCED WATERS FROM OIL AND GAS EXTRACTION OPERATIONS IN OFFSHORE AND COASTAL WATERS.

In: Eighth Annual Offshore Technology Conference: 1976 Proceedings: Vol. I. p. 247-257. Houston, Tx.

The constituents of produced waters and their effects on offshore and coastal marine environments are reviewed. The composition, inputs, fates, and effects of petroleum hydrocarbons and inorganic components in produced waters are described. Considerable laboratory and field data are presented. Toxic components are in low concentrations in produced waters. Natural forces, such as dilution and evaporation, and chemical and biological reactions rapidly reduce the concentration of any toxic components in the produced waters to levels not harmful to the marine environment and biota. Field data from Timbalier Bay, Louisiana, and Texas bays and estuaries show that continuous low-level discharge of produced waters has little to no detrimental effects on the marine environment or biota.

589. Korringa, P. (1968).

BIOLOGICAL CONSEQUENCES OF MARINE POLLUTION WITH SPECIAL REFERENCE TO THE NORTH SEA FISHERIES.

Helgolander wiss. Meeresunters. 17:126-140.

Fish are not usually killed by petrochemical waste products, but these chemicals (phenols and related products in particular) frequently lead to development of an unpleasant flavor in fish and shellfish. As long as the oil floats, the hazards for fish and fish food are limited, but when emulsified, direct contact is feasible. Often the emulsifying agents are far more poisonous to marine organisms than the oil itself. The French, in avoiding such chemicals altogether after the Torrey Canyon incident, obtained excellent results using "craie de Chempagne", chalk mixed with 1% of a stearate, which evidently furthers microbial oxidation of the oil.

590. Korringa, P. (1973).

THE IMPORTANCE OF OIL POLLUTION IN THE NORTH SEA.

In: Inputs, Fates and Effects of Petroleum in the Aquatic Environment. Background Information for the Workshop Ocean Affairs Board, NSF. Airlie, Va. 21-25 May 1973.

The author concludes that although a great deal of oil enters the North Sea, only organisms frequenting the air-sea interfere, such as birds, are adversely affected. There is no evidence of harm to fish stocks, though extensive use of dispersants may cause such harm by causing the majority of the oil to enter the water column.

591. Kuhl, H. and H. Mann. (1967).

DIE TOXIZITÄT VERSCHIEDENER ÖKBEKÄMPFUNGSMITTEL FÜR SEE-UND SUBUASSERTIERE. (THE TOXICITY OF VARIOUS OIL-COUNTERACTING AGENTS FOR SEA- AND FRESHWATER ANIMALS.)

Helgo, Wiss. Merresunters., 16:321-327.

Tanker accidents at sea have led to the examination of the toxic effects on organisms of 14 oil-emulsifying agents both in fresh- and sea-water. The lethal limits of the substances examined were between 0.001 and 0.1 ml/l. For an appraisal of these values it is important to know that some substances cause different reactions in fresh-water and sea-water. Crude oil mixtures (Iraq-Crude-Oil) have similar lethal limits. A layer of crude oil alone on the surface of the water is less detrimental than a mixture of crude oil and emulsifying agents. On the part of the fisheries considerable objections should be raised against the use of such agents. In cases of soilage of beaches, harbours, and industrial plants, it must be decided whether damages to the local flora and fauna can be accepted or not.

592. Kuhnhold, W.W. (1969).

DER EINFLUSS WASSERLOSLICHER BESTANDTEILE VON ROHOLEN UND ROHOLFRAKTIONEN AUF DIE ENTWICKLUNG VON HERINGSBRUT. (THE INFLUENCE OF WATER-SOLUBLE COMPOUNDS OF CRUDE OILS AND THEIR FRACTIONS ON THE ONTOGENETIC DEVELOPMENT OF HERRING FRY (CLUPEA HARENGUS L.))

Ber. dt. wiss. Kommn Meeresforsch., 20:165-171.

Fertilized eggs and yolk sac larvae of the autumn spawning herring from Fehmarn were kept in jars under a film of crude oil or one of its fractions (crude oil of Venezuela, Libya, Iran and 7 fractions from light benzene to residue oil). The amount of oil or fraction per litre was 20 ml and 1 ml. The rates of mortality and hatching were determined. The lethal influence of different quantities of crude oil and their fractions on larvae was observed and gradual changes of swimming activity were noted. Oils of different origin differ in their toxicity. Crude oil of Libya seemed to be less harmful than the two others. The influence of the fractions seemed to decrease with increasing boiling points, whereas this phenomenon was partly inverted when the fraction had been emulsified.

593. Kuhnhold, W.W. (1969).

EFFECT OF WATER SOLUBLE SUBSTANCES OF CRUDE OIL ON EGGS AND LARVAE OF COD AND HERRING.

Copenhagen, International Council for the Exploration of the Sea, Fisheries Improvement Committee (CM 1969/E17). 15 p.

594. Kuhnhold, W.W. (1973).

THE INFLUENCE OF CRUDE OILS ON FISH FRY.

In: Marine Pollution and Sea Life. Fishing News (Books) Ltd. London pp. 315-317.

Cod eggs of different stages and young larvae of cod (Gadus merrhua) herring (Clupea harengus) and plaice (Pleuronectes platessa) were contaminated with dissolved and dispersed crude oil of different origins and character. Larvae are most susceptible at the critical phase of beginning feeding. Observed influences can vary widely depending on the type of crude oil spilled. "Natural" oil dispersions obtained without chemicals gradually lose their toxicity. Dispersions stabilized with dispersants keep on increaseing their deleterious effect for days. Larvae do not seem to be able to avoid oil contaminated water as the chemoreceptors are probably blocked or destroyed. If larvae remains in oil dispersions they have little chance of survival.

595. Kuhnhold, W.W. (1978).

EFFECTS OF WATER-SOLUBLE FRACTION (WSF) OF A BUNKER C OIL ON COD EGGS AND LARVAE.

In: In the Wake of the Argo Merchant Proceedings of a Conference and Workshop held at the University of Rhode Island, January 11-13, 1977.Center for C Kingston, Rhode Island.

One-half, 3, and 7 day old eggs and 2,4, and 8 day old larvae were exposed to the water soluble fraction of Bunker C oil in static tests. The initial concentrations of the test medium were 10, 100, and 600 ppb of total CCl_4 extractable hydrocarbons (IR). The hatching success of viable larvae and the difference in 50% survival time between control and treated larvae was measured. In the same tests the heart beat rates of the treated embryos were measured, and a comparison between observed beat rate reduction and viable hatch is drawn. An attempt is made to extrapolate laboratory findings to field conditions, which existed at the time of the Argo Merchant spill.

596. Kuhnhold, W.W. (in press).

THE EFFECT OF MINERAL OILS ON THE DEVELOPMENT OF EGGS AND LARVAE OF MARINE SPECIES.

In: Proceedings of ICES - Workshop: Petroleum Hydrocarbons in the Marine Environment.

597. National Academy of Sciences, Ocean Affairs Board, (1973).

BACKGROUND PAPERS FOR A WORKSHOP ON INPUTS, NOTES, AND EFFECTS OF PETROLEUM IN THE MARINE ENVIRONMENT. 2 VOLS.

National Academy of Sciences, Washington, D.C. 836 pp.

Numerous aspects of petroleum in marine environments are discussed in papers collected as reference information for experts working with petroleum in the ocean. Subject areas include inputs of petroleum to the marine environment; chemical and biological analytical techniques; the fates of petroleum in the ocean caused by such processes as weathering, dispersion, biodegradation and biological uptake; and effects on coastlines, coastal biota, marine resources, and human health.

598. Lacaze, J.C. (1974).

ECOTOXICOLOGY OF CRUDE OILS AND THE USE OF EXPERIMENTAL MARINE ECOSYSTEMS.

Mar. Poll. Bull., Vol. 5:153-156.

Ecotoxicological investigations are generally undertaken in the laboratory on some constituents of ecosystems. The complementary synthetic aspect, comprising the analysis of the overall effect of a pollutant on an ecosystem, also falls within the framework of the science of pollution. The present study deals with the effects of a crude Kuwait oil on the primary production of experimental ecosystems.

599. Lacaze, J.C. and O. Villedon de Naide (1976).

INFLUENCE OF ILLUMINATION ON PHYTOTOXICITY OF CRUDE OIL.

Marine Pollution Bulletin, 7(4):73-76.

This report deals with the effect of illumination on the toxicity of Kuwait crude oil to the microalgae (Phaeadactylum tricornutum) as measured by primary production. The toxicity of extracts made from a crude is about two to three times greater when the latter is previously subjected to illumination of sufficient intensity and duration. The incorporation of a chemical dispersant (Corexit 8666) magnifies this phenomenon. In the case of a weathered crude oil mixed in equal parts with the dispersant, illumination raises the toxicity of the extracts by a factor of about 30.

600. Lake, J.L. and C. Hershner (1977).

PETROLEUM SULFER-CONTAINING COMPOUNDS AND AROMATIC HYDROCARBONS IN THE MARINE MOLLUSKS MODIOLUS DEMISSUS AND CRASSOSTREA VIRGINICA.

In: Proceedings 1977 Oil Spill Conference. p. 627-632. Amer. Petrol. Inst. Wash. D.C.

The in situ recovery of the mussel Modiolus demissus and the oyster Crassostrea virginica from successive small experimental dosings of No. 2 fuel oil was examined to determine the retention and release of petroleum hydrocarbons and petro-sulfur compounds from these marine mollusks. Extracts were obtained from the organisms over a four-month recovery period, and were analyzed by flame ionization detection (FID) and flame photometric detection (FPD) gas chromatography and gas chromatography-mass spectrometry (GCMS). Results showed a large majority of the petroleum compounds that were present in these organisms after two weeks of recovery were lost by the 15th week. Both mollusks showed an enrichment of aromatic (releative to saturated) hydrocarbons during the first portion of recovery. As the recovery time lengthened, the aromatics were lost more rapidly than the saturates. Mussels showed relative increases in some individual aromatic hydrocarbons during the recovery period. The oysters, however, appeared to non-selectively depurate the aromatic hydrocarbons. The higher molecular weight petro-sulfur compounds were retained for the longest time periods. During the study period these compounds appeared to be lost from the mollusks at rates similar to those observed for the aromatic hydrocarbons.

601. Landner, L. (1975).

OIL SPILL PROTECTION IN THE BALTIC SEA.

Water Pollution Control Federation. Journal, 47(4):796-809.

Present problems regarding the direct effects and treatment of oil spills are discussed, and legislative restrictions for water pollution control in Swedish waters are outlined. Responsibilities of an oil spill research group consisting of the Swedish Coast Guard, the National Environmental Protection Board, the Swedish Petroleum Institute, and the Water and Air Pollution Research Laboratory are discussed. Research on environmental effects of oil spills includes the determination of the acute toxicity of different oil dispersants, studies on composite effects of oil spills on faunal communities in the littoral zone of the Baltic Sea, studies on transformation and decomposition of an oil spill as a result of microbial activity, and the development of analytical procedures for oil analysis.

602. Lane, F.W., A.D. Bauer, H.F. Fisher, and P.N. Harding. (1926).

EFFECT OF OIL POLLUTION ON MARINE AND WILDLIFE.

Rept. U.S. Comm. Fish. App. 5(995):171-181.

An early review of the input and impact of oil on the environment, particularly on fish, shellfish and fowl.

603. LaRoche, G. (1974).

VALUE OF OIL POLLUTION MONITORING IN MARINE ORGANISMS.

In: NBS Special Publication 409, Marine Pollution Monitoring (Petroleum, Proceedings of a Symposium and Workshop Held at NBS, Gaithersburg, Maryland, May 13-17, 1974.

National Bureau of Standards. pp. 249-250.

This article is an analysis of the oil pollution monitoring program and a proposal that the emphasis of the program should concentrate on determining the precise nature of products which are biologically damaging and how much can be tolerated by a viable environment.

604. LaRoche, G., R. Eisler and C.M. Tarzwell. (1970.)

BIOASSAY PROCEDURES FOR OIL AND OIL DISPERSANT TOXICITY EVALUATION.

J. Water Pollut. Control Fed., 42(11):1982-1989.

Laboratory procedures are listed for the determination of relative 96-hr toxicities of crude oils, oil-spill removers, and oil-dispersant mixtures to representative cyprinodontiform teleosts, polychaete annelids, and decapod crustaceans. Salient features of the method include the use of disposable glassware, a synthetic seawater formulation, high-speed reciprocating shakers, controlled aeration, and DSS as a reference toxicant. The method may be used to test any product for toxicity to appropriate organisms in media of any salinity.

605. Lasday, A.H. and E.W. Mertens (1976).

FATE AND EFFECTS OF OIL ON MARINE LIFE: PROGRESS REPORT ON RESEARCH SPONSORED BY THE AMERICAN PETROLEUM INSTITUTE.

In: Eighth Annual Offshore Technology Conference: 1975 Proceedings: Bol. I., pp. 275-283. Houston, Tx.

Principal topics discussed are the uptake and depuration of hydrocarbons by marine animals and the weathering and dissipation of spilled crude oil. Temporary exposure of a marine organism to oil does not result in permanent contamination. Since the oil is released, it cannot be concentrated by moving up the food chain to ultimately become a health hazard to man. As the composition of a spilled oil changes rapidly with time, toxicity is reduced due to evaporation of the most toxic compounds. Thus, the residues of oil after an offshore platform mishap become relatively inert before they reach the most biologically sensitive shoreline area.

606. Latiff, S.A. (1969).

PRELIMINARY RESULTS OF THE EXPERIMENTS ON THE TOXICITY OF OIL COUNTERACTING AGENT (ESSO COREXIT 7664). WITH AND WITHOUT IRAQ CRUDE OIL, FOR SELECTED MEMBERS OF MARINE PLANKTON.

Arch. Fishereiwiss., 29(2-3): 182-185.

1. Corexit was less toxic than Oil-Ex, Anti-Oil TS 5, Sillarit, Vecom B 24, Struktol J 502, PS 777, Gamlen, Elimax, Slix, Peroklean and Moltoklar.

2. The addition of crude oil as in the case of Sillarit or Struktol J 502 reinforced the toxicity of Corexit.

3. The lethal limits of corexit for P. pileus, spionid larvae and young Crangon crangon without Irag crude oil were 0.667, 0.889 and

1.600 ml/l sea water respectively; the corresponding figures after the addition of crude oil were brought down to 0.222, 0.222 and 0.364 ml/l sea water respectively.

607. LeBoeuf, B. (1971).

OIL CONTAMINATION AND ELEPHANT SEAL MORTALITY: A "NEGATIVE" FINDING.

In: Biological and Oceanographical Survey of the Santa Barbara Channel Oil Spill, 1969-1970, Vol. 1. pp. 277-281. Allan Hancock Foundation Sea Grant Publ. 2. D. Straughan, (ed.)

When crude oil from the Santa Barbara Channel oil spill washed up on an elephant seal rookery just before March 17, 1969, over 100 pups were oiled. The National Park Service requested an investigation, the results of which indicated that the oil caused neither sickness nor mortality. This paper presents additional data which support the conclusion that oil fouling had no deleterious effect on the health of elephant seal pups.

608. Lee, R.F. (1975).

FATE OF PETROLEUM HYDROCARBONS IN MARINE ZOOPLANKTON.

In: Conf. on Prevention and Control of Oil Pollution. pp. 549-553. Amer. Petrol. Inst., Wash., D.C.

Several groups of zooplankton from the coasts of California, British Columbia, and in the Arctic, including copepods, euphausids, amphipods, crab zoea, ctenophores, and jellyfish rapidly took up 3H-benzpyrene, ^{14}C-benzpyrene, ^{3}H-methylcholanthrene, and ^{14}C-naphthalene from seawater solution. These hydrocarbons were metabolized to various hydroxylated and more polar metabolites by crustaceans but not by ctenophores or jellyfish. Up to 22×10^{-4} mg of benzpyrene was ingested by the temperate water copepod *Calanus plumchrus*, and transfer of this copepod to fresh seawater resulted in the discharge of most benzpyrene with less than 1×10^{-5} g remaining after 17 days. When depuration was continued beyond 17 days, no further hydrocarbon loss was observed. *Calanus hyperboreus* from the Arctic took up to 11×10^{-4} ug of ^{3}H-benzpyrene and a 28-day depuration experiment still showed the presence of benzpyrene in the copepod although again less than 1 x 10-5 ng.

609. Lee, R.F. (1976).

METABOLISM OF PETROLEUM HYDROCARBONS IN MARINE SEDIMENTS.

In: Sources, Effects and Sinks of Hydrocarbons in the Aquatic Environment. Proceedings of the Symposium, America University, Washington D.C. Aug. 9-11, 1976 p. 333-344.

The degradation of petroleum hydrocarbons in aquatic sediments result from the interaction of microfauna, meiofauna and macrofauna. Populations of hydrocarbon degrading microbes are high in areas of petroleum input, resulting in a rapid degradation of the alkanes with slower attack on isoalkanes, cycloalkanes and aromatic hydrocarbons. In the process of feeding, the interstitial community (meiofauna), and the benthic macrofauna expose deeper sediments to the water-sediment interface where there is more microbial activity. The polychaete worms take up hydrocarbons from the sediment and have an active enzyme system in the lower portion of their intestine which metabolizes these compounds. Hydrocarbons on resuspended sediments are recycled by passage through filter feeding bivalves. Bacteria and animals metabolize aromatic hydrocarbons by different mechanisms with bacteria procuding cis-diols while animals degrade them to trans-diols. Since bacteria use hydrocarbons as a carbon source there is ring cleavage of the diols with eventual degradation to carbon dioxide. Animals excrete the diols or their conjugated products.

610. Lee, R.F. (1977).

FATE OF PETROLEUM COMPONENTS IN ESTUARINE WATERS OF THE SOUTHEASTERN UNITED STATES.

Proceedings 1977 Oil Spill Conference. p. 611-616. Amer. Petrol. Inst., Wash., D.C.

Radiolabeled hydrocarbons and phenols were added to water samples from the Skidaway and Cooper Rivers, two estuarine rivers on the U.S. South Atlantic coast. The adsorption of hydrocarbons to particles and microbial degradation of different petroleum components were the processes studied. Alkanes, low molecular weight aromatics (benzene, toluene, naphthalene and methylnaphthalene) and phenols were rapidly degraded to $^{14}CO_2$. Low degradation rates were observed for the higher weight polycyclic aromatic hydrocarbons, fluorene, anthracene, benz(a)anthracene and benz(a)pyrene, and from 12 to 70% of these hydrocarbons were absorbed to suspended particles in the water. Radioautographs of particles after the addition of ^{3}H-benz(a)pyrene and ^{3}H-hexadecane to the water samples indicated the hydrocarbons associated with detrital particles. This detritus was composed of a mixture of clay, organic matter, plankton remains and living microbes. One area of the Cooper River had visible oil slicks and the degradation rates of added heptadecane (20 ug/l), naphthalene (30ug/l) and methylnaphthalene (30 ug/l) were 0.4, 2.8 and 1.1 ug/l/day, respectively. In contrast, at a downstream site, where there were no visible slicks, the degradation rate of these same hydrocarbons were 0.1, 0.7 and 0.1 ug/l/day, respectively. Estuarine water had much higher hydrocarbon degradation rates than offshore and Gulf Stream waters.

611. Lee, R.F., R. Sauerheber, and A.A. Benson. (1972).

PETROLEUM HYDROCARBONS: UPTAKE AND DISCHARGE BY THE MARINE MUSSEL, MYTILUS EDULIS.

Science, 177: 344-346.

The common marine mussel Mytilus edulis has been observed to rapidly take up mineral oil, (^{14}C)heptadecane, 1,2,3,4-tetrahydronaphthalene, (^{14}C)toluene, (^{14}C)naphthalene, and (^{3}H)3,4-benzopyrene from seawater solution. This species of mussel did not metabolize any of these compounds, and transfer of the mussel to fresh seawater, after exposure to the hydrocarbon in solution, resulted in the discharge of most of the hydrocarbon, although significant amounts remained (between 1 and 400 micrograms per mussel). The nontoxic paraffinic hydrocarbons mineral oil and heptadecane were taken up (10 milligrams per mussel) to a much greater extent than the aromatic hydrocarbons (2 to 20 micrograms per mussel.)

612. Lee, R.F., and A.A. Benson (1973).

FATES OF PETROLEUM IN THE SEA: BIOLOGICAL ASPECTS.

In: Inputs, Fates, and Effects of Petroleum the Marine Environment. Background Information for the Workshop, Ocean Affairs Board, NSF. Airlie Va., 21-25 May 1973.
This report summarizes various studies on the uptake, metabolism and discharge of hydrocarbons by selected species of phytoplankton, zooplankton, fish, and invertebrates using radioactive hydrocarbons.

613. Lee, R.F., R. Sauerheber and G.H. Dobbs. (1972).

UPTAKE, METABOLISM AND DISCHARGE OF POLYCYCLIC AROMATIC HYDROCARBONS BY MARINE FISH.

Mar. Biol., 17:201-208.

The uptake, metabolism and discharge of two polycyclic aromatic hydrocarbons, ^{14}C-naphthalene and ^{3}H-3,4-benzopyrene, were studied in 3 species of marine fish (mudsucker or sand goby, Gillichthys mirabilis; sculpin, Oligocottus maculosus; sand dab, Citharichthys stigmaeus). The path of hydrocarbons through the fish included entrance through the gills, metabolism by the liver, transfer of hydrocarbons and their metabolites to the bile, and, finally, excretion. The gall bladder was a major storage site of labeled hydrocarbons and their metabolites. The major product of ^{3}H-3,4-benzopyrene metabolism was tentatively identified as 7,8-dihydro-7,8-dihydroxybenzopyrene. The ^{14}C-naphthalene was metabolized to 1,2-dihydro-1,2-dihydroxynaphthalene after 24 h exposure. The urine appeared to be the major avenue for discharge of labeled hydrocarbon from the body. Our laboratory results indicated that certain polycyclic aromatic hydrocarbons were rapidly taken up from seawater by the above fish, but detoxification mechanisms existed for efficient removal of these compounds from their body tissues.

614. Lee, W.Y. (1977).

SOME LABORATORY CULTURED CRUSTACEANS FOR MARINE POLLUTION STUDIES.

Marine Pollution Bulletin, 8(11):58-59.

This article describes culture techniques for the planktonic copepod Arcatia tonsa, the isopod Sphaeroma quadridentatum and the amphipod Amphithoe valida for their use in toxicity studies. Preliminary results are given for experiments on the toxicity of the water soluble fraction of fuel oils.

615. Lee, W.Y. & J.A.C. Nicol (1977).

THE EFFECTS OF THE WATER SOLUBLE FRACTIONS OF NO. 2 FUEL OIL ON THE SURVIVAL AND BEHAVIOR OF COASTAL AND OCEANIC ZOOPLANKTON

Environ. Pollut (12) p. 279.

Acute effects of water-soluble fractions (WSF) of No. 2 fuel oil on both coastal and oceanic zooplankton were studied and their LC_{50} for various exposure times (1 to 72h) compared. Coastal zooplankton seemed to be more resistant to the WSF than oceanic zooplankton. This difference was probably caused mainly by the dissimilar species composition of the two zooplankton populations under investigation. The evidence from this study indicates that, on a species or taxon basis, there are some species in coastal waters more vulnerable to oils than among oceanic zooplankton and it is strongly recommended that further studies of the tolerance of both populations to various petroleum hydrocarbons be carried out at the same time.

A vital staining method was used to distinguish the dead from the immobile forms. Expected variations both in the curves of mortality compared with time and in the curves of mortality compared with concentration of oil are explained and a possible method to decrease variability is suggested.

Change of behavior of coastal zooplankton due to the WSF of No. 2 fuel oil was also abserved during the first hour of exposure.

616. Lef, W.Y., M.F. Welch and J.A.C. Nicol (1977).

SURVIVAL OF TWO SPECIES OF AMPHIPODS IN AQUEOUS EXTRACTS OF PETROLEUM OILS.

Mar. Poll. Bull. 8(4) 92-94.

Aqueous extracts of two petroleum oils, No. 2 fuel oil and Southern Louisiana crude, were tested on two amphipods, Granmarus mucronatus and Amphithoe valida, for survival. The oils were toxic at concentrations of 0.8 ppm (fuel oil) and 2.4 ppm (S. Louisiana crude). Mortalities increased with the concentration and length of exposure. Few or no young were produced at these and higher concentrations. (breeding adults were decreasing rapidly in numbers). The amphipods are more sensitive to aqueous extracts of these oils than are benthic polychaetes and shrimp, for which data are available.

617. Lehman, E.J. (1975).

THE BIOLOGICAL EFFECTS OF OIL SPILLS (A BIBLIOGRAPHY WITH ABSTRACTS).

National Technical Information Service, Springfield, Va. NTIS/PS/118.

This bibliography is composed of 107 selected abstracts of Government-sponsored research reports. Includes effects on microorganisms, plants, and animals along with research on residues and metabolic products of various oil components.

618. Lembaga Minyak Dan Gas Bumi (1974).

COASTAL ZONE POLLUTION IN INDONESIA WITH EMPHASIS ON OIL. A RECONNAISSANCE SURVEY.

National Technical Information Service, Springfield, VA. 186 p.

In 1972 and 1973 the LEMIGAS Study Group on Pollution (SGP) and the Smithsonian Institution jointly undertook a survey on marine pollution by oil in Indonesia. This document contains a review of existing knowledge concerning oil pollution in tropical waters, a survey of Indonesian marine resources vulnerable to oil pollution, and a review of the present status of oil pollution based largely upon field interviews and visits to various installation on and offshore. It seems that pollution by oil in offshore waters is not yet a serious problem in Indonesia. The Indonesian fish catch statistics reviewed do not prove or disprove the adverse impact of oil pollution on high seas fisheries. "Tambaks" or brackish water fish ponds are the most important coastal resources, in terms of present and potential value, that could be adversely affected by oil pollution. Other forms of pollution are also of immediate concern such as industrial effluents and organochlorine insecticides in agricultural run-off. Domestic waste waters may also be causing problems. Knowledge of coral reef ecosystems and of the manner in which they are affected by oil pollution is insufficient to permit conclusions. Tourism and recreation in the Kepulauan Seribu are adversely affected by beach oil pollution, apparently originating from ship traffic. Reliable information on marine pollution levels and marine resources, based on scientific research, surveys and statistical data collection, does not presently exist. Coastal water pollution is not presently monitored except for visual observations. (Sinha OEIS)

619. Lemmetyinen, R. (1966).

JÄTEOLJYN VESILINNUILLE AIHEUTTAMISTA TUHOISTA ITAMEREN ALUEELA. (DAMAGE TO WATERFOWL IN THE BALTIC AREA CAUSED BY WASTE OIL.)

Suomen Riista. 19:63-71.

Oil containers of tankers are often cleaned at sea. This leaves millions of tons of waste oil at sea each year, which has a considerable contaminating effect.

The most easily observable harmful effects of oil are those to waterfowl. It is estimated that hundreds of thousands, if not millions, are destroyed this way every year.

Oil damage reduces the waterfowl populations. The number of long-tailed ducks migrating through Finland in 1958-60 was one tenth of what it had been in 1937-40. A decrease in the numbers of velvet scoters (Melanitta fusca) has also been noted in Sweden.

Oil damage in Finland is less because the effect of the Gotland dumping area does not spread as far as Finland. Moreover, the number of waterfowl wintering in Finland is small. The greatest oil damage to waterfowl occurred in 1949, 1951 and 1955. The greatest catastrophe in Finland was in January 1955 in Southern Aland. It is estimated that quite 10,000 birds were killed. From 1959 to 1965, according to the archives of the Game Research Institute, large numbers (several hundred individuals) of oil-damaged birds have been found only three times. Other observations made in the 1960's have been limited to some random, slightly oil-damaged individuals probably arriving from the southern Baltic.

620. LePemp, Xavier, Jean-Claude Lacaze and Olivier Villedon de Naide (1976).

TOXICITY OF CRUDE OIL TO PRIMARY PHYTOPLANKTONIC PRODUCTION IN RANCE ESTUARY: EFFECT OF TEMPERATURE AND PERIOD OF CONTACT.

Bull. Mus. Natl. Hist. Nat. Ecol. Gen. 32, 107-110. (French with English Summary)

The toxicity of a crude oil to phytoplankton rises with temperature in the case of a biocenose-extract contact time of 24 hrs. By reducing the exposure time to 4 h, the toxicity is reduced to 1/7 and is no longer dependent on temperature.

621. LePetit, J. and M.H. Barthelemy (1968).

LES HYDROCARBURES EN MER: LE PROBLEME DE L'EPURATION DES ZONES LITTORALES PAR LOS MICROORGANISMES.

Annales de l'Institute Pasteur, 114(2), 149-158.

A qualitative and quantitative analysis of the gas-oil degradation by microorganisms in coastal sea-area was carried out. Fast disappearance of gas-oil compounds occurs when the microorganisms are supplied with sources of nitrogen and phosphorus. It is noted that interesting results are observed in the presence of inorganic compounds such as $PO_4H(NH_4)_2$ or more complex substances such as sewages. (In French, English Summary).

622. LePetit, J., M.H. N'guyen and S. Tagger. (1977).

DATA ON THE ECOLOGY OF A LITTORAL MARINE ZONE RECEIVING OIL REFINERY WASTES.

Environ. Pollut. 13(1):41-56. (French with English Summary).

Physical and chemical conditions in the effluent area are not favorable to phytoplanktonic population equilibrium, but seem to be so for hydrocarbon degradation by bacteria.

623. LePetit, J., M.H. N'Guyen and L. Deveze,

ETUDE DE L'INTERVENTIA DE LEVURES DANS LA BIO-DEGRADATION EN MER DES HYDROCARBONS (STUDY OF THE INTERVENTION OF YEASTS IN THE BIO-DEGRADATION OF HYDROCARBONS IN THE SEA).

Ann. Inst. Pasteur, 118(5):709-720.

The occurence of yeasts involved in biodegradation of accidental hydrocarbon slicks has been studied in two littoral marine areas near Marseille, one of which was directly affected by oil refinery effluents and the second free from all pollution.

The studies made during a year have revealed profound differences between the two areas. Seven species have been isolated by their ability to grow on gas oil. One species (*Candida guillermondii* var. *membranoefaciens*) was temporarily present in the non-affected area. In the polluted area, two species (*Candida tropicalis* and *Candida lipolytica*) present in distillery overflow, were permanent and three other species (*Tarulopsis dattila*, *Torulopsis famata* and *Candida famata*) were temporary.

The conclusions are that a very limited number of species - particularly in areas free from permanent pollution -- were able to metabolize hydrocarbon fractions. It does not seem that under natural conditions, yeasts play an important part in hydrocarbon elimination in the sea.

624. Leppakoski, E. (1973).

EFFECTS OF AN OIL SPILL IN THE NORTHERN BALTIC.

Marine Pollution Bulletin, 4(6):93-94.

Oil pollution from the tanker "Palva" which ran aground in Finnish waters in 1969 provides an example of the hazards of oil spills in cold waters. The "Palva" incident and its aftermath were studied by Finnish biologists and same of their findings are reported. The chief casualties were eider ducks, but long-term effects appear small. From 23% to 33% (2,400-3,000 birds) died in 1969. The rocky, steep topography of the area affects the spreading of oil and cleansing operations. The presence of ice can inhibit oil spreading but makes damage prevention measures impossible.

625. Levy, E.M. (1972).

EVIDENCE FOR THE RECOVERY OF THE WATERS OFF THE EAST COAST OF NOVA SCOTIA FROM THE EFFECTS OF A MAJOR OIL SPILL.

Water, Air and Soil Pollution, 1(2):144-148.

A quantitative chemical investigation of Western North Atlantic waters a year after a spill of approximately 16,000 metric tons of Bunker C fuel oil by the oil tanker Arrow in Chedabucto Bay, Nova Scotia is reported. The background levels of residual oils in the Western North Atlantic off the east coast of Nova Scotia decreased from approximately 6 to about 2 ugl^{-1}.

626. Lewis, H.F. (1942).

DESTRUCTION OF WATERFOWL BY OIL.

Wilson Bull., 54, 217.

627. Lewis, J.B. (1971).

EFFECT OF CRUDE OIL AND AN OIL SPILL DISPERSANT ON REEF CORALS,

Mar. Poll. Bull., 2(4):59.

This report describes the results of laboratory experiments showing the effect of crude oil and an oil-spill detergent upon four common species of Carribbean corals.

628. Lichatowich, J.A., P.W. O'Keefe, J.A. Strand and W.L. Templeton. (1973).

DEVELOPMENT OF METHODOLOGY AND APPARATUS FOR THE BIOASSAY OF OIL.

In: Conference on Prevention and Control of Oil Spills pp. 659-666. Amer. Petrol. Inst., Wash., D.C.

Bioassay of petroleum or its components presents technical problems not encountered in testing of soluble and less volatile materials. The literature includes numerous accounts of toxicity for both crude and refined oil. In most instances, the indices of toxicity are based on metered inflow. Few such studies, however, consider the concentrations of oil in the water column to which the test organisms is exposed.

Essentially oil and water form a two-phase system. Even on a continuous flow basis, oil cannot be maintained as homogeneous oil-water mixture within a bioassay test system. Homogenization techniques produce a totally artificial environment dissimilar to natural conditions characterized by a slick of floating oil. Furthermore, since subsurface oil concentrations may represent a small fraction of the metered inflow, currently applied indices of toxicity based on metered inflow may be erroneous.

This presentation summarizes techniques that may be applied in the bioassay of oil and other non-miscible materials. Special attention is directed to the above problems. Bioassay procedures are described that are conducted in flow-through tanks equipped with gravity oil metering systems and static mixers to equilibrate diluent water.

Oil concentrations measured at different depths are utilized to calculate the mean level of exposure of the test organisms in the water column. Habitat preference and behavior of the test organism during bioassay were assessed in relationship to toxicity.

629. Linden, O. (1975).

ACUTE EFFECTS OF OIL AND OIL/DISPERSANT MIXTURE ON LARVAE OF BALTIC HERRING.

Ambio:J. Human Environ., Res. Manage., 4(3):130-133.

This report describes the acute effects of a crude oil and a mixture of the same oil and two commonly used oil spill dispersants on newly hatched larvae of Baltic spring-spawning herring Clupea harengus membras L. The results of this investigation show that herring larvae are 50-100 times more sensitive to an oil dispersion that is obtained by adding a dispersant to the oil, than to a "natural" oil dispersion without a dispersant. It is also shown that the acute toxicity of a self-dispersed crude oil decreases considerably in 24 and 72 hours, but if the oil is dispersed by a dispersant, the high toxicity remains almost unchanged in the same time.

630. Linden, O. (1976).

EFFECTS OF OIL ON THE AMPHIPOD GAMMARUS OCEANICUS.

Environ. Poll. 10:239-250.

The effects of a number of oils (one crude and two refined products) were tested under various conditions on larvae and adults of the amphipod Gammarus oceanicus. Acute toxicity tests were performed, as well as long-term bioassays. Larvae were found to be several hundred times more sensitive to the oils than the adults during acute exposure. A number of sublethal effects appeared during long-term bioassays. The adults showed impaired swimming performance, decreased tendency to precopulate, impaired light reaction and decreased production of larvae. Decreased growth was found among larvae during chronic exposure to crude oil. Delayed mortality occurred among adults after a short-term exposure to crude oil with a long recovery period.

631. Lonning, S. (1977).

THE SEA URCHIN EGG AS A TESTING OBJECT IN OIL POLLUTION STUDIES.

In: Petroleum Hydrocarbons in the Marine Environment. K.D. McIntyre and K. Whittle (Eds), Rapp. P.-v. Reun. Cons. int. Explor. Mer. 171, 186-188.

632. Lockwood, A.P.M. (editor)(1976).

Effects of Pollutants on Aquatic Organisms Vol 10 193 pp.

Cambridge University Press

The papers included in this volume were presented at a seminar arranged under the auspices of the UK Society for Experimental Biology at Liverpool in April, 1975, and cover topics such as the pathways and rates of uptake, detoxification and release from the body of foreign substances, effects of toxins on specific physiological systems and adaptations of organisms to chronic low levels of pollutants. Most of the major marine pollutants are covered.

633. Lonning, S. and B.S. Hagstrom. (1975).

THE EFFECTS OF CRUDE OILS AND DISPERSANT COREXIT 8666 ON SEA URCHIN GAMETES AND EMBRYOS.

Norw. J. Zool, 23:121-130.

Kuwait and Ekofisk crude oils, with and without Corexit 8666 were administered to sea urchin gametes and embryos, both for short and longer term exposures. Noted that the test substances had a moderate effect on fertilization and early development; more harmful effects during further differentiation. Ultramicrographs showed that corexit 8606 brought about an increase and an aggregation of oil droplets within the cells.

634. Lonning, S. and B.E. Hagstrom. (1975).

THE EFFECTS OF OIL DISPERSANTS ON THE CELL IN FERTILIZATION AND DEVELOPMENT.

Norw. J. Zool., 23(2):131-134.

Report on the effect of nine different oil disperisants on the fertilization and development of sea urchin and fish eggs. Observed inhibition, pathologies, cytolysis.

635. Lonning, S. and B.E. Hagsstrom, (1976).

DELETERIOUS EFFECTS OF COREXIT 9527 ON FERTILIZATION AND DEVELOPMENT.

Mar. Pollut. Bull., 7 124-127.

The effect of the water soluble oil dispersant Corexit 9527 was tested on larvae from several species of sea urchins and marine fishes. Severe effects in fertilization and development were registered often resulting in pathological larvae and rapid cytolysis. The combination of Corexit 9527 with oil was found to be even more dangerous to the embryo than Corexit or oil alone.

636. Ludemann, D. (1968).

GEWASSERVERSCHMUTZUNG DURCH AUSSENBORD-MORTOREN UND DEREN WIRKUNG AUF FAUNA UND FLORA. (WATER POLLUTION THROUGH OUTBOARD MOTORS AND THEIR EFFECT UPON FAUNA AND FLORA.)

Helgolander wiss. Meeresunters, 17:356-369.

Tests were conducted in tanks and ponds to determine the effect of outboard motor operation on fish and fish food organisms. During pond tests, fish turned out to be sensitive indicators for the degree of water pollution because accumulation of combustion products in the water can be tested very quickly in terms of fish flesh flavour. Experiments in aquariums containing a concentration of 1:2000 demonstrated that detrimental changes in flavour of the fish disappeared after some days exposure to clean fresh water. The pond experiments further revealed a significant reduction in the number of certain microorganisms. After termination of tests, the chemical and biological conditions improved within a few weeks.

637. Ludwig, H.F. and L.G. Rich (1962).

THE OCCURANCE, EFFECTS AND FATE OF OIL POLLUTING THE SEA.

Intern. Conf. Water Poll. Res., London.

638. Ludvik, J., et al. (1968).

ULTRASTRUCTURAL CHANGES IN THE YEAST CANDIDA LIPOLYTICA CAUSED BY PENETRATION OF HYDROCARBONS INTO THE CELL.

Experientia, 24(10) 1066-1068.

Report on the differences in ultra-structure between yeast raised on glucose and yeast raised on hydrocarbon. Found the yeast raised on hydrocarbon had thickened cell membrane with more invaginations; more endoplasmic reticulium, more fat vacuoles, more ribosomes, more mitochondria, and fewer glycogen granules.

639. Ludzack, F.L., and D. Kinkead. (1956).

PERSISTENCE OF OILY WASTES IN POLLUTED WATER UNDER AEROBIC CONDITIONS.

Ind. Eng. Chem. 48:263-267.

This work reports the effect of common variables related to stream pollution on the rate of oil destruction by microorganisms. Organisms capable of biochemical destruction of oily waste in water (except for a trace of stable and odorous material) are abundant in nature. Oxidation of oil was not observed at low temperatures; at summer water temperatures the half-life of the oil was approximately one week. Biological stabilization was associated with the sedimentation of oil emulsions, and frequent reseeding was necessary to maintain biological activity. This work is a guide to understanding the behavior of streams that are polluted with oily wastes, the nature of oil decomposition, and its effects on water quality.

640. Lund, E.J. (1957).

CRUDE OIL ON THE OYSTER.

Publ. Inst. Mar. Sci. Univ. Tex. 4:328-341.

The capacity of an oyster to clear turbid sea water suspensions was used as a physiological index of the sensitivity of the oyster to crude oil, bleed water, and the soluble fraction of oil. The threshold concentration of bleedwater in seawater was between 3 and 6%. Soluble fraction, obtained by countercurrent had no effect at 6% concentration. No effect could be offered with water in contact with crude oil.

641. Lytle, J.S. (1975).

FATE AND EFFECTS OF CRUDE OIL ON AN ESTUARINE POND.

In: Conference on Prevention and Control of Oil Pollution. pp. 595-600., Amer. Petrol. Inst., Wash., D.C.

Crude oil spilled in an estuarine marine environment caused short-term, acute effects on salt marsh plants. Drastic changes in both diversity and numbers in the fish population were observed immediately after the spill. Initially zooplankton populations dropped, accompanied by phytoplankton blooms. As the oil dissipated, the zooplankton population increased rapidly. Long-term effects on fauna and flora were being studied. Migration of the oil via benthic animals and tidal percolations was observed as much as 42 cm beneath the sediment surface. The sediments acted as an organic sink preserving the crude oil. Gas chromatographic analyses of sediment core sections indicate slow degradation of the crude oil with loss only of the lower molecular weight hydrocarbons after twelve months.

642. Lysyj, I.; et. al. (1972).

MULTICOMPONENT PATTERN RECOGNITION AND DIFFERENTIATION METHOD.

Anal. Chem., 44:2385-2387.

Describes a method of differentiating between hydrocarbon fractions from petroleum oils and organic matter derived from biomass, in natural waters. Specific patterns for outboard motor oil and dried algae were obtained pyrographically and identified by peaks. Mixtures of oil and algae suspensions in water were analyzed mathematically to determine proportions of each.

643. Macadam, S. (1866).

ON THE POISONOUS NATURE OF CRUDE PARAFFIN OIL AND THE PRODUCT OF ITS RECTIFICATION UPON FISH. .

Rep. Brit. Ass. Adv. Sci., 36 41-43.

644. Mackey, D. and W. Harrison (1973).

OIL AND THE CANADIAN ENVIRONMENT.

Institute of Environmental Sciences and Engineering, University of Toranto. 149 pp.

In this collection of papers, oil spills are discussed in terms of contingency planning, supertanker ports, containment, cleanup, weathering and dissolution. The effect of spills on different marine, inland water and terrestrial environments of Canada, including arctic areas, is also described. Other topics include water in oil emulsions, microbial modification of crude oils, distribution and fate of marine hydrocarbons, and transportation of crude oil.

645. Mackie, P.R., A.S. McGill and R. Hardy. (1972).

DIESEL OIL CONTAMINATION OF BROWN TROUT (SALMO TRUTTA L.).

Environ. Pollut., 3:9-16.

Hydrocarbons chemically identical to those present in diesel fuel oil have been isolated from trout caught eleven days after a spillage of diesel fuel oil had occurred in their environment. Both the fish after cooking and the hydrocarbon fraction isolated from the uncooked fish were found to smell and taste in a manner reminiscent of the fuel oil.

646. Mackie, P.R., K.J. Whittle and R. Hardy (1974).

HYDROCARBONS IN THE MARINE ENVIRONMENT I. N-ALKANES IN THE FIRTH OF CLYDE.

Estuarine and Coastal Marine Science 2,359-374.

Water, surface film, sediment, plankton and fish from the Firth of Clyde have been examined to determine the amount and distribution of hydrocarbons. All samples contained hydrocarbons although at very low levels. The distribution of n-alkanes was of two types: first, a relatively smooth increase from C_{18} to C_{26} then a decrease to C_{33} for water, plankton and fish muscle; second, a strong odd carbon number predominance in the range C_{25}-C_{33} for the sediment, benthos and fish liver samples. No evidence was found for accretion of hydrocarbons at higher levels of the food chain. It was not possible to determine unequivocally whether the hydrocarbons present in the samples were biogenic or non-biogenic.

647. Mackin, J.G. (1950).

A COMPARISON OF THE EFFECTS OF APPLICATION OF CRUDE PETROLEUM TO MARSH PLANTS AND TO OYSTERS.

Project 9 Report. Texas A&M Research Foundation.

648. Mackin, J.G. (1950).

REPORT ON A STUDY OF THE EFFECTS OF APPLICATION OF CRUDE PETROLEUM ON SALTGRASS, DISTICHLIS SPICATA (L.) Greene.

Project 9 Report, Texas A&M Research Foundation.

649. Mackin, J.G. (1973).

A REVIEW OF SIGNIFICANT PAPERS ON EFFECTS OF OIL SPILLS AND OIL FIELD BRINE DISCHARGES ON MARINE BIOTIC COMMUNITIES.

Texas A&M Research Foundation Project 737.

650. MAckin, J., and S. Hopkins. (1961).

STUDIES ON OYSTERS IN RELATION TO THE OIL INDUSTRY.

Publ. Inst. Mar. Sci. Univ. of Texas, 7:1-131.

Field and laboratory studies and examination of historical records were made in the tidal waters of Louisiana to determine the possible role of operations of oil companies on mortality of commercial oysters, Crassostrea virginica. Hydrocarbon content of sediment was measured but could not be connected with mortalities. Laboratory tests indicated that lethal levels of petroleum were higher than could occur on oyster beds. Field experiments indicated no ill effects to oysters in spills, with the exception of smothering. It is concluded that the reported mortalities of oysters are due to temperature and salinity rather than oil field operation.

651. Mackin, J. and A. Sparks. (1961).

A STUDY OF THE EFFECTS ON OYSTERS OF CRUDE OIL LOSS FROM A WILD WELL.

Publ. Inst. Mar. Sci., 7:230-261.

An oil well went out of control, caught fire, and spilled oil for two weeks in the Louisiana marshes in 1956. A series of stations was established with oyster trays and growth panels at varying distances. Measurements were made in the ensuing two years.

Mortalities of oysters in the area were primarily associated with incidence of infection by the fungus Dermocystidium marinum typical of Louisiana and were not related to distance from the well. Disease incidence, oyster set, growth, associated organisms on the reefs, and oyster conditions were usual for the Louisiana area and apparently not affected by the spillage. Oily taste in oyster meats could not be identified after two months.

652. MacLeod, W.D., D.W. Brown and R.G. Jenkins (1976).

A PILOT STUDY ON THE DESIGN OF A PETROLEUM HYDROCARBON BASELINE INVESTIGATION FOR NORTHERN PUGET SOUND AND STRAIT OF JUAN DE FUCA. NOAA Technical Memorandum ERL MESA-8.

This report presents the results of a pilot study and offers recommendations for a first year Petroleum Hydrocarbon Baseline Investigation. The pilot study has demonstrated that methodology exists to detect and measure a number of hydrocarbons in sediments, mussels and a snail (*Thais lameldasa*). Appendices identify critical intertidal sites for further study and recommends analytical procedures best suited to the particular environment.

653. MacLeod, W.D., Jr., M. Uyeda, L.C. Thomas, and D.W. Brown (1978).

HYDROCARBON PATTERNS IN SOME MARINE BIOTA AND SEDIMENTS FOLLOWING THE ARGO MERCHANT SPILL.

In: *In the Wake of the Argo Merchant. Proceedings of a Conference and Workshop held at the University of Rhode Island Jan 11-13, 1978*. Center for Ocean Management Studies, University of Rhode Island, Kingstown, Rhode Island.

Over 60 samples of biota and sediment were analyzed by glass capillary gas chromatography and mass spectroscopy to compare the pattern of 24 major alkanes and 18-21 major arenes with the corresponding cargo pattern. Of 37 samples of biota analyzed only three samples of fish stomach contents gave alkane distribution patterns resembling *Argo Merchant* cargo patterns. Results of 25 sediment samples were at variance with published preliminary ultraviolet fluorescence data; only one sediment alkane pattern marginally resembled the cargo alkane pattern. Sample arene patterns did not relate well to the cargo arene pattern.

654. Mais, K.F. (1969).

PELAGIC FISH SURVEY OF THE SANTA BARBARA OIL SPILL.

Calif. Dept. of Fish and Game, Cruise Report 69A4. February 18, 1969. 4pp.

This survey could detect no ill effect of the oil leak on the pelagic fishes in the affected area at this time.

655. Malins, D.C., W.L. Reichert and W.T. Roubal (1976).

IDENTIFICATION OF MAJOR PROCESSES IN BIOTRANSFORMATIONS OF PETROLEUM HYDROCARBONS AND TRACE METALS.

In: *Environmental Assessment of the Alaskan Continental Shelf. Principal Investigators' Reports for the Year Ending March 1976. Vol. 8. Effects of Contaminants* pp. 139-153.

The objectives of this research unit were the identification and evaluation of certain physiological and biological effects of petroleum hydrocarbons on salmon, flatfish, and spotted shrimp and their larvae. Also included were studies on the effects of trace metals on salmon and flatfish. The effects of petroleum hydrocarbons were evaluated in terms of uptake and depuration studies in which hydrocarbons were administered by diet as well as by exposure to water-soluble fractions via immersion. In both the hydrocarbon and trace metal studies, chemical and physiological parameters will be correlated with data obtained by microscopic techniques. To date, emphasis of this research unit has been largely on the establishment and standardization of experimental techniques and protocols. (Sinha OEIS)

656. Malins, D.C. and M.E. Stansby (1976).

ASSESSMENT OF AVAILABLE LITERATURE ON EFFECTS OF OIL POLLUTION ON BIOTA IN ARCTIC AND SUBARCTIC WATERS.

In: Environmental Assessment of the Alaskan Continental Shelf, Principal Investigators' Reports for the Year Ending March 1976. Vol. 8. Effects of Contaminants, p. 155-320.

Literature is being reviewed backwards from the present time to as far back as anything can be found. While a few references are found dating back as much as 50 years, a preponderance of the material has been published during the last 10 years, much of it during the past three or four years. This information is being developed both in the form of extensive bibliographic reference lists, tabulated under 20 subject headings, and by preparation of a series of critical reviews prepared by scientific specialists from the information gleaned from available reports compiled in the bibliography. Included in this report is a listing of references in rough draft form of over 150 pages.

657. Malins, D. (ed.) (1977).

EFFECTS OF PETROLEUM ON ARCTIC AND SUBARCTIC MARINE ENVIRONMENTS AND ORGANISMS.

2 Volumes. Academic Press.

Volume One of this series describes the nature and fate of petroleum in the arctic and subarctic environment, while Volume Two covers the biological effects of petroleum in these environments.

Volume I Contents:

Petroleum: Properties and Analyses in Biotic and Abiotic Systems.

Inputs, Transport Mechanisms, and Observed Concentrations of Petroleum in the Marine Environment.

Alterations in Petroleum Resulting from Physico-Chemical and Microbiological Factors.

Volume II Contents:

Acute Toxic Effects of Petroleum on Arctic and Subarctic Marine Organisms.

Marine Fish and Invertebrate Diseases, Host Disease Resistance, and Pathological Effects of Petroleum.

Metabolism of Petroleum Hydrocarbons: Accumulation and Biotransformation in Marine Organisms.

Sublethal Biological Effects of Petroleum Hydrocarbon Exposures: Bacteria, Algae, and Invertebrates.

Sublethal Biological Effects of Petroleum Hydrocarbon Exposures: Fish.

Effects of Petroleum on Ecosystems.

Biological Effects of Petroleum on Marine Birds.

Consequences of Oil Fouling on Marine Mannals.

Effects of Oil Spills in Arctic and Subartic Environments.

658. Mann, H. (1965).

EFFECTS ON THE FLAVOUR OF FISHES BY OILS AND PHENOLS.

In: Commission Internationale paur l'Exploration Scientific de la Mer Mediterranee, Monaco, April 1964. pp. 371-374.

The author reviews information on the production of undesirable flavors in fish by exposure to polluting materials in water, particularly phenolic compounds, tar derivatives, and mineral oils, and the enhancement of these flavors by the simultaneous presence of synthetic detergents. (Sinha-OEIS)

659. Mann, H. (1969).

GESCHMACKSBEEINFLUSSUNGEN BEI FISCHEN. (OFF-TASTE OF FISH).

Fette, Seifen, Anstrichmittel, 71:1021-1024.

A series of substances are present in water which are taken up by fish, resulting in an unpleasant off-taste. Natural influences are the ones due to aqueous flora (seaweed). Certain feeds like maize also cause off-taste. Especially phenolic substances and oils are responsible for unpleasant taste. These substances are deposited in the fatty parts of the fish, especially in the internal organs. The substances impairing taste and smell are taken up mainly through gill and skin, and possibly also with feed.

The deposition of phenols and oils and their adverse effect on the taste is intensified by the presence of detergents in water.

660. Manwell, C. and C.M.A. Baker (1967).

A STUDY OF DETERGENT POLLUTION BY MOLECULAR METHODS: STARCH GEL ELECTROPHORESIS OF A VARIETY OF ENZYMES AND OTHER PROTEINS.

J. Mar. Biol. Ass. U.K. 47 659-675.

Tissues from several marine species were treated with a 1% solution of BP1002. The extracts were submitted to vertical starch-gel electrophoresis in order to measure both the effect of the detergent in facilitating the breakdown of cellular structure and the irreversible effect on activation or inhibition of various enzymes and other proteins. The proteins include dehydrogenases, esterases, hemoglobins, plasma proteins, egg proteins and phycoerythrin. Detergents increase extractability of proteins from cells. Hemoglobin of some species is rendered insoluble. Certain enzymes, eg. some esterases and amylases, are activated.

661. Mark, H.B., Jr., T.C. Yu, J.S. Mattson & R.L. Kolpack. (1972).

INFRARED ESTIMATION OF OIL CONTENT IN SEDIMENTS IN PRESENCE OF BIOLOGICAL MATTER.

Environ. Sci. & Technol. 6:833-4.

The crude oil content of marine sediments was determined by IR spectrometry from the magnitude of 2925 cm^{-1}($-CH_2-$stretching band) absorbance. Biological materials also absorb at 2925 cm^{-1} and have a well-defined absorbance band at 1650 cm^{-1} (the-NH-band characteristic of proteins) whereas, crude oils do not exhibit an amide band. The relative contributions of oil and organic material of recent biological origin in marine sediments were determined from measurements of these two absorbance bands, and a correction applied which enables the calculation of the oil content in the presence of these biological materials.

662. Marshall, H.G. (1974).

PHYTOPLANKTON STUDIES IN THE COASTAL WATERS BETWEEN CAPE HATTERNS AND THE GULF OF MAINE.

In: Marine Environmental Implications of Offshore Oil and Gas Development in the Baltimore Canyon Region of the Mid-Atlantic Coast. Proceedings of Estuarine Research Federation Outer Continental Shelf Conference and Workshop

This article reviews studies on the populations of marine phytoplankton on the Atlantic coast and the reasons for fluctuations in these populations. Also reviewed is the literature on the effects of petroleum on marine phytoplankton.

663. Marsland, D. (1933).

THE SITE OF NARCOSIS IN A CELL: THE ACTION OF A SERIES OF PARAFFIN OILS ON AMOEBA DUBIA.

J. Cell. Comp. Physiol, 4, 9-33.

Higher paraffin oils gives narcotic effects when introduced into the protoplasm by microinjection technique, but not with simple immersion. Their usual inertness is attributed to insolubility.

Parrafins attached to the cell membrane by "capping" produced narcosis more rapidly than when microinjected. It is concluded that narcosis is a cell membrane phenomenon.

664. Marumo, R. and K. Kamada (1973).

OIL GLOBULES AND THEIR ATTACHED ORGANISMS IN THE EAST CHINA SEA AND KUROSHIO AREA.

Nippon Kaiyo Gakkai-Shi 29(4):155-158.

In May 1971, along 125°E in the East China Sea and the Kuroshio area, oil globules were widely distributed in the surface waters, especially the upper 4 m. The highest value, 11 mg/m^3 wet wt, was obtained at the surface layer of Station No. 3 (28°N). Blue-green algae (Trichodesmium thiebautii and T. erythraeum), pennate diatoms (e.g. Nitzschia closterium), stony corals, bryozoans, barnacles (Lepas sp.). and copepods attached to oil globules. Morphological descriptions of 2 species of Trichodesmium are given.

665. Massachusetts Institute of Technology (1977).

OIL SPILLS: PROBLEMS AND OPPORTUNITIES.

MIT/Marine Industry Collegium Opportunity Brief #9. MITSG 77-17.

In this brief, the events occurring during the grounding and breakup of the liberian tanker Argo Merchant in December 1976 are used to illustrate the size and types of problems of responding to accidental oil spills. The Argo Merchant incident provides a framework for looking at the research, technology and instrumentation needs of the future.

667. Masters, M.J., et. al. (1970).

MYXOTROPHIC GROWTH OF ALGAE ON HYDROCARBON SUBSTRATES.

In: Developments in Industrial Microbiology, Vol. 12. Symposium, Kingston, R.I. August 1970. Murray, E.D. (ed.) p. 418, Am. Inst. Biol. Sci. Washington, D.C. pp. 77-86.Am. Inst. Biol. Sev. Washington, D.C. pp. 77-86.

Enrichment techniques were applied in an attempt to select algae able to use hydrocarbons. Seven clones were isolated in pure culture of which three (*Scenedesmus quadricanda* and two isolates of *Scenedesmus brevicanda*) showed improved growth in a medium containing n-heptadecane. Marked inhibition resulted with the addition of alkanes with 14 carbon atoms or less. No heterotrophic capability was observed.

668. Matthews, J. E. and L.H. Meyers (1976).

ACUTE TOXIC EFFECTS OF PETROLEUM REFINERY WASTE WATERS ON REDAR SUNFISH.

EPA Environmental Protection Technology Series Report EPA 600/ 2-76-241, October 1976. 55 p.

Static bioassays of 24 hours' duration were performed on samples of wastewaters provided by 22 domestic petroleum refiners. These wastewaters represent three types of water discharges prevalent to this industry. Bioassays were performed using redar sunfish (*Lepomis microlophus*) as test organisms. Twenty-four hour 50 percent tolerance limits (TL50) of the various wastewaters are compared with results of chemical analyses performed during the same study. Toxicity varied considerably both between refineries and for waste streams from within a single refinery. Results of these analyses and observed behavioral symptoms of distressed fish revealed that ammonia, sulfides, and phenolics, along or in combination, were major contributors to toxicity exerted in most samples. Three refineries had samples which were more toxic than anticipated based on results of chemical analysis, indicating the presence of other toxic compounds in unknown quantities; e.g. various hydrocarbons.

669. Maynard, H.G., C.D. Gebelein, and A. Zsolnay (1977).

THE EFFECTS OF PELAGIC HYDROCARBONS ON THE ROCKY INTERTIDAL FLORA AND FAUNA OF BERMUDA.

Proceedings 1977 Oil Spill Conference. p. 499-503. Amer. Petrol. Inst., Wash. D.C.

Over the past decade, the islands of Bermuda have been exposed to an increasing influx of floating pelagic hydrocarbons ("tar balls"). Large quantities of the pelagic tar become stranded on the rocks in the intertidal zone. Tar coverage on the rocks is controlled by the slope of the shore, with the maximum amount accumulating on gently sloping or flat shores. The tar is deposited almost exclusively in the splasy zone, and, therefore, the only animals directly affected by the attached tar are those who inhabit and/or feed in this zone. Chemical analyses show that the snails, *Nodilittorina tuberculatus* and *Tectarius muricatus*, which live in the splash zone, have the highest hydrocarbon content in body tissue of all animals analyzed. In contrast, all animals sampled from immediately adjacent tide pools contained no petrogenic hydrocarbons.

The most abundant life in the intertidal zone is concentrated below this splash zone area of tar accumulation. With few exceptions, the animals from this zone have demonstrated low or zero levels of petrogenic hydrocarbons in the body tissue. The presence of tar on the rocks does not appear to adversely affect reproductive potential, size frequency or abundance of the animals in this intertidal region below the splash zone. The microscopic and macroscopic algae produce very large amounts of biogenic hydrocarbon material. In addition, however, some algal samples from sites of heavy tar accumulation contained high levels of petrogenic hydrocarbons.

670. Mayo, D.W., C.G. Cogger and D.J. Donovan (1975).

THE ECOLOGICAL CHEMICAL AND HISTOPATHALOGICAL EVALUATION OF AN OIL SPILL SITE, PART II: CHEMICAL STUDIES.

Mar. Poll. Bull. 6 p. 166-171.

The oil from the March 1971 spill in Long Cove, Searsport, Maine, was identified with the aid of adjacent tank farm samples to be No. 2, fuel oil mixed with JP5 jet fuel. Sediment sample obtained from animal collection sites were analyzed by gas chromatographic procedures and were found to contain significant quantities of petroleum hydrocarbons.

671. Mazmanidi, N.D. and G.I. Kovaleva (1973).

EXPERIMENTAL DATA ON THE EFFECT OF OIL ON SOME CHEMICAL PROPERTIES OF SEA WATER.

Oceanology 12(5):684-689.

Experimental data are presented on the effect of various concentrations of oil and dissolved oil products on some hydrochemical characteristics of seawater. As the temperature rises and the amount of oil increases, the content of oil products in the aqueous solution increases. However, processes of abiogenic and biological degradation of dissolved oil products also intensify with increasing temperature. The dissolution of oil leads to an increase in the content of carbon dioxide and organic substances, and, in the absence of aeration, the amount of DO decreases sharply. At high temperatures, these processes take place more intensely. High oil concentrations have a more depressing effect on the water microflora, with corresponding changes of BOD.

672. McAuliffe, C.D. A.E. Smalley, R.D. Groover, W.M. Welsh, W.S. Pichle, and G.B. Jones. (1975).

CHEVRON MAIN PASS BLOCK 41 OIL SPILL: CHEMICAL AND BIOLOGICAL INVESTIGATIONS.

In: Proc. Joint Conf. on Prevention and Control of Oil Spills. pp. 555-566. Amer. Petrol. Inst. Wash., D.C.

During a three-week period in 1970 an estimated 65,000 barrels of 34° API gravity crude oil were discharged from the Chevron Main Pass Block 41C Platform, 11 miles east of the Mississippi River Delta. Two thousand barrels of chemical dispersants were sprayed on the platform and surrounding water surface.

It is estimated that between 25-30% of the oil evaporated during the first 24 hours, 10-20% was recovered from the water surface, less than 1% dissolved, and less than 1% of the oil was identified in sediments within a 5-mile radius of the platform. The remaining oil emulsified and dispersed to undetectable levels, biodegraded, or photooxidized.

The highest measured concentrations in water at the platform and at 1 mile were: oil-in-water emulsion, 70 to 1 ppm; dissolved hydrocarbons, 0.2 to 0.001 ppm; dispersant 1-3 to unmeasurable (<0.2 ppm).

Total extractable organic matter was highest in sediments near the Mississippi River Delta and in the inland bays.

Spilled oil, identified in bottom sediments by gas chromatography, showed rapid weathering after 1 week to 1 month and at the end of 1 year was reduced to a few percent of the amount after the spill. Spilled oil was not found in the sediment below 1.5 inches.

Over 550 species of benthic organisms were identified in 233 benthic samples. The number of species and number of individuals of benthic organisms showed low values in some samples near the platform. However, seasonal variations, bottom sediment type, and possibly other environmental parameters made it impossible to determine whether these locations had been affected by the spilled oil.

There was no correlation of number of species, number of individuals, or other biological parameters with the hydrocarbon content of the sediments for samples from within a 10-mile radius of the platform. This lack of correlation suggests lack of significant effect of oil on benthic organisms.

Extensive trawl samples showed no alteration in the annual life cycle of commercially important shirmp. Blue crabs were observed throughout the area, and the number of species of fish collected were comparable to a prior survey.

673. McCauley, R.N. (1966).

BIOLOGICAL EFFECTS OF OIL POLLUTION IN A RIVER.

Limnol. Oceanogr., 11:475-486.

Physical, chemical and biological conditions in the water and sediments of Muddy River, Massachusetts, were observed from autumn 1961 through summer 1963 to determine the effects of oil pollution on biological activity. Samples from above, in, and below the polluted area were collected and analyzed.

The heavy bunker oil pollutant formed a thin partial film on the surface of the water that partially excluded the oxygen from the water but not sufficiently to destroy developing plankton. Low biochemical oxygen demand correlated with consistently high concentrations of oil in the sludge in the polluted region indicating slow decomposition of the oil by microorganisms.

The oil was markedly toxic to the plankton and to the macrofauna of the sediments. The following plankters tolerated the pollution even during periods of highest oil concentration: Lyngbya, Oscillatoria, Ankistrodesmus, Chlamydomonas, Closterium, Gonium, Scenedesmus, Asterionella, Cyclotella, Fragilaria, Meridion, Navicula, Tabellaria, Euglena, Trachclomonas, Vorticella, Asplanchna, Keratella, Polyarthra, Cyclops and Nemata types.
In the sediments, Gammarus, Agrion nymphs, and Dugesia were unable to tolerate conditions in the region of oil pollution while Tubifex, Tendipes larvae, Nemata, and Hirundinea types were tolerant and remained.

674. McCormick, J.M. & P.T. Quinn (1975)

PHYTOPLANKTON DIVERSITY AND CHLOROPHYLL-A IN A POLLUTED ESTUARY.

Mar. Pollut. Bull. 6 105-6.

675. McGinnis, D.R. (1971).

OBSERVATIONS ON THE ZOOPLANKTON OF THE EASTERN SANTA BARBARA CHANNEL FROM MAY 1969 TO MARCH 1970.

In: Biological and Oceanographical Survey of the Santa Barbara Channel Oil Spill 1969-1970. Vol. 1, compiled by, D. Straughan, pp. 49-59. Allan Hancock Foundation, University of Southern California.

676. McIntyre, A.D. (1976).

ECOLOGICAL AFFECTS OF MARINE POLLUTANTS.

In: Second FAO/SIDA Training Course on Marine Pollution in Relation to Protection of Living Resources: Methods For Detection, Measurement and Monitoring of Pollutants in the Aquatic Environment. United Nations, Food and Agriculture Organization. UNIPUB, New York, p. 47-55.

Topics discussed include entry of pollutants into the biota and the effects of pollutants as determined from field and experimental studies. Three types of substances can be considered regarding entry to the biota: those normally present at low concentrations in the sea and taken up by marine organisms at transfer rates proportional to the environmental concentrations, without any threshold; those substances such as N,P, and Si whose concentrations vary from month to month so that a trophic level such as the primary producers will have evolved a range of species adapated to the range of concentrations and a threshold response might be expected; and artificially produced substances like DDT, not naturally present in the sea and for which only experimental tests can show the nature of the transfer from environment to organisms. Entry of pollutants into the biosphere may occur at any trophic level but is probably most efficient in the transfer from water to microorganisms. There is a tendency for persistent substances to accumulate and be concentrated in the higher trophic levels of the food chain. Two ways in which pollutant effects can be demonstrated include field observations, which must usually involve long time series of data, and experimental studies on single species or interacting populations over long periods. Topics considered under field studies are the observation of the gross effects of pollution, the detection of subtle effects such as population fluctuations and variations, and the evaluation of eutrophication. Topics discussed under experimental studies include short-term toxicity experiments, experiments with natural water on individual species, food chain experiments, and parent-offspring experiments.

677. McKee, H.C. and D.S. Tarazi (1974).

DEVELOPMENT OF SAMPLE PREPARATION METHODS FOR ANALYSIS OF MARINE ORGANISMS.

Ecological Research Series EPA-660/3-74-026. 61pp.

Laboratory methods were developed for processing, extracting, purifying, concentrating and measuring specific organic pollutants found in marine organisms. They provide new techniques for measuring organic contaminants in water to establish monitoring procedures, identify sources of contamination, evaluate methods of treatment, or for other uses in water quality management. They are more specific than conventional water quality parameters, such as BOD, since individual compounds can be measured. Quantitative measurement of many organic contaminants is possible from 0.2 to 0.5 ppm in a 5-g sample. Compounds tested included saturated hydrocarbons to C_{22} aromatics to C_9, alcohols to C_7 amines to C_6 glycols to C_6 unsaturated hydrocarbons to C_{10} and various ketones, phenols, esters, heterocyclic compounds. acids, sulfides, amines and chlorinated hydrocarbons. With most of these recoveries of 70%-90% were obtained.

678. McLusky, D., D. Bryant, M. Elliott, M. Teare and G. Moffat (1976).

INTERTIDAL FAUNA OF THE INDUSTRIALIZED FORTH ESTUARY.

Marine Pollution Bulletin 7(3) 48-52.

The principal effect of pollution in the Firth of Forth on the Scottish east coast is observed in the lifeless areas adjacent to petrochemical discharge pipes and in other areas of the upper Forth exhibiting a general reduction in the number of species. The upper Forth survives as a biological habitat despite the large pollution input; this is due to the diluting effect of inflowing, clean seawater at each side. The principal threat to the biological habitat remains various reclamation proposals to remove large areas of mudflats. If care is taken in the selection of such areas, if they are small, and if adequate treated discharges for industry are installed, wildlife and industry could coexist in the upper Forth.

679. McManus, D.A. and D.W. Connell. (1972).

TOXICITY OF THE OIL DISPERSANT, COREXIT 7664, TO CERTAIN AUSTRALIAN MARINE ANIMALS.

Search, 3:222-224.

The present study was initiated to determine the short-term toxicity of an oil dispersant (Corexit 7664) on four species of subtropical marine animals: Centropogon australis, (fortesque fish); Ambassis marianus, (perchlet); Diogenes sp., (hermit crab); and Paleomonetes sp., (shrimp). These present laboratory experiments indicate that comparatively high concentrations of the surfactant are needed to induce mortalities in the test species. In field applications concentrations of the surfactant finally attained in a treated aquatic area will depend on such physical factors as depth of water, mixing caused by wave action, the quantity used and the frequency of application. In a complex natural population the stage of development and condition of an animal as well as environmental factors may have a considerable influence on the exhibited toxicity. Also, in a spill situation, the surfactant can be expected to be mixed with refined or crude petroleum products which may have a marked effect on the exhibited toxicity. In this present examination no attempt has been made to observe long-term sublethal effects which may be of particular importance. However, it was noted that the test animals in almost all concentrations exhibited a greatly reduced mobility and reaction to stimuli compared with the control animals.

680. Mechalas, B.J., T.J. Meyers and R.L. Kolpack. (1973).

MICROBIAL DECOMPOSITION PATTERNS USING CRUDE OIL.

In: The Microbial Degradation of Oil Pollutants. Louisiana State University and Agricultural and Mechanical College. Center for Wetland Resources, Sea Grant Program Report LSU-SG-73-01 pp. 67-79.

A mixed culture of microorganisms, acclimated to decomposition of crude oil, was used in a series of incubation experiments to determine the sequence of microbial degradation in a Santa Barbara, California, crude oil. The molecular weight distribution of the crude oil was: C_1 to C_{10}, 29%; C_{10} to C_{30}, 52%; and greater than C_{30}, 19%. At least 15%, by weight, of this oil was composed of n-alkanes, or straight chain paraffins. Gas chromatograms of the stock crude oil were characterized by (in order of prominence), an envelope of n-paraffins, six highly resolved isoprenoid hydrocarbons, and more than a hundred smaller peaks that were partially resolved above the base envelope. Microbial degradation of the crude oil is initially characterized by a rapid disappearance of the n-paraffin envelope. This degradation starts with the low molecular weight components and progresses toward the higher molecular weight compounds. The isoprenoids are also progressively reduced simultaneously with the reduction of the paraffins. In addition, the base envelope and fine fingerprint region subsequently undergo degradation and the base envelope become progressively skewed toward the higher molecular weight end of the chromatogram. Biodegradation of the Santa Barbara crude oil by a mixed microbial population was initiated simultaneously on all components, but the sequential patterns of decomposition were affected by rate differences. Chromatograms of naturally weathered oils collected from southern California beaches are remarkably similar to chromatograms of oil samples which have undergone extensive microbial decomposition in the laboratory.

681. Medeires, G.C. and J.W. Farrington (1974).

IDOE-5 INTERCALIBRATION SAMPLE: RESULTS OF ANALYSIS AFTER SIXTEEN MONTHS STORAGE.

In: NBS Special Publication 409, Marine Pollution

Monitoring (Petroleum), Proceedings of a Symposium and Workshop held at NBS, Gaithersburg, Maryland, May 13-17, 1974. pp. 167-169.

This article reports the feasibility of preparing and storing lipid extracts for at least sixteen months. A cod liver lipid extract was spiked with 371.8 mg of a distillate cut of South Louisiana crude per gram of lipid in January 1972. The sample was stored under N_2 at 0^oC in the dark in a glass bottle with a Teflon-lined cap. In February 1974, lipid concentrations of each subsample were determined and aliquots were saponfied. Non-saponifiable lipids were extracted in pentane and the hydrocarbons quantitated by gas chromatography. The results of these analyses and those obtained 18 months earlier are in agreement.

682. Menzel, D.W. (1977).

SUMMARY OF EXPERIMENTAL RESULTS: CONTROLLED ECOSYSTEM EXPERIMENTS.

Bulletin of Marine Science, 27(1),142-145.

The first effects of pollutants in controlled ecosystem pollution environments appear to be universal. There is a short term response of bacterial populations which may be measured by changes in heterotrophic potential, oils and metals first impact phytoplankton by causing a rapid decline in most centrate diatoms. The sensitivity of zooplankton to metals leading to mortality is a direct function of the size of the organisms. The rate to which copper was removed from solution was directly related to the level of primary production.

683. Mertens, E.W. (1973).

A LITERATURE REVIEW OF THE BIOLOGICAL IMPACT OF OIL SPILLS IN MARINE WATER.

In: Input, Fates, and Effects of Petroleum in the Aquatic Environment. Background Information for the Workshop. Ocean Affairs Board, NSS Airlie, Va. 21-25 May 1973.

The author reviews the reports of several spill incidents and concludes that oil does little lasting damage to the various environments. Bioassay methods are reviewed and it is concluded that there is little standarization and that the results do not seem to be applicable to the field. The lack of occurance of sublethal effects in the field is also noted.

684. Mertens, E.W. (1974).

AN OVERVIEW OF THE PETROLEUM INDUSTRIES MARINE ENVIRONMENTAL RESEARCH.

Proceedings of Marine Environmental Implications of Offshore Drilling in the Eastern Gulf of Mexico. R.E. Smith (ed.) Institute of Oceanography, State University System of Florida, St. Petersburg, Florida.

The efforts of the petroleum industry to study the fate and the biological effects of oil spilled in the marine environment are discussed. Research work supported by the API, especially the program that is under the sponsorship of the Fate of Oil Task Force, is described. This program includes investigations of oil and phytoplankton, development of new bioassay techniques, development of improved chemical analysis for oil, effects of oil on oysters, fate of oil in the water environment, and spill surveys.

685. Mertens, E.W. (1976).

THE IMPACT OF OIL ON MARINE LIFE: A SUMMARY OF FIELD STUDIES.

In: Sources, Effects and Sinks of Hydrocarbons in the Aquatic Environment. Proceedings of the Symposium, American University, Washington D.C. Aug 9-11, 1976.

Extensive field studies on the effects of chronic low level exposure of oil to marine life have been conducted at Santa Barbara; Lake Maracaibo, Venezuela; Bermuda; and Timbalier Bay, Louisiana, in the Gulf of Mexico. No measurable effects have been observed on such indicators of the health of the local marine communities as population levels of various organisms; species diversity; and size, growth rate, or reproducibility of various organisms. Moreover, there is no evidence of adverse effects such as abnormal growths and biomagnification of petroleum fractions in the food chain.

686. Meyerhoff, R.D. (1975).

ACUTE TOXICITY OF BENZENE, A COMPONENT OF CRUDE OIL, TO JUVENILE STRIPED BASS (MORONE SAXATILIS).

J. Fish. Res. Bd. Canada 30 1864-1866.

The acute toxicity of benzene, a major constituent in crude oil of volatile aromatic compounds, to 1.5 plus or minus 0.5 gram juvenile striped bass (Morone saxatilis) was studied in a continuous flow laboratory bioassay system. At 17.4°C and 29ppt salinity, the lethal threshold concentration and the 96-h LC50 for benzene were 10.9 *microliters/liter.* The 95% confidence interval was 10.9 plus or minus 0.2 microliters/liter and the probit line slope, "S", was 1.1. Possible toxic mechanisms were discussed.

687. Meyers, S.P. and Ahearn, D.G. (1970).

MYCOLOGICAL DEGREDATION OF PETROLEUM PRODUCTS IN MARINE ENVIRONMENTS.

FAO tech. conf. mar. Pollut., Rome, pap. E-25. Also in: Marine Pollution and Sea Life, M. Ruivo (ed.) FAO, Fishing News (Books) Ltd. London. pp. 481-485.

This paper describes studies done along the Louisiana coast to determine (1) the hydrocarbonoclastic ability of yeast and yeast-like fungi from a broad range of environments and (2) the response of the dominant micota of the marshland biosphere to sudden intrusion of oil via spills.

688. Michael, A.D., C.R. Van Raalte, and L.S. Brown. (1975).

Long-term effects of an oil spill at West Falmouth, Massachusetts.

In: Conference on Prevention and Control of Oil Pollution. pp. 573-582. Amer. Petrol. Inst. Wash. D.C.

A small spill of No. 2 fuel oil occurred near Wild Harbor, Massachusetts, in September 1969. The benthic fauna of the Wild Harbor Marsh, boat basin, and offshore area was sampled through the fourth and fifth years after the spill (1973,1974). Sediment samples were analyzed for the presence of petroleum hydrocarbons. Gas chromatography produced evidence of hydrocarbons typical of weathered fuel oil in the sediments of the marsh, boat, basin, and two offshore stations. The numbers of benthic species at the offshore stations and the marsh were slightly, but significantly, lower than those found at control stations. Population densities were similar to control areas for the offshore stations but not in the case of the marsh. The boat basin was still heavily affected. Some stations were characterized by the presence of opportunistic species. The recovery process in terms of the total benthos has leveled off, but there was evidence for further recovery during the course of the study.

689. Micks, D.W., G. Chambers, J. Jennings, and A. Rehmet. (1967).

MOSQUITO CONTROL AGENTS DERIVED FROM PETROLEUM HYDROCARBONS. I. LABORATORY EFFECTIVENESS.

J. Econ. Entomol. 60:426-429.

One hundred ten hydrocarbons derived from petroleum were evaluated against the eggs, larvae and pupae of the southern house mosquito, Culex pipiens quinquefasciatus Say. (=C. Fatigans (Wiedemann)), and the yellow-fever mosquito, Aedes aegypti (L.) using 6 different test procedures. Of the test materials, 56 ranged from 2 to 8 times as effective as the no. 2 diesel fuel standard against larvae, 25 produced 100% mortality in C. fatigans pupae when applied at the rate of 5 gallons per acre, 20 exhibited a greater residual effect than the standard and 25 were faster acting than the control.

The test materials were generally more effective against the aquatic stages of C. p. quinquefasciatus than those of A. aegypti. The 2 test procedures involving the water surface application of oils to containers of larvae and pupae were found to be the most satisfactory for routine evaluation of the materials.

690. Miget, R.J. 1973.

BACTERIAL SEEDING TO ENHANCE BIODEGRADATION OF OIL SLICKS.

In: The Microbial Degradation of Oil Pollutants. Center for Wetland Resources, LSU, Baton Rouge, La., Publ. No. LSU-SG-73-01. Ahearn and Meyers, (eds.), pp 291-309.

Evaluations have been made to determine the feasibility of adding selected hydrocarbon-oxidizing bacteria and required nutrient salts to an oil slick to enhance biodegradation of the polluting hydrocarbon. Fifty active mixed cultures were isolated. Culture characteristics including cell morphology, temperature tolerance, and resistance to chemical dispersants were determined. Biodegradation of adsorbed vs. non-adsorbed oil was compared, and media for mass cultivation of organisms was developed.

Simulated field, or tank, experiments showed the effectiveness of microbial seeding varied more with the type and quantity of crude oil used than with such factors as inoculum density or nutrient salt concentration. Initial 24-hr losses were generally twice as large in bacterial seeded tanks relative to uninoculated controls. Biological Oxygen Demand and Total Organic Carbon analyses of tank water indicated little metabolic product pollution of the water.

691. Mileikousky, S.A. (1970).

THE INFLUENCE OF POLLUTION ON PELAGIC LARVAE OF BOTTOM INVERTEBRATES IN MARINE NEARSHORE AND ESTAURINE WATERS.

Marine Biology 6:350-356.

Review article on effect of various pollutants on the larvae of benthic invertebrates.

692. Miles, H.D., M.J. Coign and L.R. Brown (1975).

THE ESTIMATION OF THE AMOUNT OF EMPIRE MIX CRUDE OIL IN MULLET, SHRIMP, AND OYSTERS BY LIQUID CHROMATOGRAPHY.

In: Proceedings 1975 Conference on Prevention and Control of Oil Pollution. EPA, API, USCG., Amer. Petrol. Inst., Wash., D.C.

This paper presents a method for rapidly estimating the amount of oil taken up by small (0.1 g) samples of specific tissues from mullet, shrimp, and oysters that have been subjected to exposure to Empire Mix crude oil under controlled laboratory conditions. The results obtained by utilizing the liquid chromatographic (LC) method described in this paper are compared to results obtained using conventional gas chromatographic (GC) techniques. This comparison demonstrates that either method is valid for relatively large samples of tissue from mullet, shrimp, or oysters. Data from routine bioassay experiments have shown that 50% of the samples of shrimp tissue, 23% of the mullet tissue samples, and 49% of the oyster tissue samples showed the presence of oil only by the LC methods. Further, this LC method for estimating oil in these organisms affords a greater amount of replications for a given quantity of biological material and affords the opportunity to conduct multiple analyses on a given tissue.

693. Miles, D.H., M.J. Coign, and L.R. Brown (1977).

A LIQUID CHROMATOGRAPHIC FLUORESCENCE TECHNIQUE FOR ESTIMATING CRUDE OIL IN WATER, SEDIMENT AND BIOLOGICAL MATERIAL.

In: Proceedings 1977 Oil Spill Conference. Amer. Petrol. Inst., Wash. D.C.

This paper presents a method for the rapid detection of crude oil in the presence of large amounts of biological material. The method involves the use of high pressure liquid chromatography with chloroform as the solvent, an excitation wavelength of 403 nm. and an emission wavelength in the range of 418 nm. Of the five crude oils employed in this investigation. Saudi Arabian crude oil was the least responsive to the above technique and yet is still detectable in quantities of less than 1 ug.

Reproducibility studies indicated that the percent error of repetitive injection of Saudi Arabian crude oil samples was 1.3%. Repetitive injections of spiked shrimp samples gave a percent error of 3.7%. This is excellent reproducibility for residue-type samples which undergo a number of manipulations during workup. Thus, this method is selective, sensitive, reproducible, and affords a rapid analysis.

694. Miget, R.J., Oppenheimer, C.H. Kator, H.I., and LaRock, P.A. (1969).

MICROBIAL DEGREDATION OF NORMAL PARAFFIN HYDROCARBONS IN CRUDE OILS.

In: Proc. Joint Conf. on Prevention and Control of Oil Spills. American Petroleum Institute, Wash., D.C., p 327.

Experiments designed to measure the oxidation and degradation of crude oils by naturally occurring marine microorganisms are presently being conducted. Fifty active oil degrading cultures have been isolated in enriched seawater containing crude oil. Oil degradation has been determined with gas chromatography, wet combustion, and by measurement of surface tension. Normal paraffin hydrocarbons through C-26 are degraded by two different groups of microorganisms- those growing in the oil phase only and those growing in the aqueous phase. Emulsification of the crude oil through production of surfactants was observed in many of the enriched cultures. Microbial degradation of 35 to 55 per cent of oxidizable crude oil occurred within 60 hours.

695. Mills, E.R. (1972.)

TOXICITY OF VARIOUS OFF-SHORE CRUDE OILS AND DISPERSANTS TO MARINE AND ESTUARINE SHRIMP.

In: Proceedings of Annual Southeastern Association of Fish and Game Commissioners Conference, 25:642-650.

The acute effects of four crude oils and two oil spill removers on four species of marine shrimp (*Penaeus setiferus*, *P. aztecus*, *Palaemonetes vulgaris*, and *P. pugio*) were determined. Results of 48-hour bioassays showed that distinctive differences in toxicity existed between crude oils from different areas with all shrimp tested. The oil spill removers were much more toxic than the crude oils. Addition of the oil spill removers to all crude oils at recommended application ratios increased the toxicity of both the crude oils and the oil spill removers, indicating a synergistic effect. The *Palaemonetes* species appeared more tolerant to all toxicants.

Evidence indicates that the most serious effects of oil pollution would be noted in the shallower areas where high concentrations of toxic compounds may build up.

696. Miltin, L. (ed.) (1976).

BIOLOGICAL EFFECTS OF OIL POLLUTION OF WATER.

Distirbuted by National Aeronautics and Space Administration. Bibliography No. MSU613.

This bibliography was prepared by North Carolina Science and Technology Research Center for dissemination under the auspices of the National Aeronautics and Space Administration.

697. Minchew, C.D. and J.D. Yarbrough (1977).

THE OCCURRENCE OF FIN ROT IN MULLET (MUGIL CEPHALUS) ASSOCIATED WITH CRUDE OIL CONTAMINATION OF AN ESTUARINE POND-ECOSYSTEM.

Journal of Fish. Biology, 10 319-323.

Empire Mix crude oil (4.0-5.0 ppm) was introduced into two estuarine pond-ecosystems equipped with tidal simulation and stocked with mullet, shrimp, and oysters. Six to eight days following the spill all mullet examined from the treated ponds had varying degrees of fin rot on one or more fins. The fin erosion involved primarily the caudal, pectoral and pelvic fins with the caudal fin the most severely damaged. The damage to the fins varied from a slight discoloration with no visible fraying to complete erosion of all the fin elements. A gram negative rod tentatively identified as Vibrio sp. is considered the primary pathogen responsible for the fin erosion. The infection was primarily external as indicated by kidney cultures of the affected fish. The course of the infection was documented over a 56-day period following the oil spill. The high incidence of fin rot which occurred in the estuarine pond-ecosystems did not occur during numerous acute exposures of mullet to crude oil in the laboratory.

698. Ministry of Defense, Great Britian (1973).

THE FATE OF OIL AT SEA.

Great Britian Ministry of Defense, Defense Research Information Centre, Orpington. Report DRIC-BR-35830. 61 pp.

The effects of natural forces such as wind, wave motion, currents, temperature and other physical, chemical, and biological factors on movement, dispersal, and destruction of treated and untreated oil at sea and in the intertidal zone were studied. The behavior of oil from the point of discharge and subsequent movement are considered.

These include physical effects (spreading, evaporation, emulsification, and dissolution) and photochemical and biological factors causing degradation.

699. Minter, K.W. (1965).

STANDING CROP AND COMMUNITY STRUCTURE OF PLANKTON IN OIL REFINERY EFFLUENT HOLDING PONDS.

Diss. Abstr. 26, 1840.

700. Mironov, O.G. (1968).

HYDROCARBON POLLUTION OF THE SEA AND ITS INFLUENCE ON MARINE ORGANISMS.

Helgolander Wiss, Meeresunters, 17:335-339.

Marine oil pollution is becoming a major problem. The amount of pollution by oil and oil products may be expected to increase in the near future due to (a) the increase in number of sea going ships, including the tanker fleet, (b) the use of shelf zones for oil drilling, (c) poor international legislative measures to prevent oil pollution in the open seas.

Hydrocarbon products, especially oils, exert detrimental effects on the hyponeuston (organismic community near the water surface), eggs and larvae of fishes, e.g., the plaice (Rhombus maeoticus) phyto- and zooplankton, nectonic organisms, including adult fishes (via direct damage or by causing them to emigrate), and a variety of benthic organisms.

In general, eggs and larval stages of marine organisms seem to be more sensitive than their adult counterparts.

There is great need for long-term studies employing sublethal criteria.

Marine birds are killed by the thousand and hundred-thousands per year due to oil pollution.

Hydrocarbon pollution represents a new, unfavorable, ecological factor which may lead to permanent changes in the biological structure of the oceans and coastal waters, and which finally may reduce their productivity.

701. Mironov, O.G. (1969).

BLACK SEA MICROORGANISMS GROWING ON HYDROCARBONS.

Microbiol., 38(4):608-610.

Microorganisms capable of growing on petroleum hydrocarbons and petroleum products as a sole source of carbon and energy were isolated from Black Sea water. The microorganisms belong to the genera: Bacterium, Pseudobacterium, Pseudomonas, Vibrio, Achromobacter, Micrococcus, Bacillus, Spirillum and Sarcina. This suggests participation of this group of microorganisms in the self-purification of petroleum products from sea water.

702. Mironov, O.G. (1969).

EFFECT OF OIL POLLUTION UPON SOME REPRESENTATIVES OF THE BLACK SEA ZOOPLANKTON.

Zool. Zh., 48:980-984.

Report on the toxicity of Malgokek oil, mineral oil, and black oil at concentrations of .1 to .001 ml/1 upon Acartia, Paracalanus, Penillia, Centropages and Oithona. Found accelerated death rate at .001 ml/1 and at .1 ml/1; all organisms died within the first day.

703. Mironov, O.G. (1969).

SELF-PURIFICATION OF SEAWATER FROM CONTAMINATION BY PETROLEUM PRODUCTS.

Gidrobiol. Zh., 5(4):47-51.

Petroleum-oxidizing microorganisms and ordinary marine heterotrophic bacteria were grown in seawater and in peptone water, and were observed. It was found that microorganisms capable of utilizing hydrocarbons as their only source of carbon and energy constitute an insignificant portion of the total number of heterotrophs in seawater. They are more sensitive to temperature and can utilize other sources of carbon; members of the genera Pseudomonas, Pseudobacterium, Bacterium and Vibrio grew well on a whole series of organic compounds, and usually more rapidly than on hydrocarbons. Physical and chemical factors play a dominant role in the initial stage of degradation as regards changes that occur in the surface contamination, as indicated by data on the quantity of dissolved oxygen.

704. Mironov, O.G. (1969).

THE DEVELOPMENT OF SOME BLACK SEA FISHES IN SEA WATER POLLUTED BY PETROLEUM PRODUCTS. (IN RUSSIAN).

Voprosy Ikhtiologii, 9(6):919-922.

A study has been made of the development of the fertilized eggs of Engraulis encrasicholus ponticus Alex., Scorpaena porcus L. and Crenilabrus tinca L. in sea water containing 0.1 - 0.001 ml/liter of petroleum, solar oil and black oil. The different species' sensitivity to the petroleum products employed has been clarified. A harmful effect of the substances selected (death of the organism) was clearly traced to a concentration of 0.001 ml/liter. It is suggested that lower concentrations of petroleum, solar oil and black oil will also be found to be toxic for the hydrobionts concerned. The consequences of such intoxication may not be revealed in the direct death of the eggs or prelarvae, but at later stages in development or in future generations.

705. Mironov, O.G. (1970).

ON THE ROLE OF MICROORGANISMS GROWING ON OIL IN PURIFICATION AND AS AN INDICATION OF OIL POLLUTION IN THE SEA.

Okeanologija, 10 820-7

706. Mironov, O.G. (1970).

THE EFFECT OF OIL POLLUTION ON THE FLORA AND FAUNA OF THE BLACK SEA.

FAO Tech. Conf. Mar. Pollut., Rome. Paper E-92. (also in Mironove (1972))

707. Mironov, O.G. (1972).

EFFECT OF OIL POLLUTION ON FLORA AND FAUNA OF THE BLACK SEA.

In: Marine Pollution and Sea Life. M. Ruivo, (ed.) Fishing News (Books) Ltd. London. pp 222-224.

This article reviews the results of the authors determination of the sensitivity of a wide variety of Black Sea organisms to crude oil and diesel oil. 16 references.

708. Mirenov, O.G., L.H. Kiryukhina, M.I. Kucherenko, and E.P. Tarkhova, (1975).

Haukova dumka: Kiev, USSR pp. 143

The self purification of the waters and bottom sediments of the coastal zone of the Soviet shores of the Black Sea (USSR) from petroleum is discussed. Data on the numbers, species composition, distribution and biochemical characteristics of petroleum-oxidizing bacteria are presented and the physiochemical properties and processes of the transformation of organic substances from the marine bottom sediments are analyzed. The capacity of this marine area for self purification is evaluated.

709. Mironov, O.G., and L.A. Lanskaya. 1968.

THE CAPACITY OF SURVIVAL IN SEAWATER POLLUTED WITH OIL PRODUCTS INHERENT IN SOME MARINE PLANKTONIC AND BENTHOPLANKTONIC ALGAE.

Bot. Zhurn. 53:661-669.

The data are given on the effect of different concentrations of black oil and kerosene from 10.0 ml/l to 0.0001 ml/l on some marine planktonic and bentho-planktonic algae collected from the Atlantic Ocean, Black Sea, Red Sea and Mediterranean Sea. The data are indicative of great differences in the sensitivity of different species to the pollution of sea water with oil products, the lethal concentrations of black oil and kerosene for the most resistent species concentrations of black oil and kerosene for the most resistant species exceeding by several thousand times those for the most sensitive species. On the basis of the data obtained, it is assumed that there are some general principles governing the effect of the water pollution with oil products on microscopic algae. These principles appear to be, common to different seas and oceans.

710. Mironov, O.G. and L.A. Lanskaya (1969).

GROWTH OF MARINE MICROSCOPIC ALGAE IN SEAWATER CONTAMINATED WITH HYDROCARBONS.

Biologiva Morya, 17 31-8. (In Russian).

711. Mironov, O.G. and T.L. Shchekaturina (1976).

HYDROCARBONS IN MARINE ORGANISMS.

Gidrobial Zh. 12(6) 5-15. (Russian with English summ.)

Natural oil petroleum hydrocarbons are differentiated in organisms by IR, GLC, and mass spectrometry. Criteria are presented for differentiating between hydrocarbons accumulated due to biosynthesis and due to pollution. The examples of oil hydrocarbons absorption and distribution in marine biota and possibilities of biological monitoring of oil pollution are analyzed.

712. Mitchell, R. (1974).

THE EFFECTS OF POLLUTANTS ON MARINE MICROBIAL PROCESSES: A FIELD STUDY.

Government Reports Announcements, 74(26):148-149 (Abstract only).

Results are presented of a field study of Red Sea corals. Concentrations of crude oil, Cu, and available organic matter, insufficient to kill the coral directly, upset the microbiological balance on the coral surface. The pollutants stimulated excessive mucus production by the coral. Bacteria were attracted to the mucus and grew on it. Three factors associated with bacterial growth were responsible for the death of the coral colonies: oxygen depletion, chemical toxins, and bacterial predators.

713. Mitchell, C.T., E.K. Anderson, L.G. Jones and W.J. North (1969).

ECOLOGICAL EFFECTS OF OIL SPILLAGE IN THE SEA.

In: Water Pollution Control Federation 42nd Annual Conference held October 5-10, 1969, Dallas, Texas. 10 pp. (preprint)

Ecological consequences following oil spillage vary with oceanographic conditions, character of the liberated substance, and nature of any cleanup activities that may follow. A spillage of diesel fuel in a small cove on the open coast of Mexico in 1957 produced definable changes for a distance of about five miles. The recent spillage of crude oil in the Santa Barbara Channel affected certain bird species profoundly but did not initially cause significant mortalities among intertidal and shallow subtidal organisms. After several weeks of exposure, however, losses appeared among certain attached species such as barnacles and mussels. Various criteria for assessing ecological consequences are described and findings of field observations after the two spillages are explained in terms of literature on biological effects of exposure to oil. (Sinha-OEIS)

714. Mitchell, C.T., E.A. Anderson. L.J. Jones, and W.J. North. (1970).

WHAT OIL DOES TO ECOLOGY.

J. Water Pollut. Control. Fed. 42(5, part 1):812-818.

Ecological consequences following oil spillages range from mild disturbances to catastrophes. Effects in any instance are influenced by amount and character of the spillage, organisms involved, and many physical variables such as wind, currents, and sunshine. Some of the important factors affecting oil spillages and offer suggestions for assessing ecological damage are discussed.

Unlike many of the products man liberates into the environment, crude oil is a naturally occurring substance. From time to time it appears on the earth's surface by natural processes of exudation. Along the California coast there are many natural seepages. These seepages do not disperse large amounts of oil compared to some of the human accidents that liberate petroleum. Nevertheless the seepages are not totally negligible. The presence of oil in the biosphere may have encouraged evolution of microorganisms capable of utilizing the carbon and other elements in oil. The widespread occurence of such microorganisms act in preventing accumulation of oil on the earth's surface. In assessing ecological effects we must remember that oil spillages do not necessarily introduce a permanent or totally foreign pollutant into natural communities.

715. Mitchell, R. and I. Chet. (1975).

BACTERIAL ATTACK OF CORALS IN POLLUTED SEAWATER.

Microbiol. Ecology. 2(3):227-233.

Coral heads of the genus Platigyra exposed to low concentrations of crude oil, copper sulfate, potassium phosphate, or dextrose were killed in periods of 5 to 10 days in aquarium studies. The chemicals stimulated the production of large quantities of mucus by the corals. In aquaria treated with antibiotics to prevent microbial growth, Platigyra survived the presence of these chemicals in the water, indicating a role of the microflora in the death of the corals. Evidence was obtained implicating predatory bacteria, Desulfovibrio and Beggiatoa, in the destruction of the stressed coral colonies.

716. Mitchell, R., S. Togel and I. Chet. (1972).

BACTERIAL CHEMORECEPTION: AN IMPORTANT ECOLOGICAL PHENOMENON INHIBITED BY HYDROCARBONS.

Water Res., 6:1137-1140.

Motile marine bacteria have been shown to display chemoreception. They are attracted to a wide range of organic compounds. The response is highly specific for each microorganism. Chemoreception is also involved in the biodegradation of phytoplankton and enteric bacteria by bacterial predators. This ability of bacteria to detect living and non-living substrates is totally inhibited by hydrocarbons. The ecological implications of this type of sublethal effect on the self-purifying capacity of the sea and on the behavior of marine animals is discussed.

717. Moffitt, J. and R.T. Orr. (1938).

RECENT DISASTROUS EFFECTS OF OIL POLLUTION ON BIRDS IN THE SAN FRANCISCO BAY REGION.

California Fish and Game, 24:239-244.

Oil pollution of coastal waters contiguous to San Francisco Bay, the result of a shipwrecked oil tanker, presented unusual hazards to the avifauna of the areas affected during March and April, 1937. Pollution extended along 55 miles of coast line, centering at the Golden Gate and reaching from 15 to 20 miles out to sea. Its effects were felt not only by species of birds occurring along the open coast but also by those forms inhibiting shallow bays.

Among the offshore species of birds, California murres suffered most and the incident may have inflicted disastrous losses among proximal nesting colonies. Scoters and western grebes were species next in order affected. Offshore ranging forms such as murrelets, anklets shearwaters and petrels were apparently spared because the oil did not extend sufficiently far from shore to embrace their habitats. In the quiet bays, western grebes, white-winged scoters, ruddy ducks, cared grebes and red-throated loons suffered most in the order named.

Although several kinds of gulls were commonly observed in both habitats, so few were found incapacitated by oil that it was concluded that these birds escaped largely by reason of their feeding and resting habits.

718. Mohammad, M-B.M. (1974).

EFFECT OF CHRONIC OIL POLLUTION ON A POLYCHEATE.

Marine Pollution Bulletin, 5 (2):21-24.

The tube-building polychaete Pomatoleios kraussii is an important fouling organism in the Arabian Gulf. Studies have been made of its growth and survival on plates immersed in the water at two sites at Kuwait, one subject to frequent small spillages at an oil terminal, the other free from oil pollution. The temporal sequence and diversity of other encrusting organisms has also been documented at the same sites. P. Kraussii survival decreases as the area coated with oil increases.

719. Mommaerts - Billiet, F. (1972).

GROWTH AND TOXICITY TESTS ON THE MARINE NANO-PLANKTONIC ALGAE PLATYMONAS TERTETRATHELE (G.S. WEST) IN THE PRESENCE OF CRUDE OIL AND EMULSIFIERS.

Environ. Pollut., 4:261-282.

Cultures of Platymonas with above 50 ppm of emulsifier with an aromatic solvent exhibited a very long lag phase. Diminished growth rates were observed for all the products tested. Mixtures of oil and emulsifier showed a toxicity close to that of the mixture's concentration of emulsifier. Fine structure modifications were investigated and possible ecological effects are discussed.

720. Monaghan, P.H. and C.B. Koons (1975).

RESEARCH NEEDED TO DETERMINE CHRONIC EFFECTS OF OIL ON THE MARINE ENVIRONMENT.

Marine Pollution Bulletin, 6(10), 157-159.

This report outlines the conclusions of a panel of knowledgeable scientists which met in Houston, Texas on Nov. 4-6, 1974 with regard to (1) research needs for identifying and measuring possible chronic effects of oil on the marine environment and (2) highlight priority work required if only limited funds were available. It was agreed that high priority should be given to an ecosystem approach involving multidisciplinary studies.

721. Moore, S.F. (1973).

TOWARDS A MODEL OF THE EFFECTS OF OIL ON MARINE ORGANISMS.

In: Inputs, Fates, and Effects of Petroleum in the Aquatic Environment, Background Information for the Workshop, Ocean Affairs Board, NSF, Airlie, Va. 21-25 May 1973.

This paper summarizes a model of the effects of petroleum on marine ecosystems. The effects covered are toxicity, sublethal effects, tainting incorporation of polycyclic aromatic hydrocarbons, coating of organisms, and habital changes induced by spilled oil. These effects are related to the soluble aromatic hydrocarbon derivitives (SAD) contained in various petroleum products, and the sensitivity of various classes of organisms to SAD.

722. Moore, S.F. and Dwyer, R.L. (1974).

EFFECTS OF OIL ON MARINE ORGANISMS: A CRITICAL ASSESSMENT OF PUBLISHED DATA.

Water Res., 8 819-827.

Effects of oil on marine organisms are categorized as: (1) direct lethal toxicity; (2) sub-lethal disruption of physiological/behavioral activities; (3) effects of direct coating; (4) incorporation of hydrocarbons; and (5) alteration of habitat, especially substrate character. Occurrence of one or more of these effects depends on the composition of oil to which organisms are exposed. Weathering processes significantly alter the composition of spilled oil, resulting in wide variations in biological effects. A set of oil fractions, distinguished by boiling point range and hydrocarbon type, provide a convenient basis for including the important chemical aspects of the impact problem. Adult marine organisms may exhibit lethal toxic effects from exposures to 1-100 ppm soluble aromatic derivative hydrocarbons (SAD). Sub-lethal effects may be caused by SAD concentrations in the range 10-100 ppb. Oil exposed to the atmosphere for 1-2 days loses soluble fractions and non-toxic effects, habitat alteration and coating, become important effects. Effects of several spills are reviewed in light of the above considerations.

723. Moore, S.F., G.R. Chirlin, G.J. Puccia, B.P. Schrader (1974).

POTENTIAL BIOLOGICAL EFFECTS OF HYPOTHETICAL OIL DISCHARGES IN THE ATLANTIC COAST AND GULF OF ALASKA.

Massachusetts Institute of Technology Sea Grant Report 74-19, 121 pp.

This report is an analysis of the primary biological effects of potential oil discharges resulting from hypothetical oil production activity on the Atlantic/Alaskan outer continental shelf. Qualitative predictions are attempted which are rough order of magnitude estimates of physical, chemical and biological changes likely to occur due to oil release into the marine environment. The study consists of (1) an environmental inventory, (2) summary of response and sensitivity of individual organisms to petroleum (3) analysis of population/community level responses to oil, and (3) assessment of potential effects of specific oil discharges associated with hypothetical OCS petroleum developments.

Numerous references.

724. Moore, S.F. and B.P. Schrader. (1975).

ECOLOGICAL ANALYSIS OF HYPOTHETICAL OIL SPILLS OCCURRING IN THE NEARSHORE WATERS OF LONG ISLAND, NEW YORK.

In: 21st Annual Inst. Env. Sci., Mt. Prospect, Ill., 1:55-63.

This paper describes the results of a study to investigate the potential ecological effects of oil spills which could occur in the nearshore waters of Long Island, New York. Such spills are envisioned as possible due to both proposed offshore petroleum developments and trans-shipment activities in nearshore waters. The results form part of the information base which can assist the Nassau-Suffolk Counties Regional Planning Board to plan utilization of Long Island's coastal zone. The objectives of the study were two-fold: 1) to develop estimates of biological effects of hypothetical crude oil spills which are as specific as possible given the existing data, and 2) to lay out the framework for this analysis so that such an analysis may later be done for other events not specifically treated herein, and so that further research needs are defined.

725. Morozov, N.V., R.B. Petrova and G.N. Petrov. (1969).

THE ROLE OF HIGHER WATER PLANTS IN THE SELF-PURIFICATION OF OIL-POLLUTED RIVERS.

Hydrobiol. J. 5(4):37-42.

The role of higher water plants in the disposal of an oil film is demonstrated in the paper. It is established that the bacterial self-purification of oil-polluted river water is accelerated when water plants are present. It is noted that oil is conducive to plant growth.

726. Morozov, N.V. and A.V. Torpishcheva (1973).

MICROORGANISMS OXIDIZING PETROLEUM AND PETROLEUM PRODUCTS IN THE PRESENCE OF HIGHER AQUATIC PLANTS (in Russian).

Gidrobiol. Zh. 9 p. 66-73.

The presence of macrophytes promotes an increase of the number of oil-oxidizing bacteria and doubles and triples the bacterial decomposition of oil. A determination of the species composition of bacteria participating in the breakdown of oil and its products in water in the presence of higher aquatic plants showed that the qualitative composition is represented by the genera Bacillus, Bacterium, Achromobacter, Pseudomonas, Chromobacterium, Micrococcus, Sarcina and Planosarcina. In experiments with plants the 1st 3 genera dominated quantitatively: Bacillus and Bacterium accounted for 69% in the experiment with Scirpus lacustris, Bacillus for 71% with Typha angustifolia and Achromobacter for 90% with Typha latifolia. The bacteria accompanying Sc. lacustris demonstrated maximum activity with respect to the oxidation of hydrocarbons.

727. Morris, R.J. (1973).

UPTAKE AND DISCHARGE OF PETROLEUM HYDROCARBONS BY BARNACLES.

Mar. Poll. Bull., Vol. 4:107-109.

The hydrocarbon content of barnacles living on tarballs has been compared with the hydrocarbon composition of the tarballs. While there is some contamination of the barnacles there is no evidence of gross pollution and the analyses suggest that oil hydrocarbons are assimilated and then discharged, unmetabolized quite rapidly.

728. Morris, R.J. (1974).

LIPID COMPOSITION OF SURFACE FILMS AND ZOOPLANKTON FROM THE EASTERN MEDITERRANEAN.

Mar. Poll. Bull. Vol. 5:105-109.

Report on a lipid analysis of natural surface films and zooplankton. Found petroleum hydrocarbons in the surface layer and high levels of non-natural hydrocarbons in the lipids of some near-surface zooplankton.

729. Morrow, J.E. (1973).

OIL-INDUCED MORTALITIES IN JUVENILE COHO AND SOCKEYE SALMON.

J. of Marine Research, 31(3):135-143.

Advanced parr of coho slamon (Oncorhynchus kisutch) and sockeye salmon (O. nerka) were exposed in laboratory tanks to oil poured on the surface of artificial seawater in amounts ranging from 500 to 3500 ppm equivalent, at water temperatures of 3^{o}, 8^{o}, and $13^{o}C$. Statistically significant increases in the mortality rates over control animals were observed at all oil concentrations and at all temperatures. The mortality rates appeared to be directly related to oil concentration and inversely to temperature. Oil that had been exposed to air for 30 days did not produce mortality that was significantly greater than that of the control groups. Stress behavior under the influence of oil is described.

730. Morrow, J.E. (1974).

EFFECTS OF CRUDE OIL AND SOME OF ITS COMPONENTS ON YOUNG COHO AND SOCKEYE SALMON.

Office of Research and Development. USEPA, Washington, DC EPA-660/3-73-018. pp. 37.

Young coho and sockeye salmon, acclimiated to 30 o/oo salinity, were exposed in various ways to different amounts of crude oil from the Prudhoe Bay field. Oil poured on the surface of the water in 95 liter (25 gallon) aquaria produced significant mortalities when the oil concentration was 500 ppm or greater. Fish dipped into a crude oil film, or with a drop of oil placed directly on each gill, showed no significant mortalities. The same was true of fish force-fed crude oil at 1 g per 100 g body weight. Oil that had been exposed to air for 30 days produced no significant mortalities.

Among oil components tested for toxicity on coho salmon, aliphatic compounds were not lethal. Mono-cyclic aromatics were generally toxic, the degree of toxicity increasing with the degree of unsaturation.

It is suggested that the toxicity of these substances is brought about through alteration of cell membrane permeability, especially in the gills. This results in a rapid increase of mono-valent ions in the blood and probably also interferes with CO_2-HCO_3 regulation

731. Morrow, J.E. , R.L. Gritz and M.P. Kirton. (1975).

EFFECTS OF SOME COMPONENTS OF CRUDE OIL ON YOUNG COHO SALMON.

Copeia. 2:326-331.

Among oil components tested for toxicity to young coho salmon, aliphatic compounds produced no significant mortalities. Mono-cyclic aromatics were generally toxic, the degree of toxicity increasing with the degree of unsaturation. It is suggested that the toxicity of these substances is brought about through alteration of cell membrane permeability, especially in the gills. This results in a rapid increase in the concentration of monovalent ions in the blood and probably also interferes with CO_2HCO_3 regulation.

732. Morton, B. (1975).

POLLUTION OF HONG KONG'S COMMERCIAL OYSTER BEDS.

Mar. Poll. Bull., 6 117-122.

733. Morton, Brian and R.S.S. Wa (1977).

THE TOXIC EFFECTS OF HYDROCARBONS UPON THE NAUPLIAR AND ADULT STAGES OF BALANUS (CRUSTACEA: CIRRIPEDIA)

Mar. Pollut. Bull. 8 p. 232-236.

The effect of kerosene and BP 1002 upon the naupliar and adult stages of *Balanus amphitrite amphitrite* and *Balanus variegatus variegatus* has been studied. The percentage non-motility and actual mortality of the naupliar larvae and the adults of both species has been generally shown to be a function of the dosage and treatment time of these two hydrocarbons. Both barnacles (nauplii and adults) have a similar susceptibility to the hydrocarbons tested, the nauplii being killed at lower concentrations than the adults. Cirral activity of the adults was significantly reduced when the barnacles were treated with 10 and 100 ppm BP 1002.

Preliminary experiments have also been performed to compare the toxicity of BP 1002 and kerosene with that of "Bukomkleen" and "Chemkleen". It was found that BP 1002 was the most toxic to these barnacles with a lower and similar toxicity found for Chemkleen and Bukomkleen. The toxicity of kerosene is comparatively low.

734. Mostert, Noel (1974).

SUPERSHIP. Alfred A. Knope, New York. 332 p.

This book is an account of the operation and impact of the supertankers. Included are accounts of the impact of supertanker disasters on the marine ecosystem.

735. Motohiro, T. (1962).

STUDIES ON THE PETROLEUM ODOUR IN CANNED CHUM SALMON.

Bull. Fac. Fisheries, Hokkaido Univ., 10, 2-65.

736. Motohiro, R. and Z. Iseya (1976).

EFFECTS OF WATER POLLUTED BY OIL ON AQUATIC ANIMALS: II. H-PARAFFINS. AROMATIC HYDROCARBONS AND CRUDE OIL CONCENTRATION ON TAINT IN SCALLOP (PECTEN YESSOENSIS)

Hokkaido Daigaku, Supporo, Japan. Suisangakubu, Hakodate. Hokkaido Daigaka Suisangakubu Kenkyu Iho 26(4) 367-371.

An organoleptic examination of taint in scallop adductor muscle indicated that N-paraffins are less important in causing taint than are crude oil, xylene, toluene, and mixtures of hydrocarbons which cause the taint in concentrations of 0.1-0.2 mg/g. At 0.3 mg/g, N-Tetradecane and/or N-hexadecane do not cause the taint.

737. Motohiro, T. and H. Inoue. (1973).

N-PARAFFINS IN POLLUTED FISH BY CRUDE OIL FROM 'JULIANA' WRECK.

Bull. Fac. Fisheries, Hokkaido Univ. 23 204-8.

Samples of salmon, mullet and black sea bream were obtained from polluted water after the wreck of the ship Juliana to detect n-paraffins as a measure of crude oil contamination. Gas chromatographic analysis of tissue from mullet and black sea bream revealed qualitative similarity consisting of 9 peaks, of which 8 were identical with those of C_{13}-C_{20} n-paraffins. Little hydrocarbon was found in the muscle from salmon.

738. Motohiro, T. and Z. Iseya (1976).

EFFECTS OF WATER POLLUTED BY OIL ON AQUATIC ANIMALS: III PRETREATMENT IN DETECTION OF N-PARAFFINS IN MARINE SEDIMENTS BY GAS CHROMOTOGRAPHY.

Hokkaido Daigaku, Supporo, Japan. Suisangakubu, Hakodabe. Hokkaido Daigaku Suisangukubu Kenkyu Iho, 26(4) 372-380.

Preliminary treatments of marine sediments to detect n-paraffins by GC analysis are most successful using petroleum ether and benzene= 90:10 (vol/vol) as the solvent for column chromatography separation and n-hexane and benzene=95:5 (vol/vol) for TLC. With pretreatment, n-paraffins below C_{13} tend to disappear due to evaporation losses.

739. Moulder, D.S. and K. Varley. (1971).

A BIBLIOGRAPHY ON MARINE AND ESTUARINE OIL POLLUTION.

Plymouth: Publ. Laboratory Marine Biology Assoc., U.K.

References to almost 1100 papers on marine and estuarine oil pollution published over the past 100 years are contained in this bibliography. The references are arranged by subject in 15 main sections including: Oil pollution sources, properties, and detection; analysis and identification; biological effects; methods of containment and treatment: and reports on major oil spills.

740. Mulkins-Phillips, G.J. and J.E. Stewart (1973).

DISTRIBUTION OF HYDROCARBON-UTILIZING BACTERIA IN NORTHWESTERN ATLANTIC WATERS AND COASTAL SEDIMENTS.

In: Inputs, Fates, and Effects of Petroleum in the Marine Environment. Background Information for the Workshop, Ocean Affairs Board, NSF, Airlie, Va., 21-25 May 1973.

The most probable number method was used in this study to determine what fraction of the total population of microorganisms could utilize hydrocarbons as a sole carbon source in the Northwestern Atlantic marine areas. Hydrocarbon utilizing bacteria are ubiquitous in Northwestern Atlantic coastline sediments and in adjacent waters.

741. Mulkins-Phillips, G.J. and J.E. Stewart (1974).

DISTRIBUTION OF HYDROCARBON-UTILIZING BACTERIA IN NORTHWESTERN ATLANTIC WATERS AND COASTAL SEDIMENTS.

Can. J. Microbiol. 20:955-962.

An extensive survey was carried out to aid in understanding the role of indigenous microorganisms in the removal of oil from Northwestern Atlantic temperate to arctic marine environments. The presence of hydrocarbon-utilizing microorganisms was demonstrated in sediments and adjacent waters taken from Bermuda, Canadian Northwest Atlantic and Eastern Canadian Arctic marine shorelines. In addition, surface-water samples (5 m depth) taken at 11 different stations along a transect between Halifax and Bermuda, with one exception, showed the presence of significant numbers of hydrocarbon-utilizing microorganisms. The hydrocarbon-utilizing bacteria present included Nocardia, Pseudomonas, Flavobacter, Vibrio and Achromobacter species. The fraction of the total heterotrophic bacteria represented by the hydrocarbon utilizers ranged up to 100% depending upon the area's previous history of oil spillage; the bulk of the values were less than 10%. The frequency of specific hydrocarbon utilization in decreasing order was hexadecene-1, pristane, hexadecane, dibenzothiophrene, anthracene, and decalin. The location, numbers, variety and broad capacity of the microbial hydrocarbon utilizers illustrate their ubiquity and indicate the microbial potential for removal or conversion of oil in the environments examined.

742. Mulkins-Phillips, G.J. and J.E. Stewart. (1974).

EFFECT OF ENVIRONMENTAL PARAMETERS ON BACTERIAL DEGRADATION OF BUNKER C OIL, CRUDE OILS AND HYDROCARBONS.

Appl. Micro. 28:915-922.

Mixed microbial cultures, previously enriched on Bunker C fuel oil, grew on and degraded Bunker C fuel oil at temperatures ranging from 5 to 28°C. At 15°C, 41 to 85% of the benzene soluble components of Bunker C disappeared after incubation for 7 days; at 5°C the values ranged from 21 to 52% after 14 days of incubation. A Nocardia sp. isolated from a culture enriched on Bunker C oil grew on Venezuelan crude oil. Bunker C hexadecane and a hydrocarbon mixture at temperatures of 5 and 15°C. The 10°C decrease in temperature resulted in an average 22 fold decrease in generation time of the bacteria. Gas liquid chromatographic measurements of Venezuelan and Arabian crude oils which had been incubated with the Nocardia sp showed significant degradation of the n-alkane portion and the chromatographically unresolved components of the oils. The concentration of elemental nitrogen required to bring about the disappearance of 1 mg of hexadecane by the Nocardia sp. was 0.5 mg. The results confirm suggestons that the rate of natural biodegradation of oil in marine temperate-to-polar zones is probably limited by low temperatures and phosphorus concentrations, but suggest that the concentrations of nitrogen occurring naturally are probably not rate-limiting factors.

743. Murphy, J.F. and R.W. Stone. (1955).

THE BACTERIAL DISSIMILATION OF NAPHTHALENE
Canadian Journal of Microbiology. 1:579-588.

Data are presented indicating that the major pathway for the oxidation of naphthalene by a strain of Pseudomonas occurs via salicylic acid, which is further oxidized through catechol to β-ketoadipic acid. On the basis of growth, simultaneous adaptation, and cell-free extract experiments, the following compounds are regarded as unlikely intermediates in naphthalene dissimilation: 1,4-naphthoquinone, α-naphthol, β-naphthol, 1,3-dihydroxynaphthalene, 2,3-dihydroxynaphthalene, 1,5-dihydroxynaphthalene, phenol, trans-o-hydroxycinnamic acid, and phthalic acid. Evidence was found that a second pathway of naphthalene oxidation produces 1,2-naphthoquinone. 1,2-dihydroxy-naphthoquinone. The k,2-naphthoquinone was not further metabolized and was found to be responsible for the characteristic brown to reddish orange color of the culture medium. Ommission of $FeCl_2$ and $MgSO_4$ from the basal medium prevented the formation of salicylic acid but did not interfere with the production of k,2-naphthoquinone.

744. Murphey, T.A. (1971).

ENVIRONMENTAL EFFECTS OF OIL POLLUTION.

Journal of Sanitary Engineering, Division Proceedings of the American Society of Civil Engineers, 8221, 361-371.

745. Mustonen, M. and P. Tulkki (1969).

THE 'PALVA' OIL TANKER DISASTER IN THE FINNISH SW ARCHIPELAGO. IV. BOTTOM FAUNA IN THE OIL POLLUTED AREA.

Aqua. Fennica. 137-141.

The currents in the area of the Kokar archipelago are strong as can be determined by the bottom quality, the vegetation and the consistency of the bottom fauna. The actual soft bottom species are restricted to sheltered placed between islands and to the deepest spots in the area. The oil from MT PALVA has settled onto the bottom of the Kokar archipelago waters to such a small extent that its effects cannot be seen in the benthos. This was noted on the basis of benthos samples taken both three months after the accident and during the following summer. The number of species, the biomass and the composition of the species in the area may be considered normal for the Archipelago Sea. Traces of the crude oil were found in sediments in the summer of 1969.

746. Myers, E.P. and C.G. Gunnerson (1976).

HYDROCARBONS IN THE OCEAN.

MESA Special Report, U.S. Dept. of Commerce.

Measurements of hydrocarbons in ocean waters throughout the world are presented to supply baseline information. The data indicate that most surface and near-surface waters have from 1 to 10 parts per billion total hydrocarbons. Both biogenic and petroleum hydrocarbons appear to be ubiquitous, with some indications of more petroleum hydrocarbons in coastal waters and shipping lanes. A short section is included on the fate of petroleum hydrocarbons in marine organisms and its reported effect.

747. Myrehoff, R.D. (1975).

ACUTE TOXICITY OF BENZENE, A COMPONENT OF CRUDE OIL, TO JUVENILE STRIPED BASS (MORONE SAXATILIS).

J. Fish. Res. Bd. Can. 32(10): 1864-1866.

The acute toxicity of benzene to 1.5 $\pm$0.5-g juvenile striped bass (Morone saxatilis) was studied in a continuous flow laboratory bioassay system. At 17.4 C and 29 ppt salinity, the lethal threshold concentration and the 96-h LC50 for benzene were 10.9µl/liter. The 95% confidence interval was 10.9$\pm$ 0.2µl/liter and the probit line slope, "S", was 1.1. Possible toxic mechanisms are discussed.

748. Nadeau, R.J. and T.H. Roush (1973).

A SALT MARSH MICROCOSM: AN EXPERIMENTAL UNIT FOR MARINE POLLUTION STUDIES.

Proceedings Joint Conference for the Prevention and Control of Oil Spills. API, EWPCA, USCG. p. 671-683. Amer. Petrol. Inst., Wash. D.C.

Present day bioassay procedures are inadequate to assess impact of a pollutant upon the environment. Using a single species tested under rigid laboratory conditions does not produce ecologically relevant information.

A salt marsh microcosm was established and monitored to assess its applicability as a water pollution research tool toward determining the impact of oil spills upon coastal salt marshes. Growth of the major grass species was a measure of similarity between a nearby native salt marsh and the microcosm. No significant differences in growth were observed in low (Spartina alterniflora) and high marsh (Spartina patens and Distichlis spicata) species during most of the growing season.

Gas chromotography, ultraviolet and fluroescent spectrophotometry were used to monitor the fate of oil released into one side of the microcosm. High boiling range hydrocarbons probably of biogenic origin, interfered with quantification by ultraviolet and fluorescent spectroscopy, but could be separated by gas chromatography for qualitative examination.

Salt marsh microcosms can be easily used for studying the fate and effects of pollutants through a program of careful observation and monitoring.

749. Nadeau, R.J. and E.T. Berggnist (1977).

EFFECTS OF THE MARCH 18, 1973 OIL SPILL NEAR CABO ROJO, PUERTO RICO ON TROPICAL MARINE COMMUNITIES.

In: Proceedings 1977 Oil Spill Conference. p. 535-538. Amer. Petrol. Inst., Wash. D.C.

During the early morning hours of March 18, 1973 the Greek tanker, Zoe Colocotronis spilled 37,000 barrels of Venezuelan crude oil into the coastal waters of southern Puerto Rico. About 24,000 bbl of oil washed ashore at Cabo, Rojo, contaminating sandy beaches, turtle grass, and rocky shore communities.

Within 48 hours following the spill, dead and moribund invertebrates, representing several distinct phyla were being deposited along the beach and intertidal zone. Population analysis of the affected mangrove prop root and sublittoral turtle grass (Thalassia) communities revealed marked increases within certain affected population. In one area (1.0 hectare) the red (Rhizophora mangle) and black (Avicinnia nitita) mangrove trees have defoliated and died during the three years following the spill. Analysis of the sediments in this area indicates significant levels of petroleum hydrocarbon residues were present as of January 1976.

750. Nadeau, R.J. and T.H. Roush (1972).

BIOLOGICAL EFFECTS OF OIL POLLUTION. SELECTED BIBLIOGRAPHY II.

Environmental Protection Agency. Available through NTIS.

This bibliography contains references on the biological effects of oil including general aspects, specific spill incidents, general effects, carcinogenic effects, microbial utilizations, and the effects on birds, fish, shellfish, marine and freshwater invertebrates, plants, and dissolved oxygen.

751. Nagell, B., M. Notini and O. Grahn. (1974).

TOXICITY OF FOUR OIL DISPERSANTS TO SOME ANIMALS FROM THE SEA.

Mar. Biol. (Berl.), 28;237-243.

Four oil dispersants of interest for practical use in the Baltic Sea were tested as regards toxicity to animals from the littoral zone of the same area. The dispersants tested were Corexit 7664, Berol TL-188, Berol TL-198, all waterbase dispersants, and BP 1100-X, an oil-base dispersant. Two species of fish, two species of bivalves and two species of crustaceans were tested. Significant differences in toxicity were found between the water-based dispersants above 1700 ppm. Below this concentration there were no significant differences. The dispersants contain similar surfactants in similar concentrations, but differ with respect to types and amount of solvent. Differences in toxicity to different animal types were found between the water-base dispersants and the oil-base dispersants. The toxicity of Corexit 7664 was (96 h LC50 approximate values): fish, 1000 ppm; bivalves, 2000 ppm; crustaceans, 10,000 ppm. The toxicity order was strikingly reversed for BP 1100-X: crustaceans, 150 ppm; bivalves, 2000 ppm; fish, 10,000 ppm. This difference in toxicity for different animal types is suggested to be connected mainly to differences in the chemical character of the outer layer of the body surface of the animal.

752. National Academy of Sciences (1975).

ASSESSING POTENTIAL OCEAN POLLUTANTS.

A Report of the Study Panel on Assessing Potential Ocean Pollutants to the Ocean Affairs Board. Commission on Natural Resources, National Research Council. National Academy of Sciences, Washington, D.C. 185 pp.

This volume contains a review of the sources and biological effects of aromatic hydrocarbons.

753. National Academy of Sciences, (1975).

In: Petroleum in The Marine Environment. Workshop on Inputs, Fates, and the Effects of Petroleum in the Marine Environment, Airlie House, Airlie, Virginia May 21-25 1973.

National Academy of Sciences, Washington D.C. pp. 107.

This volume represents the results of a workshop on the inputs, chemical and biological fates and biological effects of petroleum in the marine environment. A section on analytical methods is included.

754. National Oceanic and Atmospheric Administration (1977).

ENVIRONMENTAL ASSESSMENT OF THE ALASKAN CONTINENTAL SHELF.

Environmental Research Laboratories, National Oceanic and Atmospheric Administration, U.S. Department of Commerce. 14 Volumes with 2 annual summaries and a March 1977 Executive Summary.

These volumes contain an assessment of the environment of the Alaskan Outer Continental Shelf, particularly the areas of proposed petroleum production leases. Numerous studies are included on the biological effect of oil pollution.

755. National Petroleum Council Committee on Ocean Petroleum Resources, Legal Group (1975).

PROTECTION OF THE MARINE ENVIRONMENT.

Natural Resources Lawyer, 8(3):511-543.

Sources of ocean petroleum pollutants, in millions of barrels/ day and fractions of the total, are estimated as follows: land-based activities, 67(54%); all vessel activities, 43 (35%); natural seeps, 12(10%); and offshore production, 2(1%). LOT procedures, segregated ballast design, and the Oil Record Book are discussed as measures to reduce discharges from vessels. The minimization of accidental and operational discharges from offshore oil exploration and production activities is reviewed. The cleanup of oil spills and the environmental impact of petroleum on the marine environment are surveyed. The structure, administration, and accomplishments of IMCO are examined in connection with the setting of safety and pollution standards for vessels. The roles of TOVALOP and CRISTAL in the reimbursement of pollution damage

and cleanup expenses are delineated. The action plan of the Marine Environment Protection Committee is summarized in tabular form; an explanation of the required action, previous work, and the initial course of action is given for each subject.

756. National Science Foundation (1972).

BASELINE STUDIES OF POLLUTANTS IN THE MARINE ENVIRONMENT AND RESEARCH RECOMMENDATIONS: THE IDOE BASELINE CONFERENCE, May 24-26, 1972, New York, 1972.

Office for the International Decade of Ocean Exploration.

This volume resulting from a three-day workshop in May 1972 contains an appraisal of man's impact upon the marine environment. Well-documented, man-induced changes in the composition of seawater, of its plants and animals and of its sediments are summarized. One chapter is devoted to petroleum.

757. National Security Industrial Association (1975).

REPORT ON THE RELATIONSHIP BETWEEN THE OFFSHORE PETROLEUM INDUSTRIES AND THE U.S. GOVERNMENT.

Petroleum Panel, Ocean Science and Technology Advisory Committee, National Security Industrial Association, Washington, D.C. 25 pp.

This paper includes recommendations as to which research topics most critically require exploration in order to understand the effect of oil on the marine environment.

758. Neff, J.M., J.W. Anderson. (1973).

UPTAKE AND DEPURATION OF PETROLEUM HYDROCARBONS IN THE ESTUARINE CLAM RANGIA CUNEATA.

Proc. Natl. Shellfish. Assoc., 64:6-7.

Clams, Rangia cuneata, were exposed to oil-in-water dispersions and water-soluble fractions of #2 fuel oil and South Louisiana crude oil or to sea water solutions of specific aromatic petroleum hydrocarbons. The rate of uptake of oil hydrocarbons by the tissues during exposure and rate of depuration when the clams were returned to oil-free sea water was determined by gas chromatographic and ultraviolet spectrophotometric techniques.

Clams rapidly accumulate oil-derived n-paraffins and aromatic hydrocarbons from oil in water dispersions and solutions. Aromatic hydrocarbons are accumulated to a greater extent than n-paraffins relative to their respective concentrations in the exposure water. The alkylnaphthalenes, 2 methylnaphthalene and dimethylanaphthalenes were the hydrocarbons accumulated to the greatest extent from the oil-in-water dispersions. Following return of the clams to oil-free sea water depuration of all classes of oil hydrocarbons was very rapid, though depuration rate was dependent on the hydrocarbon type. N-paraffins were depurated most rapidly followed by napthalene and alkynaphthalenes. Alkyl benzenes and polycyclic aromatics appear to be depurated most slowly. Depuration is essentially complete within 1-2 weeks after exposure to oil.

759. Neff, J. and J.W. Anderson. (1975).

ACCUMULATION, RELEASE AND DISTRIBUTION OF BENZOPYRENE-C^{14} IN THE CLAM RANGIA CUNEATA.

In: Conference on Prevention and Control of Oil Spills, pp. 469-471.

Groups of estuarine clams, *Rangia cuneata*, were exposed for 24 hours to synthetic seawater containing in solution 0.0305 ppm benzoαpyrene-C^{14}. In two experimental exposures, average total concentrations of benzoαpyrene (BAP) in the clam tissues were 7.2 ppm and 5.7 ppm, approximately 200 times above the ambient level. The majority of the radioactivity was localized in the viscera which contains the digestive system, gonads, and heart. The other tissues analyzed, the mantle, gills, and adductor muscle, and foot, each contained 3-16% of the radioactivity. When returned to isotope-free seawater, the clams immediately began to release the accumulated BAP. After 30 days only 0.07 ppm BAP remained in the tissues. BAP could not be detected (limits of detection, 0.01 ppm) in clams maintained in isotope - free seawater for 58 days. During depuration, the distribution of radioactivity in the tissues remained relatively constant. The viscera contained most of the activity at all sampling times.

760. Neff, J.M. and J.W. Anderson. (1975).

ULTRAVIOLET SPECTROPHOTOMETRIC METHOD FOR DETERMINATION OF NAPHTHALENE AND ALKYLNAPHTHALENES IN TISSUES OF OIL-CONTAMINATED MARINE ANIMALS.

Bull. Environ. Contamination and Toxicology. 14(1):122-128.

The ultraviolet spectrophotometric technique described in this paper has been used in the laboratory for the past year in studies of the accumulation and retention of petroleum hydrocarbons by several species of marine invertebrates and fish. As little as 0.1 ppm of naphthalene and alkylnaphthalenes have been detected in tissues without difficulty. The detection limits in seawater are in the range of .01 to .05 ppm.

761. Neff, J.M. and J.W. Anderson, B.A. Cox, R.B. Laughlin, Jr., S.S. Rossi, and H.E. Tatem. (1976).

EFFECTS OF PETROLEUM ON SURVIVAL, RESPIRATION AND GROWTH OF MARINE ANIMALS.

In: Sources, Effects & Sinks of Hydrocarbons in the Aquatic Environment. Proceedings of the Symposium, American University, Washington, D.C. 9-11 August 1976 p. 516-539.

Petroleum products vary tremendously in their toxicities to marine animals. The relative toxicity of an oil is, in most cases, directly correlated to its content of aromatic hydrocarbons. The most toxic aromatics are the phenanthrenes. There is a wide interspecies variation in the sensitivity of marine animals to petroleum. Estuarine and benthic species are often, but not always, more tolerant than oceanic species. Larvae and juveniles are often, but not always, more sensitive than the adults. Both respiration and early growth and development of marine animals are affected by exposure to sublethal concentrations of oils. These sublethal responses are variable and in most cases are rapidly reversible when the animals are returned to oil-free sea water.

762. Neff, J.M., B.A. Cox, D. Dixit and J.W. Anderson (1976).

ACCUMULATION AND RELEASE OF PETROLEUM-DERIVED AROMATIC HYDROCARBONS BY FOUR SPECIES OF MARINE ANIMALS.

Marine Biology, 38(3):279-289.

When exposed to oil-contaminated seawater, marine animals accumulate a variety of petroleum hydrocarbons in their tissues. Generally, the aromatic hydrocarbons are accumulated to a greater extent and are retained longer than the alkanes. The following species were tested: Rangia cuneata, Crassostrea virginica, Fundulus similus, and Penaeus aztecus. In all species tested, accumulation of aromatic hydrocarbons appears to be dependent primarily on a partitioning of the hydrocarbons between the exposure water and the tissue lipids. Binding of hydrocarbons to tissue lipids is by hydrophobic interactions and not by covalent bonding. Bioaccumulation factors (tissue:water concentration ratio) increase in proportion to the increase in mol wt of the aromatic hydrocarbons. When returned to oil-free seawater, marine animals rapidly release the accumulated hydrocarbons from their tissues. Release rates are species-dependent. Shrimp and fish, which can metabolize aromatic hydrocarbons, release them more rapidly than clams and oysters, which apparently lack the detoxifying enzymes. Release of hydrocarbons to background or undetectable levels requires from 2 to 60 d. The high mol wt aromatic hydrocarbons are released more slowly than the low mol wt hydrocarbons.

763. Nelson-Smith, A. (1967).

OIL, EMULSIFIERS AND MARINE LIFE.

J. Devon Trust Nat. Conserv., July (suppl.), 29-33.

764. Nelson-Smith, A. (1968).

A CLASSIFIED BIBLIOGRAPHY OF OIL POLLUTION.

In: Biological Effects of Oil Pollution on the Littoral Community. Supplement to Volume 2, J.D. Carthy and D.R. Arthur, (eds.). Field Studies Council, U.K.

A bibliography of some 800 entries, 420 of which refer to the biological effects of oil pollution or cleansing techniques.

765. Nelson-Smith, A. (1968).

BIOLOGICAL CONSEQUENCES OF OIL POLLUTION AND SHORE CLEANSING.

In: The Biological Effects of Oil Pollution on Littoral Communities. Supplement to Volume 2 of Field Studies, J.D. Carthy and D.R. Arthur, (eds.). FIeld Studies Council, U.K.

The 1957 Tampico Maru incident in Baja California, the Torrey Canyon incident, and several incidents in the Milford Haven oil port are compared with regard to their impact on the littoral community.

766. Nelson-Smith, A. (1968).

THE EFFECTS OF OIL POLLUTION AND EMULSIFIER CLEANSING ON SHORE LIFE IN SOUTH-WEST BRITIAN.

J. Appl. Ecol. 5:97-107.

In considering the effects of oil pollution on British shores, it is also necessary to consider the effect of the emulsifier cleansing which in recent years has inevitably followed it. The reported toxicities of crude oil, emulsifiers and their active constituents are briefly reviewed. Of three major oil spills in Milford Haven, one in 1962 provided evidence of a marked increase in algal cover following heavy limpet mortalities. The most recent, in January 1967, polluted shores on which the distribution and abundance of common plants and animals was well known, so that the immediate effects could be accurately determined. Effects similar in nature but greater in extent were recorded in Cornwall following the wreck of the Torrey Canyon in March 1967. Many of the mechanisms which protect shore animals from natural environmental extremes are ineffective against stranded oil, whilst emulsifiers tend to make it an even greater biological danger.

767. Nelson-Smith, A. (1969).

MICRO-RESPIROMETRY AND EMULSIFIER TOXICITY:

Field Studies Council Oil Pollution Research Unit, Ann. Rep. 1969, U.K.

768. Nelson-Smith, A. (1970).

THE PROBLEM OF OIL POLLUTION OF THE SEA.

Adv. Mar. Biol., 8:215-306.

A review of marine oil pollution including sources, properties of petroleum, effects of oil pollution, and removal of spill oil.

769. Nelson-Smith, A. (1971).

BIOLOGICAL CONSEQUENCES OF OIL POLLUTION AND SHORE CLEANSING.

In: The Ecological Effects of Oil Pollution on Littoral Communities. E.B. Cowell, (ed.) Institute of Petroleum, London pp. 73-80.

770. Nelson-Smith, A. (1971).

EFFECTS OF OIL ON MARINE PLANTS AND ANIMALS.
PP. 273-280

In: Water Pollution by Oil. Institute of Petroleum, London.

Crude petroleum and other heavy oils differ from most substances that pollute aquatic environments in that they are largely insoluble and form coherent masses that float on the surface or become stranded on shore. Damage can thus be caused at a considerable distance from their point of release. Freshly spilt crude oil is chemically toxic; with time its residue has a greatly reduced toxicity but can still cause undesirable mechanical effects. Mechanical damage and toxic effects of oil in the field are described along with the biological effects of clean-up.

771. Nelson-Smith, A. (1972).

EFFECTS OF THE OIL INDUSTRY ON SHORE LIFE IN ESTUARINES.

R. Soc. Lond. Proc., Series B, Vol. 180, pp. 487-496.

Crude petroleum and products refined from it may be spilt at any point from well up rivers to far out at sea. Crude oils are moderately toxic; some products may be very harmful, but heavy fuel oils are almost inert. Toxic fractions are removed by weathering, but oils spilt around tanker-terminals in estuaries reach the shore very soon after release. In Milford Haven, spillages average some 50 tons per year, about 0.0001% of the volume handled. Oil which has not been emulsified rarely penetrates mud or sand but is trapped on salt-marsh vegetation; annuals and shrubby perennials are badly affected, although other perennials recover well. On rocky shores, grazong molluscs may be killed, especially if aromatic-based emulsifiers are used to remove the oil. This permits the widespread growth of seaweeds, with repercussions on other shore life. Repeated spills may gradually eliminate some gastropods. Chronic pollution by oil in low concentrations can gravely damage salt-marsh and produces detectable effects on rocky shores. Speed is essential in dealing with a spillage; the most effective treatment is dispersal with emulsifiers and this is best done before the slick becomes stranded. Oiled shores should be left alone whenever possible; mechanical removal is preferable to spraying.

772. Nelson-Smith, A. (1973).

OIL POLLUTION AND MARINE ECOLOGY.

Plenum Press, New York, 260 p.

Review of the inputs, fate, and effects of petroleum and dispersants in the marine environment. Extensive bibliography.

773. Neushul, M. (1970).

EFFECTS OF POLLUTION ON POPULATIONS OF INTERTIDAL AND SUBTIDAL ORGANISMS.

Paper presented at: Santa Barbara Oil Symposium, Santa Barbara, December 17, 1970, p. 165-172.

The author participated in 3 pollution studies on the California coast. The first dealt with the effects of discharged wastes on kelp, the second with the effects of an oil pollution incident; both of these studies were sponsored by the State Water Quality Control Board. The third study dealt with the amounts and distribution of of oil and the initial effects of the Santa Barbara Oil Spill (1970). The results of each of these and related studies are discussed and the implications of this overview are considered.

774. New England Natural Resources Center (1975).

GEORGES BANK CONFERENCE: MARINE ENVIRONMENTAL ASSESSMENT NEEDS ON THE GEORGES BANK RELATED TO PETROLEUM EXPLORATION AND DEVELOPMENT. PROCEEDINGS OF A CONFERENCE AND WORKSHOP AT BENTLEY COLLEGE, WALTHAM, MASSACHUSETTS, 20-22 May 1975.

A project of the New England Natural Resources Center. Sponsored by the Bureau of Land Management, U.S. Department of the Interior. 187 pp.

The purpose of this conference was to assess the state of knowledge in the Georges Bank area of the North Atlantic Outer Continental Shelf and provide recommendations for baseline and monitoring research efforts in that area. The findings of workshops in biological, chemical, geological, and physical oceanography are reported as well as transcripts of plenary sessions.

775. Nicholson, N. (1972).

THE SANTA BARBARA OIL SPILL IN PERSPECTIVE.

Calif. Coop. Ocean. Fish. Invest. Rep., 16:130-149.

This report describes long-term trends in the littoral community of the Southern California coast, primarily in terms of the algae; and also describes the observed effects of crude oil. It concludes that there is a developing instability of association of macroalgae possibly due to altered air and water chemistry since the turn of the century. The observed effects of crude oil was primarily mechanical. It is noted that chronic presence of oil (Coal Oil Point) in the intertidal zone produces a beach with fewer plant species, but those that can tolerate or evade the effects of crude oil are highly abundant.

776. Nicholson, N. and R.L. Cimberg. (1971).

THE SANTA BARBARA OIL SPILLS OF 1969: A POST-SPILL SURVEY OF THE ROCKY INTERTIDAL, PP. 325-400.

In: BIOLOGICAL AND OCEANOGRAPHICAL SURVEY OF THE SANTA BARBARA CHANNEL OIL SPILLS, 1969-1970. D. Straughan, (ed.) Allen Hancock Foundation, Univ. of Southern California, Los Angeles.

This report of a survey of the Southern California intertidal from a 13 month period concludes that changes in the intertidal canal by the oil spills are difficult to distinguish from those caused by other factors. A baseline survey however, was established for this coast oil for the channel islands. A decline was noted in macro algae species in comparison to a survey conducted ten years previous to the present survey.

777. Nicol, J.A.C., W.H. Donahue, R.T. Wang, and K. Winters (1977).

CHEMICAL COMPOSITION AND EFFECTS OF WATER EXTRACTS OF PETROLEUM ON EGGS OF THE SAND-DOLLAR MELITTA QUINQUIESSPERFORATA.

Mar. Biol. (Berl.) 40 309-316.

Sperm and eggs of sand dollars. Melitta quinquiesperforata (Leske), were subjected to two petroleum oils, and effects determined. The oils chosen were Kuwait crude and No. 2 fuel oil, supplied by the American Petroleum Institute. Water-soluble extracts (WSF) from oil-sea water mixes were prepared and the major aromatic components in the WSF of the fuel oil were identified. WSF of No. 2 fuel oil depressed respiration, mobility of sperm, interfered with fertilization and cleavage and retarded larvel development. The effects were detectable at dilutions of 4% and less (about 0.6 ppm of WSF). Kuwait crude was much less toxic. There was no effect on water permeability of the egg membrane. Results are compared with similar studies on other marine organisms.

778. North, W.J. (1973).

POSITION PAPER ON EFFECTS OF ACUTE OIL SPILLS.

In: Inputs, Fates and Effects of Petroleum in the Aquatic Environment, Background Information for the Workshop. Ocean Affairs Board, NSF. Airlie, Va. 21-25 May 1973.

The author reviews several spill incidents and notes that there is little reported long term damage to impacted ecosystems. He then presents more specific information on the Tampico Maru spill in Baja California, concluding that ecological change due to oil spillage may require very long recovery periods since the area after 15 years is still in the process of recovering.

779. North, W.J., M. Henshal and K.A. Clendemning. (1964).

SUCCESSIVE BIOLOGICAL CHANGES OBSERVED IN A MARINE COVE EXPOSED TO A LARGE SPILLAGE OF MINERAL OIL.

Int. Comm. Sci. Expl. Medit. Sea, pp 335-354.

This article reports the biological consequences of the oil pollution resulting from the March 29, 1957 wreck of the "Tampico Maru" in a small cove on the coast of Baja Calif. The oil escaped over a period of eight months as the tanker broke up. The tanker and its subsequent wreckage drastically changed the surf pattern in the cove, as well as flooding the cove with oil. Some of the biological changes caused by the wreck persist seven years after the event. Most of the drastic mortality seems to be associated with the oil itself, in as much as (1) many animals were found dead outside of the cove where surf remained normal (2) spray zone appeared normal while water zones were devastated, (3) Anthopleura, an invertebrate known to be resistant to the effects of oil, remained abundant. (4). laboratory results indicates that .1% oil emulsions in seawater adversely affected kelp photosynthesis and the ability of urchins to grasp substrates and (5) emulsions of at least five concentrations were prevalent at the site.

780. Nuzzi, R. 1973.

EFFECTS OF WATER SOLUBLE EXTRACTS OF OIL ON PHYTOPLANKTON.

In: Conference on Prevention and Control of Oil Spills. pp. 809-814. Amer. Petrol. Inst., Wash., D.C.

This paper presents evidence indicating that soluble constituents of No. 2 fuel oil are toxic to phytoplankton cultured axenically and also exert an effect on natural phytoplankton populations.

781. Ocean Affairs Board, National Academy of Sciences (1973).

BACKGROUND PAPERS FOR A WORKSHOP ON INPUTS, FATES AND EFFECTS OF PETROLEUM IN THE MARINE ENVIRONMENT.

Volumes I and II. OSB, NAS.

These volumes are composed of background papers for the conference. The articles on biological effects of oil pollution are entered separately in this bibliography.

782. Oceanographic Commission of Washington (1974).

A COMPENDIUM OF CURRENT ENVIRONMENTAL STUDIES ON PUGET SOUND AND NORTHWEST ESTUARINE WATERS.

Pacific Northwest Sea. 370 pp.

This reference tool is a descriptive record of 1974 marine research conducted in Puget Sound, Washington coastal waters, and related estuaries. Over 250 studies are comprehensively summarized. Arranged in fourteen major research categories, these project summaries are also indexed by investigator, subject, geographical area, and both sponsoring and performing organization. Marine science disciplines treated include such areas as: Physical, Chemical, and Biological Oceanography; Fisheries-Pollution and Water Quality; Marine Bio-systems and Ecology; Engineering and Technology; Coastal Zone Management. Provides the user with the knowledge of who is doing what research, where, when and for whom.

783. O'Connor, R. (1967).

THE TORREY CANYON. A CENSUS OF BREEDING AUKS IN CORNWALL.

Seabird Bulletin, 4, 38-45.

784. Oda, A. (1969).

LABORATORY EVALUATION OF CHEMICAL OIL DISPERSANTS.

In: Proc. Joint Conference on the Prevention and Control of Oil Spills.

(API/EPA/USCG), New York, NY. pp. 193-197. Amer. Petrol. Inst., Wash., D.C.

This paper describes some of the methods which can be used to evaluate chemical oil dispersants in order to obtain some preliminary data related to their effectiveness as dispersants and problems that may result from their use. Most of the techniques are quite simple and can be done fairly rapidly in the laboratory. Some of these were borrowed from the standard procedures employed in water and waste water treatment practices and include jar tests, bioassays, oxygen uptake measurements, and threshold odor determinations. Data received from these tests may be of some value in situations where a selection of a suitable dispersant must be made on the basis of only limited knowledge and experience.

785. Odham, G. (1971).

CLEANING AND REHABILITATION OF OILED SEABIRDS.

In: Proc. Joint Conf. on Prevention and Control of Oil Spills, 1971. (API/EPA/USCG) pp. 453-456. Amer. Petrol. Inst., Wash. D.C.

When detergents are used to wash oiled seabirds, the natural feather wax is removed, as the solubility and emulsifying properties of the contaminating oil and feather wax are almost identical. Due to the importance of wax in maintaining water repellency and heat insulation, no seabird can be returned to its natural environment until the wax has been replaced in one way or another. Attempts at accomplishing this with various synthetic "unit waxes" have been made, but were unsatisfactory; overdoses were given, resulting in a plumage with the same properties as the original oiled plumage. To overcome this problem, a new cleaning agent was formulated: Larodan 127, which consists of a crystalline dispersion of hydrophilic lipid crystals in water with unit wax embedded in the crystal matrix.

786. Ogata, M. and Y. Miyake (1973).

IDENTIFICATION OF SUBSTANCES IN PETROLEUM CAUSING OBJECTIONABLE ODOUR IN FISH.

Water Research, 7(10): 1493-1504.

Seawater, industrial wastes, and fish and eels kept in the sea or industrial waste for a certain period were analyzed to identify substances causing an offensive odor in fish from the sea adjacent to petroleum and petrochemical industries. Gas chromatography, UV and IR absorption spectra, and the mass spectrum were employed. Toluene imparts the offensive odor to fish near Mizushima, Japan. Aromatic hydrocarbons (benzene and o-, m-, and p-xylene) other than toluene and some aliphatic hydrocarbons are also probable substances that impart an offensive odor to fish. Gasoline rich in olefine imparts offensive odor to fish more than gasoline rich in paraffin or naphthene.

787. Ogata, M. and T. Ogura. (1976).

PETROLEUM COMPONENTS AND OBJECTIONABLE MALODOROUS SUBSTANCES IN FISH FLESH POLLUTED BY BOILER FUEL OIL.

Water Res. 10(5): 407-412.

Green fish (Girella punctata) and eel (Angulla rostrata) were reared in two types of artificially oil-polluted test dilutions for the purpose of measuring the petroleum substances infiltrating the flesh. One test dilution contained untreated mineral oil and the other test dilution contained residue mineral oil after chemical treatment. Vapors from fish flesh samples were analyzed by gas chromatography. Unsaturated aliphatic hydrocarbons and some aromatic hydrocarbons were revealed as sources of the repugnant odor.

788. Ogata, M., Y. Miyake, S. Kina, K. Matsunaga and M. Imanaka (1977).

TRANSFER TO FISH OF PETROLEUM PARAFFINS AND ORGANIC SULFUR COMPOUNDS.

Water Research, 11 p. 333-338.

In a study of the uptake of petroleum products by fish, laboratory tests followed by gas chromatography demonstrated absorption of paraffins, organic sulfur compounds and hydrocarbons by eels after exposure to Arabian Light Crude oil. Analysis of eel flesh indicated straight and branched chain paraffins in the C13, C14 and C15 groups but no chromatographic peaks indicating n-alkanes. Paraffin C13-C15 groups increased with duration of rearing time in eel flesh. The results indicated that organic sulfur compounds having relatively low boiling points in oil-contaminated water can transfer to eel flesh and will increase with length of exposure. Aromatic hydrocarbons were also present in oil treated eels, the concentration ratios descending in the order of toluene m-oip-xylene o-xylene and benzene. An obnoxious odor was detected in eels exposed to petroleum for 1, 3, 7 and 15 days. This experiment demonstrated that crude oil organic sulfur compounds transfer from water to fish and therefore organic sulfur compounds in fish may be used as an indicator of oil pollution.

789. Ogren, L. and J. Pearce. (1968).

OIL POLLUTION - A THREAT TO MARINE RESOURCES AND RECREATION.

Underwater Naturalist, 5(2):6.

The authors were called to San Juan, Puerto Rico, on March 7, 1968, to assess the damage caused by the sinking of the tanker Ocean Eagle. Only limited amounts of detergents were used, and the damage to pelagic and bottom-dwelling fish seemed to be slight.

Heavy coatings of oil can directly interfere with the respiration of many intertidal organisms. Large areas heavily polluted by oil tend to become anaerobic; often as the result of activity of increased numbers of bacteria which can feed on the oil. Petroleum products may also be directly toxic to both marine flora and fauna. Where oil covering is heavy or tarry, various animal species may starve. Aquatic birds are especially suceptible to oil pollution as they may be killed or have their flight inhibited by surprisingly small amounts of oil.

Topographical and geological features of coastlines may be altered by heavy oil pollution. Many beaches are rendered useless for recreation by oily residues. Residues may foul fishing lines, nets, boat hulls, and other marine gear.

The use of emulsifiers to disperse the oil actually causes more problems than it solves, as these emulsifiers may be lethal to marine organisms in concentrations small as .01 ppm. Cleanup methods by mechanical means are more desirable biologically, but are frequently inefficient and costly.

790. Oguri, M. and R. Kanter. (1971).

PRIMARY PRODUCTIVITY IN THE SANTA BARBARA CHANNEL. pp. 17-48.

In: Biological and Oceanographical Survey of the Santa Barbara Channel Oil Spill. D. Straughan, (ed.). Allan Hancock Foundation, University of Southern California.

The productivity of the Santa Barbara Basin is the result of a number of factors. Patterns of seasonal enrichment of the waters and the resultant increase in population of phytoplankton and their productivity rely upon currents for distribution. The currents also interact with shores, producing upwelling and currents and eddies that can result in holding a population in fertile areas.

There is no conclusive evidence from this study of any major effect on phytoplankton that can be attributed directly to the presence of oil in the environment. The use of dispersants, however, may result in marked reductions in productivity. The longevity of any such effect would depend on the currents and rate of dilution, as well as the type and quantity of the dispersants.

791. Olivieri, R., et al. (1976).

MICROBIAL DEGRADATION OF OIL SPILLS ENHANCED BY A SLOW-RELEASE FERTILIZER.

Appl. Env. Microbial., 31(5):629-634.

The improved cleanup of marine oil spills by stimulating biodegradation through the use of a slow-release fertilizer is reported. A paraffin-supported fertilizer containing $MgNH_4PO_4$ as active ingredient was developed and evaluated in laboratory and field experiments using quantitative infrared spectrometry and chromatographic techniques. The biodegradation of Sarir crude oil in the sea was considerably enhanced by paraffin-supported fertilizer. After 21 days 63% had disappeared as compared to 40% in the control area.

792. Olla, B.L. and C. Samet (1974).

BEHAVIOR OF MARINE ORGANISMS AS A MEASURE OF PETROLEUM CONTAMINATION.

In: Marine Environmental Implications of Offshore Oil and Gas Development in the Baltimore Canyon Region of the Mid-Atlantic Coast. Proceedings of the Estuarine Research Federation Conference and Workshop. Estuarine Research Federation, p. 437-450.

This article reviews the literature on the behavioral effects of petroleum pollution with an emphasis on using behavior as a bioassay of oil contamination. Subjects covered include behavior as a measure of stress, reproduction, feeding, activity and spontaneous movement, rhythms of activity, migration, schooling, aggression and predation.

793. O'Neill, T.B. (1973).

BIODEGREDATION OF OIL IN SEAWATER FOR MARINE POLLUTION CONTROL.

U.S. Naval Civil Engineering Laboratory, Port Hueneme, Calif. Annual Report 3. 17 pp. (Ref. Order No. HD-763-342).

Hydrocarbonoclastic microorganisms were isolated from local beaches and secured from the American Type Culture Collection. The ability of pure and mixed cultures to degrade marine diesel, Bunker C fuel, and crude oil was investigated. Mixed cultures are much more active than pure cultures. The additions of organic enrichment (e.g. yeast extract), inorganic salts (nitrates and phosphates), and aeration were highly beneficial.

Also see: O'Neill, T.B. (1977) "The Biodegradation of Oil in Seawater for Naval Pollution Control". U.S. Naval Civil Engineering Laboratory, Port Hereneme, Calif. July 1977. 92 p. Available from National Technical Information Service. AD-A042 375/6SL.

794. Onuf, C.P. (1973).

AN ANALYSIS OF THE MAIN SCIENTIFIC PAPERS DEALING WITH LONG-TERM, LOW-LEVEL EFFECTS OF OIL POLLUTION.

In: Input, Fates, and Effects of Petroleum in the Aquatic Environment. Background Information for the Workshop. Ocean Affairs Board, N.S.F., Airlie, VA. 21-25 May 1973.

Papers on field studies of oil fields, field studies of refinery wastes, field studies of natural seeps and laboratory studies of sublethal effects are discussed. It is concluded that demonstrable effects of chronic pollution are often associated with concentrations that approach acutely toxic levels, that off-shore oil production areas apparently have little impact on the biota, that no respectable field experiments on estuarines have been reported, and that refineries are likely to cause biological damage, but prediction of its seriousness is impossible.

795. Onuf, C.P. (1973).

THE BIOLOGICAL AND ECOLOGICAL EFFECTS OF OIL POLLUTION IN TROPICAL WATERS, AN ANNOTATED BIBLIOGRAPHY.

National Technical Information Service PB-248-899.

The bibliography contains 112 references to biological and ecological effects of oil pollution in tropical waters with some involving effects in colder, high altitude waters. Formal annotations are supplemented by comments made by the compiler.

796. Oppenheimer, C.H., W. Gunkel, and G. Gassmann (1977).

MICROORGANISMS AND HYDROCARBONS IN THE NORTH SEA DURING JULY-AUGUST 1975.

In: Proceedings 1977 Oil Spill Conference. p. 593-609. Amer. Petrol. Inst., Wash., D.C.

The 1975-1976 North Sea Oil Ecology Investigation is designed to determine the dynamics of oil pollution in the North Sea and to serve as a baseline study at the start of the rather extensive oil exploitation of the seabed of the North Sea. In designing the experiment, particular attention has been paid to the 1974-1975 research effort of the Gulf Universities Research Consortium directed towards determining the effect, if any, of offshore oil exploitation in Louisiana on the area's ecology. As a result, both projects address the distribution of hydrocarbons and their possible concentration in the water, sediment, and living organisms, and the determination of the rates of degradation and effect of hydrocarbons on the food web. Preliminary analyses and study of cruise data taken in the North Sea during July-August 1975 indicates that there appears to be a tendency for higher numbers of microorganisms to be associated with the most active oil field, "Ekofsk"; there is also some indication of mucrobial response to outflow from the Elbe River. The uniform low levels of hydrocarbons in the sediments suggest that microorganisms are active as shown by ratios of higher hydrocarbon bacteria to heterotrophs in the "Ekofsk" area.

797. Orton, J.H. (1925).

POSSIBLE EFFECTS ON MARINE ORGANISMS OF OIL DISCHARGED AT SEA.

Nature, London, 15:910-911.

An early paper which supports the view that oil is of no ecological consequence.

798. O'Sullivan, A.J. and A.J. Richardson. (1967).

THE TORREY CANYON DISASTER AND INTERTIDAL MARINE LIFE.

Nature, 214:448-452 and 541-542.

On March 18, 1967, the tanker Torrey Canyon ran aground on the Seven Stones reef off Land's End. At least 60,000 tons of crude oil has since been released. In mopping up, large quantities of detergent have been used to emulsify the oil. The effects of the oil and detergent on the intertidal marine life have been examined at two areas of the Cornish coast. The report paints a dismal picture.

799. Ottway, S. (1971).

THE COMPARATIVE TOXICITIES OF CRUDE OILS.

In: The Ecological Effects of Oil Pollution on Littoral Communities. E.B. Cowell, (ed) pp. 172-180.

A description is given of preliminary work to investigate the relative toxicities of different crude oils and to establish any correlations between toxicity and physical or chemical properties of the oils. Toxicity was found to vary with temperature, but not in a consistent way for all oils. As a general rule, toxicities of oils with a high percent distillate boiling below 149°C are lower at the highest temperature. No clear-cut correlations of toxicity with chemical composition data are immediately apparent, although certain tendencies are indicated. Crude oils were found to vary in the light they transmit.

800. Ottway, S.M. (1971).

THE "THUNTANK 6" Spill.

In: Field Studies Council, Oil Pollution Research Unit, Orielton Field Centre, Annual Report 1971.

The effect of the oil spill created by the grounding of Thuntank 6 was examined. Very little biological damage occurred, this being attributed to the efficiency and success of emulsifying operations. Where oil did come ashore it was treated with low toxicity emulsifier or removed mechanically. The most noticeable biological effects were the mortalities of *Patella vulgata* and of gammarid crustacea in rock pools. Some algae were observed to be turning white. No great changes in abundance of any of the dominant intertidal fauna or flora were apparent.

801. Pancirov, R.J. and R.A. Brown (1975).

ANALYTICAL METHODS FOR POLYNUCLEAR AROMATIC HYDROCARBONS IN CRUDE OILS, HEATING OILS, AND MARINE TISSUES. pp. 103-113.

In: Proceedings 1975 Conference on Prevention and Control of Oil Pollution. American Petroleum Institute, Washington, D.C.

This paper primarily covers the first phase of a project to demonstrate analytical methods in their ability to measure individual polynuclear aromatic hydrocarbons in typical petroleum oils and marine animal tissues. The study of petroleum oils is complete as described herein. Work on marine tissues is in its initial stage as an analytical method and is shown to be capable of measuring benz(a)anthracene and benzo(a)pyrene when added to clams at the 5 parts per billion (ppb) level. Evaluation of results indicate a detectability of 1 ppb.

802. Paradis, M. and R.C. Ackman. (1975).

DIFFERENTIATION BETWEEN NATURAL HYDROCARBONS AND LOW LEVEL DIESEL OIL CONTAMINATION IN COOKED LOBSTER MEAT.

J. Fish Res. Bd., Can., 32(2):316-320.

A combination of total lipid extraction, column chromatography and temperature-programmed gas chromatography was required to demonstrate disputed low level diesel oil contamination in cooked lobster meat. A specific diesel oil contaminant was indicated but identifiable components were not greatly in excess of the same compounds which were also found to be a normal background in organoleptically acceptable canned lobster meat.

803. Parker, B.L. and J.D. Brammer (1975).

EFFECTS OF CHRONIC OIL CONTAMINATION ON AQUATIC DIPTERANS. A STATE OF THE ART REPORT.

Government Reports Announcements 7 5(2):117

A literature search was conducted to prepare a state-of-the-art review and to determine research needs on petroleum pollution in aquatic environments. Oil contamination of marine and freshwater habitats was reviewed. Sources of petroleum pollution in Lake Champlain were stressed. The biological (toxic, behavioral and physiological) effects of oil contamination on marine and aquatic organisms were examined with emphasis on aquatic stages of mosquitoes. Fluroescence spectrophotometry, mass spectrometry, and gas chromatography were discussed as methods useful in detection of petroleum fractions in water. GLC was the most widely used method for both qualitative and quantitative analysis.

804. Parker, C.A. (1971).

THE EFFECT OF SOME CHEMICAL AND BIOLOGICAL FACTORS ON THE DEGRADATION OF CRUDE OIL AT SEA, pp. 237-244.

In: P. Hepple, (ed.) Water Pollution by Oil. Institute of Petroleum, London.

This paper outlines some possible routes by which crude oil at sea may be degraded and describes some experiments designed to investigate three of these routes, namely, solubility and dispersion, consumption by zooplankton and photochemical oxidation.

805. Parker, P.L. (1974).

EFFECTS OF POLLUTANTS ON MARINE ORGANISMS.

National Science Foundation. Reproduced by NTIS. 45 pp.

This volume summarizes the deliberations of a workshop meeting of The Effects of Pollutants on Marine Organisms Program. Research focused on determining sublethal effects of low levels of chemical pollutants, including petroleum. Hydrocarbons are broken down into low and high molecular weights. Extensive bibliog.

806. Parker, P.L., J.D. Brammer, M.E. Whalon, and W.O. Berry (1976).

CHRONIC OIL CONTAMINATION AND AQUATIC ORGANISMS WITH EMPHASIS ON DIPTERA: STATUS AND BIBLIOGRAPHY.

Wat. Resour. Bull., La., 12 291-305.

807. Parker, P.L., K. Winters, C. Van Baalen, J.C. Batterson and R.S. Scalon (1976).

PETROLEUM POLLUTION: CHEMICAL CHARACTERISTICS AND BIOLOGICAL EFFECTS.

In: Sources, Effects and Sinks of Hydrocarbons in the Aquatic Environment. Proceedings of the Symposium American University Washington D.C. 9-11 August 1976.

Water soluble fractions of four crude oils were prepared. The rates of solution and mixing for various components of this fraction were measured. The effects of isolated components were tested on microalgae. Biologically active fractions were isolated which affect growth rate of the algae. Hydrocarbon acted of the waters, sediment and biota of the South Texas Outer Continental Shelf were measured. Little petroleum derived hydrocarbons were found with the exception of neuston, which contained pelagictar.

808. Parrack, J.D. (1967).

NOTES ON THE TREATMENT AND REHABILITATION OF OILED SEABIRDS.

Seabird Bulletin, 3, 18.

809. Parrack, J.D. (1967).

THE WRECK OF OILED BIRDS IN THE NORTH-EAST EARLY IN 1966.

Seabird Bulletin, 3, 12-16.

810. Parslow, J.S.F. (1967).

CHANGING STATUS AMONG BREEDING BIRDS IN BRITAIN & IRELAND.

Br. Birds 60(2-46):177-202.

Decreased numbers in many colonies of guillemots in the U. K. from 1939 to 1945 are thought to be due to excessive oil pollution at sea during World War II. Many thousands of guillemots are killed by oil pollution each year, and this

is probably the main cause of their decline in the south of England. Oil pollution may be to blame for decreased numbers of puffins at some colonies also.

811. Payne, J.F. (1976).

FIELD EVALUATION OF BENZOPYRENE HYDROXLYASE INDUCTION AS A MONITOR FOR MARINE PETROLEUM POLLUTION.

Science, 191(4230):945-946.

Fish from petroleum-contaminated sites in the marine environment have elevated levels of benzopyrene hydroxylase activity in liver and gill tissue. This sublethal response appears to be a practical biological monitor for marine petroleum pollution.

812. Payne, J.F. (1977).

MIXED FUNCTION OXIDASES IN MARINE ORGANISMS IN RELATION TO PETROLEUM HYDROCARBON METABOLISM AND DETECTION.

Mar. Poll. Bull. 8 pp. 112-116.

Several phyla from the coastal Northwest Atlantic were investigated for mixed function oxidases. Enzyme activity was related to hydrocarbon metabolism and detection in the marine environment. The major oxidase considered was aryl hydrycarbon hydrobylase (AHH). AHH was not detectable in some marine organisms; enzyme activity may be related to phylogeny. The ability to respond to pollutant hydrocarbons by AHH induction is not a universal response for organisms possessing AHH. There was some substrate specifically in the MFO induced by petroleum in fish. Several MFO activities were examined but only AHH appeared as a useful enzyme monitor for petroleum. No invertebrate so far examined for MFO can be considered a useful monitoring species.

813. Payne, J.F. and W.R. Penrose. (1975).

INDUCTION OF ARYL HYDROCARBON (BENZO(ALPHA) PYRENE) HYDROXYLASE IN FISH BY PETROLEUM.

Bull. Environ. Contamination and Toxicology. 14(1):112-116.

The existence of inducible aryl hydrocarbon hydroxylases (AHH) in fish may provide a convenient means of assessing previous exposure to petroleum or other products containing polycyclic aromatic hydrocarbons. Brown trout were collected from a lake on the Avalon Peninsula of Newfoundland that appeared to be unpolluted, and from a lake in the city of Saint John's which is considered to be polluted by oil and other contaminants. Capelin were collected at the seashore. Significant increases in the specific activity of liver AHH were observed with 17 d in trout and capelin. Specific activities of liver AHH of trout from clean and "polluted" lakes were significantly different, indicating that environmental factors are reflected in the enzyme levels. Whether these factors consist of, or include, oil contamination is difficult to prove in field measurements. The fish from the "polluted" lake had a strong and distinctly oily taste. The fluorescence extractable from the sediments was much greater in the "polluted" than in the control lake, and the pattern of blue fluorescence was distributed unevenly over the length of the thin-layer chromatograms, similar to chromatograms of whole crude oil. The clean pond sediments yielded a weak blue, narrow band near the solvent front. All sediment extracts showed a band of orange fluorescence at the origin which was not present in crude oil.

814. Pearce, J.B. (1974).

BENTHIC ASSEMBLACES IN THE DEEPER CONTINENTAL SHELF WATERS OF THE MIDDLE ATLANTIC BIGHT.

In: Marine Environmental Implications of Offshore Oil and Gas Development in the Baltimore Canyon Region of the Mid-Atlantic Coast. Proceedings of the Estuarine Research Federation Conference and Workshop. Estuarine Research Federation. 297-318.

This article reports the results of those cruises to examine the benthos of the continental shelf waters outside the New York Bight apex. Impact of petroleum on the benthos is discussed.

815. Pearson, J.D. (1976).

SUBLETHAL EFFECTS - EFFECTS ON SEA GRASS.

In: Environmental Assessment of the Alaskan Continental Shelf. Principal Investigators' Reports for the Year Ending March 1976, Vol. 8. Effects of Contaminants p. 377-389.

This study is directed at evaluating the effects of selected petroleum hydrocarbons (dodecane, toluene and napthalene) on rates of photosynthesis in Zostera marina. Since Z. marina is a major contributor to primary production in many ecological niches along the Alaskan coastline, it is imperative to understand what possible effects of plant exposure to low-levels of the more water soluble and toxic components of petroleum. Deleterious effects on seagrass could disrupt whole food chain. (Sinha OEIS)

816. Peltier, J.C., W. DuPont and J.P. DuPont. (1976).

BIOECOLOGICAL CONSEQUENCES OF AN ACCIDENTAL OIL SPILL ON ROCKY SHORES OF THE NORMANDY COAST: RESULTS ONE YEAR AFTER OIL POLLUTION ON NOV. 26th 1974.

C.R. Seluces SOC BIOL FIL 170(2):422-448 (French with English summary).

Along shores where detergents were not used, mussels have progressively excreted the hydrocarbons accumulated in their bodies; the other fixed animals show no change. Along the shores where the detergents were used, their spread had noxious consequences, with modifications of fixed species colonizing the rocks.

817. Percy, J.A. (1976).

RESPONSES OF ARCTIC MARINE CRUSTACEANS TO CRUDE OIL AND OIL-TAINTED FOOD.

Environ. Pollut., 10(2):155-162.

The responses of several arctic marine crustaceans to oil masses and oil-tainted food have been investigated. None of the species were attracted to crude oil. Amphipods tended to avoid oil masses; however, the response was significantly diminished if the oil was weathered or if the animals were pre-exposed to light crude oil emulsions. Untainted food was preferentially selected over oil-tainted food. In contrast, an isopod was generally neutral to the presence of oil masses and consumed oil-tainted food as readily as untainted material.

818. Percy, J.A. (1977).

RESPONSES OF ARCTIC MARINE BENTHIC CRUSTACEANS TO SEDIMENTS CONTAMINATED WITH CRUDE OIL.

Environ. Pollut. 13(1) 1-10.

The responses of several arctic marine benthic crustaceans to sediments experimentally contaminated with crude oil were examined. The amphipod <u>Onisimus affinus</u> overwhelmingly selected clear rather than oil contaminated sediments. The response was most pronounced at low concentrations and the ability to discriminate was abolished at the highest concentrations. Weathering of the oil one week reduced the avoidance response.

819. Percy, J.A. and T.C. Mullin. (1975).

EFFECTS OF CRUDE OILS ON ARCTIC MARINE INVERTEBRATES.

Beaufort Sea Project Technical Report No. 11.
Environment Canada, Victoria BC 167 pp.

820. Percy, J.A. and T.C. Mullin (1977).

EFFECTS OF CRUDE OIL ON THE LOCOMOTORY ACTIVITY OF ARCTIC MARINE INVERTEBRATES.

Mar. Pollut. Bull. <u>8</u> 35-40.

The effects of exposure to seawater dispersions of northern crude oils on the locomotory activity of two Arctic marine invertebrates, the amphipod <u>Onisimus affinis</u> and the coelenterate <u>Halitholus</u>

cirratus have been examined. Low concentrations of oil significantly impair activity in both species. The ecological implications of such sublethal effects may be important.

821. Perkins, E.J. (1968).

THE TOXICITY OF OIL EMULSIFIERS TO SOME INSHORE FAUNA.

In: The Biological Effects of Oil Pollution on Littoral Communities.

J.D. Carthy and D.R. Arthur (eds.) 81-90.

LC_{50}'s were determined for the effect of several emulsifiers on several species of littoral invertebrates. It is concluded that oil emulsifiers currently in use are extremely toxic and may produce 100% mortality at concentrations as low as 10 ppm sustained for 96 hours. The tolerence varied with organism, season and conditions.

822. Perkins, E.J. (1970).

SOME EFFECTS OF "DETERGENTS" IN THE MARINE ENVIRONMENT.

Chem. Ind. 1:14-22.

Detergents have a considerable toxicity, ranging from less than 1 ppm to more than 1000 ppm. Three species of mollusks (Littorina saxatilis, Littorina littorea, and Nucella lapillus) were exposed to 25% BP 1002 in sea water, while L. littorea and Nucella were subjected to similar mixtures of Dasic "Slickgone" and "Tarsolvent". An experiment with Bucinnum undatum was performed with "Slickgone" and "Tarsolvent", after which all animals were placed in live boxes and placed offshore on 3 May 1968. Where possible, the organisms were checked once a week, for a period of 22 weeks. All three detergents induced decreased growth rates and increased mortality rates.

823. Perkins, E.J. (1972).

SOME PROBLEMS OF MARINE TOXICITY STUDIES,

Mar. Pollut. Bull. 3 13-14.

824. Perkins, E.J., E. Gribbon, and J.W.M. Logan (1973).

OIL DISPERSANT TOXICITY.

Marine Pollution Bulletin, 4(6):90-93.

Toxicity tests using a wide variety of shore animals reveal that the latest generation of dispersants have low toxicity. The new formulations tested were BP 1100X and Shell Dispersant LT.

Results of tests are compared to toxicity of early generation oil emulsifiers. When mixed with crude oil, the new emulsifiers are less toxic than the older types. No induced long-term effects on growth or mortality of treated animals were noted.

825. Peters, A.F. (ed.) (1974).

IMPACT OF OFFSHORE OIL OPERATIONS.

Applied Science Publishers for the Institute of Petroleum. 205 pp.

This book contains the eight main papers given at a conference, organised by the Institute of Petroleum, on "The Impact of Offshore Oil Operations." The discussion following each paper is given in full. Considerable attention is paid to the causes, prevention and amelioration of pollution.

826. Peterson, R.T. (1942).

BIRDS AND FLOATING OIL.

Audubon Mag. 44, 217-225

This article reviews reports of destruction of seabirds by oil slicks, particularly in conjunction with WWII tanker sinkings. Methods of treatment are described.

827. Petrocelli, S.R., J.W. Anderson, W.M. Sackett, B.J. Presley and C.S. Giam. (1974).

RESULTS OF RESEARCH INTO THE EFFECTS OF SUBLETHAL CONCENTRATIONS OF SELECTED COMPOUNDS ON THE PHYSIOLOGICAL RESPONSE OF MARINE AND ESTUARINE ORGANISMS.

Progress report to IDOE Pollutant Effects Meeting in Sidney, B.C., Canada.

This report is a summary of research completed or in progress under the Biological Effects Program (BEP) of the Office of the IDOE of NSF. It includes a review of data and conclusions described in earlier progress reports as well as details of new studies.

828. Pierce, R.H., Jr., A.M. Cundell and R.A. Traxler (1975).

PERSISTENCE AND BIODEGRADATION OF SPILLED RESIDUAL FUEL OIL ON AN ESTUARINE BEACH.

Appl. Micro. 29(5):646-652.

The enrichment of hydrocarbon degrading bacteria and the persistence of petroleum hydrocarbons on an estuarine beach after a spill of residual fuel oil on 11 April 1973 in Upper Narragansett Bay, R.I. was investigated. A rapid enrichment occurred during days 4 to 16 after the oil spill and a significant population of hydrocarbon-degrading bacteria was maintained in the beach sand for at least a year. The concentration of petroleum hydrocarbons in the mid-tide area declined rapidly during the bacterial enrichment period, remained fairly constant throughout the summer, and then declined to a low concentration after 1 year. An increased concentration of branched and cyclic aliphatic hydrocarbons in the low-tide sediment 128 days after the spill suggested a migration of hydrocarbons during the summer. Hydrocarbon biodegradation was apparent during the winter months at a rate of less than 1 ug of hydrocarbon per g of dry sediment per day.

829. Pilpel, N. (1968).

THE NATURAL FATE OF OIL ON THE SEA.

Endeavour, 27(10):11-13.

Although millions of tons of oil have been spilt on to the sea in the last half-century, the surface of the ocean still remains relatively clean, for certain natural processes occur which cause the disappearance of the oil. These include evaporation, the formation of emulsions, sinking, auto-oxidation, and oxidation by micro-organisms. The last is probably the most effective, and destroys oil at the rate of some hundreds of grams per cubic metre of contaminated ocean per year. In this article an account is given of the sources of oil pollution, the steps that are being taken to reduce it, and the manner in which it is dispersed and destroyed by natural agencies.

830. Polak, R., A. Filion, S. Fortier, K. Cooper, and J. Lanier (1978).

OBSERVATIONS ON ARGO MERCHANT OIL IN ZOOPLANKTON OF NANTUCKET SHOALS.

In: In the Wake of the Argo Merchant. Proceedings of a Conference Held at the University of Rhode Island. January 11-13, 1978. Center for Ocean Management Studies, University of Rhode Island, Kingston, Rhode Island.

Zooplankton samples taken in February and July 1977 on Nantucket Shoals following the Argo Merchant oil spill were examined microscopically, then hexane extracts were analyzed by synchronous scanning spectrofluorometry. At fourteen of twenty-two sites in February, the hexane extracts contained Argo Merchant oil. Microscopic examination indicated "oil-like" material present in the intestine and on the cuticle.

831. Polikarpov, G.G., V.N. Yegorov, V.N. Ivanov, A.V. Tokareva and I.A. Feleppov. (1971).

OIL AREAS AS AN ECOLOGICAL NICHE.

Priroda 11 (translated by N. Precoda). Pollut. Abstr. 3:72-5TC-0451. Sci. Biblog. p. TC-84.

The ecological significance of the final stages of "evolution" of oil transformed into discrete clumps is discussed. Oil aggregates in the central part of the Atlantic Ocean are described and the quantitative distribution and properties of the biotope are considered.

832. Polisois, G., A. Tessier, P.G.C. Campbell, and J.P. Villeneuve. (1975).

DEGRADATION OF PHENOLIC COMPOUNDS DOWNSTREAM FROM A PETROLEUM REFINERY COMPLEX.

J. Fish. Res. Board Can. 32:2125-2131.

Measurements downstream from refinery outfalls in the region of Montreal East have shown that, under favorable temperature conditions, the concentration of phenolic substances in the river water rapidly diminishes with distance from the refineries. Mass balance calculations at different transverse sections show that this decrease in concentration cannot be attributed to dilution only. Laboratory experiments performed on river water samples demonstrate the effects of water temperature and sterilization on the rate of phenol breakdown. Results support the idea that biodegradation is responsible for the self-purification of phenolics in the St. Lawrence River.

833. Poljakova, J.N. (1962).

DISTRIBUTION OF HYDROCARBON OXIDIZING MICROORGANISMS IN WATER OF NEVA BAY . (in Russian).

Mikrobiol., 31: 1016-1081.

Microorganisms oxidizing hydrocarbons contained in polluting oil are common in Neva Bay and were found at all sampling points.

The greatest numbers of hydrocarbon-oxidizing microflora are found in the shipping regions of Neva Bay.

The numbers of hydrocarbon-oxidizing bacteria increase in the summer period and reach a maximum in July-August. This is presumably due to the optimum temperature conditions for bacteria in the water and the heavy shipping traffic at this time.

Hydrocarbon-oxidizing microorganisms are most abundant in the surface layer of water, in direct contact with the oil film.

Rod-shaped forms of the genera Pseudomonas and Mycobacterium play the leading role in the oxidation of oil products.

The presence of large numbers of microorganisms oxidizing oil hydrocarbons indicates a high rate of bacterial self-purification of the water.

AD-A064 196 COAST GUARD RESEARCH AND DEVELOPMENT CENTER GROTON CONN F/G 13/2
BIOLOGICAL EFFECTS OF OIL POLLUTION - A OMPREHENSIVE BIBLIOGRAP--ETC(U)
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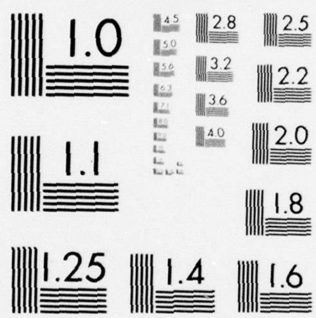

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

834. Ponat, A. (1975).

INVESTIGATIONS ON THE INFLUENCE OF CRUDE OIL ON SURVIVAL AND OXYGEN CONSUMPTION OF IDOTEA BALTICA AND GAMMARUS SALINUS

Kieler Meeresforshungen 31 26-31.

The influence of crude oil from Venezuela, Libya and Iran was observed with respect to Idotea baltica and Gammarns salinus. Prior to the measurements, the animals were spread out on sand and exposed to a 0.1 mm layer of crude oil for four hours. After this period they were transferred back to seawater of 15% salinity at 15°C. The mean time of survival for G. salinus varied between one and two days. I. baltica showed greater resistance. Oxygen consumption of G. salinus was reduced by Iran crude oil to 40% of the normal value and to 70% of the normal value in Idotea.

835. Portmann, J.E. (1972).

RESULTS OF ACUTE TOXICITY TESTS WITH MARINE ORGANISMS USING A STANDARD METHOD.

In: Marine Pollution and Sea Life, M. Ruivo (ed.) FAO, Fishing News (Books) LTD, London. pp. 212-217.

A standard static bioassay using Cragon and Cardium is usual to measure 48 hr. LC_{50} for a variety of toxins, including oil dispersants.

836. Portmann, J.E. (1972).

TOXICITY-TESTING WITH PARTICULAR REFERENCE TO OIL-REMOVING MATERIALS AND HEAVY ETALS.

In: Marine Pollution and Sea Life, FAO, Fishing News (Books) Ltd. London. pp. 217-221.

This article discusses the problems involved with toxicity-testing. A small section on tainting is included. Several references.

837. Portmann, J.E. (ed.)(1976)

MANUAL OF METHODS IN AQUATIC ENVIRONMENT RESEARCH.

Pt. 2 Guidelines for the Use of Biological Accumulations in Marine Pollution Monitoring. FAO Fisheries Technical Paper FIRI/T 150. 84 pp.

This volume is a collection of documents which deal with the role of biological accumulators in monitoring programs, monitoring of radionuclides, monitoring of trace elements other than radionuclides, monitoring of petroleum hydrocarbons, monitoring of chlorinated hydrocarbons, miscellaneous substances, a pilot study on monitoring bioaccumulation in marine organisms, and analytical considerations.

A Matrix Table is included which was a corporate effort and intended as a quick means of indicating which organism might be suitable for monitoring a particular contaminant.

838. Portmann, J.E., and P.M. Connor. (1968).

THE TOXICITY OF SEVERAL OIL-SPILL REMOVERS TO SOME SPECIES OF FISH AND SHELLFISH.

Mar. Biol., 1:322-329.

The toxicity of 12 solvent emulsifiers was examined, using 4 marine species of shellfish. Using 2 of these test species the toxicities of 3 solvent emulsifiers were examined in more detail, particular attention being paid to the time of exposure at different concentrations required to cause death. The effect of crude oil mixed with those 3 materials was also examined. Details are also given of some preliminary experiments with solvent emulsifiers on larvae of the shore crab (*Carcinus maenas*) and the brown shrimp (*Crangon crangon*).

839. Potter, J. (1973).

DISASTER BY OIL. OIL SPILLS: WHY THEY HAPPEN; WHAT THEY DO; AND HOW WE CAN END THEM.

Macmillan Company, New York. 307 pp.

Oceanic spills are examined as to how they occur, what damage they cause, and how they can be ended. Detailed accounts of the following specific oil spill disasters are given: the S.S. *Torrey Canyon* stranding, the S.S. *Ocean Eagle* disaster, the M.S. *General Colocotronis* stranding, and the Santa Barbara Channel drilling platform blow out.

840. Powell, N.A., C.S. Sayce, and D.F. Tufts, (1970).

HYPERPLASIA IN AN ESTUARINE BRYOZOAN ATTRIBUTAL TO COAL TAR DERIVATIVES.

J. Fish. Res. Board Can., 27(11):2095-2096.

Report on the result of placing colonies of *Schizoporella unicornis* in close proximity to coal tar derivatives in an estuary: noted hyperplasia of ovicells. There is a possibility that the organism can be used is a qualitative, perhaps even a quantitative indicator of oil pollution in coastal areas.

841. Powers, K.D. and T. Rumago (1978).

EFFECT OF *ARGO MERCHANT* OIL ON BIRD POPULATIONS OFF THE NEW ENGLAND COAST. 15 DECEMBER 1976 THROUGH JANUARY 1977.

In: In the Wake of the Argo Merchant. Proceedings of a Conference and Workshop Held at the University of Rhode Island. January 11-13, 1978. Center For Ocean Management Studies, University of Rhode Island, Kindston, Rhode Island.

Bird observations were made in the vicinity of the Argo Merchant spill site from 15-24 December 1976. 1120 birds of 13 species were sighted, almost 92% of which were gulls. Approximately half the gulls were visibly oiled. From 20 December 1976 to 24 January 1977, 68 live and 107 dead oiled birds were collected from the beaches of Nantucket and Martha's Vineyard. These birds were mostly alcids (47%), gulls (29%), and loons (19%). Results from bird observations made at sea during January 1977 indicated greater numbers of birds on the periphery and outside of the affected area, but larger proportions of visibly oiled birds totaled birds counted within the oil slick area. Data indicate that the Argo Merchant spill probably had minimal effects on coastal and marine bird populations off the New England coast.

842. Pratt, S. (1978).

INTERACTIONS BETWEEN PETROLEUM AND BENTHIC FAUNA AT THE ARGO MERCHANT SPILL SITE.

In: In the Wake of the Argo Merchant. Proceedings of a Conference and Workshop Held at the University of Rhode Island, January 11-13, 1978. Center for Ocean Management Studies, University of Rhode Island, Kingston, Rhode Island.

Funding was provided for collection and archiving of quantitative benthic grab samples from the spill site. Observations during collection and preliminary examination of nine samples from three stations indicate the form of petroleum in sediments and potential for interaction with organisms. Petroleum was found as particles less than 1 mm in diameter both adhering to coarse sands and free in interstitial spaces. No decrease in density or diversity of the limited interstitial fauna was detectable. Interstitial harpacticoid copepods and polychaetes had petroleum in their guts. Larger burrowing amphipods had petroleum adhering to appendages.

843. Pritchard, P.H. and T.J. Starr (1972).

MICROBIAL DEGREDATION OF OIL IN CONTINUOUS CULTURE.

In: Workshop: Microbial Degredation of Oil Pollutants, Dec. 4-6, Atlanta, Georgia. pp. 7-20.

With the exception of a few nuclear powered vessels, contemporary naval forces depend upon oil as their source of energy. Occasional carelessness, accidents, and routine cleaning of fuel tanks cause oil pollution. This effort will be devoted to obtaining a better understanding of how biological degradation of oil takes place and may give an insight into how this process may be artifically increased. The principal investigator will study (1) the rates of crude oil degradation by bacteria, (2) the effects of environmental parameters on these rates, (3) the mechanisms by which bacteria oxidize and modify crude oil, and (4) the chemical and toxicological properties of the metabolic and products of crude oil decompositon. Degradation rates of octane appear to be a function of the bacterial species employed and the flow rate of the continuous culture system. Using a bacterial isolate from batch culture, octane disappeared from a chemostat at a rate of 0.39 mg/day. If the flow rate was doubled with the same isolate, the degradation rate tripled.

844. Prokop, J.F. (1950).

REPORT ON A STUDY OF MICROBIAL DECOMPOSITION OF CRUDE OIL.

Texas A&M Research Foundation, Project 9.

The oxidation of a number of hydrocarbons has been reported by many observers. Organisms capable of oxidizing hydrocarbons are widespread in nature. Sea water containing $(NH_4)_2$ HPO_4, and enriched with crude oil, provides a medium favorable for the physiological activities of hydrocarbon oxidizing microorganisms. Inoculating selective media by the minimum dilution method provides a satisfactory method for determining the population of hydrocarbon oxidizing microorganisms in an inoculum. Modification of physical appearance, microbial multiplication, reduction of pH, oxygen consumption in manometers and glass-stoppered bottles, and methylene blue decolorization may be employed to demonstrate that hydrocarbons are oxidized by microorganisms.

In environments where conditions are favorable for the development of hydrocarbon oxidizers large quantities of hydrocarbons may be oxidized to CO_2 and H_2O.

845. Prouse, N.J. and D.C. Gordon, Jr. (1974).

THE EFFECTS OF THREE OILS ON THE GROWTH OF THE DINOFLAGELLATE *DUNALIELLA TERTIOLUCTA* AND THE DIATOM *FRAGILARIA* SP. IN AXENIC BATCH CULTURES.

International Council for the Exploration of the Sea, C.M. 1974/2:41. 6 pp.

846. Prouse, H.J. and D.C. Gordan, Jr. (1976).

INTERACTIONS BETWEEN DEPOSIT FEEDING POLYCHEATE *ARENICOLA MARINA* AND OILED SEDIMENT.

In: Sources, Effects, and Sinks of Hydrocarbons in the Aquatic Environment, Proceedings of the Symposium, American University, Washington, D.C. 9-11 August 1976.

The deposit feeding polychaete _Arenicola_ _marina_ can be a sensitive indicator of the effects of oil pollution on marine ecosystems. Concentrations of oil in both water and sediment commonly occurring in spill situations can force worms to surface or stop feeding activity. Lower concentrations can reduce the rate of cast production and presumably feeding. Oil concentrations in casts are substantially lower than in unworked sediment indicating that the working activity of _Arenicola_ can be an important factor in the weathering of oil in sediment. These results are preliminary and are being expanded with further experiments.

847. Prouse, H.J., D.C. Gordon, Jr., and P.D. Keizer (1976).

THE EFFECTS OF LOW CONCENTRATIONS OF OIL ACCOMMODATED IN SEA WATER ON THE GROWTH OF UNIALGAL MARINE PHYTOPLANKTON CULTURES.

J. Fish. Res. Bol. Cana. _33_ 810-818.

Effects of Venezuelan crude, Kuwait crude, and No. 2 fuel oils were investigated. The oil concentrations used were 1 mg/l. Minor stimulation or inhibition of growth was apparent but in only 2 experiments was the growth of oil-contamined cultures statistically different from controls (in both cases, stimulation). Extrapolation of the results to the natural environment is complicated by several factors, including the variability in organism response and the variability in the concentration and composition of oil during the experiments. Oil concentrations encountered in polluted seawater can affect the growth of phytoplankton, but the effects are minor and short-lived.

848. Pulich, W.M., Jr., K. Winters, and C. Van Baalen. (1974).

THE EFFECT OF A NO. 2 FUEL OIL AND TWO CRUDE OILS ON THE GROWTH AND PHOTOSYNTHESIS OF MICROALGAE.

Mar. Biol, _28_, 87-94.

The water soluble fractions of No. 2 fuel oil, Southern Louisiana crude, and Kuwait crude are toxic in varying degrees to representative types of micro algae: two blue-green algae, a diatom, two green algae and a dinoflagellate. Lethality, growth and photosynthesis were measured. The toxic activity is mainly localized in medium and higher boiling fractions.

849. Raitcheva, V. and O. Zlatarev. (1970).

CHRONIC EFFECT OF PETROLEUM DERIVATIVES ON ENZYME CONSTELLATIONS.

Ind. Med. Surg., 39(8):345-346.

Tanker fleet employees having contact with petroleum products were studied as to the toxic effects of such derivatives. A selected enzyme constellation was chosen for study. The changes observed may serve as diagnostic criteria of damage from contact with such products.

850. Ramamurthy, V.D. (1974).

OIL TANKER DISASTER IN NORTH-WEST COAST OF INDIA.

Curr. Sci. (Bangalore), 43:293-294.

A report on the release of 18,000 tons of L.D.O. (black oil) off Porbandar Coast, and the resultant effects on marine life, following the break-up of the tanker Cosmos Pioneer on 18th June, 1973.

851. Ramseiser, R.O., G.S. Gantecheff, L. Colby (1973).

OIL SPILL AT DECEPTION BAY, HUDSON STRAIT.

Canada. Inland Waters Branch. Scientific Series No. 29. 61 pp.

Approximately 427,000 gal of Arctic diesel oil and gasoline were spilled over permafrost and sea ice at Deception Bay, Quebec, when a tank farm was destroyed by a slush avalanche. The cause and extent of the spill, characteristics of the avalanche, physiography and geology of the area, and affected areas; the behavior of the oil on ice, in the tidal-crack system, and on land; biological observations of the marine and terrestrial environments; chemical observations; daily observations of oil distribution; the oil budget; prevention, containment, and cleanup of oil spills; and post-operation activities are reported. The spreading and dispersion mechanisms and the general behavior of oil in ice-infested waters are fundamentally different than oil in ice-free water. The procedures currently used to prevent, monitor, detect, contain and clean up oil spills in the open seas could be adapted for use in ice-infested waters. Greater care should be taken in site selection for structures in the Arctic since many phenomena occurring in remote regions are not well understood. Fucus and Mytilus were the intertidal species most affected by the spill and its aftermath, and both were apparently harmed more by heat from the burning of oil from the sea ice than from the oil. An estimated 50% of certain inshore subtidal bivalves (17% of the total biota) and 5% of the polychaete fauna could have died from the effects of the oil.

852. Ranwell, D.S. (1968).

EXTENT OF DAMAGE TO COASTAL HABITATS DUE TO THE TORREY CANYON INCIDENT.

In: The Biological Effects of Oil Pollution on Littoral Communities. Supplement to Vol. 2 of Field Studies, J.D. Carthy and D.R. Arthur, (eds.). Field Studies Council, U.K.

The full range of oil-contaminated habitats was inspected from the air and on the ground in Cornwall, and on the ground in Brittany. This paper describes dimensions of oil pollution on the two coastlines, the extent of damage to coastal habitats (and their flora in particular), due to oil and decontamination activities, and draws conclusions from the available information.

853. Ranwell, D.S. (1968).

LICHEN MORTALITY DUE TO TORREY CANYON OIL AND DECONTAMINATION MEASURES.

Lichenologist, 4, 55-56.

854. Ranwell, D.S. and D. Hewett (1964).

OIL POLLUTION IN POOLE HARBOUR AND ITS EFFECTS ON BIRDS.

Bird Notes, 31, 192-197.

855. Rashid, M.A. (1974).

DEGRADATION OF BUNKER C OIL UNDER DIFFERENT COASTAL ENVIRONMENTS OF CHEDABUCTO BAY, NOVA SCOTIA.

Estuarine and Coastal Marine Science. 2:137-144.

The results given in this paper tend to indicate that the extent of degradation of spilled oil in marine areas depends in a large measure upon the environmental conditions of coastal areas. The degradation is rapid in the high energy environment but is relatively slow in protected areas. Bacterial as well as oxidative processes appear to alter the composition of oil.

Oils exposed to high energy shoreline environments lose n-alkanes more rapidly. This loss is probably due to bacterial degradation because no other known physical or chemical process can account for this. With weathering the saturated and aromatic hydrocarbons decrease with a corresponding increase in the non-hydrocarbons, particularly in resins and NSO compounds. These changes which are possibly due to microbial and oxidative degradation processes are prominent in the oils of high energy environment. The rates of degradation of saturated and aromatic fractions appear to be the same.

856. Reeve, M.R., G.D. Grice, V.R. Gibson, M.A. Walter, K. Darcy, and T. Ikeda, (1976).

A CONTROLLED ENVIRONMENTAL POLLUTION EXPERIMENT (CEPEX) AND ITS USEFULNESS IN THE STUDY OF LARGER MARINE ZOOPLANKTON UNDER TOXIC STRESS.

In: Effects of Pollutants on Aquatic Organisms, A.P.M. Lochwood (ed.), Vol. 2 pp. 145-162. Society for Experimental Biology Seminar Series. Cambridge: Cambridge University Press.

857. Rechnitzer, A.B. and C. Limbaugh (1956).

AN OCEANOGRAPHIC AND ECOLOGICAL INVESTIGATION OF THE AREA SURROUNDING THE UNION OIL COMPANY SANTA MARIA REFINERY OUTFALL, OSO FLACO, CALIFORNIA.

Univ. Calif. Inst. Mar. Resources, 56-5, 1-46.

858. Reimer, A.A. (1975).

EFFECTS OF CRUDE OIL ON CORALS.

Mar. Poll. Bull. 6(3):39-43.

Corals are key members of the tropical reef communities, by providing habitat for other organisms and entering importantly into the overall metabolism of the reef community. Concern has been expressed several times at the collapse of the community that would result from damage to corals by oil pollution. So far relatively few experimental studies of the susceptibility of coral to oil have been carried out. In this study four Panamanian coral species have been exposed to marine diesel and bunker oil. These may cause delayed death, but probably more importantly interfere with feeding and metabolism at sub-lethal concentrations.

859. Reimer, A.A. (1975).

EFFECTS OF CRUDE OIL ON THE FEEDING BEHAVIOR OF THE ZOANTHID PALYTHOA VARIABILIS.

Environ. Physiol. and Biochem. 5(4)258-265.

Oils and solutions at 10^{-1}M of naturally occurring amino acids, proline analogs and the tripeptide glutathione were imbibed by 1-mm^2 pieces of Whatman no. 4 filter paper and offered to polyps by dropping one over a group of tentacles. Several oil-water mixtures were prepared by placing oil over the surface in a 250-ml finger bowl and bubbling air through it for 30 min to produce a suspension of fine oil droplets in which a group of experimental polyps was placed. The effect of a 30-min exposure to oil was studied by placing polyps in a dry dish and pouring oils over them; polyps were submerged in the oil for 30 min. P. variabilis has a well-coordinated, stereotyped feeding response similar to that described for other zoanthids. The feeding reaction can be elicited by the heterocyclic amino acid proline and by some of its analogs. The addition of an OH group or of a glycyl group annuls the activity of the proline molecule. Substitutions or additions to the imino group do not alter the effectivity of the activator. The size of the ring can be altered within certain limits without affecting the activity of the molecule. Feeding reactions culminating with ingestion can be elicited by Marine Diesel and Bunker-C oils. Exposure to oil affects the ability of polyps to discriminate between inert and chemically active particles for 3 to 5 d; responses to proline are not altered for $<$ 3d following the exposure but become slower and are present in fewer polyps after that period. Oil is retained in the coelenteron for several days following exposure and is periodically released in the form of tiny droplets.

860. Reisfeld, A., E. Rosenberg, and D. Gutnick (1972).

MICROBIAL DEGRADATION OF CRUDE OIL: FACTORS AFFECTING THE DISPERSION IN SEAWATER BY MIXED AND PURE CULTURES.

Applied Microbiology, 24(3):363-368.

By means of the enrichment culture technique, a mixed population of microorganisms was obtained which catalyzed the dispersion of crude oil in supplemented seawater. From this enrichment culture, 8 pure cultures were isolated and studied; only 1 of which, RAG-1 tentatively characterized as a member of the genus Arthrobacter, brought about significant dispersions of crude oil. The other 7 isolates gave rise to colonies on supplemented oil agar, but were neither able to disperse oil nor to stimulate the dispersion catalyzed by RAG-1. The dispersion of crude oil by either RAG-1 or the enrichment culture was absolutely dependent on exogenous sources of N and P and completely inhibited by 10^{-2} M azide. The increase in cell number of RAG-1 was directly proportional to the concentration of crude oil added to the medium over the range 0.05-1.0 mg/ml. Within this linear region, 1.0 mg of crude oil yielded 9×10^{7} cells and approximately 65% of the oil was converted into a nonbenzene extractable form. Accompanying the emulsification, but neither necessary or sufficient for oil dispersion, was a decrease in the pH from 7.6 to 5.0. When seawater was supplemented with 0.029 dipotassium phosphate and 3.8 m M ammonium suffate and inoculated with RAG-1, oil dispersion occurred with 1 d. This dispersion could also be brought about by the supernatant following separation of the cells from the medium or a hexadecane medium within 60 min.

861. Reish, D.J. (1965).

THE EFFECT OF OIL REFINERY WASTES ON BENTHIC MARINE ANIMALS IN LOS ANGELES HARBOR, CALIFORNIA.

Symposium Commission Internationale exploration scientifique Mer. Mediterranee, Monaco, 1964, 355-361.

862. Reish, D.J. (1972).

MARINE AND ESTUARINE POLLUTION.

Water Pollution Control Federation Journal, 44(6):1218-1226

The 1971 literature on marine and estuarine pollution is reviewed. Monitoring and surveys of physical and biological characteristics of polluted areas, oil pollution, indicator organisms, bioassays, malformations, mocroorganisms and water movements are discussed.

The effects on organisms of wastewater effluents and the concantrations and metabolism of pollutants by various animals and algae were also studied.

863. Remmert, H. (1970).

INFLUENCE OF INDUSTRIAL EFFLUENTS ON ARTHROPODS OF THE MARINE SUPRALITTORAL ZONE. (in German, Engl. Summary).

Oecologia, 5: 158-164.

Limosina brachystoma can be reared even when the food and substratum (dry leaves of Urtica or almost any other plant) are moistened with 15% NaCl p.a. or with 15% NaCl plus KCl. Orchestia lives about three weeks if kept on a substratum moistened with a solution of 15% NaCl (Food: Fucus).

H_2SO_4, on the other hand, is fatal especially, for Orchestia.

Burning oil gives off pollutants into the surrounding water. These pollutants are fatal for all the animals studied even at very low concentrations. But in air (not in water) these pollutants disappear within one week and the substratum may be colonized again.

Crude oil which has floated in the sea for a long time is not any longer poisonous to the animals studied. It does not hinder rapid propagation of all species. Larvae of the flies and--to a lesser extent--of the amphipodes rummage in their substratum and disperse a big piece of old crude oil into fine parts throughout the petri dish.

864. Renzoni, A. (1973).

INFLUENCE OF CRUDE OIL, DERIVATIVES AND DISPERSANTS ON LARVAE.

Mar. Poll. Bull., Vol. 4:9-13.

The effect of a mixture of oil and emulsifiers on marine life was investigated and toxicity levels were established. Gametes, developing eggs and larvae of oysters (Crassostrea angulata and C. gigas) and mussels (Mytilus galloprovincialis) were used in studies in which they were exposed to 3 crude oils, 3 derivatives and 1 dispersant (Corexit 8666). The various types of hydrocarbons examined showed no toxicity toward developing eggs, embryos or larvae of all 3 species of bivalves examined except at a final concentration of 1 0/00, where decreased fertilization occurs. Significant toxicity is evident in the altered fertilizing capacity of the sperm.

865. Renzoni, A. (1975).

TOXICITY OF THREE OILS TO BIVALVE GAMETES AND LARVAE.

Marine Pollution Bulletin, 6(8):126-128.

Water soluble extracts of three crude oils, Kuwait, Nigerian and Prudehoe Bay have been tested using the sperm and eggs of two marine bivalves. Fertilization is depressed and developmental abnormalities sometimes appear after exposure to these toxins. The spermatozoa, in particular, are very sensitive to the water-soluble fractions of these oils. Nigerian crude is particularly toxic.

866. Revelle, R., et. al. (1971).

OCEAN POLLUTION BY PETROLEUM HYDROCARBONS,

In: Man's Impact on Terrestrial and Oceanic Ecosystems, W.H. Matthews, F.E. Smith, and E.D. Goldberg, MIT Press, Cambridge, Massachusetts, pp 297-318.

A review of inputs, consequences and removal of oil in the marine environment.

867. Rice, S.D. (1973).

TOXICITY AND AVOIDANCE TESTS WITH PRUDHOE BAY OIL AND PINK SALMON FRY

In: Proceedings, Joint Conference on the Prevention and Control of Oil Spills. American Petroleum Institute, Washington, D.C., pp 667-670.

With the potential of oil pollution harming Alaska's marine resources, experiments were conducted at the National Marine Fisheries Service, Auke Bay Fisheries Laboratory to determine the concentrations of Prudhoe Bay crude oil that are acutely toxic to pink salmon fry in fresh water and seawater and also the concentrations of this oil that the fry would avoid. Observed 96-hr TLM values were 88 mg/liter in seawater in August. Among fry held in seawater, older fry were more susceptible to oil toxicity than younger fry and older fry were also more sensitive in their detection and avoidance of oil; older fry in seawater avoided oil concentrations as low as 1.6 mg oil/liter water. The avoidance of oil by salmon fry was quite apparent and suggests that there is potential for oil pollution to change their migration behavior.

868. Rice, S.D. and J.F. Karinen (1976).

ACUTE AND CHRONIC TOXICITY, UPTAKE, AND DEPURATION AND SUBLETHAL METABOLIC RESPONSE OF ALASKAN MARINE ORGANISMS TO PETROLEUM HYDROCARBONS.

In: Environmental Assessment of the Alaskan Continental Shelf. Principal Investigators' Reports for the Year Ending March 1976, Vol. 8. Effects of Contaminents, p. 25-47.

This study was designed to determine the acute and chronic toxicity of crude oil and its component fractions on physiological and behavioral mechanisms of selected arctic and subarctic organisms and to determine recovery rates of selected organisms in laboratory and field studies. Temperature has little effect on toxicity, so that data generated at 12 deg. C can be extrapolated to colder climates. Oil exposures stimulate metabolism in fish, rather than depress metabolism, as in crabs. (Sinha OEIS)

869. Rice, S.D., D.A. Moles and J.W. Short (1975).

THE EFFECT OF PRUDHOE BAY CRUDE OIL ON SURVIVAL AND GROWTH OF EGGS, ALEVINS, AND FRY OF PINK SALMON (ONCORHYNCHUS GORBUSCHA).

In: Conference on Prevention and Control of Oil Pollution. pp. 503-507. Amer. Petrol Inst.

Standard 96-hour bioassays with "total" oil solutions in fresh water and seawater determined differences in sensitivity of the developing life stages of pink salmon (*Oncorhynchus gorbuscha*). Eggs were the most resistant and emergent fry (yolk sac absorbed) the most sensitive to acute 4-day exposures. In fresh water, the 96-hour median tolerance limit (TL_m) of fry was 0.4 ml oil/liter mixed mechanically (12 ppm as measured in subsurface water by infrared spectrophotometry). In seawater, it was 0.04 ml oil/liter mixed mechanically (6 ppm as measured in subsurface water by infrared spectrophotometry).

Three life stages of alevins were exposed to 10-day sublethal exposures of the water-soluble fraction to determine what doses might affect growth. Growth was affected most severely in alevins exposed during later developmental stages. Decreased growth was observed in fry after 10-day exposures at the lowest dose tested - 0.075 ml oil/liter mixed by water agitation (0.73 ppm in subsurface water by infrared spectrophotometry-less than 10% of the 96-hour TL_m limit for that life stage).

In fresh water, susceptibility of early life history stages of pink salmon to oil pollution is great at the time of emergence (completion of yolk absorption). Susceptibility is even greater in seawater after fry migration.

870. Rice, S.D. and J.M. Short, (1976).

ACUTE TOXICITY OF COOK INLET CRUDE OIL AND NO. 2 FUEL OIL TO SEVERAL ALASKAN MARINE SPECIES.

In: Symposium on Sources, Effects and Sinks of Hydrocarbons in the Aquatic Environment, Aug. 9-11, 1976. Proceedings of the Symposium, American University, Washington, D.C. 9-11 August 1976.

96-hour static bioassays were performed on 27 different vertebrates and invertebrates of Alaskan Marine species using the water-soluble fraction of Cook Inlet crude oil and Number 2 fuel oil. The two different oils were about equally toxic. Fish were consistently more sensitive. Intertidal invertebrates were the most resistant. Alaskan marine species may be slightly more sensitive than similar species in other regions. However, this sensitivity may be due to the greater persistance of hydrocarbons at lower temperatures.

871. Rice, S.D., R.E. Thomas, and J.W. Short (1976).

EFFECT OF PETROLEUM HYDROCARBONS ON BREATHING AND COUGHING RATES AND HYDROCARBON UPTAKE-DEPURATION IN PINK SALMON DRY.

In: Environmental Assessment of the Alaskan Continental Shelf. Principal Investigators' Reports for the Year Ending March 1976, Vol. 8. Effects of Contaminants, pp. 88-118.

Pink salmon fry, Oncorhynchus gorbuscha, were exposed to the water-soluble fraction of Cook Inlet and Prudhoe Bay crude oils, and No. 2 fuel oil. During 22 h exposures, breathing and coughing rates initially increased as the dose increased but then decreased after several hours. Breathing and coughing rates increased significantly during exposures to oil concentrations as low as 30% of the 96 h median tolerance limit as determined by ultraviolet spectroscopy. It is speculated that the increased respiration rate reflects an increased energy demand for enzyme synthesis. Chronic exposure requiring elevated energy demands may be detrimental to the survival of a population.

872. Richards, A.G. (1941).

DIFFERENTIATION BETWEEN TOXIC AND SUFFOCATING EFFECTS OF PETROLEUM OILS ON LARVAE OF THE HOUSE MOSQUITO. (Culex pipiens).

Trans. Amer. Entomol. Soc. 67 161-196.

873. Richardson, F. (1956).

SEABIRDS AFFECTED BY THE FREIGHTER 'SEAGATE'.

Murrelet, 37, 20-22.

874. Robertson, B., et. al. (1973).

HYDROCARBON BIODEGRADATION IN ALASKAN WATERS

In: The Microbial Degradation of Oil Pollutants. Ahearn and Meyers, (eds.) Center for Wetland Resources, Baton Rouge, La., Publ. No. LSU-SG-73-01. pp 171-184.

Populations of hydrocarbon-oxidizing organisms were of the order of 1/cc in Alaska's Cook Inlet and Port Valdez, less in the Arctic Ocean. Distribution decreased with salinity in Cook Inlet and with depth in Port Valdez. In situ oxidation of ^{14}C-dodecane (91 ug/liter) started within hours and proceeded at a rate of 1 ug/liter-day. Storage of Cook Inlet crude oil for four years in sea water at $10^{o}C$ effected removal of most visible components. Mixing had a major effect on oil slick stability. The solubilization process was little affected by added silt, a major component of many Alaskan estuaries. Isolated organisms had unique preferences for various components of kerosene and emulsified crude oil, and responded in a normal way to incubation temperature, E_a 14.5 to 16 kcal/mole. Some effects of crude oil inhibition are discussed. Calculations show that motility, particularly in combination with chemotaxis, is necessary for rapid slick inoculations.

875. Robichaux, T.J. and H.N. Myrick. (1972).

CHEMICAL ENHANCEMENT OF THE BIODEGRADATION OF CRUDE OIL POLLUTANTS.

J. Petrol. Technol. Vol. 24:16-20.

Biodegredation of oil can be enhanced by emulsifying the oil and seeding it with hydrocarbon-degrading microorganisms.

876. Roger, E. (1965).

CONTRIBUTION TO THE STUDY OF THE POLLUTION OF MUSSELS BY PETROLEUM PRODUCTS.

In: Commission Internationale pour l'Exploration Scientific de la Mer Mediterranee, Monaco, April 1964. p. 367-369.

After enumerating the sources, types and polluting characteristics of various petroleum products discharged into sea water and rivers, the author discusses the conditions under which these products cause pollution of mussels, the nature of the damage caused, the removal of petroleum products by self-purification and methods for preventing this type of pollution.

877. Roland, J.V., G.E. Moore and M.A. Bellanco (1977).

THE CHESAPEAKE BAY OIL SPILL - FEBRUARY 2, 1976: A CASE HISTORY.

In: Proceedings 1977 Oil Spill Conference. p. 523-527. Amer. Petrol. Inst., Wash. D.C.

On February 2, 1976, one of the worst oil spills in recent history occurred in the lower Chesapeake Bay. Approximately 250,000 gallons of No. 6 oil were discharged into the bay after a barge, the STC-101 sank in a storm near the mouth of the Potomac River. The oil contaminated extensive beach and marsh areas on both sides of the bay. Cleanup operations lasted almost a month and the cost approached $400,000. The U.S. Coast Guard estimated that 167,000 gallons of oil were recovered by cleanup crews. The remaining oil is believed to be widely dispersed over large areas of the bay-possibly tied up in fringe marsh grass, buried under sand on the beaches or carried out into the Atlantic Ocean. The heavily-contaminated fringe marsh grasses were cut, leaving the root systems intact, in order to protect the fragile marsh areas. An overall assessment of the environmental damages caused by the spill is almost complete. Estimates of the number of waterfowl killed range from 20,000 to 50,000 birds. Damage to shellfish and other aquatic resources is still under study. Preliminary reports indicate that damages to the environment may not be as severe as initially expected.

878. Rosenberg, D.M. and A.P. Wiens. (1976).

COMMUNITY AND SPECIES RESPONSES OF CHIRONOMIDAE (DIPTERA) TO CONTAMINATION OF FRESHWATERS BY CRUDE OIL AND PETROLEUM PRODUCTS WITH SPECIAL REFERENCE TO THE TRAIL RIVER, NORTHWEST TERRITORIES.

J. Fish. Research Bd. Can. 33 1955-1963.

On oiled and unoiled artificial substrates in the Trail River, Northwest Territories, communities of chironomidae were different during open-water periods but were similar over winter. Ten species of Chironomidae showed a positive response to the presence of oil, 9 species showed a negative response and 10 species were apparently unaffected. 11 species of Chironomidae showing either positive or negative responses to contamination by oil or petroleum products were evaluated for their potential to indicate oil contamination of freshwater ecosystem. Three criteria were used: taxonomic soundness, wide distribution and numbers in the community. Cricotopus bicinctus and C. veripes would fulfill this role.

879. Rosenberg, D.M., A.P. Wiens, and O.A. Swether (1977)

RESPONSES TO CRUDE OIL CONTAMINATION BY CRICOTOPUS BICINCTUS AND C. MACKENZIENSIS (DIPTERA:CHIRONOMIDAE) IN THE FORT SIMPSON AREA, NORTHWEST TERRITORIES.

J. Fish. Res. Bd. Can. 34 254-261.

C. bicinctus and C. mackenziensis, two common midges in the Fort Simpson area, NWT were examined for changes resulting from experimental field exposure to Norman Wells crude oil. Larvae of both species were always present in higher numbers on oiled than unoiled artificial substrates but numbers of C. bicinctus increased more quickly than C. mackenziensis in response to the oil.

880. Rosenthal, H. and W. Gunkel (1967).

EFFECT OF CRUDE OIL-EMULSIFIER MIXTURES ON MARINE FISH FRY AND THEIR FOOD ANIMALS.

Helgolander Wissenschaftliche Meersuntersuchungen, 16(4), 315-320.

Reports tests of the effects of crude oil-emulsifier mixtures on the larvae of Clupea harengus and Agonus cataphractus L. Lethal concentrations were determined. Crude oil along did not cause damage to herring larvae during the four day observation period.

881. Rossi, S.S. (1977).

BIOAVAILABILITY OF PETROLEUM HYDROCARBONS FROM WATER, SEDIMENTS AND DETRITUS TO THE MARINE ANNELID NEANTHES ARENACEODENTATA.

In: Proceedings 1977 Oil Spill Conference. p. 621-625. Amer. Petrol. Inst., Wash. D.C.

Uptake, retention, metabolism and depuration of diaromatic hydrocarbons by the polychaete. Neanthes arenaceodentata, were examined in experiments utilizing seawater solutions and sediments contaminated with either No. 2 fuel oil water-soluble fractions or radiolabelled naphthalenes. Polychaetes rapidly accumulate ^{14}C-naphthalene (magnification factor =40X) from solution during short-term exposure (24 hr). Worms slowly released hydrocarbons accumulated during acute exposure down to undetectable levels (<0.05 ppm) within 300 hours after return to clean seawater. ^{14}C-naphthalene accumulated from solution was metabolized by polychaetes and associated microflora apparently play no role in uptake, release or metabolism. Analyses of worms held for 28 days in clay-silt sediments artifically contaminated with No. 2 fuel oil (9μg total naphthalenes/g wet sediment) indicate that naphthalenes were not accumulated by worms at tissue concentrations above 0.1 ppm. Polychaetes likewise failed to accumulate ^{14}C-methylnaphthalene/g dry detritus) for 16 consecutive days. These data suggest that petroleum hydrocarbons bound to sediment particles or particulate organic matter are less available to marine worms than those in solution.

882. Rossi, S.S., et al. (1976).

TOXICITY OF WATER-SOLUBLE FRACTIONS OF FOUR TEST OILS FOR THE POLYCHAETOUS ANNELIDS, NEANTHES ARENACEODENTATA AND CAPITELLA CAPITATA.

Environ. Poll., 10:9-17.

The toxicity of water-soluble fractions of two refined and two crude oils to two species of laboratory-reared polychaetes was determined. The two refined oils (No. 2 fuel oil and bunker "C" residual oil) proved most toxic to both species. South Louisiana crude oil was less toxic than either of the refined oils, yet more toxic than Kuwait crude oil.

The higher concentrations of toxic diaromatic compounds (naphthalenes) found in refined oils probably accounted for major differences between the toxicity of refined versus crude oils. Capitella capitata was slightly more sensitive to three of the four oils than was Neanthes arenaceodentata. Both species appear to be quite similar to fish and crustaceans in their sensitivity to these four oils.

883. Rossi, S.S. and J.W. Anderson (1976).

TOXICITY OF WATER-SOLUBLE FRACTIONS OF NO. 2 FUEL OIL AND SOUTH LOUISIANA CRUDE OIL TO SELECTED STAGES IN THE LIFE HISTORY OF THE POLYCHACTE, NEANTHES ARENACEODENTATA.

Bull. of Environ. Contamin. and Toxicol., 16(1). pp. 18-24.

The results of bioassays concerning the toxicity of petroleum hydrocarbons (PHC's) on 4 juvenile and 2 adult stages of Neanthes arenaceodentata indicated that significant differences in sensitivity exist among life stages. Young stages of N. arenaceodentata exhibited a high tolerance of PHC's. 20 ref.

884. Rossi, S.S. and J.W. Anderson (1977).

ACCUMULATION AND RELEASE OF FUEL-OIL DERIVED DIAROMATIC HYDROCARBONS BY THE POLYCHEATE NEANTHES ARENACHEODENTATA.

Marine Biology 39 51-55.

Male and gravid female Neanthes were experimentally exposed to a sublethal concentration of #2 fuel oil seawater extract for 24 hours. Within 1 hour both sexes had incorporated in equal portions most of the diaromatic hydrocarbons eventually accumulated. When returned to hydrocarbon-free seawater, male worms slowly released naphthalenes down to undetectable level. Gravid females retained essentially all of the accumulated naphthalenes until egg release, with subsequent dramatic decrease. Zygote and trochophore larvae contained 18 ppm naphthalene. As trochophore larvae developed into 18-segment juveniles, naphthalene concentration dropped to near undetectable levels. The 32 segment worms were free of naphthalenes.

885. Rossi, S.S. and J.W. Anderson (1977).

EFFECT OF NO. 2 FUEL OIL AND SOUTH LOUISIANA CRUDE OIL WATER-SOLUBLE FRACTIONS ON HEMOGLOBIN COMPENSATION AND HYPOXIA TOLERANCE IN THE POLYCHAETOUS ANNELID, NEANTHES ARENACEODENTATA (MOORE).

Marine Science Communications, 13 117-131.

Exposure to sublethal concentrations of No. 2 fuel oil water-soluble fractions (WSFs) did not affect the ability of Neanthes arenaceodentata to increase its body hemoglobin content in response to hypoxia. Similar treatment using water-soluble fractions of South Louisiana crude oil likewise indicated little disruption of compensatory ability. Reduced dissolved oxygen (DO) concentrations did not significantly alter the toxicity of No. 2 Fuel Oil WSFs to

N. arenaceodentata. Low D. O concentrations markedly increased the toxicity of So. La. crude oil WSFs, producing a synergistic effect. Results were defined relative to the concentration of naphthalenes and total dissolved hydrocarbons in experimental media. Possible effects of petroleum hydrocarbons on the respiratory physiology of marine infauna were briefly considered.

886. Rossi, S.S., J.W. Anderson and G.S. Ward (1976).

TOXICITY OF WATER-SOLUBLE FRACTIONS OF FOUR TEST OILS FOR THE POLYCHEATONS ANNELIDS, NEANTHES ARENACEODENTATA AND CAPITELLA CAPITATA.

Environmental Pollution, 10:9-17.

The toxicity of water-soluble fractions of two refined and two crude oils to two species of laboratory-reared polychaetes was determined. The two refined oils (No. 2 fuel oil and bunker "C" residual oil) proved most toxic to both species. South Louisiana crude oil was less toxic than either of the refined oils, yet more toxic than Kuwait crude oil. The higher concentrations of toxic diaromatic compounds (naphthalenes) found in refined oils probably accounted for major differences between the toxicity of refined versus crude oils. *Capitella capitata* was slightly more sensitive to three or the four oils than was *Neanthes arenaceodentata*. Both species appear to be similar to fish and crustaceans in their sensitivity to these four oils.

887. Roubal, W.T. and T.K. Collier. (1975).

SPIN-LABELING TECHNIQUE FOR STUDYING MODE OF ACTION OF PETROLEUM HYDROCARBONS ON MARINE ORGANISMS.

U.S. Natl. Mar. Fish Serv. Fish. Bull., 73:299-305.

Spin-labeling studies of membrane-contaminant interaction are being conducted by biochemists at the Northwest Fisheries Center in Seattle, Washington. The aim of these studies is to gain a better understanding of the mode of action of hydrocarbon contaminants at the molecular level. Basic spin-labeling theory together with experimental results are presented and discussed. Spin-labeling holds great promise not only for environmental studies but also for drug research, toxicology and pharmacology as well.

888. Roubal, W.T., D.H. Boree, T.K. Collier, S.I. Stranahan. (1977).

FLOW-THROUGH SYSTEM FOR CHRONIC EXPOSURE OF AQUATIC ORGANISMS TO SEAWATER-SOLUBLE HYDROCARBONS FROM CRUDE OIL: CONSTRUCTION AND APPLICATIONS.

In: Proceedings 1977 Oil Spill Conference. p. 551-555. Amer. Petrol. Inst., Wash., D.C.

Flow-through systems circumvent problems associated with static systems for exposing aquatic organisms to water-soluble hydrocarbons by providing an uninterrupted supply of water-soluble fraction with minimal compositional variations. Moreover, there is little accumulation of deleterious excretory products. Yet the design of a flow-through system for crude petroleum poses practical problems. All exposed surfaces of equipment become coated with thick oily residues, which, if ignored, result in changes in water flow rates and in levels of soluble hydrocarbons.

To circumvent such problems, a modular system was built which can be adjusted to compensate for oil accumulation. Analysis of the water-soluble fraction prepared from Prudhoe Bay crude oil showed it to contain primarily low molecular weight aromatic compounds as follows (average concentration, ppm): benzene, 0.26 toluene, 2.45; total xylenes, 1.73; C3- and C4-substituted benzenes, 0.26; naphthalene, 0.01, 1-methyl naphthalene, 0.02; 2-methyl naphthalene, 0.02; C2-substituted naphthalenes, 0.05; and C3-substituted naphthalenes, 0.03. Hydrocarbon analysis of muscle tissue from coho salmon exposed to a water-soluble fraction for 5 weeks is presented.

888-A. Royal Society of London (1972).

A DISCUSSION ON FRESHWATER AND ESTUARINE STUDIES OF THE EFFECTS OF INDUSTRY.

Series B, 180(1061):363-536. Royal Society of London Proceedings, Series B.

The effects of the changes in the character of inland and estuarine waters brought about by industrial activity are considered. Among the topics discussed are artificial radioactivity in estuarine systems, pollution in Southampton Water, effects of paper mill wastes on the marine benthic environment, effects of the oil industry on shore life in estuaries, effects of warm water discharges on marine life, and mathematical models for water quality estuaries.

889. Ruel, M., S.L. Ross, E. Nagy, J.B. Sprague (1973).

GUIDELINES ON THE USE AND ACCEPTABILITY OF OIL SPILL DISPERSANTS.

Environmental Protection Service Report Series EPS 1-EE-72-1. Environmental Emergency Branch, Canada. 60 pp.

The foundation of Environment Canada Guidelines on the Use and Acceptability of Oil Spill Dispersants is presented. A standard list of dispersants will be prepared on the basis of these guidelines. Only dispersants satisfying the acceptability criteria shall be allowed for use and, except in the case of extreme emergency, only with the express permission of Environment Canada or delegated provincial authorities. The use of dispersants is also subject to the requirements of the provinces concerned. Uses are limited to well specified spill situations and a detailed report on each use is required. Dispersants must contain no highly toxic compounds, must satisfy toxicity and biodegradability specifications, must be reasonably effective under conditions of use, and must be applied in a recommended manner. Procedures for having a dispersant placed on the standard list are presented along with labeling requirements and recommended methods for determining toxicity, biodegradability and effectiveness.

890. Ruivo, Mario (ed.) (1972).

MARINE POLLUTION AND SEA LIFE.

F.A.O. Fishing News (Books) LTD 624 p.

This volume contains edited contributions and summaries of discussions at the FAO Technical Conference on Living Resources and Fishing, organized by the Department of Fisheries, Fishery Resources Division, of FAO and held at FAO Headquarters in Rome from 9 to 18 December 1970. Individual articles on biological effects of oil pollution are entered separately in this bibliography.

891. Rushton, W. and E. Jee. (1928).

FUEL OIL AND AQUATIC LIFE.

Salmon and Trout Magazine. 31:89-94.

The gill fibers and mouths of yearling trout were painted with fuel oil without causing apparent damage to the fish. Oysters exposed to the removal of one valve were thickly smeared with fuel oil, but on immersion, in water, for a few seconds, the whole coating was found to leave the surface of the animal and rise to the top of the water. A caddis fly larva succumbed within 3 days. Freshwater snails, however, survived for four days and seemed unharmed.

892. Rutzler, K. and W. Sterrer. (1970).

OIL POLLUTION: DAMAGE OBSERVED IN TROPICAL COMMUNITIES ALONG THE ATLANTIC SEABORD OF PANAMA.

Bioscience, 20:222-224.

On 13 December 1968, the 3400-ton tanker S.S. Witwater ruptured on its way to the Atlantic entrance of the Panama Canal. Nearly 20 thousand barrels of diesel oil and Bunker C were released and driven by strong offshore winds toward the Galeta Island coastline. Use of detergents was avoided, and the Smithsonian Tropical Research Institute Staff reduced the threat to marine life by burning and pumping off the oil.

A spray of mixed seawater and oil covered trees and shrubs in the supralittoral zone to a height of 2 meters, killing many of them. Supralittoral spray pools and upper mesolittoral tide pools were covered by a layer of oil up to 2 cm thick, and were found to be devoid of life. The lower mesolittoral and infralittoral zones were only temporarily affected; the waves began to erode the oil as soon as they had discharged it. The reefs seemed to be the least affected communities of all. The sandy beaches looked clean at first glance, but were completely permeated with oil beneath a newly deposited clean upper layer. The meiofauna population of this ecosystem was dramatically reduced. The mangroves suffered the most, their roots being coated with oil. The fiddler crab population (*Uca* sp.) of the mangrove area was greatly reduced. The intertidal algal community on the stilt roots and its inhabitating microfauna were nearly eliminated in all exposed areas as were the sedentary animals of this zone. Young sea turtles (*Caretta* sp.) were observed dead and dying. A number of oil-smeared herons and one dying cormorant were observed.

893. Sabo, D.J., *et al*. (1975).

PETROLEUM HYDROCARBON POLLUTION AND HEPATIC LIPOGENESIS IN THE MARINE FISH *FUNDULUS HETEROCLITUS*.

Fed. Proc. 34:810.

Hepatic lipogenesis from glucose-1-C_{14}, glucose-6-D_{14} and acetate-1 -C_{14} in liver slices obtained from field populations of *Fundulus* living in oil contaminated waters was compared to those taken from an uncontaminated control area. Livers from contaminated fish synthesized approximately six times more lipid from glucose-1-C_{14} when compared to control animals. The reverse was observed when glucose-6-C_{14} was the substrate. Acetate-1-C_{14} was metabolized equally in both groups. Liver glucose-6-phosphate dehydrogenase activity was elevated in homogenates from contaminated fish. Electron microscopis examination of livers from contaminated fish demonstrated proliferation of the rough endoplasmic reticulum, decreased glycogen and lipid stores, and an increase in free ribosomes. The results suggest that in *Fundulus* environmental petroleum hydrocarbons stimulate lipolysis through aerobic glycoysis, depress anaerobic glycolysis and increase utilization of energy stores.

894. Sackett, W.M. and J.M. Brooks (1974).

USE OF LOW-MOLECULAR-WEIGHT HYDROCARBON CONCENTRATIONS AS INDICATORS OF MARINE POLLUTION.

In: *NBS Special Publication 409, Marine Pollution Monitoring (Petroleum), Proceedings of a Symposium and Workshop Held at NBS, Gaithersburg, Maryland, May 13-17, 1974*.
National Bureau of Standards.

Dissolved low-molecular-weight hydrocarbon concentrations in surface water have been determined for several throusand miles of cruise tracks in the Gulf of Mexico for the period 1971-1974. Large areas of coastal water offshore Texas and Louisiana have up to six orders of magnitude higher concentrations of low-molecular-weight hydrocarbons than open ocean surface water. These high levels are probably petroleum-derived and due to offshore petroleum production operations. The observed high levels of C_1 to C_3 hydrocarbons do not seem to be detrimental to marine life but may be indicators of more toxic petroleum components.

895. Sage, B.L. (1968).

POLLUTION - COST TO WILDLIFE.

Petroleum Review, April, 1968: 123-124.

This article describes some of the findings reported at a symposium on marine oil pollution. Experiments are briefly described of the effects of oils and emulsifiers on amoeba. Insoluble substances had little effect. More volatile fractions caused insensitivity to external stimuli followed by a dramatic change in the appearance of the cell. Recovery cannot take place when high concentrations are involved. Anionic emulsifiers caused bursting and removal of the cell membrane. Cationic types act in lower concentrations and "fix" the membrane and then the whole cell. Non-ionic emulsifiers act similarly but at higher concentrations.

Some studies on microbiol. degredation of crude oil are also described. It is concluded that microbial degredation of oil at sea depends on temperature, pressure, and oxygenation; first degraded are the aliphatic, olefinic, and naphthenic compounds. Little is known on the degradation of heterocyclic compounds.

896. St. Amant, L.S. (1970).

BIOLOGICAL EFFECTS OF PETROLEUM EXPLORATION AND PRODUCTION IN COASTAL LOUISIANA.

In: Santa Barbara Oil Symposium, Santa Barbara, December 16-18, 1970. Holmes, R.W. and F.A. DeWatt, (eds.). University of California.

897. St. Amant, L.S. (1973).

SOME CONSIDERATIONS OF THE CHRONIC EFFECTS OF PETROLEUM IN THE MARINE ENVIRONMENT.

In: Inputs, Fates and Effects of Petroleum in the Marine Environment. Background Information for the Workshop, Ocean Affairs Board, NSF, Airlie, Va 21-25 May 1973.

This paper reviews the effects of chronic pollution, particularly with regard to the oil production along the Louisiana coast. It is concluded that marine ecosystems are quite resilient since the high rate of chronic pollution along the coast is accompanied by high production of marine life. The most critical studies on the effects of this pollution would have to address themselves to the generative capacity and energy flow of the system rather than temporary mortalities. These studies have not yet been done.

898. Sanders, H.L., Grassle, J.F. And Hampson. G.R. (1972).

THE WEST FALMONTH OIL SPILL. I. BIOLOGY.

Tech. Rept. WHOI -72-20, April 1972. Woods Hole, MA: Woods Hole Oceanogr. Inst.

The continuing biological effects of the West Falmonth Oil Spill are documented from the inception of the study in Sept 1969 to Nov. 1971.

899. Sanders, H. (1973).

SOME BIOLOGICAL EFFECTS RELATED TO THE WEST FALMOUTH OIL SPILL.

In: Inputs, Fates, and Effects of Petroleum in the Aquatic Environment. Background Information for the Workshop. Ocean Affairs Board, NSF. Airlie, Va. 21-25 May 1973.

Benthic sampling stations were established after the Number 2 fuel oil spill at West Fulmonth. The samples were examined for species composition and oil concentration. The author concludes that the species and density patterns for the polycheates, gastropods, bivalves and ampeliscid amphipods follow transposal and spatial stress gradients induced in the concentration and relative degredation of the #2 fuel oil spilled. Superimposed on these gradients are perturbations initiated by aperiodic infusions of less degraded fuel oil at different stations in the sampling area and a breeding season for much of the benthos that is primarily restricted to the summer months.

900. Sanders, M.K. (1970).

ANOTHER OIL SPILL AT SANTA BARBARA.

Mar. Poll. Bull., 1(2):18-19.

An increase in the steady leakage of ten barrels per day around Union Oil Company's Platform A in the Santa Barbara Channel was noted by platform workers on Sunday, 14 December 1969. By Tuesday a slick of brown crude oil covered an area of 5 by 10 miles. The Union Oil Company ascertained that the oil was coming from a split in the pipeline which transports the oil from the platform to the shore. None of the automatic safety devices worked, so the leak was halted manually, and the pipeline repaired by Sunday 21, December. In the meantime, some 1000 barrels of oil had escaped into the sea. Dispersants were used to break up the slick. Environmental damage, as usual, was heaviest to birds.

901. Sawyer, T.K. (1978).

MICROSCOPIC OBSERVATIONS ON VERTEBRATES AND INVERTEBRATES COLLECTED NEAR THE ARGO MERCHANT OIL SPILL.

In: In the Wake of the Argo Merchant. Proceedings of a Conference and Workshop Held at the University of Rhode Island, January 11-13, 1978. Center for Ocean Management Studies, University of Rhode Island, Kingston, Rhode Island.

Biota collected at the *Argo Merchant* spill site were preserved at sea and sent to the NMFS Laboratory, Oxford, Md for histological examination. Specific lesions caused by spilled oil were not apparent in any of the animals examined. Some *Ammodytes* larvae had ocular lesions, malformations or lack of pigmentation of the eye. Several winter flounder and alewives had edematous gills and deteched epithelium. The olfactory epithelium of several yellowtail flounder appeared to be hyperplastic. Mollusks showed us microscopically reservable effects of the oil spill. Hermit crabs had an abundance of large granulocytic hemocytes, but the normal state is not known. The hermit crabs also had large, sessile, ciliated protozoans on the external surfaces of antennae, which may indicate the absence of oil.

902. Scarratt, D.J. and V. Zitko. (1972).

BUNKER C OIL IN SEDIMENTS AND BENTHIC ANIMALS FROM SHALLOW DEPTHS IN CHEDABUCTO BAY, NOVA SCOTIA.

J. Fish Res. Board Can., 29:1347-1350.

Soft sediments showed considerable fluctuations in Bunker C oil content but little evidence of diminution of Bunker C concentration in the 26 months following the wreck of the tanker *Arrow*. Coarse sediment samples and most benthic species showed maximum oil concentrations about 1 year after the wreck and some reduction since then. Herbivorous or browsing species had higher oil content than carnivorous or omnivorous species. There is evidence from fluorescence emission spectra that some carnivorous or omnivorous species are able to assimilate and partly metabolize Bunker C oil, but no evidence that Bunker C or its fluorescent derivatives and fractions were being concentrated in higher parts of the food chain.

903. Scheier, A. and D. Gominger (1976).

A PRELIMINARY STUDY OF THE TOXIC EFFECTS OF IRRADIATED VS. NON-IRRADIATED WATER-SOLUBLE FRACTIONS OF NO. 2 FUEL OIL.

Bull. of Environ. Contamin. and Toxicology. 16(5), p. 595-603.

The toxic effects of the water soluble fraction of No. 2 fuel oil on a number of test organisms was presented. Exposure to ultra violet light was found to increase toxicity of the pollutant. The test species investigated were the grass shrimp, sheephead minnow, mummichog, channel catfish and the bluegill sunfish.

8 ref.

904. Schenk, J.E. (1975).

EFFECTS OF OUTBOARD MARINE ENGINE EXHAUST ON THE AQUATIC ENVIRONMENT.

Progress in Water Technology, 7(5458), p 675-676.

With respect to the pollutional effect of outboard engines no acute effect on biological communities was observed. Species abundance, richness and population similarity of phytoplankton populations in both the leaded and non-leaded fuel test lakes were not affected. Analysis of zooplankton and periphyton data showed no effects due to 2-cycle outboard motor emmission. No marked changes in fish behavior or populations were observed. With leaded fuel increased lead levels in the water column and sediment were indicated in addition to increased hydrocarbon levels. 17 ref.

905. Schramm, W. (1972).

INVESTIGATIONS ON THE INFLUENCE OF OIL POLLUTION ON MARINE ALGAE. I. THE EFFECT OF CRUDE OIL FILMS ON THE CO_2 AND GAS EXCHANGE OUTSIDE THE WATER.

Mar. Biol. (Berl.), 14:189-198 (in German)

CO_2 uptake was measured in marine algae coated with various thicknesses of various types of crude oil. CO_2 uptake was found to be depressed to varying degrees in emersed plants. Exposed plants were able to photosynthesize longer than controls. The author concludes that there are two effects which probably interfere with gas exchange: (1) lowering of diffusion rates by the oil film and (2) total effects of crude oil components.

906. Schultz, D. and L.B. Tebo, Jr. (1975).

BOONE CREEK OIL SPILL.

In: Conference on Prevention and Control of Oil Pollution. pp. 583-588. Amer. Petrol. Inst., Wash. D.C.

During the months of March through September 1972, a biological survey was conducted on the effects of a 7,000-gallon diesel fuel spill into Boone Creek, a small stream near Salem, South Carolina. Boone Creek empties into Lake Keowee, an impoundment on the Keowee River.

Macroinvertebrate organisms, periphyton and fish were collected, preserved, identified and enumerated. Sediment samples were taken for hydrocarbon analysis.

Oil was observed in the creek during the entire six-month study period.

Locations downstream from the oil spill generally contained reduced numbers and types of organisms.

An estimated 90% of the fish community was killed during the initial oil spill.

Periphyton growth, dominated by diatoms, increased at locations downstream from the oil spill during May and June.

Analysis of substrate sediment samples revealed hydrocarbons still present in Boone Creek and Lake Keowee 13 months after the spill occurred.

907. Schwartz, J.R. *et al*. (1975).

DEEP-SEA BACTERIA GROWTH AND UTILIZATION OF HYDROCARBONS AT AMBIENT AND *IN SITU* TEMPERATURE AND PRESSURE.

Can. J. Microbiol. 21:682-687.

A mixed culture of bacteria was obtained from the sediment-water interface of a core sample taken off the coast of Florida at a depth of 4940m. The mixed culture was found capable of utilizing n-hexadecane as a sole carbon source for growth at the *in situ* temperature ($4^{\circ}C$) and pressure (500 atm). The rate of utilization under deep-ocean conditions was found to be much slower than the rate observed at ambient pressure (1 atm) and low temperature ($4^{\circ}C$).

908. Seadock, Incorporated (1974).

ENVIRONMENTAL REPORT.

Seadock, Inc. 2 Volumes.

This volume describes a proposed deepwater port installation and assesses its probable impact on the Texas offshore environment.

909. Seki, H. (1973).

SILICA GEL MEDIUM FOR ENUMERATION OF PETROLEUMLYTIC MICROORGANISMS IN THE MARINE ENVIRONMENT.

Appl. Micro. 26:318-320.

A silica gel medium was developed for the enumeration of petroleumlytic microorganisms in the marine environment. The medium was satisfactorily used for the investigation of the vertical distribution of bacteria in seawater from the surface to 1,000 m depth of western north Pacific central water as well as the neritic region of Japan.

910. Seki, H. (1976).

METHOD FOR ESTIMATING THE DECOMPOSITION OF HEXADECANE IN THE MARINE ENVIRONMENT.

Applied and Environmental Microbiology, 31(3):439-441.

Water samples from Tokyo Bay were collected during July and Aug. 1974. Following addition of 0.5μ Ci of $1\text{-}^{14}C$ hexadecane, a 20-ml portion of each sample was incubated in the dark at 25°C-30°C. The quantity of hexadecane oxidized by microorganisms was estimated by quantitating radioactive carbon dioxide ($^{14}CO_2$) trapped in ethanolamine following acidification. Subsamples of each surface sample were incubated in test tubes of various diameters to examine the effect of the surface area of the hexadecane film and its proximity to the microorganisms on the rate of hexadecane decomposition. Within several minutes of initial incubation, $^{14}CO_2$ was liberated in appreciable amounts, and the rate of oxidation was linear in 15 hr for every sample. Surface area of the incubation vessel significantly affected hexadecane oxidation. The rate of hexadecane decomposition was 0.1-1.3ug/h/l of seawater at the surface layer in the polluted gyre of the inner part of the bay. A similar horizontal distribution pattern was found for the density of hexadecane-decomposing bacteria.

911. Sharp, J.M. and J.W. Tyson (1975).

THE OFFSHORE ECOLOGY INVESTIGATION.

In: Offshore Technology Conference: Seventh Annual: Proceedings: Vol. III. pp. 499-504. Houston, Tx.

Biological, chemical and physical experiments were conducted by the OEI to assess the environmental-ecological impact of petroleum drilling and production off the Louisiana coast. Eight synoptic field sampling and data collecting exercises were completed in Timbalier Bay, Louisiana and offshore to a 100-ft depth. Comparisons are made between the shallow water bay system and the adjoining nearshore shelf region and platform locations experiencing prolonged intensive production and nearby and distant control locations experiencing no drilling or production. Seventy-nine percent of the investigations demonstrated no harmful or beneficial impact; 21% required further interpretation but did not exhibit harmful impact. Beach-dwelling animals apparently have not been harmed by drilling and production activities and commercial fish catches experienced an increase in total harvest. No harmful impact on the environment from production or drilling has been demonstrated.

912. Shaw, D.G., A.J. Paul, L.M. Cheek, and H.M. Feder (1976).

MACOMA BALTICA: AN INDICATOR OF OIL POLLUTION.

Marine Pollution Bulletin 7(2):29-31.

In an experiment designed to simulate stranding of an oil slick on a mudflat, a significant increase in mortality of this species was found to accompany increasing concentration of petroleum in sediment and increasing duration of exposure.

913. Shaw, D.G., A.J. Paul and E.R. Smith (1977).

RESPONSES OF THE CLAM MACOMA BALTHICA TO PRUDHOE BAY CRUDE OIL.

In: 1977 Oil Spill Conference Proceedings p. 493-494. Amer. Petrol. Inst., Wash., D.C.

The responses of the bivalve mollusk *Macoma balthica* to crude oil have been studied under laboratory conditions designed to simulate the stranding of oil on intertidal sediments in which this animal resides. The relationship of dry tissue weight to shell length, an indirect indicator of general health and fitness, was not significantly altered by exposure to oil at a level which did result in significant mortalities. This suggests that death is caused by a metabolically specific mode of poisoning rather than by a general weakening of the animal. In a second experiment, animals were subjected to two temporarily separated oiling events. Neither in mortalities nor in gas chromatographic analysis of tissues for hydrocarbons were cumulative effects observed. It was also found that a previously-reported tendency of *M. balthica* to burrow to the sediment surface in the presence of oil increases with decreasing depth of available sediment. We suggest that this behavior may be used as a convenient indicator of oil pollution.

914. Shelford, V.E. (1917).

AN EXPERIMENTAL STUDY OF THE EFFECTS OF GAS WASTE UPON FISHES, WITH SPECIAL REFERENCE TO STREAM POLLUTION.

Bull. Ill. State Lab. Nat. Hist. 11:381-412.

Illuminating gas, gas liquor, and thirty-one out of thirty-four representatives of the chief groups of compounds found in gas and gas-liquor are very toxic to fishes. From one to fifteen hundred parts per million are fatal to an orange spotted sunfish in one hour.

As a rule the smaller fishes are more readily affected than the larger, down to the smallest fry studied; the minimum amount of the various substances required to kill fishes must be established by using the most sensitive stages which are probably the smallest fry.

Fishes usually react positively to the compounds and mixtures studied; i.e. enter the polluted water from the pure water readily and turn back into the polluted water when pure water is encountered. The danger to fishes is increased greatly thereby. Fishes often develop a "preference" for the polluted water after a number of trials of both kinds.

On account of the extreme toxicity of gases such as CO and ethylene, and of benzene and other volatile matter, water which has been in contact with gases should not be introduced into streams.

Various types of manufacturing and by-product recovering plants, while they remove different substances do not leave a harmless residue; on account of the fact that the very toxic substances such as carbon monoxide, benzene and naphthalene differ widely in their properties, residues from all such plants will be almost certain to be toxic.

The results thus far obtained may throw some light on the poisonous effect of the various compounds from the pharmaceutical standpoint, and may be of assistance in the matter of standardization of drugs with fishes.

915. Shelton, R.G.J. (1969).

DISPERSANT TOXICITY TEST PROCEDURES.

In: Proc. Joint Conference on the Prevention and Control of Oil Spills. (API/EPA/USCG), pp. 187-191. Amer. Petrol. Inst. Wash., D.C.

The toxicity of chemicals used to disperse oil is considered on the basis of British experience and in relation to effects on fisheries and marine life. It is concluded that although toxic dispersants may be of value in treating oil at sea, they should not be used in large quantities in shallow coastal water, over shellfish beds or fish nursery grounds, or in estuaries. When oil comes ashore the problem should be reduced by mechanical means and chemical methods used only on high-amenity beaches.

Toxicity-testing procedures for dispersants have so far been based upon the determination of LC_{50} values in static-water aerated tanks at $15^{o}C$ over a 48-hour period, but a continuous-flow apparatus is being devised. Test animals regularly used are *Pandalus montagui*, *Crangon crangon*, *Carcinus maenas* and *Cardium edule*, but the fish *Solea solea* and *Limanda limanda* and the lobster *Homarus gammarus* are now being included.

A large number of commercially available dispersants have been tested and also some experimental formulations. Some recently-developed materials for use at sea have low toxicities but are of little value for treating oil which has come ashore. Tainting by oil and dispersants may affect fisheries by adding unwanted flavours to fish and shellfish and so affecting marketability over several weeks.

In this paper the investigation of the toxicity of chemicals used to disperse oil at sea and on the shore is discussed in relation to the general problem of the effects on fisheries and marine life of oil and the methods used to deal with oil spills.

916. Shelton, R.G.J. (1971).

EFFECTS OF OIL AND OIL DISPERSANTS ON THE MARINE ENVIRONMENT.

Proc. Royal Soc., Ser. B., 177(1048):411-422.

The main types of oil which pollute the sea are described and the effects of weathering on the physical properties and toxicity of spilt oil are considered. The biological consequences of oil pollution are discussed and particular consideration is given to the effects on the marine environment and on commercial fisheries of the various methods which have been used in the treatment of oil spills. Current research on oil pollution topics is briefly reviewed and a number of unresolved problems are examined with suggestions for possible future research.

917. Shelton, T.B. and J.V. Hunter. (1975).

ANAEROBIC DECOMPOSITION OF OIL IN BOTTOM SEDIMENTS.

Water Pollution Control Federation. Journal 47(9):2256-2270.

A significant portion of oil pollutants discharged into receiving waters is incorporated into bottom sediment in which decomposition takes place under anaerobic conditions. Natural sediments containing oil pollutants were placed in a draw-and-fill experimental system, and the decomposition process was followed for 30 wk under anaerobic conditions with high sulfate levels in the overlying waters. Oils were lost from sediments with time and were lost more rapidly than other organic matter present. There was a steady release of organic C with time. The sediments consolidated under their own wt. There was no observable change in the benzene extract (aromatic compounds) with time, and functional group analysis indicated an increased loss of oxy-compounds.

918. Sherman, K. and D. Busch (1978).

THE ARGO MERCHANT SPILL AND THE FISHERIES.

In: In the Wake of the Argo Merchant. Proceedings of a Conference and Workshop held at the University of Rhode Island, January 11-13, 1978. Center for Ocean Management Studies, University of Rhode Island, Kingston, Rhode Island.

Although there has been evidence of oil contamination in fish, shellfish, ichthyoplankton and zooplankton populations in the area of the spill, the impact of oil spilled from the Argo Merchant on fish stocks has not been catostrophic.

919. Shih, H.H. (1971).

A LITERATURE SURVEY OF OCEAN POLLUTION.

Report No. 71-6. Institute of Ocean Science and Engineering. Catholic University of America. Washington, D.C. 116 pp.

A survey of past studies on the problems of ocean pollution is presented and research areas in which there are notable deficiencies in knowledge are identified. Available literature, documented as well as unpublished, pertaining to all phases of ocean pollution were surveyed. A general description of ocean pollution in the world is given. The chief pollutants, including oil spills, waste disposal, radioactive wastes, thermal discharges, chemical cargos, and man's activities, and the sources of these pollutants are discussed. The effects and the control of various types of ocean pollutants and a list of terminology, often encountered in fields related to ocean pollution, are given.

920. Shimkin, M., *et al*. (1951).

AN INSTANCE OF THE OCCURRENCE OF CARCINOGENIC SUBSTANCES IN CERTAIN BARNACLES.

Science, 113:650-651.

Extracts obtained from the thatched barnacle (*Tetraclita squamosa rubescens*) showed indications of the presence of polycyclic aromatic hydrocarbons in chromatography and in their extinction curves (crystals in hexane solution). Carbon and hydrogen content, as well as molecular weight, correspond to calculated values for benzpyrenes. Spectroscopy indicated the presence of 3,4-benzpyrene in the crystalline mixture. The material was dissolved in tricaprylin, 5 mg/ml. The solution was then injected subcutaneously into 12 C_3H mice, 0.5 mg in 0.1 ml; and into 12 more C_3H mice, 0.25 mg in 0.05 ml. Within 36 weeks, four mice from the first group and two from the second had developed tumors of the spindle-cell sarcoma type, with local invasion of areolar and muscular tissue, at the injection sites. Examination of these tumors and comparison of results with those from previous work confirmed the presence of 3,4-benzpyrene, a polycyclic aromatic hydrocarbon and known carcinogen. Since this type of chemical is not a normal metabolic product of barnacles, the 3,4-benzpyrene must have reached the barnacles accidentally, possibly from a ship or submarine oil well, or from the wooden pilings where the barnacles were collected, which had received a surface coating of creosote some 10 years earlier.

921. Shindler, D.B., B.F. Scott and D.B. Carlisle (1975).

EFFECT OF CRUDE OIL ON POPULATIONS OF BACTERIA AND ALGAE IN ARTIFICIAL PONDS SUBJECT TO WINTER WEATHER AND ICE FORMATIONS.

Verhandlungen Internationale Vereinigung fur Theoretische and Angewante Limnologie, 19 2138-2144.

Field and experimental studies in Ottawa, Canada under winter ice conditions indicated that oil added to water greatly affected microorganisms present. After oil from a spill enters the lake waters an initial selection of one or a few bacterial types takes place, followed by a development of greater diversity. The initial bacteria are similar or closely related to types reported to degrade crude oil. Ponds remained aerobic the following summer and supported strictly aerobic bacteria such as Azobacter. Bacterial populations indicated an accelerated rate of eutrophication.

922. Shipton, J., J.H. Last, K.E. Murray, and G.L. Vale. (1970).

STUDIES ON A KEROSENE-LIKE TAINT IN MULLET (MUGIL CEPHALUS).
II. CHEMICAL NATURE OF THE VOLATILE CONSTITUENTS.

J. Sci. Food Agric. 21:433-436.

The composition of a volatile extract from mullet (*Mugil cephalus*) possessing a "kerosene" taint has been shown by gas chromatography and spectral analyses to be very similar, qualitatively and quantitatively, to that of a commercial sample of kerosene.

923. Sidhu, G.S., G.L. Vale, J. Shipton and K.E. Murray (1970).

A KEROSENE-LIKE TAINT IN MULLET (MUGIL CEPHALUS).

In: *Marine Pollution and Sea Life*, M. Ruivo (ed.) pp. 546-50.
Fishing News (Books) Ltd, London.

Australian mullet with a kerosene-like taint were examined by gas liquid chromatography, combined gas chromatography-mass spectrometry, and infra-red and proton magnetic resonance spectrometry. The results clearly establish the qualitative identity of the tainted mullet oil and a commercial kerosene. Radioactive tracer experiments indicate that taints from water can be picked up through gills of fish in a few hours.

924. Simpson, A.C. (1968).

OIL, EMULSIFIERS AND COMMERCIAL SHELLFISH.

Suppl. to Vol. 2 of Field Studies, Field Studies Council, London, 91-98.

Oil alone will not harm crustaceans or sub-littoral molluscs, and is most unlikely to harm intertidal molluscs; it can, however, cause serious tainting if it comes into contact with the shells of commercially valuable intertidal molluscs. Tainting by ingestion of droplets of oil can happen but is likely to be rare. Oil spills should be kept out of estuaries in which intertidal mollusc beds occur, by the use of physical protection such as that provided by booms.

In view of the very high toxicity of the currently used solvent/emulsifiers, care should be exercised in their use where shellfish (and other marine fauna requiring protection) occur.

Each situation of oil-spill has to be treated on its merits, and where important shellfisheries occur the solvent/emulsifiers should only be used when it is evident that local hydrographic conditions will disperse the quantities to be applied, without risk of harm to the fisheries.

925. Simpson, A.C. (1968).

THE TORREY CANYON DISASTER AND FISHERIES.

Min. Agric. Fish Food Lab. Leaf 1., 18 (pp.43).

926. Sinha, E. (ed.) (1970).

COASTAL/ESTUARINE POLLUTION, AN ANNOTATED BIBLIOGRAPHY.

Ocean Engineering Information Service, La Jolla, California.

This bibliography contains 631 abstracts of literature on detection, identification, and analysis of parameters of pollution and pollutants; sources of pollution, coastal and estuarine processes; effects of pollution; water quality management and waste heat utilization. A bibliography of bibliographies, separate identification of these books, patents and detailed subject and author indexes are included. Sources include journals, symposia, government reports, institutional studies, and industrial contract reports. It covers the period 1965-1970.

927. Sinha, E. (1971).

METHODS, MODELS, AND INSTRUMENTS FOR STUDIES OF AQUATIC POLLUTION: AN ANNOTATED BIBLIOGRAPHY.

Ocean Engineering Information Series Vol 5. Ocean Engineering Information Service, La Jolla, California. 32 pp.

Over 200 abstracts of literature providing substantial scientific and technical information on methods, models and instruments used in studies of aquatic pollution and means of abatement are included. These deal with the detection, identification and measurement of the parameters of pollution, biotic constituents, detergents and nutrients, pesticides, oil, metals, and non-metallic toxicants. Various aspects of water quality management are encompassed.

928. Smail, J., et al. (1972).

NOTES ON BIRDS KILLED IN THE 1971 SAN FRANCISCO OIL SPILL.

Calif. Birds, 3:25-32.

On 18 January 1971 two tankers collided in the mouth of San Francisco Bay and 840,000 gallons of bunker C fuel oil were spilled. Tides and currents quickly moved most of the oil out of the Bay, and in the following several days it spread 17 km out into the Pacific Ocean and along the coast from Drake's Bay on the Point Reyes National Seashore southward almost to Point Ano Nuevo. The oil thus covered a sizable portion of one of the most important wintering areas for aquatic birds on the west coast of North America.

This paper summarizes bird mortality resulting from the oil and presents information gained from inspecting over 1100 bird carcasses.

929. Smith, A.N. (1968).

EFFECTS OF OIL POLLUTION AND EMULSIFIER CLEANING ON SHORE LIFE IN SOUTH-WEST BRITIAN.

Journal of Applied Ecology 5, 97-107.

This paper discusses the effects on shore life of various episodes of oil pollution, followed by treatment with emulsifier, which have occurred off southwest Britian between 1960, when the Esso Portsmouth caught fire and released its cargo of crude oil at Milford Haven, and 1967, when the Torrey Canyon struck a reef off Land's End. The reported toxicities of crude oil, emulsifiers, and their active constituents, are reviewed and, based on a range of observations, common littoral plants and animals are placed in a rough order of susceptibility to oil and emulsifiers.

930. Smith, J.E. (1970).

TORREY CANYON, POLLUTION AND MARINE LIFE, REPORT BY THE PLYMOUTH LABORATORY OF THE MARINE BIOLOGICAL ASSOCIATION OF THE UNITED KINGDON.

Cambridge University Press. 196 pp.

This report is based on a ten week survey and analysis by the scientific staff of the Plymouth Laboratory of some biological consequences resulting from the release of 117,000 tons of crude oil from the "Torrey Canyon". It includes a description of the properties of oil and detergents, the results of sea and shore surveys, the offshore spread and toxic effects of detergents sprayed on shores, the results of toxicity experiments, and a summary of the lessons learned.

931. Smith, R.L., J.G. Pearson, and J.A. Cameron (1976).

ACUTE EFFECTS - PACIFIC HERRING ROE IN THE GULF OF ALASKA.

In: Environmental Assessment of the Alaskan Continental Shelf. Principal Investigators Reports for the Year Ending March 1976. Volume 8. Effects of Contaminants, p. 325-343.

The objective of this study is to delineate the toxicity of soluble components of crude oil under simulated natural conditions. Toxicity is measured in terms of hatching success and gross morphological abnormalities. Herring spawn in a habitat which is particularly susceptible to the influence of crude oil. Many of the roe are deposited in the intertidal, the larger usually being deposited highest on the beach. Since the larger eggs normally produce the larvae with the greatest chance of reaching adulthood, the presence of oil on the water and on the beach will select against the highest quality of eggs in particular and will cause an increased mortality in general. Spills or seepage during the three to four week reproductive period could have significant impact on egg and larval mortality. These mortality rates are already high in nature. Development activities could have a major impact on the herring fishery in Alaska.

932. Smithsonian Institution (1974).

UNITED NATIONS ENVIRONMENT PROGRAM: DIRECTORY OF NATIONAL AND INTERNATIONAL POLLUTION MONITORING PROGRAMS. VOLS. 1 TO 3.

Smithsonian Institution, Center For Short-Lived Phenomena.

Preliminary results of a worldwide survey of long-term monitoring activities that measure any of 25 selected pollutants and water quality indicators are documented. Information on 17 international environmental monitoring programs involving 136 participating countries is presented. Data on 807 national or regional pollution monitoring programs that currently operate in 81 countries are listed. The purpose of each program, how the programs are administered, and the pollutants monitored are given. Information is provided on the physical medium monitored (including air, soil, marine water, fresh water, drinking water, plants, animals, food, and man) the geographical areas covered.

934. Smithsonian Institution Science Information Exchange (1971).

ENVIRONMENTAL POLLUTION: A GUIDE TO CURRENT RESEARCH.

CCM Information Corporation, New York. 855 pp.

The Science Information Exchange receives, organizes, and disseminates information about research in progress in the life, physical, and social sciences. Its mission is to assist the planning and managmenet of research activities supported by Government and non-Government agencies and institutions. It helps program directors and administrators to avoid unwarranted duplication. In a first attempt to provice a meaningful look at the shape, complexity and direction of current and recent research, abstracts of projects are provided and divided into broad subject areas: Ecological systems; physical sciences applied to pollution; effects of pollution; air and water pollution; and cuases of pollution. A subject index, research index, and supporting agency index are included.

935. Snow, N.B. and B.F. Scott (1975).

THE EFFECT AND FATE OF CRUDE OIL SPILT ON TWO ARCTIC LAKES.

In: Proceedings Joint Conference for the Prevention and Control of Oil Spills. p. 527-534. Amer. Petrol. Inst. Wash. D.C.

Two lakes in the Mackenzie Delta were partitioned and oil was spilt on a partitioned section. The oiled and non-oiled sectons are compared with regard to zoobenthos, surface orgins, phyoid and chemical parameters and the degredation of the oils.

936. Soikkeli, M. and Virtanen, J. (1972).

THE "PALVA" OIL TANKER DISASTER IN THE FINNISH SOUTHEASTERN ARCHIPELAGO. II. EFFECTS OF OIL POLLUTION ON THE EIDER (SOMATERIA MOLLISSIMA) POPULATION ON THE ARCHIPELAGOS OF KŐKAR AND FÖGLO, SOUTHWESTERN FINLAND.

"Aqua Fennica" 1972, 122-128.

937. Soli, Giorgio (1971).

HYDROCARBON-OXIDIZING BACTERIA AND THEIR POSSIBLE USE AS CONTROLLING AGENTS OF OIL POLLUTION IN THE OCEAN.

U.S. Office of Naval Research, Washington, D.C. Technical Report No. 1. 24 pp.

Organisms which can digest petroleum hydrocarbons in a saline environment were studied and the conditions under which the biological process of oil degradation can be enhanced for degradation of large oil spills were investigated. Among the strains tested, three were effective hydrocarbon oxiders Corynebacterium, Arthrobacter and Achromobacter.

938. Soli, G. (1972).

HYDROCARBON-OXIDIZING BACTERIA AND THEIR POSSIBLE USE AS CONTROLLING AGENTS OF OIL POLLUTION IN THE OCEAN.

U.S. Office of Naval Research. Technical Report No. 2.19 pp.

Several strains of bacteria, isolated from marine environments, were characterized for their hydrocarbon oxidizing abilities using gas chromatography and a complex synthetic mixture of hydrocarbons. Attempts were made at a broad classification of these organisms on the basis of their behavior towards normal paraffins, isoparaffins, cycloparaffins, and aromatics present in crude oils. All strains except one digested normal paraffins and some oxidized all 3 isoparaffins in the mixture as well as cycloparaffins and aromatics. Although a variety of bacteria can oxidize hydrocarbons at random, it may be possible to recognize a rudimental pattern if their oxidative abilities are viewed in terms of groups of hydrocarbons rather than individual compounds. The action of combined strains on the synthetic hydrocarbon mixture was studied; no particular benefit could be derived as compared to the use of single strings. A preliminary study was also made of the effect of undegraded and degraded crude oil on different species of marine phytoplankton.

When oil was in direct contact with the cells, a poisonous effect was evident; when oil was not in direct contact, different organisms manifested different sensitivities to it. Diatoms were more susceptible than dinoglagellates.

939. Soli, G. and E.M. Bens, (1973).

SELECTIVE SUBSTRATE UTILIZATION BY MARINE HYDROCARBONOCLASTIC BACTERIA.

Biotech. Bioeng. 15:285-297.

Several strains of bacteria, isolated from marine environments, were characterized for their hydrocarbon oxidizing abilities using a complex synthetic mixture of hydrocarbons. Attempts were made at a broad classification of these organisms on the basis of their behavior towards four major groups of hydrocarbons, normal paraffins, iso-paraffins, cyclo-paraffins, and aromatics, known to be present in crude oils. Although bacteria appear to be able to oxidize hydrocarbons at random, this study has shown that it may be possible to recognize a rudimental pattern if we view their oxidative abilities in terms of groups of hydrocarbons rather than individual compounds. A study of the action of combined strains on the synthetic hydrocarbon mixture was performed. It was found that no particular benefit could be derived as compared to the use of single strains.

940. Sorensen, J. and M. Demers (1973).

COASTAL ZONE BIBLIOGRAPHY: CITATIONS TO DOCUMENTS ON PLANNING, RESOURCES MANAGEMENT AND IMPACT ASSESSMENT.

IMR Technical Report IMR TR-43. Institute of Marine Resources, University of California. La Jolla. 131 pp.

A computer-automated bibliography was developed to assess the environmental and socioeconomic impacts of coastal development and resource use. The references document actual occurrence and research reports on each of the potential impacts.

941. Soto, C., J.A. Hellebust, and T.C. Hutchinson (1974).

THE EFFECTS OF AQUEOUS EXTRACTS OF CRUDE OIL AND NAPHTHALENE ON THE PHYSIOLOGY AND MORPHOLOGY OF A FRESHWATER GREEN ALGAE.

In: Proceedings of the 19th congress of the International Association of Theoretical and Applied Limnology, Winnipeg, Canada.

942. Soto, C., J.A. Hellebust, T.C. Hutchinson and T. Sawa. (1975).

EFFECT OF NAPHTHALENE AND AQUEOUS CRUDE OIL EXTRACTS ON THE GREEN FLAGELLATE CHLAMYDOMONAS ANGULOSA. I. GROWTH.

Can. J. Bot. Vol. 53:109-117.

Report on the effects of aqueous crude oil extracts and naphthalene on the Chlamydomonas angulosa grown in open and closed systems. In the open system, with a saturated solution of naphthalene, 61% of the cells were killed initially. The generation time of the survivors was the same as the controls. Naphthalene in a closed system killed a higher percentage of cells but a shorter generation time was observed when growth resumed. A prolonged lag phase was observed when growth resumed. A prolonged lag phase was characteristic of all naphthalene treatments.

The effects of aqueous extracts of crude oils was tested using different crude oils, fresh and aged extracts, and open and closed systems. The extracts were all inhibitory but the effects were less severe than with naphthalene. Possible implications are discussed.

943. Soto, C., J.A. Hellebust and T.C. Hutchinson (1975).

EFFECT OF NAPHTHALENE AND AQUEOUS CRUDE OIL EXTRACTS ON THE GREEN FLAGELLATE CHLAMYDOMONAS ANGULOSA. II PHOTOSYNTHESIS AND THE UPTAKE AND RELEASE OF NAPTHALENE.

Can. J. Bot. Vol. 53:118-126.

Rate of photosynthesis, mortality, and generation time measured for Chlamydomonas in open and closed systems containing napthalene or aqueous extracts of various crudes. Both napthalene and the extracts were inhibitory, the naphthalene more so.

944. Spencer, E.F., Jr., R.J. Ringwood, and R.M. Brennan (1975).

THE STATE OF LOUISIANA SUPERPORT AUTHORITY ENVIRONMENTAL PROTECTION PLAN - OIL AND OYSTERS.

Water Resources Bulletin, 11(4):836-847.

In 1972 Louisiana created the Deep Draft Harbor and Terminal Authority to plan, promote, and develop a deepwater crude oil terminal. The authority was charged to develop an environmental protection plan to preserve the unique coastal marshland while permitting industrial and economic growth. The current status of the superport project and the development of the environmental protection plan are described.

945. Spooner, M.F. (1967).

BIOLOGICAL EFFECTS OF THE TORREY CANYON DISASTER.

J. Devon Trust Nat. Conserv. July (suppl.) 25-26.

946. Spooner, M.F. (1968).

PRELIMINARY WORK ON COMPARATIVE TOXICITIES OF SOME OIL SPILL DISPERSANTS AND A FEW TESTS WITH OIL AND COREXIT.

Plymouth, Marine Biological Association of the United Kingdom.

947. Spooner, M. 1969.

SOME ECOLOGICAL EFFECTS OF MARINE OIL POLLUTION.

In: <u>Proceedings of Joint Conference on Prevention and Control of Oil Spills</u>. (API/EPA/USCG), New York, NY. Amer. Petrol. Inst. Wash. D.C. pp. 313-316.

Oil at sea affects chiefly species associated with the surface; damage at sea by oil and dispersants after Torrey Canyon were not as bad as expected.

Slicks sometimes disappear naturally, how apart from physical actions may this be taking place? Bacteria can, under experimental conditions very favorable to their growth, assist in dispersal, sinking and decomposition of oil, and zooplankton can ingest oil droplets, but are these factors of significance at sea?

On shores after Torrey Canyon, far more damage was done by excess detergent than by oil. Repopulation is following the expected sequence, most affected shores being still abnormal. Observations on oil left untreated in Cornwall, at Eleuthera and on the Devon coast show slow removal by various natural means, including the browsing action of fauna.

Toxic detergents can affect the sublittoral zone, including species of economic importance. Areas liable to repeated pollution, such as estuaries and salt marshes, require special care. The use of newer dispersants of low toxicity is desirable here and on shores.

948. Spooner, M. (1970).

OIL SPILL IN TARUT BAY, SAUDI ARABIA.

Mar. Poll. Bull., 1:166-167.

During a storm on the night of 20 April, 1970, a pipeline broke on land near the northwest shore of Tarut Bay in Saudi Arabia, and some 100,000 barrels of Arabian light crude oil flowed into the bay. Slicks were dispersed with Corexit 7664 before escaping from the bay into the open Persian Gulf. The effects on various forms of marine fauna immediately after the spill, a few days after the spill, and three to four weeks following the spill are discussed.

949. Spooner, M. and C.J. Corkett (1974).

A METHOD FOR TESTING THE TOXICITY OF SUSPENDED OIL DROPLETS ON PLANKTONIC COPEPODS USED AT PLYMOUTH.

In: Ecological Aspects of Toxicity Testing of Oils and Dispersants. L.R. Beynon and E.B. Cowell (ed.) John Wiley & Sons New York pp. 69-74.

The method described here enables an even dispersion of oil droplets to be continuously available by using vessels undergoing slow inversion on a wheel. Faecal pellet counts were used as a measure of activity, and the effects seen at the concentrations and times of exposure chosen were usually sublethal, survivors showing good recovery of feeding rates. The toxic effects of the oil may be operative in two ways, as solutes or actually injested as droplets. Either of these may have a narcotic effect and possibly other consequences.

950. Spooner, M.F. and G.M. Spooner, (1968).

THE PROBLEM OF OIL SPILLS AT SEA, ILLUSTRATED BY THE STRANDING OF THE GENERAL COLOCOTRONIS.

Mar. Biol. Ass. Plymouth, England.

951. Spratt, J.D. (1970).

PELAGIC FISH SURVEY OF SANTA BARBARA OIL SPILL. CALIFORNIA DEPT. OF FISH AND GAME, MARINE RESOURCES OPERATIONS.

State Fisheries Laboratory, Terminal Island, Cruise Report, No. 70-A-2, 4 pp., March 5, 1970.

This paper reports the results of the third and last cruise in a series of survey cruises designed to determine the effect of the 1969 Santa Barbara Channel oil leak on the pelagic fishes of the area.

A total of 88 miles of acoustic search was conducted. Nine northern anchovy (Engraulis mordax) and 2 rockfish (Sebastes sp.) schools were detected by echo scatter; the individual groups of fish here were too small to consider as schools, Sonar detected 4 northern anchovy and 1 unidentified schools.

Nearly all northern anchovy schools located were in the area between Santa Barbara and Port Hueneme on the mainland side of the channel. The largest concentration of fish was found just south of Santa Barbara. School sizes were in general very small or composed of continuous scatter. No northern anchovy schools of commercial size were found.

The previous oil spill surveys found an unusual abundance of northern anchovies in this area. The smaller number of anchovy schools recorded during this cruise compares favorably with the number previously found on 12 regular pelagic fish surveys in this area since 1965. The diversification of species found and their apparent normal condition suggests that to date the 1969 oil spill has had no deleterious effect on the pelagic fishes in the Santa Barbara Channel.

952. Stainken, D.M. (1975).

PRELIMINARY OBSERVATIONS ON THE MODE OF ACCUMULATION OF #2 FUEL OIL BY THE SOFT SHELL CLAM, MYA ARENARIA.

In: Conference on Prevention and Control of Oil Spills. pp. 463-468. Amer. Petrol. Inst., Wash., D.C.

Chemical analysis has shown that various components of oils can accumulate within marine invertebrates. Several mechanisms by which this may occur have been conjectured. This paper offers experimental verification of a mechanism by which a commercially important bivalve, *Mya arenaria*, can accumulate oil within its tissues. The paper also documents the behavioral response of *Mya arenaria* and deleterious ecological side effects resulting from oil accumulation.

Young *Mya* (25-35 mm) were exposed to #2 fuel oil and an oil soluble dye (Oil Red O) which were ultrasonically emulsified in water. The concentrations tested were 50 ppm, 100 ppm and 150 ppm. Exposures were done in both natural and artificial seawater at $4^{\circ}C$ and $22^{\circ}C$. Exposure periods ranged from 3 hours to 4 days.

Macroscopic observations were performed to determine the effects of the dyed oil contacting the gill surfaces and the means by which the oil was either ingested or ejected. Definite patterns of response to the dyed oil were established. Essentially, the clams treat oil micelles and globules as food or detritus particles. The smallest oil micelles are passed by ciliary currents directly to the stomach. Larger globules are bound by mucus secretated by the gill ctenidia. Gas chromatography and mass spectrometry confirmed the binding of oil-mucus. The oil-mucus is ingested or rejected by means of the clam ciliary pathways. Implications of the oil-mucus mechanism and the ejection of this mucus into the environment are discussed.

953. Stainken, D.M. (1976).

A DESCRIPTIVE EVALUATION OF THE EFFECTS OF NO. 2 FUEL OIL ON THE TISSUES OF THE SOFT SHELL CLAM, MYA ARENARIA.

Bull. Environ. Contam. and Tox. 16 730-738.

The soft shell clam, Mya arenaria, was exposed to emulsions of No. 2 fuel oil having concentrations of 10, 50, and 100 ppm for 28 days to simulate contact with winter oil spills. No radical tissue aberrations were observed at any oil concentration. At 100 ppm. some edema of the pallial muscle was observed. Leukocytes were observed in the pallial blood sinuses, under the mantle epithelium and within the anterior adductor muscle. The intestine, style sac, and diverticula appeared very vacuolar. At 50 ppm, the effects were less marked except in the diverticula and intestine. The clams exposed to 10 ppm showed some reduction in size of diverticula, and the diverticula, stomach and intestine were vacuolated in appearance. The vacuolization appeared in all clams and seemed to result from the laboratory environment. However, this effect was exacerbated in the oil exposed clams compared to controls. Cellular glycogen content was depleted and a reduction in cellular cytoplasm was observed, most maredly in clams exposed to 100 ppm oil, but also in clams exposed to 50 ppm. This may be a result of reduced feeding.

954. Stainken, D.M. (1976).

THE EFFECT OF A NO. 2 FUEL OIL AND SOUTH LOUISIANA CRUDE OIL ON THE BEHAVIOR OF THE SOFT SHELL CLAM, MYA ARENARIA. L.

Bull. Environ. Contam. and Tax. 16 724-29.

The sublethal effects of No. 2 fuel oil and a South Louisiana crude oil on the soft shell clam, *Mya arenaria*, were studied in tests conducted at 4 and 14°C, to simulate winter oil-spill conditions. At oil concentrations of 50 ppm, mucus was given off through the pedal opening and siphon. Higher oil concentrations resulted in poportionally higher mucus secretion, although crude oil effects were never as severe as the effect of fuel oil. Both oils depressed muscular contraction. At concentrations greater than 100 ppm, the pedal opening musculature became totally relaxed and did not contract. The adductor muscles also lost the ability to contract rapidly. These responses were enhanced at 14°C compared to 4°C. The response of clams to phenol was slightly different with less mucus secretion. Muscles remained at one length, turgid, and lost their irritability. The energy drains imposed on the clam by mucus production and expulsion and resulting disruption of normal feeding mechanisms occurred at oil concentrations far below the LC50.

955. Stebbings, R. (1970).

RECOVERY OF SALT MARSH IN BRITTANY 16 MONTHS AFTER HEAVY POLLUTION BY OIL.

Environ. Poll., 1(2):163-167.

Two visits separated by sixteen months were made to salt marshes and a shingle spit in Brittany, where oil was stranded in the spring of 1968, to assess macrochanges in floral composition and the overall effects of heavy contamination by weathered oil. Most salt marsh plant species survived all but the heaviest contamination. Oil appeared to prevent gaseous interchange between soil and sir, yielding reducing conditions which led to chlorotic symptoms in plants. As the oil was rapidly denatured, salt marshes can be important for retaining oil during this process and preventing pollution elsewhere.

956. Steed, D.L. and B.J. Copeland. (1967).

METABOLIC RESPONSES OF SOME ESTUARINE ORGANISMS TO AN INDUSTRIAL EFFLUENT.

Contr. mar. Sci. Univ. Tex. 12:143-159.

The oxygen consumption rates of several species of estuarine organisms were measured in various concentrations of a petrochemical company effluent. Test solutions used were of concentrations less than the TLm value, as determined by the toxicity bioassay method. It was learned that both short term and chronic exposure exert stress conditions causing organisms to experience changes in metabolic requirements. A typical response was a decreased metabolic rate in low concentrations and an increased rate upon prolonged exposure or in concentrations approaching the TLm value. However, responses may vary with the type effluent used, length of exposure and with the particular species under study.

These data were interpreted with respect to the ecological requirements of individual organisms and entire populations. It is apparent that populations may experience gross deleterious effects, without apparent "fish kills", under what may normally be interpreted to be "safe" pollution levels.

957. Stegeman, J.J. (1974).

HYDROCARBONS IN SHELLFISH CHRONICALLY EXPOSED TO LOW LEVELS OF FUEL OIL.

In: Pollution and Physiology of Marine Organisms, F.J. Vernberg (ed.). pp. 329-348.

Crassostrea virginica was used as the experimental organism in a flow-through acquaculture system to determine the level to which petroleum hydrocarbons are accumulated, the duration of hydrocarbon residence in the organism and the composition of the hydrocarbon mixture in the water and, subsequently in the organism.

958. Stegeman, J.J. and D.J. Sabo (1974).

UPTAKE AND RELEASE OF PETROLEUM HYDROCARBONS BY SOME MARINE ORGANISMS AND SOME METABOLIC IMPLICATIONS.

In: Marine Environmental Implications of Offshore Oil and Gas Development in the Baltimore Canyon Region of the Mid-Atlantic Coast. Proceedings of the Estuarine Research Federation Conference and Workshop. Estuarine Research Federation, p. 339-350.

This report briefly summarizes some of the information available concerning the contamination of marine animals by petroleum hydrocarbons and poetntial metabolic effects of such contamination.

Acute effects appear to be membrane relaxed whereas chronic effects would include this as well as other metabolic alterations. Chronically contaminated organisms exhibit alterations in metabolic rates and pathways and changes in structural integrety of cells which appear to be long lasting.

959. Stegeman, J.J. and D.J. Sabo (1976).

ASPECTS OF THE EFFECTS OF PETROLEUM HYDROCARBONS ON INTERMEDIARY METABOLISM AND XENOBIOTIC METABOLISM IN MARINE FISH.

In: Sources, Effects and Sinks of Hydrocarbons in the Aquatic Environment. Proceedings of the Symposium, American University, Washington, D.C. 9-11 August 1976.

Aspects of normal intermediary metabolism and xenobiotic metabolism are considered in relation to low levels of petroleum contamination. Petroleum hydrocarbons appear to be associated with altered patterns of lipid metabolism, characterized by a net decline in lipogenesis, in hepatic tissue of Fundulus heteroclitus or Stenotomus versicolor contaminated either in the environment or experimentally at less than 200 ppb. There also is an association between environmental contamination and low lipogenesis rates in gill, muscle and brain in F. heteroclitus. Various properties of cytochrome P-450 mixed-function oxidases in fish, including EPR characteristics, indicate a basic similarity with the system in mammals. Treatment of teleost fish with 3-methylcholanthrene or 5,6-benzoflavone results in induction of mixed-function oxidase activity. Evidence exists suggesting induction of mixed-function oxidases occurs in fish environmentally contaminated by petroleum, although in at least some cases the appearance of increased activity can be ascribed to factors other than induction.

960. Stegeman, J.J. and J.M. Teal. (1973).

ACCUMULATION, RELEASE AND RETENTION OF PETROLEUM HYDROCARBONS BY THE OYSTER CRASSOSTREA VIRGINICA.

Mar. Biol., 22:37-44.

Two Crassostrea virginica populations, differing in fat content, were experimentally exposed to a complex petroleum-hydrocarbon fraction. The hydrocarbons in this mixture were accumulated by both groups of oysters, and their lipid content, as well as the concentration of hydrocarbon in the water, were found to affect the rate and extent of accumulation. Hydrocarbons accumulated were rapidly, although incompletely, discharged when the oysters were transferred to an uncontaminated system. Amounts of hydrocarbons discharged and amounts retained after discharge are probably related to the level of contamination. The data can be interpreted as indicating that equilibration and occurrence of multiple compartments where hydrocarbons can reside are factors involved in the uptake and retention of non-biogenic hydrocarbons by oysters. The petroleum hydrocarbons contained in the oysters differed from the contaminating oil by displaying a greater aromatic content. In addition, gas-liquid chromatograms of aliphatic fractions of the hydrocarbons in the oysters rapidly showed a degraded appearance; the possibility that the oysters themselves are modifying the oil cannot be excluded.

961. Steinhardt, R.A., H. Morita and E.S. Hodgson. (1966).

MODE OF ACTION OF STRAIGHT CLAIN HYDROCARBONS ON PRIMARY CHEMORECEPTORS OF THE BLOWFLY, PHORIMEA REGINA.

J. cell comp. Physiol., 67, 53-62.

962. Stirling, Hadrian P. (1977).

EFFECTS OF A SPILL OF MARINE DIESEL OIL ON THE ROCKY SHORE FAUNA OF LAMMA ISLAND,

Hong Kong, Environ. Pollut. (12) pp. 93-117.

The acute toxic and long-term ecological effects of marine diesel oil on common littoral fauna were studied at three rocky shores on Lamma Island, Hong Kong, which were contaminated to different degrees. Acute mortality of gastropods was greatest at the moderately contaminated site where oil-dispersant chemicals were applied to floating slicks nearby, but long-term disturbances were most significant at the heavily oiled site where dispersants were not used. Animals were collected on the oiled beaches and taken to the laboratory, where their recovery in clean seawater was studied. This indicated that bivalve-molluscs and the gastropods Monodonta labio and Thais clavigera were the most sensitive and Clypeomorus humilis and Planaxis sulcatus the least. Field observations of acute mortality were consistent with this order of species sensitivity. The greatest population reduction was observed in Monodonta labio and Nerita albicilla which were eliminated for at least 13 months from the site receiving the most oil. Species resistant to oil in recovery experiments did not show significant long-term reductions.

963. Stoermer, F.C. and A. Vinsjansen (1976).

MICROBIAL DEGREDATION OF EKOFISK OIL IN SEAWATER BY SACCHAROMYCOPSIS LIPOLYTICA.

Ambio., 5(3):141-142.

The yeast was grown in 1.01 of seawater containing 10 mg potassium monohydrogen phosphate, 1.0 g ammonium sulfate, and 5 ml of oil in a shaker working at 120 strokes/min at 20°C and 8°C. These 2 temperatures were chosen because the average temperature in the North Sea basin S of 61° long. During winter is approximately 6°C. In summer, the average temperature in the same area is 14°C. The pH was held constant at 8.1 by the automatic addition of NaOH. Every 2nd day, 5-ml samples were removed and analyzed by gas chromatography. The acid production, or NaOH consumption, was plotted. After 5 d at 20°C, the curve flattened out for 24 hr after which 10 ml NaOH was consumed in 24 hr. From then on, only a negligible amount of acid was produced. At 8°C, the acid production started very slowly after 6 d, and became exponential 4 d later. Its doubling time was 38 hr, or almost twice as long as at 20°C. Without external pH control at 20°C, the pH dropped to 3.7 in 3 d, then slowly increased to 4.0 after 4 d. The main hydrocarbon oxidation occurred simultaneously with the decrease in pH. In all experiments, the normal alkanes with intermediate chain lengths were metabolized first, and the branched ones last. At the end of the experiments, the biodegraded sample was dispersed.

964. Stoll, D.R. and R.R.L. Guillard (1974).

SYNERGISTIC EFFECT OF NAPHTHALENE TOXICITY AND PHOSPHATE DEFICIENCY IN A MARINE DIATOM.

In: Abstracts, 37th Annual Meeting, American Society of Limnology and Oceanography.

965. Stone, J.H. and J. Michael Robbins (1973).

LOUISIANA SUPERPORT STUDIES. REPORT 3. RECOMMENDATIONS FOR THE ENVIRONMENTAL PROTECTION PLAN.

Center for Wetland Resources, Louisiana State University, Baton Rouge. 530 pp.

This volume inventories environmental resources of coastal and offshore Louisiana, describes probable impact of the construction of an offshore port, and makes recommendations for the environmental protection plan.

966. Straughan, A. (1972).

SANTA BARBARA OIL SPILL -- INTERTIDAL AND SUBTIDAL SURVEYS.

Calif. Coop. Oceanic Fish. Invest. Rep., 16:122-124.

There was some initial damage to certain algae and a surf grass on the Channel Islands, but later surveys revealed that these plants had recovered. The invertebrates generally appeared to have remained healthy and viable. Our surveys indicated that all the fish observed were free from oil, and showed no signs of starvation due to oil on the plants and animals in their food chain.

Species diversity appeared to have remained the same as before the oil leak. During our diving survey, we found no indication that there had been any modification in the number of species present.

967. Strand, J.A., W.L. Templeton, J.A. Lichatowich and C.W. Apts. (1971).

DEVELOPMENT OF TOXICITY TEST PROCEDURES FOR MARINE PHYTOPLANKTON.

In: Proceedings of a Joint Conference on Prevention and Control of Oil Spills. pp. 279-286. Washington, American Petroleum Institute.

Recommended bioassay procedures are presented that can be routinely applied to evaluate the relative toxicity of oil, chemical dispersants, and oil-dispersant mixtures to 1) naturally occurring populations of phytoplankton, and 2) representative marine phytoplankters grown in pure culture. The methods presented, in general, represent 1) application of techniques routinely employed in the measurement of marine primary productivity, and 2) application of the Inhibitory Toxicity Test, a tentative method devised by the American Society for Testing and Materials to evaluate acute toxicity of industrial wastes to diatoms.

968. Straughan, Dale, (1969).

THE SANTA BARBARA STUDY.

In: Proceedings Joint Conference on Prevention and Control of Oil Spills. p. 309-311. Amer. Petrol. Inst., Wash. D.C.

This paper gives an outline of the unique problems associated with determining the effects of the oil spill in the Santa Barbara channel and the general outline of biological studies associated with the spill.

969. Straughan, D. (1970).

SANTA BARBARA OIL POLLUTION PROJECT.

Mar. Poll. Bull., 1(4) 61-62.

This article is a 12-month progress report of the research programme instituted by the Allan Hancock Foundation in January 1969 when an offshore oil well ruptured 10.6 km from Santa Barbara, California. The field sampling programme under the contract from Western Oil and Gas Association is now complete.

970. Straughan, D. (ed.) (1971).

BIOLOGICAL AND OCEANOGRAPHICAL SURVEY OF THE SANTA BARBARA CHANNEL OIL SPILL 1969-1970. VOL. 1. BIOLOGY AND BACTERIOLOGY 426 p.

Allan Hancock Foundation, University of Southern California.

This volume is "a compendium of the findings of all persons working either directly within the project or on the problem" of research on the environmental impact of the Santa Barbara blowout of January 1969.

971. Straughan, D. (1971).

BREEDING AND LARVAL SETTLEMENT OF CERTAIN INTERTIDAL INVERTEBRATES IN THE SANTA BARBARA CHANNEL FOLLOWING POLLUTION BY OIL.

In: Biological and Oceanographical Survey of the Santa Barbara Oil Spill 1969-70. Vol. 1, 223-244, Allan Hancock Foundation, Sea Grant Publ. 2, D. Straughan (ed.).

In the sedentary species, no reduction in breeding due to oil pollution was found in two sessile barnacles, Chthamalus fissus and Balanus glandula, but, contrary to preliminary reports, breeding rate was reduced in the stalked barnacle, Pollicipes polymerus, and the mussel, Mytilus californianus. THe latter two species occur in lower intertidal areas than the former, and were exposed to liquid petroleum for longer periods than upper intertidal species. Hence, these species were probably more exposed to the chemical effects of oil pollution than upper intertidal species, while the upper intertidal species were exposed mainly to the physical effects. However, as long as only a small fraction of the entire population of these species is exposed to oil pollution, the species as a whole are not endangered by it.

972. Straughan, D. (1971).

THE INFLUENCE OF OIL AND DETERGENTS ON RECOLONIZATION IN THE UPPER INTERTIDAL ZONE.

In: Proc. Joint Conf. on Prevention and Control of Oil Spills, pp. 437-440. API/EPA/USCG. Amer. Petrol. Inst., Wash., D.C.

Recolonization of asbestos fouling plates treated variously with oil and detergents is dependent on the season of the year. The presence of oil favors Chthamalus fissus but retards algal settlement.

973. Straughan, D. (1971).

OIL POLLUTION AND SEA BIRDS.

In: Biological and Oceanographical Survey of the Santa Barbara Channel Oil Spill 1969-70, Vol. 1, p. 307. Allan Hancock Foundation. Sea Grant Publ. 2, D. Straughan (ed.).

An estimated loss of 3600 birds, excluding those which perished at sea and failed to drift ashore, can be attributed to the oil spill up until March 31, 1969. Swimming species, such as loons, grebes, and cormorants, had the highest mortality. In contrast, few gulls, terns, or shore species died even though abundant groups were seen in the area.

974. Straughan, D. (1971).

OIL POLLUTION AND WILDLIFE AND FISHERIES IN THE SANTA BARBARA CHANNEL.

In: Trefethen, James B. (ed.). Transactions of the 36th North American Wildlife and Natural Resources Conference Symposium. VII. p. 534. Wildlife Management Institute, Washington, DC pp. 219-229.

A survey of the effects of the Santa Barbara Channel oil spill on marine animals. Avian populations remained relatively stable, most birds seemingly avoiding oil-fouled areas. Swimming birds suffered the highest mortality rate, whereas coastal species had a much lower rate and aerial species the lowest. Marine mammals apparently suffered no ill effects from the spill. There were few changes in fish populations and species diversity was maintained. There were no reports of tainted fish, crustaceans, or cephalopods after the spill.

975. Straughan, D. (1971).

WHAT HAS BEEN THE EFFECT OF THE SPILL ON THE ECOLOGY IN THE SANTA BARBARA CHANNEL?

In: Biological and Oceanographical Survey of the Santa Barbara Oil Spill 1969-1970. D. Straughan (ed.)., Vol. 1, Biology and Bacteriology, Allan Hancock Foundation, Univ. of S. Calif. pp. 401-426.

This study has shown significant mortality in bird populations, in populations of the intertidal barnacle *Chthamalus fissus*, in the marine grass *Phyllospadix torreyi* and the marine alga *Hesperophycus harveyanus*. Mortality in other areas can be attributed to other sources or possibly to a combination of oil and other sources. Recolonization commenced in the intertidal areas within seven weeks of the spill. As of November, 1970, most intertidal areas now have a "normal" population of intertidal invertebrates. Sublethal effects include a reduction in breeding in *Pollicipes polymerus* in localized areas.

976. Straughan, D. (1972).

FACTORS CAUSING ENVIRONMENTAL CHANGES AFTER AN OIL SPILL.

J. Pet. Tech. 24(3) 250-254.

Nine factors that individually and in combination result in the recording of different spills are discussed. The biological damage caused by an oil spill is governed by a combination of several factors including: the type of oil spilled, the dose of oil, the physiography of the area, the weather conditions at the time of the spill, the biota of the area, the season of the spill, previous exposure of the area to oil, exposure to other pollutants, and the treatment of the spill. With this highly complex situation, it is impossible to predict, except in a general way, the impact of an oil spill.

977. Straughan, D. (1972).

BIOLOGICAL EFFECTS OF OIL POLLUTION IN THE SANTA BARBARA CHANNEL.

In: Mar. Pollut. and Sea Life., Ruivo (ed.), p 355-359. London, Fishing News Books, for FAO.

This paper gives the results of a study of effects of an oil pollution incident in June 1969 in the Santa Barbara Channel. The study lasted 12 months in order to determine initial and the long-lasting effects of the contamination by oil. The recuperative capacity of the location was also ascertained.

The blowout occurred in an area of naturally occurring leakages, during a time of abnormally intense rainfall and the intervention of man. These facts are taken into account in the interpretation of the data. Three principal conclusions were obtained:

1. It is difficult to demonstrate that the contamination of petroleum causes harm in the location.
2. The harm suffered by the flora and fauna was not as great as believed at first.
3. The location is returning to normalcy.

978. Straughan, D. (1976).

EFFECTS OF NATURAL CHRONIC EXPOSURE TO PETROLEUM HYDROCARBONS ON SIZE AND REPRODUCTION IN MYTILUS CALIFORNICUS CONRAD.

In: Proceedings Symposium on Pollution and Physiology of Marine Organisms, Milford, Connecticut November 3-6, 1975.

979. Straughan, D. (1976).

SUBLETHAL EFFECTS OF NATURAL CHRONIC EXPOSURE TO PETROLEUM IN THE MARINE ENVIRONMENT.

American Petroleum Institute Publication No. 4280, Washington D.C.

980. Straughan, D. (1977).

THE SUBLETHAL EFFECTS OF NATURAL CHRONIC EXPOSURE TO PETROLEUM ON MARINE INVERTEBRATES.

In: Proceedings 1977 Oil Spill Conference. p. 563-568. Amer. Petrol. Inst. Wash. D.C.

Comparative field studies were conducted in an area of natural chronic exposure to petroleum (Coal Oil Point) and at control sites between 1972 and 1974. Studies of the larger (mesh 2 mm) benthic infaunal invertebrates in shallow water (20-35 m) revealed organisms living in sediments with total CCl_4 extractables higher than 10,000 mg/l at Coal Oil Point. These sediments contained petroleum hydrocarbons were generally less than 100 mg/l.

Petroleum hydrocarbons were recorded in tissues of abalone, mussels, and stalked barnacles from Coal Oil Point, although it is notable that all detected petroleum hydrocarbons were in the viscera and not in the foot of abalone. Data obtained in these studies did not reveal a significant change in reproduction, growth, or distribution that could be related to presence of petroleum in the tissues. However, there was a decrease in reproduction in stalked barnacles due to a "black body" effect of surrounding tar. There was no evidence of malformations in organisms living in the area of natural chronic exposure to petroleum. Petroleum hydrocarbons levels were higher in sediment and mussel tissues from Coal Oil Point than from the area around two producing oil rigs in the Santa Barbara Channel.

981. Straughan, D. and B.C. Abbott (1971).

OIL SPILLS: THE SANTA BARBARA OIL SPILL: ECOLOGICAL CHANGES AND NATURAL OIL LEAKS.

In: Biological and Oceanographical Survey of the Santa Barbara Channel Oil Spill 1969-1970. Vol I. Biology and Bacteriology, D. Stranghan (ed.) Allan Hancock Foundation, University of Southern California. pp. 257-262. Also in Water Pollution By Oil, p. Hepple ed.

Research on the Santa Barbara oil spill of January 1969 shows that: the oil did not cause as much damage as initially predicted; the area is recovering; and the factors that caused mortality and other changes in the biota are difficult to determine under field conditions. The reasons for the occurrence of the above include: Composition of the oil: time lag between release of the oil and arrival of oil onshore; presence of natural seeps in the area over a long period; and heavy rain and subsequent flooding.

982. Straughan, D. and D.M. Lawrence. (1975).

INVESTIGATION OF OVICELL HYPERPLASIA IN BRYOZOANS CHRONICALLY EXPOSED TO NATURAL OIL SEEPAGE.

Water, Air and Soil Pollution. 5(1):39-46.

Systemic collection and examination of bryozoans from surface, subsurface and benthic kelp fronds in an area chronically exposed to natural oil seepage revealed no instances of ovicell hyperplasia. Reasons are presented to explain the contrast between these findings and reported ovicell hyperplasia in other species exposed to creosote and petroleum hydrocarbons.

983. Strom, A.D., I.P. Danilevskaya, I.F. Tikhonruk, H.D. Vasilenko, and V.V. Vitli, Nskaya (1974).

THE ROLE OF PROTOZOA IN BIOLOGICAL PURIFICATION OF OIL INDUSTRY SEWAGE (IN RUSSIAN)

Gidrobiol Zh. 10 49-54.

An optimal technological system was developed for alkylphenol production waste purification. A relationship was found between the quality of the purified water and the number and variety of protozoa. The experimental data were mathematically processed to establish optimal parameters for the purification process.

984. Strawinski, R.J., and R.W. Stone. (1943).

THE UTILIZATION OF HYDROCARBONS BY BACTERIA.

J. Bacteriol., 40:461.

Mixed cultures of microorganisms, capable of utilizing pure hydrocarbons, were obtained from the soil by the use of an enrichment medium containing mineral salts and hydrocarbon as the sole source of carbon. Nitrogen in the form of $(NH_4)_2SO_4$, a temperature of 28°C, and a plentiful supply of air were favorable for the utilization of the hydrocarbons.

The microorganisms are motile gram-negative rods which form white, iridescent, or yellowish colonies on nutrient agar. Plate counts were made on nutrient agar, pH 7, after 11 consecutive transfers in the hydrocarbon medium. The counts were interpreted as indicative of the relative utilization of the hydrocarbons by bacteria.

Cetane, naphthalene, and biphenyl were the most rapidly attacked of 18 compounds studied, with counts ranging from one to one and one half billion microorganisms per ml. of solution. N-octane, alpha-methyl naphthalene, tetralin and t-butyl benzene were also attacked. Iso-octane, 1- and 2-octenes, decalin, n-butyl benzene and iso-butyl benzene were utilized to some extent, showing counts of 30 to 100 million bacteria per ml. Attempts to develop cultures capable of growing on benzene and toluene were unsuccessful.

985. Struhsaker, Jeannette W. et al. (1974).

EFFECTS OF BENZENE (A WATER-SOLUBLE COMPONENT OF CRUDE OIL) ON EGGS AND LARVAE OF PACIFIC HERRING AND NORTHERN ANCHOVY.

In: Pollution and Physiology of Marine Organisms. F.J. Vernberg (Ed.) p. 253-284.

This paper presents the results of preliminary experiments testing lethal and sublethal concentrations of benzene on eggs and larvae of the Pacific herring and northern anchovy. Developing embryos were exposed at two stages to contrast their sensitivity to benzene: (1) eggs a few hours after spawning and fertilization and (2) larvae a few hours before or after completion of yolk absorption. Parameters measured include percent mortality, percent abnormal larvae, types of abnormalities, length of larvae and growth, yolk utilization, feeding and respiration.

986. Struhsaker, J.W. (1977).

EFFECTS OF BENZENE (A TOXIC COMPONENT OF PETROLEUM) ON SPAWNING PACIFIC HERRING. CLUPEA HARENGUS PALLASI,

Fish. Bull. 75 p. 43-50.

Female Pacific herring were exposed to low (ppb) levels of benzene for 48 h just prior to their spawning. A significant reduction occured in survival of ovarian eggs and resultant embryos and larvae through yolk absorption. Exposure to benzene also induced premature spawning and resulted in aberrant swimming behavior and disequilibrium in adults of both sexes. The maximum accumulatiion of 14C labeled benzene and/or metabolites in ovarian eggs was greater than in later eggs and larval stages as measured in other experiments.

987. Suess, M.J. (1972).

POLYNUCLEAR AROMATIC HYDROCARBON POLLUTION OF THE MARINE ENVIRONMENT.

In: Marine Pollution and Sea Life, M. Ruivo (ed.) FAO, Fishing News (Books) Ltd. London. pp. 568-570.

This article breifly reviews the sources, effects and fate of polynuclear aromatic hydrocarbons in the marine environment. Several references.

988. Suess, M.J. (1973).

POLYNUCLEAR AROMATIC HYDROCARBON POLLUTION OF THE MARINE ENVIRONMENT.

In: Inputs, Fates, and Effects of Petroleum in the Aquatic Environment. Background Information for the Workshop. Ocean Affairs Board, NSF. Airlie, Va. 21-25, May 1973.

This paper briefly reviews the presence and effect of polynuclear aromatic hydrocarbons, particularly benzopyrene in the marine environment. It concludes that many polymuclear aromatics, especially benzopyrene, are carcnogeinic, that endogenous synthesis by flora is the major source in the open sea, supplemented by pollution; that adsorption into minerals may be a major mechanism of distribution; and that degredation will depend on depth of water, solar radiation, ambient temperature and dissolved oxygen. Food serves as one of the more important carriers of these compounds into the human body, though currently the consumption of carcinogen-containing seafood is probably not dangerous.

989. Sullivan, C.E. (1971).

A COMPARATIVE STUDY OF THE EFFECTS OF EMULSIFIERS BP 1002 BP 1100 ON THREE MUD AND SAND SPECIES.

In: Ecological Effects of Oil Pollution on Littoral Communities. E.B. Cowell, (ed.). pp. 14-21.

Toxicity tests were performed for a comparative study of 2 emulsifiers BP 1002 and the more recently developed BP 1100 on 3 mud and sand species; the cockle Cerastoderma edule; the lugworm

Arenicola marina; and Nerine spp. The emulsifiers proved toxic to all 3 species, although the susceptability did vary. Mortality due to BP 1002 was relatively high, especially in the case of the polychaete worms. Under some conditions it was seen that gradation from 100% survival to 100% mortality was very abrupt. BP 1100 proves to be less toxic to the inhabitants of the intertidal zone than BP 1002.

990. Sullivan, J.B. (1974).

MARINE POLLUTION BY CARCINOGENIC HYDROCARBONS.

In: NBS Special Publication 409, Marine Pollution Monitoring (Petroleum), Proceedings of a Symposium and Workshop Held at NBS, Gaithersburg, Maryland, May 13-17, 1974. National BUreau of Standards.

This article briefly reviews the input of polycyclic aromatic hydrocarbons into the marine environment and its level in seafoods.

991. Surber, E.W. (1971).

THE EFFECT OF OUTBOARD MOTOR EXHAUST WASTES ON FISH AND THEIR ENVIRONMENT.

J. Wash. Acad. Sci. 16:120-123.

Bluegill sunfish were placed in liveboxes and sampled at two-week intervals in (1) a lake where much water skiing occurred, (2) in a pond where outboard motors with low-pitched propellors were operated by project personnel, and (3) in a control pond where outboard motors were not operated. The fish were fried in vegetable oil and cracker meal at a temperature of 370^{o}F(188^{o}C) or baked in aluminum foil before being tasted by a taste panel of 12 members. The tainting of fish occurred at a level of about 2.6 gal outboard motor fuel/ acre-ft of water or 8 gal fuel/million gal water, and a daily fuel-use rate of 0.17 gal/million gal water (0.055 gal/acre-ft). Threshold odor, carbon chloroform extractables and chlorine demand showed significant increases in the motor lake and motor pond through the season of outboard motor operation. All water samples from the motor lake and motor pond contained less than 10 ug/l of lead determined by polarograph.

992. Swader, F.H. (1975).

PERSISTANCE AND EFFECTS OF LIGHT OIL IN SOIL.

In: Conference on Prevention and Control of Oil Pollution pp. 589-594. Amer. Petrol. Inst. Wash., D.C.

Field plots were established in areas contaminated with flood-borne oil. Field crops were used as indicator crops, the yeilds being compared with published estimated yields for the same area and soil resource. Soil samples were analyzed annually to determine the quantities of oil remaining in the soil. Greenhouse experiments were also conducted to determine a threshold level of economic damage and the residual effects of such applications.

Oil penetration was approximately 24". The initial level of oil contamination was .2% by weight, but spectacular in appearance. Shallow rooted crops were less susceptible to damage by residual oil. Some residual effect was noted one year after contamination. Light fuel oils may affect crop growth at low application rates.

993. Swedmark, M. (1974).

TOXICITY TESTING AT KRISTINEBERG ZOOLOGICAL STATION.

In: Ecological Aspects of Toxicity Testing of Oils and Dispersants. (ed. L.R. Benzon and E.B. Cowell) John Wiley & Sons New York pp. 41-51.

This presentation describes the methods used by the Kristineberg Zoological Station (1) to determine the relative toxicities of oils and dispersants in standard form required by industry and government bodies, and (2) to provide predictions of the ecological consequences of pollution in marine environments.

994. Swedmark, M., B. Braaten, E. Emanuelsson and A. Granmo.

BIOLOGICAL EFFECTS OF SURFACE ACTIVE AGENTS ON MARINE ANIMALS.

Mar. Biol., 9:183-201.

The biological effects of 5 surface active agents (the anionic ABS, LAS and LES 3 EO and the nonionic NP 10 EO and TAE 10 EO) on marine fishes, crustaceans and bivalves have been tested in continuous-flow systems. Concentrations from 100 to 0.5 ppm were normally used. Fishes were found to be more susceptible (96 hr LC 50 range: 0.8 to 6.5 ppm) than bivalves (96 hr LC 50 range: 5 to > 100 ppm) while crustaceans were considerably more resistant (96 hr LC 50 range: 25 to > 100 ppm). Within each of these 3 systematic groups, more active species were found to be more sensitive than less active species. Developmental stages were also more sensitive than adults. The resistance of crustaceans to surfactants decreased immediately after moulting. The most toxic agent for fishes and decapods was the "soft" anionic LAS, and for bivalves and barnacles the "hard" nonionic NP 10 EO. Ability to recover normal behaviour after exposure decreases with increasing concentration and time, and ceases earlier in anionic than in nonionic surfactants. The first reaction to the surfactants is increased activity (avoidance reaction of mobile species), followed successively by inactivation, immobilization and death. Nonionic surfactants affect the equilibrium in fishes. Sublethal effects appear as impaired locomotory activity and breathing rate in fishes and crustaceans, impaired byssus activity and shell closure in *Mytilus edulis*, burrowing in *Cardium edule*, *Astarte montagui* and *Astarte sulcata*. Siphon retraction is affected in *Mya arenaria* and *Cardium edule*, as is also the response to food of the *Leander* spp.

995. Swedmark, M. B.A. Granmo and S.O. Kollberg. (1973).

EFFECTS OF OIL DISPERSANTS AND OIL EMULSION ON MARINE ANIMALS.

Water Res., 7:1649-1672.

The toxicities to marine animals of nine oil dispersants, three oil emulsions with Corexit and of a dispersion of Oman crude oil, have been studied in continuous flow aquarium systems at 96-h exposures followed by a recovery period in clean seawater. New types of dispersants were found to be less toxic than older types and oil emulsions more toxic than dispersants alone or crude oil alone. Fishes and bivalves were found most sensitive. Crustaceans were the most resistant to dispersants but very susceptible to oil emulsions. The tolerance of different species was found to be related to their mode of life, more active species being more susceptible. Delayed mortality of bivalves increased their susceptibility if the recovery period was included. Effects on locomotory behavior of fishes and crustaceans, breathing rate of fish, valve-closure of bivalves and byssal thread formation of common mussels have been demonstrated for both dispersants and oil emulsions. The general sequence of such effects was: increased activity; successively impaired activity; immobilization; and death. Recovery is good for fish and crustaceans but poor for bivalves due to the delayed effects. Ecological consequences of dispersants and oil pollution in the marine environment are discussed.

996. Tagatz, M.E. (1961).

REDUCED OXYGEN TOLERANCE AND TOXICITY OF PETROLEUM PRODUCTS TO JUVENILE AMERICAN SHAD.

Chesapeake Sci., 2:65-71.

Experiments were conducted on juvenile American shad, *Alosa sapidissima*, to indicate tolerance to reduced oxygen, toxicity of petroleum products, and toxicity of petroleum products with accompanying low dissolved oxygen. All mortalities in reduced oxygen tests occurred at dissolved oxygen values of less than 2 ppm with lethal concentrations varying with the rate of reduction. No mortalities occurred when dissolved oxygen was maintained between 2 and 4 ppm. TLm (median tolerance limit) values were determined for gasoline, diesel fuel oil, and bunker oil for 24- and 48-hour periods. Gasoline was the most toxic, fuel oil somewhat less toxic, and bunker oil least toxic. The

lethality of petroleum products to shad was found to increase when accompanied by low dissolved oxygen.

997. Tagger, S., L. Deveze, J. LePetit. (1976).

THE CONDITIONS FOR BIODEGREDATION OF PETROLEUM HYDROCARBONS AT SEA.

Mar. Pollut. Bull. 7:9 172-174.

The hydrocarbon degradation potential of seawater appears higher in zones chronically polluted by these materials; they are characterized by an abundant bacterial development. The salinity of the effluent from a refinery and also its hydrocarbon content are factors affecting the speed of degredation.

998. Takahashi, F.T. and J.S. Kittredge. (1973).

SUBLETHAL EFFECTS OF THE WATER SOLUBLE COMPONENT OF OIL: CHEMICAL COMMUNICATION IN THE MARINE ENVIRONMENT.

In: The Microbial Degradation of Oil Pollutants. D.G. Rhearn and S.P. Meyer, (eds.) Center for Wetlands Resources, Louisiana State University, Baton Rouge.

Crude oil and petroleum products contain water soluble components that are potent inhibitors of chemoreceptors in marine organisms. Since many species rely on chemoreception for location of food and sexual partners, disruption of chemoreception in the marine environment by oil spills can have profound effects on survival and reproduction. These effects on species survival will not be revealed in the usual toxicity (LD) studies of pollutants.

999. Tarzwell, C.M. (1967).

CRUDE OIL AND PETROLEUM PRODUCTS. pp. 108-119.

In: Interim Report on Water Quality Requirements for Fishes, Other Aquatic Life and Wildlife. Nat. Tech. Advisory Ctee., Washington.

1000. Tarzwell, C.M. 1969.

STANDARD METHODS FOR DETERMINATION OF RELATIVE TOXICITY OF OIL DISPERSANTS AND MIXTURES OF DISPERSANTS AND VARIOUS OIL TO AQUATIC ORGANISMS.

Proc. Joint Conference on the Prevention and Control of Oil Spills. (API/EPA/USCG), New York, NY pp. 179-186. Amer. Petrol. Inst. Wash. D.C.

It is the policy of the Federal Water Pollution Control Administration of the U.S. Department of the Interior that the relative toxicity of all chemical dispersants, both alone and in combination with oil, will be determined prior to their use for the dispersion of oil

spills, and the cleaning of beaches and shore installations. Data on the relative toxicity of these materials alone--and when mixed with oil--provide the basis for the effective selection of those materials least toxic to aquatic life and for recommending or prohibiting their use.

The Department takes the position that it is the responsibility of the manufacturer of such products to provide for their product alone and in oil mixture accurate tolerance limit values based on standard short-term bioassays with designated test organisms. The standard bioassay procedure used will be the one recommended by the FWPCA. This procedure is solely for the purpose of providing data which will indicate relative toxicity of dispersants and oil dispersant mixtures. These standard tests do not indicate the long-term toxicity of these materials to aquatic organisms, safe levels for the aquatic biota or for humans, nor do they constitute an endorsement of any material by the FWPCA.

1001. Tarzwell, C.M. (1971).

TOXICITY OF OIL AND OIL DISPERSANT MIXTURES TO AQUATIC LIFE.

In: Water Pollution by Oil. Institute of Petroleum, London. P. Hepple, (ed.) pp 263-272

Chemicals used for the dispersion of oil spills are much more toxic than the oil. The dispersant-oil mixtures are more toxic than the dispersant alone, and many-fold more toxic than the crude oil. In instances where it is necessary to disperse oil spills by the use of chemicals, the least toxic and most effective dispersants should be used. Relative toxicities of the various dispersants should be determined by means of standardized short-term static bioassays.

Field investigations and short-term toxicity studies have demonstrated that crude and refined petroleum oils and by-products are detrimental in a number of ways to aquatic organisms and their environment. While many surveys and studies have been made to determine the location, nature, and extent of damage and the acute toxicity of crude and other petroleum oils in the aquatic environment, data are entirely lacking on the concentrations of these materials in the aquatic environment which are not harmful with long-term or continuous exposure. Studies should be made to determine the uptake and concentration of petroleum hydrocarbons by marine organisms and to evaluate the extent of their incorporation into tissue and possible harmful effects.

1002. Tatem, H.E. and J.W. Anderson. (1973).

THE TOXICITY OF FOUR OILS TO PALAEMONETES PUGIO (HOLTHUIS) IN RELATION TO UPTAKE OF SPECIFIC PETROLEUM HYDROCARBONS.

Am. Zool., 13:1307-1308.

The effects of water-soluble fractions (WSFs) of Southern Louisiana (So. La.), Kuwait, #2 Fuel and Bunker C oils on Palaemonetes were tested. Bioassays were performed to determine the toxicities of the oils and provide information for sublethal experiments. WSFs were prepared by mixing a 10% solution of oil on water for 20 hours and the water phases were analyzed by infrared spectrophotometry. The 48-hour TLm values at 21°C showed that the crude oils (So. La., 16.8 ppm; Kuwait, 10.2 ppm) were less toxic than refined (#2 Fuel, 5.5 ppm) or residual oil (Bunker C, 3.43 ppm). Palaemonetes were found to be more sensitive to So. La. WSF at higher temperatures (48-hour Tlm, 15.9 ppm at 24°C; 10.7 ppm at 32°C). Tests were conducted using some specific hydrocarbons found in oil. The 48-hour TLm values were: benzene, 33.0 ppm; phenol, 20.0 ppm; naphthalene, (N), 2.35 ppm; methylnaphthalene (MN), 1.00 ppm; and dimethylnaphthalene (DMN), 0.70 ppm.

In uptake and depuration experiments, it was found that hydrocarbons were concentrated in the tissues of grass shrimp exposed to WSFs. However, when Palaemonetes survive initial exposure, depuration occurred. Animals exposed to 2.6. ppm WSF of #2 fuel (0.038 ppm DMN) for six hours contained 2.07 ppm DMN, while the DMN water concentration was 0.020 ppm. After 24 hours exposure in the same solution the tissues contained only 0.32 ppm DMN (82% decrease), while the DMN water concentration was 0.013 ppm. After 435 hours in clean, filtered sea water, grass shrimp contained 0.196 ppm DMN. Therefore, the more toxic oils contained higher proportions of N, MN, and DMN which are rapidly accumulated by Palaemonetes yet are readily released if the initial exposure is not lethal.

1002-A. Taylor, T.L., J.F. Karinen and H.M. Feder (1976).

RESPONSE OF THE CLAM, MACOMA BALTHICA (LINNAEUS), EXPOSED TO PRUDEHOE BAY CRUDE OIL AS UNMIXED OIL, WATER-SOLUBLE FRACTION, AND SEDIMENT-ADSORBED FRACTION IN THE LABORATORY.

In: Environmental Assessment of the Alaskan Continental Shelf. Principal Investigators' Reports for the Year Ending March 1976. Volume 8. Effects of Contaminants, p. 48-87.

The small clam, Macoma balthica (Linnaeus, 1758), occurs throughout the coastal area of Alaska in the upper 4-8 cm of intertidal mudflats. Because it is both a deposit and suspension feeder, M. balthica is potentially susceptable to oil slicks layered on the mud and to water-soluble or sediment-adsorbed fractions of crude oil. Oil adsorbed on sediment and allowed to settle over buried M. balthica stimulated movement to the surface. The proportion of clams that moved to the surface increased as the depth of oil-contaminated sediment increased. In tests many of the clams recovered from exposure, but in nature they might have fallen to predators of adverse environmental conditions. Data on the response of M. balthica to oil can be used in the evaluation of the organisms as an indicator of the effect of oil in the sediment environment.

1003. Teal, J.M. (1976).

HYDROCARBON UPTAKE BY DEEP SEA BENTHOS.

In: Sources, Effects and Sinks of Hydrocarbons in the Aquatic Environment. Proceedings of the Symposium American University, Washington D.C. Aug. 9-11, 1976 p. 358-365.

Preliminary results are presented of analyses of sediment and benthic animals collected from 5500 m to 5800 m depth on the Nares Abyssal Plain. The animals collected include holothurians, and the rattail (Nematonurus). The sediment hydrocarbons appear to have come from plants growing either on or near land. The petroleum evidence found in one holothurian and a galatheid probably arrived on the bottom as a tarball. Animals selectively absorb hydrocarbons from their environment.

1004. Teal, J.M. and J.J. Stegeman (1973).

ACCUMULATION, RELEASE AND RETENTION OF PETROLEUM HYDROCARBONS BY THE OYSTER CRASSOSTREA VIRGINICA.

In: Inputs, Fates and Effects of Petroleum in the Marine Environment. Background Information for the Workshop, Ocean Affairs Board, NSP, Airlie, Va. 21-25 May 1973.

The lipid content of oysters, as well as the concentration of petroleum hydrocarbons in the water column, affect the rate and extent of accumulation of those hydrocarbons. The hydrocarbons were rapidly but incompletely discharged when the oysters were placed in uncon-contaminated water. Amounts discharged and retained are probably related to the level of contamination. Equilibration and the occurance of multiple compartments are major factors in the uptake and accumulation of petroleum hydrocarbons. The Oysters themselves may modify the oil.

1005. Templeton, W.L. (1971).

ECOLOGICAL EFFECTS OF OIL POLLUTION.

J. Water Pollut. Control Fed., 43:1081-1088.

This paper is made up of short descriptions of fifty-six articles, with a complete bibliographical entry for each, on the following subjects related to oil pollution:

Nature and Scope of the Problem, Toxicity to Aquatic Organisms, Fate and Behavior of Oil, Field Studies, Effects on Birds, Biological Degradation.

1006. Templeton, W.L. (1972).

ECOLOGICAL EFFECTS OF OIL POLLUTION.

Journal Water Pollution Control Federation, 44:1129-1134.

A survey of 1971 literature is presented. Toxicity of oil and dispersants to aquatic organisms, and the fate and behavior of oil are discussed. The impact of various specific oil spills and cleanup methods on vegetation and animals, particularly on birds, were investigated. The possible use of biological degradation was also considered.

1007. Templeton, W.L., E.A. Sutton, R.M. Bean, R.C. Anett, H.J. Moore (1975).

OIL POLLUTION STUDIES ON LAKE MARACAIBO, VENEZUELA.

In: Conference on Prevention and Control of Oil Pollution. pp. 489-496. Amer. Petrol. Inst. Wash. D.C.

The results of a 2-year study on the impact of oil discharges on the fishery resources of Lake Maracaibo, Venezuela, are presented. The lake system is described, together with relevant water quality, hydrographic, ecological, and fishery resources data. Sources of other types of pollution, domestic and industrial, are described and their potential impact on the system are discussed. Analysis of environmental samples--water, sediments, and biota--showed low concentrations of oil in lake water and no detectable accumulation of petroleum-derived hydrocarbons in muscle tissue of selected commercial species. The occurrence of bituminous materials in the sediments, particularly in the oil production area, suggests that the natural processes of volatilization, biodegradation, and sedimentation are the major mechanisms for the removal of oil from the surface waters. Laboratory studies on the toxicity of oil indicate that relatively high concentrations of oil are required to cause mortality. Extraction of oil with the lake water, however, indicated that concentrations of total light aromatic fractions were toxic in the parts per million range. The rapid loss, in a few hours, of light hydrocarbons from surface films of oil to the atmosphere was shown to reduce the toxicity to organisms significantly. Examination of the limited fisheries data available does not suggest that the resources are being depleted. However, consideration of the potential impact of nonpetroleum wastes indicates that they are contributing to the degradation of the water quality which, if unchecked, may subsequently reduce the biological resources of the lake.

1008. Tendron, G. (1968).

CONTAMINATION OF MARINE FLORA AND FAUNA BY OIL, AND THE BIOLOGICAL CONSEQUENCES OF THE "TORREY CANYON" ACCIDENT

In: Proc. Int. Conf. Oil Poll. of the Sea, Rome, Oct. 7-9, 1968. J. Barclay-Smith, (ed.) pp. 114-121.

Birds especially suffer as a consequence of the spread of a thin film of oil on the surface. In the natural state, a bird's feathers are an efficient protection against loss of heat and provide resistance to cold in the atmosphere or during long immersion in water at temperatures near $0^{o}C$. But if the feathers are covered with oil the protective qualities are seriously diminished and the temperature of a bird which has lost its insulating cover falls rapidly in contact with the water, and the bird dies of hypothermia. Observations suggest that fish are inclined to desert contaminated areas and go to cleaner spots. On the seacoast the action of oil is more obvious on fish fry, causing a decrease in the numbers of certain species. In tidal areas natural mollusc beds become polluted and can no longer be used as a source of food; these molluscs have been found to contain traces of 3,4-benzopyrene, a known carcinogen. Under conditions of extremely intense oil pollution, there is a general impoverishment in the flora with a prominance of certain algae, the Phaeophyceae.

Crude oil in itself is not toxic in small quantities, nor is it directly corrosive, as after a certain time, both its volatile components and the phenols and cresols disappear. It does not contain 3,4-benzopyrene. Yet its physical effects are definite, depending upon the accumulation of oil products. The action of detergents is quite different, concentrations of as little as 1 ppm having a toxic effect on fish, crustacea and molluscs. The adding of detergents to oil also inhibits any bacterial degradation which might normally take place. These detergents are generally classified in ionic, anionic and cationic types, and the last, being particularly toxic, should be entirely prohibited.

1009. Thacher, P.S. and N. Meith-Aucin (1977).

THE OCEANS HEALTH AND PROGNOSIS.

In: Ocean Yearbook 1977. University of Chicago Press.

This review covers the pollutants which have been introducted into the oceans, their observed levels, predicted increase and effects on marine life. Also considered are the international policies devised to cocenter the threat to the oceans health.

1010. Thomas, M.L.H. (1973).

EFFECTS OF BUNKER C OIL ON INTERTIDAL AND LAGOONAL BIOTA IN CHEDABUCTO BAY, NOVA SCOTIA.

J. Fish. Res. Board Can. 30:83-90.

In February 1970, a large spill of Bunker C oil occurred in Chedabucto Bay, Nova Scotia. The incident was of particular interest since large spills of this type of oil had not previously been studied. Further interest was added by the unusually cold temperatures and by the nonuse of detergents in cleanup. The effects of the oil on intertidal and lagoonal biota have been followed since the accident. Many rocky shores and lagoons were heavily oiled. On exposed shores, oil has decreased steadily since oil stopped coming ashore in mid-1970 and by August 1971 only small amounts remained. In sheltered areas, particularly lagoons, heavy oil contamination remains. The summer remobilisation and subsequent redeposition of oil added a chronic aspect to the pollution. Initial effects of oil involved minor smothering of fauna and tearing loose of algae. Longer term effects involved extensive mortalities of *Fucus spiralis* on rocky shores and *Mya arenaria* and *Spartina alterniflora* in lagoons. Other biota were not visably affected.

In all three affected species, mortalities took place either continuously or only in the second year of pollution. Causes of death are unknown. It is recommended that in all intertidal areas very heavy oil deposits should be mechanically removed and the remainder of the oil left to natural degradation.

1011. Thomas, R.E. and S.D. Rice (1975).

INCREASED OPERCULAR RATES OF PINK SALMON (ONCORHYNCHUS GORHUSCHA) FRY AFTER EXPOSURE TO THE WATER SOLUBLE FRACTION OF PRUDEHOE BAY CRUDE OIL.

Journal of the Fisheries Research Board of Canada, 32 2221-2224.

The opercular rates of pink salmon (Oncorhynchus gorbuscha) fry were measured during 24-h exposure to sublethal concentrations of the water-soluble fraction of Prudhoe Bay crude oil. Opercular rates increased significantly for as long as 9 and 12 h after exposure to watersoluble fractions prepared from oil-water solutions of 2.83 and 3.46 ppm. The increases in rates appears to be a suitable method for detecting sublethal physiological effects of stress, because the observed changes occurred at approximately 20% of the 96 h-LC50.

1012. Thompson, Harold C. Jr., R.N. Farragut and M.H. Thompson (1977).

RELATIONSHIP OF SCARLET PRAWNS (PLESIOPENAEUS EDWARDIANUS) TO A BENTHIC OIL DEPOSIT OFF THE NORTH-WEST COAST OF ARUBA, DUTCH WEST INDIES.

Environ. Pollut. 13 239-253.

Catch data resulting from sampling efforts off the north-west coast of Aruba, Dutch West Indies, demonstrated a greater catch rate of crustacea in areas where benthic oily material was collected as compared to adjacent areas where there was no oil.

Scarlet prawns (Plesiopenaeus edwardsianus) were three times more abundant in the areas where benthic oil was found. They contained no isoprenoid hydrocarbons of the type common to most biological material or the type common to petroleum. However, they did contain an unusual n-paraffin hydrocarbon series (n-C_{22}, n-C_{25}, n-C_{28}, n-C_{31}, n-C_{34}) and in the areas where the benthic oily material was collected the prawns contained much greater quantities of the five n-paraffins given in the above sequence.

A probable explanation for the greater abundance of crustacea in the area affected by the oily material is discussed.

The accumulation and metabolism of hydrocarbons by marine organisms and how these processes relate to scarlet prawns are also discussed.

1013. Thompson, S. and G. Eglington. (1976).

THE PRESENCE OF POLLUTANT HYDROCARBONS IN ESTUARINE EPIPELIC DIATOM POPULATIONS.

Estuarine and Coastal Marine Science. 4(4):417-425.

Report on the presence of a complex mixture of aliphatic hydrocarbons in the organic extracts of three populations of Severn Estuary epipelic diatoms. Capillary gas chromatography and computerized gas chromatography/mass-spectrometry indicate that these aliphatic hydrocarbons distributions are similar to the characteristic crude oil-type aliphatic hydrocarbon distributions found in Severn Estuary sediments. Crude oil-type polynuclear aromatic hydrocarbons found in the sediment were absent in the diatoms. The possible routes of selective incorporation of pollutant hydrocarbons into epipelic diatoms, and the environmental significance of this process, are discussed.

1014. Thurberg, F.P. and E. Gould (1978).

SOME PHYSIOLOGICAL EFFECTS OF THE ARGO MERCHANT OIL SPILL ON SEVERAL MARINE TELEOSTS AND BIVALVE MOLLUSES.

In: In the Wake of the Argo Merchant. Proceedings of a Conference and Workshop held at the University of Rhode Island, Jan. 11-13 1978. Center for Ocean Management Studies, University of Rhode Island, Kingston, Rhode Island.

A variety of fish and bivalve mollusks were obtained during two research cruises subsequent to the Argo Merchant oil spill. The plasma ions and osmolality of the fish blood were tested. There did appear to be a disruption of plasma ions in winter flounder and yellowtail flounder. Yellow tail serum osmolality was significantly lowered. The bivalves were examined for tissue respiration, serum ions, and respiratory enzymes. Scallops (Placopecten) and horse mussels (Modiolus) collected during the first cruise exhibited depressed gill-tissue oxygen consumption. Serum sodium and calcium levels of scallops varied from those of controls. In scallop muscle, malic dehydrogenase activity and lactate oxidation were significantly lowered though pyruvate reduction remained the same. These observations on enzyme activity repression suggest a possible weakening of the ability to shift to anerobiosis.

1015. Ticehurst, N.F. (1938).

OILED BIRDS RESORTING TO FRESH WATER.

Brit. Birds, 31, 354-355.

1016. Tissier, M. and J.L. Oudin. (1973).

CHARACTERISTICS OF NATURALLY OCCURRING AND POLLUTANT HYDROCARBONS IN MARINE SEDIMENTS.

In: Proceedings, Joint Conference on Prevention and Control of Oil Spills. American Petroleum Institute, Washington, D.C., pp. 205-214.

Hydrocarbons spilled on the sea may, naturally or by sinking agent, settle on the sea bed and pollute marine muds which are the substratum of the benthic fauna and flora. They may be absorbed by these organisms which are the basis of the nutrition for a large part of the aquatic fauna. Thus, hydrocarbon pollutants will enter by this way in the marine food chain and raise the problem of long-term toxicity. Therefore, it is important to measure the quantity of hydrocarbons in the marine sediments in order to know the level of pollution. We must, however, be able to make the distinction between indigenous hydrocarbons and crude-oil derived hydrocarbons. Both contain, n and iso-alkanes and aromatics, but their quantity, the percentage of each type of compound and the distribution of some specific molecules are often very particular. A detailed analysis of the chloroform extract of the sediment by chromatography, mass spectrometry and U.V. fluroescence can discriminate between unpolluted and polluted sediments even in the case of low level pollution. The samples which have been analysed, were collected on the French coast of the English channel in Normandie and in the Seine Bay. The unpolluted samples contain a higher percentage of heavy products (resins and asphaltenes), as well as a more important odd carbon dominance in the n-alkanes distribution than in polluted samples. The aromatic fraction of the indigenous hydrocarbons is mainly composed of polycyclic aromatic hydrocarbons without alkyl chains whereas polluted samples show many types of alkyl-aromatics.

1017. Tittley, Ian (1972).

THE KENT COAST IN 1971.

Marine Pollution Bulletin 3(9):135-138.

During the first 4 months of 1971 a series of maritime accidents resulted in the subjection of 100 km of Kent coastline to continual heavy bouts of pollution by oil and detergent. These events are summarized in tabular form together with other less widely reported instances of oil pollution occurring during the same year. Methods and organization for clearing oil slicks are noted. The effects on marine algae and plants, fish, and birds are reviewed.

1018. Tokuda, H. (1977).

FUNDAMENTAL STUDIES ON THE INFLUENCE OF OIL POLLUTION UPON MARINE ORGANISMS. I. LETHAL CONCENTRATIONS OF OIL-SPILL EMULSIFIERS FOR SOME MARINE PHYTOPLANKTON. (IN JAPANESE)

Bull. Japan. Soc. of Scientific Fish. 43 97-102.

Lethal concentrations of 84 oil-spill emulsifiers for marine phytoplankton were determined by culture experiments in 1971, 1973, 1974 and 1975. Among 3 species of phytoplankton used, Skeletonema costatum was the most sensitive. The toxicity of the oil-spill emulsifiers reduced year after year due to improvement in their components.

1019. Tokuda, H. (1977).

FUNDAMENTAL STUDIES ON THE INFLUENCE OF OIL POLLUTION UPON MARINE ORGANISMS - II. LETHAL CONCENTRATIONS OF OIL-SPILL EMULSIFIER COMPONENTS FOR MARINE PHYTOPLANKTON. (IN JAPANESE).

Bull. Japan. Soc. Scientific Fish. 43 103-106.

The lethal concentrations of solvents and non-ionic surfactants used as oil spill emulsifiers were determined for two species of marine phytoplankton by culture experiments. Skeletonema custatum was ten times more sensitive than Nitschia closterium to most of the samples. The toxicity of petroleum solvents was dependent on their aromatic content. The surfactants with hydrophobic groups such as alkyl phenol and secondary alcohol were highly toxic. The ester type surfactants were less toxic than the ether type ones. Also, there is some relation between the toxicity and the HLB of non-ionic surfactants.

1020. Tokuda, H. (1977).

FUNDAMENTAL STUDIES ON THE INFLUENCE OF OIL POLLUTION UPON MARINE ORGANISMS - III, EFFECTS OF OIL SPILL EMULSIFIERS AND SURFACTANTS ON THE GROWTH OF PORPHYRA-LAVER. (IN JAPANESE).

Bulletin of the Japanese Society of Scientific Fisheries, 43 587-593.

The inhibitory effects of oil-spill emulsifiers (6 products) and non-ionic surfactants (4 products) on the growth of a laver, Porphyra yezoensis, were investigated by culture experiments. One oil spill emulsifier composed of n-paraffin and ester-type non-ionic surfactants was so low in toxicity that its 1 ppm solution supported a layer growth rate nearly similar to that of the control, and even its 100 ppm solution exhibited a growth rate higher than 50% of the control. Polyoxyethylene (20 mole) sorbitan trioleate, an ester-type surfactant, was the least toxic of the surfactants tested and allowed the layer to grow even at the concentration of 100 ppm, while polyoxyethylene (5 mole) nonyliphenol ether was the most toxic of the ether-type surfactants used and the laver was killed within 24 hours in its 10 ppm solution. The absorption spectrum of the laver frond was not affected by a 20 hour immersion in a 1000 ppm solution of either polyoxyethylene (2 mole) oleyl ether or polyoxyethylene (20 mole) sorbitan trioleate. Changes in the cellular appearance of the laver induced by immersion in surfactant solutions prepared at various concentration were also studied by means of microscopy.

1020-A. Traxler, R.W. (1973).

BACTERIAL DEGRADATION OF PETROLEUM MATERIALS IN LOW TEMPERATURE MARINE ENVIRONMENTS, PP. 163-170.

In: The Microbial Degradation of Oil Pollutants. Center for Wetland Resources, LSU, Baton Rouge, La., Publ. No. LSU-SG-73-01. Ahearn and Meyers (eds.)

Forty-nine hydrocarbon-utilizing species of bacteria were isolated at 16 to 17°C from Chedabucto Bay, and 72 from Narragansett Bay at 2.5 to 5°C. Sediments were a better source of organisms than water column samples. Data indicate that aromatic hydrocarbon-utilizers are capable of growth on aliphatic hydrocarbons, but that the majority of the bacteria isolated on aliphatic or mixed substrates utilize aliphatic but not aromatic hydrocarbons. Further, the hydrocarbon profile data show that marine bacteria exist which can utilize aliphatic straight and branched chain hydrocarbons, cyclic hydrocarbons, and aromatic hydrocarbons in the psychrophilic temperature range. Growth rates were found to be inversely proportional to temperature level.

1021. Ukeles, R. (1963).

THE EFFECT OF SURFACE ACTIVE AGENTS ON THE GROWTH OF MARINE PHYTO-PLANKTON.

J. Protozool., 10 (suppl.), 10.

1022. U.S. Coast Guard (1976).

FINAL ENVIRONMENTAL IMPACT STATEMENT LOOP DEEPWATER PORT LICENSE APPLICATION. 4 VOLUMES.

Department of Transportation, Coast Guard, Deepwater Ports Project, Office of Marine Environment and Systems, Washington, D.C.

These volumes describe the probable impact on the Louisiana offshore environment of the construction of an offshore oil port.

1023. U.S. Coast Guard (1976).

FINAL ENVIRONMENTAL IMPACT STATEMENT, SEADOCK DEEPWATER PORT LICENSE APPLICATION. 4 VOLS.

Department of Transportation, U.S. Coast Guard, Deepwater Ports Project, Office of Marine Environment and Systems, Washington, D.C.

These volumes assess the environment, describe the nature of a proposed deepwater port, and evaluate the probable impact of such an offshore oil port on the environment of the Texas continental shelf.

1024. United States Congress (1975).

EFFECTS OF MAN'S ACTIVITIES ON THE MARINE ENVIRONMENT.

U.S. Congress, Senate, Committee on Commerce, National Ocean Policy Study, 94th Congress, 1st session. Government Printing Office. 135 pp.

Subjects covered include an overall assessment of man's influence on the oceans; activities generating marine pollution, such as shipping, ocean dumping, municipal discharges and waste heat disposal; and specific marine pollutants, e.g., petroleum, chlorinated hydrocarbons, heavy metals and municipal wastes. The necessity of chemical, physical and biological baselines for monitoring marine pollution is emphasized. Some unilateral, bilateral and multilateral activities for controlling ocean pollution on the national and international levels are reviewed; UN activitis are summarized, including the Oil Pollution Convention of 1954 and the Geneva Convention of 1958. Acts passed or proposed by the U.S. Congress for controlling ocean pollution from 1899 to the present are discussed. The technology of pollution abatement is considered for chronic and accidental sources. Appendixes are included on harmful substances in the sea, and international organizations, conferences, and conventions on marine pollution.

1025. United States Congress (1975).

OIL TRANSPORTATION BY TANKERS: AN ANALYSIS OF MARINE POLLUTION AND SAFETY MEASURES.

Congress of the United States, Office of Technology Assessment. U.S. Government Printing Office, Washington, D.C. 288 pp.

This report includes description of the ecological impact of major tanker spills and a synopsis of the amounts, sources, and effects of oil pollution from tankers.

1026. U.S. Dept. of the Interior (1973).

<u>ESTUARINE POLLUTION: A BIBLIOGRAPHY</u>.

Water Resources Information Center, U.S. Dept. of the Interior. Bibliography Series WRSIC 73-205. 506 pp.

The information bases for the bibliography comprise only <u>Selected Water Resources Abstracts</u> (SWRA). The collection is comprised of a significant descriptor index, a bibliography with abstracts, an author index, and a comprehensive index. The data base had 50,631 abstracts covering SWRA through Dec. 15, 1972.

1027. U.S. Dept. of the Interior (1973).

<u>OIL SPILLAGE: A BIBLIOGRAPHY</u>, <u>Vol</u>. <u>I</u>.

Water Resources Scientific Information Center, Bibliography Series WRSIC 73-207. 390 pp.

The information bases for the bibliography comprise only Selected Water Resources Abstracts (SWRA). The collection is comprised of a significant descriptor index, a bibliography with abstracts, a comprehensive index, and an author index. The data base had 53,230 abstracts covering SWRA through Feb. 15, 1973.

1028. U.S. Naval Biomedical Research Laboratory (1973).

FATE OF HYDROCARBONS IN BEACH SAND.

Office of Naval Research Reference Number AD-758 740.

The fate of the petroleum hydrocarbons from Chevron bunker fuel was studied in natural beaches, sand-containing lysimeters, and laboratory experiments. The importance of various physical, chemical and biological processes for the dispersal and degradation of spilled bunker fuel was evaluated. Studies at 4 sampling locations on 3 beaches in the San Francisco area affected by oil from an 840,000 gal spill of Chevron bunker fuel showed that the size of the bacterial population and distribution of bacterial genera within the beach was unaffected by the petroleum hydrocarbons remaining in the beach sand after completion of the cleanup operation. A correlation between the background oil concentration and the bacterial population is suggested. The importance of bacterial degradation of the oil entrained within a beach was studied with lysimeters implanted in a beach to control erosion.

1029. U.S. Department of the Navy, Office of Naval Research (1975).

PROGRESS ABSTRACTS. MICROBIOLOGY PROGRAM.

Office of Naval Research. Washington, D.C.

This report contains abstracts of on-going research with the Office of Naval Research Microbiology Project. Included are nine abstracts of projects on oil pollution abatement involving biodegredation as a means of abatement, and use of bacteria as a bioindicator of pollution.

1030. Vaas, K.F. (1971).

OIL RAVAGES THE BIESBOSCH.

Mar. Poll. Bull., 2(4):51-52.

The Biesbosch is a large freshwater tidal area in Holland near the mouths of the Rhine and Meuse rivers, collectively referred to as Holland's Diep-Haringvliet. On the 27th of December, 1970, one of the four oiltanks of the Electric Power Station on the Southern bank of the river Meuse burst and spilled nearly 16,000 tons of crude oil into the Meuse. Ice blocked the samller creeks of the Biesbosch during the first few days, but higher temperatures later melted this ice so that the oil became more mobile, and large parts of the Biesbosch were polluted. Many of the 10,000 geese that usually overwinter in the Biesbosch were killed. Efforts were made to remove te oil both by mechanical means and by burning.

1031. Vale, G.L., et al. (1970).

STUDIES ON A KEROSENE-LIKE TAINT IN MULLET (MUGIL CEPHALUS). I. GENERAL NATURE OF THE TAINT.

J. Sci. Fd. Agric., 21:433-436.

A taint resumbling kerosene is sometimes present in mullet (Mugil cephalus) caught near Brisbane, Australia. It is not thought to be the same as the "petroleum" taint sometimes found in cod and salmon which is caused by the thermal decomposition of dimethyl-B-propiothetin to dimethyl sulphide. The "kerosene" taint is removed from the body tissue of mullet by solvent extraction and is associated with the hydrocarbon fraction of the extract. Tainted fish differ from untainted fish in that they have fat-infiltrated livers, a higher lipid content in fillets and a different fatty acid composition of both fillets and livers.

1032. Vanderhorst, J.R., R.M. Bean, L.J. Moore, P. Wilkinson, C.I. Gibson, and J.W. Blaylock. (1977).

EFFECTS OF A CONTINUOUS LOW-LEVEL NO. 2. FUEL DISPERSION ON LABORATORY-HELD INTERTIDAL COLONIES.

In: Proceedings 1977 Oil Spill Conference. p. 557-561. Amer. Petrol. Inst., Wash., D.C.

Marine intertidal colonies on concrete substrates were exposed for six months to 0.1 and 0.6 mg/1 No. 2 fuel oil (API Ref. Oil III, 38% aromatics). A continuous supply of the fuel oil dispersion was prepared by a mixing-separation apparatus, and nonfloating material was used as the contaminant. Monitoring of No. 2 fuel was by IR analysis of CCl_4 extracts. Supplementary analyses were performed by gas chromatography, helium partitioning gas chromatography and mass spectrometry.

Colonies were obtained by straitified random sampling from an initial 500 field-colonized bricks. Field colonization time was nine months. Replicates of treatment concentrations and controls were studied under constant continuous photoperiod. Initial colonies consisted of approximately 83 species of intertidal plants and animals.

Effects were measured by comparison of species diversity, relative abundance, numbers of species, and individual frequency of occurrence patterns. Species diversity was significantly lower in treated versus control colonies as was the total number of species. Relative abundance was not significantly affected. Individual species frequency of occurrence was significantly reduced in treated colonies; this was especially so for amphipods and decapods. Significant differences were not revealed for any biological parameter between the two treatment concentrations, although data from infrared analysis indicated the two concentrations were, in fact, different.

1033. Vanderhorst, J.R., C.I. Gibson, and L.J. Moore (1976).

THE ROLE OF DISPERSION IN FUEL OIL BIOASSAY.

Bull. of Environ. Contamin. and Toxicol. 15(1), pp. 93-100.

Mortality of coon stripe shrimp (Pandalus danae) was investigated in flowing water aquarium systems receiving measured "spills" of fuel oil with differing methods of seawater delivery and analytical characterization. The results obtained presented a data base for discussion of the influence of seawater delivery methods and dispersion of bioassay systems. The measuring of aqueous phase concentrations of No. 2 fuel oil and the mortality of shrimp when three different methods of oil-seawater contact were used were discussed.

1034. Vanderhorst, J.R., C.I. Gibson and L.J. Moore (1976).

TOXICITY OF NO. 2 FUEL OIL TO COON STRIPE SHRIMP.

Marine Pollution Bulletin, 7(6):106-107.

Bioassay of a No. 2 fuel oil dispersion with shrimp in a continuous flow system using measured waterborne oil as the indicator of oil concentrations reveals a treatment more definable than those previously described in terms of volume ratios and produces lower lethal concentrations. Shrimp 96-h LC_{50} was 0.8 mg/l in this study as compared to values from 1.5 to 50 mg/l reported for other methods. Mean concentrations in tests do not give significant differences in concentration with respect to day of the test or spatial distribution in the exposure tanks.

1035. Vanderhorst, J.R., C.I. Gibson, L.J. Moore and P. Wilkinson (1977).

CONTINUOUS-FLOW APPARATUS FOR USE IN PETROLEUM BIOASSAY.

Bull. Environ. Contam. & Tox. 17 577-584.

This paper describes a system built for long-term bioassay of dispersal petroleum derivative, with small amounts of insoluble material, in stable seawater conditions. The system was tested using No. 2 fuel oil. A discussion of the problems encountered and possible application of the system to crude oil is included.

1036. Van der Linden, A.C., and G.J.E. Thijsse. (1965).

THE MECHANISMS OF MICROBIAL OXIDATIONS OF PETROLEUM HYDROCARBONS.

Adv. Enzymol. 27:469.-546.

A review of the metabolic pathways of bacterial degredation of petroleum hydrocarbons.

1037. Vandermenlen, J.H. (1975).

1970 ARROW BUNKER C IN 1974: RE-ENTRY OF STRANDED BUNKER C OIL FROM A LOW-ENERGY BEACH INTO THE MARINE ENVIRONMENT.

In: Pacific Science Association: Thirteenth Pacific Science Congress: Record of proceedings, Vol. 1. Vancouver, B.C. Can.: University of British Columbia, pp. 85-86. (Abstract only).

Tidal and beach interstitial water, selected marine invertebrates and algae from Chedabucto Bay were analyzed by fluorescence spectroscopy. Bunker C levels in the tidal water column varied from 90μg/l over the tar deposit to <1.0ug/l offshore. In interstitial water, they ranged from 20ug/l (low tide line) to 400 gm/l in sediments near or underlying the tar deposits (high tide mark.) Mya arenaria showed a similar gradient, ranging from 5.8ug/g (wet wt) at low tide to 14.2ug/g at midtide. High levels persisted even after 60 d in oil-free circulating seawater. No contamination by Bunker C was detected in the common mussel. Significant levels of Bunker C were measured in the rooted eelgrass Zostera marina, but not in the attached kelp Fucus sp. In a low energy beach, the main route of tidal removal of stranded oil deposit appears to be via the beach sediments, where residence time is extremely long. The burrowing and rooted organisms, such as M. arenaria and Z. marina, are subjected continuously to high levels of petroleum hydrocarbons.

1038. Vandermeulen, J.H. and T.P. Ahern (1976).

EFFECT OF PETROLEUM HYDROCARBONS ON ALGAL PHYSIOLOGY: REVIEW AND PROGRESS REPORT.

In: Effects of Pollutants on Aquatic Organisms, A.P.M Lockwood (ed.) Cambridge University Press pp. 107-125.

This paper reviews the general physiological effects on unicellular algae of whole crude oils, distillate fractions, and some individual constituents. Also considered in some detail are the experimental problems associated with hydrocarbons and the errors in interpretation resulting from these problems. Finally, the effects of one specific oil constituent, naphthalene, on the stability of the algal photosynthetic machinery and on ATP production are discussed.

1039. Vandermeulen, J.H., P.D. Keizer and W.R. Penrose (1977)

PERSISTANCE OF NON-ALKANE COMPONENTS OF BUNKER C OIL IN BEACH SEDIMENTS OF CHEDABACTO BAY, AND LACK OF THEIR METABOLISM BY MULLUSCS.

1977 Oil Spill Conference Proceedings. p. 469-473.

Analysis of cores from a continuously oiled beach shows that seven-year old stranded Bunker C fuel oil re-entering the beach substrate is rapidly degraded. This weathering occurs throughout the top 15 cms of the beach sediments. The aromatic and cyclo-alkane components, however, appear resistant and unaltered. Thus the beach sediments act as effective n-alkane filters, but simultaneously become enriched with aromatic hydrocarbons.

Bivalves from these oiled sediments, and from other non-oiled areas were assayed for their ability to degrade aromatic hydrocarbons, and for their ability to respond to oil exposure by induced elevated levels of aryl hydrocarbon hydroxylase (AHH). Both non-oiled *Mya arenaria*, *Mytilus edulis* and *Ostrea edulis* esposed to aquenous extracts of Kuwait crude and a Bunker C fuel oil and *M. arenaria* and *M. edulis* from *Arrow* Bunker C oiled sediments lacked the AHH system, as shown by their inability to hydroxylate benzo(a)pyrene or demethylate 14C-imipramine.

Discussion is centered on the implications of this metabolic inability to degrade aromatic hydrocarbons in bivalves residing in aromatic enriched sediments.

1040. Vaughan, B.E. (1973).

EFFECT OF OIL AND CHEMICALLY DISPERSED OIL ON SELECTED BIOTA - A LABORATORY STUDY.

Bettelle Pacific Northwest Laboratories. America Petroleum Institute Publication No. 4191. American Petroleum Institute, Washington, D.C.

1041. Venezia, L.D. and V.U. Fossato (1977).

CHARACTERISTICS OF SUSPENSIONS OF KUWAIT OIL AND COREXIT 7664 AND THEIR SHORT AND LONG TERM EFFECTS ON *TISBE BULBISETOSA* (COPEPODS: *HARPACTICOIDA*).

Mar. Biol., 42, pp. 233-237.

A technique for preparing seawater suspensions of Kuwait oil and Corexit was developed. The resulting hydrocarbon concentrations were analyzed by gas-chromatography and spectrofluorometric methods and the stability of the suspensions with time was determined. It was established that the suspensions have an effective stability from Days 3 to 15 after preparation, since in this period the concentration remained within a relatively narrow range. Adult female Tisbe bulbisetosa appeared to be quite tolerant of this type of hydrocarbon syspension, in short-term experiments, especially considering that the concentrations used in the bioassays were about 200 times higher than those measured in a relatively polluted area of the lagoon of Venice. Long-term effects on number of eggs produced, number of nauplii and hatching success for females of the third and fourth generations, subject to continuous exposure, were negligible compared with controls. 18 ref.

1042. Vermeer, Kees (1976).

COLONIAL AUKS AND EIDERS AS POTENTIAL INDICATORS OF POLLUTION.

Mar. Pollut. Bull. 7:9 165-167.

Colonial auk (Alcid) populations can be used as indicators of the effects of oil pollution on the seabirds of Canada's coastal zones. Of approximately 11 million breeding colonial alcids in Canada and in adjacent West Greenland waters, 87% are murrs. Common Eiders may serve as the best indicators of the effects of oil pollution in Canada's western Arctic where colonial alcids are scarce.

1043. Vermeer, K. and R. Vermeer. (1975).

OIL THREAT TO BIRDS ON THE CANADIAN WEST COAST.

Canad. Field Naturalist, 89 278-298.

1044. Vermeer, K. and ANweiler, G. (1975).

OIL THREAT TO AQUATIC BIRDS ALONG THE YUKON COAST.

Wilson Bull., 87 467-480.

1045. Vermeer, R. and K. Vermeer (1974).

OIL POLLUTION OF BIRDS: AN ABSTRACTED BIBLIOGRAPHY.

Canadian Wildlife Service, Pesticide Section, Manuscript Report 29:1-68.

1046. Vernberg, F.J. et. al (ed.) (1977).

PHYSIOLOGICAL RESPONSES OF MARINE BIOTA TO POLLUTANTS SYMPOSIUM.

Academic Press, New York, N.Y. 462 p.

Topics concern the influence of petroleum products, heavy metals, pesticides and polychlorinated biphenyls on the physiology of marine organisms. Information is included on functional mechanisms involved in the response to pollutants either acting singly or synergistically with other pollutants and/or normal environmental factors.

1047. Vernberg, F. John and Winona B. Vernberg (eds.) (1974).

POLLUTION AND PHYSIOLOGY OF MARINE ORGANISMS.

Academic Press, New York 492 pp.

Papers presented at a symposium on the effects of pollution on the physiological ecology of estuarine and coastal water organisms. The section on oil and dispersants includes papers by Ahearn; Strahsaker, et. al; Anderson et. al; Heitz et al; Stegeman; Dunning and Major; and Roubal, listed separately in this bibliography.

1048. Voyko, Y.V. and Y.M. Petrev (1975).

ROLE OF MUSSELS *MYTILUS EDULIS* IN REMOVAL OF PETROLEUM PRODUCTS FROM SEAWATER (UNDER EXPERIMENTAL CONDITIONS).

Hydrobiological Journal 11 19-24.

Mussels contribute to the removal of petroleum oils from seawater because of their capacity to filter water and excrete pseudofeces which occlude particles of the oil. In tanks with mussels, the water was purified twice as fast as in control tanks. After 3 weeks only 7% of the initial amount of petroleum oil remained in the tanks. Of this amount about 1.4% was deposited on the bottom of the tank, 5.6% remained in the surface film, and 0.2% was still dissolved.

1049. Walker, J.D., *et al*. (1974).

EFFECTS OF PETROLEUM ON ESTUARINE BACTERIA.

Mar. Poll. Bull., 5:186-189.

The effects of petroleum on the natural microbial flora of a given environment, that is, on the bacteria, yeasts, filamentous fungi, and achlorophyllous algae, have largely been ignored. This paper represents the first recorded investigation of the impact of petroleum on ecologically important groups of bacteria.

1050. Walker, J.D., et. al. (1975).

BACTERIAL DEGRADATION OF MOTOR OIL.

J. Water Poll. Control Federation. 47(8): 2058-2066.

Oil discharged with the affluent of wastewater treatment plants will be susceptible to microbial degredation. In the natural environment, microorganisms present in the water column will most probably degrade more oil than will the microbial population present in sediment samples collected at the same site.

1051. Walker, J.D.; et. al. (1975).

EFFECTS OF POORLY METABOLIZED HYDROCARBONS ON SUBSTRATE OXIDATION BY *CLADOSPORIUM RESINAE*.

J. Appl. Bacteriol., 39:189-195.

Twelve hydrocarbons which singly support no growth or little growth of Cladosporium resinae were examined for their effects on utilization of four substrates which do support growth of the fungus. Of the 48 combinations of an oxidizable substrate with a potential hydrocarbon substrate, 8 combinations supported increased oxygen comsumption above the level obtained with the oxidizable substrate alone. There was no evidence of co-oxidation of the potential co-substrates toluene of p-xylene; their effects on increasing O_2-uptake appear to be due to permeability changes. With hexadecane alone, the ratio hexadecane oxidized to CO_2; hexadecane taken up by cells was 97:3. Addition of p-xylene or toluene decreased that ratio slightly to 96:4 and 89:11, respectively. These high ratios of hydrocarbon oxidized to hydrocarbon taken up may be advantageous during degradation of petroleum in the natural environment, since petroleum components could be degraded without formation of a large biomass.

1053. Walker, J.D., H.F. Austin and R.R. Colwell (1975).

UTILIZATION OF MIXED HYDROCARBONS SUBSTRATE BY PETROLEUM-DEGRADING MICROORGANISMS.

General and Applied Microbiology. 21 pp. 27-29.

This report describes the first comparative study of petroleum-degrading yeasts, fungi and bacteria and their ability to degrade to mixed hydrocarbon substrate. The mixed hydrocarbon substrate employed contained aliphatic, alicyclic, aromatic and polynuclear aromatic hydrocarbons. Most of the bacteria and all of the yeasts and fungi were isolated from Chesapeake Bay. Normal alkanes were found to be less susceptible to degradation by bacteria and yeasts as the carbon chain length of the hydrocarbon increased from 10 to 20. Results obtained for some of the fungi showed that there was little correlation between chain length of normal alkane and susceptibility to biodegradation. Cumane, naphthalene, phenanthrene, pristane, 1,2-benzenthracene, pristane, 1,2-benzenthracene, perylene and pyrene were found to be degraded by microorganisms. In general the patterns observed for hydrocarbon utilization were similar for the bacteria, yeasts and fungi. However, the utilization of hydrocarbons by individual isolates varied significantly. Such information may prove useful in assessing the hydrocarbon-degrading potential of microorganisms.

1054. Walker, J.D., J.J. Calomiris, T.L. Herbert, R.R. Colwell (1976).

PETROLEUM HYDROCARBONS: DEGRADATION AND GROWTH POTENTIAL FOR ATLANTIC OCEAN SEDIMENT BACTERIA.

Marine Biology. 34(1):1-7.

Water, sediment and microorganisms were sampled at stations along a trackline in the Atlantic Ocean off the North Carolina coast at depths of 9 to 5,000 m. Selected chemical and physical parameters were measured. At 3 of the stations, microorganisms isolated from sediment were examined for ability to degrade a number of petroleum hydrocarbons. Media made up with seawater or salts solution supplemented with nitrate and phosphate were employed in the degradation studies; significant growth and hydrocarbon degradation were observed. Bacteria from sediment samples collected at a depth of 5,000 m showed greater growth and hydrocarbon degradation when cultured in a seawater medium than in media made up with salts solution. Growth of bacteria in sediment samples collected at 2 stations was suppressed in seawater medium when a 1% (Vol/Vol) mixture of 19 different petroleum hydrocarbons was added. The hydrocarbon mixture was useful in determining the hydrocarbon-degrading potential of microorganisms isolated from the ocean environment.

1055. Walker, J.D., L. Cofone, Jr. and J.J. Cooney (1973).

MICROBIAL PETROLEUM DEGRADATION: THE ROLE OF CLADOSPORIUM RESINAE.

In: Conference on Prevention and Control of Oil Spills. pp. 821-826. Amer. Petrol. Inst. Wash. D.C.

Cladosporium resinae is probably the most prevalent hydrocarbon-utilizing fungus. It has been isolated in freshwater and marine environments. It utilizes aliphatic and aromatic hydrocarbons, as well as alcohols and acids. Growth on aliphatic hydrocarbons is slow, and yields are lower than for cells cultured on acids. However, degradation of hydrocarbons is not slow, since most of the hydrocarbon is mineralized (converted to CO_2) and not assimilated to cellular carbon. Growth of the fungus was not supported by organophosphorus-, chlorinated hydrocarbon-, or natural pesticides as sole carbon source. However, the fungus was resistant to or stimulated by high concentrations (20,000 ppm) of these pesticides when cultured on hydrocarbons. This suggests that high concentrations of pesticides occurring in oil slicks would not inhibit oil degradation by *Cladosporium resinae*. Cells oxidize aldehydes, although they did not grow on them. Release of $^{14}CO_2$ from D-glucose-1-^{14}C labeled cells was not greater in the presence of hydrocarbons than under endogenous conditions, indicating that intermediate and long-chain hydrocarbons are oxidized and do not stimulate endogenous respiration. Comparison of hydrocarbon oxidation by whole cells and cell-free preparations revealed the presence of an efficient cell-free oxidizing system. The pathway of hydrocarbon oxidation has been reported for hydrocarbon-utilizing bacteria and yeasts but not for fungi. Temperature, pH and co-enzyme requirements were determined for the oxidation of hydrocarbons by *C. resinae*. Isolation of intermediates and results of experiments utilizing electron transport inhibitors support the conclusion that in *C. resinae* alkanes are oxidized to their homologous alcohol, aldehyde and acid. The range of hydrocarbon substrates degraded by constitutive enzymes of Cladosporium resinae coupled with the ability to degrade hydrocarbons in the presence of high concentrations of pesticides suggests that C. resinae may be one of the most important microorganisms capable of degrading oil in the natural environment.

1056. Walker, J.D. and R. Colwell. (1973).

MICROBIAL ECOLOGY OF PETROLEUM UTILIZATION IN CHESAPEAKE BAY.

In: Conference on Prevention and Control of Oil Spills. pp. 685-690. Amer. Petrol. Inst., Wash. D.C.

Analysis of water and sediments collected at two stations in Chesapeake Bay demonstrated four to five times the concentration of petroleum in an oil pollution site in Baltimore Harbor compared with the station in Eastern Bay which served as a control. The numbers of petroleum-degrading microorganisms, measured by direct and replica plating, in the water and sediment samples were related to the concentration of oil in each sample. Total yields of petroleum-degrading microorganisms grown on an oil substrate were greater for those organisms exposed to oil in the natural environment. Microorganisms isolated from an oil-contaminated environment produced cell yields under "natural" conditions, i.e., laboratory simulation of growth conditions in the natural environment, which equaled the yields of microorganisms which had not been previously exposed to oil and were grown under optimum conditions. Microorganisms isolated from water and sediment samples collected in Baltimore Harbor grew on substrates representative of the aliphatic, aromatic and refractory hydrocarbons. The hydrocarbon-utilizing fungus, Cladosporium resinae and actinomycetes were predominant among the hydrocarbon-utilizing isolates. Microbial degradation of petroleum in Chesapeake Bay appears to be mediated by the autochthonous microbial flora, the seasonal incidence of which is presently under study:

1057. Walker, J.D., and R.R. Colwell. (1973).

PETROLEUM DEGRADATION: ECOLOGICAL ROLE OF MARINE MICROORGANISMS.

Abstr. Annu. Meet. Am. Soc. Microbiol., 73:33.

Analysis of water and sediments collected in Chesapeake Bay demonstrated four to five times the concentration of petroleum in an oil polluted site in Baltimore Harbor, compared with Eastern Bay. The numbers of petroleum-degrading microorganisms were related to concentration of oil in water and sediment samples. Total yields of petroleum-degrading microorganisms grown on oil were greater for organisms exposed to oil in the natural environment. Microorganisms isolated from an oil-contaminated environment produced cell yields under "natural" conditions, i. e., laboratory simulation of the natural environment, which equalled yields of microorganisms grown under optimum conditions. Microorganisms from Baltimore Harbor water and sediment grew on substrates representative of carbons. Cladosporium resinae and Actinomyces spp. were predominant among the hydrocarbon-utilizing isolates. These microorganisms were also isolated from Baltimore Harbor samples on media containing naphthalene and other refractory hydrocarbons.

1058. Walker, J.D. and R.R. Colwell. (1975).

A STUDY OF THE BIODEGRADATION OF A SOUTH LOUISIANA CRUDE OIL EMPLOYING COMPUTERIZED MASS SPECTROMETRY.

In: Conference on Prevention and Control of Oil Pollution. pp. 601-606.

Inocula from oil-contaminated Colgate Creek and oil-free Eastern Bay sediment produced similar growth on a South Louisiana crude oil. The Colgate Creek inoculum was found to contain a wider variety of bacterial genera and to produce greater degradation of South Louisiana crude oil than the Eastern Bay sediment inocula. The resin fraction of the crude oil increased during growth and weathering. All of the hydrocarbon classes of the crude oil were susceptible to degradation by microorganisms present in the Colgate Creek inoculum, but not by those in the Eastern Bay samples.

1059. Walker, J.D. and R.R. Colwell. (1975).

SOME EFFECTS OF PETROLEUM ON ESTUARINE AND MARINE MICROORGANISMS.

Can. J. Microbiol. 21:305-313.

Degradation of mixed hydrocarbon substrate in a system comprising water from an environment relatively free of oil and sediment inoculum from an oil-contaminated site was significantly greater than when sediment from the non-oil-contaminated environment served as inoculum. Mixed hydrocarbon substrate, however, was observed to have a limiting effect on the growth of antochthonous bacteria from the non-oil-contaminated estuarine source. Growth and cell yield were similarly reduced when marine sediment bacteria were cultured in seawater supplemented with mixed hydrocarbon substrate. The addition of a South Louisiana crude oil or a No. 2 fuel oil to water and sediment collected from a marsh area of Chesapeake Bay showed no limiting effects on growth of the total heterotrophic microbial flora when examined over a 28-day period. However, results of these studies indicate that the effects of petroleum on microorganisms should be examined carefully under conditions closely approximating those in situ.

1060. Walker, J.D. and R.R. Colwell. (1976).

MEASURING THE POTENTIAL ACTIVITY OF HYDROCARBON-DEGRADING BACTERIA.

Appl. Env. Micro., 31(2):189-197.

(14C) hydrocarbons were utilized as a means of estimating the hydrocarbon-degrading potential of bacteria in estuarine and marine environments. Evaporation of the hydrocarbons must be considered in estimates of oxidation. Amount of mineralization of (14C) hexadecane can be equated with the total number of petroleum-degrading bacteria and the percentage of the total heterotrophic population, which they represent. Mineralization activity was found to be related to the activity of the bacterial populations during in situ incubation. Rates of mineralization were observed, as follows, for (14C) hexadecane > (14C) naphthalene > (14C) toluene > (14C) Cyclohexane. Increased rates of uptake and mineralization were observed for bacteria in samples collected from an oil-polluted harbor compared with samples from a relatively unpolluted, shellfish-harvesting area, e.g. turnover times of 15 and 60 min for these areas, respectively, using (14C) hexadecane.

1061. Walker, J.C. and R.R. Colwell. (1976).

ENUMERATION OF PETROLEUM-DEGRADING MICROORGANISMS.

Appl. Env. Micro. 31(2):198-207.

A variety of factors, including concentration of oil, antibiotics, dyes and inoculum washes, were examined to determine their effect on the total counts of microorganisms on oil-containing media. The media found to be best for enumerating petroleum-degrading microorganisms contained 0.5% (vol/vol) oil and 0.003% phenol red, with Fungizone added for isolating bacteria and streptomycin and tetracycline added for isolating yeasts and fungi. Washing the inoculum did not improve recovery of petroleum degraders. Specially, silica gel-oil medium and a yeast medium are recommended for enumeration of petroleum-degrading bacteria and yeasts and fungi, respectively. It is suggested that counts of petroleum degraders be expressed as percentage of the total population rather than total numbers of petroleum degraders per se. Incubation temperature and presence of oil was found to influence the numbers of petroleum-degrading microorganisms at a given sampling site.

1062. Walker, J.D. & R.R. Colwell (1977).

ROLE OF ANTOCHTHONOUS BACTERIA IN THE REMOVAL OF SPILLED OIL FROM SEDIMENT.

Environ. Pollut. (12).

The concentration of oil in the sediment of Colgate Creek in Baltimore Harbor of Chesapeake Bay increased significantly after accidental oil spills. A month after a spill the concentration of oil in sediment diminished by ca. 75%. Biodegredation of petroleum hydrocarbons can be considered to contribute to the large decrease in benzene-extractable material in sediment samples collected after oil spills.

1063. Walker, J.D., R.R. Colwell and L. Petrakis (1975).

BACTERIAL DEGREDATION OF MOTOR OIL.

Water Pollution Control Federation Journal, 47(8):2058-2066.

Two stations in Chesapeake Bay were sampled to obtain microorganisms capable of degrading motor oil. Bacterial degredation of motor oil was examined by using sediment samples from oil-free and oil-contaminated environments as inocula. Inoculated cultures were incubated under conditions optimizing growth and, in parallel experiments, conditions simulating the natural environment. Cell yields and the extent of degradation of the motor oil were measured. The inocula from oil-contaminated environments produced greater growth on motor oil under simulated natural conditions than did inocula from oil-free environments cultures under optimum conditions. The extent of biodegradation ranged from 62% to 79% under optimum conditions and from 40% to 57% under simulated natural conditions.

1064. Walker, J.D., R.R. Colwell and L. Petockis (1975).

BIODEGREDATION OF PETROLEUM BY CHESAPEAKE BAY SEDIMENT BACTERIA.

Can. J. Microbiol. 22:423-428.

1065. Walker, J.D., R.R. Colwell and L. Petrakis (1975.).

DEGREDATION OF PETROLEUM BY AN ALGA, PROTOTHECA ZOPFIL.

Applied Microbiology 30(1) pp. 79-81.

Prototheca zopfii is an achlorophyllous alga which degrades oil. It has been found to degrade 10 and 40% of a motor oil and crude oil, respectively, when tested under appropriate conditions. Degradation of the crude oil observed in this study compares well with the amount of degradation accomplished by bacteria, P. zopfii was found to degrade a greater percentage of the aromatic hydrocarbons in motor oil than of the saturated hydrocarbons and a greater percentage of saturated hydrocarbons in crude oil than of aromatic hydrocarbons. Resins and asphaltenes were produced during degradation of motor oil, whereas these fractions in crude oil were degraded. P. zipfii did not demonstrate preferential utilization of low homologues of cycloalkanes and aromatics as has been observed with bacteria.

1066. Walker, J.D., R.R. Colwell, Z. Vaituzis, S.A. Meyer (1975).

PETROLEUM-DEGRADING ACHLOROPHYLLOUS ALGA PROTOTHECA ZOPFII.

Nature 254(5499):423-424.

The organism was found in Colgate Creek, an oil-contaminated site in Baltimore Harbor, and was isolated in axenic culture on silica gel oil medium. The organism degraded Louisiana crude oil when grown for 30 d in an estuarine salt solution overlaid with the oil. The utilization of specific hydrocarbons in a 17-component mixed substrate on 14-d incubation is tabulated. This is the first report of oil degradation by an algal species.

1067. Walker, J.D., P.A. Seesman, T.L. Herbert and R.R. Colwell (1976).

PETROLEUM HYDROCARBONS: DEGRADATION AND GROWTH POTENTIAL OF DEEP-SEA SEDIMENT BACTERIA.

Environ. Pollut., 10(2):89-99.

Marine sediment bacteria were found to be capable of utilising a mixture of 19 petroleum hydrocarbons, referred to as mixed hydrocarbon substrate (MHS). Autoclaving and the addition of sediment inoculum were found to change the concentration of inorganic nutrients (PO_4, NO_3 and NH_4) in seawater. The concentration of inorganic nutrients affected growth of sediment bacteria and their utilisation of MHS.

1068. Walker, J.D., P.A. Seesman and R.R. Colwell. (1975).

EFFECT OF SOUTH LOUISIANA CRUDE OIL AND NO. 2 FUEL OIL ON GROWTH OF HETEROTROPHIC MICROORGANISMS, INCLUDING PROTEOLYTIC, LIPOLYTIC, CHITINOLYTIC AND CELLULOLYTIC BACTERIA.

Environ. Pollut. Vol. 9:13-33.

Muddy Creek, a sub-estuary of the Rhode River in Chesapeake Bay, was examined to determine the susceptibility of the autochthonous microorganisms to South Louisiana crude oil and No. 2 fuel oil. Muddy Creek sediment was found to be free of contaminating oil. Crude oil and fuel oil induced little noticeable effect on the yeast and fungi populations, whereas the crude oil was found to support growth of bacteria and the fuel oil to limit such bacterial growth. Normalizing the values with reference to the control cultures revealed that both the crude and fuel oils were toxic for the bacteria. The crude oil showed greater toxicity.

1069. Walsh, J. (1968).

POLLUTION: THE WAKE OF THE TORREY CANYON.

Science, 160:167-169.

Except for serious effects on some species of seabirds, the oil spilled in the Torrey Canyon disaster was not lethal to flora and fauna. But detergents used to disperse the oil proved to be highly toxic, expecially to intertidal life such as limpets and barnacles. These dispersing agents are a mixture of a surfactant, an organic solvent, and a stabilizer. Solvent enabling the surfactant to mix with the oil contain a high proportion of aromatic hydrocarbons; the higher this proportion, the more effective is the emulsifier, and the higher is its toxicity to flora and fauna. In France, however, the use of detergents was avoided, the French choosing to rely upon waves, tides, and bacterial degradation. Powdered chalk was sown upon a large slick in the Bay of Biscay in order to bind the oil into particles, which sank to the bottom.

1070. Wang, R.T. and J.A.C. Nicol (1977).

EFFECTS OF FUEL OIL ON SEA CATFISH: FEEDING ACTIVITY AND CARDIAC RESPONSES.

Bull. of Environ. Contamin. and Toxicol., 18(2),pp 170-176.

The effects of No. 2 fuel oil on survival, feeding behavior and heart rate of sea catfish (Arius felis) were investigated. The LC50 for 96 h was 0.14 ml/l. Prior to death there was much damage to surface tissue. At 0.038 ml/l, feeding responses of catfishes deteriorated and the fish could not retain their food. Several minutes after adding fuel oil the heart rate slowed. Threshold was at 0.01 ml/l; at 0.1 ml/l bradycardia was pronounced and behavior of some fish was affected. 20 ref.

1071. Wardley-Smith, J. (ed.)(1976).

THE CONTROL OF OIL POLLUTION ON THE SEA AND INLAND WATERS. THE EFFECTS OF OIL SPILLS ON THE MARINE ENVIRONMENT AND METHODS OF DEALING WITH THEM.

Graham and Trotman, London. 251 pp.

This volume contains papers dealing generally with the control and effects of oil pollution. The first section treats the sources of oil pollution, bacterial degredation and environmental effect of oil and chemical agents.

1072. Warner, J.S. (1974).

QUANTITATIVE DETERMINATION OF HYDROCARBONS IN MARINE ORGANISMS.

In: NBS Special Publication 409, Marine Pollution Monitoring (Petroleum), *Proceedings of a Symposium and Workshop held at* NBS, Gaithersburg, Maryland, May 13-17, 1974. National Bureau of Standards. pp. 195-196.

This article describes a method for analysis of marine organisms for individual hydrocarbon components. The advantage of the method is the fact that relatively large numbers of samples may be analyzed. The procedure involves aqueous caustic digestion, ether extraction, silica-gel chromatography and gas chromatography.

1073. Warner, J.S. (1975).

DETERMINATION OF SULFUR-CONTAINING PETROLEUM COMPONENTS IN MARINE SAMPLES.

In: 1975 Conference on Prevention and Control of Oil Pollution Proceedings. American Petroleum Institute, Washington, D.C. pp. 97-101.

Sulfur-containing petroleum components such as benzothiophene, dibenzothiophene, naphthobenzothiophene and their alkyl derivatives are obtained along with aromatic hydrocarbons during the determination of hydrocarbons in marine samples. By using a sulfur-specific flame photometric detector in gas chromatographic analysis, the sulfur-containing components are determined separately from the aromatic hydrocarbons. Individual sulfur-containing components are identified by retention times and mass spectrometry.

It is shown that the fingerprint of sulfur-containing components can be more definitive of an oil source than the corresponding hydrocarbon fingerprint. It is also shown that sulfur-containing components can be preferentially concentrated in the marine environment. The techniques described have been used to identify and quantitate individual sulfur-containing compounds in marine tissue and sediment samples.

1074. Warner, J.S. (1976).

DETERMINATION OF ALIPHATIC AND AROMATIC HYDROCARBONS IN MARINE ORGANISMS.

Analytical Chemistry. 48(3):578-583.

A simple and sensitive procedure is described that is suitable for determining aliphatic and aromatic hydrocarbons in large numbers of samples of marine organisms. The procedure involves aqueous caustic digestion, ether extraction, silica gel chromatography and gas chromatography. Recoveries greater than 70% were obtained from organisms that contained petroleum components at levels of .1 to 10 mg/g. Many of the aromatic hydrocarbons were identified by chemical ionization mass spectrometry. The method is applicable to a wide variety of organisms.

1075. Watson, J.A., J.P. Smith, L.C. Ehrsam, R.H. Parker, W.C. Blanton, D.E. Solomon, and C.J. Blanton. (1971).

BIOLOGICAL ASSESSMENT OF A DIESEL SPILL, ANACORTES, WASHINGTON.

Final report, prepared by Texas Instruments for U.S. Environmental Protection Agency, Washington, D.C.

A survey to assess the biological damage resulting from the 26 April 1971 diesel spill at Anacortes, Washington, was conducted between May 9 and May 12, 1971. Analyses of samples of hydrocarbon content using gas chromatography clearly indicate diesel contamination of sediments and water in the high-impact areas. The evidence for environmental damage are both visual (oozing of oil from intertidal sediments) as revealed by photographs and verbal documentation and circumstantial as revealed by the detailed analysis of the faunal data collected during this study. Several common intertidal invertebrates (chitons, large limpets, large and small pelecypods, and large gastropods) and one fish (the common stickleback) were completely absent from the high-impact areas, although they were often collected or observed in 1958 and 1966 in the same region and locally reported to be common before the spill. The control area on Orcas Island was the richest of all regions sampled. Diversity indices illustrated that the lowest diversities were obtainted from the areas of largest visible amounts of oil.

1076. Weber, C.I., (1973).

BIOLOGICAL FIELD AND LABORATORY METHODS FOR MEASURING THE QUALITY OF SURFACE WATERS AND EFFLUENTS.

U.S. Environmental Protection Agency Publication EPA-670/4-73-001. 187 pp.

A manual was developed to provide pollution biologists with the most recent methods for measuring the effects of environmental contaminants on freshwater and marine organisms in field and laboratory studies which are carried out to establish water quality criteris for the recognized beneficial uses of water and to monitor surface water quality.

1077. Weiss, F.T. (1974).

FATE OF SPILLED OILS.

In: Marine Environmental Implications of Offshore Oil and Gas Development in the Baltimore Canyon Region of the Mid-Atlantic coast. Proceedings of Estuarine Research Federation Outer Continental Shelf Conference and Workshop. Estuarine Research Federation. p. 185-197.

This paper reviews the literature on the fate of spilled oil including microbial degredation, biochemical uptake metabolism, and discharge of oil and accumulation of oil in the food web.

1078. Wells, P.G. (1972).

INFLUENCE OF VENEZUELAN CRUDE OIL ON LOBSTER LARVAE.

Mar. Poll. Bull., Vol. 3:105-106.

Emulsions of crude oil are lethal to larvae of the American lobster at concentrations of 100 ppm and appear to have sublethal effects at concentrations down to 1 ppm.

1079. Wells, P.G. and J.B. Sprague. (1976).

EFFECTS OF CRUDE OIL ON AMERICAN LOBSTER LARVAE IN THE LABORATORY.

J. Fish Res. Bd. Can., 33(7):1604-1614.

Four-day LC50s for Venezuelan Tia Juana crude oil were 0.86 mg/liter for first-stage larvae of the American lobster (Homarus americanus) and 4.9 mg/liter for third- and fourth-stage larvae. The 30-day LC50 was 0.14 mg/liter for larvae starting the test in their first stage. The threshold for retardation of larval development was about the same as the 30-day LC50. Decreased food consumption was demonstrated at 0.19 mg/liter. More "intermediate" larvae developed in oil exposures but no threshold was estimated. The ratio of "safe" to acutely lethal concentrations was about 0.03.

Oil concentrations decreased during exposures; stated values could be multiplied by 0.59 to arrive at conventional average exposures. Stirring and ultrasonic vibration for 30 min dispersed averages of 7.4 and 18% of added oil. This and other techniques apparently dispersed similar components since toxicities were the same when based on measured concentrations. Aged dispersions were also equally toxic on a measured basis. Particles larger than 1.2 u made up 84-96% of the dispersed oil and were about one-third as toxic as smaller particles and dissolved oil. For the reference toxicant DSS, the 4-day LC50 was 0.72 mg/liter for first-stage larvae indicating that lobster larvae are sensitive. Post-larval lobsters dug significantly more burrows when the substrate contained oil but did not avoid oiled substrate nor was growth or survival affected for substrates containing up to 1740 mg/liter of oil.

1080. Wertenbaker, W. (1974).

ANATOMY OF AN OIL SPILL.

Marine Technology Society. Journal, 8(3):16-28.

The grounding of a barge on rocks in Buzzards Bay, near West Falmouth Harbor, on Sept. 15, 1969 resulted in a spill of 650-700 tons of No. 2 fuel oil. The travel of the resulting slick with time and varying weather is noted; visible effects on shore areas are correlated with kills of flora and fauna. A decline in animal population of $2x10^5$ to 2 individuals/m^2 was recorded in some areas; in some cases the effects on shore life were devastating where no visible pollution occurred. The long-term monitoring of the pollution and its effects on the marine community is delineated; biological damage was prominent after 2 yr. The relative ineffectiveness of all present means of dealing with oil after a spill is evident. The proposed equipment of tankers with separate ballast tanks and double bottoms to reduce pollution is discussed.

1081. Westree, Barbara (1977).

BIOLOGICAL CRITERIA FOR THE SELECTION OF CLEANUP TECHNIQUES IN SALT MARSHES.

Proceedings 1977 Oil Spill Conference p. 231-235.

During the removal of oil spills in salt marshes, intensive application of manpower and/or equipment may result in physical abuse and injury to the salt marsh far in excess of that caused by the oil itself. Physical characteristics of a salt marsh dictate the distribution and behavior of oil in the marsh. The salt marshes of the United States were grouped into categories based on their physical characteristics. The biological features of each marsh category most sensitive to oil contamination and state-of-the-art cleanup technology were identified. Types and degrees of effect of oils were similarly categorized. Techniques for cleanup were compared to the behavior of uncontained oil in the marsh and the potential for damage evaluated. Degrees of damage were compared and least damaging cleanup strategies selected.

1082. Wharfe, J.R. (1975).

A STUDY OF THE INTERTIDAL MACROFAUNA AROUND THE BP REFINERY (KENT) LIMITED.

Environ. Pollut., 9:1-12.

A study of the species composition and seasonal quantitative estimates of the mud flat fauna of the lower Medway estuary revealed the complete absence of bivalves and a reduction in the number of annelids, particularly Nereis diversicolor and the tubificid Peloscolex benedeni, around the foreshore of the BP Refinery (Kent) Limited.

Cores taken for particle size analysis, oil content, organic matter, redox potential and free sulphide ion levels show the extent of the effects to be restricted to an area approximately 1 1/2 km in either direction from the refinery outfall. Possible causes of the effects shown are discussed.

1083. Whelan, Thomas; John T. Ishmael, W.S. Bishop (1976).

LONG-TERM CHEMICAL EFFECTS OF PETROLEUM IN SOUTH LOUISIANA WETLANDS. -1. ORGANIC CARBON IN SEDIMENTS AND WATERS.

Mar. Pollut. Bull. 7:8 150-155.

The chemical effects of chronic petroleum input into a shallow water marsh were examined by measuring hydrocarbon levels and dissolved organic carbon content of sediments associated with two active oil fields in South Louisiana. Annual levels of total organic carbon in the surface waters of the oil fields were higher by 1 mg C/l in the salt marsh and 5 mg C/l in the fresh marsh than the respective control sites. Average dissolved organic carbon concentrations in the interstitial waters of cores taken within the oil field environments were 105% higher than the control in the salt marsh and 43% higher than the control in the fresh marsh. Significantly lower ratios of C_{17} to pristane occured in both oil field sediments; however, average odd-even predominance values were not indicative of petroleum contaminated sediments. The results indicate that microbial processes are responsible for dissolution of petroleum into dissolved organic carbon and that dissolved organic carbon concentrations may be a more significant measure of chronic petroleum input.

1084. White, P.T. (1971).

BAREHANDED BATTLE TO CLEANSE THE BAY.

National Geographic Mag., 139(6):866-811.

The Oregon Standard and Arizona Standard crashed near the Golden Gate Bridge in San Francisco Bay at 1:42 a.m., January 18, 1971. A total of 840,000 gallons of Bunker C oil was spilled into the Bay from the Oregon Standard. Barges, boats, and Army helicopters dropped tons of straw onto the oil to soak it up, and the straw was retrieved by barge-borne cranes, men with pitchforks in boats, and an army of volunteers on the beaches.

The tide coated mollusks with oil on Agate Beach, choking them. Many birds were affected. Half were western grebes, one fifth were scoters, and the rest included 27 other species. Rescused birds were bathed in mineral oil and dried in a flour and corn meal mixture, then force-fed a mixture of water, fish, antibiotics and vitamin B_1 by syringe. Even so, a survival rate of only three to five per cent was predicted. Some birds were taken to a special treatment center at a University of California warehouse in Richmond where they enjoyed a much higher survival rate of 31.9%.

1085. Wiebe, A.H. (1935).

THE EFFECTS OF CRUDE OIL ON FRESH WATER FISH.

Trans. Amer. Fish Soc., 65:324-350.

The effect of crude oil upon several species of fish was investigated. This invettigation confirms the mechanical action of crude oil. It has also been shown that crude oil contains a water soluble fraction which is very toxic to fish. The toxic properties of the water-soluble fraction of crude oil can be eliminated under experimental conditions by mechanical aeration. It follows from these experiments that the promiscuous discharge of crude oil and other waste oils into our natural bodies of water is detrimental to fish life and should be prohibited.

1086. Wihlm, J.L. and T.C. Dorris. (1966).

SPECIES DIVERSITY OF BENTHIC MACROINVERTEBRATES IN A STREAM RECEIVING DOMESTIC AND OIL REFINING EFFLUENT.

Am. Midl. Nat., 76:427-449.

A study was made of physiochemical conditions and benthic macroinvertebrate community structure in a stream receiving domestic and oil refinery effluents. Measures derived from information theory, diversity per individual and redundancy, were found to be more precise measures of stream conditions as reflected by benthic macroinvertebrate populations than traditional methods.

1087. Wilber, C.G. (1973?)

THE BIOLOGICAL ASPECTS OF WATER POLLUTION.

Charles C. Thomas, Springfield, Ill.

Chapter 6 of this volume reviews the biological effects of oil pollution.

1088. Wildish, D.J. (1974).

LETHAL RESPONSE BY ATLANTIC SALMON PARR TO SOME POLYOXYETHYLATED CATIONIC AND NONIONIC SURFACTANTS.

Water Research, 8(7):433_437.

Lethal response of Atlantic salmon parr, as 96-hr LD50, is semilogarithmically related to the number of moles of ethylene oxide in the polymethylateal surfactant. Evidence is presented which suggests that polymethylated esters with 18-20 moles of ethylene oxide are partially detoxified in the animal, resulting in changes in lethal response. Possible physiological explanations for the relationship between polyoxyethylene chain length and lethality involve uptake rates and attainment of a concentration of surfactant at the unknown active site.

1089. Wilson, D.P. (1968).

LONG-TERM EFFECTS OF LOW CONCENTRATIONS OF AN OIL-SPILL REMOVER ("DETERGENT"): STUDIES WITH THE LARVAE OF SABELLARIA SPINULOSA.

J. Mar. Biol. Ass. U.K. 48:177-186.

The "detergent BP 1002 at concentrations of 1 ppm was detected immediately by the larvae of Sabelleria spinulosa which were intensely irritated by it. In loosely covered vessels, allowing the solvent fraction to evaporate, larvae seemed at first to recover but died several seeks later, the control larvae remaining active and normal. The surfactant and stabilzer fractions at concentrations of 2.5 ppm killed the larvae within a day or two.

1090. Wilson, D.P. (1969).

TEMPORARY ADSORPTION ON A SUBSTRATE OF AN OIL SPILL REMOVER (DETERGENT): TESTS WITH LARVAE OF SABELLARIA SPINULOSA.

J. Mar. Biol. Assn., U.K., 48:183-186.

Sand was soaked for 90 min in sea water containing the "detergent" BP 1002 in concentrations of 1000 and 100 ppm (mg/1) and then thoroughly washed. Larvae crawling on it soon afterwards were damaged, but the toxic effect disappeared after some days.

1091. Wilson, K.W. (1970).

THE TOXICITY OF OIL-SPILL DISPERSANTS TO THE EMBRYOS AND LARVAE OF SOME MARINE FISH.

In: FAO Tech. Conf. Mar. Pollut., Rome, Italy. Paper E-45.
Also in: Marine Pollution and Sea Life. M. Ruivo (ed.), FAO, Fishing News (Books) Ltd. London. pp. 318-322.

Larvae of herring (Clupea), pilchard (Sardina), Plaice (Pleuronectes), Sole (Solea), Lemon sole (Microstomus) and haddock (Melanogrammus) were exposed to various concentrations of BP100Z oil dispersant. Toxicity, delayed effects and behavioral changes were monitored.

1092. Wilson, K.W. (1974).

TOXICITY TESTING FOR RANKING OILS AND OIL DISPERSANTS.

In: Ecological Aspects of Toxicity Testing of Oils and Dispersants, L.R. Benyen and E.B. Cowell, (ed.). John Wiley & Sons. New York. pp. 11-22.

This account describes some of the factors to be considered in establishing a standard technique of toxicity testing for ranking oil dispersants.

1093. Wilson, K.W. (1976).

EFFECTS OF OIL DISPERSANTS IN THE DEVELOPING EMBRYOS OF MARINE FISH.

Marine Biol. 36:259-268.

The effects of oil disperstants BP1002, Finasol ESK and Corexit 7664 on the development of herring, Clupea harengus L., plaice, Pleuronectes platessa L. and sole, Solea solea (L.) have been studied. Treatment of developing embryos for 100 h with BP 1002 and Finasol ESK gave rise to abnormalities in cell division and differentiation, to reductions in heart-rate, eye pigmentation, growth rate and hatching success above concentrations of 10 parts/10^6. Larvae with abnormal flexures of the spine, which prevented them from feeding successfully, resulted from exposure to 5 parts/10^6. Treatment of the embryos with dispersants throughout the period from fertilization to hatching (15 to 20 days) produced similar abnormalities at slightly lower concentrations. Corexit did not produce any demonstrable deleterious effects on embryos exposed to concentrations up to 5000 parts/10^6, the highest tested.

1094. Winters, K., J.C. Batterson and C. Van Baalen, (1977).

PHENALEN-1-ONE: OCCURENCE IN A FUEL OIL AND TOXICITY TO MICROALGAE.

Environmental Science and Technology, Vol. 11(3) p. 270-272.

Phenalen-1-one was isolated and characterized from the water soluble fraction of a No. 2 fuel oil. Phenahen-1-one had two very different effects on the growth of microalgae. With blue-green algae there was an abrupt toxicity, independent of wavelength, at 5 ppm. With blue green algae toxicity was strongly wavelength dependent. In white light 250 ppb was lethal; with the same lamp screened by a sharp-cut yellow filter (530 nm) growth rate was not affected until the concentration reached 10 ppm. The growth inhibition of a dilution by phenalen-1-one was also wavelength dependent, but the concentration required was some twenty fold that for green algae.

1095. Winters, K., R.O'Donnell, J.C. Batterton and C. Van Baalen (1976).

WATER-SOLUBLE COMPONENTS OF 4 FUEL OILS - CHEMICAL CHARACTERIZATION AND EFFECTS ON GROWTH OF MICROALGAE.

Mar. Biol. 36(3):269-277.

Approximately 50% of the compounds in the water solubles from 4 fuel oils were identified via gas chromatography and mass spectrometry. In addition to the well-described types of compounds (naphthalenes, benzenes) expected in water-soluble extracts, we have found phenols, anilines, and indoles. Of these classes of compounds methyl, dimethyl and trimethyl derivatives are present in relatively high concentrations. The water solubles from the 4 fuel oils showed considerably different inhibitory effects to growth of 6 microalgae, 2 blue-greens, 2 greens and 2 diatoms. Two of the fuel-oil extracts, Baytown and Montana were lethal to blue-green algae. This was in part traceable to their content of p-toluidine which was found to be toxic to Agmenellum quadruplicatum, Strain PR-6, lug in the algal lawn-pad assay and 100ug/l in liquid culture. The water-soluble fraction from New Jersey fuel oil was lethal to the 2 green algae, with lesser effects on the 2 blue-greens. The 2 estuarine diatoms used as test organisms were not greatly inhibited by Baytown, Montana or New Jersey fuel-oil water-soluble extracts. However, earlier work with an American Petroleum Institute fuel oil and the diatom Thallassiosira pseudonana (3H) showed that 3H was a very sensitive organism. Water solubles from the Baton Rouge fuel oil were almost without effect on the growth of all 6 microalgae. On the other hand, with water solubles from toxic fuel oils such as Baytown or New Jersey the data clearly suggest that their potential for environmental damage is high, either through selective or enrichment effects on natural populations or through a lowering of total primary production.

1096. Winters, K. and P.L. Parker (1972).

NATURAL AND MANMADE HYDROCARBONS IN THE OCEANS.

Proceedings Gordon Conference on Chemical Oceanography. New London, New Hampshire, 25 pp.

The presence of petroleum-derived organic matter in the Gulf of Mexico and other selected locations was investigated by measuring the abundance of paraffins in marine materials. Normal paraffin concentrations were higher in waters over the shelf than in the open ocean. Plankton were useful petroleum pollution indicators, especially in cases where single species could be collected at several locations. Higher organisms from the open sea did not appear to be highly polluted with petroleum. Transporting samples was a severe problem.

1097. Woodin, S.A., et al. (1972).

EFFECT OF DIESEL OIL SPILL ON INVERTEBRATES.

Mar. Poll. Bull., Vol. 3:139-143.

Transect surveys demonstrate the initial mortality from diesel oil spill of the fauna of a cobble beach, followed by major recolonization of oil sensitive species with planktonic larvae within six months. Spectrophotometric analysis shows apparent persistence of the oil in both the sediment and animal tissues.

1098. Wormald, Ann P. (1976).

EFFECTS OF A SPILL OF MARINE DIESEL OIL ON THE MEIOFAUNA OF A SANDY BEACH AT PICNIC BAY, HONG KONG.

Environ. Pollut. 11:117-129.

The meiofauna of littoral sandy beaches in Picnic Bay, Hong Kong, was almost totally destroyed within four days of pollution by a heavy marine diesel oil in November 1973, and recovery was monitored over the following 14 months. A few nematodes reappeared within one month of the spill but harpacticoids did not return in any numbers for 8 months, by which time the oil content had decreased by 50%. Apparently normal populations were established by September 1974, the lower shore supporting much larger numbers than the steeper, coarser and drier upper shore. By January 1975 Picnic Bay supported larger meiofauna communities than an unaffected shore, although numbers are lower than reported elsewhere at these lattitudes.

1099. Wragg, L.E. (1954).

EFFECT OF DDT AND OIL ON MUSKRATS.

Can. Field Nat. 68:11-13.

Fuel oil has a persistent and cumulative wetting effect on muskrats. The results of these tests suggest that the oil in which DDT is sprayed on marshes in which muskrats are living is likely to have a more deleterious effect on the animals than the DDT.

1100. Wright, A. (1976).

THE USE OF RECOVERY AS A CRITERIA FOR TOXICITY.

Bulletin of Environmental Contamination and Toxicology, Vol. 15, No. 6, p. 747-749.

State II nauplii of the barnacle Elminius modestus were exposed to various nonionic, anionic and cationic surfactants to determine the 30 min. EC50's producing immobility. On the basis of these tests, the relative toxicities of the different decyl surfactants would be in descending order, nonionic greater than anionic greater than cationic. In order to simulate environmental conditions in which concentrations of toxins would fluctuate and allow for recovery of the organism, nauplii were exposed to equitoxic concentrations of the decyl surfactants for thirty minutes and then placed in aerated sterile sea water. Observations of the condition of the nauplii for up to 48 hours showed lowest recovery from exposure to cationic surfactants, followed by anionic and nonionic. This sequence is the complete reverse of that determined on the basis of the 30 min.

1101. Wright, P. (1971).

HIGH POLLUTION TOLL OF SHETLAND SEABIRDS.

London Times, 3, June 7, 1971.

Mortality from oil pollution in seabirds' breeding colonies off the Shetland Islands may have been as high as 10,000. Most of the harm occurred around Bressay Island, in one of the most important breeding grounds for almost every species of northern European seabird. The source of the oil is not known, but it probably came from fishing vessels or their supply ship.

1102. Yarbrough, J.D., J.R. Heitz, and J.E. Chambers (1976).

PHYSIOLOGICAL EFFECTS OF CRUDE OIL EXPOSURE IN STRIPED MULLET, MUGIL CEPHALUS.

Life Sciences 19 755-760.

Juvenile mullet (*Mugil cephalus*) were exposed to a surface slick of Empire Mix crude oil for a three week period in a simulated estuarine ecosystem. Liver weight to body weight ratios were increased in the mullet from the oil-treated ponds when compared to those from the control ponds. Activities of alkaline phosphatase, which were elevated in gill and muscle of oil-treated mullet, and beta -glucuronidase, which was elevated in the muscle of oil-treated mullet, may be related to the degree of stress the animals were experiencing. Malic dehydrogenase, which was depressed in the livers and elevated in the muscle of oil-treated organisms, indicate changes in aerobic metabolism in response to the stress of crude oil exposure. Muscle acetylcholinesterase was not affected by oil exposure.

1103. Yee, J.E. (ed.) (1967).

OIL POLLUTION OF MARINE WATERS.

U.S. Department of the Interior, Department Library, Washington D.C. Bibliography No. 5. 27 pp.

This bibliography contains 253 selected references from the literature written on oil pollution from 1950 to 1967. THe bibliography has been arranged in broad subject categories. An author index is appended.

1104. Zajic, J.E., B. Supplisson, and B. Volesky (1974).

BACTERIAL DEGRADATION AND EMULSIFICATION OF NO. 6 FUEL OIL.

Environmental Science and Technology, 8(7):664-668.

Bacterial cultures were isolated from sewage which removed almost completely the paraffinic components from Grade 6 fuel oil (Bunker C oil). Of the major components in fuel oil, only the saturate fraction decreases during biodegradation. These microbes produce a very active emulsifying agent for Grade 6 fuel oil. This emulsifier is synthesized from the paraffinic components in the fuel oil. Oil globules are 3-16u size. This emulsifier appears to be a high-molecular-wt polysaccharide. Low temperatures and high salt levels tend to inhibit the emulsification process, although emulsification does occur. It would appear that the major emulsification process involved in a massive oil spill is attributed to microbial emulsification.

1105. Zechmeister, L. and B.K. Koe. (1952).

THE ISOLATION OF CARCINOGENIC AND OTHER POLYCYCLIC AROMATIC HYDROCARBONS FROM BARNACLES.

Arch. Biochem. Biophys., 35:1-11.

By chromatographic resolution of certain barnacle extracts (Tetraclita squamosa rubescens) several crystalline fractions, all intensely fluroescent, were obtained containing anthracene, phenanthrene, chrysene, fluoranthene, 1,12-benzperylene, and 3,4-benzpyrene. The latter fraction showed a strong carcinogenic effect in mice. The compounds mentioned do not represent normal metabolic products of the barnacles studied but probably originate from tarry materials floating along the Southern California coast.

1106. Zitko, V. (1971).

DETERMINATION OF RESIDUAL FUEL OIL CONTAMINATION OF AQUATIC ANIMALS.

Bull. Environ. Contam. and Tox., 5:559-564.

Chromatography and spectroscopy have been used to identify and measure crude oil and petroleum products in water. Crude oil and petroleum products cause unpleasant tainting of fish and shellfish, but only a few papers describe the determination of these materials in aquatic animals. This paper describes a simple spectrofluorometric method for the quantitative determination of heavy residual fuel oil (Bunker C) in aquatic animals.

1107. Zitko, V. and S.N. Tibbo. (1971).

FISH KILL CAUSED BY AN INTERMEDIATE OIL FROM COKE OVENS.

Bull. Environ. Contam. Toxicol. 6(1):24-25.

Intermediate oil from coke ovens was identified as the causative agent in a large kill of herring (Clupea harengus) in North Sydney Harbour, Nova Scotia. The distribution of oil in the tissues indicates that the oil was taken up primarily through the body surface.

1108. Zitko, V. (1975).

AROMATIC HYDROCARBONS IN AQUATIC FAUNA.

Bull. Env. Contam. & Tocicol., 14(5):621-631.

A rapid method for screening of aquatic fauna for the presence of polynuclear aromatic hydrocarbons is described. The mixture of hydrocarbons is separated from lipids by column chromatography on alumina, characterized and quantitated by fluorometry with pyrene as a fluorescence standard. The method can be used to detect contamination of aquatic fauna by crude oil, fuel oils, and creosote oil. The detection of crude, Bunker C, and creosote oil in the described method is approximately 100, 50 and 100 microgram/gram lipid, respectively. Polynuclear aromatic hydrocarbons of these oils were not detectable in samples of fish and seals. Creosote oil in concentrations ranging from 202 to 3254 micrograms/gram lipid was detected in the samples of shellfish.

1109. Zobell, C.E. (1946).

ACTION OF MICROORGANISMS ON HYDROCARBONS.

Bacteriology Review, 10 pp. 1-49.

This review article covers mineral requirements of hydrocarbon oxidizers, effect of oxygen tension, effect of organic matter, temperature requirements, dispersion of hydrocarbons in culture media, criteria of hydrocarbon utilization, oxidation products, kinds of hydrocarbons attached, occurence of hydrocarbon oxidizers in nature, microbial modification of oil, modification of petroleum products, action on rubber hydrocarbons, activities of hydrocarbon oxidizers in the soil, microorganisms as indicators of oil deposits, bacteriostatic hydrocarbons and derivatives.

1110. ZoBell, C.E. (1950).

ASSIMILATION OF HYDROCARBONS BY MICROORGANISMS.

Adv. Enzymol., 10:443-486.

A review of the subject including a description of experimental methods; the occurence of hydrocarbon-oxidizing organisms; the action of hydrocarbons on microorganisms; microbial oxidation of gaseous hydrocarbons; the relative oxidizability of different classes of hydrocarbons; the action of microorganisms on hydrocarbon derivatives; the products of hydrocarbon oxidation; microbial modification of petroleum and its products; microbial decomposition of rubber hydrocarbons; assimilation of hydrocarbons by animals; and the production of hydrocarbons by microorganisms.

1111. ZoBell, C.E. (1962).

OIL POLLUTION IN THE SEA.

Jour. WPCF, 34(3):259-260.

The oil pollution problem is worldwide. Boat harbors, bays, beaches, and estuaries and even the open sea in some places are polluted with various kinds of oily substances, ranging from thin liquid films to large lumps of tarry solids. Mineral oils predominate. Sources of oil polluting the sea include: ships using their cargo or fuel tanks for carrying oil and carrying salt water alternately; wash waters, wrecks, bilge water, and accidental spills; discharge from engines during normal operation; submarine seepage; and terrestrial drainage.

Oil in the sea immobilizes water fowl by penetrating to the skin, thus displacing air in the feathers and destroying their natural insulation and buoyancy. Health and marketability of shellfish may be affected, but only in highly localized areas does the well-being or food supply of fish appear to be affected. Seaweeds and phytoplankton are also injured. Oils have a relatively high oxygen demand, which may result in oxygen depletion of the water.

The movement, modification and persistence of oil at sea are influenced by many factors, including the presence or absence of mocroorganisms. In general, emulsified materials, oils absorbed on solids, and thin films of oil are much more susceptible to autoxidation and microbial decomposition than are thick layers or lenses of oil, and virtually all types are susceptible to microbial oxidation. Microbial oxidation is most rapid when the HC molecule is in intimate contact with waters, and at temps, ranging from 15 to 35°C. An average of one-third of the HC may be converted into bacterial cells.

1112. Zohell, C. (1964).

THE OCCURRANCE, EFFECTS AND FATE OF OIL POLLUTING THE SEA.

Adv. Water Pollut. Res. 3, 85-109.

1113. Zobell, C.E. (1969).

MICROBIAL MODIFICATION OF CRUDE OIL IN THE SEA.

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BIOLOGICAL EFFECTS OF OIL POLLUTION - A OMPREHENSIVE BIBLIOGRAP--ETC(U)
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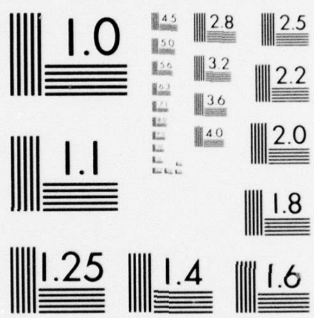

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

In: Proceedings of a Joint Conference on Prevention and Control of Oil Spills, pp. 317-336, American Petroleum Institute, Wash, D.C.

Virtually all kinds of hydrocarbons and crude oils from many fields are susceptible to microbial oxidation. More than a hundred species of bacteria, yeasts, and fungi are able to oxidize hydrocarbons. Each species is limited in the kinds of hydrocarbons it can attack. Each species is also limited by the temperature, salinity, surface tension, pH, oxygen tension, and other environmental conditions at which it is biochemically active. Environmental conditions also affect the rate of microbial reproduction and oil oxidation. Enrichment cultures, consisting of several different species growing under optimal conditions, tend to convert crude oils and refinery products mainly to carbon dioxide and microbial biomass. From 10 to 90 per cent of the carbon may be converted into microbial biomass.

Oil-oxidizing bacteria are most abundant in coastal waters and mud where oil pollution is chronic. Such bacteria are extremely scarce in the open sea. In unpulluted waters the ratio of oil oxidizers to the total bacterial population in marine environments ranges from 1:100 to 1:10,000. In chronically oil-polluted coastal areas from 5 to 50 per cent of the bacteria may be able to oxidize one or more kinds of hydrocarbons. In such areas, bacteria in well-oxygenated waters might oxidize oil at rates ranging from 0.02 to 2 grams per square meter per day at 20^{o} to $30^{o}C$.

1114. ZoBell, C.E. (1971).

SOURCES AND BIODEGRADATION OF CARCINOGENIC HYDROCARBONS.

Proceedings of Joint Conf. on Prev. & Contr. of Oil Spills, pp. 441-451, American Petroleum Institute, Washington, D.C.

Carcinogenic hydrocarbons (CHC) are widely distributed in air, soil, marine mud, water, oils (vegetable as well as mineral), and other materials. Most organisms appear to contain little or no CHC, but from 1 to more than 1,000 ug/kg has been detected in certain plants and animals. A major source of CHC is the combustion or pyrolysis of carbonaceous materials, including fossil fuels, organic refuse, forest fires, etc. Airborne, liquid, or solid pollutants tend to find their way into soil, streamsm lakes and the sea. Pertinent to the problem of oil spills is the quantity of CHC contributed by such spills as compared with that from aerial transport, terrestrial drainage, biosysthesis of CHC and other sources.

Evidence is presented for the synthesis of carcinogenic hydrocarbons by various species of bacteria, algae, and higher plants. Although some may be retained by their tissues, a good many animals metabolize various carcinogenic hydrocarbons and excrete the oxidation products. In most aquatic environments as well as in moist aerobic soil, bacteria bring about the degradation of CHC.

1115. ZoBell, C.E., C.W. Grant and H.F. Haas. (1943).

MARINE MICROORGANISMS WHICH OXIDIZE PETROLEUM HYDROCARBONS.

Bull. Amer. Assoc. Petrol. Geol. 27(9):1175-1193.

Bacteria are found in the sea which are capable of utilizing petroleum ether, gasoline, kerosene, lubricating oils, crude oils, petrolatum, paraffine wax, mineral oil, methane, pentane, hexane, decane, trimethylpentane, tetratriacontane, benzene, xylene, toluene, cyclohexane, anthrocene, naphthalene, and other hydrocarbons. Sea water from the euphotic zone contains 10 to 1,000 hydrocarbon oxidizing bacteria per liter, and 100 to 100,000 such bacteria have been found per gram of recent marine sediments. All samples of sediments regardless of distance from land, water depth, or core depth have shown the presence of hydrocarbon-oxidizing bacteria. Most of the bacteria oxidize hydrocarbons only in the presence of free oxygen although some of them can utilize nitrate as a hydrogen acceptor. Possibly some of them can activate sulphate as a hydrogen acceptor. Hydrogen sulphide in concentrations exceeding 0.0001 mol per liter inhibits the bacterial oxidation of petroleum hydrocarbons.

Within certain limits long-chain hydrocarbons are oxidized more readily than those of smaller molecular weight and aliphatic compounds are more susceptible to bacterial oxidation than cyclic or aromatic hydrocarbons. Compounds with unsaturated bonds are attacked more readily than saturated compounds. Carbon dioxide, methane, organic acids, and bacterial protoplasm are among the products resulting from the bacterial utilization of petroleum hydrocarbons. Species of Proactinamyces, Actinomyces, Pseudomonas, Micromonospora, Mycobacterium and possibly other genera of marine microorganisms are able to oxidize hydrocarbons.

Although the reaction will take place in an aqueous system, the presence of sand, silt, diatomaceous earth and other inert adsorbents accelerates the bacterial oxidation of hydrocarbons. Samples of crude oil added to marine sediments are radpidly destroyed under aerobic conditions. The activity of hydrocarbon-oxidizing bacteria, which appear to be widespread in occurrence, may account for the failure of certain workers to find petroleum hydrocarbons in sediment samples. Similarly such bacteria might prevent the accumulation of detectable quantities of hydrocarbons in experiments with mixed cultures designed to demonstrate the transformation of organic matter into hydrocarbons. Our work suggests that one might expect to find oil accumulating in recent sediments or in experimental material only if conditions are inimical to the activity of hydrocarbon-oxidizing bacteria.

1116. ZoBell, C.E. and J.F. Prokop. (1966).

MICROBIAL OXIDATION OF MINERAL OILS IN THE BARATARIA BAY BOTTOM DEPOSITS.

Z. Allg. Mikrobiol. 6:143-162.

It was observed that mixed microflora from Barataria Bay mud brought about the reduction of sulfate and also the gradual destruction of mineral oil under strictly anaerobic conditions. Only a small percentage of the enrichment and pure cultures of sulfate-reducing bacteria studied were active in mineral media enriched with mineral oil as the sole source of energy.

1116-A. Zobova, H.A., L.G. Solenova, H.D. Mazmanidi, and A.P. Il'nitskiy (1976).

ACCUMULATION OF BENZ(A)PYRENE BY SOME BLACK SEA ORGANISMS UNDER EXPERIMENTAL CONDITIONS.

Oceanology, 16(3):259-261.

The mussel *Mytilus galloprovincialis*, the whiting *Odontogadus merlangus*, and the pickeral *Spicara smaris* were exposed to this carcinogen at about 0.01 and 0.1u g/1 of seawater for 96 hr. The mussels but not the fish accumulated the compound. The gall bladder was the principal site of accumulation of benz(a)pyrene and its metabolites.

1117. Zoutendyk, P. (1972).

OIL POLLUTION OF THE CAPE INFANTA COASTLINE.

Zool. Afr., 7:533-536.

Observations on oil pollution over the past 24 years have been made along the Cape Infanta coastline. Although no shipping disasters have occurred in the area, the oil cover of the rocks has increased markedly in places, with signs of affecting the intertidal fauna. It is concluded that the cumulative pollution by oil under present conditions may in time produce results similar to those encountered after large oil spills.

1118. Zsolnay. A. (1973).

HYDROCARBON AND CHLOROPHYLL: A CORRELATION IN THE UPWELLING REGION OFF WEST AFRICA.

Deep Sea Res. 20:923-925.

A significant linear correlation (r=0.63,<<0.001) between the non-aromatic hydrocarbons and the chlorophyll-a content in the euphotic zone of the water off West Africa existed between 4 March and 10 March 1972. This showed that the hydrocarbons present were the result of phytoplankton activity. The line of the estimating equation tended to go through the origin, indicating that the hydrocarbons in the euphotic zone were not due to a pollution source.

1119. Zsolnay, A. (1974).

HYDROCARBON CONTENT AND CHLOROPHYLL CORRELATION IN THE WATERS BETWEEN NOVA SCOTIA AND THE GULF STREAM.

Proceedings Symp. at Gaithersburg, MD May 13-17, 1974. U.S. Dept. of Commerce, National Bu. Standards. Spec. Publ. No. 409. pp 255-256.

Samples were taken on the CSS Dawson during a cruise and chlorophyll content of phytoplankton was determined. Results show that hydrocarbon content decreases greatly as the chlorophyll concentrations become high. This indicates a feedback mechanism between amount of phytoplankton and concentration of hydrocarbon material. These studies indicate that a casual relationship exists between the hydrocarbon and chlorophyll concentrations in the euphotic zones.

1120. Zsolnay, A. (1973).

THE RELATIVE DISTRIBUTION OF NON-AROMATIC HYDROCARBONS IN THE BALTIC IN SEPTEMBER 1971.

Marine Chemistry, 1(2):127-136.

The relative distribution of the total nonaromatic (saturated and olefinic) hydrocarbons and of the total saturated hydrocarbons was determined for the central Baltic in Sept. 1971. Only a 1-l. sample was required. The hydrocarbons were removed with liquid-liquid extraction, purified with liquid chromatography, and then determined by a micro-adsorption detector. Since hydrocarbons in nature are a complicated mixture, it was impossible to determine their absolute concentration. The results give the concentration in respect to a standard, consisting of water extracted from the Kiel Bight. The hydrocarbons originated largely in situ at the sediment-water interface, presumably synthesized by anaerobic bacteria. Low hydrocarbon values appeared in regions that would favor the presence of aerobic bacteria.

1121. Albers, P.H. (1977)

EFFECTS OF EXTERNAL APPLICATIONS OF FUEL OIL ON HATCHABILITY OF MALLARD EGGS.

In: Fate and Effects of Petroleum Hydrocarbons in Marine Ecosystems and Organisms, D.A. Wolfe (Ed.), Pergamon Press, N.Y., 1977. pp 158-163 (12 refs.)

An experiment was performed to determine the toxicity of oil to incubating eggs. Number 2 fuel oil, a mixture of 9 paraffin compounds, and propylene glycol were applied to the surface of artificially incubated mallard (*Anas platyrhynchos*) eggs. Seven groups of 50 eggs each were treated with 1, 5, 10, 20, and 50 ul of fuel oil, 50 ul of the paraffin mixture, and 50 ul of propylene glycol. Fifty untreated eggs served as a control. Microliter syringes were used to apply the liquid around the air cell end of the egg on the 8th day of incubation. Embryonic mortality was significantly greater ($P \leq 0.01$) in all oil treated groups and the paraffin mixture group than in the control group. Most of the embryonic mortality for the oiled eggs occurred within 72 hours of treatment. Hatching and post-hatching (4 weeks) weights of the ducklings in all treatment groups were not significantly different ($P \leq 0.01$) from the control. Thus, the transfer of even small quantities of oil to the egg surface is sufficient to reduce hatchability.

1122. Albers, P.H. and R.C. Szavo (1977)

EFFECTS OF EXTERNAL APPLICATIONS OF NO. 2 FUEL OIL ON COMMON EIDER EGGS

In: Fate and Effects of Petroleum Hydrocarbons in Marine Organisms and Ecosystems, D.A. Wolfe, Ed., Pergammon Press, p. 164-167, 1977. 4 tab, 13 ref.

Because eggs of marine birds may be exposed to oil adhering to the feathers of adult birds, a study was undertaken to determine the effects of oil contamination. Two hunderd common eider eggs were divided into four experimental sets of 50 each. Two sets were treated with No. 2 fuel oil in amounts of 5 microliters to 20 microliters of propylene glycol, a neutral blocking agent. The fourth set served as a control. Hatching success was 96 percent for the eggs treated with 20 microliters propylene glycol, 96 percent for the controls and 92 percent for the eggs treated with 5 microliters oil hatched. Only 69 percent of the eggs treated with 20 microliters of oil survived a significant reduction in hatchability (P 0.05). Mean Hatching weights for all sets were statistically equal. Thus, oil pollution may significantly increase embryonic mortality in marine birds.

1123. Albers, P.H. and R.C. Szaro (1978)

EFFECTS OF NO. 2 FUEL OIL ON COMMON EIDER EGGS.

Marine Pollut. Bull., Vol. 9 No. 5, pp 138-139, May 1978.

An oil spill near a breeding colony could result in the transfer of oil from the plumage and feet of incubating birds to their eggs. Microlitre amounts of No. 2 fuel oil were applied externally to common eider eggs in an island breeding colony in Maine. Clutches of eggs treated with 20 ul of fuel oil had significantly greater embryonic mortality than the control clutches when they were examined 7 days after treatment. The results are similar to those of an earlier study of artificially incubated common eider eggs and indicate that nest site conditions do not affect embryotoxicity of No. 2 fuel oil.

1124. Alexander, M.M., P. Longabucco, D.M. Phillips (1978)

THE ECOLOGICAL IMPACT OF BUNKER C OIL ON FISH AND WILDLIFE IN ST. LAWRENCE RIVER MARSHES

In: Proceedings of Conference on Assessment of Ecological Impacts of Oil Spills, Keystone, Col., 14-17 Jun 1978.

The marshes in the bays of the St. Lawrence River were impacted to varying degrees with No. 6 bunker oil from the NEPCO 140 barge on June 23, 1976. The clean-up process began immediately but it was abundantly evident that the fish and wildlife had suffered extensive losses.

A follow-up investigation, funded by EPA, is now entering its second year. This study includes the total economic and social impact as well as the ecological impact of the oil on fish and wildlife in the marsh areas. The current report covers the findings of the first year's investigation of the ecological impact of the oil on the fish and wildlife in the marsh ecosystem. It includes both biological and chemical analyses.

The objectives of the study are: (1) to determine the relative abundance and diversity of various groups of biota on comparable oiled and unoiled marshes. (2) To determine the presence, movement and concentration in the food web of polynuclear aromatic hydrocarbon compounds and their potential for influencing fish and wildlife populations.

Seven similar cattail marsh areas were selected for study. Two of these areas were heavily oiled, two moderately oiled, two slightly oiled and one unoiled. Because the thick number 6 bunker oil only penetrated a few meters into the dense vegetation at the marsh edge, the investigation was centered on the marsh-bay interface. The greatest attention was given to (a) those species having a small home range (benthos and frogs) and (b) the young of species with greater mobility that had not yet moved (fish, ducks and muskrats). A wide variety of known sampling and marking techniques were used in determining diversity and abundance.

Samples for chemical analysis were taken at various times from the study sites. These included bottom mud, cattail roots, cattail tops, tissues of young ducklings and muskrats, young frogs, young fish and petroleum residual in the environment. All equipment and containers were washed with cyclohexane. Samples were frozen and shipped by air to the analytical laboratory. The presence and the amounts of polynuclear aromatics were determined by high pressure liquid chromatography. The peaks were identified through the use of a mass spectrometer.

The impact of the oil on the fish and wildlife of the marsh community seems to be more subtle than outwardly apparent. There appears to be a slight drop in species diversity on the more heavily oiled areas.

For fish species the major documented difference involved the juvenile large mouth bass which were rare or absent in the more heavily oiled areas. No noticeable differences in amphibians or retiles were recorded. However, precise measurements were not possible due to a lack of adequate sampling methods.

The unoiled or slightly oiled areas tended to have the greater waterfowl populations. However, all areas supported ducks and some of the heavily oiled areas were quite productive. Little measurable difference in the mammal populations could be attributed to the level of oil impact.

The impacted edge of cattail stands grew taller and more rapidly than the unimpacted cattails. However, the impacted stands did not produce floral heads, whereas unimpacted stands were in full bloom.

The chemical analyses indicted the presence and some accumulation of some polynuclear aromatics in the food chain. However, the separation of normal biological compounds from petroleum derived compounds was not always clear.

The lack of prior base-line data from the specific marshes in this study makes it difficult to draw precise conclusions. Based on this first year's study, it appears possible that the long range impact of number 6 bunker oil on fish and wildlife in the St. Lawrence River marshes may be of the same general magnitude as that found to be present between two similar marshes along the River with their individual ecological variabilities.

1125: Anderson, J.M. (1977)

RESPONSES TO SUBLETHAL LEVELS OF PETROLEUM HYDROCARBONS: ARE THEY SENSITIVE INDICATORS AND DO THEY CORRELATE WITH TISSUE CONCENTRATION

In: Fate and Effects of Petroleum Hydrocarbons in Marine Organisms and Ecosystems. D.A. Wolfe, (Ed.), Pergammon Press, p. 95-114, 1977.12 fig, 2 tab, 63 ref.

A reivew of recent literature on the sublethal effects of various hydrocarbon pollutants was presented. Numerous technical problems encountered in laboratory analyses were addressed. Considerable emphasis was placed on the difficulty of inter-study comparisons due to varying experimental designs.

1126. Anderson, J.W., L.J. Moore, J.N. Blaylock, D.L. Woodruff, and S.L. Kiesser (1977)

BIOAVAILABILITY OF SEDIMENT-SORBED NAPHTHALENES TO THE SIPUNCULID WORM, PHASCOLOSOMA AGASSIZII

In: Fate and Effects of Petroleum Hydrocarbons in Marine Organisms and Ecosystem. D.A. Wolfe, (Ed.), Pergammon Press, p. 276-285, 1977.2 fig, 4 tab, 11 ref.

The peanut worm was exposed to petroleum hydrocarbons from Prudhoe Bay crude (PBC) oil. Uptake and release of naphthalene and alkylnaphthalenes were compared for worms exposed to hydrocarbons in solution, oil on the surface of sediments and oil mixed in sediment. Sipunculids exposed for 24 hr to a water-soluble fraction of PBC contained from 2 to 10 times the concentration of naphthalenes initially in the water. Depuration of naphthalenes was rapid when worms were transferred to clean water and/or sediment. After two weeks of depuration, both water- and sediment-exposed worms released napthalenes to background levels. From these results it does not appear that significant bioaccumulation of naphthalenes occurs from hydrocarbon fractions bound to sediment.

1127. Anom (1977)

CONTAMINATION SHORT-LIVED FOLLOWING NORTHEAST SPILL

Petroleum Engineer, Vol. 49, No. 6, June 1977, pp. 11-12.

Material submitted by many organizations on the effects of the December 1976 oil spill off the coast of Massachusetts was compiled and analyzed by NOAA's Environmental Data Service. Number 6 fuel oil did not enter the water column, but tended to form large pancakes, and oil detected in the water column was lightweight cutter stock. No oil contamination greater than 250 ppb was observed, and no oil was observed on the ocean floor beneath the spill. Spilled oil contaminated zooplankton components of the oceanic food web near the wreck. Pollock eggs collected near the spill were contaminated, with a high proportion of dead, moribund, and deformed embryos, and sand lance larvae appeared impacted by oil contamination with the spill zone. The economic impact of the oil spill cannot be assessed fully without additional study.

1128. Arhelger, S.D., B.R. Robertson, and D.K. Button (1977)

ARCTIC HYDROCARBON BIODEGRADATION

In: Fate and Effects of Petroleum Hydrocarbons in Marine Organisms and Ecosystems. D.A. Wolfe, Ed., Pergammon Press, p. 270-275, 1977.2 fig, 4 tab, 16 ref.

Supplemented sterile sea water was inoculated with small sample volumes of raw sea water and exmined for oil related microbial activity. A ubiquitous Alaskan water microbial population of 10 to the 3rd power to 10 to the 5th power/1 was indicated. Population estimates were based on the smallest sample volume that, when diluted into a supplemental sea water medium, produced cultures that would generate colonies on agar plates, became turbid, formed ATP, or disrupted added oil slicks.

1129. Atlas, R.M. (1977)

STUDIES ON PETROLEUM BIODEGRADATION IN THE ARCTIC

In: Fate and Effects of Petroleum Hydrocarbons in Marine Organisms and Ecosystems. D.A. Wolfe, Ed., Pergammon Press, p. 261-269, 1977.1 fig. 6 tab, 6 ref

Microorganisms capable of biodegrading petroleum were found to be widely distributed in the Beaufort and Chukchi Seas, but to constitute only a low percentage of the indigenous heterotrophic microbial populations. Concentration of hydrocarbon utilizing microorganisms were lower in ice than in water of sediment. Hydrocarbon biodegradation potential was also lower in ice than in water of sediments. Rates of biodegradation were found to be limited by temperature and concentrations of available nitrogen and phosphorus. Residual oil had similar percentages of hydrocarbon classes as fresh oil; biodegradation of all oil component classes, including paraffinic and aromatic fractions, apparently proceeded at similar rates.

1130. Ayers, R.W. (1978)

EFFECTS OF THE BARGE STC-101 SPILL ON SHALLOW WATER INVERTEBRATES OF LOWER CHESAPEAKE BAY

In: Proceedings of Confer. on Assessment of Ecological Impacts of Oil Spills, Keystone, Col., 14-17 June 1978.

On February 2, 1976 approximately 250,000 gallons of #6 fuel oil were discharges into lower Chesapeake Bay after the barge STC-101 sank in a storm near the mouth of the Potomac River. The oil spread over beaches and marsh areas on both eastern and western shores of the bay. The eastern shore was the most severely affected with hundreds of miles of marsh and beach shoreline coated with thick, tar-like oil. A clean-up effort netted approximately 167,000 gallons of oil from intertidal areas by scraping beaches and harvesting marsh vegetation. Oil was left on the fragile marsh surfaces and inaccessible subtidal substrates.

Forty stations were sampled along ten transects perpendicular to the shoreline on both eastern and western shores of the Chesapeake Bay. Because there were no background or pre-spill data on benthic populations in the affected areas, samples were collected from oiled and non-oiled sites with comparable environments. Substrate samples were collected using grab core devices from intertidal and subtidal environments. Macroinvertebrate populations were quantitatively examined and sediment particle size analyses were conducted at each station.

Normal analysis of the intertidal stations resulted in two major clusters, the tidal creek stations and the fringing marsh stations. Only one station exhibited signs of adverse effect which could have been caused by the oil. Inverse analysis revealed an assemblage of organisms typical of intertidal areas. The three subtidal depths were analysed in a similar manner. Particular attention was paid to station clusters or populations assemblages which might have resulted from the spilled oil. The results indicated that invertebrate assemblages occured according to the area sampled. The types and numbers of organisms varied as one moved from shallow sand to eelgrass beds or deeper sandy substrates. No effects attributable to the oil spill could be detected at the subtidal stations.

The shoreline invertebrate populations appeared to have escaped any catastrophic damage as a result of the February 1976 oil spill. One heavily oiled marsh area was slow to recover but in general any ecological damage from this oil spill was short-term and of a low magnitude.

1131. Batterton, J.C., K. Winters, and C. Van Baalen (1977)

TOXICITY OF CRUDE OILS AND FUEL OILS PRESENTED DIRECTLY TO MICROALGAE

Journal of Phycology. Report No. 13, 1977. International Seaweed Symposium, Phycological Soc. of America and Internat. Phycological Soc.

Crude oils were much less inhibitory than fuel oils to the growth of a green alga, a blue-green alga and a diatom. Baton Rouge and New Jersey fuel oil samples were toxic, but the Montana fuel oil was nontoxic. Heating (90 deg-110 deg C) detoxified the fuel oils. Chemical analyses of the nontoxic and toxic fuel oils before and after heating were compared to determine what compounds might be involved. Classes of aromatic compounds not accountable for the toxicity of whole fuel oils included naphthalenes, methylnaphthalenes, dibenzothiophenes, phenanthrenes, and compounds with volatilities greater than methylnaphthalenes. The accumulated chemical data suggests that the toxicity of these fuel oils is due to the less water-soluble compounds in the higher boiling aromatic fraction. Earlier work with water soluble fractions of these fuel oils showed reversed toxicity patterns to growth due to other types of compounds.

1132. Beynon, L.R. and E.B. Cowell (1974)

ECOLOGICAL ASPECTS OF THE TOXICITY TESTING OF OILS AND DISPERSANTS

Applied Science Publishers, Ltd., Essex, England. 149 pp. (Book)

CONTENTS: 1. Introduction. 2. Oils and dispersants: chemical considerations. 3. Toxicity testing for ranking oils and oil dispersants. 4. Toxicity tests for predicting the ecological effects of oil and emulsifier pollution on littoral communities. 5. Toxicity testing at Kristineberg Zoological Station. 6. Effects on community metabolism of oil and chemically dispersed oil on Baltic bladder wrack, Fucus vesiculosus. 7. Toxicity testing at the Station Marine d'Endoume. 8. A method for testing the toxicity of suspended oil droplets on planktonic copepods used at Plymouth. 9. Toxicity testing at the Biologische Anstalt, Helgoland, West Germany. 10. A critical examination of present practice. 11. The toxicity testing of oils and dispersants: a European view.

1133. Bieri, R.H., and Stamoudis (1977)

THE FATE OF PETROLEUM HYDROCARBONS FROM A NO. 2 FUEL OIL SPILL IN A SEMINATURAL ESTUARINE ENVIRONMENT

In: Fate and Effects of Petroleum Hydrocarbons in Marine Organisms and Ecosystems. D.A. Wolfe, (Ed.), Pergammon Press, p. 332-344, 1977.2 fig, 4 tab, 24 ref.

Oysters, Crassostrea virginica, and clams, Mercenaria mercenaria, were exposed to surface spills of No. 2 fuel oil in an estuarine area under seminatural conditions. The results showed that accomodated petroleum hydrocarbons in water reach their maximum concentration a few hours after the spills and then disperse very rapidly. Most hydrocarbons were below detection 25 hours after the spills. In oysters, while substantial hydrocarbon concentrations were present within 6 hours after the spill, uptake continued in some cases past 100 hours for both branched aliphatic and aromatic hydrocarbons, and appeared to be related to molecular weight. Clams acquired hydrocarbons at much lower concentrations than oysters.

1134. Birchard, E.C., G. Greene, A. Telford, and S.A.M. Conover (1978)

ASSESSMENT OF THE ECOLOGICAL EFFECTS OF AN OIL SPILL IN AN OFFSHORE SUB-ARCTIC ENVIRONMENT

In: Proceedings of Confer. on Assessment of Ecological Impacts of Oil Spills Keystone, Col., 14-17 June 1978.

The waters of the eastern Canadian arctic and sub-arctic, specifically Baffin Bay, Davis Strait and Labrador Sea hold the potential for some of the largest, but as yet undiscovered, oil and gas formations remaining in Canada. A large portion of the offshore waters have been leased to petroleum companies by the canadian Government and extensive seismic operations have been carried out with results similar to the geological formations found in the North Sea. On the Greenland side, in Danish waters, offshore exploration has been in progress now for a number of years.

Since 1976 a program of field studies and investigations have been undertaken for the southern portion of the Davis Strait and nearby waters to gather data that will assist in designing the technology of a drilling system and which will be used to assess the ecological implications of drilling in the area, with primary concern for the effect of an underwater blowout. Limited historical information was available for the flora and fauna of the area from earlier scientific expeditions and from the diaries of voyagers, whalers, and sealers. Data collection in this recent program has been carried out by shipboard surveys and sampling, aerial surveys, and shorebased ground surveys. Information was obtained on microbiota, phytoplankton, zooplankton, zoobenthos, fish (eggs, larvae & adult), marine mammals and birds. Representative shoreline sites along the south-east coast of Baffin Island were systematically sampled for biological productivity.

In addition, the collection of physical and chemical oceanographic data, along with meteorological and climatological data, was complied to prepare a series of fate of oil sceanaries for various oil spill blowouts. Based on these scenarios (i.e. the worst-case situation) the probable ecological effects were identified using the baseline information collected in the field programs, and effects were ranked as to major, moderate or minor impact.

This classification system, based on the ability of the resident population or species to return to their former numbers and distribution following a spill, was used in the overall assessment process to identify the major ecological risks involved in allowing drilling to go ahead. More specifically, the classification assisted in setting priorities for contingency planning with respect to identifying sensitive areas and species that would require maximum protection in the event of an oil spill.

1135. Blus, L.J., S.M. Wiemeyer, J.A. Kerwin, R.C. Stendell, J.M. Ohlendorf, and L.F. Stickel (1975)

IMPACT OF ESTUARINE POLLUTION ON BIRDS

In: Estuarine Pollution Control and Assessment, Proc. of a Conference, Vol. 1 pp. 57-71, (numerous refs.)

Pollution of estuaries affects bird populations indirectly through changes in habitat and food supply. The multi-factor pollution of Chesapeake Bay has resulted in diminution of submerged aquatic plants and consequent change in food habits of the canvasback duck. Although dredgespoil operations can improve wildlife habitat, they often result in its demise.

Pollution of estuaries also affects birds directly, through chemical toxication, which may result in outright mortality or in reproductive impairment. Lead from industrial sources and roadways enters the estuaries and is accumulated in tissues of birds. Lead pellets deposited in estuaries as a result of hunting are consumed by ducks with sufficient frequency to result in large annual die-offs from lead poisoning. Fish in certain areas, usually near industrial sources, may contain levels of mercury high enough to be hazardous to birds that consume them. Other heavy metals are present in estuarine birds, but their significance is poorly known. Oil exerts lethal or sublethal effects on birds by oiling their feathers, oiling eggs and young by contaminated parents, and by ingestion of oil-contaminated food. Organochlorine chemicals, of both agricultural and industrial origin, travel through the food chains and reach harmful levels in susceptible species of birds in certain estuarine ecosystems. Both outright mortality and reproductive impairment have occurred.

1136. Boehm, P.D. and Quinn, J.G. (1977)

HYDROCARBONS: IN SEDIMENTS AND BENTHIC ORGANISMS FROM A DREDGE SPOIL DISPOSAL SITE IN RHODE ISLAND SOUND

EPA - 600/3-77-092, Nov 1977, Environmental Research Laboratory. Office of Research and Development, U.S. Environmental Protection Agency, Narragansett, Rhode Island.

The hydrocarbon contents of surface sediments, sediment cores and ocean quahogs (Arctica islandica) from Rhode Island Sound have been determined. Hydrocarbon concentrations in surface sediments normally range from 1.0 to 56.1 ug/g, largely dependent on sediment type and sedimentation rates. However, concentrations up to 301 ug/g are observed in surface samples from a dredge spoil deposit located in the study area. Based on (1) qualitative and quantitative hydrocarbon distributions in the sediments, (2) the hydrocarbon to organic carbon ratio, and (3) the ratio of the concentration of a prominent cycloalkene compound to organic carbon, the normal hydrocarbon geochemistry of the region is defined. Using these criteria, the effect of the dredge spoil deposit (containing 5 to 20 X 10^3 metric tons of hydrocarbons) is seen to be insignificant beyond 2 km from the disposal site.

Hydrocarbon contents of the ocean quanog do not reflect the sediment distributions qualitatively of quantitatively. Throughout the study area the clams' hydrocarbon contents vary by a factor of 2.5 (2.6 to

6.4 g/g wet) while the sediment concentrations vary by two orders of magnitude. The hydrocarbon assemblage in the clams exhibits a lower boiling point distribution than that in the sediments.

Key components of the surface sediments are two cycloalkene compounds of molecular weight 344 and 348. Their concentration covaries very significantly with the organic carbon content of the sediment. A major component of *Arctica* is another related cycloalkene of molecular weight 342. This compound is not present in the sediment.

A sediment core from the area shows a decreasing concentration of hydrocarbons and a decreasing percentage of unresolved components (UCM) with increasing depth. It is proposed that the rapid increase in the quantity of the UCM observed at a certain depth within the sediment, can serve as a chemical marker in the recent sedimentary record. This marker corresponds to the onset of the industrial revolution and the increased usage of petroleum products.

1137. Burns, K.A. and J.L. Smith (1977)

DISTRIBUTION OF PETROLEUM HYDROCARBONS IN WESTERNPORT BAY (AUSTRALIA): RESULTS OF CHRONIC LOW LEVEL INPUTS

In: *Fate and Effects of Petroleum Hydrocarbons in Marine Ecosystems and Organisms*, D.A. Wolfe (Ed.), Pergamon Press, N.Y., 1977
pp 442-453 (many refs.)

A study of hydrocarbons in Westernport Bay was undertaken to assess the impact of the chronic low level input associated with man's use of the environment even in the absence of major oil spills. Aims of this project are (1) to measure amount of background hydrocarbon pollution associated with present land development, (2) to identify sources and levels of inputs, (3) to measure hydrocarbon accumulation from chronic input, (4) to gain a detailed picture of the partitioning of hydrocarbons in this environment which includes measurements of hydrocarbons in the water column, sediments and selected organisms, and (5) to assess the impact of chronic petroleum discharge on the structure and productivity of the ecosystem.

Analysis of solid samples included solvent extraction, saponification, column chromatography to separate saturated from unsaturated fractions and determination by gas chromatographic, fluorescence and gravimetric methods. Seawater hydrocarbons were abosrbed on mixed resin columns, eluted with solvents and analyzed similarly to solid samples.

The mussel, *Mytilus edulis*, was the major indicator species used to establish problem areas and probable sources of petroleum input. Two major sources of pollution were identified, refinery and other industrial outfalls, and boating activities. Other possible sources are domestic disposal operations. Pollution levels varied from no detectable petroleum hydrocarbons to amounts close to saturation levels of body lipids in mussels (29 mg/g lipid).

The discussion includes means of relating amounts found in indicator species to levels of input, and implications on the toxicity to various components of the ecosystem.

1138. Busdosh, M., K.W. Dobra, A. Horowitz, S.E. Neff, and R.M. Atlas (1978)

POTENTIAL LONG-TERM EFFECTS OF PRUDHOE BAY CRUDE OIL IN ARCTIC SEDIMENTS ON INDIGENOUS BENTHIC INVERTEBRATE COMMUNITIES.

In: Proceedings of Confer. on Assessment of Ecological Impacts of Oil Spills, Keystone, Col., 14-17 June 1978

Laboratory and field experiments were performed to determine the potential toxicity of Prudhoe Bay crude oil to indigenous Arctic benthic invertebrates. Toxicity was measured as mortality and as sublethal behavioral changes in feeding, movement and burrowing activities. When sediment was contaminated with fresh Prudhoe Bay crude oil, burrowing activity of the amphopod *Boeckosimus* (= Onisimus) *affinis* was reduced for a one month period, during which the oil underwent weathering changes. These changes in the oil were determined by gas-liquid chromatography. Exposure to weathered oil did not inhibit burrowing activity. Given a choice, in laboratory studies with oil contaminated or uncontaminated sediment, the amphipods selectively burrowed into the uncontaminated sediment. Exposure in experimental chambers to sediment contaminated with fresh oil also resulted in decreased movement and feeding activity during the month that the oil underwent initial weathering. Mortality rates were low for amphipods exposed to sediment contaminated with fresh or weathered oil. Behavioral changes in feeding and movement appear to be temporary and associated with the light hydrocarbons present in fresh crude oil.

In situ contamination of Arctic sediment with fresh Prudhoe Bay crude oil, during late Spring, resulted in initial mortality of benthic invertebrates. Recolonization of oil contaminated sediment was monitored for approximately one year. Amounts of residual oil were quantified using spectrofluorometic methods. Recolonization began within two weeks of oil contamination. The benthic community recolonizing oil contaminated areas was significatnly different in species composition from that in unoiled reference areas. Isopods did not appear to be attracted or repelled by the oil. Depending on the species, polychaetes were either attracted or repelled by the oil. Amphipods avoided recolonizing oil contaminated areas. The preference for burrowing in unoiled substrate shown in the laboratory studies appears to be reflected in the avoidance of oil contaminated sediment in the *in situ* Arctic benthic community studies.

1139. Caldwell, R.S., E.M. Caldarone and M.H. Mallon (1977)

EFFECTS OF A SEAWATER-SOLUBLE FRACTION OF COOK INLET CRUDE OIL AND ITS MAJOR AROMATIC COMPONENTS ON LARVAL STAGES OF THE DUNGENESS CRAB, CANCER MAGISTER DANA

In: Fate and Effects of Petroleum Hydrocarbons in Marine Ecosystems and Organisms, D.A. Wolfe (Ed.), Pergamon Press, N.Y., 1977, pp 210-220 (13 refs.)

Larval stages of the Dungeness crab, Cancer magister Dana, were exposed continuously to dilutions of Cook Inlet crude oil water-soluble fraction (WSF) of seawater solutions of naphthalene or benzene for periods lasting up to 60 days. Effects on survival, duration of larval development and size were employed as indicators of toxic effects. The lowest concentration of the WSF at which toxic effects were seen was 4.0% of the full strength WSF (0.0049 mg/l as naphthalene or 0.22 mg/l as total dissolved aromatics). The lowest concentration at which toxic effects were observed with naphthalene was 0.13 mg/l and with benzene was 1.1 mg/l.

The concentration of aromatic hydrocarbons in the WSF were inversely related to the degree of alkylation in each of the benzene and naphthalene families, but the acute toxicity of the 12 compounds was directly related to the degree of alkyl substitution. In addition, naphthalene and its derivatives were more toxic than benzene and its derivatives, but less concentrated approximately equally to the acute toxicity of the WSF. The collective toxicity of these compounds tested individually accounted for only 8.45% of the WSF acute toxicity. Since benzene contributed a greater fraction of the WSF toxicity in the chronic experiments (approximately 30%) it is suggested that the toxicity of this compound may involve a different mechanism in long term exposures than in acute tests.

1140. Carr, R.S., and Reish, D.J. (1977)

THE EFFECT OF PETROLEUM HYDROCARBONS ON THE SURVIVAL AND LIFE HISTORY OF POLYCHAETOUS ANNELIDS.

In: Fate and Effects of Petroleum Hydrocarbons in Marine Organisms and Ecosystems. D.A. Wolfe, (Ed.), Pergammon Press, p. 168-173, 1977.5 tab, 11 ref.

The toxicity of seawater-soluble fractions of No. 2 fuel oil and South Louisiana crude oil to five species of polychaetous annelids was determined. The results of these 28-day bioassays indicate a wide variability in sensitivity among the species tested with the two oils. The water soluble fractions of No. 2 fuel oil were more toxic to all species tested than South Louisiana crude oil. The effects of Petrochemicals on reproduction were measured for some species. Using the number of offspring produced as a measure of effect, a significant suppression in reproduction was noted at some concentrations of fuel oil. However, a reproductive stimulation was observed for one species exposed.

1141. Dall, K., G.E. O'Ficks, B. Owman, G. Rahame, and L.E. Wis (1978)

EFFECT OF OILS ON TEXTURE AND TASTE

Mar. Poll. Bull., Vol. 9, pp 95-97.

The toxicity of hydrocarbons is so variable that generalizations have negative value, but whether toxic or not the mere presence of oils generally taints living cells because of the oleophillic properties of certain organelies, and many thereby modify food chains. Assuming that benefit would accrue from more experimentation in this neglected field, a test programme has established and evaluated both the direct effects and the organoleptic consequences of a range of product oils on two common species which contribute much to food chains of coastal biocoenososes. These are (1) the coastal anacanthinid teleost Melanogrammus aegelfinus (Haddock) and (2) the ubiquitous tuberosum Supralittoral Phanerogram Solanum (potato).

1142. Dieter, M.P. (1977)

ACUTE AND CHRONIC STUDIES WITH WATERFOWL EXPOSED TO PETROLEUM HYDROCARBONS.

In: Prog. Rev. Proceedings of - Environ. Effects of Energy Related Activites on Marine/Estuarine Ecosystems. Interagency Energy-Environ. Res and Develop. Prog. Rept., C. Hall and W. Preston (Eds.), Wash., D.C., Oct 1977, pp 35-42, (4 refs).

The research program at Patuxent wildlife Research Center has been evaluating the biological effects of petorluem hydrocarbons on all stages of the waterfowl life cycle. This studies include: (1) the hatchability of eggs exposed to oils; (2) the development of ducklings fed oil from the day of hatch; and (3) reproduction in adult waterfowl fed oil. The third study is complemented by another where adult waterfowl were fed a chemically defined mixture representative of the concentration and type of aromatic compounds present in oil. In addition, experiments have been initiated to evaluate biological responses to petroleum hydrocarbons incorporated via the food chain. Analytical development is proceeding in concert with all of these biological studies.

1143. Dow, R.L. (1978)

SIZE-SELECTIVE MORTALITIES OF CLAMS IN AN OIL SPILL SITE

Mar. Pollut. Bull., Vol. 9, No. 2, Feb 1978, pp 45-48. (2 refs.)

Mixed No. 2 fuel oil and JP5 jet fuel, following an oil spill into Long Cove, Searsport, Maine, U.S.A., in March 1971 became concentrated locally at levels up to more than 250 ppm in intertidal sediments from 15 to 25 cm below the surface and continued until 1976 to kill successive year class juvenile clams. As in normal growth behavior they burrowed down through redistributed overlying clean sediments into the oil concentration beneath.

1144. Eastin, W.G. and D.J. Hoffman (1978)

BIOLOGICAL EFFECTS OF PETROLEUN ON AQUATIC BIRDS

In: Proceedings of Confer. on Assessment of Ecological Impacts of Oil Spills, Keystone, Col., 14-17 Jun 1978

The objectives of these studies included the following assessments: (1) the hatchability and embryonic development of eggs exposed to oil, (2) the development of ducklings fed oil from the time of hatching, (3) the effects of oil ingention on adult waterfowl including reproduction, and (4) the accumulation of petroleum hydrocarbons incorporated via the food chain.

Incubation studies in the laboratory and in the field have revealed that avian embryos of various species are extremely sensitive to egg oiling. External application of 1-20 ul of South Louisiana crude oil on days 3 or 8 of artificially incubated eggs resulted in high mortality that was dose related with some teratogenic effects. Oils tested included Bunker 'C' and No. 2 fuel oil, South Louisiana, Kuwait, and Prudhoe Bay Alaska crude oil. Similar egg oiling studies with common eiders (Semateria mollissima), great black-backed gulls (Larvus marinus), sandwich terns (Thalasseus sandvicensis), Louisiana herons (Hydranassa tricolor), and laughing gulls (Larus atricilla) demonstrated the same magnitude of toxicity. Field studies with nest incubated eggs and experiments with weathered oil also resulted in considerable embryonic mortality. Additional studies conducted with different classes and mixtures of aromatic hydrocarbons in petroleum indicate that the presence of tetracyclic aromatic hydrocarbons is a contributing factor.

Toxic effects in mallards fed 0.25 percent South Louisiana crude oil from hatching to 8 weeks of age included biochemical changes indicative of kidney and liver pathology, and higher concentrations of oil (2.50 to 5.00 percent) resutled in stunting with little development of flight feathers, enlarged livers, and reduced spleen weights. The biochemical responses in adult mallards fed 0.25 or 2.5 percent South Louisiana crude oil were not as intense as in ducklings but egg production declined in hens fed 2.5 percent oil. Liver function tests in mallard drakes fed a mixture of aromatic compounds found in South Louisiana crude oil suggested they adapted by enhancing the clearance rate of the toxicants.

1145. Engelhardt, F.R. (1978)

PETROLEUM HYDROCARBONS IN ARCTIC RINGED SEALS, PHOCA HISPIDA, FOLLOWING EXPERIMENTAL OIL EXPOSURE

In: Proceedings of Confer. on Assessment of Ecological Impacts of Oil Spills, Keystone, Col., 14-17 Jun 1978

Ringed seals were exposed to petroleum hydrocarbons by oil immersion and ingestion, the study was carried out under arctic conditions, using experimental oil spills and oil contaminated food. A Norman Wells crude oil was spiked with H-E-Benzene and C-14-Naphthalene. Analyses of seal tissues and body fluids for labelled fraction, as well as total petroleum hydrocarbon concentration, showed a significant tissue uptake. High levels in bile and urine indicate these to be routes of excretion. An induction of detoxification was noted within two days of exposure. The uptake and distribution of hydrocarbons is discussed in relation to ecological implication of ringed seal contamination, as well as to pathological and endocrinological toxicity effects.

1146. Engelhardt, F.R., J.R. Geraci and T.G. Smith (1977)

UPTAKE AND CLEARANCE OF PETROLEUM HYDROCARBONS IN THE RINGED SEAL, PHOCA HISPIDA.

J. Fish. Res. Bd. Can., 34(8):1143-1147.

Ringed seals, Phoca hispida, showed rapid absorption of hydrocarbons from Normal Wells crude oil into body tissues and fluids when exposed by both immersion and ingestion. Relatively low but significant levels were found in tissue, blook, and plasma. Levels in bile and urine were high indicating these to be routes of excretion.

1147. Evans, R., and Hester, F.J. (1977)

OUTER CONTINENTAL SHELF DEVELOPMENT IN THE SANTA BARBARA CHANNEL: LACK OF DETECTABLE IMPACT ON FISHERIES

In: Proceedings of 9th Annual Offshore Technology Conference, held in Houston, TX, May 2-5, 1977, Vol. 1 (of 4), p 261-267, OTC 2756, 1977.1 fig, 4 tab, 11 ref.

The sport and commercial fish catch in the Santa Barbara Channel over a 20 year period was examined in an attempt to detect possible changes in catch that might be associated with OCS activity in the area during that same period. Such changes were not found, indicating that the effects of OCS activities were non-existent, or minor compared to natural changes in the ocean climate or to fishing pressure on the resources themselves.

1148. Fries, C.R. and M.R. Tripp (1977)

CYTOLOGICAL DAMAGE IN MERCENARIA MERCENARIA EXPOSED TO PHENOL

In: Fate and Effects of Petroleum Hydrocarbons in Marine Ecosystems and Organisms, D.A. Wolfe (Ed.), Pergammon Press, N.Y., 1977. pp 174-181 (12 refs.)

Adult clams were exposed to various concentrations (1, 10, 100, 1000, 10000, 25000, 50000 parts per billion) of phenol in artificial seawater 25 ^{o}/oo) for 24 hours. Control animals were placed in artificial seawater only. Gills, gut, digestive gland and blood cells (hemocytes) were damaged. Basophilic tissue staining was evident at the lower concentrations of phenol; moderate necrosis and sloughing of ciliated ephithelial layers were seen at higher concentrations. Blood sinuses were distended and contained precipatated hemolymph. In the gill, only the chitinous supporting rods remained at 50000 PPB phenol.

Electron microscopy also shows damage to epithelial cells. Cell and nuclear membranes remain intact at low concentrations; intracellular organelles (lysosomes, mitochondria, etc.) are in various stages of disintegration. At 10000 PPB cell membranes rupture. Hemocytes show extensive intracellular damage; at 1000 PPB and above only the hyaline cells remain intact.

1149. Fucik, K.W., and Neff, J.M. (1977)

EFFECTS OF TEMPERATURE AND SALINITY OF NAPHTHALENES UPTAKE IN THE TEMPERATURE CLAM, RANGIA CUNEATA AND THE BOREAL CLAM, PROTOTACA STAMINEA.

In: Fate and Effects of Petroleum Hydrocarbons in Marine Organisms and Ecosystems, D.A. Wolfe, (Ed.) Pergammon Press, p. 305-312, 1977.4 fig, 2 tab, 22 ref.

Both species were exposed to a 25% WSF (water soluble fraction) of Southern Louisiana crude oil for three days under varying temperature and salinity regimes. In three uptake experiments, the greatest napthalenes concentrations were measured in those clams exposed at the lowest temperatures. Statistical analysis confirmed that napthalenes uptake in the different temperature-salinity groups in each experiment was significantly different. Temperature was shown to have the greatest effect on this difference. Temperature and salinity had no effect on the release of naphthalenes in either R. cuneata or P. staminea.

1150. Gibson, D.T. (1976)

THE MICROBIAL DEGRADATION OF AROMATIC PETROLEUM PRODUCTS

Office of Naval Research Contract N00014-76-C-0102, Univ. of Texas at Austin, Annual Report, June 30, 1976.

The biodegradation of ortho-xlene by a species of Nocardia is initiated by nuclear oxidation to form 3,4-dimethylcatechol. The latter compound is apparently formed from cis-3,4-dimethyl-3, 5-cyclohexadien-1, 2-diol (cis-o xylene dihydrodiol). Enzymatic fission of 3,4-dimethylcatechol produces an acid, 2-hydroxy-5-methyl-6-oxohepta-2,4-dienoic acid, that undergoes spectral changes at acid and alkaline pH. Further metabolism of the ring-fission product occurs by a hydrolytic reaction that forms acetic and 2-oxohex-4-enoic acids. Enzymatic hydration of the latter compound to give 4-hydroxy-2-oxohexanoate is followed by an aldolase reaction that produces pyruvate and propionaldehyde. The pathway proposed for the biodegration of o-xylene is analogous to those reported for the degradation of a number of aromatic compounds.

Commercial samples of 2-, 3- and 4-chlorobiphynyl contain umpurities that cause lag periods in the growth of Beijerinckia on succinate. Purified preparations of these compounds also inhibited the initiation of growth of this organism but not to the same extent. Preliminary observations suggest that inhibition may be associated with the ease of oxidation of the monochlorinated biphenyl isomers.

1151. Gibson, D.T. (1977)

BIODEGRADATION OF AROMATIC PETROLEUM HYDROCARBONS

In: Fate and Effects of Petroleum Hydrocarbons in Marine Organisms and Ecosystems. D.A. Wolfe. (Ed.), Pergammon Press, p 36-46, 1977.7 fig, 4 tab, 54 ref.

An overview of the degradation pathways of aromatic hydrocarbons by prokaryotic and eukaryotic organisms was presented. Tables listing monocyclic and polycyclic aromatic compounds that are oxidized by bacteria and the specific organism responsible were provided. The paucity of information on the biodegradation of the aromatic hydrocarbons present in crude oil was also discussed.

1152. Gordon and Breach (1972)

A GUIDE TO MARINE POLLUTION

Food and Agriculture Organization, U.N., New york, 109 pp

Ecological effects of marine pollutants; problems of fisheries in estuaries and coastal waters; methods for chemical analysis of water; toxicity testing in a continuous flow system; oil and oil dispersants.

1153. Gruger, E.H., Robisch, P.A., and Wekell, M.M. (1977)

EFFECTS OF CHLORINATED BIPHENYLS AND PETROLEUM HYDROCARBONS ON THE ACTIVITY OF HEPATIC ARYL HYDROCARBON HYDROXYLASE OF COHO SALMON (ONCORHYNCHUS KISUTCH) AND CHINOOK SALMON (O. TSHAWYTSCHA)

In: Fate and Effects of Petroleum Hydrocarbons in Marine Organisms and Ecosystems. D.A. Wolfe, (Ed.), Pergammon Press, p. 323-331, 1977.4 tab, 31 ref.

Saltwater-adapted coho and chinook salmon were fed two mixtures of test compounds: one composed of chlorobiphenyls and the other of petroleum hydrocarbons. Induction of aryl hydrocarbon (benzo(a)pyrene) hydroxylase activity occurred in hepatic microsomes from coho salmon within the first two weeks of hydrocarbon exposure. This induction was potentiated by the presence of chlorobiphenyls; however, no effect on enzyme acitivty was found with chlorobiphenyls alone. The results indicate that chlorobiphenyls act synergistically with hydrocarbons to induce the enzyme system in coho salmon. In chinook salmon, the activity of aryl hydrocarbon hydroxylase in hepatic microsomes was depressed by the chlorobiphenyls and hydrocarbons, administered both separately and together. It was concluded that chlorobiphenyls in marine environments may alter the activity of hydroxylases regulating the accumulation and discharge of petroleum hydrocarbons in organisms.

1154. Harris, R.P., V. Berdugo, E.D.S. Corner, C.C. Kilvington, and S.C.M. O'Hara (1977)

FACTORS AFFECTING THE RETENTION OF A PETROLEUM HYDROCARBON BY MARINE PLANTONIC COPEPODS

In: Fate and Effects of Petroleum Hydrocarbons in Marine Organisms and Ecosystems. D.A. Wolfe, (Ed). Pergammon Press, p. 286-304, 1977.6 fig, 7 tab, 29 ref.

14C-1-Naphthalene was used as a model compound to study the retention of an aromatic hydrocarbon by marine planktonic copepods during 24-hour exposure experiments. Seven species were investigated, including representative estuarine, neritic and oceanic forms. Significant positive correlations were demonstrated between naphthalene retention and copepod size measure as dry weight and total lipid content; but a negative correlation was observed with temperature; and retention was diminished in animals starved for progressively longer periods. Amounts of the hydrocarbon absorbed on the surfaces of the animals appeared to be only a small fraction of the totals accumulated.

1155. Hayes, M.O., J. Michel, and P.J. Brown (1977)

VULNERABILITY OF COASTAL ENVIRONMENTS OF LOWER COOK INLET, ALASKA TO OIL SPILL IMPACT.

Proceedings of the 4th International Conference on Port and Ocean Engineering under Arctic conditions (POAC 77), Newfoundland Memorial University, Canada, September 26-30, 1977.

The coastal waters of lower Cook Inlet, Alaska, like many arctic areas, will undergo exploratory petroleum drilling in the near future. In preparation for the increased potential for oil spills, a field study of the coastal morphology and sediments, with emphasis on the behavior of spilled oil, was conducted in June 1976. A total of 1216 km of shoreline was classified into erosional (45%), neutral (38%) and depositional (17%) types, which were further divided into 16 subclasses on the basis of small-scale morphological features. This classification was used in conjunction with a vulnerability index of potential oil spill damage, developed through study of two major oil spills, to predict the longevity of oil in the different coastal environments of the inlet. On a scale from 1-10, 45% of the shoreline was given low values of 1-4, which means that oil would be dispersed by natural processes within less than six months after a spill on these coasts. Values from 4-6 were assigned to 13.4% of the shoreline, where oil residence time may be up to one year. A 6-10 rating was assigned to 41.5% of the shoreline, where oil contamination may remain for periods of from two to ten years, or possibly more should no major clean-up procedures be initiated. We propose that the use of this type of vulnerability indexing, in conjunction with a biological susceptibility index and oil spill trajectory models, would provide a rational basis for decision making concerning the location of on-and off-shore oil facilities and the design of oil spill contingency plans.

1156. Hawkes, J.W. (1977)

THE EFFECTS OF PETROLEUM HYDROCARBON EXPOSURE ON THE STRUCTURE OF FISH TISSUES

In: Fate and Effects of Petroleum Hydrocarbons in Marine Organisms and Ecosystems. D.A. Wolfe, (Ed.) Pergammon Press, p. 115-128, 1977.15 fig, 1 tab, 36 ref.

Literature on the sublethal effects of petroleum hydrocarbons at cellular and subcellular levels in fish was reviewed. New data presented dealt with the effects of crude oil on several species of fish. The electron microscope was used extensively to demonstrate alterations in tissue structure due to the exposure to the water soluble fraction of crude oil.

1157. HO, C.L. and H. Karim (1978)

IMPACT OF ADSORBED PETROLEUM HYDROCARBONS ON MARINE ORGANISMS

In: Marine Pollution Bulletin, Vol. 9, Number 6/June 1978, pp 156-162.

Adsorptions of South Louisiana crude oil from seawater by clays, non-clay minerals and sediments were conducted in the laboratory. Effect of sediment-adsorbed and water dispersed crude oil on adult oysters were investigated in aquaria. Hydrocarbons in oyster tissues and surrounding water were identified by gas chromatography. Field specimens from an area of a new oil spill and an area five months after an oil spill were also analysed. Evidence of secondary chemical effect of aged oil in sediments on oyster mortality is presented. Oil coated asbestos surfaces severely reduced recruitment of sedentary larval organisms.

1158. Hodgins, H.O., W.D. Gronlund, J.L. Mighell, J.W. Hawkes, and P.A. Robisch (1977)

EFFECT OF CRUDE OIL ON TROUT REPRODUCTION

In: Fate and Effects of Petroleum Hydrocarbons in Marine Ecosystems and Organisms, D.A. Wolfe (Ed.), Pergamon Press, N.Y., 1977, pp 143-150 (18 refs.)

Prudhoe Bay crude oil was incorporated into the diet (1 g oil/kg food) of adult rainbow trout during sexual maturation to assess the effects of long-term petroleum exposure on salmonid fish reproductive success. Parallel control fish received identical rations, except without added petroleum. When the fish reached maturity, six to seven months after initiation of petroleum exposure, a total of 31 test and 10 control crosses were made. Mean survival through hatching was 86% and 90% for test and control eggs, respectively; the difference was non-significant (P = 0.10). Test and control males were virtually identical in fertility. Mean survival from hatching to swim-up fry stage of development was 76% for test and 91% for control fish; again the difference was not significant (P = 0.10). In addition, no gross morphological or histological abnormalities were observed in offspring of petroleum-fed fish. The results of these studies were, therefore, that there was no significant impairment of reproductive success detected from this type of dietary exposure to petroleum.

1159. Holt, S., S. Rabalias, N. Rabalias, J.S. Holland, and S. Cornelius (1978)

EFFECTS OF AN OIL SPILL ON SALT MARSHES AT HARBOR ISLAND, TEXAS

In: Proceedings of Confer. on Assessment of Ecological Impacts of Oil Spills, Keystone, Col., 14-17 June 1978.

On October 13, 1976, an American Petrofina Company pipeline ruptures, dumping about 377 barrels of crude oil into the cordgrass (*Spartina alterniflora*) and black mangrove (*Aviconnia germinans*) marshes at Harbor Island in Redfish Bay near Port Aransas, Texas. The Corpus Christi Oil Spill Control Association made several trips to the area using a variety of oil removal techniques including: suction trucks, absorbant pads, clipping and burning vegetation, and substrate removal. A biological and chemical survey was begun the day following the spill. A single study site (4 stations ranging from above mean high tide to below mean low tide) was selected to monitor the benthos. Observation survey was begun the day following the spill. A single study site (4 stations ranging from above mean high tide to below mean low tide) was selected to monitor the benthos. Observation surveys of marsh vegetation were made on periodic trips to the area. Particular attention was paid to monitoring various types of clean-up procedures (including no cleanup of some areas) and various concentrations of oil coverage.

Spartina which was burned showed reduced standing crop in the next growing season compared to burned but unoiled *Spartina*.

The effects on the benthos were not as devastating as seen in other inshore oil spills but reduced infaunal density and changes in species composition, such as relatively high density of *Capitella capitata* following the spill, indicated some adverse effects on the benthos. Black mangrove showed short-term (2-4 weeks) adverse effects in loss of oil coated leaves and seeds but long-term (nine months) adverse effects were negligible except where they had been burned. Spartina suffered substantial long-term damage in both "cleaned" and uncleaned areas.

Following a moderate sized spill of crude oil into a Gulf coast Spartina-mangrove marsh there were only minor immediate toxic effects but substantial long term "smothering" effects were seen.

1160. Hsiao, S.I.C., D.W. Kittle, and M.G. Foy (1978)

EFFECTS OF CRUDE OILS AND THE OIL DISPERSANT COREXIT ON PRIMARY PRODUCTION OF ARCTIC MARINE PHYTOPLANKTON AND SEAWEED

Environ. Pollut. (15)(1978)

Effects of crude oil and Corexit on primary production of arctic marine phytoplankton were studied in situ. The production rate varied with types and concentrations of crude oil, method of preparation of oil-seawater mixtures, environmental conditions and species composition of each sample tested. In samples with the same species composition, inhibition of production generally increased with increasing oil concentration. The crude oil-Corexit mixtures were more toxic than crude oil or Corexit alone.

In situ primary production of the seaweeds, Laminaria saccharine (L.) Lamouroux and Phyllophora truncata (P.) Newroth et Taylor, was significantly inhibited by all types and concentrations of oil tested.

1161. Jackim, E. and C. Lake (1977)

POLYNUCLEAR AROMATIC HYDROCARBONS IN ESTUARINE AND NEARSHORE ENVIRONMENTS.

In: Abstracts, The Fourth Biennial Internat. Estuarine Res. Confer., Estuar. Res. Feder., Mt. Pocono, PA, Oct. 2-5, 1977.

Polynuclear aromatic hydrocarbons (PNAH) are widely distributed in the marine environment. Researchers have found PNAHs in sediment and water samples throughout the world's coastal regions. Though the biosynthesis of PNAHs is certainly possible, recent research indicates the major source of PNAHs is likely to be combustion products. Since the high molecular weight fraction of oil is very resistant to degradation in estuarine waters, oil could be a significant source of PNAHs in oil-polluted areas. PNAHs occur in higher concentrations in marine animals than in terrestrial organisms. Levels in marine organisms range from traces to over 2000 ug/kg (dry weight) and are dependent on ambient levels and organism species. Since most carcinogenic hydrocarbons arise as a result of mans activity it is not surprising that animal levels differ greatly depending upon location. Filter feeding animals and bottom dwellers have higher concentrations of PNAs than other feeding types and pelagic fish.

There is a controversy concerning the rate of depuration of benzprene and other PNA's in shellfish. Most studies indicate a short biological half life (1-5 weeks). Other studies with naturally exposed field animals indicate a slow turnover approaching the life span of the animal.

1162. Karinen, J.F., and Taylor, T.L. (1977)

RESPONSE OF THE CLAM, MACOMA BALTHICA (LINNAEUS), EXPOSED TO PRUDHOE BAY CURDE OIL AS UNMIXED OIL, WATER-SOLUBLE FRACTION, AND OIL-CONTAMINATED SEDIMENT IN THE LABORATORY.

In: Fate and Effects of Petroleum Hydrocarbons in Marine Organisms and Ecosystems. D.A. Wolfe, (Ed.), Pergammon Press, p 229-237, 1977.3 fig. 1, tab, 19 ref.

This clam will likely be subjected to oil slicks layered on the mud and to water-soluble fractions (WSF) of crude oil or oil-contaminated sediment. Gentle settling of crude oil over clam beds had neglible effects on clams observed for 2 months. Water-soluble and oil-treated sedminet (OTS) fractions of Prudhoe Bay crude oil inhibited burrowing and caused clams to move to the sediment surface. Although short-term exposures of clams to the WSF of crude oil and OTS caused few deaths, behavioral responses of clams to oil may be of great importance to their survival in the natural environment.

1163. Kiceniuk, J.W., W.R. Penrose and W.R. Squires (1978)

OIL DISPERSANTS CAUSE BRADYCARDIA IN A MARINE FISH

Mar. Pollut. Bull. Vol. 9, No. 2, Feb 1978, pp 42-45 (13 refs.)

The symptoms of detergent poisoning have been observed to be similar to those of asphyxic hypoxia (Marchetti, 1965). If hypoxia is in any way involved in the toxicity of detergents the sublethal physiological effects of the detergents in oil dispersants would be expected to be similar to the effect of hypoxia alone. When subjected to hypoxia fish decrease their heart rate and incarease the ventilation volume (Holeton & Randall, 1967; Butler and Taylor, 1975; Randall, 1966). Heart rate in fish is precisely controlled and compensated (Kiceniuk, 1975; Kiceniuk and Jones, in press). This study was undertaken to determine (a) whether heart rate of a marine fish is affected by oil dispersants and if so, (b) what components of oil dispersants are effective in producing the response, and (c) at what relative concentrations?

1164. King, K.I., Mix, M.C., Riley, R.T., Schaffer, R.L., and Trenholm, S.R.

CHEMICAL CARCINOGENS IN THE MARINE ENVIRONMENT BENZO(A)PYRENE IN ECONOMICALLY IMPORTANT BIVALVE MOLLUSKS FROM OREGON ESTUARIES

In: Fate and Effects of Petroleum Hydrocarbons in Marine Organisms and Ecosystems. D.A. Wolfe, (Ed.), Pergammon Press, p. 421-431, 1977.6 fig, 2 tab, 32 ref.

Levels of carcinogenic polycyclic aromatic hydrocarbons present in bivalve mollusks from Oregon's estuaries were studied. Because of many unique features in their life history and biology, indigenous shellfish were found to be useful for monitoring the marine environment. Detectable levels of benzo(a)pyrene were found in commercially important shellfish from 38 of 44 sampling sites in five Oregon Bays.

1165. Koons, C.B., and Weiss, F.T. (1977)

EFFECTS OF PRODUCED WATERS ON THE MARINE ENVIRONMENT

In: Oceans '77', Proceedings of 3rd Annual Conference held in Los Angeles, CA on October 17-19, 1977, Vol 2, p 40B-1-40B-10, 1977.1 fig, 4 tab, 41 ref.

Detailed data on the composition of produced waters are now more completely available, especially for inorganic ions. A review of these data and their significance leads to the conclusion that toxic components are present in very low concentrations in produced waters if at all. Natural forces such as dilution, evaporation, photooxidation and biological reactions rapidly reduce the concentration of any hydrocarbon or organic toxic components in the produced waters to levels not harmful to the marine environment and biota.

1166. Kooyman, G.L., R.W. Davis and M.A. Castellini (1977)

THERMAL CONDUCTANCE OF IMMERSED PINNIPED AND SEA OTTER PELTS BEFORE AND AFTER OILING WITH PRUDHOE BAY CRUDE

In: Fate and Effects of Petroleum Hydrocarbons in Marine Organisms and Ecosystems. D.A. Wolfe, (Ed.), Pergammon Press, p. 151-157, 1977.1 fig, 3 tab, 13 ref.

Thermal conductance (C) of the sea otter and several species of pinniped pelts was determined during immersion, after oiling, and after cleaning. Most affected by oiling was the sea otter pup in which (C) was doubled. Least affected was the sea lion in which no change in (C) occurred. Washing slightly reduced (C) of the adult otter and fur seal. The results indicated that even a light oiling would have marked detrimental effects on the thermoregulatory abilities of otters and fur seal at sea. The thermal effects of oiling on other adult pinnipeds while at sea would be slight.

1167. Kopperdahl, F., C. Hazel and N. Morgan (1975)

OIL SPILLS IN CALIFORNIA AND EFFECTS OF CLEANUP AGENTS

Water Resources Control Bd., No. 56, Jan., 106 pp. 26 Ref.

The objective of this study was to provide technical data that could be used to evalute the extent of oil spillage and use of oil spill cleanup agents in California; the relationship between the accumulation of petroleum residues in fish and the use of dispersant-type oil spill cleanup agents; and the time required for weathering and biological removal of oil residues on exposed surfaces at intertidal depths. Tainting of fish flesh by petroleum products was investigated by organoleptic and gas chromatography methods. Experiments on the weathering of oils and recolonization of plant and animal life on oil-coated surfaces were designed to determine feasible methods to evaluate the time required for oil-polluted shores to cleanse themselves by natural process.

1168. Kraybill, H.F., C.J. Dawe, J.C. Harshbarger and R.G. Tardiff (Eds.) 1977

AQUATIC POLLUTANTS AND BIOLOGIC EFFECTS WITH EMPHASIS ON NEOPLASIA

New York Academy of Sciences Conference Proceedings, Sept. 27-29, 1976, 604 pp.
ISBN:0-89072-044-4

The objectives of the conference were to put into perspective the various concentrations of pollutants in the water supply of countries that are influenced by industrial and geographical patterns. Furthermore, the effect of such contaminants was evaluated in various biological systems, with particular emphasis on neoplastic disease. The potential public health hazard was evaluated within the framework of current methodology and information resources, with a broad spectrum of inorganic organic and radiological contaminates covered. Includes some papers on biologic effects of oil pollution.

1169. Krebs, C.T. and K.A. Burns (1977)

LONG TERM EFFECTS OF AN OIL SPILL ON POPULATIONS OF THE SALT-MARSH CRAB UCA PUGNAX.

Science, 197(4302):484-487.

A spill of fuel oil at West Falmouth, Massachusetts, in 1969, contaminated contiguous salt marshes with up to 6,000 micrograms of oil per gram (PPM) of wet mud and affected local populations of Uca pugnax. Directly related to high-sediment oil content were reduced crab density, reduced ratio of females to males, reduced juvenile settlement, heavy overwinter mortality, incorporation of oil into body tissues, behavioral disorders such as locomotor impairment, and abnormal burrow construction. Concentrations of weathered fuel oil greater than 1,000 ppm were directly toxic to adults, while those of 100 to 200 ppm were toxic to juveniles. Cumulative effects occurred at lower concentrations. Recovery of the marsh from this relatively small oil spill is still incomplete after 7 years.

1170. Kuhnhold, W.W., D.E. Euerich, J. Lake, and J.J. Stegeman (1978)

LONG-TERM EFFECTS OF LOW CONCENTRATIONS OF THE WATER-ACCOMMODATED FRACTION OF NO. 2 FUEL OIL ON REPORDUCTION IN WINTER FLOUNDER

In: Proceedings of Confer. on Assessment of Ecological Impacts of Oil Spills, Keystone, Col., 14-17 June 1978.

The impact of the water-accomodated fraction of No. 2 fuel oil on reproduction of winter flounder was investigated by measuring percent egg fertilization, total hatch, 24 hour viable hatch, duration of hatching period, incidence of abnormalities during embryogenises, and larval growth and survival.

To determine when impact ocurrs, the variables were assessed for eggs and larvae exposed during the following stages.

1) egg incubation only
2) fertilization and egg incubation
3) adult gonad maturation and fertilization and incubation
4) adult gonad maturation only

Observation of larval growth and survival for several weeks were conducted only after phase 4.).

To assess stress of the exposed adult fish, series of individuals were examined for uptake of hydrocarbons into eggs, and for biochemical and histolocical changes in the liver.

A flow-through system was employed to maintain the nominal oil concentrations of 10 and 100 ppb total CCl_4 extracts.

Adult fish were exposed in circular containers of 400 1, eggs were exposed in 250 ml beakers at flow-through as well. Incubation of eggs and rearing of larvae for growth rate and survival after exposure (phase 4.) were conducted in 30 1 aquaria.

Expressed as reduction in the hatching success of viable larvae the impact of the water-accomodated fraction (WAF) of No. 2 fuel oil is only significant at the 100 ppb level, and only if the exposure period includes the embryo stage. The influence of parental exposure only shows higher mortality of the larvae only after several weeks. This late effect can not be deducted from the biochemical pattern in the exposed adults.

1171. Lanier, J.J. and M. Light (1978)

CILIATES AS BIOINDICATORS OF OIL POLLUTION

In: Proceedings of the Conference on Assessment of Ecological Impacts of Oil Spills, Keystone, Col., 14-17 June 1978 Coord. By Amer. Inst. of Biol. Sci., Keystone Lodge,

Oil uptake, toxicity, and community diversity experiments were conducted with members of the marine microfaunal community, primarily ciliate protozoa, in order to explore the possibility of using these organisms as biological indicators of oil pollution. Euplotes diadaleos ingests approximately 1 ng/min of emulsified crude oil over a three hour period. The 90 hr LC50 of crude oil to Euplotes is 1.7 ppm. The toxicity of crude oil is directly correlated with the log of the oil concentration between 0 and 74 ppm with one interesting exception: the population of Euplotes increases dramatically at 8 ppm. In field experiments, population, species number, and community diversity were monitored in artificial substrates in saltwater ponds experimentally treated with various crude oils. The oil descended through the water column and accumulated in the substrates as droplets bound to detritus and inorganic particles. The rate of descent is directly correlated with the salinity of the pond. Population and species number of the microfaunal community increased over pre-spill levels during the 21 days monitored except in the pond oiled with Nigerian crude oil.

1172. Laughlin, R.B., and Neff, J.M. (1977)

INTERACTIVE EFFECTS OF TEMPERATURE, SALINITY SHOCK AND CHRONIC EXPOSURE TO NO. 2 FUEL OIL ON SURVIVAL, DEVELOPMENT RATE AND RESPIRATION OF THE HORSESHOE CRAB, LIMULUS POLYPHEMUS

In: Fate and Effects of Petroleum Hydrocarbons in Marine Organisms and Ecosystems. D.A. Wolfe, (Ed.), Pergammon Press, p 182-191, 1977.4 fig, 2 tab, 17 ref.

Eggs and the first three instars of the horshoe carb were exposed to water-soluble fractions (WSF) of No. 2 fuel oil. Survival of larvae decreased with decreasing temperature and increasing WSF concentration. The significance of differences in growth and development rates were difficult to determine because of high variability in these traits. These appear to be the least sensitive indicators of petroleum hydrocarbon stress. The respiration rate of oil-exposed animals was significantly higher than that of controls at nearly all salinity/temperature combinations. The interaction of salinity and WSF exposure on respiratory rate was highly significant. The data suggest that the ability to adapt to new environmental conditions rather than maintenance of any give equilibrium metabolic state is an important parameter to consider when evaluating the impact of petroleum on estuarine organisms.

1173. Lawler, G.C., B.J. Fiorito, J.P. Holmes, J.C. Laseter, and R.S. Szaro (1978)

QUANTIFICATION OF PETROLEUM HYDROCARBONS IN SELECTED TISSUES OF MALE MALLARD DUCKLINGS CHRONICALLY EXPOSED TO SOUTH LOUISIANA CRUDE OIL

In: Proceedings of Confer. on Assessment of Ecological Impacts of Oil Spills, Keystone, Col., 14-17 June 1978

Replicate hydrocarbon analyses of selected tissues from oil-dosed mallard ducklings were performed. Gas chromatography and combined gas chromatography and mass spectroscopy, utilizing high resolution glass capillary columns, were used to identify and quantitate accumulated oil hydrocarbons. Liver, kidney, brain, and abdominal fat tissues from male and female ducklings fed 0; 250; 2,500; 25,000; 50,000 ppm of South Louisiana Crude Oil in dry feed for six weeks were analyzed. Our data, to date, indicate that more saturated than aromatic petroleum hydrocarbons accumulate in each tissue type. The fat accumulated more oil hydrocarbons than any of the other tissues analyzed. For example, abdominal fat exposed to 50,000 ppm oil-laced feed accumulated 412 ppm wet weight of saturated petroleum hydrocarbon compared to 8 ppm by the liver, which contained more oil-derived saturated hydrocarbons than either the kidney or brain. The concentration of accumulated petroleum hydrocarbons increased with increased oil dosage.

Individual petroleum hydrocarbons were present in the ppb range in the liver, kidney, and brain, and in the ppm range in the abdominal fat. Petroleum derived isoprenoid alkanes accumulated in the oil-dosed tissues to a greater extent than the normal alkanes. This suggests that the normal alkanes were metabolized at a greater rate than the branched-chain alkanes. Naphthalene, both methylnaphthalenes, and various di- and trimethylnapthalenes were detected in each oil-dosed tissue type. The data obtained in this study are correlated with reported physiological effects of oil on the liver, kidney, and brain. Differences between the accumulated petroleum hydrocarbons in tissues of chronically and acutely oil-exposed ducks are discussed.

1174. Lee, R. (1978)

SHORT-TERM EFFECTS OF OIL ON PLANKTON IN CONTROLLED ECOSYSTEM ENCLOSURES

In: Proceedings of Confer. on Assessment of Ecological Impacts of Oil Spills, Keystone, Col., 14-17 June 1978

A number of experiments at the controlled ecosystem pollution experiment (CEPEX) in Saanich Inlet, Canada, have involved additions of crude and fuel oils to controlled ecosystem enclosures (ca. 2m diameter and 15m deep - 60,000 liters).

The first effects observed were decreases in large phytoplankton cells with increases in small-celled phytoplankters, increases in standing stock of bacteria and decreases in number of otenophores. The bacteria and small phytoplankton cells may have served as food for microzooplankton, particularly protozoans, whose numbers increased markedly a few days after oil addition. The large bacterial population which included petroleum degrading species resulted in rapid utilization of nitrogen and phosphorus in the oil treated enclosures.

After three summers of adding oil, we conclude that it is difficult to predict the effects of oil on a mixed phytoplankton population. During the first summer a low concentration of fuel oil (approximately 10 ug liter of non-volatile hydrocarbons) caused a slight decrease in diatoms and a stimulation of microflagellate growth, particularly Chrysochromulina kappa. The second summer the population of the dominant diatom in the water, Ceratualina bergonii, declined dramatically after fuel oil addition (approximately 40 ug/liter). The flagellate, Chrysochromulina kappa became the dominant phytoplankter. The third summer diatoms, mainly Chaetoceros chains (20-50 u) were dominant in the water. Fuel oil addition (100 ug/liter) resulted in smaller Chaetoceros (less than 5 u) chains but no stimulation of microflagellates. The water in spring and early summer in Saanich inlet is rich in nutrients due to upwelling and has a phytoplankton population characterized by large diatom chains, often species of Chaetoceros. Mid-summer water is stratified with resulting nutrient stress and diatoms are unimportant in the phytoplankton. instead dinoflagellates and microflagellated are the dominant phytoplankters. Our results indicate fuel oil has a greater effect on the mid-summer phytoplankton community than on the upwelled community of spring. High concentrations of crude oil were required to produce the effects observed with fuel oil. Because of the rapid loss of all petroleum components from the water we believe the observed effects are of short term. probably less than 30 days, in these temperate waters.

1175. Lee, R.F. (1977)

ACCUMULATION AND TURNOVER OF PETROLEUM HYDROCARBONS IN MARINE ORGANISMS

In: Fate and Effects of Petroleum Hydrocarbons in Marine Organisms and Ecosystems. D.A. Wolfe, (Ed.), Pergammon Press, p 60-70, 1977.3 tab, 61 ref.

This review deals with the uptake, storage and discharge of petroleum hydrocarbons by marine organisms under laboratory and field conditions. Organisms collected from oil spill and chronically polluted areas were analyzed. Special attention was directed toward the ability of animals to depurate their hydrocarbons accumulated after exposure to oil. Organisms studied were: benthic algae; zooplankton; benthic crustaceans; benthic worms; bivalves; and fish. Bivalves received emphasis because of the extensive amount of laboratory and field studies on their accumulation of petroleum.

1176. Lee, W.Y., K. Winters and J.A.C. Nicol (1978)

THE BIOLOGICAL EFFECTS OF THE WATER-SOLUBLE FRACTIONS OF A NO. 2 FUEL OIL ON THE PLANKTONIC SHRIMP, LUCIFER FAXONI

Environ. Pollut. (15)(1978)

The biological effects of water-soluble fractions (WSFs) of a No. 2 fuel (heating) oil on the planktonic shrimp, Lucifer faxoni, were investigated.

Biological parameters used to assess toxicity were survival, respiration, feeding rate and degree of activity. In the survival and feeding studies two experiments were carried out, one with freshly prepared WSF (Exp. 1), the other with WSF exposed to air for 48 h (Exp. 2) before the animals were introduced. Based on survival data for fourteen days exposure, critical levels of toxicities in Exp. 1 were about 0.2 ppm, while in Exp 2 they were around 2 ppm. A similar trend was found in studies of feeding and degree of activity. Unexposed extracts (Exp. 1) were more toxic and the effect on feeding was immediate and irreversible; exposed WSF was less toxic, the effect on feeding was delayed and reversible.

The chemical composition of fresh WSF and of WSF exposed to air from 6h to 5 days was determined. Alkyl benzenes, indans, and naphthalenes were rapidly lost from the exposed solution, with only negligible concentrations remaining after 24 h. In contrast, certain non-hydrocarbon compounds such as alkyl anilines, phenols, and indoles were generally present even after 5 days at greater than 50% of their initial concentration.

The biological and chemical data appear to indicate that the higher toxicity of fresh WSF to L. faxoni was due to volatile aromatic hydrocarbons. It seems that the toxicity of oil spills could be markedly less than some laboratory results suggest because there is reduced toxicity following weathering by evaporation.

Respiration rates of L. faxoni during an 8 h exposure to freshly prepared WSF rose with increasing concentrations up to 30% of WSF, then fell with further increases of concentration of WSF.

1177. Lopez, S.M. (1978)

ECOLOGICAL SIGNIFICANCE OF PETROLEUM SPILLAGE IN PUERTO RICO

In: Proceedings of Confer. on Assessment of Ecological Impacts of Oil Spills, Keystone, Col., 14-17 June 1978

In order to develop an approach that can aid in assessing the impacts of oil spills a typical Puerto Rican coastal environment is viewed in terms of its major marine ecosystems: coral reefs, sea grass beds, mangrove forests, and benthos of soft bottom estuaries. Case studies of oil spills in Puerto Rico have involved comparison of abundance and diversity of organisms and species in spill areas versus carefully-matched, similar environs in no-spill areas. The relative vulnerability of these ecosystems was demonstrated. Coral reefs are least impacted owing to their sub-tidal nature and high energy situation. Beds of the sea grass Thalassia testadinum exhibit relatively minor, short-term effects. This comparative approach has shown, however, that oil coating of fringing stands of the red mangrove Rhizophora mangle and the associated intertidal communities of their prop roots impairs productivity and destroys the attached organisms. Oil becomes trapped and may not be retrieved or cleaned from the mangrove forest. Analysis by GC/IR of extracts from sediments within the mangal have shown the abundance and persistence of petroleum hydrocarbons in correlation with the absence of benthic organisms four years after an oil spill.

In assessing the long-term, chronic effects in this approach we further propose to determine the biological availability of potentially hazardous petroleum hydrocarbons to dwellers of the mangrove ecosystem: mangrove oyster (Crassostrea rhizophora), the mud clam (Lucina pectinata) and species of mullet (Mugil). Biological tissues are assayed by GC/MS and the source and transfer mechanism of the compounds that are found are determined through controlled exposure of clean organisms to the various components of the ecosystem. Concurrently, the histopathology of affected tissues would be studied to assess impact on the health of the organism and the significance to the human consumer.

Previous studies of oil spills in Puerto Rico are reivewed and up to date results of on-going research are discussed in the paper.

1178. MacKay, D.W. (1976)

ASPECTS OF MARINE POLLUTION CONTROL (1976)

Effluent and Water Treatment Journal, Vol. 10, No. N16, Oct. 1976, pp. 511-514.

Criteria for marine pollution control must take into account the physical, chemical, and biological condition, uses, and diluting capacity of receiving waters. Fundamental differences between freshwater and marine situations must be considered. While coastal waters and, to a more limited extent, estuaries have a considerable capacity for absorbing pollutants without detriment to the environment, the capacity varies with circumstances. Consideration should be given to the interaction between effluents from different outfalls and inputs from the sources such as rivers, adjacent marine areas, and the atmosphere. Pollutants entering the sea dissolved or suspended in fresh water are subject to considerable alterations and may change their nature entirely, become locked away in the sediments of the inner estuary, interact with other pollutants and become harmless, or 2 or more relatively harmless compounds may combine to become toxic. Because the possibilitites are endless, monitoring waters and biota is an immense task. The qualifications for survey personnel are discussed. The survey vessel needed for marine pollution survey work is described in detail.

1179. Malins, D.C. (1977)

BIOTRANSFORMATION OF PETROLEUM HYDROCARBONS IN MARINE ORGANISMS INDIGENOUS TO THE ARCTIC AND SUBARCTIC

In: Fate and Effects of Petroleum Hydrocarbons in Marine Organisms and Ecosystems. D.A. Wolfe, (Ed.), Pergammon Press, p 47-59, 1977.3 fig, 6 tab, 45 ref.

The metabolism of the aromatic hydrocarbon fraction of petroleum by marine organisms was evaluated. It was pointed out that studies on the effects of petroleum on marine organisms have centered on the parent hydrocarbons rather than the potentially toxic metabolites. The biochemical pathways used by various plankton, invertebrates and fish to metabolize aromatic hydrocarbons were discussed. Particular emphasis was directed toward metabolite alterations of enzyme systems, tissue locations of various metabolities, and possible mutagenic activity.

1180. McAuliffe, D.C. (1977)

DISPERSAL AND ALTERATION OF OIL DISCHARGED ON A WATER SURFACE

In: Fate and Effects of Petroleum Hydrocarbons in Marine Organisms and Ecosystems. D.A. Wolfe, (Ed.), Pergammon Press, p 19-35, 1977.2 fig, 3 tab, 98 ref.

The fate of oil discharged to a water surface was reviewed. The physical, chemical, and biological alterations it subsequently undergoes were discussed in reference to methods for minimizing the adverse environmental consequences. The use of chemical dispersants to produce oil-water emulsions, which dilute and degrade more rapidly than a slick, was presented as a promising method to lessen the effects of oil spills.

1181. McDermott, D. and G.A. Alexander (1977)

CHEMICAL STUDIES OF OFFSHORE OIL PLATFORMS

In: Southern California Coastal Water Research Project Annual Report for the Year Ended 30 June 1976, p 129-135, 1977.1 fig, 5 tab, 2 ref.

As part of the effort to determine if drilling and oil production operations had an effect on organisms found around two oil platforms, chemical analyses of the nearby sediments and of the tissues of several marine animals found in the area were made. Levels of copper, zinc, hexane extractable materials, and volatile solids in sediments around the oil platforms were similar to average coastal background levels and were well below levels observed in sediments contaminated by municipal wastewater outfalls. The petroleum hydrocarbon content of all sediment samples collected was higher than values observed in areas with no natural seeps. The gas chromatographic fingerprints for all samples were indicative of highly weathered oil, indicating no recent contamination of the sediments. No statistically significant differences in metals were observed for yellow rock crabs collected from the oil platforms and control sites and no detectable amount of petroleum hydrocarbons were observed in any of the animals analyzed. (Singa - OEIS)

1182. Mecklenburg, T.A., S.D. Rice, and J.F. Karinen (1977)

MOLTING AND SURVIVAL OF KING CRAB (PARALITHODES CAMTSCHATICA) AND COONSTRIPE SHRIMP (PANDALUS HYDINOTUS) LARVAE EXPOSED TO COOK INLET CRUDE OIL WATER-SOLUBLE FRACTION

In: Fate and Effects of Petroleum Hydrocarbons in Marine Ecosystmes and Organisms, D.A. Wolfe (Ed.), Pergamon Press, N.Y., 1977 p. 221-228 (25 refs.)

Larvae of coonstripe shrimp and king crab were exposed to solutions of the water-soluble fraction (WSF) of Cook Inlet crude oil in a series of bioassays on intermolt stages I and II and the molt period from stage I to stage II. Molting larvae were more sensitive than molting king crab larvae. When molting larvae were exposed to high concentrations of the WSF (1.15-1.87 ppm total hydrocarbons) for as little as 6 hr, molting success was reduced by 10-30% and some deaths occurred. When larvae were exposed to these high concentrations for 24 hr of longer, molting declined 90-100% and the larvae usually died. The lowest concnetrations tested (0.15-0.55 ppm total hydrocarbons) did not inhibit molting at the length of exposure, but many larvae died after molting. Median lethal concentrations (LC50's) based on 144 hr of observation for molting coonstripe shrimp and 120 hr for molting king crab were much lower than the 96-hr LC50's, showing that the standard 96-hr LC50 is not always sufficient for determining acute oil toxicity. Although the LC50's for intermolt larvae are higher than levels of petroleum hydrocarbons reported for chronic and spill situations, some of the LC50's for molting larvae exposed 24 hr and longer are similar to or below these environmental levels. Comparisons of sensitivity to oil between different crustacean species or life stages should be based on animals tested in the same stage of the molt cycle, such as intermolt.

1183. Michael, A.D. (1977)

THE EFFECTS OF PETROLEUM HYDROCARBONS ON MARINE POPULATIONS AND COMMUNITIES

In: Fate and Effects of Petroleum Hydrocarbons in Marine Organisms and Ecosystems. D.A. Wolfe, (Ed.), Pergammon Press, p. 129-137, 1977.1 tab, 33 ref.

Literature on the effects of oil spills on plankton, invertebrates, fish, birds and mammals was summarized. Several recent studies on marine populations were discussed in order to illustrate the short-comings of many investigations. The need for more detailed analyses of how these populations are altered or eliminated by acute and chronic exposure to oil was emphasized.

1184. Michael, A.D. and B. Brown (1978)

EFFECTS OF LABORATORY PROCEDURE ON FUEL OIL TOXICITY

Environ. Pollut. (15)(1978), pp 277-287, 21 refs.

Laboratory testing of No. 2 fuel oil toxicity to the amphipod Neohaustorius schmitzi in artificial sea water demonstrated that each of several experimental factors produced significant variation in test results. Variables examined were: presence of substrate (sand), concentration of oil (0.05 or 0.025 ml/litre), stirring rate, age of the oil/water mixutre, evaporation and temperature.

1185. Milan, C.S., and T. Whelan III (1978)

ACCUMULATION OF PETROLEUM HYDROCARBONS IN A SALT MARSH ECOSYSTEM EXPOSED TO STEADY STATE OIL INPUT

In: Proceedings of Confer. on Assessment of Ecological Impacts of Oil Spills, Keystone, Col., 14-17 June 1978

The distribution of petroleum derived hydrocarbons was studied in various trophic levels of a salt marsh ecosystem exposed to a steady-state petroleum input. This information is used in deriving a mechanism of petroleum transfer and removal through an ecosystem following an oil spill which occurred or extended into the estuarine environment. The study area was an active oil field in south Louisiana which has been producing petroleum for 30 years. Two uncontaminated control sites were chosen for comparison which bordered the fringes of the oil field and represented the extreme environmental conditions (temperature and salinity) which could occur throughout the year within the oil field.

Hydrocarbons were extracted from tissue using NaOH digestion followed by ethyl ether partitioning of the total lipid fraction. Silica gel-alumina chromatography was used to isolate the hydrocarbons and separate the aliphatic from the aromatic fraction. Alkane concentrations were quantified by gas chromatography. Semi-quantitative determination of the aromatic fraction was made by fluorescence spectroscopy.

The results indicated that exposed vegetation (Spartina alternaflora) in the oil field contained up to 20 times greater hydrocarbon concentrations (enrichment factors) than vegetation in the control areas. Near-bottom waters, sessile benthic organisms, mobile benthic organisms and free-swimming detritus feeders contained hydrocarbon enrichment factors of 40, 4, 3, and 2, respectively. Near-surface waters and free-swimming resident organisms contained no appreciable hydrocarbon enrichment.

Based upon these data, a mechanism of transfer and removal of petroleum hydrocarbons is proposed which is initiated by adsorption of floating oil by exposed subaerial vegetation. Oil-laden detritus, formed during seasonal plant growth and death, is transferred to the water column and eventually incorporated into the sediment. This process also aids in removing dissolved and suspended oil which does not reach the vegetation. High enrichment of hydrocarbons in the sediment and low enrichment in the water column were reflected by enrichment factors in the benthic and water column residents, respectively.

Estuarine sediments act as a sink for oil, hence causing enhanced enrichment of petroleum in benthic organisms.

1186. Mix, M.C., R.T. Riley, K.I. King, S.R. Trenholm and R.L. Schaffer (1977)

CHEMICAL CARCINOGENS IN THE MARINE ENVIRONMENT BENZO(A)PYRENE IN ECONOMICALLY IMPORATNT BIVALVE MOLLUSKS FROM OREGON ESTUARIES

In: Fate and Effects of Petroleum Hydrocarbons in Marine Ecosystems and Organisms, D.A. Wolfe (Ed.), Pergamon Press, N.Y., 1977 pp 421-431 (32 refs.)

We have recently begun to study levels of carcinogenic polycyclic aromatic hydrocarbons that are present in bivalve mollusks from Oregon's estuaries. Because of many unique features in their life history and biology, indigenous shellfish are useful for monitoring the marine environment. In this paper, we describe benzo(a)pyrene (BAP) levels in economically - important shellfish populations from several sites in five Oregon bays. We have assayed BAP levels in clams (Tresus capax, Saxidomus giganteus, Mya arenaria), mussels (Mytilus edulis) and oysters (Crassostrea gigas) from Tillamook, Netarts, Yaquina, Alsea and Coos Bays. Detectable levels of BAP were present in bivalves from 38 of the 44 sampling sites. High levels (greater than 15 ng/g) were present in mussels collected from the Newport bayfront in Yaquina Bay and from a marina in Tillamook Bay. Significant levels (greater than 5 ng/g) were present in M. arenaria collected from an area adjacent to the shipping docks in Coos Bay.

1187. Motohiro, T. and Z. Iseya (1976)

EFFECTS OF WATER POLLUTED BY OIL ON AQUATIC ANIMALS. IV. QUANTITATIVE DETERMINATION OF C_{14} - C_{24} N-PARAFFINS IN MARINE SEDIMENTS AND SCALLOPS (PECTEN YESSOENSIS).

Bull. Fac. Fish. Hokkaido Univ., 27 (3/4):191-196.

A study was made to determine whether gas chromatography for quantitative detection was applicalbe to n-paraffins, and to determine whether the C_{14} - C_{24} n-paraffin concentrations could be detected quantitatively in marine sediments. A comparison of the concentrations of n-paraffin composition from C_{14} to C_{24} in marine sediments and in scallops was also made.

Concentrations of n-paraffins in unknown samples were determined by calculating the areas of the chromatograms and by referring to the standard curve. The area of each peak on the chromatogram has given good correlation with the concentration of n-paraffin so the standard curve could be used for the quantitative determination of n-paraffin concentrations. n-Paraffins from C_{14} to C_{24} were contained in the marine sediments which were collected from the fishing ground of scallops and a similar chromatogram pattern was also obtained from the sample of scallops.

1188. Odu, C.T.I. (1978)

THE EFFECT OF NUTRIENT APPLICATION AND AERATION ON OIL DEGRADATION IN SOIL

Environ. Pollut. (15)(1978)

Oil Degradation was determined in oil-polluted (1 or 2 ml of light Nigerian crude/20 g soil, equivalent to 5 and 10% pollution) soils treated with $(NH_4)_2SO_4$ and with nutrient elements with and without enhanced aeration. There was no significant difference in oil degradation in soils with and without enhanced aeration, nor in soils treated with and without $(NH_4)_2SO_4$ and/or nutrients after 4 weeks incubation. After 12 weeks, oil degradation was significantly higher ($p = 0.05$) in the $(NH_4)_2SO_4$ and nutrient treated soils in comparison to the untreated soils, and in soils with enhanced aeration in comparison to the undistrubed soil, at the 5% oil pollution level.

Warburg respirometer studies showed more oxygen consumption (significant at $p=0.05$) in the polluted soils compared with the unpolluted soils. In oil-polluted soils oxygen consumption was depressed significantly ($p = 0.05$) by the addition of $(NH_4)_2SO_4$, but was enhanced significantly ($p = 0.05$) by the addition of $(NH_4)_2SO_4$ and nutrient elements. The respiratory quotient (RQ) was reduced from 0.81 in unpolluted soils to 0.62 in oil-polluted soils.

1189. Odu, C.T.I. (1978)

FERMENTATION CHARACTERISTICS AND BIOCHEMICAL REACTIONS OF SOME ORGANISMS ISOLATED FROM OIL-POLLUTED SEAS

Environ. Pollut. (15)(1978), pp 271-276, 7 refs.

Biochemical tests were carried out with microorganisms isolated from soil soaked with oil for over three years in the oil-producing Ogoni area, and from an oil-saturated teak plantation soil at Ibadan, remote from oil-producing areas. Both soils contained bacteria, fungi and yeast capable of attacking petroleum hydrocarbons. On the basis of morphology and colour of colonies and fermentation characteristics, six and five different types of bacteria respectively were isolated from the Ogoni and Ibadan soils, and two yeast and nine fungal isolates were obtained from both soils. All the organisms isolated were capable of growth in a petroleum hydrocarbon medium and five and two respectively of the isolats from the Ogoni and Ibadan soils were capable of growth in a nitrogen-free medium. (Dept. of Agronomy, Univ. of Ibadan, Ibadan, Nigeria)

1190. O'Neill, T.B. (1977)

BIODEGRADATION OF OIL IN SEAWATER FOR NAVAL POLLUTION CONTROL

Naval Construction Battalion Cntr., Final Rept., June 1977, 8 pp, 4 ref.

The report describes the isolation and utilization of pure and mixed microbial cultures for experiments on the biodegradation of crude oil Bunker C fuel and marine diesel. Many microbial species were found that had hydrocarbonoclastic activity. When pure cultures were combined in mixtures the activity was much greater, 91% oxidation in seven days, than the activity of any one of the component species when used in a pure culture.

1191. O'Sullivan, A.J. (1978)

THE AMOCO CADIZ OIL SPILL

Marine Pollut. Bull., Vol., No. 5, May 1978, pp 123-128

This report gives a preliminary account of the events surrounding the wreck of the Amoco Cadiz on the Britanny coast in March 1978 which caused the most massive oil pollution on record.

The Amoco Cadiz was carrying 120,000 tons of light Iranian crude oil and 100,000 tons of light Arabian crude as well as the remains of her own fuel oil when she grounded on the coast of Brittany on 17 March. She lost most, if not all this oil by 30 March, making this the largest oil spillage ever recorded.

Some 200 km of the coastline of Brittany, including areas of outstanding ecological and biogeographical interest, and whose landscape, flora and fauna are a major basis for the economy of the region, are affected. Much oil still remains on the shore and at sea, and the situation continues to change daily.

This paper can therefore be no more than a preliminary account of events. It is based on the author's observations extending ofver one week from 24 March to 1 April, and on discussions with colleagues at the Marine Biological Station at Roscoff.

At this stage long-term biological effects cannot be predicted with certainty, and these must remain the subject of later work and observations.

1192. Percy, J.A. (1977)

EFFECTS OF DISPERSED CRUDE OIL UPON THE RESPIRATORY METABOLISM OF AN ARCTIC MARINE AMPHIPOD, ONISIMUS-(BOEKISIMUS) AFFINIS

In: Fate and Effects of Petroleum Hydrocarbons in Marine Ecosystems and Organisms, D.A. Wolfe (Ed.), Pergamon Press, N.Y., 1977 pp 192-200 (14 refs.)

Short-term lethality is an unsuitable criterion for assessing the ecological effects of pollutants. A variety of sublethal physiological effects may impair an organism's ability to function normally and lead to a reduction or elimination of sensitive populations in a polluted area. The effects of exposure to sublethal concentrations of dispersed crude oils upon the respiratory metabolism of a marine amphipod have been examined. At low oil concentrations metabolism is significantly depressed but with increasing concentration a reversal of the response occurs. A possible explanation for this complex response is presented. The effects of other factors, such as oil type, presence of dispersants, nutritional state of the animals and weathering of the oil, upon the metabolic response are also considered.

1193. Platt, H.M. (1978)

ASSESSMENT OF THE MACROBENTHOS IN AN ANTARCTIC ENVIRONMENT FOLLOWING RECENT POLLUTION ABATEMENT

In: Marine Pollution Bulletin, Vol. 9, Number 6/June 1978, pp 149-153

Quantative population data for shallow Antarctic soft-bottom communities in King Edward Cove, South Georgia indicate that although once grossly polluted by organic effluent and fuel oil from a whaling station, the fauna recovered within some eight years after contamination ceased. The results are discussed in relation to comparable studies in other polar and temperate areas.

1194. Quinn, J.G. and T.L. Wade (1974)

HYDROCARBON ANALYSES OF IDOE INTERCALIBRATION SAMPLES OF COD LIVER OIL AND TUNA MEAL.

Graduate School of Oceanography Marine Memorandum Series No. 23, Univ. of Rhode Island. 7 pp, (6 refs)

A cod liver oil intercalibration sample, spiked with South Louisiana Crude Oil, and an intercalibration sample of tuna meal were analyzed for hydrocarbons as part of the baseline studies of pollutants in the marine environment sponsored by the National Science Foundation's Office for the International Decade of Ocean Exploration. This report describes the saponification/extraction procedures, thin layer chromatographic techniques, and gas chromatographic screening method used in the hydrocarbon analyses and discusses the results of these measurements.

1195. Reish, D.J., T.J. Kauwling, and A.J. Mearns (1976)

MARINE AND ESTUARINE POLLUTION

Journ. of Water Pollut. Control Feder., Vol. 48, No. 6, Jun 1976, pp 1439-1459, 243 refs.

The 1974 and 1975 literature on marine and estuarine pollution is reviewed. Discusses bioindicators, political, economic and environmental aspects of oil pollution and biological effects of oil spills.

1196. Rice, S.D., J.N. Short, and J.F. Karinen (1977)

COMPARATIVE OIL TOXICITY AND COMPARATIVE ANIMAL SENSITIVITY

In: Fate and Effects of Petroleum Hydrocarbons in Marine Organisms and Ecosystems. D.A. Wolfe, (Ed.), Pergammon Press, p. 78-94, 1977.1 fig, 3 tab, 48 ref.

This review covered studies dealing with the ability of crude and refined oils to kill marine animals. Literature was summarized on the subjects of: (1) the behavior of oil in water; (2) the methodology problems assoicated with bioassay; (3) the comparative toxicity of oil water mixtures, oils and components of oils; and (4) the comparative sensitivity of different life stages and species.

1197. Roesijadi, G., D.L. Woodruff and J.W. Anderson (1978)

BIOAVAILABILITY OF NAPHTAHLENES FROM MARINE SEDIMENTS ARTIFICIALLY CONTAMINATED WITH PRUDHOE BAY CRUDE OIL

Environ. Pollut. (15)(1978)

Uptake of naphthalenes from sand and detritus contaminated with Prudhoe Bay crude oil was examined in the detritivorous clam Macoma inquinata. Concentrations of naphthalenes were determined by ultraviolet spectrophotometry and the use of radiolabelled ^{14}C-2-methylnaphthalene. Exposure of M. inquinata to contaminatd sediments indicated that uptake of naphthalenes as a result of consumption of sediment was insignificant. However, naphthalenes which were released from sediment to the surrounding water were available for uptake by the clams. Our results were consistent with the results of other studies which examined bioavailability of naphthalenes from oil-contaminated sediments.

1198. Rossi, S.S., G.W. Rommel, and A.A. Benson (1978)

HYDROCARBONS IN BENTHIC INVERTEBRATES FROM THE SOUTHERN CALIFORNIA BIGHT

In: Proceedings of Confer. on Assessment of Ecological Impacts of Oil Spills, Keystone, Cd., 14-17 June 1978

1199. Rossi, S.S. and J.W. Anderson (1977)

EFFECT OF NO. 2 FUEL OIL AND SOUTH LOUISIANA CRUDE OIL WATER-SOLUBLE FRACTIONS ON HEMOGLOBIN COMPENSATION AND HYPOXIA TOLERANCE IN THE POLYCHAETOUS ANNELID, NEANTHES ARENACEODENTATA (MOORE)

Marine Science Communications, 3(2):117-131, 1977.

Exposure to sublethal concnetrations of No. 2 Fuel Oil water-soluble fractions (WSFs) did not affect the ability of N. arenaceodentata to increase its body Hb content in response to hypoxia. Similar treatment using water-soluble fractions of South Louisiana crude oil likewise indicated little disruption of compensatory ability. Reduced DO concentrations did not significnatly alter the toxicity of No. 2 Fuel Oil WSFs to N. arenaceodentata. Low DO concentrations markedly increased the toxicity of South Louisiana crude oil WSFs, producing a synergistic effect. Results were defined relative to the concentration of naphthalenes and total dissolved hydrocarbons in experimental media. Possible effects of petroleum hydrocarbons on the respiratory physiology of marine infauna were briefly considered.

1200. Sanders, H.L. (1977)

PATTERNS IN THE AFTERMATH OF THE WEST FLAMOUTH OIL SPILL.

In: Abstracts, The Fourth Biennial Internat. Estuarine Res. Confer. Estuar. Res. Feder., Mt. Pocono, PA, Oct 2-5, 1977.

Long-term studies of the responses of macrobenthos to the West Flamouth oil spill indicate the importance of understanding the life histories and population dynamics of constituent species. The most heavily contaminated bottoms remained severely oiled for at least 57 months. After initial annihilation of the benthos, the opportunisitic Capitella capitata explosively increased. Subsequsently, animal densities flucturated drastically, there were rapid and dramatic species changes and diversity remained low. Intermediatley oiled bottoms showed an initial marked depression in density of benthos, but density and diversity dramatically increased almost one year after the spill. Densities later fluctuated and faunal changes were rapid and successional rather than seasonal.

Diversity and density patterns for marginally oiled bottoms displayed considerably less temporal and spatial variability and the fauna was much more homogeneous throughout the entire sampling period. The communities were in equilibrum rather than in successional change.

1201. Schultz, D.M. and J.G. Quinn (1977)

SUSPENDED MATERIAL IN NARRAGANSETT BAY: FATTY ACID AND HYDROCARBON COMPOSITION.

Organic Geochemistry, Pergamon Press, Gt. Britain, pp 27-36, (numerous refs.)

Suspended material collected at various stations in Narragansett Bay was analyzed for fatty acids and hydrocarbons. The qualitative and quantitative distributions of these compounds indicated that the influence of sewage and other pollutnats was greatest in the river areas. Based on concentrations of polyunsaturated fatty acids, the highest denstities of phytoplankton were interpreted to occur at the mid and lower Bay stations, and the percentage of phytoplankton in suspended material was estimated from the concentration of heneicosa-hexaene. The concentrations of fatty acids and hydrocarbons in the suspended material decreased from the river stations to the mid and lower Bay stations, closely following a similar trend observed in the sediment. Possible sources of the suspended material and the influence of these sources on this material in various areas of the Bay are discussed, and attempts are made to interrelate the suspended material, resuspended sediment, phytoplankton, and sewage effluent with chemical and biochemical diagenetic changes.

1202. Scott, B.F. and D.B. Shindler (1978)

IMPACT OF CRUDE OIL ON PLANKTONIC FRESHWATER ECOSYSTEMS

In: Proceedings of Confer. on Assessment of Ecological Impacts of Oil Spills, Keystone, Col., 14-17 June 1978

A series of five controlled oil spills were carried out in artificial inground freshwater ponds to ascertain the effect of a crude oil stress on the microorganisms in the water column. Samples were taken every two weeks from the oiled ponds and from untreated control ponds for enumeration and identification of bacteria, phytoplankton, protozoa and zooplankton, and for chemical analysis of the water, including pH, BOD, dissolved oxygen, alkalinity, total organic carbon, nitrogen total phosphorus as well as other factors. In addition, samples of the oil were analyzed by gas-liquid chromatography as the experiments progressed. All experiments were initiated by adding a single dose of crude oil to individual ponds during the Canadian winter seasons (January or February). Observations and sampling were continued until at least the following autumn. Four experiments involved the addition of crude oil to the water under the 50 cm thick snow and ice cover (two experiments using 90L Normal Wells crude, one using 45L Normal Wells crude, and one using 90L Pembina crude oil). A fifth experiment involved a spill of 540L Normal Wells crude oil on top of the snow and ice cover of a pond. The amounts of oil added in the under-ice experiments were either 0.05 or 0.1% of the fluid volume of the ponds, the surface spill was about 1% of the fluid volume of the ponds, the surface spill was about 1% of the fluid volume of the ponds, the surface spill was about 1% of the fluid volume of the ponds, the surface spill was about 1% of the fluid volume.

The major biological effects of the oil became obvious, beginning in early spring, during and after the ice had melted. Only small changes in the numbers and distribution of the phytoplankton, zooplankton and bacteria were observed in the oiled ponds during the month or so after the spills, while a thick ice and snow cover remained. As the ambient temperature increased and the water became warmer during the spring, zooplankton populations in the oiled ponds decreased markedly while heterotrophic bacteria increased; the extent of these changes correlated with the amount of oil initially added to each pond. For instance, by mid-summer, in the ponds treated with 90L Pembina or Norman Wells oil, zooplankers which were numerous in the control pond were reduced by 50 - 100%, while heterotrophic bacteria were 10-fold more numerous than in the control pond.

Analyses of the oil floating on the surface of the water and in the ponds' sediments at the end of the experiments indicated that some fractions of the oil had been partially degraded.

The general findings of this study are in agreement with studies on experimental oil spills in small lakes and in other experimental ponds. chlorophyll measurements in the oiled ponds were several-fold higher than in the control ponds, perhaps partly because of the absence of large zooplankton populations which could consume algae. The species distribution of phytoplankton in each pond was latered by the type and amount of oil added. In the summer (July through August) the phytoplankton populations in the ponds treated with Norman Wells oil and in the control ponds were either dominated by or contained a large number of Chlorophyta of various genera along with some Cyanophyta and lower numbers of many other algae. In the pond where the Pembina oil was used, a unique summer bloom of Zoomastigophera, a class of protozoa, occurred. The summer water quality measurements reflected the biological status of the oiled ponds; dissolved oxygen, alkalinity and pH were lowest and BOD, total organic carbon and chlorophyll a, highest in the ponds containing the most oil. The results indicate that the biota, including bacteria, algae, and zooplankton, are greatly affected by the presence of crude oil. Moreover, the modulation of the effects by the climatic conditions appear particularly significant. The results reflect the impact of oil on processes occurring in the water column of ponds or shallow lakes and appear also to be pertinent to probable effects of oil in quiescent embayments of larger, more complex lakes.

1203. Sharpley, J.M. and A.M. Kaplan (Eds.) 1976

PROCEEDINGS OF THE 3RD INTERNATIONAL BIODEGRADATION SYMPOSIUM.

Applied Science Publishers, Ltd., Essex, England, 1138 pp.

This volume, the third in the series, contains 108 papers presented at the 3rd International Biodegradation Symposium, held at the University of Rhode Island, USA, in Agusut 1975, and arranged under the auspices of the Biodeterioration Society.

The programme of the symposium was developed so as to cover major topics in biodegradation and biodeterioration and each session was arranged by a recognised leader in the particular field.

Includes 21 papers on metabolism of hydrocarbons, oils, fuels and lubricants.

1204. Soule, D.F., C.R. Feldmeth, M.K. Wicksten, J.K. Dawson and M. Oguri (1978)

BIOLOGICAL IMPACTS OF THE SANSINENA OIL SPILL.

In: Proceedings of Confer. on Assessment of Ecological Impacts of Oil Spills, Keystone, Col., 14-17 June 1978.

Water column organisms, which are good indications of short term stress, have been monitored for some five years in the outer Los Angeles Harbor by the Environmental Projects of the University of Southern California when the tanker Sansinena exploded on December 17, 1976. Primary productivity measurements and zooplankton samples had been taken on December 8 at a station beside the blast site. Within days after the accident, samples were again taken in the area, and the sampling was continued on a monthly basis thereafter.

Studies in the area had also included monthly measurements of physical parameters such as temperature, salinity, dissolved oxygen, pH, and some turbidity through the water column as well as nutrients and some sediment chemistry and grain size analysis. Biota studied monthly included microbials, phytoplankton productivity, chlorophylls and assimilation ratios, zooplankton species and numbers, meroplankton-fouling fauna and sea birds. Benthic organisms were samples quarterly and fish trawl were occasiona made.

The objectives of the present study were to document the initial impact on the water column biota, and to determine the nature and rate of recovery in the area.

Phytoplankton productivity is measured by the ^{14}C method of inoculating water samples in paired light and dark glass stoppered bottles; these are incubated in a standard light source box (Doty box) with circulating ambient temperature sea water. Samples are filtered and counted in a low background Geiger counter. Pigments are determined by filtering sea water samples on HA Millepore filters. These are fixed with $MgSO_4$ and placed in a dessicator until extraction into 90% acetone and peak absorbances are measured in a spectrophotometer.

Zooplankton are collected by surface horizontal tows, depending upon the space available at a given station, using a 253u mesh 1/2 meter conical nylon net with a flow meter attached. Settling volumes are measured, species identified, and numbers per cubic meter calculated.

1205. Spies, R.B., P.H. Davis, and D.H. Stuermer (1978)

THE INFAUNAL BENTHOS OF PETROLEUM CONTAMINATED SEDIMENTS: A COMMUNITY STUDY OF A NATURAL OIL SEEP

In: Proceedings of Confer. on Assessment of Ecological Impacts of Oil Spills, Keystone, Col., 14-17 June 1978.

The benthic fauna of a natural submarine oil seep in the Santa Barbara Channel is being studied in order to better understand the effects of chronically contaminated coastal sediments. Community and population changes of the infaunal macrobenthos of the Isla Vista Oil Seep are being compared to a nearby area similarly situated. Samples have been collected every 8 weeks for 2 years. The seep sediments support a well-developed and diverse infauna representative of the Northria-Tellina assemblage, which is common to shallow areas of the mainland shelf of southern California. Relative to the comparison station the seep sediments are enriched in numbers of individuals and species but these differences occur in such a way that Shannon-Weaver Diversity (H') is about the same for each area and through time. Rank correlation analysis of common species suggests the same basic species composition for each area. A majority of species populations have higher densities in the seep sediments with particularly large differences seen for some deposit feeders, such as oligochaete worms. However, biomass of polychaete worms, the predominate group, is not significantly higher. Fluctuations in numbers of individuals species and polychaete biomass are correlated in the two areas, with maximum values in the Spring-Summer and minimum values in the Fall-Winter periods. Concordance among ranks of the ten most common species from the study period at each station indicates that short-term persistence stability is lower at the oil seep. This may be due to greater larval settling and possibly greater predation at the oil seep. A hypothesis for trophic enrichment by petroleum degrading microbes and mats of the sulfide-oxidizing Beggiatoa is presented. The toxicity of the oil and the role that adaptation plays in allowing a diverse community to exist in these sediments is discussed. Our findings suggest that moderate trophic enrichment of deposit feeding communities occurs without change.

1206. Stainken, D. (1977)

THE ACCUMULATION AND DEPURATION OF NO. 2 FUEL OIL BY THE SOFT SHELL CLAM, MYA ARENARIA L.

In: Fate and Effects of Petroleum Hydrocarbons in Marine Organisms and Ecosystems. D.A. Wolfe, (Ed.), Pergammon Press, p. 313-322, 1977 .5 fig, 2 tab, 29 ref.

Young soft shell clams were exposed to subacute concentrations of No. 2 fuel oil-in-water emulsions under simulated winter (4C) spill conditions. A pattern of accumulation and discharge of petroleum constituents, an experimental depuration time and a potential transport mechanism of aromatic compounds from the fuel oil to the clams were experimentally determined. Clams accumulated the greatest amount of hydrocarbons within one week after the initial exposure. The accumulated hydrocarbons decreased each week as the hydrocarbon content of the water decreased. The depuration period was determined when the clams were transferred to an uncontaminated system for 14 days subsequent to the 28 day oil exposure.

1207. Steele, J.L. (1977)

EFFECTS OF CERTAIN PETROLEUM PRODUCTS ON REPRODUCTION AND GROWTH OF ZYGOTES AND JUVENILE STAGES OF THE ALGA FUCUS EDENTATUS DE LA PYL

In: Fate and Effects of Petroleum Hydrocarbons in Marine Organisms and Ecosystems. D.A. Wolfe, (Ed.), Pergammon Press, p. 138-142, 1977.3 tab, 12 ref.

A method has been devised to utilize easily obtainable eggs of Fucus as a bioassay. The effects of various petroleum products on growth and early development of the zygote has been studies. A crude oil had much less effect on Fucus growth than did No. 2 fuel oil or two jet fuels. When exposure occured immediately prior to and during release of gametes, no germination or growth occurred with any of the oil types, even at the lowest concentration used.

1208. Stein, R.J., E.R. Gundlach, and M.O. Hayes (1978)

THE URQUIOLA OIL SPILL (5/12/76): OBSERVATIONS OF BIOLOGICAL DAMAGE ALONG THE SPANISH COAST

In: Proceedings of Confer. on Assessment of Ecological Impacts of Oil Spills, Keystone, Col., 14-17 June 1978.

A massive oil spill resulted from the grounding and subsequent explosion of the supertanker Urquiola on 12 May 1976 at the entrance to La Coruna harbor in northwest Spain. A total of 99-100,000 tons of Persian Gulf crude oil was lost, of which approximately 25-30,000 tons washed onto 215 km of shoreline. Over 2000 tons of dispersants were applied around the wreck site. Detailed observations of oil impact were made at 32 stations from 17 May to 10 June 1976. An additional 4 areas were analyzed in detail from 4-10 June to determine spill effects on the benthic community. At each locality, two replicate samples (30 x 30 x 25 cm quadrants) were collected from 5 or more sites. Benthic macrofauna (greater than 0.8 cm) were counted and measured to determine species diversity, distribution and abundance. Unfortunately, pre-spill benthic population data were not available.

Biological damage was visibly apparent along sheltered rocky coasts, some fine-sand beaches, marshes and tidal flats. In sheltered rocky areas near the wreck site, extremely heavy oil accumulations smothered all intertidal life. In other areas, limpets lost firm contact with the substrate and were easily peeled off. Small fish appeared disoriented. On fine-sand beaches, thousands of dead amphipods were found along the high tide swash line. Detailed study of a sheltered fine-sand tidal flat showed population mortality of 70% for the edible cockle (Cerastoderma edule) and 10-30% for three other clam species. Comparison of class size of killed cockles shows no relationship, indicating death caused by a physical, not physiological, disturbance. Clogging of the respriatory apparatus is suggested. At another location, mobile crabs (Carcinus maenas) seemed to suffer no ill effects. Marsh grasses (Spartina and Juncus) showed partial recovery (green shoots) 3 weeks after heavy oiling. High energy rocky areas showed little sign of oil impact.

1209. Straughan, D. (1977)

BIOLOGICAL SURVEY OF INTERTICAL AREAS IN THE STRAITS OF MAGELLEN IN JANUARY 1975, FIVE MONTHS AFTER THE METULA OIL SPILL

In: Fate and Effects of Petroleum Hydrocarbons in Marine Organisms and Ecosystems. D.A. Wolfe, (Ed.) Pergammon Press, p. 247-260, 1977.2 fig, 7 tab, 23 ref.

Field sampling was conducted in areas in the Straits of Magellen that were oiled and unoiled by oil spilled from the tanker Metula in August 1974. Marsh plants had started to grow through oil in the oiled areas. High levels of petroleum hydrocarbons were recorded in mussels in the oiled areas. The presence of byssus threads alone suggested recent loss of mussels in part of the heavily oiled area. The Kuwait crude oil spilled in the Straits of Magellen is similar to that spilled from the Torrey Canyon. In both instances there was large scale mousse formation. It is suggested that it is this physical impact that is the most significant factor and not the cold water conditions.

1210. Szaro, R.C. (1977)

EFFECTS OF PETROLEUM ON BIRDS

In: Trans. of the 42nd North American Wildlife and Natur. Res. Conf., 1977. Wildlife Management Inst., Wash., D.C. pp 374-381. (many refs.)

The chronic effects of oil pollution on aquatic birds are not well known. Our preliminary studies indicate that oil ingestion is probably not a major cause of seabird mortality. Oil ingestion may affect the physiological and reproductive condition of seabirds. Moreover, a substantial number of seabird eggs may be destroyed each year by oil contamination. Such laboratory studies now need to be extended to the field. Further laboratory studies are needed to measure the accumulation and persistence of oil in tissues and to interpret the significance of oil residues in tissues.

1211. Szaro, R.C. and P.H. Albers (1977)

EFFECTS OF EXTERNAL APPLICATIONS OF NO. 2 FUEL OIL ON COMMON EIDER EGGS

In: Fate and Effects of Petroleum Hydrocarbons in Marine Ecosystems and Organisms, D.A. Wolfe (Ed.), Pergamon Press, N.Y., pp 164-167, (13 refs.)

Because eggs of marine birds may be exposed to oil adhering to the feathers of adult birds, a study was undertaken to determine the effects of oil contamination. Two hundred common eider eggs (Somateria mollissima) were divided into four experimental sets of 50 each. Two sets were treated with No. 2 fuel oil in amounts of 5 ul and 20 ul; a third with 20 ul of propylene glycol, a neutral blocking agent. The fourth set served as a control. Hatching success was 96 percent for the eggs treated with 20 ul propylene glycol, 96 percent for the controls, and 92 percent for the eggs treated with 5 ul oil hatched. Only 69 percent of the eggs treated with 20 ul of oil survived: a significant reduction in hatchability (P is less than 0.05). Mean hatching weights for all sets were statistically equal. Thus, oil pollution may significantly increase embryonic mortality in marine birds.

1212. Tatem, H.E. (1977)

ACCUMULATION OF NAPHTHALENES BY GRASS SHRIMP: EFFECTS ON RESPIRATION, HATCHING AND LARUAL GROWTH

In: Fate and Effects of Petroleum Hydrocarbons in Marine Organisms and Ecosystems. D.A. Wolfe, (Ed.) Pergammon Press, p 201-209, 1977.4 fig, 25 ref.

Estuarine grass shrimp, Palaemonetes pugio, were exposed in artificial seawater to petroleum hydrocarbons from a No. 2 fuel oil. Exposure water and organisms were sampled periodically for naphthalene concentrations. Naphthalene levels in the exposure solution decreased rapidly while concentrations in the shrimp tissue increased dramatically. After 6 hr, tissue levels of methylnaphthalene were 150 times greater than water levels. Depuration of hydrocarbons was rapid and began during the exposure period; however, complete depuration did not occur. Respiratory rates were transiently depressed following exposure. Naphthalenes were also demonstated to suppress larval hatching success and larval growth. A single 72-hour exposure of gravid female shrimp to PH (1.44 ppm) has a detrimental effect on larval hatching. Control females released an average of 45 larvae compared to 9 larvae for exposed females. A concentration of 0.72 ppm PH did not have a significant effect on larval hatching. Grass shrimp larvae continuously exposed to PH

(0.85 = 0.52 ppm) weighted significantly less than control animals after 12 days. Removal of larvae to clean seawater resulted in accelerated growth. Exposure of adult grass shrimp to sublethal levels of PH or naphthalenes initially resulted in increased activity and disoriented swimming patterns. Animals which survived exposures seemed to recover completely when placed in uncontaminated seawater.

1213. Taylor, T.L. and J.F. Karinen (1977)

RESPONSE OF THE CLAM, MACOMA BALTHICA (LINNAEUS), EXPOSED TO PRUDHOE BAY CRUDE OIL AS UNMIXED OIL, WATER-SOLUBLE FRACTION, AND OIL-CONTAMINATED SEDIMENT IN THE LABORATORY

In: Fate and Effects of Petroleum Hydrocarbons in Marine Ecosystems and Organisms, D.A. Wolfe (Ed.), Pergamon Press, N.Y., 1977. pp 229-237

The small clam, *Macoma balthica* (Linnaeus 1758), will likely be subjected to oil slicks layered on the mud and to water-soluble fractions of crude oil or oil-contaminated sediment. Groups of adult clams in or on their natural sediment were exposed in flow-through aquaria at 7^{o}-12^{o}C to various concentrations of Prudhoe Bay crude oil layered on the mud surface, the water-soluble fraction (WSF) of the crude oil, and oil-treated sediment (OTS).

Gentle settling of crude oil over clam beds had negligible effects on clams observed for 2 months. Water-soluble and oil-treated sediment fractions of Prudhoe Bay crude oil inhibited burrowing and caused clams to move to the sediment surface. Responses were directly proportional to concentrations of the WSF or amount of OTS. The 1-hr and 72-hr effective median concentrations of the WSF for the responses of burrowing by unburied clams and surfacing by buried clams were 0.234 and 0.367 ppm naphthalene equivalents respectively. The interpolated amount of OTS needed for a 50% surfacing response within 24 hr was 0.67 g OTS cm^{-2}.

Although short-term exposures of clams to the WSF of crude oil and OTS caused few deaths, behavioral responses of clams to oil may be of great importance to their survival in the natural environment. In these laboratory tests, many of the clams recovered, but in nature clams that come to the sediment surface may be eaten by predators or die from exposure.

1214. Teal, J.M. (1977)

FOOD CHAIN TRANSFER OF HYDROCARBONS

In: Fate and Effects of Petroleum Hydrocarbons in Marine Organisms and Ecosystems. D.A. Wolfe, (Ed.), Pergammon Press, p 71-77, 1977.36 ref.

Routes for the uptake of petroleum hydrocarbons by aquatic organisms other than foodweb magnification were examined. The pathway emphasized was that of foodweb transfer. Methods of pollutant transport considered included: transport by migrating or surface-feeding fish; sinking of materials such as tar particles; and hydrocarbon concentration in fecal pellets.

1215. Thomas, M.L. (1977)

LONG TERM BIOLOGICAL EFFECTS OF BUNKER C OIL IN THE INTERTIDAL ZONE

In: Fate and Effects of Petroleum Hydrocarbons in Marine Ecosystems and Organisms, D.A. Wolfe (Ed.), Pergamon Press, N.Y., 1977 pp 238-245 (20 refs.)

In February, 1970 a large spill of Bunker C oil occurred in Chedabucto Bay, Nova Scotia, Canada when the tanker "Arrow" grounded. Oil from the tanker has persisted for over six years on rocks and in intertidal sediments on the shores of the bay. During this period mortalities of common species in all major communities on both exposed and sheltered shores have occurred. On rocky shores, the dominant fucoid algae suffered heavy initial mortalities which were more severe at high tidal levels. Recolonization has proceeded from lower to higher levels but has not yet occurred in the high tide zone. Delayed recolonization appears to be related to long term toxicity. In salt-marsh and sheltered lagoonal communities, the dominant grass, salt marsh cord grass, suffered heavy mortality delayed one year from the initial spill, recovery commenced two years later and is proceeding steadily. Soft-shell clams in lagoonal sediments have shown persistent mortalities proportional to oil content of sediments. This pattern appears to be a result of direct toxicity, environmental change caused by oil and sub-lethal metabolic effects.

1216. Tokuda, H. (1977)

FUNDAMENTAL STUDIES ON THE INFLUENCE OF OIL POLLUTION UPON MARINE ORGANISMS - III. EFFECTS OF OIL-SPILL EMULSIFIERS AND SURFACTANTS ON THE GROWTH OF PORPHYRA-LAVER

Bull. Japan Soc. Scient. Fish., 43(5):587-593.(In Japanese; English abstract.)

Inhibitory effects of oil-spill emulsifiers (6 products) and non-ionic surfactants (4 products) on the growth of a laver, *Porphyra yezoensis*, were investigated by culture experiments. One oil-spill emulsifier composed of n-paraffin and ester-type non-ionic surfactants was so low in toxicity that its 1 ppm solution supported a laver growth rate nearly similar to that of the control; its 100 ppm solution exhibited a growth rate higher than 50% of the control. Polyoxyethylene (20 mole) sorbitan trioleate, an ester-type surfactant, was the least toxic of the surfactants tested and allowed the laver to grow even at 100 ppm, while polyoxyethylene (5 mole) nonylphenol ether was the most toxic of the ether-type surfactants used and the laver was killed within 24 hours in 10 ppm solution. The absorption spectrum of the laver frond was not affected by a 20-hour immersion in a 1,000 ppm solution of either polyoxyethylene (2 mole) oleyl ether or polyoxyethylene (20 mole) sorbitan trioleate. Changes in cellular appearance of the laver induced by immersion in surfactant solutions prepared at various concentrations were also studied by optical microscopy.

1217. Traxler, R.W. (1978)

PETROLEUM DEGRADATION IN LOW TEMPERATURE MARINE AND ESTUARINE ENVIRONMENTS.

Univ. of Rhode Island Dept. of Plant Pathology-Entomology Final Report to Office of Naval Research, Contract N00014-76-C-0138, 1 Jan. 1978.

Hydrocarbon utilizing bacteria were isolated from several low temperature water and sediments and were found to represent 15 different genera. All isolated were psychrotolerant and had Q10 values ranging from 1.3-2.4 and metabolized representative aromatic, naphthenic and aliphatic hydrocarbons. In situ degradation rates were demonstrated to be much lower than laboratory rates and were on the order of magnitude of ngs of substrate per day. The sediment microbial populations in an oiled beach were shown to select for hydrocarbon metabolizing organisms and this selection correlated with degradation of hydrocarbons in the sediments. Hydrocarbon metabolizing microorganisms contain inclusions not present in the same organisms grown on peptone. The inclusions are identified as hydrocarbon oxidation products and are not pooled hydrocarbon.

1218. U.S. Coast Guard (1978)

WORKING WITH ORGANIC SOLVENTS

Safety and Health Review, March 1978. Dept. of Transportation, U.S. Coast Guard, pp 4-6. (Reprint from Lifeline, Industrial Hygiene Dept.)

A short article on safety which reviews organic solvents and their use. Recommends health and safety procedures to minimize the risk of injury and illness related to occupational exposures to organic solvents. Chemical groupings reviewed include aliphatic hydrocarbons, aromatic hydrocarbons, halogenated hydrocarbons, and alcohols.

1219. Vanderhorst, J.R., J.W. Anderson, P. Wilkinson, and D.L. Woodruff (1978)

ESTIMATION OF EFFECTS FROM OIL ON INTERTIDAL POPULATIONS: EXPERIMENTAL PERTURBATION VERSUS NATURAL VARIATION

In: Proceedings of Confer. on Assessment of Ecological Impacts of Oil Spills, Keystone Col., 14-17 June 1978.

Experiments involving oil-spiked sediments in trays placed in the lower intertidal zone have a demonstrated utility in assessment of crude oil retention by sediments and oil uptake and depuration by selected organisms. The goal of the present study was to evaluate data obtained on recruitment of organisms to control and oil-treated trays to elucidate possibly subtle effects and provide quantitative criteria for use in design of future experiments.

Sediment preparation methods and experimental approach have been previously described. In general the approach involved three installations of 6 fiberglass trays each in the lower intertidal align zone of Sequim Bay, Washington. For each installation, control and oil-treated trays were used. Pretreatment of sediment involved sieving to increase homogenety and a freezing-thawing regime to ensure the absence of living organisms. Sampling over a one-year period involved removal of randomly selected cores which extended from the sediment surface to the bottom of the trays. Statistical evaluation of data on animal occurrence and abundance used parametric and nonparametric tests.

A total of 42 species of animals were identified from the experimental trays. In some cases (*Mysella tumida* and *Psephidia lordi*), it was possible to identify juvenile and mature cohorts. For some of the parameters, it was observed that mean magnitude was less in oil-treated as compared to control trays (e.g., abundance of juvenile *M. tumida* 27% less in treated). The data presented specify the probability that the observed effects are, in fact, non zero (alpha = probability of a Type I error), and the probability that real effects do not exceed the observed magnitude (beta - probability of Type II error). The study partitions the observed variation in occurrence and abundance (where appropriate) into sources associated with sampling time, cores, experimental trays, and treatment with oil.

Because of confounding factors (salinity, temperature, other pollutants), evaluation of effects in field studies is difficult or often impossible. The field experiment, as here described, eliminated or greatly reduces the influence of confounding factors. The primary utility of the data here presented is in the identification of critical variability factors in the recruitment of marine benthic organisms in the Puget Sound region. The data provide a quantitative basis for selection of sample size in terms of cores, and of tray size. The approach presented is appropriate for use in the evaluation of other parameters in experimental field studies of oil pollution effects.

1220. Vandermeulen, J.H. and T.C. Hemsworth (1977)

ALTERED GRAZING PATTERNS IN A COPEPOD/ALGA ECOSYSTEM BY LOW LEVEL NAPHTHALENE EXPOSURE

Internat. Counc. for the Exploration of the Sea, C.M. 1977/E:70 Plankton Committee. (Bedford Inst. of Oceanogr., Dartmouth, N.S.)

The predator-prey balance in an experimental copepod/alga ecosystem (*Calanus finmarchicus* and *Monochrysis lutheri*) is significantly disrupted by small amounts of naphthalene.

Algal mortality due to copepod predation was significantly higher in the presence of 0.5 and 1.0 ppm naphthalene than in control populations of algae and copepods without naphthalene, or containing only algae and naphthalene. This increased predation pressure in the presence of naphthalene is a function of both naphthalene concentration and of exposure time.

Dinoflagellate motility is significantly and predictably disrupted by 0.1, 0.5 and 1.0 ppm naphthalene. The breakdown of normal algal motility is a direct function of naphthalene concentration and of exposure time.

Alteration fo the predator-prey balance between *C. finmarchicus* and *M. lutheri* is due to the breakdown of algal motility, and the differential susceptibility of the copepod and the alga to the pollutnat.

The notion of an "Ecological LD_{50}" for pollutants is considered.

1221. Weller, G. and D.W. Norton (1977)

OIL IN THE ARCTIC: 2. THE OUTER CONTINENTAL SHELF ENVIRONMENTAL ASSESSMENT PROGRAM

1223. Whipple, J.A., T.G. Yocom, D.R. Smart, and M. Cohen (1978)

EFFECTS OF CHRONIC CONCENTRATIONS OF THE WATER-SOLUBLE FRACTION OF COOK INLET CRUDE OIL ON SPAWNING STAGES OF ADULT STARRY FLOUNDER

In: *Proceedings of Confer. on Assessment of Ecological Impacts of Oil Spills, Keystone, Col., 14-17 June 1978*.

One of the more important questions remaining in studies of the effect of petroleum hydrocarbons on marine organisms is the potential effect at chronically low exposures. Constant chronic input from point sources, such as in estuaries, may ultimately be of greater importance than that of catastrophic oil spills. Emphasis in these studies should be placed on the most critical or sensitive life history stage. With this in view, our research has concentrated on effects during egg, embryo and larval stages. We have observed, that the effects of pollutant stress are more severe at any stage if the organisms are also stressed by environmental extremes or are in poor "condition" from inadequate nutrition. On this basis, we hypothesized that the organism at time of spawning may be the most sensitive to toxic petroleum hydrocarbons. The objective of this study was to determine the effect of part per billion concentrations of the water-soluble fraction (WSF) of crude oil on adult flounder and littleneck clams when epxosed prior to spawning, and to determine subsequent effects on their eggs and larvae.

1224. White, D.H. and L.F. Stickel (1975)

IMPACTS OF CHEMICALS ON WATERFOWL REPRODUCTION AND SURVIVAL

In: Trans. of the First Internat. Waterfowl Sympos., St. Lous, MO, Feb. 1975, pp. 137-142, (7 pp of refs.)

Residues of organochlorine pesticides, PCB's, heavy metals, and other toxic chemicals are ubiquitous in the biosphere and are commonly found in tissues and eggs of wild birds. This paper reviews research on the effects of these chemicals, with particular reference to waterfowl.

Oil spills have killed man, waterfowl as a result of oiled feathers and the intake of oil and more indirect physiological effects have been shown experimentally.

Pollutants may affect waterfowl indirectly by changing the habitat and directly as a result of intake of toxic substances. They are unlikely to have been directly limiting factors in populations of such species as mallards. Their involvement with problems of other species, including canvasbacks (*Aythya valisineria*) and mergansers has still to be explored.

1225. Witham, R. (1978)

DOES A PROBLEM EXIST RELATIVE TO SMALL SEA TURTLES AND OIL SPILLS?

In: Proceedings of Confer. on Assessment of Ecological Impacts of Oil Spills, Keystone, Col., 14-17 June 1978.

A green turtle was tagged and released by me at Cape Florida, Dade County, Florida on 21 January 1976. When released, the turtle had a carapace length of 10.2 cm. It was found dead on the beach at Hutchinson Island, Martin County, Florida on 9 February 1976. There was tar in its mouth. A small untagged green turtle, carapace length 7.5 cm, was found on shore at Hutchinson Island during mid-October of 1976. It was covered with oil. The turtle was taken to an aquarium, where it was cleaned of external oil. This turtle at first refused to eat, but after being force fed, it did begin to eat limited amounts of food. However, it never regained its strength and it died on 9 November 1976.

A juvenile green turtle was found upside down and disoriented in the surf at Merritt Island National Wildlife Refuge. The turtle has tar in its mouth. After the turtle was taken to the laboratory, the tar was removed and the turtle subsequently recovered. Kleerekoper and Bennett (unpublished research sponsored by API) reported behavioral changes in juvenile green turtles that were exposed to Louisiana crude oil solutes. One of their turtles exhibited positive response to the point source of the solutes.

While the evidence is meager, these data suggest that a problem may exist via-a-vis small sea turtles and oil spills.

1226. Wolfe, D.A. (Ed.) (1976)

FATE AND EFFECTS OF PETROLEUM HYDROCARBONS IN MARINE ORGANISMS AND ECOSYSTEMS

In: Proceedings of a Symposium Nov. 10-12, 1976, Seattle, Wash. D.A. Wolfe and others (Eds.) Pergamon Press, I.D. #021613-7

This volume presents most of the papers which were presented November 10-12, 1976 at an international symposium by the same title, held at the Olympic Hotel in Seattle, Washington. The Symposium consisted of three half-day plenary sessions of invited papers and three half days of concurrent sessions for contributed papers describing original research results. On the final afternoon, a Panel was convened to discuss future research priorities in this field. The Symposium was sponsored by the National Oceanic and Atmospheric Administration and the Environmental Protection Agency to provide a vehicle for documenting the current status of research on the fates and effects of petroleum in marine environments, and for identifying areas still in need of future research.

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0037 ANALYSIS FOR HYDROCARBONS; OYSTERS; UPTAKE AND DEPURATION; GROWTH; CRASSOSTREA
0141 ANALYSIS FOR HYDROCARBONS; TRACERS; PHYTOL; ZOOPLANKTON; FISH; OLEFINS; FOOD CHAIN; BIOGENIC VS. PETROLEUM
1157 ANALYSIS FOR HYDROCARBONS; SOUTH LOUISIANA CRUDE OIL; OYSTERS; CRASSOSTREA; MORTALITY; GAS CHROMATOGRAPHY
1124 ANALYSIS FOR HYDROCARBONS; FISH; FUEL OIL; BUNKER C; DUCKS; MUSKRATS;

CATTAILS; ST. LAWRENCE RIVER; MARSHES
1177 ANALYSIS FOR HYDROCARBONS; PUERTO RICO; OIL SPILLS; ECOSYSTEM; MANGROVE; CORAL REEFS; ESTUARIES; MULLET; OYSTER; CLAM; HISTOPATHOLOGY; REVIEW
1194 ANALYSIS FOR HYDROCARBONS; THIN LAYER CHROMATOGRAPHY; GAS CHROMATOGRAPHY
1181 ANALYSIS FOR HYDROCARBONS; CONTINENTAL SHELF; CRABS; UPTAKE; CALIFORNIA; OFFSHORE PLATFORMS
1187 ANALYSIS FOR HYDROCARBONS; SCALLOPS; PECTEN; PARAFFINS; GAS CHROMATOGRAPHY
1173 ANALYSIS FOR HYDROCARBONS; DUCKS; MALLARDS; NAPHTHALENE; PHYSIOLOGICAL EFFECTS; SOUTH LOUISIANA CRUDE OIL
0002 ANALYSIS FOR PETROLEUM HYDROCARBONS; FISH; TAINTING; WHITEFISH
1202 ANALYSIS FOR PETROLEUM HYDROCARBONS; NORMAN WELLS & PEMBINA CRUDE OIL; ASSESSMENT OF SPILLS; MICROORGANISMS; BACTERIA; PROTOZOA; PHYTOPLANKTON; ZOOPLANKTON; CANADA
0130 ANALYSIS FOR PHC'S; HYDROCARBON; N-ALKANE; METHYLANAPHTHALENE; SHELLFISH; COLUMN CHROMATOGRAPHY; GAS-LIQUID CHROMATOGRAPHY
0094 ANALYSIS OF HYDROCARBONS; HYDROCARBONS IN SEAWATER
0051 ANALYSIS OF HYDROCARBONS; CLAMS; NARRAGANSETT BAY; CHARLESTOWN POND R.I.
0801 ANALYTICAL METHODS; POLYNUCLEAR AROMATIC HYDROCARBONS; PETROLEUM OILS; MARINE TISSUES; BENZ(A)ANTHRACENE; BENZO(A)PYRENE
0036 ANALYTICAL METHODS (UV,GC); OYSTERS; UPTAKE AND DEPURATION; GALVESTON BAY, TEXAS; ANALYSIS FOR HYDROCARBONS; CRASSOSTREA; GULF OF MEXICO
0052 ANALYTICAL TECHNIQUES; COLLECTION OF ABSTRACTS; ABSTRACTS; SAMPLING METHODS; BIOLOGICAL ASSESSMENT
0526 ANALYTICAL TECHNIQUES; HYDROCARBONS; CONTENT ANALYSIS; THIN LAYER CHROMATOGRAPHY; SEDIMENTS
0753 ANALYTICAL TECHNIQUES; REVIEW WORKSHOP; INPUTS; BIOLOGICAL EFFECTS
0330 ANAS; DUCKS; MALLARDS; CRUDE OIL; INGESTION; EGGS; EMBRYOTOXICITY
0299 ANAS; BIRDS; MALLARDS; CRUDE OIL; PHYSIOLOGY; DEHYDRATION; MUCOSAL TRANSFER RATE; DISPERSANTS; INTESTINAL ABSORPTION
0300 ANAS; OIL; MALLARDS; PHYSIOLOGY; INTESTINAL ABSORPTION; MUCOSAL TRANSFER RATES; CRUDE OILS; BOILING FRACTIONS
0951 ANCHOVY; SANTA BARBARA SPILL; FISH; POPULATION; DIVERSITY; PELAGIC; ROCKFISH; ECHO SOUNDING
0985 ANCHOVY; BENZENE; HERRING; EGGS; LARVAE; TOXICITY; ABNORMALITIES; GROWTH; RESPIRATION; FEEDING
0584 ANEROBIC BACTERIA; SEDIMENT; NITROGEN FIXATION; ARCTIC; BACTERIA; PETROLEUM FRACTIONS; BEAUFORT SEA; ESKIMO LAKES NWT
0917 ANEROBIC CONDITIONS; BIODEGRADATION; SEDIMENTS
0787 ANGULLA; TAINTING; GREEN FISH; EEL; FUEL OIL-BOILER; CONTENT ANALYSIS; GIRELLA
0770 ANIMALS; REVIEW; OIL; MARINE; PLANTS
0236 ANNELIDA; DIESEL FUEL; PELAGIC LARVAE; ENCHINODERMATA; ARTHROPODA; TOXICITY; SYMPTOMS
0884 ANNELIDS; FUEL OIL #2; NAPHTHALENE; POLYCHAETE; NEANTHES; UPTAKE &DEPURATION; DEVELOPMENT; MALE; FEMALE; EGGS; LARVAE
1193 ANTARCTIC; MACROBENTHOS; ASSESSMENT; FUEL OIL; BENTHIC ECOLOGY
0779 ANTHOPLEURA; TAMPICO MARU SPILL; CHRONIC; SURF CONDITIONS; MORTALITIES; SUCCESSION; RECOVERY; BAJA, CALIF.; KELP; PHOTOSYNTHESIS

1061 ANTIBIOTICS; BIODEGRADATION; MICROORGANISMS; ENUMERATION;
CONCENTRATION; INOCULUM WASHES
0011 APHANIZOMENON; PETROLEUM PRODUCTS; BLUE GREEN ALGAE; SCENEDESMUS;
GROWTH; MORPHOLOGY; PROTOCOCCAL ALGAE
0101 AQUATIC; CRUDE OIL; POND; ARCTIC; PHYSICAL PARAMETERS; PHYTOPLANKTON;
VASCULAR PLANTS; CHIRONOMID; PRUDHOE CRUDE OIL; ARCTIC -TUNDRA;
ALASKA- BARLOW; BENTHIC ORGANISMS; PLANKTON
0803 AQUATIC; LAKE CHAMPLAIN; MOSQUITOS
0408 AQUATIC ANIMALS; PHYSIOLOGY; POLLUTANTS
1105 AQUATIC ANIMALS; TAINTING; HYDROCARBON CONTENT; SPECTROFLUOROMETRY;
BUNKER C
0999 AQUATIC LIFE &WILDLIFE; CRUDE OIL; PETROLEUM PRODUCTS; WATER QUALITY;
FISH
0096 AQUATIC ORGANISMS; BIBLIOGRAPHY- OIL POLLUTION EFFECTS
0632 AQUATIC ORGANISMS; COLLECTION OF PAPERS; POLLUTANTS; PHYSIOLOGY
0806 AQUATIC ORGANISMS; CHRONIC CONTAMINATION; DIPTERA; FLIES;
BIBLIOGRAPHY
0471 ARABIAN LIGHT CRUDE; METULA SPILL; STRAIT OF MAGELLAN;
ECOSYSTEM IMPACT
0799 ARABIAN LIGHT CRUDE OIL; FISH; PARIFFINS; GAS CHROMATOGRAPHY; EELS;
TAINTING; ORGANIC SULFUR
0614 ARCATIA; TOXICITY; SPHAEROMA; AMPHITHOE; FUEL OIL;
WATER SOLUBLE FRACTION
0063 ARCTIC; MICROBIAL POPULATIONS; PROTOZOANS; BLUE GREEN ALGAE; DIATOMS;
DEGRADATION; YEAST; SPECIES DIVERSITY; GREEN ALGAE; NATURAL SEEPAGE;
PRUDHOE CRUDE OIL; ALASKA-PRUDHOE BAY; CAPE SIMPSON;
NUTRIENT ENRICHMENT
0071 ARCTIC; LICHENS; ALGAE-NASTOC; RESPIRATION; PHOTOSYNTHESIS;
NITROGEN FIXATION; PRUDHOE CRUDE OIL
0065 ARCTIC; PHOTOSYNTHESIS; RESPIRATION; NITROGEN FIXATION; BACTERIA;
ALGAE; FUNGI; CRUDE OIL; NATURAL GAS; MICROORGANISMS
0062 ARCTIC; MICROORGANISMS; PRUDHOE BAY; VALDEZ; UMIAT; NATURAL SEEPAGES;
ALASKA -PRUDHOE BAY; CAPE SIMPSON
0101 ARCTIC; CRUDE OIL; POND; PHYSICAL PARAMETERS; PHYTOPLANKTON;
VASCULAR PLANTS; CHIRONOMID; AQUATIC; PRUDHOE CRUDE OIL;
ARCTIC -TUNDRA; ALASKA- BARLOW; BENTHIC ORGANISMS; PLANKTON
0066 ARCTIC; PROTOZOA; ALGAE; FUNGI; PLANTS; LICHENS; PSEUDOMONAS;
MICROORGANISMS; PRUDHOE CRUDE OIL; NATURAL OIL SEEPAGE;
ALASKA-PRUDHOE BAY; CAPE SIMPSON
0102 ARCTIC; PHYTOPLANKTON; PRODUCTIVITY; OIL SEEP; ABUNDANCE; BACTERIA;
ALASKA; CAPE SIMPSON; NATURAL OIL SEEP; PHYTOPLANKTON PRODUCTIVITY;
BACTERIA
0234 ARCTIC; INVERTEBRATES; REPRODUCTION; RECOVERY; RECOLONIZATION
0206 ARCTIC; BIODEGRADATION; RADIOACTIVE TRACER; GEOGRAPHIC DISTRIBUTION;
EFFECT OF CLAY PARTICLES ON RATE; ENUMERATION; RATE; DISSOLVED PHASE
0242 ARCTIC; REVIEW; BIOLOGICAL CONSEQUENCES; BIRDS; COMMERCIAL FISHERIES;
COASTAL FLORA AND FAUNA; PUBLIC HEALTH
0328 ARCTIC; ALGAE; PRIMARY PRODUCTIVITY; MACKENZIE VALLEY CRUDE OIL;
SPECIES COMPOSITION
0407 ARCTIC; INVERTEBRATES; RECRUITMENT; BROODING; MICROBIAL DEGRADATION;
TEMPERATURE; RECOLONIZATION
0501 ARCTIC; PHYTOPLANKTON; PHOTOSYNTHESIS; GROWTH; PLANTS;
COMMUNITY EFFECTS; PERIPHYTON; POPULATION COMPOSITION;
SEASONAL SUCCESSION; MACKENZIE VALLEY NWT
0584 ARCTIC; SEDIMENT; NITROGEN FIXATION; BACTERIA; ANEROBIC BACTERIA;

PETROLEUM FRACTIONS; BEAUFORT SEA; ESKIMO LAKES NWT
0528 ARCTIC; TERRESTRIAL PLANTS; TAIGA; TUNDRA
0509 ARCTIC; OFFSHORE PRODUCTION; BEAUFORT SEA; HYPOTHETICAL SPILL
0608 ARCTIC; ZOOPLANKTON; BENZPYRENE; UPTAKE; DEPURATION; PACIFIC COAST; AROMATIC HYDROCARBONS; NAPTHALENE; RADIOACTIVE TRACERS; CALANUS
0524 ARCTIC; TERRESTRIAL PLANTS; MICROBIAL DEGRADATION; ENHANCEMENT
0656 ARCTIC; BIBLIOGRAPHY; SUBARCTIC; REVIEW
0657 ARCTIC; ARCTIC; SUBARCTIC
0820 ARCTIC; CRUDE OIL; AMPHIPOD; COELENTERATE; LOCOMOTORY ACTIVITY; SUBLETHAL EFFECTS; ONISIMUS; HALITHOLUS
0819 ARCTIC; CRUDE OIL; MARINE; INVERTEBRATES; BEAUFORT SEA
0817 ARCTIC; CRUSTACEA; ISOPODS; AMPHIPODS; BEHAVIOR; ATTRACTION; REPULSION; TAINTING; CRUDE OIL
0935 ARCTIC; CRUDE OIL; LAKES; MACKENZIE DELTA; WATER COLUMN; SEDIMENTS; ZOOBENTHOS; DEGRADATION
1160 ARCTIC; DISPERSANTS; COREXIT; CRUDE OIL; PHYTOPLANKTON; PRODUCTIVITY; ALGAE
1145 ARCTIC; NORMAL WELLS CRUDE OIL; SEALS; RINGED SEALS; BENZENE; NAPHTHALENE; PATHOLOGICAL EFFECTS; UPTAKE & INGESTION
1138 ARCTIC; BENTHIC INVERTEBRATES; AMPHOPOD; BEHAVIORAL EFFECTS; MORTALITY; ISOPODS
1128 ARCTIC; BIODEGRADATION; MICROORGANISMS
1136 ARCTIC; QUAHOG; CYCLOALKANES; CONTINENTAL SHELF; CLAMS; RHODE ISLAND
1129 ARCTIC; BIODEGRADATION; MICROOGANISMS; TEMPERATURE; NUTRIENTS; OXYGEN REQUIREMENTS; CRUDE OIL; AROMATICS; PARAFFINS; BEAUFORT SEA; CHUKCHI SEA
1134 ARCTIC; SUB ARCTIC; BAFFIN BAY; DAVIS STRAIT; LABRADOR SEA; ASSESSMENT OF SPILLS; PHYTOPLANKTON; ZOOPLANKTON; ZOOBENTHOS; FISH; MAMMALS; BIRDS
1179 ARCTIC; PETROLEUM HYDROCARBONS; MUTAGENESIS; PLANKTON; FISH; METABOLISM
1221 ARCTIC; CONTINENTAL SHELVES; ASSESSMENT OF SPILLS; REVIEW; POTENTIAL OIL SPILLS
0868 ARCTIC & SUBARCTIC ORGANISMS; TOXICITY; ACUTE; CHRONIC; CRUDE OIL; COMPONENT; PHYSIOLOGY; BEHAVIOR; TEMPERATURE; METABOLISM
0101 ARCTIC -TUNDRA; CRUDE OIL; POND; ARCTIC; PHYSICAL PARAMETERS; PHYTOPLANKTON; VASCULAR PLANTS; CHIRONOMID; AQUATIC; PRUDHOE CRUDE OIL; ALASKA- BARLOW; BENTHIC ORGANISMS; PLANKTON
0846 ARENICOLA; POLYCHAETE; BEHAVIOR; FEEDING; WEATHERING
0174 ARGO MERCHANT; FISHERIES; FOOD CHAIN
0223 ARGO MERCHANT SPILL; SYMPOSIUM
0191A ARGO MERCHANT SPILL; HISTOLOGY; LESIONS; PEARL FORMATION; CANCER; MODIOLUS; ZOOPLANKTON
0462 ARGO MERCHANT SPILL
0665 ARGO MERCHANT SPILL; RESEARCH NEEDS
0653 ARGO MERCHANT SPILL; HYDROCARBON CONTENT ANALYSIS; GLASS CAPILLARY GAS CHROMATOGRAPHY
0841 ARGO MERCHANT SPILL; BIRDS
0830 ARGO MERCHANT SPILL; ZOOPLANKTON
0842 ARGO MERCHANT SPILL; BENTHIC FAUNA; SPECIES DIVERSITY; POPULATION DENSITY; INTERTIDAL FAUNA; HARPACTICOID COPEPODS; POLYCHAETES; AMPHIPODS
0918 ARGO MERCHANT SPILL; FISHERIES; NANTUCKET SHOALS
0901 ARGO MERCHANT SPILL; HISTOPATHOLOGY; AMMODYTES; FLOUNDER (WINTER&YELLOWTAIL); ALEWIVES; CRABS(HERMIT); HYPERPLASIA;

EDEMA; HEMOCYTES; CILIATES
1014 ARGO MERCHANT SPILL; WINTER FLOUNDER; YELLOW TAIL FLOUNDER; MODIOLUS; PLACOPECTEN; RESPIRATORY ENZYMES; MALIC DEHYDROGENASE; OSMOLALITY; PYRUVATE REDUCTION; ANAEROBIOSIS
1127 ARGO MERCHANT SPILL; FUEL OIL; EMBRYOGENESIS; HATCHING SUCCESS; MORPHOLOGY; POLLOCK; CEPHALACHORDATA; AMPHIOXUS
0184 AROMATIC; ALIPHATIC; SUB-LETHAL EFFECTS
1074 AROMATIC; ALIPHATIC; DETERMINATION TECHNIQUES; MARINE ORGANISMS; ETHER EXTRACTION; SILICA GEL CHROMATOGRAPHY; GAS CHROMATOGRAPHY; MASS SPECTROMETRY
0307 AROMATIC COMPOUNDS; DEGRADATION; BACTERIA
1151 AROMATIC HC' S; BIODEGRADATION; CRUDE OIL; BACTERIA
1139 AROMATIC HC'S; CRUDE OIL; CRAB; CANCER; NAPHTHALENE; BENZENE; TOXICITY; REPRODUCTION & DEVELOPMENT
1108 AROMATIC HYDROCARBON; POLYCYCLIC AROMATIC HC'S; CONTENT ANALYSIS; BUNKER C; CREOSOTE; SEALS; FISH; SHELLFISH; PAH; FLUOROMETRY; FUEL OIL
0201 AROMATIC HYDROCARBON CONTENT; HYDROCARBON CONTENT; METABOLISM; FIDDLER CRAB; UCA; OXIDATION; CLEARANCE
0048 AROMATIC HYDROCARBONS; TOXICITY; FOOD CHAIN; FATTY TISSUES
0157 AROMATIC HYDROCARBONS; ALGAE; BENZPYRENE; TUMOR LIKE GROWTHS; CARCINOGENISIS
0458 AROMATIC HYDROCARBONS; CRUDE OIL; REFINED OIL; TOXICITY; BACTERIA; WATER SOLUBLE FRACTION; WEATHERING; GROWTH RATE; MAXIMUIM CELL DENSITY
0600 AROMATIC HYDROCARBONS; PETRO SULFAR COMPOUNDS; MODIOLUS; CRASSOSTREA; RETENTION; FLAME IONIZATION DETECTION; FLAME PHOTOMETRIC DETECTION; GAS CHROMATOGRAPHY; GAS CHROMATOGRAPHY-MASS SPECTROMETRY
0608 AROMATIC HYDROCARBONS; ZOOPLANKTON; BENZPYRENE; UPTAKE; DEPURATION; PACIFIC COAST; ARCTIC; NAPTHALENE; RADIOACTIVE TRACERS; CALANUS
0611 AROMATIC HYDROCARBONS; MYTILUS; CONTENT ANALYSIS; UPTAKE; DEPURATION; RETENTION; MUSSEL; RADIOACTIVE TRACERS; PARAFFINS
0786 AROMATIC HYDROCARBONS; TAINTING; JAPANESE COAST; FISH; EELS; GAS CHROMATOGRAPHY; IR ABSORPTION; UV ABSORPTION; MASS SPECTRUM; TOLUENE; MIZUSHIMA, JAPAN; GASOLINE
1154 AROMATIC HYDROCARBONS; ZOOPLANKTON; COPEPODS; NAPHTHALENE; PHYSIOLOGICAL EFFECTS; RETENTION; DEVELOPMENT
1186 AROMATIC HYDROCARBONS; BENZOPYRENE; CLAMS; MUSSELS; OYSTERS; OREGON; ESTUARINE; UPTAKE; CARCINOGENS; MOLLUSCS
1218 AROMATIC HYDROCARBONS; ORGANIC SOLVENTS; HUMAN EFFECTS; ALIPHATIC HYDROCARBONS
1150 AROMATIC PETROLEUM PRODUCTS; BIODEGRADATION; XYLENE; MICROORANISMS; BACTERIA; NOCARDIA
0127 AROMATICS; SALT MARSH; ESTUARY; YORK RIVER; SOUTH LA. CRUDE; HYDROCARBON ANALYSIS; CONTROLLED ECOSYSTEM; FUNDULUS; GAS CHROMATOGRAPHY; GC-MS
0356 AROMATICS; MYTILUS; CONTENT ANALYSIS; METABOLISM; PETROLEUM; BIOGENIC; MUSSELS; KIEL BIGHT, W. GERMANY
0355 AROMATICS; MYTILUS; MUSSELS; UPTAKE; DEPURATION; BIOGENIC; PETROLEUM; KIEL BIGHT
0419 AROMATICS; BENZ(A)PYRENE; DNA BINDING; POLCYCLIC
0546 AROMATICS; BACTERIAL DEGRADATION; PSEUDOMONAS; METABOLIC PATHWAYS
0736 AROMATICS; TAINTING; SCALLOPS; PARAFFINS; CRUDE OIL
0730 AROMATICS; SALMON; TOXICITY; CRUDE OIL; PRUDHOE BAY; ALIPHATIC; CELL MEMBRANE PERMEABILITY

0731 AROMATICS; SALMON; TOXICITY; CRUDE OIL; ALIPHATICS;
CELL MEMBRANE PERMEABILITY
0761 AROMATICS; TOXICITY; PHENATHRENES; ESTUARINE; BENTHIC; OCEANIC;
LARVAE; JUVENILES; RESPIRATION; GROWTH; SUBLETHAL
1039 AROMATICS; CYCLO-ALKANE; SEDIMENTS; BUNKER C; BEACH SEDIMENTS;
CHEDABUCTO BAY, NOVA SCOTIA; ARROW SPILL; METABOLISM; MOLLUSCS; MYA;
OSTREA; MYTILUS; ARYL HYDROCARBON HYDROXYLASE; BENZOPYRENE;
RADIOACTIVE TRACER
1129 AROMATICS; BIODEGRADATION; MICROOGANISMS; ARCTIC; TEMPERATURE;
NUTRIENTS; OXYGEN REQUIREMENTS; CRUDE OIL; PARAFFINS; BEAUFORT SEA;
CHUKCHI SEA
1131 AROMATICS; MICROFLORA; PHYTOPLANKTON; ALGAE; CRUDE OIL; FUEL OIL;
TOXICITY; NAPHTHALENE; PHENANTHRENE; ALGAE-GREEN; ALGAE-BLUE GREEN;
DIATOMS; GROWTH
1142 AROMATICS; DUCKS; HATCHABILITY; GROWTH; EFFECTS ON ORGANISMS;
REPRODUCTION & DEVELOPMENT
0191 ARROW SPILL; BIRDS; MORTALITIES; IRVING WHALE SPILL; NOVA SCOTIA;
SPECIES ENDANGERMENT; NEWFOUNDLAND
0175 ARROW SPILL; BIRDS; MORTALITIES; CHEDABUCTO BAY, NOVA SCOTIA
0258 ARROW SPILL; ZOOPLANKTON; HYDROCARBON CONTENT; CHEDABUCTO BAY;
BUNKER C; OIL INGESTION; SEDIMENTATION; FECES
0625 ARROW SPILL; WESTERN NORTH ATLANTIC; CHEDABUCTO BAY,NOVA SCOTIA;
BUNKER C; RECOVERY
0855 ARROW SPILL; OIL; DEGRADATION; BIODEGRADATION; ENVIRONMENTAL FACTORS;
ENERGY; BACTERIA; BUNKER C; CHEDABUCTO BAY
1037 ARROW SPILL; CHEDABUCTO BAY,NOVA SCOTIA; BUNKER C;
FLUORESCENCE SPECTROSCOPY; MYA; KELP; HYDROCARBON CONTENT ANALYSIS
1039 ARROW SPILL; AROMATICS; CYCLO-ALKANE; SEDIMENTS; BUNKER C;
BEACH SEDIMENTS; CHEDABUCTO BAY, NOVA SCOTIA; METABOLISM; MOLLUSCS;
MYA; OSTREA; MYTILUS; ARYL HYDROCARBON HYDROXYLASE; BENZOPYRENE;
RADIOACTIVE TRACER
1010 ARROW SPILL; CHEDEBUCTO BAY, NOVA SCOTIA; BUNKER C; MORTALITIES;
INTERTIDAL; WINTER; CHRONIC POLLUTION; FUCUS; MYA; SPARTINA
1215 ARROW SPILL; FUEL OIL; BUNKER C; CHEDABUCTO BAY; NOVA SCOTIA;
LONG TERM EFFECTS; CORDGRASS; MARSH; ALGAE; TOXICITY
0405 ARTEMIA; TOXICITY; FUNDULUS; PIMEPHALES; KUWAIT; WEST TEXAS;
MARINE DIESEL; FUEL OIL; LUBE OIL
0303 ARTHROBACTER; CHEDABUCTO BAY, NOVA SCOTIA; CAPE SIMPSON, ALASKA;
NATURAL SEEP; PSEUDOMONAS; TEMPERATURE
0937 ARTHROBACTER; CORYNEBACTERIUM; ACHROMOBACTER; RATE ENHANCEMENT;
HYDROCARBON-OXIDIZING BACTERIA
0860 ARTHROBACTER; BIODEGRADATION; DISPERSION; BACTERIA
0236 ARTHROPODA; DIESEL FUEL; PELAGIC LARVAE; ENCHINODERMATA; ANNELIDA;
TOXICITY; SYMPTOMS
0863 ARTHROPODS; SUPRALITTORAL; LIMOSINA; ORCHESTIA; EFFLUENTS; TOXICITY;
CRUDE OIL; FLIES; AMPHIPODES
0972 ARTIFICAL SUBSTRATE; OIL; DETERGENT; RECOLONIZATION; SETTLEMENT
0879 ARTIFICAL SUBSTRATES; CRUDE OIL; MIDGES; CRICOTOPUS;
FORT SIMPSON, NWT, CANADA; FIELD EXPERIMENTS; LARVAE
1012 ARUBA WEST INDIES; PRAWNS, SCARLET; PLESIOPENAEUS;
BENTHIC OIL DEPOSIT; ATTRACTION; HYDROCARBON CONTENT ANALYSIS;
BACTERIA; CHEMICAL ATTRACTIONS; METABOLISM
0010 ARYL HYDROCARBON HYDROXYLASE; METABOLISM; POLYCYCLIC HYDROCARBONS;
ENZYME SYSTEM; TROUT
0813 ARYL HYDROCARBON HYDROXYLASE; BENZOPYRENE; HYDROXYLASE INDUCTION;

0144 BACTERIA; DEGRADATION; SEDIMENTS; PERSISTANCE;
WEST FALMOUTH OIL SPILL; BUZZARD BAY
0226 BACTERIA; DEGRADATION; FUNGI; TEMPERATURE
0193 BACTERIA; BIODEGRADATION; PETROLEUM FRACTIONS; MARINE
0192 BACTERIA; SEDIMENTS; LOUISIANA BAY; OXIDATION; AEROBIC; ANAEROBIC
0205 BACTERIA; DEGRADATION; FUNGI; EMULSIONS; TOXICITY; TAINTING
0225 BACTERIA; DEGRADATION; FUNGI; TEMPERATURE; OXIDATION; ASSIMILATION
0208 BACTERIA; CRUDE OIL; DEGRADATION
0188 BACTERIA; DEGRADATION; AEROBIC; ANAEROBIC; PHYSICAL CHANGE;
CHEMICAL CHANGE
0307 BACTERIA; AROMATIC COMPOUNDS; DEGRADATION
0259 BACTERIA; BUNKER C; SAN FRANCISCO; POPULATIONS; DIVERSITY; BEACHES
0317 BACTERIA; DEGRADATION; CRUDE OIL; SEA WATER; AUTO OXIDATION;
WEATHERING
0312 BACTERIA; REVIEW; BIODEGRADATION; FRACTIONS; CRUDE OIL;
ENVIRONMENTAL FACTORS
0314 BACTERIA; DEGRADATION; ACTINOMYCETES; FILAMENTOUS FUNGI; YEAST;
PHYCOMYCETES
0402 BACTERIA; DEGRADATION; OXIDATION; HYDROCARBONS; AEROBIC; ANAEROBIC
0449 BACTERIA; BIODEGRADATION; SEAWATER; OXIDATION; HYDROCARBONS
0468 BACTERIA; OIL-DEGRADING; POPULATIONS; TORREY CANYON; FIELD STUDY;
EMULSIFIERS; BEACHES
0458 BACTERIA; CRUDE OIL; REFINED OIL; TOXICITY; WATER SOLUBLE FRACTION;
AROMATIC HYDROCARBONS; WEATHERING; GROWTH RATE;
MAXIMUIM CELL DENSITY
0469 BACTERIA; BIODEGRADATION; DISTRIBUTION; OIL-OXIDIZING BACTERIA;
NORTH SEA; ABUNDANCE; WATER; SEDIMENT
0622 BACTERIA; REFINERY WASTES; BIODEGRADATION; PHYTOPLANKTON
0563 BACTERIA; SALT MARSH; ESTUARY; YORK RIVER; FUNGI; LOUISIANA CRUDE;
SEDIMENTS; PETROLEUM DEGRADING
0584 BACTERIA; SEDIMENT; NITROGEN FIXATION; ARCTIC; ANEROBIC BACTERIA;
PETROLEUM FRACTIONS; BEAUFORT SEA; ESKIMO LAKES NWT
0609 BACTERIA; MARINE SEDIMENT; METABOLISM; MICROFAUNA; MEIOFAUNA;
MACROFAUNA; DEGRADATION; POLYCHAETE WORMS; BIVALVES; EXCRETION
0510 BACTERIA; CRUDE OIL; FUEL OIL #2; BUNKER C; METABOLISM; INHIBITION;
RADIOACTIVE TRACER; CONTROLLED ECOSYSTEM
0516 BACTERIA; BIODEGRADATION; SUBSTRATE SELECTION; SUCCESSION
0716 BACTERIA; CHEMORECEPTION; INHIBITION; HYDROCARBONS
0708 BACTERIA; PURIFICATION; BLACK SEA; DEGRADATION; WATER; SEDIMENTS
0703 BACTERIA; DEGRADATION
0726 BACTERIA; DEGRADATION; MACROPHYTES; SPECIES COMPOSITION
0715 BACTERIA; CORAL; PLATIGYRA; STRESS; CRUDE OIL; MUCUS PRODUCTION;
DESULFOVIBRIO; BEGGIATOA
0694 BACTERIA; DEGRADATION; PARAFFIN; CRUDE OIL; GAS CHROMATOGRAPHY;
EMULSIFICATION
0705 BACTERIA; DEGRADATION; INDICATORS
0701 BACTERIA; BLACK SEA; DEGRADATION; SELF-PURIFICATION
0741 BACTERIA; DEGRADATION; DISTRIBUTION; NORTHWEST ATLANTIC;
COASTAL SEDIMENTS
0844 BACTERIA; DEGRADATION; OXIDATION
0828 BACTERIA; DEGRADATION; ESTUARY; BEACH; FUEL OIL; ENRICHMENT; RATE;
NARRAGANSET BAY; HYDROCARBON CONCENTRATION; SEDIMENTS; MIGRATION
0833 BACTERIA; BIODEGRADATION; MICROORGANISMS OXIDIZING HC'S;
DISTRIBUTION; NEVA INLET, RUSSIA; SEASONAL DISTRIBUTION
0855 BACTERIA; OIL; DEGRADATION; BIODEGRADATION; ENVIRONMENTAL FACTORS;

ENERGY; BUNKER C; CHEDABUCTO BAY; ARROW SPILL
0796 BACTERIA; HYDROCARBON ANALYSIS; SEDIMENTS; NORTH SEA; SEAWATER; PELAGIC TAR
0843 BACTERIA; BIODEGRADATION; RATES; MECHANISM; TOXICITY OF METABOLIC AND PRODUCTS; FLOW RATE IN CHEMOSTAT
0860 BACTERIA; BIODEGRADATION; DISPERSION; ARTHROBACTER
0947 BACTERIA; TORREY CANYON SPILL; DEGRADATION; ZOOPLANKTON; LITTORAL; SUBLITTORAL; CLEAN UP
0939 BACTERIA; DEGRADATION; SELECTIVITY
0910 BACTERIA; BIODEGRADATION; HEXADECANE; RADIOACTIVE TRACER; TOKYO BAY; WATER COLUMN
0875 BACTERIA; BIODEGRADATION; MICROORGANISMS; ENHANCEMENT; EMULSIFICATION; SEEDING
0921 BACTERIA; OIL; ALGAE; OTTAWA; ICE
1059 BACTERIA; BIODEGRADATION; LIMITING EFFECTS; SOUTH LOUISIANA CRUDE; FUEL OIL # 2
0984 BACTERIA; DEGRADATION; SOIL
1050 BACTERIA; DEGRADATION; MOTOR OIL; TREATMENT EFFLUENT; DISTRIBUTION; WATER COLUMN; SEDIMENTS
1049 BACTERIA; ESTUARIES; TOXICITY
1053 BACTERIA; MICROORGANISMS; YEAST; FUNGI; CHESAPEAKE BAY; SUBSTRATE SELECTION
1052 BACTERIA; DEGRADATION; GROWTH POTENTIAL; SEDIMENTS; NORTH ATLANTIC
1056 BACTERIA; DEGRADATION; FUNGUS; CLADOSPORIUM; WATER; SEDIMENTS; CHESAPEAKE BAY; HYDROCARBON CONCENTRATION
1020A BACTERIA; DEGRADATION; LOW TEMPERATURE
1062 BACTERIA; BIODEGRADATION; SEDIMENTS; CHESAPEAKE BAY
1036 BACTERIA; DEGRADATION; METABOLIC PATHWAYS
0997 BACTERIA; POTENTIAL; SEAWATER; CHRONIC POLLUTION; DEGRADATION; PETROLEUM HYDROCARBONS; SALINITY
1012 BACTERIA; PRAWNS, SCARLET; PLESIOPENAEUS; BENTHIC OIL DEPOSIT; ARUBA WEST INDIES; ATTRACTION; HYDROCARBON CONTENT ANALYSIS; CHEMICAL ATTRACTIONS; METABOLISM
1064 BACTERIA; DEGRADATION; SEDIMENTS; CHESAPEAKE BAY
1029 BACTERIA; BIODEGRADATION; MICROORGANISMS
1120 BACTERIA; HYDROCARBON CONTENT ANALYSIS; BALTIC SEA
1109 BACTERIA; DEGRADATION; REVIEW
1068 BACTERIA; SUSCEPTIBILITY; FUNGI; TOXICITY; ESTUARY; SOUTH LOUISIANA CRUDE OIL; FUEL OIL #2; CHESAPEAKE BAY; GROWTH
1111 BACTERIA; REVIEW; MARINE OIL POLLUTION; INPUTS; FATES; DEGRADATION
1067 BACTERIA; DEGRADATION; SEDIMENTS; DEEP SEA; INORGANIC NUTRIENTS; GROWTH POTENTIAL
1116 BACTERIA; BIODEGRADATION; SEDIMENTS; BARATARIA BAY; ANAEROBIC; BENZ(A)PYRENE; ACCUMULATION; MYTILUS; WHITING; PICKEREL
1150 BACTERIA; BIODEGRADATION; AROMATIC PETROLEUM PRODUCTS; XYLENE; MICROORANISMS; NOCARDIA
1104 BACTERIA; BIODEGRADATION; BUNKER C; EMULSIFICATION
1114 BACTERIA; CARCINOGENESIS; HYDROCARBONS; INPUT; METABOLISM; SYNTHESIS; DEGRADATION
1115 BACTERIA; BIODEGRADATION; SUBSTRATE; DISTRIBUTION; HYDROGEN ACCEPTOR; ABSORBENTS
1113 BACTERIA; CRUDE OIL; DEGRADATION; YEAST; FUNGI; SUBSTRATE; DISTRIBUTION
1110 BACTERIA; DEGRADATION; METHODS; RELATIVE OXIDIZABILITY; ASSUMLATION
1151 BACTERIA; BIODEGRADATION; CRUDE OIL; AROMATIC HC' S

0152 BALTIMORE CANYON-MID ATLANTIC; CHRONIC LEAKAGE; SPILLS;
BENTHIC ORGANISMS
1066 BALTIMORE HARBOR; CHESAPEAKE BAY; BIODEGRADATION; ALGA; PROTOTHECA
1116 BARATARIA BAY; BIODEGRADATION; BACTERIA; SEDIMENTS; ANAEROBIC;
BENZ(A)PYRENE; ACCUMULATION; MYTILUS; WHITING; PICKEREL
1130 BARGE STC-101; FUEL OIL; CHESAPEAKE BAY; INVERTEBRATES;
ASSESSMENT OF SPILLS
0733 BARNACLE; BP1002; KEROSENE; CHEMKLEEN; BALANUS; ADULT; NAUPLIUS;
TOXICITY; CIRRAL ACTIVITY
0980 BARNACLE; SUBLETHAL EFFECTS; CHRONIC EXPOSURE;
COAL OIL POINT, CALIF.; SEDIMENTS; BENTHIC IN-FAUNA; ABALONE; MUSSEL
0971 BARNACLE; SANTA BARBARA SPILL; BREEDING RATES; MUSSELS; CHTHAMALUS;
BALANUS; POLLICIPES; MYTILUS; INTERTIDAL
0045 BARNACLES; SANTA BARBARA SPILL; CLEANUP; COMMUNITY SURVEY; BIRDS;
LIMPETS; MUSSEL; CHITONS; INTERTIDAL ORGANISMS
0232 BARNACLES; SAN FRANCISCO SPILL; RECRUITMENT; BUNKER C; BALANUS;
CHTHAMALUS; MUSSEL; MYTILUS; LIMPETS; COLLISELLA
0291 BARNACLES; CHRONIC POLLUTION; LIMPETS; REFINERY EFFLUENT; TRANSECTS;
ABUNDANCE
0279 BARNACLES; TOXICITY; BEHAVIOR; LARVAE; DETERGENTS; BP1002; DASIC;
ELMININS; SOLVENT; SURFACTANT
0337 BARNACLES; PETROLEUM; TOXICITY; LARVAE; DEVELOPMENT; PHOTOTAXIS
0295 BARNACLES; MILFORD HAVEN, BRITAIN; ROCKY SHORE; OIL PORT;
TOP SHELL (MONDONTA); LITTORINA
0404 BARNACLES; SANTA BARBARA; INTERTIDAL; COMMUNITIES; SURF GRASS
0585 BARNACLES; CARCINOGENS; CONTENT ANALYSIS; BENZPYRENES
0727 BARNACLES; TAR BALL; CONTENT ANALYSIS; METABOLISM; UPTAKE;
DEPURATION
0664 BARNACLES; EAST CHINA SEA; KUROSHIO; TAR BALLS; ATTACHED ORGANISMS;
BLUE GREEN ALGAE; PENNATE DIATOMS; STONY CORALS; BRYOZOANS; COPEPODS
0920 BARNACLES; TETRACLITA; CARCINOGENSIS; BENZ(A)PYRENE
1100 BARNACLES; TOXICITY; RECOVERY; SURFACTANTS; NAUPLII; ELMINIUS
1105 BARNACLES; CARCINOGENS; CONTENT ANALYSIS; TETRACLITA; BENZOPYRENE
0348 BASELINE; BENZO(A)PYRENE; CARCINOGENS; SOUTHERN CALIFORNIA; MUSSELS;
MYTILUS; BIOGENIC
0652 BASELINE INVESTIGATION; PETROLEUM HYDROCARBONS; PUGET SOUND;
SEDIMENTS; MUSSELS; SNAILS; THAIS; INTERTIDAL
1095 BATON ROUGE; MICROALGAE; WATER SOLUBLE FRACTION;
HYDROCARBON ANALYSIS; GAS CHROMATOGRAPHY; MASS SPECTROMETRY; BAYTOWN;
MONTANA; NEW JERSEY
1095 BAYTOWN; MICROALGAE; WATER SOLUBLE FRACTION; HYDROCARBON ANALYSIS;
GAS CHROMATOGRAPHY; MASS SPECTROMETRY; MONTANA; BATON ROUGE;
NEW JERSEY
0828 BEACH; DEGRADATION; BACTERIA; ESTUARY; FUEL OIL; ENRICHMENT; RATE;
NARRAGANSET BAY; HYDROCARBON CONCENTRATION; SEDIMENTS; MIGRATION
1039 BEACH SEDIMENTS; AROMATICS; CYCLO-ALKANE; SEDIMENTS; BUNKER C;
CHEDABUCTO BAY, NOVA SCOTIA; ARROW SPILL; METABOLISM; MOLLUSCS; MYA;
OSTREA; MYTILUS; ARYL HYDROCARBON HYDROXYLASE; BENZOPYRENE;
RADIOACTIVE TRACER
0054 BEACH SURVEY; BIRDS; MORTALITIES
0244 BEACH SURVEYS; BIRDS; MORTALITIES; POPULATION; CHRONIC SPILLAGE;
TREATMENT; DISPERSANTS
0454 BEACHED BIRDS COUNTS; BIRDS; MORTALITIES; ENGLAND/SCOTLAND
0302 BEACHES; WEST CORK, IRELAND; MECHANICAL DAMAGE
0259 BEACHES; BACTERIA; BUNKER C; SAN FRANCISCO; POPULATIONS; DIVERSITY

0479 BEACHES; METULA SPILL; STRAIT OF MAGELLAN; ESTUARIES
0468 BEACHES; BACTERIA; OIL-DEGRADING; POPULATIONS; TORREY CANYON; FIELD STUDY; EMULSIFIERS
0509 BEAUFORT SEA; OFFSHORE PRODUCTION; ARCTIC; HYPOTHETICAL SPILL
0584 BEAUFORT SEA; SEDIMENT; NITROGEN FIXATION; ARCTIC; BACTERIA; ANEROBIC BACTERIA; PETROLEUM FRACTIONS; ESKIMO LAKES NWT
0819 BEAUFORT SEA; CRUDE OIL; ARCTIC; MARINE; INVERTEBRATES
1129 BEAUFORT SEA; BIODEGRADATION; MICROOGANISMS; ARCTIC; TEMPERATURE; NUTRIENTS; OXYGEN REQUIREMENTS; CRUDE OIL; AROMATICS; PARAFFINS; CHUKCHI SEA
0573 BEDFORD BASIN NOVA SCOTIA; TOXICITY; GREEN SEA URCHIN; VENEZUELAN CRUDE OIL; OIL SPERSE
0444 BEDFORD BASIN, NOVA SCOTIA; PHYTOPLANKTON; PHOTOSYNTHESIS; NORTH WESTERN ATLANTIC; VENEZUELAN CRUDE; FUEL OIL#2; FUEL OIL#6
0373 BEETLE; INSECTS; POPULATION SURVEY; SANTA BARBARA; CREVICE FAUNA; LITTORAL; THALASSOTRECHUS
0715 BEGGIATOA; CORAL; PLATIGYRA; BACTERIA; STRESS; CRUDE OIL; MUCUS PRODUCTION; DESULFOVIBRIO
0016 BEHAVIOR; MUSSEL; FILTERING ABILITY; BLACK SEA; TOLERANCE
0090 BEHAVIOR; ECOSYSTEMS; WALES; REFINERY EFFLUENTS
0057 BEHAVIOR; LOBSTERS; SNAIL,NASSARIUS
0200 BEHAVIOR; BIRDS; EIDERS
0165 BEHAVIOR; BIRDS; GULLS; GUILLIMOTS; KITTIWAKES
0151 BEHAVIOR; CHRONIC OIL POLLUTION; COASTAL ECOSYSTEM; SUBLETHAL EFFECTS; METABOLISM; FOOD CHAIN MAGNIFICATION; WETLANDS; ESTUARIES
0279 BEHAVIOR; BARNACLES; TOXICITY; LARVAE; DETERGENTS; BP1002; DASIC; ELMININS; SOLVENT; SURFACTANT
0278 BEHAVIOR; HYDROCARBONS; ZOOPLANKTON; FISH; TOXICITY; TAINTING; UPTAKE; METABOLISM; DEPURATION; ACCUMULATION
0316 BEHAVIOR; GREY SEALS; PEMBROKESHIRE WEST WALES; GROWTH; MORTALITY
0361 BEHAVIOR; CRUDE OIL; RED SEA; MACROFAUNA; TOXICITY; DEPTH; SUBLETHAL EFFECTS; PHYSIOLOGY; METABOLISM; DISPERSANT
0422 BEHAVIOR; CRUDE OIL; SEALS; PATHOLOGICAL EFFECTS; COATING; IMMERSION; INGESTION
0580 BEHAVIOR; CRUDE OIL; CRUSTACEA; FEEDING; POLYAROMATIC HYDROCARBONS; ALIPHATIC; CHEMORECEPTION
0579 BEHAVIOR; CRUDE OIL; INVERTEBRATES; CHEMORECEPTION
0615 BEHAVIOR; WATER SOLUBLE FRACTION; FUEL OIL #2; ZOOPLANKTON COASTAL; ZOOPLANKTON OCEANIC; TOXICITY
0581 BEHAVIOR; CRABS; OYSTERS; CHEMORECEPTION; SUBLETHAL EFFECTS; NAPTHALENE; BIOASSAY
0577 BEHAVIOR; REEF COMMUNITY; RESPIRATION; CALMING EFFECTS; GAS EXCHANGE; FIELD FENCING TECHNIQUES; CRUDE OIL; TOXIXCTY; HERON IS. GREAT BARRIER REEF AUSTRALIA
0533 BEHAVIOR; BIOASSAY; BIOELECTRIC ACTION POTENTIALS; PROCAMBARUS; HYDROCARBONS
0628 BEHAVIOR; BIOASSAY; METHODOLOGY; TOXICITY
0630 BEHAVIOR; AMPHIPOD; TOXICITY; LARVAE; GAMMARUS; FECUNDITY
0846 BEHAVIOR; POLYCHAETE; ARENICOLA; FEEDING; WEATHERING
0817 BEHAVIOR; ARCTIC; CRUSTACEA; ISOPODS; AMPHIPODS; ATTRACTION; REPULSION; TAINTING; CRUDE OIL
0818 BEHAVIOR; CRUSTACEA; CRUDE OIL; SEDIMENTS; AMPHIPOD; ONISIMUS; AVOIDANCE; WEATHERING
0913 BEHAVIOR; CLAM; MACOMA; PRUDHOE BAY CRUDE OIL; HYDROCARBON ANALYSIS;

GAS CHROMATOGRAPHY; BURROWING
0868 BEHAVIOR; TOXICITY; ACUTE; CHRONIC; CRUDE OIL; COMPONENT; PHYSIOLOGY; ARCTIC & SUBARCTIC ORGANISMS; TEMPERATURE; METABOLISM
0904 BEHAVIOR; OUTBOARD ENGINE EXHAUST; SPECIES ABUNDANCE; DIVERSITY; PHYTOPLANKTON; ZOOPLANKTON; PERIPHYTON; FISH; POPULATION
0914 BEHAVIOR; HYDROCARBONS; GAS WASTES; FISH; TOXICITY; ATTRACTION; SUNFISH (ORANGE-SPOTTED)
0986 BEHAVIOR; BENZENE; HERRING; CULPEA; SPAWNING; OVARIAN EGGS; EMBRYOS; LARVAE; RADIOACTIVE TRACER
0995 BEHAVIOR; DISPERSANTS; EMULSIONS; TOXICITY; SUBLETHAL EFFECTS; ACTIVITY; MOTILITY; BIVALVES; CRUSTACEANS; FISH; OIL EMULSION; CONTINUOUS FLOW; LOCOMOTION
0994 BEHAVIOR; SURFACTANTS; FISH; CRUSTACEANS; BIVALVES; TOXICITY; DEVELOPMENT; ACTIVITY; BYSSUS THREAD; MOULTING
1162 BEHAVIOR; CLAMS; CRUDE OIL; MORTALITY
1079 BEHAVIOR; LOBSTER; HOMARUS; LARVAE; TOXICITY; GROWTH; VENEZUELA CRUDE OIL; FOOD CONSUMPTION; DISPERSIONS
1169 BEHAVIOR; CRABS; WEST FALMOUTH SPILL; MORTALITY; UPTAKE; BURROWING; TOXICITY; FUEL OIL; CRAB-SALT MARSH; MASS.
0061 BEHAVIOR AND FEEDING; LOBSTER; CHEMOSENSORS; CRUDE OIL
1002A BEHAVIOR-BURROWING; MACOMA; ALASKA; MUD FLATS
1091 BEHAVIORAL CHANGES; DISPERSANT; TOXICITY; FISH; LARVAE; HERRING; PILCHARD; PLAICE; SOLE; LEMON SOLE; HADDOCK; BP1002; DELAYED EFFECTS; EMBRYOLOGY
1138 BEHAVIORAL EFFECTS; ARCTIC; BENTHIC INVERTEBRATES; AMPHOPOD; MORTALITY; ISOPODS
1212 BEHAVIORAL EFFECTS; SHRIMP; LARVAL GROWTH; UPTAKE; DEPURATION; FUEL OIL #2; HATCHING SUCCESS
1220 BEHAVIORAL EFFECTS; COPEPODS; CALANUS; ALGAE; MONOCHRYSIS; NAPHTHALENE; MOTILITY
1213 BEHAVIORAL EFFECTS; CLAM; MACOMA; PRUDHOE BAY CRUDE OIL; ALASKA; BURROWING
0792 BEHAVIORAL EFFECTS OF OIL POLLUTION; REVIEW
0668 BEHAVIORAL SYMPTOMS; PETROLEUM REFINERY EFFLUENT; SUNFISH,REDEAR; LEPOMIS; TOXICITY; FRESH WATER FISH
0761 BENTHIC; TOXICITY; AROMATICS; PHENATHRENES; ESTUARINE; OCEANIC; LARVAE; JUVENILES; RESPIRATION; GROWTH; SUBLETHAL
1086 BENTHIC; STREAM; MACROINVERTEBRATES; OIL REFINERY EFFLUENT; DIVERSITY INDICES
0161 BENTHIC ALGAL COMMUNITIES; FUEL OIL#2; NIGERIAN CRUDE; CRANKCASE OIL; PRIMARY PRODUCTIVITY; TOXICITY; RECOVERY; ALGAL BLUE GREEN
0120 BENTHIC ANIMALS; TOXICITY; INTERTIDAL; DIVERSITY; RECOVERY; YORK RIVER; BUNKER C; FUEL OIL#6
0366 BENTHIC COMMUNITIES; FUEL OIL#2; NIANTIC BAY, CT.; AMPHIPODS; HERMIT CRABS; HYDROCARBON CONTENT ANALYSIS; GAS CHROMATOGRAPHY
1193 BENTHIC ECOLOGY; ANTARCTIC; MACROBENTHOS; ASSESSMENT; FUEL OIL
0121 BENTHIC FAUNA; SALT MARSH; YORK RIVER; ISOLATED ECOSYSTEM; SOUTH LA. CRUDE; WEATHERED OIL; PHYTOPLANKTON; FISH; PERIPHYTON; ATP; MARSH GRASS; POLYCHAETES; INSECT LARVAE; AMPHIPODS; OLIGOCHAETE
0381 BENTHIC FAUNA; SANTA BARBARA
0688 BENTHIC FAUNA; FUEL OIL#2; WEST FALMOUTH, WILD HARBOR, MASS.; SEDIMENTS; HYDROCARBON CONTENT; OPPORTINUSTIC SPECIES; RECOVERY; GAS CHROMATOGRAPHY; DIVERSITY; POPULATIONS
0842 BENTHIC FAUNA; ARGO MERCHANT SPILL; SPECIES DIVERSITY; POPULATION DENSITY; INTERTIDAL FAUNA; HARPACTICOID COPEPODS;

POLYCHAETES; AMPHIPODS
0745 BENTHIC FAUNA; PALVA OIL SPILL INCIDENT; DIVERSITY; BIOMASS; POPULATIONS
1205 BENTHIC FAUNA; SANTA BARBARA CHANNEL CALIFORNIA; NATURAL OIL SEEPS; ISLA VISTA OIL SEEP; POLYCHAETES; BIOMASS; TOXICITY
0072 BENTHIC FLORA; TOXICITY; ABSORBANTS; BIODEGRADATION; FUEL OIL
0980 BENTHIC IN-FAUNA; SUBLETHAL EFFECTS; CHRONIC EXPOSURE; COAL OIL POINT, CALIF.; SEDIMENTS; ABALONE; MUSSEL; BARNACLE
0691 BENTHIC INVERTEBRATES; PELAGIC LARVAE; TOXICITY; ESTUARINE
1138 BENTHIC INVERTEBRATES; ARCTIC; AMPHOPOD; BEHAVIORAL EFFECTS; MORTALITY; ISOPODS
1198 BENTHIC INVERTEBRATES; PETROLEUM HYDROCARBONS; CALIFORNIA
1208 BENTHIC MACROFAUNA; URQUIOLA SPILL; SPAIN; PERSIAN GULF CRUDE OIL; FISH; SPARTINA; TOXICITY
0861 BENTHIC MARINE ANIMALS; REFINERY EFFLUENT; LOS ANGELES HARBOR
0149 BENTHIC MICROINVERTEBRATE COMMUNITY; OUTBOARD ENGINE EMMISSIONS; PHYTOPLANKTON; SPECIES DIVERSITY; FIXATION; CHLOROPHYLL; ZOOPLANKTON POPULATION DYNAMICS; GASOLINE
1012 BENTHIC OIL DEPOSIT; PRAWNS, SCARLET; PLESIOPENAEUS; ARUBA WEST INDIES; ATTRACTION; HYDROCARBON CONTENT ANALYSIS; BACTERIA; CHEMICAL ATTRACTIONS; METABOLISM
0101 BENTHIC ORGANISMS; CRUDE OIL; POND; ARCTIC; PHYSICAL PARAMETERS; PHYTOPLANKTON; VASCULAR PLANTS; CHIRONOMID; AQUATIC; PRUDHOE CRUDE OIL; ARCTIC -TUNDRA; ALASKA- BARLOW; PLANKTON
0152 BENTHIC ORGANISMS; CHRONIC LEAKAGE; SPILLS; BALTIMORE CANYON-MID ATLANTIC
0672 BENTHIC ORGANISMS; OFFSHORE DRILLING; SPILL INCIDENT; MISSISSIPPI DELTA; WATER COLUMN; SEDIMENT; WEATHERING; MIGRATES IN SEDIMENTS; DIVERSITY; POPULATIONS; SHRIMP; BLUE CRABS
1161 BENTHIC ORGANISMS; POLYNUCLEAR AROMATIC HYDROCARBONS; ESTUARINE; UPTAKE; RETENTION; DEPURATION; SHELLFISH; BENZOPYRENE
1175 BENTHIC ORGANISMS; CRUDE OIL; ALGAE; ZOOPLANKTON; CRUSTACEANS; POLYCHAETES; MOLLUSCS; FISH; UPTAKE; RETENTION; DEPURATION; REVIEW
1219 BENTHIC ORGANISMS; CRUDE OIL; SEDIMENTS; WASHINGTON; INTERTIDAL ZONE; UPTAKE & DEPURATION; ASSESSMENT OF SPILLS; PUGET SOUND; RECRUITMENT
1204 BENTHIC ORGANISMS; LOS ANGELES HARBOR; SANSINEA SPILL; PRODUCTIVITY; ZOOPLANKTON; ASSESSMENT OF SPILLS; BIRDS; FISH; PHYTOPLANKTON
0902 BENTHIC SPECIES; HYDROCARBON CONCENTRATION; FLUORESCENCE ANALYSIS; SEDIMENTS; FOOD CHAIN CONCENTRATION; CHEDABUCTO BAY; FUEL OIL -BUNKER C; NOVA SCOTIA
0709 BENTHOPLANKTONIC ALGAE; TOXICITY; BLACK OIL; KEROSENE; MARINE PLANKTONIC ALGAE
0567 BENTHOS; CASPIAN SEA; CRUDE OIL; GROWTH; REPRODUCTION; CHIRONOMUS; CERASTODERMA; NAIS; NEREIS; PYRGOHYDROBIA; ABRA
0814 BENTHOS; CONTINENTAL SHELF; NEW YORK BIGHT
0899 BENTHOS; WEST FALMOUTH SPILL; FUEL OIL #2; SPECIES DIVERSITY
0801 BENZ(A)ANTHRACENE; POLYNUCLEAR AROMATIC HYDROCARBONS; ANALYTICAL METHODS; PETROLEUM OILS; MARINE TISSUES; BENZO(A)PYRENE
0419 BENZ(A)PYRENE; DNA BINDING; POLCYCLIC; AROMATICS
0613 BENZ(A)PYRENE; FISH; NAPTHALENE; RADIOACTIVE TRACER; UPTAKE; METABOLISM; DISCHARGE; SCULPIN; OLIGOCOTTUS; GOBY; GILLICHTHYS; SAND DAB; CITHARICHTHYS
0759 BENZ(A)PYRENE; UPTAKE; DEPURATION; DISTRIBUTION; RADIO ASSAY; RANGIA; CLAMS
0920 BENZ(A)PYRENE; BARNACLES; TETRACLITA; CARCINOGENSIS

0990 BENZ(A)PYRENE; PAH; BP; CARCINGENIC;
POLYCYCLIC AROMATIC HYDROCARBONS
1116 BENZ(A)PYRENE; BIODEGRADATION; BACTERIA; SEDIMENTS; BARATARIA BAY;
ANAEROBIC; ACCUMULATION; MYTILUS; WHITING; PICKEREL
0076 BENZENE; SALMON-CHINOOK; GROWTH
0182 BENZENE; SALMON, CHINOOK; STRIPED BASS; RESPIRATORY RATES; NARCOSIS;
ONCORHYNCHUS; MORONE
0213 BENZENE; TOXICITY; COOK INLET CRUDE OIL; WATER SOLUBLE FRACTION
0125 BENZENE; GASOLINE FRACTIONS; TOLUENE; XYLENE; TOXICITY;
MOSQUITO LARVAE; AEDES AEGYPTI; WATER SOLUBLE FRACTIONS
0350 BENZENE; PHYTOPLANKTON; AMPHIDINIUM; SKELETONEMA; CRICOSPHAERA;
DUNALIALLA; TOLUENE; XYLENE; FUEL OIL#2; GROWTH
0467 BENZENE; TOXICOLOGY; ULTRAVIOLET SPECTROPHOTMETRY; ALKYLBENZENES;
BLOOD; KEROSENE
0572 BENZENE; FRESH WATER; CHLORELLA VULGARIS; ALGAE; TOXICITY; GROWTH;
PHOTOSYNTHESIS; XYLENE; TOLUENE; NAPTHALENE
0571 BENZENE; PHYTOPLANKTON; CRUDE OIL; FIELD EXPERIMENT; INHIBITED;
STIMULATION; LABORATORY STUDIES; TOXICITY; PH; FRACTIONS; XYLENE;
TOLUENE
0686 BENZENE; TOXICITY; STRIPED BASS; CONTINUOUS FLOW
0747 BENZENE; TOXICITY; STRIPED BASS; MORONE; JUVENILES
1002 BENZENE; SHRIMP; TOXICITY; CONTENT ANALYSIS; DEPURATION; CRUDE OIL;
FUEL OIL #2; BUNKER C; PALAEMONETES; TEMPERATURE; PHENOL;
NAPHTHALENE
0985 BENZENE; HERRING; ANCHOVY; EGGS; LARVAE; TOXICITY; ABNORMALITIES;
GROWTH; RESPIRATION; FEEDING
0986 BENZENE; BENZENE; HERRING; CULPEA; SPAWNING; OVARIAN EGGS; EMBRYOS;
LARVAE; BEHAVIOR; RADIOACTIVE TRACER
1145 BENZENE; NORMAL WELLS CRUDE OIL; SEALS; ARCTIC; RINGED SEALS;
NAPHTHALENE; PATHOLOGICAL EFFECTS; UPTAKE & INGESTION
1139 BENZENE; CRUDE OIL; CRAB; CANCER; NAPHTHALENE; AROMATIC HC'S;
TOXICITY; REPRODUCTION & DEVELOPMENT
1176 BENZENE; FUEL OIL# 2; ZOOPLANKTON; SHRIMP; RESPIRATION; TOXICITY;
FEEDING BEHAVIOR; MOBILITY; NAPHTHALENE; PHENOL
0348 BENZO(A)PYRENE; CARCINOGENS; SOUTHERN CALIFORNIA; MUSSELS; MYTILUS;
BASELINE; BIOGENIC
0347 BENZO(A)PYRENE; MUSSELS; MYTILUS; RELEASE
0346 BENZO(A)PYRENE; MYTILUS; MONITORING; MUSSELS; CARCINOGEN;
VANCOUVER HARBOR; CREOSOTED
0343 BENZO(A)PYRENE; CARCINOGENS; MONITORING; DETERMINATION TECHNIQUES;
TISSUES; SEDIMENT; POLYCYCLIC AROMATICS; THIN-LAYER
0345 BENZO(A)PYRENE; CARCINOGENS; MUSSELS; MONITOR; MYTILUS
0801 BENZO(A)PYRENE; POLYNUCLEAR AROMATIC HYDROCARBONS;
ANALYTICAL METHODS; PETROLEUM OILS; MARINE TISSUES;
BENZ(A)ANTHRACENE
0344 BENZOPYRENE; ACCUMULATOR ORGANISMS; MONITORING; CARCINOGENS; MUSSELS;
MYTILUS; POLYCYCLIC AROMATIC HYDROCARBONS
0813 BENZOPYRENE; HYDROXYLASE INDUCTION; FISH;
POLYCYCLIC AROMATIC HYDROXYLASE; ARYL HYDROCARBON HYDROXYLASE;
BROWN TROUT; NEWFOUNDLAND; TAINTING; THIN-LAYER CHROMATOGRAPHY
0988 BENZOPYRENE; POLNUCLEAR AROMATIC HYDROCARBONS; CARCINOGENSIS;
SYNTHESIS; DISTRIBUTION; DEGRADATION
1039 BENZOPYRENE; AROMATICS; CYCLO-ALKANE; SEDIMENTS; BUNKER C;
BEACH SEDIMENTS; CHEDABUCTO BAY, NOVA SCOTIA; ARROW SPILL;
METABOLISM; MOLLUSCS; MYA; OSTREA; MYTILUS;

ARYL HYDROCARBON HYDROXYLASE; RADIOACTIVE TRACER
1008 BENZOPYRENE; BIRDS; FISH; TAINTING; MOLLUSCS; ALGAE; TOXICITY; TORREY CANYON SPILL
1161 BENZOPYRENE; POLYNUCLEAR AROMATIC HYDROCARBONS; ESTUARINE; UPTAKE; RETENTION; DEPURATION; BENTHIC ORGANISMS; SHELLFISH
1153 BENZOPYRENE; SALMON; COHO; PHYSIOLOGICAL EFFECTS; ARYL HYDROCARBON HYDROXYLASE; CYTOLOGICAL
1105 BENZOPYRENE; BARNACLES; CARCINOGENS; CONTENT ANALYSIS; TETRACLITA
1164 BENZOPYRENE; MOLLUSCS; BIVALVES; ESTUARIES; OREGON; POLYCYCLIC AROMATICS; CARCINOGENS
1186 BENZOPYRENE; CLAMS; MUSSELS; OYSTERS; OREGON; ESTUARINE; UPTAKE; AROMATIC HYDROCARBONS; CARCINOGENS; MOLLUSCS
0811 BENZOPYRENE HYDROXYLASE; FISH; BIOINDICATOR; SUBLETHAL RESPONSE; ENZYMES; MONITOR
0026 BENZPYRENE; POLYNUCLEAR AROMATIC HYDROCARBONS; CARCINOGENS; BIOGENESIS
0157 BENZPYRENE; ALGAE; AROMATIC HYDROCARBONS; TUMOR LIKE GROWTHS; CARCINOGENISIS
0266 BENZPYRENE; METABOLISM; ENZYME INDUCTION
0608 BENZPYRENE; ZOOPLANKTON; UPTAKE; DEPURATION; PACIFIC COAST; ARCTIC; AROMATIC HYDROCARBONS; NAPTHALENE; RADIOACTIVE TRACERS; CALANUS
0585 BENZPYRENES; BARNACLES; CARCINOGENS; CONTENT ANALYSIS
0324 BERING SEA; FISHES; TOXICITY; TEMPERATURE
0138 BERMUDA; CRUDE OIL; FATE; WEATHER; MICROBIAL DEGRADATION; BIOLOGICALLY ACTIVE FRACTIONS; MARTHA'S VINEYARD
0685 BERMUDA; FIELDS STUDIES; CHRONIC POLLUTION; SANTA BARBARA SPILL; LAKE MARACAIBO, VENEZUELA; TIMBALIER BAY, LA.; POPULATION LEVELS; DIVERSITY; SIZE; GROWTH RATE; REPRODUCTION; ABNORMAL GROWTHS; BIOMAGNIFICATION
0669 BERMUDA; PELAGIC HYDROCARBONS; TAR BALLS; ROCKY INTERTIDAL; FLORA; FAUNA; SPLASH ZONE; NODILITTORINA; TECTARIUS; HYDROCARBON ANALYSIS; ALGAE
0751 BEROL; TOXICITY; INTERTIDAL; BALTIC SEA; LITTORAL ZONE; COREXIT; BP1100; WATER BASE; OIL BASE; SOLVENT
0932 BIBLIOGRAPHIES; DIRECTORY; POLLUTION MONITORING
0488 BIBLIOGRAPHY; BIOINDICATORS
0489 BIBLIOGRAPHY; BIBLIOGRAPHY
0536 BIBLIOGRAPHY; DIRECTORY-OCEAN WASTE DISPOSAL
0617 BIBLIOGRAPHY
0656 BIBLIOGRAPHY; ARCTIC; SUBARCTIC; REVIEW
0696 BIBLIOGRAPHY
0806 BIBLIOGRAPHY; CHRONIC CONTAMINATION; AQUATIC ORGANISMS; DIPTERA; FLIES
0739 BIBLIOGRAPHY; MARINE; ESTUARINE; OIL POLLUTION
0795 BIBLIOGRAPHY; TROPICS
0926 BIBLIOGRAPHY; COASTAL /ESTUARINE POLLUTION
0940 BIBLIOGRAPHY; COASTAL DEVELOPMENT
1026 BIBLIOGRAPHY; ESTUARINE POLLUTION
1027 BIBLIOGRAPHY; BIBLIOGRAPHY; OIL SPILLAGE
1045 BIBLIOGRAPHY; BIRDS; OIL POLLUTION OF BIRDS
1005 BIBLIOGRAPHY; REVIEW; OIL POLLUTION; TOXICITY; FATE &BEHAVIOR OF OIL; BIRDS; BIODEGRADATION; FIELD STUDIES
1103 BIBLIOGRAPHY; OIL POLLUTION 1950-67
0934 BIBLIOGRAPHY -DIRECTORY; POLLUTION
0096 BIBLIOGRAPHY- OIL POLLUTION EFFECTS; AQUATIC ORGANISMS

0927 BIBLIOGRAPHY-AQUATIC POLLUTION
0764 BIBLIOGRAPHY-OIL POLLUTION
0325 BIBLOGRAPHY; SUMMARIES
0326 BIBLOGRAPHY; BIBLOGRAPHY; REVIEW; SUMMARIES
1030 BIESBOSCH TIDAL AREA; OIL SPILL INCIDENT; BIRDS-GEESE; MORTALITY; HOLLAND; CRUDE OIL
0359 BIOACCUMULATION; CRUDE OIL; DETERGENT; OCTOCORALS; CRUSTACEANS; MOLLUSCS; ECHINODERMS; FISH; TOXICITY; SUBLETHAL; DEVELOPMENTAL STAGES; RED SEA; FEEDING RATE; PHYSIOLOGY; LIVER ENLARGEMENT; HEMATOCRIT
0039 BIOASSAY; OYSTERS; CRUDE OIL; REFINED OILS; CRASSOSTREA; FUEL OIL #2; BUNKER C; SOUTH LA. CRUDE; KUWAIT CRUDE
0183 BIOASSAY; ALASKA; SHRIMP; COON-STRIPE SHRIMP; KING CRABS; COOK INLET CRUDE; TOXICITY; STATIC; WATER SOLUBLE FRACTION
0339 BIOASSAY; TOXICITY; EFFLUENT INDUSTRIAL WASTE; BIOASSAY TECHNIQUES
0533 BIOASSAY; BEHAVIOR; BIOELECTRIC ACTION POTENTIALS; PROCAMBARUS; HYDROCARBONS
0529 BIOASSAY; CONTINUOUS FLOW; TOXICITY; SUBLETHAL EFFECTS; WATER SOLUBLE FRACTION; WHOLE OIL FRACTION; MINNOW; FLOUNDER; SHRIMP; SCALLOP; QUAHOG; MUSSEL; MUD SNAIL
0530 BIOASSAY; BIOASSAY; SOLUBLE FRACTION; TOXICITY; LARVAE; JUVENILE; SUBLETHAL EFFECTS
0581 BIOASSAY; CRABS; OYSTERS; CHEMORECEPTION; SUBLETHAL EFFECTS; NAPTHALENE; BEHAVIOR
0537 BIOASSAY; FISH; TOXICITY; OIL-REFINERY EFFLUENT; METABOLIC RATES; COMPARISION OF SPECIES; FRESH WATER
0604 BIOASSAY; OIL; DISPERSANTS; TOXICITY; METHODOLOGY
0628 BIOASSAY; METHODOLOGY; BEHAVIOR; TOXICITY
0784 BIOASSAY; DISPERSANTS; EVALUATION; EFFECTIVNESS; TOXICITY; BOD; THRESHOLD ODOR
0748 BIOASSAY; SALT MARSH; MICROCOSM; GAS CHROMATOGRAPHY; SPECTROPHOTOMETRY; ULTRAVIOLET; FLUORESENT
0915 BIOASSAY; DISPERSANTS; TOXICITY; TAINTING; FISHERIES; TESTING PROCEDURES; STATIC; FLOW THROUGH
0888 BIOASSAY; FLOW THROUGH; METHODOLOGY; SALMON
0870 BIOASSAY; TOXICITY; COOK INLET CRUDE; STATIC; FISH; INVERTEBRATES; ALASKA
1020 BIOASSAY; ALGAE; EMULSIFIERS; TOXICITY; GROWTH; POPULATION; TISSUES; LAVER; PORPHYRA
1034 BIOASSAY; FUEL OIL #2; COON STRIPE SHRIMP; TOXICITY
1035 BIOASSAY; BIOASSAY; CONTINUOUS FLOW; PETROLEUM; TECHNIQUE; METHODOLOGY; FUEL OIL #2
1196 BIOASSAY; TOXICITY; REVIEW; CRUDE OIL; MORTALITY; GROWTH STAGES
0106 BIOASSAY OF DETERGENTS; REVIEW-BIOLOGICAL ECOLOGICAL EFFECTS
0339 BIOASSAY TECHNIQUES; BIOASSAY; TOXICITY; EFFLUENT INDUSTRIAL WASTE
0683 BIOASSAYS; REVIEW; SPILL INCIDENTS; SUBLETHAL EFFECTS
0389 BIOCHEMICAL; REVIEW; INPUT; DEGRADATION; NON-BIOLOGICAL; BACTERIAL
0017 BIOCHEMICAL OXYGEN DEMAND; NOVOROSSIYSK BAY,RUSSIA; OXYGEN-DISSOLVED
0889 BIODEGRADABILITY; DISPERSANTS; TOXICITY
0103 BIODEGRADATION; METABOLIC PATHWAYS; NEW JERSEY COAST; TEMPERATURE; NUTRIENT MINERALS; BACTERIA -HYDROCARBON UTILIZING
0064 BIODEGRADATION; CRUDE OIL; SUBSTRATE COMPOSITION; TEMPERATURE
0093 BIODEGRADATION; CRUDE OIL; NITRIFICATION; AMMONIA PRODUCTION; MICROORGANISMS
0008 BIODEGRADATION; YEAST; MOLDS; FUNGAL ECOLOGY; UPTAKE

0007 BIODEGRADATION; MICROORGANISMS HYDROCARBON UTILIZING; BACTERIA
0069 BIODEGRADATION; REVIEW-OIL POLLUTION; CONTROL OF OIL POLLUTION; FATE AND EFFECTS
0072 BIODEGRADATION; TOXICITY; ABSORBANTS; BENTHIC FLORA; FUEL OIL
0053 BIODEGRADATION; BACTERIA; RATE INCREASE BY GENETIC MANIPULATORS
0067 BIODEGRADATION; DEGRADATION; COMPONENT PREFERENCE; GAS CHROMATOGRAPHY; MASS SPEC.; RATE AND EXTENT; CO2 PRODUCTION; PREFERENTIAL DEGRADATION; MINERALIZATION; PARAFFINNIC CRUDE OIL; BACTERIA
0049 BIODEGRADATION; CLEANUP; NUTRIENT ADDITION
0068 BIODEGRADATION; ABUNDANCE; DISTRIBUTION; BIOINDICATOR; ENUMERATION; CRUDE OIL- SWEDEN; TEMPERATURE; LEVEL OF OIL; MICROORGANISMS; RARITAN BAY N.J.; GAS CHROMATOGRAPHY
0075 BIODEGRADATION; BACTERIA
0009 BIODEGRADATION; YEAST; LOUISIANA CRUDE; TRICHOSPORON
0070 BIODEGRADATION; NUTRIENTS; OLEOPHILIC FERTILIZER; CLEANUP OF OIL SLICKS
0006 BIODEGRADATION; YEAST; GUPPY; LOUISIANA CRUDE OIL; FUNGI
0104 BIODEGRADATION; BACTERIA; TEMPERATURE; NITROGEN; PHOSPHORUS; LIMITING FACTORS
0148 BIODEGRADATION; SEDIMENTS; OYSTERS; SCALLOPS; TOXICITY; CONTENT ANALYSIS; WEST FALMOUTH OIL SPILL; BUZZARD BAY; GAS CHROMATOGRAPHY
0189 BIODEGRADATION; METABOLIC PRODUCTS; TOXICITY TO FISH; NUTRIENTS-NITROGEN AND PHOSPHATE
0124 BIODEGRADATION
0217 BIODEGRADATION; DISPERSANTS; TOXICITY; BIRDS; OXYGEN TRANSPORT
0206 BIODEGRADATION; ARCTIC; RADIOACTIVE TRACER; GEOGRAPHIC DISTRIBUTION; EFFECT OF CLAY PARTICLES ON RATE; ENUMERATION; RATE; DISSOLVED PHASE
0193 BIODEGRADATION; PETROLEUM FRACTIONS; BACTERIA; MARINE
0304 BIODEGRADATION; SOFT-SHELL CLAM; MYA; MICROFLORA
0262 BIODEGRADATION; MICROORGANISMS; CHESAPEAKE BAY
0312 BIODEGRADATION; REVIEW; BACTERIA; FRACTIONS; CRUDE OIL; ENVIRONMENTAL FACTORS
0342 BIODEGRADATION; REVIEW
0388 BIODEGRADATION
0470 BIODEGRADATION
0451 BIODEGRADATION; IRISH STARDUST - ALERT BAY 1973; ALERT BAY, CANADA; RECOVERY; HEAVY FUEL OIL
0449 BIODEGRADATION; BACTERIA; SEAWATER; OXIDATION; HYDROCARBONS
0418 BIODEGRADATION; CRUDE OIL; DISPERSANTS; ECOSYSTEMS
0380 BIODEGRADATION; RATE; OXYGEN LEVEL; MONOD'S MODEL
0406 BIODEGRADATION; REVIEW
0466 BIODEGRADATION; GAS OIL; FUNGUS
0469 BIODEGRADATION; BACTERIA; DISTRIBUTION; OIL-OXIDIZING BACTERIA; NORTH SEA; ABUNDANCE; WATER; SEDIMENT
0622 BIODEGRADATION; REFINERY WASTES; BACTERIA; PHYTOPLANKTON
0516 BIODEGRADATION; BACTERIA; SUBSTRATE SELECTION; SUCCESSION
0621 BIODEGRADATION; RATE ENHANCEMENT; NITROGEN; PHOSPHORUS
0671 BIODEGRADATION; RATE; TEMPERATURE; OXYGEN AVAILILITY; BOD
0698 BIODEGRADATION; DISPERSAL
0791 BIODEGRADATION; ENHANCEMENT; FERTILIZER
0843 BIODEGRADATION; RATES; BACTERIA; MECHANISM; TOXICITY OF METABOLIC AND PRODUCTS; FLOW RATE IN CHEMOSTAT
0835 BIODEGRADATION; OIL; DEGRADATION; ENVIRONMENTAL FACTORS; ENERGY;

BACTERIA; BUNKER C; CHEDABUCTO BAY; ARROW SPILL
0740 BIODEGRADATION; MICROORGANISMS; DISTRIBUTION; NORTHWESTERN ATLANTIC
0833 BIODEGRADATION; MICROORGANISMS OXIDIZING HC'S; DISTRIBUTION;
NEVA INLET, RUSSIA; SEASONAL DISTRIBUTION; BACTERIA
0832 BIODEGRADATION; PHENOL; REFINERY EFFLUENT; ST. LAWRENCE RIVER
0793 BIODEGRADATION; RATES; MIXED CULTURE; ORGANIC ENRICHMENT;
INORGANIC SALTS; AERATION
0917 BIODEGRADATION; ANEROBIC CONDITIONS; SEDIMENTS
0910 BIODEGRADATION; HEXADECANE; RADIOACTIVE TRACER; TOKYO BAY;
WATER COLUMN; BACTERIA
0874 BIODEGRADATION; ALASKA; TEMPERATURE; SALINITY; MORTALITY; CHEMOTAXIS;
COOK INLET; VALDEZ
0875 BIODEGRADATION; BIODEGRADATION; MICROORGANISMS; BACTERIA;
ENHANCEMENT; EMULSIFICATION; SEEDING
0860 BIODEGRADATION; DISPERSION; ARTHROBACTER; BACTERIA
1029 BIODEGRADATION; BACTERIA; MICROORGANISMS
1065 BIODEGRADATION; ALGAE; PROTOTHECA; SUBSTRATE SELECTION
1061 BIODEGRADATION; MICROORGANISMS; ENUMERATION; CONCENTRATION;
ANTIBIOTICS; INOCULUM WASHES
0963 BIODEGRADATION; YEAST; GAS CHROMATOGRAPHY; TEMPERATURE;
ACID PRODUCTION; SUBSTRATE SELECTION
1062 BIODEGRADATION; BACTERIA; SEDIMENTS; CHESAPEAKE BAY
1060 BIODEGRADATION; POTENTIAL; MARINE; RADIOMETRY; HEXADECANE
1059 BIODEGRADATION; BACTERIA; LIMITING EFFECTS; SOUTH LOUISIANA CRUDE;
FUEL OIL # 2
1054 BIODEGRADATION; SEDIMENTS; ATLANTIC COAST; NORTH CAROLINA
1005 BIODEGRADATION; REVIEW; OIL POLLUTION; TOXICITY;
FATE &BEHAVIOR OF OIL; BIRDS; FIELD STUDIES; BIBLIOGRAPHY
1063 BIODEGRADATION; MOTOR OIL; CHESAPEAKE BAY; SEDIMENTS
1129 BIODEGRADATION; MICROOGANISMS; ARCTIC; TEMPERATURE; NUTRIENTS;
OXYGEN REQUIREMENTS; CRUDE OIL; AROMATICS; PARAFFINS; BEAUFORT SEA;
CHUKCHI SEA
1116 BIODEGRADATION; BACTERIA; SEDIMENTS; BARATARIA BAY; ANAEROBIC;
BENZ(A)PYRENE; ACCUMULATION; MYTILUS; WHITING; PICKEREL
1151 BIODEGRADATION; CRUDE OIL; AROMATIC HC' S; BACTERIA
1104 BIODEGRADATION; BUNKER C; EMULSIFICATION; BACTERIA
1066 BIODEGRADATION; CHESAPEAKE BAY; BALTIMORE HARBOR; ALGA; PROTOTHECA
1150 BIODEGRADATION; AROMATIC PETROLEUM PRODUCTS; XYLENE; MICROORANISMS;
BACTERIA; NOCARDIA
1128 BIODEGRADATION; ARCTIC; MICROORGANISMS
1115 BIODEGRADATION; BACTERIA; SUBSTRATE; DISTRIBUTION; HYDROGEN ACCEPTOR;
ABSORBENTS
1189 BIODEGRADATION; MICROORGANISMS; BACTERIA; FUNGI; YEASTS; CRUDE OIL;
NIGERIA
1190 BIODEGRADATION; BIODEGRADATION; BUNKER C; MARINE DIESEL;
MICROORGANISMS; CRUDE OIL
1203 BIODEGRADATION; SYMPOSIA; OILS
1174 BIODEGRADATION; ESTUARIES; CANADA; SAENICH INLET; CRUDE OIL;
FUEL OIL; PHYTOPLANKTON; CEPEX; DIATOMS
1188 BIODEGRADATION; CRUDE OIL-NIGERIAN; NUTRIENTS; OXYGEN CONSUMPTION
1180 BIODEGRADATION; DISPERSANTS; CRUDE OIL
1217 BIODEGRADATION; TEMPERATURE; ESTUARIES; MICROORGANISMS
1167 BIODEGRADATION; CALIFORNIA; TAINTING; PETROLEUM; CLEANING AGENTS;
GAS CHROMATOGRAPHY; ORGANOLEPTIC
0525 BIODEGRADATION RATE; SEDIMENTS; CONTINENTAL SHELF SEDIMENTS;

OXYGEN AVAILABILITY
0533 BIOELECTRIC ACTION POTENTIALS; BIOASSAY; BEHAVIOR; PROCAMBARUS; HYDROCARBONS
0532 BIOELECTRIC ACTION POTENTIALS; HYDROCARBONS; BIOINDICATOR; REMOTE ELECTRODES; CRUSTACEANS; ACTIVITY
0026 BIOGENESIS; POLYNUCLEAR AROMATIC HYDROCARBONS; CARCINOGENS; BENZPYRENE
0356 BIOGENIC; MYTILUS; CONTENT ANALYSIS; METABOLISM; PETROLEUM; MUSSELS; KIEL BIGHT, W. GERMANY; AROMATICS
0250 BIOGENIC; PARAFFINS; ALGAE; ZOOPLANKTON; PHYTOPLANKTON; SEDIMENT; PRISTANE; PETROLEUM
0355 BIOGENIC; MYTILUS; MUSSELS; UPTAKE; DEPURATION; PETROLEUM; AROMATICS KIEL BIGHT
0349 BIOGENIC; BENZO(A)PYRENE; CARCINOGENS; SOUTHERN CALIFORNIA; MUSSELS; MYTILUS; BASELINE
0377 BIOGENIC; HYDROCARBON; CONTENT ANALYSIS; SEDIMENTS; MERCENARIA; CLAMS; NARRAGANSET BAY; PETROLEUM
0642 BIOGENIC VS PETROLEUM HYDROCARBONS; PYROGRAPHICS; OUTBOARD MOTOR OI ALGAE
0139 BIOGENIC VS. PETROLEUM; HYDROCARBONS; CONTENT ANALYSIS; MARINE PHYTOPLANKTON; TRACER; FOOD CHAIN
0141 BIOGENIC VS. PETROLEUM; TRACERS; PHYTOL; ZOOPLANKTON; FISH; ANALYSIS FOR HYDROCARBONS; OLEFINS; FOOD CHAIN
1118 BIOGENIC VS. PETROLEUM; HYDROCARBONS; CHLOROPHYLL-A CORRELATION WIT PHYTOPLANKTON; WEST AFRICA
0711 BIOGENIC VS. PETROLEUM HC'S; HYDROCARBON; CONTENT ANALYSIS; IR; GLC; MASS SPECTROMETRY; MONITORING
0661 BIOGENIC VS. PETROLEUM HYDROCARBONS; INFRA-RED SPECTROMETRY; CRUDE OIL; SEDIMENTS
0802 BIOGENIC VS.PETROLEUM HYDROCARBON; DIESEL OIL; LOBSTER; CHROMATOGRAPHY
0068 BIOINDICATOR; ABUNDANCE; DISTRIBUTION; ENUMERATION; CRUDE OIL- SWEDEN; TEMPERATURE; LEVEL OF OIL; MICROORGANISMS; BIODEGRADATION; RARITAN BAY N.J.; GAS CHROMATOGRAPHY
0110 BIOINDICATOR; MYTILUS; MUSSELS
0532 BIOINDICATOR; HYDROCARBONS; BIOELECTRIC ACTION POTENTIALS; REMOTE ELECTRODES; CRUSTACEANS; ACTIVITY
0811 BIOINDICATOR; FISH; BENZOPYRENE HYDROXYLASE; SUBLETHAL RESPONSE; ENZYMES; MONITOR
0488 BIOINDICATORS; BIBLIOGRAPHY
0878 BIOINDICATORS; OIL POLLUTION; CHIRONOMIDAE; FRESH WATER; TRAIL RIVER, NWT, CANADA; FRESHWATER; MIDGES
0912 BIOINDICATORS; CLAMS; MACOMA BALTICA; MUD FLATS; CRUDE OIL
1137 BIOINDICATORS; AUSTRALIA; UPTAKE; RETENTION; DEPURATION; GAS CHROMATOGRAPHY; MYTILUS; MUSSEL; EFFECT ON ECOSYSTEM; TOXICIT
1125 BIOINDICATORS; REVIEW; SUBLETHAL EFFECTS; TOXICITY; UPTAKE; RETENTION; DEPURATION; METHODS OF DETECTION OF HC'S IN ORGANISM
1195 BIOINDICATORS; REVIEW; POLLUTION; ESTUARINE; MARINE; OIL POLLUTION
1171 BIOINDICATORS; PROTOZOA; CILIATES; EUPLOTES; SAUDI ARABIAN CRUDE; EMPIRE MIX CRUDE; MICROFAUNA; COMMUNITY DIVERSITY EXPERIMENTS
0750 BIOLOGICAL
0052 BIOLOGICAL ASSESSMENT; COLLECTION OF ABSTRACTS; ABSTRACTS; SAMPLING METHODS; ANALYTICAL TECHNIQUES
1222 BIOLOGICAL BASELINE; ESTERO BAY; ASSESSMENT OF SPILLS; CONTINGENCY PLANNING; POTENTIAL OIL SPILLS

0242 BIOLOGICAL CONSEQUENCES; REVIEW; BIRDS; COMMERCIAL FISHERIES; COASTAL FLORA AND FAUNA; ARCTIC; PUBLIC HEALTH
0769 BIOLOGICAL CONSEQUENCES; REVIEW; OIL POLLUTION; SHORE CLEANING
0133 BIOLOGICAL EFFECTS; MARINE ENVIRONMENT; REVIEW
0134 BIOLOGICAL EFFECTS; REVIEW ARTICLE; OIL CONTAMINATION
0575 BIOLOGICAL EFFECTS; REVIEW; SOURCES; PERSISTANCE; TOXICITY
0512 BIOLOGICAL EFFECTS; REVIEW ARTICLE; INPUT; FATE
0721 BIOLOGICAL EFFECTS; MODEL; TOXICITY; SUBLETHAL EFFECTS; TAINTING; POLYCYCLIC AROMATIC HYDROCARBONS; COATING; SOLUBLE AROMATIC HYDROCARBON DERIVITIES
0753 BIOLOGICAL EFFECTS; REVIEW WORKSHOP; INPUTS; ANALYTICAL TECHNIQUES
0772 BIOLOGICAL EFFECTS; REVIEW; INPUT; FATE; CLEANUP; OIL; DISPERSANTS
0945 BIOLOGICAL EFFECTS; TORREY CANYON SPILL
1076 BIOLOGICAL EFFECTS; PROCEDURES MANUAL
1087 BIOLOGICAL EFFECTS OF OIL POLLUTION; REVIEW
0246 BIOLOGICAL FATES; REVIEW; MACROORGANISMS
0119 BIOLOGICAL INDICATORS; DIVERSITY INDICIES; SHANNON DIVERSITY INDEX; EVENNESS INDEX
0111 BIOLOGICAL INDICATORS; SPECIES DIVERSITY INDICIES; FISH; GALVESTON BAY TEXAS
0400 BIOLOGICAL MONITOR; MYTILUS; UPTAKE; DEPURATION; HYDROCARBON CONTENT ANALYSIS; PHYSIOLOGICAL STRESS; MUSSELS; ACCUMULATION
0520 BIOLOGICAL RESPONSES; REVIEW
0105 BIOLOGICAL SAMPLERS; MONITORING INSTRUMENTS; SAMPLERS; SEDIMENT SAMPLERS; WATER SAMPLERS
0968 BIOLOGICAL SURVEY; SANTA BARBARA SPILL
0138 BIOLOGICALLY ACTIVE FRACTIONS; CRUDE OIL; FATE; WEATHER; MICROBIAL DEGRADATION; MARTHA'S VINEYARD; BERMUDA
0970 BIOLOGY; SANTA BARBARA SPILL; BACTERIOLOGY
0685 BIOMAGNIFICATION; FIELDS STUDIES; CHRONIC POLLUTION; SANTA BARBARA SPILL; LAKE MARACAIBO, VENEZUELA; BERMUDA; TIMBALIER BAY, LA.; POPULATION LEVELS; DIVERSITY; SIZE; GROWTH RATE; REPRODUCTION; ABNORMAL GROWTHS
0745 BIOMASS; PALVA OIL SPILL INCIDENT; BENTHIC FAUNA; DIVERSITY; POPULATIONS
1205 BIOMASS; SANTA BARBARA CHANNEL CALIFORNIA; NATURAL OIL SEEPS; ISLA VISTA OIL SEEP; BENTHIC FAUNA; POLYCHAETES; TOXICITY
0275 BIOSYNTHESIS; POLYCYCLIC AROMATIC HYDROCARBONS; METABOLISM; UPTAKE; FOOD WEB TRANSFER
0555 BIOSYNTHESIS; HYDROCARBONS; MICROFLORA; BREAKDOWN; METHODS; METABOLISM; TERRESTRIAL
0807 BIOTA; WATER SOLUBLE FRACTIONS; CRUDE OIL; MICROALGAE; GROWTH RATE; HYDROCARBON ANALYSIS; SEDIMENTS; WATERS; SOUTH TEXAS OUTTER CONTINENTAL SHELF
1007 BIOTA; LAKE MARACAIBO, VENEZUELA; FISHERIES; SEDIMENTS; WATER; HYDROCARBON CONTENT ANALYSIS; TOXICITY
0336 BIRD MORTALITY; OLYMPIC ALLIANCE-DOVER STRAITS 1975; CORMORANT; AUKS; OIL SPILL INCIDENT; ENGLAND
1084 BIRD TREATMENT; SAN FRANCISCO SPILL; BIRDS; MORTALITIES
0095 BIRDS; OIL POLLUTION
0113 BIRDS; REHABILITATION
0112 BIRDS; TORREY CANYON; REHABILITATION AND CLEANING; PATHOLOGICAL EFFECTS
0114 BIRDS; REHABILITATION

0047 BIRDS; TAY RIVER; VENEZUELAN CRUDE OIL
0012 BIRDS; SPILLS; SAN FRANCISCO BAY; FRANK BUCK - TANKER SPILL (1937); WEST COAST U.S.
0054 BIRDS; MORTALITIES; BEACH SURVEY
0045 BIRDS; SANTA BARBARA SPILL; CLEANUP; COMMUNITY SURVEY; LIMPETS; BARNACLES; MUSSEL; CHITONS; INTERTIDAL ORGANISMS
0046 BIRDS; SANTA BARBARA SPILL; COMMUNITY SURVEY; KELP; SCALLOPS; ASSESSMENT
0240 BIRDS; CLEANING; FEATHER WETTING; ENTERITIS; REHABILITATION
0190 BIRDS; MORTALITIES
0172 BIRDS; TORREY CANYON; MORTALITIES; GUILLEMOTS; RAZORBILLS
0217 BIRDS; DISPERSANTS; TOXICITY; BIODEGRADATION; OXYGEN TRANSPORT
0214 BIRDS; MORTALITY; SANTA BARBARA
0244 BIRDS; MORTALITIES; BEACH SURVEYS; POPULATION; CHRONIC SPILLAGE; TREATMENT; DISPERSANTS
0191 BIRDS; MORTALITIES; ARROW SPILL; IRVING WHALE SPILL; NOVA SCOTIA; SPECIES ENDANGERMENT; NEWFOUNDLAND
0165 BIRDS; GULLS; GUILLIMOTS; KITTIWAKES; BEHAVIOR
0245 BIRDS; CLEANING; FEATHER WETTING
0159 BIRDS
0198 BIRDS
0175 BIRDS; ARROW SPILL; MORTALITIES; CHEDABUCTO BAY, NOVA SCOTIA
0170 BIRDS; MORTALITIES; CONSERVATION; GUILLEMOTS
0239 BIRDS; CONSERVATION
0166 BIRDS; OIL; EFFECT; REVIEW; MORTALITIES; PHYSIOLOGY
0163 BIRDS; OIL; BREEDING; DISTRIBUTION; STRANDINGS; WEATHER
0200 BIRDS; EIDERS; BEHAVIOR
0177 BIRDS; REVIEW; PHYSIOLOGY; REHABILITATION; MARINE FAUNA
0167 BIRDS; MORTALITIES; REVIEW
0173 BIRDS
0169 BIRDS; TORREY CANYON; MORTALITY
0168 BIRDS; MORTALITIES; SPECIES ENDANGERMENT; CONSERVATION; REHABILITATION
0242 BIRDS; REVIEW; BIOLOGICAL CONSEQUENCES; COMMERCIAL FISHERIES; COASTAL FLORA AND FAUNA; ARCTIC; PUBLIC HEALTH
0264 BIRDS; CLEANING
0335 BIRDS; PANTHER SPILL; MORTALITY
0258 BIRDS; TERNS; DRY TORTUGAS; TERNS
0352 BIRDS; SNOW GEESE
0305 BIRDS; NORTH SEA OIL; CROMARTY FIRTH,SCOTLAND
0299 BIRDS; MALLARDS; CRUDE OIL; PHYSIOLOGY; ANAS; DEHYDRATION; MUCOSAL TRANSFER RATE; DISPERSANTS; INTESTINAL ABSORPTION
0456 BIRDS; OIL; CLEANING; NETHERLANDS; FEATHER WETTING
0491 BIRDS; OIL; INGESTION; MOBILITY; TOXICOLOGICAL EFFECTS; DUCKS
0454 BIRDS; MORTALITIES; ENGLAND/SCOTLAND; BEACHED BIRDS COUNTS
0437 BIRDS; POPULATIONS; MIGRATION; WINTER QUARTERS; BREEDING
0473 BIRDS; FATALITIES
0460 BIRDS; OIL; CLEANING; PATHOLOGY; SANTA BARBARA CRUDE; POLYCOMPLEX A-11
0492 BIRDS; OIL; DUCKS; REPRODUCTION; INGESTION; HATCHABILITY; COATING
0495 BIRDS; OIL; DUCKS; INGESTION; TOXICITY; PHYSIOLOGICAL EFFECTS; HISTOPATHOLOGY
0455 BIRDS; MORTALITY; TAY ESTUARY, SCOTLAND; EIDERS
0490 BIRDS; MEDWAY ESTUARY; OIL SPILL INCIDENT
0430 BIRDS; KENT; OIL POLLUTION

0453 BIRDS; MORTALITIES; TAY ESTUARY, SCOTLAND
0369 BIRDS; MIGRATION; OIL POLLUTION
0368 BIRDS; MIGRATION; OIL POLLUTION
0619 BIRDS; BALTIC; WASTE OIL; MORTALITIES
0517 BIRDS; CALIFORNIA MURRE
0548 BIRDS; MORTALITIES; DENMARK
0514 BIRDS; SANTA BARBARA SPILL; CLEANUP; ECOLOGICAL IMPACTS;
LITTORAL COMMUNITIES; KELP BEDS
0513 BIRDS; TORREY CANYON; DETERGENT; LIMPETS; PLANKTON; FISHERIES;
CRAIE DE CHAMPAGNE
0558 BIRDS; HAMILTON TRADER SPILL; IRISH SEA
0700 BIRDS; REVIEW-OIL POLLUTION; LARVAE; SUBLETHAL EFFECTS; PRODUCTIVITY;
FISH; PHYTOPLANKTON; ZOOPLANKTON; EGGS; PLAICE
0717 BIRDS; MORTALITIES; SAN FRANCISCO SPILL-1937; WATERFOWL; GULLS
0626 BIRDS; MORTALITIES
0783 BIRDS; TORREY CANYON; AUKS; CORNWALL, ENGLAND
0808 BIRDS; TREATMENT
0854 BIRDS; ENGLAND; OIL POLLUTION
0785 BIRDS; CLEANING; LARODAN 127; FEATHER WAX
0841 BIRDS; ARGO MERCHANT SPILL
0809 BIRDS; MORTALITY
0826 BIRDS; OIL; TREATMENT; WW2 TANKER SINKINGS
0810 BIRDS; BREEDING COLONIES; OIL; WORLD WAR 2 OIL POLLUTION; GUILLEMOTS;
PUFFINS
0873 BIRDS; MORTALITIES
0900 BIRDS; SANTA BARBARA SPILL; OIL SPILL INCIDENT; CLEANUP
0936 BIRDS; FINLAND; PALVA; EIDER; SOMATERIA
0892 BIRDS; PANAMA; S.S. WITWATER SPILL; TROPICS; INTERTIDAL;
TERRESTRIAL PLANTS; LITTORAL; MANGROVE; REEF; MEIOFAUNA; SEA TURTLES;
DIESEL OIL; BUNKER C
0928 BIRDS; MORTALITIES; SAN FRANCISCO BAY; AUTOPSIES; FUEL OIL-BUNKER C
0877 BIRDS; CHESAPEAKE BAY; SPILL INCIDENT; FUEL OIL # 6;
ENVIRONMENTAL ASSESSMENT; MORTALITIES; SHELL FISHERIES; MARSH GRASS
0973 BIRDS; MORTALITIES; SANTA BARBARA SPILL
1005 BIRDS; REVIEW; OIL POLLUTION; TOXICITY; FATE &BEHAVIOR OF OIL;
BIODEGRADATION; FIELD STUDIES; BIBLIOGRAPHY
1017 BIRDS; KENT, ENGLAND; MARINE ALGAE PLANTS; FISH
1044 BIRDS; YUKON
0975 BIRDS; SANTA BARBARA SPILL; INVERTEBRATES; ALGAE; MORTALITIES;
RECOLONIZATION; SUBLETHAL EFFECTS; PHYLLOSPADIX; CHTHAMALUS;
POLLICIPES; HESPEROPHYCUS
1042 BIRDS; ALCIDS; INDICATOR SPECIES; AUKS; MURRS; EIDERS
0974 BIRDS; SANTA BARBARA SPILL; SURVEY; MARINE MAMMALS; DIVERSITY;
FISHERIES; TAINTING
1015 BIRDS
1043 BIRDS; CANADA; PACIFIC
1008 BIRDS; FISH; TAINTING; MOLLUSCS; BENZOPYRENE; ALGAE; TOXICITY;
TORREY CANYON SPILL
1045 BIRDS; BIBLIOGRAPHY; OIL POLLUTION OF BIRDS
1135 BIRDS; ESTUARINE; DUCKS; FISH; CHESAPEAKE BAY; HATCHING SUCCESS;
TOXICITY
1134 BIRDS; ARCTIC; SUB ARCTIC; BAFFIN BAY; DAVIS STRAIT; LABRADOR SEA;
ASSESSMENT OF SPILLS; PHYTOPLANKTON; ZOOPLANKTON; ZOOBENTHOS; FISH;
MAMMALS
1144 BIRDS; HATCHING SUCCESS; EMBRYONIC DEVELOPMENT; EIDERS; GULKS;

MALLARDS; PATHOLOGICAL EFFECTS; FUEL OIL; CRUDE OIL
1069 BIRDS; TORREY CANYON SPILL; TOXICITY; DETERGENTS; INTERTIDAL; CHALK
1084 BIRDS; SAN FRANCISCO SPILL; MORTALITIES; BIRD TREATMENT
1101 BIRDS; MORTALITY; SHETLAND IS., BRITAIN; OIL
1204 BIRDS; LOS ANGELES HARBOR; SANSINEA SPILL; PRODUCTIVITY; ZOOPLANKTON; ASSESSMENT OF SPILLS; BENTHIC ORGANISMS; FISH; PHYTOPLANKTON
1183 BIRDS; PLANKTON; INVERTEBRATES; MAMMALS; TOXICITY; REVIEW; PETROLEUM HYDROCARBONS; ECOSYSTEM
1210 BIRDS; EGGS; OIL; INGESTION
1030 BIRDS-GEESE; BIESBOSCH TIDAL AREA; OIL SPILL INCIDENT; MORTALITY; HOLLAND; CRUDE OIL
0073 BIVALVES; CRUDE OIL; DISPERSANTS
0609 BIVALVES; MARINE SEDIMENT; METABOLISM; MICROFAUNA; MEIOFAUNA; MACROFAUNA; DEGRADATION; POLYCHAETE WORMS; BACTERIA; EXCRETION
0865 BIVALVES; TOXICITY; SPERMATOZOA; FERTILIZATION; DEVELOPMENTAL ABNORMALITIES; PRUDHOE BAY CRUDE; KUWAIT CRUDE; NIGERIAN CRUDE
0864 BIVALVES; DISPERSANT; SHELLFISH; LARVAE; SPERMATOZOA; TOXICITY; OYSTERS; CRASSOSTREA; MUSSEL; FERTILIZATION; DEVELOPMENT
0962 BIVALVES; TOXICITY; LONG TERM EFFECTS; INTERTIDAL; GASTROPODS; DIESEL FUEL, MARINE; ROCKY SHORE; FAUNA; LAMMA IS.; HONG KONG; DISPERSANTS; RECOVERY
0994 BIVALVES; SURFACTANTS; FISH; CRUSTACEANS; TOXICITY; BEHAVIOR; DEVELOPMENT; ACTIVITY; BYSSUS THREAD; MOULTING
0995 BIVALVES; DISPERSANTS; EMULSIONS; TOXICITY; SUBLETHAL EFFECTS; ACTIVITY; MOTILITY; CRUSTACEANS; FISH; BEHAVIOR; OIL EMULSION; CONTINUOUS FLOW; LOCOMOTION
1164 BIVALVES; BENZOPYRENE; MOLLUSCS; ESTUARIES; OREGON; POLYCYCLIC AROMATICS; CARCINOGENS
0228 BLACK MANGROVE; LITTORAL COMMUNITIES; FLORIDA KEYS; ROCKY PLATFORM; MANGROVE FRINGE; SEA GRASS FLATS; MANGROVE SWAMP; CRUSTACEANS; ECHINODERMS; RED MANGROVE; PEARL OYSTER
0704 BLACK OIL; TOXICITY; FISH; DEVELOPMENT; PETROLEUM; EUGRAULIS; SCORPAENA; CRENILABRUS; SOLAR OIL
0709 BLACK OIL; TOXICITY; KEROSENE; MARINE PLANKTONIC ALGAE; BENTHOPLANKTONIC ALGAE
0016 BLACK SEA; MUSSEL; BEHAVIOR; FILTERING ABILITY; TOLERANCE
0708 BLACK SEA; PURIFICATION; DEGRADATION; WATER; SEDIMENTS; BACTERIA
0706 BLACK SEA; OIL POLLUTION; FLORA; FAUNA
0702 BLACK SEA; ZOOPLANKTON; TOXICITY; CRUDE OIL; MINERAL OIL; ACARTIA; PARACALANUS; PENILLIA; CENTROPAGES; OITHONA
0707 BLACK SEA; OIL POLLUTION; FLORA; FAUNA; CRUDE OIL; DIESEL OIL
0701 BLACK SEA; BACTERIA; DEGRADATION; SELF-PURIFICATION
0737 BLACK SEA BREAM; PARAFFINS; FISH; CRUDE OIL; JULIANA WRECK; SALMON; MULLET; GAS CHROMATOGRAPHY
0411 BLEED WATER; REVIEW; SPREADING OF OIL; GASEOUS EXCHANGE; TOXICITY; TAINTING; OYSTERS; DIATOMS; OFFSHORE DRILLING
0640 BLEED WATER; OYSTERS; FILTERING RATE; CRUDE OIL; WATER SOLUBLE FRACTION
0467 BLOOD; TOXICOLOGY; ULTRAVIOLET SPECTROPHOTMETRY; BENZENE; ALKYLBENZENES; KEROSENE
0961 BLOWFLY; CHEMORECEPTION
0583 BLUE CRAB; CRUDE OIL; PALATABILITY; BROWN SHRIMP; TAINTING; LOUISIANA CRUDE OIL
0672 BLUE CRABS; OFFSHORE DRILLING; SPILL INCIDENT; MISSISSIPPI DELTA;

WATER COLUMN; SEDIMENT; WEATHERING; MIGRATES IN SEDIMENTS; DIVERSITY; POPULATIONS; SHRIMP; BENTHIC ORGANISMS

0848 BLUE GREEN; CRUDE OIL; SOUTH LOUISIANA CRUDE; KUWAIT CRUDE; FUEL OIL#2; GROWTH RATE; PHOTOSYNTHESIS; MICROALGAE-TOXICITY; DIATOM; DINOFLAGELLATE

0063 BLUE GREEN ALGAE; MICROBIAL POPULATIONS; PROTOZOANS; DIATOMS; DEGRADATION; YEAST; SPECIES DIVERSITY; GREEN ALGAE; NATURAL SEEPAGE; PRUDHOE CRUDE OIL; ARCTIC; ALASKA-PRUDHOE BAY; CAPE SIMPSON; NUTRIENT ENRICHMENT

0011 BLUE GREEN ALGAE; PETROLEUM PRODUCTS; APHANIZOMENON; SCENEDESMUS; GROWTH; MORPHOLOGY; PROTOCOCCAL ALGAE

0664 BLUE GREEN ALGAE; EAST CHINA SEA; KUROSHIO; TAR BALLS; ATTACHED ORGANISMS; PENNATE DIATOMS; STONY CORALS; BRYOZOANS; BARNACLES; COPEPODS

0903 BLUEGILL; TOXICITY; FUEL OIL-#2; SHRIMP(GRASS); MINNOW; MUMMICHOG; CATFISH(CHANNEL)

0991 BLUEGILL; OUTBOARD MOTOR EXHAUST WASTE; FISH; TAINTING; LEAD

0212 BLUEGILL SUNFISH; NAPHTHENIC ACID; TOXICITY; POND SNAIL; WATER HARDNESS; TEMPERATURE

0539 BLUEGILLS; OUTBOARD MOTORS; TAINTING; TOXICITY; FISH; FISH REPRODUCTION; FATHEAD MINNOWS

0690 BOD; BACTERIAL DEGRADATION; SLICK-SEEDING; ADDITIVES; ENHANCEMENT; MICROBIAL SEEDING; TOTAL ORGANIC CARBON; NUTRIENT SALT

0671 BOD; BIODEGRADATION; RATE; TEMPERATURE; OXYGEN AVAILILITY

0673 BOD; BUNKER C; RIVER; MUDDY RIVER, MASS.; PLANKTON; TOXICITY; MACROFAUNA; NEW ENGLAND

0784 BOD; DISPERSANTS; EVALUATION; EFFECTIVNESS; TOXICITY; BIOASSAY; THRESHOLD ODOR

0483 BODY WEIGHT; MYTILUS; SANTA BARBARA SPILL; GROWTH

0799 BOILING FRACTION; CRUDE OIL; TOXICITY; INTERTIDAL ORGANISMS; LIGHT TRANSMISSION; TEMPERATURE

0300 BOILING FRACTIONS; OIL; MALLARDS; PHYSIOLOGY; INTESTINAL ABSORPTION; ANAS; MUCOSAL TRANSFER RATES; CRUDE OILS

0905 BOONE CREEK OIL SPILL; FISH; PERIPHYTON; SEDIMENTS; STREAM; DIESEL FUEL; MACROINVERTEBRATES; HYDROCARBON ANALYSIS; SOUTH CAROLINA

0990 BP; PAH; CARCINGENIC; POLYCYCLIC AROMATIC HYDROCARBONS; BENZ(A)PYRENE

0156 BP 1002; ALGAE; PRASINOLADUS; EMULSIFIERS; TOXICITY; TEMPERATURE

0185 BP 1002; KUWAIT CRUDE; SURFACTANT; LICHENS; LICHINA; CARBON FIXATION; EMULSIFIER

0294 BP1002; TOXICITY; DISPERSANTS; RECOVERY ASSESSMENT

0279 BP1002; BARNACLES; TOXICITY; BEHAVIOR; LARVAE; DETERGENTS; DASIC; ELMININS; SOLVENT; SURFACTANT

0386 BP1002; EMULSIFERS; LITTORAL ORGANISMS; BP1100; COCKLES; POLYCHAETE; PRAWN

0424 BP1002; OIL; DISPERSANTS; TOXICITY; POLYCHAETE; GAMETE FORMATION; SPAWNING; GROWTH; MORTALITY; CIRRATULUS; CIRRIFORMIA; COREXIT; ESSOLVENE

0733 BP1002; KEROSENE; CHEMKLEEN; BARNACLE; BALANUS; ADULT; NAUPLIUS; TOXICITY; CIRRAL ACTIVITY

0660 BP1002; DETERGENTS; ELECTROPHORESIS; ENZYMES; PROTEINS

0822 BP1002; LITTORINA; NUCELLA; BUCINNUM; DETERGENTS; GROWTH; MORTALITY; TARSOLVENT

0989 BP1002; TOXICITY; DISPERSANTS; BP1100; COCKLE-CERASTODERMA;

LUGWORM-ARENICOLA; NERINE
1090 BP1002; DETERGENT; SABELLARIA; LARVAE; TOXICITY;
SUBSTRATE ABSORPTION
1093 BP1002; FISH; SOLE; PLAICE; HERRING; LARVAE; DETERGENT;
DEVELOPMENTAL ABNOMALITIES; FINASOL; COREXIT
1091 BP1002; DISPERSANT; TOXICITY; FISH; LARVAE; HERRING; PILCHARD;
PLAICE; SOLE; LEMON SOLE; HADDOCK; DELAYED EFFECTS; EMBRYOLOGY;
BEHAVIORAL CHANGES
1163 BP1002; DISPERSANTS; CUNNER; HYPOXIA; RESPIRATION; COREXIT;
TRITON X-100; SODIUM LAURYL SULPHATE
0311 BP1100; OLEOPHILIC "FLUFF"; DETERGENT; OIL; TOXICITY; PORCELAIN CRAB;
MECHANISM OF ACTION
0298 BP1100; LITTORAL COMMUNITIES; EMULSIFIERS; CHRONIC EFFLEUNT
0386 BP1100; EMULSIFERS; LITTORAL ORGANISMS; BP1002; COCKLES; POLYCHAETE;
PRAWN
0751 BP1100; TOXICITY; INTERTIDAL; BALTIC SEA; LITTORAL ZONE; COREXIT;
BEROL; WATER BASE; OIL BASE; SOLVENT
0989 BP1100; TOXICITY; DISPERSANTS; BP1002; COCKLE-CERASTODERMA;
LUGWORM-ARENICOLA; NERINE
0824 BP1100X; DISPERSANTS; SHELL DISPERSANT LT; FAUNA
0555 BREAKDOWN; HYDROCARBONS; MICROFLORA; METHODS; BIOSYNTHESIS;
METABOLISM; TERRESTRIAL
0163 BREEDING; BIRDS; OIL; DISTRIBUTION; STRANDINGS; WEATHER
0437 BREEDING; BIRDS; POPULATIONS; MIGRATION; WINTER QUARTERS
0616 BREEDING; TOXICITY; FUEL OIL #2; CRUDE; AMPHIPODS;
WATER SOLUBLE FRACTION
0810 BREEDING COLONIES; BIRDS; OIL; WORLD WAR 2 OIL POLLUTION; GUILLEMOTS;
PUFFINS
0971 BREEDING RATES; SANTA BARBARA SPILL; BARNACLE; MUSSELS; CHTHAMALUS;
BALANUS; POLLICIPES; MYTILUS; INTERTIDAL
0649 BRINE; REVIEW; OIL SPILLS; MARINE BIOTA
0929 BRITAIN; LITTORAL COMMUNITY; TOXICITY; CRUDE OIL; EMULSIFIER;
MILFORD HAVEN; ESSO PORTSMOUTH SPILL; TORREY CANYON SPILL; LANDS END
0233 BRITTANY; TORREY CANYON SPILL; FISHERIES
0852 BRITTANY; TORREY CANYON; COASTAL HABITATS; PLANTS; EMULSIFIERS;
CORNWALL
0955 BRITTANY; SALT MARSH; PLANTS; WEATHERED OIL; DEGRADATION;
GAS EXCHANGE; RETENTION; TORREY CANYON
1191 BRITTANY FRANCE; AMOCO CADIZ SPILL; CRUDE OILS -IRANIAN & ARABIAN
0407 BROODING; ARCTIC; INVERTEBRATES; RECRUITMENT; MICROBIAL DEGRADATION;
TEMPERATURE; RECOLONIZATION
0583 BROWN SHRIMP; CRUDE OIL; PALATABILITY; BLUE CRAB; TAINTING;
LOUISIANA CRUDE OIL
0838 BROWN SHRIMP; DETERGENTS; TOXICITY; SHORE CRAB; CARCINUS; CRAGON;
LARVAE; FISH
0035 BROWN SHRIMP,PANAEUS; ESTUARINE ANIMALS; UPTAKE AND DEPURATION;
TOXICITY; RESPIRATION; SOUTH LA. CRUDE; KUWAIT CRUDE; FUEL OIL #2;
BUNKER C; MINNOW; GRASS SHRIMP,PALAEMONTES; WATER SOLUBLE FRACTION;
OIL WATER DISPERSION; NAPHTHALENES
0813 BROWN TROUT; BENZOPYRENE; HYDROXYLASE INDUCTION; FISH;
POLYCYCLIC AROMATIC HYDROXYLASE; ARYL HYDROCARBON HYDROXYLASE;
NEWFOUNDLAND; TAINTING; THIN-LAYER CHROMATOGRAPHY
0840 BRYOZOA; HYPERPLASIA; SCHIZOPORELLA; CARCINOGENS; OVICELLS;
INDICATOR
0664 BRYOZOANS; EAST CHINA SEA; KUROSHIO; TAR BALLS; ATTACHED ORGANISMS;

BLUE GREEN ALGAE; PENNATE DIATOMS; STONY CORALS; BARNACLES; COPEPODS
0982 BRYOZOANS; HYPERPLASIA; OVICELL; CHRONIC EXPOSURE; NATURAL SEEPAGE
0822 BUCINNUM; LITTORINA; NUCELLA; DETERGENTS; GROWTH; MORTALITY; BP1002;
TARSOLVENT
0120 BUNKER C; TOXICITY; BENTHIC ANIMALS; INTERTIDAL; DIVERSITY; RECOVERY;
YORK RIVER; FUEL OIL#6
0038 BUNKER C; OYSTERS; CRUDE OIL; REFINED OILS; CRASSOSTREA; BIOASSAY;
FUEL OIL #2; SOUTH LA. CRUDE; KUWAIT CRUDE
0034 BUNKER C; WATER SOLUBLE FRACTION; OIL IN WATER DISPERSION;
CRUSTACEANS; FISH; TOXICITY; ESTUARINE; SOUTH LA. CRUDE;
KUWAIT CRUDE; FUEL OIL #2; CYPRINODON; MENIDIA; FUNDULUS; PENAEUS;
PALEOMONETES; MYSIDOPSIS
0035 BUNKER C; ESTUARINE ANIMALS; UPTAKE AND DEPURATION; TOXICITY;
RESPIRATION; SOUTH LA. CRUDE; KUWAIT CRUDE; FUEL OIL #2; MINNOW;
GRASS SHRIMP,PALAEMONTES; BROWN SHRIMP,PANAEUS;
WATER SOLUBLE FRACTION; OIL WATER DISPERSION; NAPHTHALENES
0232 BUNKER C; SAN FRANCISCO SPILL; RECRUITMENT; BARNACLES; BALANUS;
CHTHAMALUS; MUSSEL; MYTILUS; LIMPETS; COLLISELLA
0231 BUNKER C; SAN FRANCISCO SPILL; INVERTEBRATES; COMMUNITIES;
SMOTHERING; RECRUITMENT; INTERTIDAL; RECOVERY; TRANSECTS
0268 BUNKER C; ARROW SPILL; ZOOPLANKTON; HYDROCARBON CONTENT;
CHEDABUCTO BAY; OIL INGESTION; SEDIMENTATION; FECES
0259 BUNKER C; BACTERIA; SAN FRANCISCO; POPULATIONS; DIVERSITY; BEACHES
0484 BUNKER C; LITTORINA; SUBLETHAL EFFECTS; DISPERSANT; RESPIRATION;
COREXIT; CRAWLING RATES
0465 BUNKER C; WATER SOLUBLE FRACTION; CRAB; SAN FRANCISCO BAY;
PACHYGRAPSUS
0464 BUNKER C; SEDIMENTS; SAN FRANCISCO; DISPERSION; DISSOLUTION;
WEATHERING; MICROBIAL DEGRADATION; SAND COLUMN DISTRIBUTION
0595 BUNKER C; TOXICITY; EGGS; LARVAE; COD; WATER SOLUBLE FRACTION;
HATCHING SUCCESS
0510 BUNKER C; BACTERIA; CRUDE OIL; FUEL OIL #2; METABOLISM; INHIBITION;
RADIOACTIVE TRACER; CONTROLLED ECOSYSTEM
0625 BUNKER C; WESTERN NORTH ATLANTIC; CHEDABUCTO BAY,NOVA SCOTIA;
ARROW SPILL; RECOVERY
0673 BUNKER C; RIVER; MUDDY RIVER, MASS.; BOD; PLANKTON; TOXICITY;
MACROFAUNA; NEW ENGLAND
0742 BUNKER C; DEGRADATION; TEMPERATURE; NOCARDIA; RATE LIMITING FACTORS
0855 BUNKER C; OIL; DEGRADATION; BIODEGRADATION; ENVIRONMENTAL FACTORS;
ENERGY; BACTERIA; CHEDABUCTO BAY; ARROW SPILL
0858 BUNKER C; CRUDE OIL; CORAL; PANAMA; DIESEL MARINE; TOXICITY;
METABOLISM; FEEDING
0882 BUNKER C; TOXICITY; POLYCHAETES; CRUDE; NAPHTHALENE; FUEL OIL #2;
WATER SOLUBLE FRACTION; NEANTHES; CAPITELLA; SOUTH LOUISIANA CRUDE;
KUWAIT
0892 BUNKER C; PANAMA; S.S. WITWATER SPILL; TROPICS; INTERTIDAL;
TERRESTRIAL PLANTS; LITTORAL; MANGROVE; REEF; MEIOFAUNA; SEA TURTLES;
BIRDS; DIESEL OIL
0886 BUNKER C; KUWAIT CRUDE; SOUTH LOUISIANA CRUDE; FUEL OIL # 2;
TOXICITY; WATER SOLUBLE FRACTION; NAPHTHALENE; NEANTHES; CAPITELLA
0859 BUNKER C; FEEDING BEHAVIOR; COELENTERATA; DISCRIMINATION; RETENTION;
PALYTHOA; CHEMORECEPTION; MARINE DIESEL
1002 BUNKER C; SHRIMP; TOXICITY; CONTENT ANALYSIS; DEPURATION; CRUDE OIL;
FUEL OIL #2; PALAEMONETES; TEMPERATURE; BENZENE; PHENOL; NAPHTHALENE
1037 BUNKER C; ARROW SPILL; CHEDABUCTO BAY,NOVA SCOTIA;

FLUORESCENCE SPECTROSCOPY; MYA; KELP; HYDROCARBON CONTENT ANALYSIS
1039 BUNKER C; AROMATICS; CYCLO-ALKANE; SEDIMENTS; BEACH SEDIMENTS; CHEDABUCTO BAY, NOVA SCOTIA; ARROW SPILL; METABOLISM; MOLLUSCS; MYA; OSTREA; MYTILUS; ARYL HYDROCARBON HYDROXYLASE; BENZOPYRENE; RADIOACTIVE TRACER
1028 BUNKER C; SANDY BEACH; DISPERSION; DEGRADATION; SAN FRANCISCO; SAN FRANCISCO SPILL; BACTERIAL POPULATION &DIVERSITY
1010 BUNKER C; CHEDEBUCTO BAY, NOVA SCOTIA; MORTALITIES; INTERTIDAL; ARROW SPILL; WINTER; CHRONIC POLLUTION; FUCUS; MYA; SPARTINA
1104 BUNKER C; BIODEGRADATION; EMULSIFICATION; BACTERIA
1124 BUNKER C; FISH; FUEL OIL; DUCKS; MUSKRATS; CATTAILS; ANALYSIS FOR HYDROCARBONS; ST. LAWRENCE RIVER; MARSHES
1106 BUNKER C; TAINTING; HYDROCARBON CONTENT; AQUATIC ANIMALS; SPECTROFLUOROMETRY
1108 BUNKER C; AROMATIC HYDROCARBON; POLYCYCLIC AROMATIC HC'S; CONTENT ANALYSIS; CREOSOTE; SEALS; FISH; SHELLFISH; PAH; FLUOROMETRY; FUEL OIL
1215 BUNKER C; FUEL OIL; CHEDABUCTO BAY; NOVA SCOTIA; ARROW SPILL; LONG TERM EFFECTS; CORDGRASS; MARSH; ALGAE; TOXICITY
1190 BUNKER C; BIODEGRADATION; MARINE DIESEL; MICROORGANISMS; CRUDE OIL
0996 BUNKER OIL; SHAD; ALOSA; TOXICITY; PETROLEUM PRODUCTS; DISSOLVED OXYGEN; SYNERGISM; GASOLINE; FUEL OIL
0913 BURROWING; CLAM; MACOMA; PRUDHOE BAY CRUDE OIL; HYDROCARBON ANALYSIS; GAS CHROMATOGRAPHY; BEHAVIOR
1143 BURROWING; SOFT-SHELL CLAM; FUEL OIL; UPTAKE; RETENTION; DEPURATION; MORTALITY; SEARSPORT-MAINE
1213 BURROWING; CLAM; MACOMA; PRUDHOE BAY CRUDE OIL; ALASKA; BEHAVIORAL EFFECTS
1169 BURROWING; CRABS; WEST FALMOUTH SPILL; MORTALITY; UPTAKE; BEHAVIOR; TOXICITY; FUEL OIL; CRAB-SALT MARSH; MASS.
0144 BUZZARD BAY; DEGRADATION; BACTERIA; SEDIMENTS; PERSISTANCE; WEST FALMOUTH OIL SPILL
0145 BUZZARD BAY; WEST FALMOUTH OIL SPILL; RECOVERY; HYDROCARBON CONTENT ANALYSIS
0148 BUZZARD BAY; SEDIMENTS; OYSTERS; SCALLOPS; BIODEGRADATION; TOXICITY; CONTENT ANALYSIS; WEST FALMOUTH OIL SPILL; GAS CHROMATOGRAPHY
0146 BUZZARD BAY; WEST FALMOUTH SPILL; WEATHERING; IDENTIFICATION; HYDROCARBON CONTENT; SEDIMENTS; DEGRADATION; SHELLFISH; OYSTERS
0271 BYSSAL THREAD PRODUCTION; WATER ACCOMODATED FRACTION; MYTILUS; MUSSELS; STARFISH; ASTERIS; RESPIRATION; FEEDING; REPRODUCTION; FUEL OIL #2
0994 BYSSUS THREAD; SURFACTANTS; FISH; CRUSTACEANS; BIVALVES; TOXICITY; BEHAVIOR; DEVELOPMENT; ACTIVITY; MOULTING
0891 CADDIS FLY; FUEL OIL; TROUT; OYSTER; SNAILS
0277 CALANUS; COPEPOD; UPTAKE; DEPURATION; NAPHTHALENE; METABOLISM; FOOD WEB; WATER SOLUBLE FRACTION; DIETARY ROUTE OF ENTRY; RADIOACTIVE TRACERS
0486 CALANUS; RETENTION; COPEPOD; ZOOPLANKTON; EURYTEMORA; UPTAKE; DEPURATION
0487 CALANUS; NAPHTHALENE; ACCUMULATION; COPEPOD; RADIOACTIVE; LONG TERM EXPOSURE; LOW LEVEL CONCENTRATIONS; MARINE ZOOPLANKTON; PERSISTENT EXPOSURE; UPTAKE/DEPURATION; EURYTEMORA
0608 CALANUS; ZOOPLANKTON; BENZPYRENE; UPTAKE; DEPURATION; PACIFIC COAST; ARCTIC; AROMATIC HYDROCARBONS; NAPTHALENE; RADIOACTIVE TRACERS
1220 CALANUS; COPEPODS; ALGAE; MONOCHRYSIS; NAPHTHALENE;

BUNKER C; OIL INGESTION; SEDIMENTATION; FECES
0855 CHEDABUCTO BAY; OIL; DEGRADATION; BIODEGRADATION;
ENVIRONMENTAL FACTORS; ENERGY; BACTERIA; BUNKER C; ARROW SPILL
0902 CHEDABUCTO BAY; HYDROCARBON CONCENTRATION; FLUORESCENCE ANALYSIS;
SEDIMENTS; BENTHIC SPECIES; FOOD CHAIN CONCENTRATION;
FUEL OIL -BUNKER C; NOVA SCOTIA
1215 CHEDABUCTO BAY; FUEL OIL; BUNKER C; NOVA SCOTIA; ARROW SPILL;
LONG TERM EFFECTS; CORDGRASS; MARSH; ALGAE; TOXICITY
0175 CHEDABUCTO BAY, NOVA SCOTIA; BIRDS; ARROW SPILL; MORTALITIES
0303 CHEDABUCTO BAY, NOVA SCOTIA; CAPE SIMPSON, ALASKA; NATURAL SEEP;
ARTHROBACTER; PSEUDOMONAS; TEMPERATURE
1039 CHEDABUCTO BAY, NOVA SCOTIA; AROMATICS; CYCLO-ALKANE; SEDIMENTS;
BUNKER C; BEACH SEDIMENTS; ARROW SPILL; METABOLISM; MOLLUSCS; MYA;
OSTREA; MYTILUS; ARYL HYDROCARBON HYDROXYLASE; BENZOPYRENE;
RADIOACTIVE TRACER
1020A CHEDABUCTO BAY, NOVA SCOTIA; BACTERIA; DEGRADATION; LOW TEMPERATURE
0625 CHEDABUCTO BAY,NOVA SCOTIA; WESTERN NORTH ATLANTIC; ARROW SPILL;
BUNKER C; RECOVERY
1037 CHEDABUCTO BAY,NOVA SCOTIA; ARROW SPILL; BUNKER C;
FLUORESCENCE SPECTROSCOPY; MYA; KELP; HYDROCARBON CONTENT ANALYSIS
1010 CHEDEBUCTO BAY, NOVA SCOTIA; BUNKER C; MORTALITIES; INTERTIDAL;
ARROW SPILL; WINTER; CHRONIC POLLUTION; FUCUS; MYA; SPARTINA
1012 CHEMICAL ATTRACTIONS; PRAWNS, SCARLET; PLESIOPENAEUS;
BENTHIC OIL DEPOSIT; ARUBA WEST INDIES; ATTRACTION;
HYDROCARBON CONTENT ANALYSIS; BACTERIA; METABOLISM
0189 CHEMICAL CHANGE; DEGRADATION; BACTERIA; AEROBIC; ANAEROBIC;
PHYSICAL CHANGE
0074 CHEMICAL COMPOSITION; CARCINOGENIC HYDROCARBONS;
CARCINOGENIC ACTIVITY
0059 CHEMICAL SIGNALS; SNAIL,NASSARIUS; LOBSTERS; KEROSENE
0733 CHEMKLEEN; BP1002; KEROSENE; BARNACLE; BALANUS; ADULT; NAUPLIUS;
TOXICITY; CIRRAL ACTIVITY
0581 CHEMORECEPTION; CRABS; OYSTERS; SUBLETHAL EFFECTS; NAPTHALENE;
BEHAVIOR; BIOASSAY
0594 CHEMORECEPTION; CRUDE OIL; FISH FRY; DISPERSANTS; COD; GADUS;
HERRING; CLUPEA; TOXICITY; EMBRYOLOGY
0579 CHEMORECEPTION; CRUDE OIL; INVERTEBRATES; BEHAVIOR
0580 CHEMORECEPTION; CRUDE OIL; CRUSTACEA; BEHAVIOR; FEEDING;
POLYAROMATIC HYDROCARBONS; ALIPHATIC
0541 CHEMORECEPTION; NASSARIUS; CHEMOTAXIS; KEROSENE;
WATER SOLUBLE FRACTION
0716 CHEMORECEPTION; BACTERIA; INHIBITION; HYDROCARBONS
0859 CHEMORECEPTION; FEEDING BEHAVIOR; COELENTERATA; DISCRIMINATION;
RETENTION; PALYTHOA; MARINE DIESEL; BUNKER C
0867 CHEMORECEPTION; PINK SALMON; CRUDE OIL; TOXICITY; AVOIDANCE;
JUVENILE; MIGRATION; AGE
0961 CHEMORECEPTION; BLOWFLY
0998 CHEMORECEPTION; CRUDE OIL; PRODUCERS; SUBLETHAL EFFECTS;
WATER SOLUBLE FRACTION; INHIBITORS
0061 CHEMOSENSORS; LOBSTER; BEHAVIOR AND FEEDING; CRUDE OIL
0058 CHEMOTAXIS; LOBSTERS; ALEWIVES; HORSESHOE CRAB; FLATWORM; KEROSENE
0541 CHEMOTAXIS; NASSARIUS; KEROSENE; WATER SOLUBLE FRACTION;
CHEMORECEPTION
0540 CHEMOTAXIS; NASSARIUS (MARINE SNAIL); KEROSENE
0874 CHEMOTAXIS; BIODEGRADATION; ALASKA; TEMPERATURE; SALINITY; MORTALITY;

COOK INLET; VALDEZ

0263 CHESAPEAKE BAY; BACTERIAL DEGRADATION; FUNGUS; SEASONAL FLUCTUATION; SPECIES DISTRIBUTION

0262 CHESAPEAKE BAY; BIODEGRADATION; MICROORGANISMS

0503 CHESAPEAKE BAY; OIL SPILL INCIDENT; SALT MARSH; POPULATIONS; MUSSEL; OYSTERS; SNAIL; MARSH GRASS

0877 CHESAPEAKE BAY; SPILL INCIDENT; FUEL OIL # 6; ENVIRONMENTAL ASSESSMENT; BIRDS; MORTALITIES; SHELL FISHERIES; MARSH GRASS

1063 CHESAPEAKE BAY; BIODEGRADATION; MOTOR OIL; SEDIMENTS

1066 CHESAPEAKE BAY; BALTIMORE HARBOR; BIODEGRADATION; ALGA; PROTOTHECA

1057 CHESAPEAKE BAY; DEGRADATION; WATER; SEDIMENTS; CLADOSPORIUM

1053 CHESAPEAKE BAY; MICROORGANISMS; YEAST; BACTERIA; FUNGI; SUBSTRATE SELECTION

1056 CHESAPEAKE BAY; DEGRADATION; BACTERIA; FUNGUS; CLADOSPORIUM; WATER; SEDIMENTS; HYDROCARBON CONCENTRATION

1062 CHESAPEAKE BAY; BACTERIA; BIODEGRADATION; SEDIMENTS

1064 CHESAPEAKE BAY; DEGRADATION; BACTERIA; SEDIMENTS

1135 CHESAPEAKE BAY; ESTUARINE; BIRDS; DUCKS; FISH; HATCHING SUCCESS; TOXICITY

1130 CHESAPEAKE BAY; FUEL OIL; INVERTEBRATES; ASSESSMENT OF SPILLS; BARGE STC-101

1068 CHESAPEAKE BAY; BACTERIA; SUSCEPTIBILITY; FUNGI; TOXICITY; ESTUARY; SOUTH LOUISIANA CRUDE OIL; FUEL OIL #2; GROWTH

0015 CHEVRON OIL PLATFORM; OIL SPILL INCIDENT; GULF OF MEXICO; OFFSHORE WELLS

0564 CHIONOECETES; PRUDHOE CRUDE; CRABS; MOLTING

0101 CHIRONOMID; CRUDE OIL; POND; ARCTIC; PHYSICAL PARAMETERS; PHYTOPLANKTON; VASCULAR PLANTS; AQUATIC; PRUDHOE CRUDE OIL; ARCTIC -TUNDRA; ALASKA- BARLOW; BENTHIC ORGANISMS; PLANKTON

0878 CHIRONOMIDAE; OIL POLLUTION; BIOINDICATORS; FRESH WATER; TRAIL RIVER, NWT, CANADA; FRESHWATER; MIDGES

0567 CHIRONOMUS; CASPIAN SEA; BENTHOS; CRUDE OIL; GROWTH; REPRODUCTION; CERASTODERMA; NAIS; NEREIS; PYRGOHYDROBIA; ABRA

0358 CHITON; MACROFAUNA; RED SEA; TOXICITY; CRUDE OIL; DISPERSANT; CORAL; HETEROXENIA; GASTROPODS; MUSSELS; SEA URCHIM; HERMIT CRAB; SHRIMP; GOATFISH; RABBITFISH

0045 CHITONS; SANTA BARBARA SPILL; CLEANUP; COMMUNITY SURVEY; BIRDS; LIMPETS; BARNACLES; MUSSEL; INTERTIDAL ORGANISMS

0943 CHLAMYDOMONAS; NAPTHALENE; WATER SOLUBLE FRACTION; PHOTOSYNTHESIS; GREEN ALGAE; UPTAKE; DEPURATION

0942 CHLAMYDOMONAS; CRUDE OIL; NAPTHALENE; WATER SOLUBLE FRACTION; TOXICITY; GROWTH

0570 CHLORELLA; CRUDE OIL; GROWTH RATES; WATER SOLUBLE FRACTIONS; TOXICITY; STIMULATION

0572 CHLORELLA VULGARIS; FRESH WATER; ALGAE; TOXICITY; GROWTH; PHOTOSYNTHESIS; BENZENE; XYLENE; TOLUENE; NAPTHALENE

0149 CHLOROPHYLL; OUTBOARD ENGINE EMMISSIONS; PHYTOPLANKTON; SPECIES DIVERSITY; FIXATION; ZOOPLANKTON POPULATION DYNAMICS; BENTHIC MICROINVERTEBRATE COMMUNITY; GASOLINE

1119 CHLOROPHYLL; HYDROCARBON; FEED BACK; WESTERN ATLANTIC

0674 CHLOROPHYLL-A; PHYTOPLANKTON; DIVERSITY; ESTUARY

1118 CHLOROPHYLL-A CORRELATION WITH; HYDROCARBONS; PHYTOPLANKTON; BIOGENIC VS. PETROLEUM; WEST AFRICA

0802 CHROMATOGRAPHY; BIOGENIC VS.PETROLEUM HYDROCARBON; DIESEL OIL;

AD-A064 196 COAST GUARD RESEARCH AND DEVELOPMENT CENTER GROTON CONN F/G 13/2
BIOLOGICAL EFFECTS OF OIL POLLUTION - A OMPREHENSIVE BIBLIOGRAP--ETC(U)
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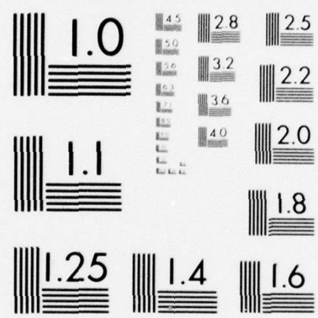

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

LOBSTER
1016 CHROMATOGRAPHY; SEDIMENTS; HYDROCARBON ANALYSIS; MASS SPECTROMETRY; UV FLUORESCENCE; PETROLEUM
0375 CHROMATOGRAPHY-COLUMN GAS,THIN LAYER; PETROLEUM; HYDROCARBON; CONTENT ANALYSIS; MARINE ORGANISMS; SPECTROMETRY; UV; IR
1010 CHRONIC POLLUTION; CHEDEBUCTO BAY, NOVA SCOTIA; BUNKER C; MORTALITIES; INTERTIDAL; ARROW SPILL; WINTER; FUCUS; MYA; SPARTINA
0249 CHRONIC; GENERAL M.C. MEIGS SPILL; SURVEYS; HYDROCARBON CONTENT; INTERTIDAL; WASHINGTON COAST; FUEL OIL-NAVY SPECIAL; SEA URCHINS; STRONGYLOCENTRUS
0281 CHRONIC; SALT MARSH; SPARTINA; PUCCINELLA; WEATHERING; RECOVERY; CORNWALL
0771 CHRONIC; ESTUARINES; OIL POLLUTION; SPILLS; SALT MARSH; ROCKY SHORE; EMULSIFIERS; CLEANING
0779 CHRONIC; TAMPICO MARU SPILL; SURF CONDITIONS; MORTALITIES; SUCCESSION; RECOVERY; BAJA, CALIF.; ANTHOPLEURA; KELP; PHOTOSYNTHESIS
0869 CHRONIC; TOXICITY; ACUTE; CRUDE OIL; COMPONENT; PHYSIOLOGY; BEHAVIOR; ARCTIC & SUBARCTIC ORGANISMS; TEMPERATURE; METABOLISM
1117 CHRONIC; AFRICAN COAST; INTERTIDAL
1223 CHRONIC CONCENTRATIONS; COOK INLET CRUDE OIL; FLOUNDER; FISH; CLAMS; EGGS; LARVAE; HISTOPATHOLOGY; MORTALITY
0806 CHRONIC CONTAMINATION; AQUATIC ORGANISMS; DIPTERA; FLIES; BIBLIOGRAPHY
0720 CHRONIC EFFECTS; PROPOSED RESEARCH NEEDS
0775 CHRONIC EFFECTS; LITTORAL; MACROALGAE; ASSOCIATION INSTABILITY; COAL OIL POINT; SANTA BARBARA SPILL
0849 CHRONIC EFFECTS; HUMAN; ENZYME CONSTELLATION
0298 CHRONIC EFFLEUNT; LITTORAL COMMUNITIES; EMULSIFIERS; BP1100
0283 CHRONIC EXPOSURE; MILFORD HAVEN; SALT MARSH; ROCKY SHORE; RECOVERY; DETERGENTS; EMULSIFIERS
0957 CHRONIC EXPOSURE; OYSTER; PHSIOLOGICAL EFFECTS; RETENTION; DEPURATION; CRASSOSTREA
0982 CHRONIC EXPOSURE; BRYOZOANS; HYPERPLASIA; OVICELL; NATURAL SEEPAGE
0980 CHRONIC EXPOSURE; SUBLETHAL EFFECTS; COAL OIL POINT, CALIF.; SEDIMENTS; BENTHIC IN-FAUNA; ABALONE; MUSSEL; BARNACLE
0978 CHRONIC EXPOSURE; MYTILUS; SIZE; REPRODUCTION
0979 CHRONIC EXPOSURE; SUBLETHAL EFFECTS
0152 CHRONIC LEAKAGE; SPILLS; BENTHIC ORGANISMS; BALTIMORE CANYON-MID ATLANTIC
0151 CHRONIC OIL POLLUTION; COASTAL ECOSYSTEM; SUBLETHAL EFFECTS; METABOLISM; BEHAVIOR; FOOD CHAIN MAGNIFICATION; WETLANDS; ESTUARIES
0117 CHRONIC POLLUTION; ACUTE POLLUTION; PHYTOMETRIC; PHYTOSOCIALOGY; DIVERSITY
0291 CHRONIC POLLUTION; LIMPETS; BARNACLES; REFINERY EFFLUENT; TRANSECTS; ABUNDANCE
0282 CHRONIC POLLUTION; REVIEW; SALT MARSH; REFINERY EFFLUENT; RECOVERY; SPARTINA; PUCCINELLIA; OENANTHE
0685 CHRONIC POLLUTION; FIELDS STUDIES; SANTA BARBARA SPILL; LAKE MARACAIBO, VENEZUELA; BERMUDA; TIMBALIER BAY, LA.; POPULATION LEVELS; DIVERSITY; SIZE; GROWTH RATE; REPRODUCTION; ABNORMAL GROWTHS; BIOMAGNIFICATION
0718 CHRONIC POLLUTION; OIL PORT; POMATOLEIOS; GROWTH; TOXICITY; KUWAIT; DIVERSITY; SUCCESSION
0794 CHRONIC POLLUTION; REVIEW; FIELD STUDIES; OFFSHORE PRODUCTION;

REFINERIES; ESTUARIES; SUBLETHAL EFFECTS; NATURAL SEEPS
0897 CHRONIC POLLUTION; LOUISIANA; COASTAL OIL PRODUCTION; TOXICITY; TAINTING
0997 CHRONIC POLLUTION; POTENTIAL; SEAWATER; DEGRADATION; BACTERIA; PETROLEUM HYDROCARBONS; SALINITY
0244 CHRONIC SPILLAGE; BIRDS; MORTALITIES; BEACH SURVEYS; POPULATION; TREATMENT; DISPERSANTS
0286 CHRONIC SPILLAGE; ROCKY SHORE; SALT MARSH; OIL PORT; EXPERIMENTAL SPILLS
0588 CHRONIC SPILLAGE; OFFSHORE PRODUCTION; PRODUCED WATERS; TIMBALIER BAY LA.; TEXAS BAYS
0289 CHRONIC TOXICITY; PLANTS; CRUDE OIL FRACTIONS; TERRESTRIAL; ACUTE TOXICITY
0296 CHRYSSI P. GOULANDRIS SPILLAGE; DISPERSANTS; TOXICITY; FINA NOVAGE SPILLAGE; TORREY CANYON SPILL; GULF REFINERY SPILL
0232 CHTHAMALUS; SAN FRANCISCO SPILL; RECRUITMENT; BUNKER C; BARNACLES; BALANUS; MUSSEL; MYTILUS; LIMPETS; COLLISELLA
0975 CHTHAMALUS; SANTA BARBARA SPILL; BIRDS; INVERTEBRATES; ALGAE; MORTALITIES; RECOLONIZATION; SUBLETHAL EFFECTS; PHYLLOSPADIX; POLLICIPES; HESPEROPHYCUS
0971 CHTHAMALUS; SANTA BARBARA SPILL; BREEDING RATES; BARNACLE; MUSSELS; BALANUS; POLLICIPES; MYTILUS; INTERTIDAL
1129 CHUKCHI SEA; BIODEGRADATION; MICROOGANISMS; ARCTIC; TEMPERATURE; NUTRIENTS; OXYGEN REQUIREMENTS; CRUDE OIL; AROMATICS; PARAFFINS; BEAUFORT SEA
0901 CILIATES; ARGO MERCHANT SPILL; HISTOPATHOLOGY; AMMODYTES; FLOUNDER (WINTER&YELLOWTAIL); ALEWIVES; CRABS(HERMIT); HYPERPLASIA; EDEMA; HEMOCYTES
1171 CILIATES; BIOINDICATORS; PROTOZOA; EUPLOTES; SAUDI ARABIAN CRUDE; EMPIRE MIX CRUDE; MICROFAUNA; COMMUNITY DIVERSITY EXPERIMENTS
0733 CIRRAL ACTIVITY; BP1002; KEROSENE; CHEMKLEEN; BARNACLE; BALANUS; ADULT; NAUPLIUS; TOXICITY
0424 CIRRATULUS; OIL; DISPERSANTS; TOXICITY; POLYCHAETE; GAMETE FORMATION; SPAWNING; GROWTH; MORTALITY; CIRRIFORMIA; BP1002; COREXIT; ESSOLVENE
0421 CIRRATULUS; SUBLETHAL EFFECTS; INTERTIDAL; POLYCHAETE; SOUTH HAMPTON, ENGLAND; CIRRIFORMIA
0424 CIRRIFORMIA; OIL; DISPERSANTS; TOXICITY; POLYCHAETE; GAMETE FORMATION; SPAWNING; GROWTH; MORTALITY; CIRRATULUS; BP1002; COREXIT; ESSOLVENE
0421 CIRRIFORMIA; SUBLETHAL EFFECTS; INTERTIDAL; POLYCHAETE; SOUTH HAMPTON, ENGLAND; CIRRATULUS
0613 CITHARICHTHYS; FISH; NAPTHALENE; BENZ(A)PYRENE; RADIOACTIVE TRACER; UPTAKE; METABOLISM; DISCHARGE; SCULPIN; OLIGOCOTTUS; GOBY; GILLICHTHYS; SAND DAB
1057 CLADOSPORIUM; DEGRADATION; WATER; SEDIMENTS; CHESAPEAKE BAY
1055 CLADOSPORIUM; DEGRADATION; FUNGUS; OXIDIZING SYSTEM; PATHWAYS-METABOLIC; PESTICIDES; RADIOACTIVE TRACER EXPERIMENTS
1051 CLADOSPORIUM; DEGRADATION; OXYGEN CONSUMPTION; COOXIDATION; TOLUENE; XYLENE; HEXADECANE
1056 CLADOSPORIUM; DEGRADATION; BACTERIA; FUNGUS; WATER; SEDIMENTS; CHESAPEAKE BAY; HYDROCARBON CONCENTRATION
0099 CLAM; CARCINOGENISIS; MERCENARIA
0341 CLAM; OIL; MORTALITY; SEARSPORT MAINE; MYA
0410 CLAM; RANGIA; NAPHTHALENES; TRINITY BAY, TEXAS; OIL SEPARATOR PLATFORM; UPTAKE; DEPURATION; SEDIMENTS;

HYDROCARBON ANALYSIS; GAS CHROMATOGRAPHY
0508 CLAM; CRASSOSTREA; OYSTER; MERCENARIA; SURFACTANT; LARVAE;
DEVELOPMENT; GROWTH; SURVIVAL; TOXICITY
0913 CLAM; MACOMA; PRUDHOE BAY CRUDE OIL; HYDROCARBON ANALYSIS;
GAS CHROMATOGRAPHY; BEHAVIOR; BURROWING
1177 CLAM; PUERTO RICO; OIL SPILLS; ECOSYSTEM; MANGROVE; CORAL REEFS;
ESTUARIES; ANALYSIS FOR HYDROCARBONS; MULLET; OYSTER; HISTOPATHOLOGY;
REVIEW
1206 CLAM; MYA; FUEL OIL #2; UPTAKE; RETENTION; DEPURATION
1213 CLAM; MACOMA; PRUDHOE BAY CRUDE OIL; ALASKA; BURROWING;
BEHAVIORAL EFFECTS
1149 CLAM-BOREAL; TEMPERATURE; SALINITY; NAPHTHALENE; CLAMS;
SOUTHERN LOUISIANA CRUDE OIL; UPTAKE & DEPURATION; CLAM-TEMPERATURE
1149 CLAM-TEMPERATURE; TEMPERATURE; SALINITY; NAPHTHALENE; CLAMS;
SOUTHERN LOUISIANA CRUDE OIL; UPTAKE & DEPURATION; CLAM-BOREAL
0098 CLAMS; HYPERPLASIA; HISTOPATHOLOGY; MYA; CARCINOGENISIS
0100 CLAMS; MERCENARIA; CANCER; TUMORS; NEOPLASM; HISTOPATHOLOGY;
SEARSPORT,MAINE
0051 CLAMS; NARRAGANSETT BAY; CHARLESTOWN POND R.I.;
ANALYSIS OF HYDROCARBONS
0029 CLAMS; UPTAKE AND DEPURATION; PETROLEUM HYDROCARBONS; OYSTERS
0150 CLAMS; MERCENARIA; DISSOLVED ORGANIC MATTER(DOM); FILTER-FEEDING;
UPTAKE; FUEL OIL#2
0340 CLAMS; GROWTH; SURVIVAL
0288 CLAMS; HYDROCARBON CONCENTRATIONS; NAPHTHALENE; SHRIMP; OYSTERS;
SEDIMENT; FUEL OIL#2; DEPURATION
0377 CLAMS; HYDROCARBON; CONTENT ANALYSIS; SEDIMENTS; MERCENARIA;
NARRAGANSET BAY; PETROLEUM; BIOGENIC
0758 CLAMS; UPTAKE; DEPURATION; CONTENT ANALYSIS; CRUDE OIL; FUEL OIL #2;
SOLUBLE FRACTIONS; GAS CHROMATOGRAPHY
0759 CLAMS; BENZ(A)PYRENE; UPTAKE; DEPURATION; DISTRIBUTION; RADIO ASSAY;
RANGIA
0912 CLAMS; BIOINDICATORS; MACOMA BALTICA; MUD FLATS; CRUDE OIL
1162 CLAMS; CRUDE OIL; BEHAVIOR; MORTALITY
1136 CLAMS; ARCTIC; QUAHOG; CYCLOALKANES; CONTINENTAL SHELF; RHODE ISLAND
1149 CLAMS; TEMPERATURE; SALINITY; NAPHTHALENE;
SOUTHERN LOUISIANA CRUDE OIL; UPTAKE & DEPURATION; CLAM-BOREAL;
CLAM-TEMPERATURE
1133 CLAMS; FUEL OIL; CRASSOSTREA; QUAHOG; ESTUARINE; ALIPHATICS;
MERCENARIA; OYSTERS; UPTAKE; RETENTION; DEPURATION
1148 CLAMS; QUAHOGS; PHENOL; TOXICITY; METHODOLOGY;
HISTOPATHOLOGICAL EFFECTS; CYTOLOGY
1197 CLAMS; PRUDHOE BAY CRUDE OIL; NAPHTHALENE; MACOMA; UPTAKE; SEDIMENTS
1186 CLAMS; BENZOPYRENE; MUSSELS; OYSTERS; OREGON; ESTUARINE; UPTAKE;
AROMATIC HYDROCARBONS; CARCINOGENS; MOLLUSCS
1223 CLAMS; COOK INLET CRUDE OIL; FLOUNDER; FISH; CHRONIC CONCENTRATIONS;
EGGS; LARVAE; HISTOPATHOLOGY; MORTALITY
0947 CLEAN UP; TORREY CANYON SPILL; DEGRADATION; ZOOPLANKTON; BACTERIA;
LITTORAL; SUBLITTORAL
0924 CLEAN UP PROCEDURES; OIL; SHELLFISH; TOXICITY; DETERGENTS; TAINTING
0420 CLEAN-UP; DISPERSANTS; MORTALITIES; INTERTIDAL;
THAMES ESTUARY, ENGLAND
1081 CLEAN-UP; SALT MARSHES; SENSITIVITY TO OIL; SENSITIVITY TO CLEAN-UP
0245 CLEANING; BIRDS; FEATHER WETTING
0240 CLEANING; BIRDS; FEATHER WETTING; ENTERITIS; REHABILITATION

0170 CONSERVATION; BIRDS; MORTALITIES; GUILLEMOTS
0239 CONSERVATION; BIRDS
0168 CONSERVATION; BIRDS; MORTALITIES; SPECIES ENDANGERMENT; REHABILITATION
0044 CONTAINMENT AND CLEANUP OF OIL; TORREY CANYON SPILL
0457 CONTAMINATION; SAMPLING TECHNIQUES
0496 CONTAMINATION; PLANKTON; SAMPLING METHODS; NYLON NETS
0202 CONTENT ANALYSIS; SALT MARSH ECOSYSTEM; FOOD CHAIN CONCENTRATION; WEST FALMOUTH,MASS; FUEL OIL #2; HYDROCARBON CONTENT
0148 CONTENT ANALYSIS; SEDIMENTS; OYSTERS; SCALLOPS; BIODEGRADATION; TOXICITY; WEST FALMOUTH OIL SPILL; BUZZARD BAY; GAS CHROMATOGRAPHY
0139 CONTENT ANALYSIS; HYDROCARBONS; MARINE PHYTOPLANKTON; BIOGENIC VS. PETROLEUM; TRACER; FOOD CHAIN
0356 CONTENT ANALYSIS; MYTILUS; METABOLISM; PETROLEUM; BIOGENIC; MUSSELS; KIEL BIGHT, W. GERMANY; AROMATICS
0375 CONTENT ANALYSIS; PETROLEUM; HYDROCARBON; MARINE ORGANISMS; CHROMATOGRAPHY-COLUMN GAS,THIN LAYER; SPECTROMETRY; UV; IR
0377 CONTENT ANALYSIS; HYDROCARBON; SEDIMENTS; MERCENARIA; CLAMS; NARRAGANSET BAY; PETROLEUM; BIOGENIC
0461 CONTENT ANALYSIS; HYDROCARBON ANALYSIS; METHODS COMPARSION; COLUMN CHROMATOGRAPHY
0399 CONTENT ANALYSIS; HYDROCARBONS; DEPURATION; TEMPERATURE; MUSSELS; MYTILUS; LAGOON OF VENICE, ITALY
0611 CONTENT ANALYSIS; MYTILUS; UPTAKE; DEPURATION; RETENTION; MUSSEL; RADIOACTIVE TRACERS; AROMATIC HYDROCARBONS; PARAFFINS
0526 CONTENT ANALYSIS; HYDROCARBONS; THIN LAYER CHROMATOGRAPHY; SEDIMENTS; ANALYTICAL TECHNIQUES
0585 CONTENT ANALYSIS; BARNACLES; CARCINOGENS; BENZPYRENES
0711 CONTENT ANALYSIS; HYDROCARBON; BIOGENIC VS. PETROLEUM HC'S; IR; GLC; MASS SPECTROMETRY; MONITORING
0727 CONTENT ANALYSIS; BARNACLES; TAR BALL; METABOLISM; UPTAKE; DEPURATION
0787 CONTENT ANALYSIS; TAINTING; GREEN FISH; EEL; FUEL OIL-BOILER; GIRELLA; ANGULLA
0758 CONTENT ANALYSIS; CLAMS; UPTAKE; DEPURATION; CRUDE OIL; FUEL OIL #2; SOLUBLE FRACTIONS; GAS CHROMATOGRAPHY
0760 CONTENT ANALYSIS; NAPHTHALENE; ALKYLNAPHTHALENE; ULTRAVIOLET SPECTROPHOTOMETRY; TECHNIQUES; TISSUES; SEAWATER
1002 CONTENT ANALYSIS; SHRIMP; TOXICITY; DEPURATION; CRUDE OIL; FUEL OIL #2; BUNKER C; PALAEMONETES; TEMPERATURE; BENZENE; PHENOL; NAPHTHALENE
1031 CONTENT ANALYSIS; TAINTING; MULLET; MUGIL; KEROSENE; HISTOPATHOLOGY; AUSTRALIA
1108 CONTENT ANALYSIS; AROMATIC HYDROCARBON; POLYCYCLIC AROMATIC HC'S; BUNKER C; CREOSOTE; SEALS; FISH; SHELLFISH; PAH; FLUOROMETRY; FUEL OIL
1105 CONTENT ANALYSIS; BARNACLES; CARCINOGENS; TETRACLITA; BENZOPYRENE
1073 CONTENT ANALYSIS; SULFUR CONTAINING PETROLEUM COMPONENTS; FLAME PHOTOMETRIC DETECTOR
0452 CONTINENTAL SHELF; REVIEW; EFFECTS; ORGANISMS
0814 CONTINENTAL SHELF; BENTHOS; NEW YORK BIGHT
1136 CONTINENTAL SHELF; ARCTIC; QUAHOG; CYCLOALKANES; CLAMS; RHODE ISLAND
1181 CONTINENTAL SHELF; CRABS; UPTAKE; CALIFORNIA; OFFSHORE PLATFORMS; ANALYSIS FOR HYDROCARBONS
0525 CONTINENTAL SHELF SEDIMENTS; BIODEGRADATION RATE; SEDIMENTS;

OXYGEN AVAILABILITY
1221 CONTINENTAL SHELVES; ARCTIC; ASSESSMENT OF SPILLS; REVIEW; POTENTIAL OIL SPILLS
0301 CONTINENTIAL SHELF; REVIEW; FISH; OFFSHORE PRODUCTION; SHELLFISH
1222 CONTINGENCY PLANNING; ESTERO BAY; ASSESSMENT OF SPILLS; POTENTIAL OIL SPILLS; BIOLOGICAL BASELINE
0529 CONTINUOUS FLOW; BIOASSAY; TOXICITY; SUBLETHAL EFFECTS; WATER SOLUBLE FRACTION; WHOLE OIL FRACTION; MINNOW; FLOUNDER; SHRIMP; SCALLOP; QUAHOG; MUSSEL; MUD SNAIL
0686 CONTINUOUS FLOW; TOXICITY; BENZENE; STRIPED BASS
0995 CONTINUOUS FLOW; DISPERSANTS; EMULSIONS; TOXICITY; SUBLETHAL EFFECTS; ACTIVITY; MOTILITY; BIVALVES; CRUSTACEANS; FISH; BEHAVIOR; OIL EMULSION; LOCOMOTION
1035 CONTINUOUS FLOW; BIOASSAY; PETROLEUM; TECHNIQUE; METHODOLOGY; FUEL OIL #2
0179 CONTINUOUS FLOW BIOASSAY; TOXICITY; OUTBOARD MOTOR EXHAUST; GOLDFISH; CARASSINS; TOLUENE; XYLENE; TRIMETHYLBENZENE
0069 CONTROL OF OIL POLLUTION; BIODEGRADATION; REVIEW-OIL POLLUTION; FATE AND EFFECTS
0127 CONTROLLED ECOSYSTEM; SALT MARSH; ESTUARY; YORK RIVER; SOUTH LA. CRUDE; HYDROCARBON ANALYSIS; FUNDULUS; AROMATICS; GAS CHROMATOGRAPHY; GC-MS
0510 CONTROLLED ECOSYSTEM; BACTERIA; CRUDE OIL; FUEL OIL #2; BUNKER C; METABOLISM; INHIBITION; RADIOACTIVE TRACER
0682 CONTROLLED ECOSYSTEM; BACTERIAL POPULATIONS; PHYTOPLANKTON; CENTRATE DIATOMS; ZOOPLANKTON
0856 CONTROLLED ECOSYSTEM; ZOOPLANKTON
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0578 COOK INLET; ALASKA; CRUDE OIL
0874 COOK INLET; BIODEGRADATION; ALASKA; TEMPERATURE; SALINITY; MORTALITY; CHEMOTAXIS; VALDEZ
1155 COOK INLET; COASTAL ENVIRONMENT; ALASKA; HYPOTHETICAL SPILLS; VULNERABILITY INDEX
1182 COOK INLET; CRUDE OIL; CRAB; SHRIMP; ALASKA; EMBRYOGENESIS; GROWTH
0183 COOK INLET CRUDE; ALASKA; SHRIMP; COON-STRIPE SHRIMP; KING CRABS; TOXICITY; BIOASSAY; STATIC; WATER SOLUBLE FRACTION
0870 COOK INLET CRUDE; TOXICITY; BIOASSAY; STATIC; FISH; INVERTEBRATES; ALASKA
0871 COOK INLET CRUDE; SALMON, PINK; PRUDHOE BAY CRUDE; FUEL OIL#2; WATER SOLUBLE FRACTION; RESPIRATION; COUGHING; UPTAKE & DEPURATION
0213 COOK INLET CRUDE OIL; TOXICITY; WATER SOLUBLE FRACTION; BENZENE
1223 COOK INLET CRUDE OIL; FLOUNDER; FISH; CLAMS; CHRONIC CONCENTRATIONS; EGGS; LARVAE; HISTOPATHOLOGY; MORTALITY
1033 COON STRIPE SHRIMP; TOXICITY; FUEL OIL #2; PROCEDURES
1034 COON STRIPE SHRIMP; BIOASSAY; FUEL OIL #2; TOXICITY
0183 COON-STRIPE SHRIMP; ALASKA; SHRIMP; KING CRABS; COOK INLET CRUDE; TOXICITY; BIOASSAY; STATIC; WATER SOLUBLE FRACTION
1051 COOXIDATION; DEGRADATION; CLADOSPORIUM; OXYGEN CONSUMPTION; TOLUENE; XYLENE; HEXADECANE
0097 COPEPOD; TOXICITY; CRUDE OIL FRACTIONS; GASOLINE; KEROSENE; TIGRIODUS
0123 COPEPOD; REPRODUCTION; NAPHTHALENE; EURYTEMORA; EGG PRODUCTION; HEATING OIL; WATER SOLUBLE FRACTION

0277 COPEPOD; UPTAKE; DEPURATION; NAPHTHALENE; METABOLISM; CALANUS;
FOOD WEB; WATER SOLUBLE FRACTION; DIETARY ROUTE OF ENTRY;
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0486 COPEPOD; RETENTION; ZOOPLANKTON; CALANUS; EURYTEMORA; UPTAKE;
DEPURATION
0487 COPEPOD; NAPHTHALENE; ACCUMULATION; RADIOACTIVE; LONG TERM EXPOSURE;
LOW LEVEL CONCENTRATIONS; MARINE ZOOPLANKTON; PERSISTENT EXPOSURE;
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0587 COPEPOD; OXYGEN TRANSFER; TOXICITY; TIGRIOPUS
1041 COPEPOD; KUWAIT CRUDE OIL; SUSPENSION; COREXIT 7664;
GAS CHROMATOGRAPHY; SPECTROFLUOROMETRY; TOXICITY; LONG-TERM EFFECTS;
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0382 COPEPODS; PORT VALLEY, ALASKA; INTERTIDAL; SEDIMENT;
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0664 COPEPODS; EAST CHINA SEA; KUROSHIO; TAR BALLS; ATTACHED ORGANISMS;
BLUE GREEN ALGAE; PENNATE DIATOMS; STONY CORALS; BRYOZOANS;
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0949 COPEPODS; TOXICITY TESTING; SUBLETHAL EFFECTS; TECHNIQUE; DROPLETS;
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1132 COPEPODS; TOXICITY; PETROLEUM FRACTION/CLEANING AGENT; FUCUS;
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1154 COPEPODS; ZOOPLANKTON; NAPHTHALENE; AROMATIC HYDROCARBONS;
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1220 COPEPODS; CALANUS; ALGAE; MONOCHRYSIS; NAPHTHALENE;
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0077 CORAL; FEEDING BEHAVIOR; OIL-SEDIMENT PARTICLES
0358 CORAL; MACROFAUNA; RED SEA; TOXICITY; CRUDE OIL; DISPERSANT;
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0450 CORAL; CRUDE OIL
0550 CORAL; TOXICITY; AIR EXPOSURE; OIL; ENIWETOK ATOLL
0627 CORAL; CRUDE OIL; DETERGENT; TOXICITY
0715 CORAL; PLATIGYRA; BACTERIA; STRESS; CRUDE OIL; MUCUS PRODUCTION;
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0858 CORAL; CRUDE OIL; PANAMA; DIESEL MARINE; BUNKER C; TOXICITY;
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0549 CORAL REEF COMMUNITY; OIL
0618 CORAL REEF COMMUNITY; INDONESIA; FISHERIES; OFFSHORE PRODUCTION;
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1177 CORAL REEFS; PUERTO RICO; OIL SPILLS; ECOSYSTEM; MANGROVE; ESTUARIES;
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0260 CORALS; CRUDE OIL; TOXICITY; HETEROXENIA; RED SEA; SUBLETHAL EFFECTS;
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0712 CORALS; RED SEA; CRUDE OIL; MICROORGANISMS; MUCUS PRODUCTION
1159 CORDGRASS; CAPITELLA; MANGROVES; CRUDE OIL; MARSH; TEXAS;
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1215 CORDGRASS; FUEL OIL; BUNKER C; CHEDABUCTO BAY; NOVA SCOTIA;
ARROW SPILL; LONG TERM EFFECTS; MARSH; ALGAE; TOXICITY
1185 CORDGRASS; MARSH; ECOSYSTEM; PETROLEUM HYDROCARBON; LOUISIANA;
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0218 COREXIT; DISPERSANTS; OIL; FISH; SEA URCHINS; FERTILIZATION;
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0424 COREXIT; OIL; DISPERSANTS; TOXICITY; POLYCHAETE; GAMETE FORMATION;
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0484 COREXIT; LITTORINA; SUBLETHAL EFFECTS; BUNKER C; DISPERSANT; RESPIRATION; CRAWLING RATES
0606 COREXIT; DETERGENT; TOXICITY; PLANKTON; CRANGON
0679 COREXIT; DISPERSANTS; TOXICITY; FISH; SHRIMP; SUB-TROPICAL; CENTROPOGON; DIOGENES; PALEOMONOTES; AMBASSIS
0635 COREXIT; OIL; DISPERSANTS; SEA URCHIN; FISH; EGGS; EMBRYO; FERTILIZATION; DEVELOPMENT
0633 COREXIT; EMBRYOLOGY; SEA URCHIN; OIL; DISPERSANTS; ULTRASTRUCTURE
0751 COREXIT; TOXICITY; INTERTIDAL; BALTIC SEA; LITTORAL ZONE; BEROL; BP1100; WATER BASE; OIL BASE; SOLVENT
0946 COREXIT; DISPERSANTS; OIL; TOXICITY
1093 COREXIT; FISH; SOLE; PLAICE; HERRING; LARVAE; DETERGENT; DEVELOPMENTAL ABNOMALITIES; BP1002; FINASOL
1160 COREXIT; DISPERSANTS; CRUDE OIL; ARCTIC; PHYTOPLANKTON; PRODUCTIVITY; ALGAE
1163 COREXIT; DISPERSANTS; CUNNER; HYPOXIA; RESPIRATION; BP1002; TRITON X-100; SODIUM LAURYL SULPHATE
1041 COREXIT 7664; KUWAIT CRUDE OIL; SUSPENSION; GAS CHROMATOGRAPHY; SPECTROFLUOROMETRY; COPEPOD; TOXICITY; LONG-TERM EFFECTS; REPRODUCTION; EGG PRODUCTION; HATCHING SUCCESS
0599 COREXIT 8666; TOXICITY; KUWAIT CRUDE; PHYTOPLANKTON; PHAEODACTYLUM TRICORNUTUM; PRIMARY PRODUCTION; ILLUMINATION
0475 COREXIT 9527; DISPERSANTS; SEA URCHIN; FERTILIZATION
0948 COREXIT-7664; OIL SPILL INICIDENT; PERSIAN GULF; DISPERSANTS; MARINE FAUNA; TARUT BAY, SAUDI ARABIA
0336 CORMORANT; OLYMPIC ALLIANCE-DOVER STRAITS 1975; BIRD MORTALITY; AUKS; OIL SPILL INCIDENT; ENGLAND
0281 CORNWALL; SALT MARSH; SPARTINA; PUCCINELLA; CHRONIC; WEATHERING; RECOVERY
0852 CORNWALL; TORREY CANYON; COASTAL HABITATS; PLANTS; EMULSIFIERS; BRITTANY
0798 CORNWALL, ENGLAND; TORREY CANYON SPILL; OIL; DETERGENT; INTERTIDAL
0783 CORNWALL, ENGLAND; TORREY CANYON; BIRDS; AUKS
0937 CORYNEBACTERIUM; ARTHROBACTER; ACHROMOBACTER; RATE ENHANCEMENT; HYDROCARBON-OXIDIZING BACTERIA
0850 COSMOS PIONEER; INDIA; OIL SPILL INCIDENT; ECOLOGICAL IMPACT
0871 COUGHING; SALMON, PINK; PRUDHOE BAY CRUDE; COOK INLET CRUDE; FUEL OIL#2; WATER SOLUBLE FRACTION; RESPIRATION; UPTAKE & DEPURATION
0505 COUPLED-COLUMN LIQUID CHROMATOGRAPHY; HYDROCARBONS CONTENT ANALYSIS; DYNAMIC HEAD SPACE SAMPLING; GAS CHROMATOGRAPHY; MASS SPECTROMETRY
0332 CRAB; HYDROCARBON CONTENT ANALYSIS; GAS CHROMATOGRAPHY; THIN LAYER CHROMATOGRAPHY; HIGH PRESSURE LIQUID CHROMATOGRAPHY; SAN FRANCISCO BAY; SPONGE; MUSSEL
0465 CRAB; BUNKER C; WATER SOLUBLE FRACTION; SAN FRANCISCO BAY; PACHYGRAPSUS
1139 CRAB; CRUDE OIL; CANCER; NAPHTHALENE; BENZENE; AROMATIC HC'S; TOXICITY; REPRODUCTION & DEVELOPMENT
1182 CRAB; CRUDE OIL; SHRIMP; ALASKA; EMBRYOGENESIS; GROWTH; COOK INLET
1169 CRAB-SALT MARSH; CRABS; WEST FALMOUTH SPILL; MORTALITY; UPTAKE; BEHAVIOR; BURROWING; TOXICITY; FUEL OIL; MASS.
0564 CRABS; PRUDHOE CRUDE; CHIONOECETES; MOLTING
0581 CRABS; OYSTERS; CHEMORECEPTION; SUBLETHAL EFFECTS; NAPTHALENE; BEHAVIOR; BIOASSAY
1181 CRABS; CONTINENTAL SHELF; UPTAKE; CALIFORNIA; OFFSHORE PLATFORMS;

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1169 CRABS; WEST FALMOUTH SPILL; MORTALITY; UPTAKE; BEHAVIOR; BURROWING; TOXICITY; FUEL OIL; CRAB-SALT MARSH; MASS.
0901 CRABS(HERMIT); ARGO MERCHANT SPILL; HISTOPATHOLOGY; AMMODYTES; FLOUNDER (WINTER&YELLOWTAIL); ALEWIVES; HYPERPLASIA; EDEMA; HEMOCYTES; CILIATES
0838 CRAGON; DETERGENTS; TOXICITY; SHORE CRAB; CARCINUS; BROWN SHRIMP; LARVAE; FISH
0835 CRAGON; TOXICITY; OIL DISPERSANTS; CARDIUM
0272 CRAIE DE CHAMPAGNE; TORREY CANYON SPILL; NOCTILUCA
0513 CRAIE DE CHAMPAGNE; TORREY CANYON; DETERGENT; LIMPETS; PLANKTON; FISHERIES; BIRDS
0606 CRANGON; DETERGENT; TOXICITY; PLANKTON; COREXIT
0161 CRANKCASE OIL; FUEL OIL#2; NIGERIAN CRUDE; BENTHIC ALGAL COMMUNITIES; PRIMARY PRODUCTIVITY; TOXICITY; RECOVERY; ALGAL BLUE GREEN
0039 CRASSOSTREA; OYSTERS; CRUDE OIL; REFINED OILS; BIOASSAY; FUEL OIL #2; BUNKER C; SOUTH LA. CRUDE; KUWAIT CRUDE
0036 CRASSOSTREA; OYSTERS; UPTAKE AND DEPURATION; GALVESTON BAY, TEXAS; ANALYTICAL METHODS (UV,GC); ANALYSIS FOR HYDROCARBONS; GULF OF MEXICO
0037 CRASSOSTREA; OYSTERS; UPTAKE AND DEPURATION; GROWTH; ANALYSIS FOR HYDROCARBONS
0160 CRASSOSTREA; OYSTERS; CRUDE OIL
0354 CRASSOSTREA; OYSTERS; HYDROCARBON CONTENT; GALVESTON BAY; COLUMN CHROMATOGRAPHY; TLC; MASS SPECTA; UV SPECTRA
0412 CRASSOSTREA; OYSTERS; CRUDE OIL; LOUISANA
0600 CRASSOSTREA; PETRO SULFAR COMPOUNDS; AROMATIC HYDROCARBONS; MODIOLUS; RETENTION; FLAME IONIZATION DETECTION; FLAME PHOTOMETRIC DETECTION; GAS CHROMATOGRAPHY; GAS CHROMATOGRAPHY-MASS SPECTROMETRY
0508 CRASSOSTREA; OYSTER; MERCENARIA; CLAM; SURFACTANT; LARVAE; DEVELOPMENT; GROWTH; SURVIVAL; TOXICITY
0651 CRASSOSTREA; OYSTER; LOUISIANA; OIL SPILL; MORTALITY; GROWTH; SET; DISEASE INCIDENCE; TAINTING
0650 CRASSOSTREA; OYSTERS; MORTALITIES; SEDIMENT HYDROCARBONS; DRILLING OPERATIONS; TEMPERATURE; SALINITY
0762 CRASSOSTREA; UPTAKE &DEPURATION; RANGIA; FUNDULUS; PENAEUS
0957 CRASSOSTREA; OYSTER; CHRONIC EXPOSURE; PHSIOLOGICAL EFFECTS; RETENTION; DEPURATION
0864 CRASSOSTREA; DISPERSANT; SHELLFISH; LARVAE; SPERMATOZOA; TOXICITY; BIVALVES; OYSTERS; MUSSEL; FERTILIZATION; DEVELOPMENT
1004 CRASSOSTREA; OYSTER; UPTAKE; RETENTION; DEPURATION; PETROLEUM HYDROCARBONS
0960 CRASSOSTREA; OYSTER; UPTAKE; RETENTION; DEPURATION; PETROLEUM FRACTIONS; LIPIDS; FAT CONTENT; METABOLISM
1133 CRASSOSTREA; FUEL OIL; QUAHOG; ESTUARINE; ALIPHATICS; MERCENARIA; CLAMS; OYSTERS; UPTAKE; RETENTION; DEPURATION
1157 CRASSOSTREA; SOUTH LOUISIANA CRUDE OIL; OYSTERS; ANALYSIS FOR HYDROCARBONS; MORTALITY; GAS CHROMATOGRAPHY
0484 CRAWLING RATES; LITTORINA; SUBLETHAL EFFECTS; BUNKER C; DISPERSANT; RESPIRATION; COREXIT
0704 CRENILABRUS; TOXICITY; FISH; DEVELOPMENT; PETROLEUM; EUGRAULIS; SCORPAENA; BLACK OIL; SOLAR OIL
1108 CREOSOTE; AROMATIC HYDROCARBON; POLYCYCLIC AROMATIC HC'S; CONTENT ANALYSIS; BUNKER C; SEALS; FISH; SHELLFISH; PAH; FLUOROMETRY; FUEL OIL

0346 CREOSOTED; MYTILUS; MONITORING; MUSSELS; BENZO(A)PYRENE; CARCINOGEN; VANCOUVER HARBOR
0373 CREVICE FAUNA; INSECTS; POPULATION SURVEY; SANTA BARBARA; LITTORAL; BEETLE; THALASSOTRECHUS
0350 CRICOSPHAERA; PHYTOPLANKTON; AMPHIDINIUM; SKELETONEMA; DUNALIALLA; BENZENE; TOLUENE; XYLENE; FUEL OIL#2; GROWTH
0879 CRICOTOPUS; CRUDE OIL; MIDGES; FORT SIMPSON, NWT, CANADA; FIELD EXPERIMENTS; LARVAE; ARTIFICAL SUBSTRATES
0722 CRITICAL REVIEW; OIL; MARINE ORGANISMS
0290 CROMARTY FIRTH,SCOTLAND; OIL DEPOT
0305 CROMARTY FIRTH,SCOTLAND; BIRDS; NORTH SEA OIL
0207 CRUDE; MERCENARIA; TOXICITY; EMBRYOS; LARVAE; WATER SOLUBLE FRACTION; REFINED; WASTE; GROWTH
0616 CRUDE; TOXICITY; FUEL OIL #2; AMPHIPODS; BREEDING; WATER SOLUBLE FRACTION
0643 CRUDE; PARAFFIN; FISH
0882 CRUDE; TOXICITY; POLYCHAETES; NAPHTHALENE; BUNKER C; FUEL OIL #2; WATER SOLUBLE FRACTION; NEANTHES; CAPITELLA; SOUTH LOUISIANA CRUDE; KUWAIT
0101 CRUDE OIL; POND; ARCTIC; PHYSICAL PARAMETERS; PHYTOPLANKTON; VASCULAR PLANTS; CHIRONOMID; AQUATIC; PRUDHOE CRUDE OIL; ARCTIC -TUNDRA; ALASKA- BARLOW; BENTHIC ORGANISMS; PLANKTON
0065 CRUDE OIL; PHOTOSYNTHESIS; RESPIRATION; NITROGEN FIXATION; BACTERIA; ALGAE; FUNGI; ARCTIC; NATURAL GAS; MICROORGANISMS
0078 CRUDE OIL; SALT MARSH PLANTS; TOXICITIES; EMULSIFIERS
0061 CRUDE OIL; LOBSTER; CHEMOSENSORS; BEHAVIOR AND FEEDING
0073 CRUDE OIL; DISPERSANTS; BIVALVES
0064 CRUDE OIL; BIODEGRADATION; SUBSTRATE COMPOSITION; TEMPERATURE
0093 CRUDE OIL; BIODEGRADATION; NITRIFICATION; AMMONIA PRODUCTION; MICROORGANISMS
0038 CRUDE OIL; OYSTERS; REFINED OILS; CRASSOSTREA; BIOASSAY; FUEL OIL #2; BUNKER C; SOUTH LA. CRUDE; KUWAIT CRUDE
0060 CRUDE OIL; LOBSTER; SUBLETHAL EFFECTS
0237 CRUDE OIL; SINKING AGENTS; TOXICITY; TOAD FISH; SHELLFISH; FILTRATION RATE
0138 CRUDE OIL; FATE; WEATHER; MICROBIAL DEGRADATION; BIOLOGICALLY ACTIVE FRACTIONS; MARTHA'S VINEYARD; BERMUDA
0208 CRUDE OIL; DEGRADATION; BACTERIA
0160 CRUDE OIL; OYSTERS; CRASSOSTREA
0359 CRUDE OIL; DETERGENT; OCTOCORALS; CRUSTACEANS; MOLLUSCS; ECHINODERMS; FISH; TOXICITY; SUBLETHAL; DEVELOPMENTAL STAGES; RED SEA; FEEDING RATE; PHYSIOLOGY; BIOACCUMULATION; LIVER ENLARGEMENT; HEMATOCRIT
0317 CRUDE OIL; DEGRADATION; SEA WATER; AUTO OXIDATION; BACTERIA; WEATHERING
0361 CRUDE OIL; RED SEA; MACROFAUNA; TOXICITY; DEPTH; SUBLETHAL EFFECTS; PHYSIOLOGY; METABOLISM; BEHAVIOR; DISPERSANT
0323 CRUDE OIL; TAINTING; FISH; YELLOWTAIL; VAPOR ANALYSIS; SERIOLA; GAS CHROMATOGRAPHY
0357 CRUDE OIL; DRUPA GRANULATA; MYTILUS; PREDATION RATE; FECUNDITY; SUBLETHAL; MUSSELS; RED SEA; DISPERSANT
0269 CRUDE OIL; CARCINOGENS
0299 CRUDE OIL; BIRDS; MALLARDS; PHYSIOLOGY; ANAS; DEHYDRATION; MUCOSAL TRANSFER RATE; DISPERSANTS; INTESTINAL ABSORPTION
0330 CRUDE OIL; DUCKS; MALLARDS; ANAS; INGESTION; EGGS; EMBRYOTOXICITY

0260 CRUDE OIL; TOXICITY; CORALS; HETEROXENIA; RED SEA; SUBLETHAL EFFECTS; DEPTH PROTECTION EFFECTS; HYDROCARBON CONTENT ANALYSIS
0362 CRUDE OIL; DISPERSANT; TOXICITY; STONY CORAL
0359 CRUDE OIL; MACROFAUNA; RED SEA; TOXICITY; DISPERSANT; CORAL; HETEROXENIA; GASTROPODS; MUSSELS; CHITON; SEA URCHIN; HERMIT CRAB; SHRIMP; GOATFISH; RABBITFISH
0312 CRUDE OIL; REVIEW; BIODEGRADATION; BACTERIA; FRACTIONS; ENVIRONMENTAL FACTORS
0360 CRUDE OIL; TOXICITY; RABBIT FISH; DEPTH; SIGANUS; DISPERSANT; STATIC ASSAY; FLOW THROUGH ASSAY; SALINITY
0390 CRUDE OIL; DEGRADATION; MARINE ENVIRONMENT; BACTERIAL; NON-BIOLOGICAL
0391 CRUDE OIL; HYDROCARBON; UPTAKE; MYA; RESPIRATION; LIQUID CONTENT; SOFT SHELL CLAM
0412 CRUDE OIL; OYSTERS; CRASSOSTREA; LOUISANA
0433 CRUDE OIL; MYTILUS; MODIOLUS; CARBON BUDGET; SALINITY; STRESS; RESISTANCE; MUSSELS
0415 CRUDE OIL; LESIONS; HISTOPATHOLOGY; FISH; MENIDIA; HYPERPLASIA
0458 CRUDE OIL; REFINED OIL; TOXICITY; BACTERIA; WATER SOLUBLE FRACTION; AROMATIC HYDROCARBONS; WEATHERING; GROWTH RATE; MAXIMUIM CELL DENSITY
0372 CRUDE OIL; REVIEW; MARINE ECOSYSTEMS; TOXICITY; LONG TERM EFFECTS
0427 CRUDE OIL; OXIDATION; NUTRIENTS
0450 CRUDE OIL; CORAL
0418 CRUDE OIL; DISPERSANTS; BIODEGRADATION; ECOSYSTEMS
0422 CRUDE OIL; SEALS; BEHAVIOR; PATHOLOGICAL EFFECTS; COATING; IMMERSION; INGESTION
0432 CRUDE OIL; MYTILUS; MODIOLUS; CARBON BUDGETS; SALINITY; RESISTANCE; MUSSELS
0591 CRUDE OIL; TOXICITY; EMULSIFIERS; FRESH WATER; SALT WATER
0578 CRUDE OIL; COOK INLET; ALASKA
0583 CRUDE OIL; PALATABILITY; BROWN SHRIMP; BLUE CRAB; TAINTING; LOUISIANA CRUDE OIL
0592 CRUDE OIL; PETROLEUM FRACTIONS; HERRING; HATCHING; DEVELOPMENT; TOXICITY; EMULSIFICATION
0547 CRUDE OIL; BACTERIAL DEGRADATION
0576 CRUDE OIL; BACTERIAL DEGRADATION; CHAIN LENGTH; ENRICHMENT
0594 CRUDE OIL; FISH FRY; DISPERSANTS; COD; GADUS; HERRING; CLUPEA; TOXICITY; EMBRYOLOGY; CHEMORECEPTION
0598 CRUDE OIL; ECOTOXICOLOGY; PRIMARY PRODUCTION; EXPERIMENTAL ECOSYSTEM
0510 CRUDE OIL; BACTERIA; FUEL OIL #2; BUNKER C; METABOLISM; INHIBITION; RADIOACTIVE TRACER; CONTROLLED ECOSYSTEM
0571 CRUDE OIL; PHYTOPLANKTON; FIELD EXPERIMENT; INHIBITED; STIMULATION; LABORATORY STUDIES; TOXICITY; PH; FRACTIONS; BENZENE; XYLENE; TOLUENE
0568 CRUDE OIL; TOXICITY; CASPIAN SEA; CERASTODERMA; CHANGE; ABRA; PONTOGAMMARUS
0580 CRUDE OIL; CRUSTACEA; BEHAVIOR; FEEDING; POLYAROMATIC HYDROCARBONS; ALIPHATIC; CHEMORECEPTION
0500 CRUDE OIL; ENZYMES; OYSTERS; SHRIMP; MULLET
0620 CRUDE OIL; PHYTOPLANKTON; TEMPERATURE; TOXICITY
0570 CRUDE OIL; CHLORELLA; GROWTH RATES; WATER SOLUBLE FRACTIONS; TOXICITY; STIMULATION
0567 CRUDE OIL; CASPIAN SEA; BENTHOS; GROWTH; REPRODUCTION; CHIRONOMUS; CERASTODERMA; NAIS; NEREIS; PYRGOHYDROBIA; ABRA

0579 CRUDE OIL; INVERTEBRATES; BEHAVIOR; CHEMORECEPTION
0577 CRUDE OIL; REEF COMMUNITY; RESPIRATION; CALMING EFFECTS;
GAS EXCHANGE; FIELD FENCING TECHNIQUES; TOXIXCTY; BEHAVIOR;
HERON IS. GREAT BARRIER REEF AUSTRALIA
0553 CRUDE OIL; SAND; MICROBIAL DEGRADATION; OXYGEN AVAILABILITY; DEPTH
0640 CRUDE OIL; OYSTERS; FILTERING RATE; BLEED WATER;
WATER SOLUBLE FRACTION
0712 CRUDE OIL; CORALS; RED SEA; MICROORGANISMS; MUCUS PRODUCTION
0680 CRUDE OIL; DEGRADATION; SANTA BARBARA; WEATHERING;
SEQUENCE OF DEGRADATION; GAS CHROMATOGRAPHY
0661 CRUDE OIL; BIOGENIC VS. PETROLEUM HYDROCARBONS;
INFRA-RED SPECTROMETRY; SEDIMENTS
0719 CRUDE OIL; ALGAE; PLATYMONAS; TOXICITY; GROWTH RATES; FINE STRUCTURE;
NANO PLANKTON; EMULSIFIER
0715 CRUDE OIL; CORAL; PLATIGYRA; BACTERIA; STRESS; MUCUS PRODUCTION;
DESULFOVIBRIO; BEGGIATOA
0629 CRUDE OIL; TOXICITY; DISPERSANTS; LARVAE; HERRING; CULPEA
0627 CRUDE OIL; DETERGENT; CORAL; TOXICITY
0731 CRUDE OIL; SALMON; TOXICITY; ALIPHATICS; AROMATICS;
CELL MEMBRANE PERMEABILITY
0641 CRUDE OIL; ESTUARIES; HYDROCARBON CONCENTRATIONS; SEDIMENTS;
ZOOPLANKTON; PHYTOPLANKTON; SALT MARSH PLANTS; DIVERSITY;
POPULATIONS; FISH; MIGRATION; GAS CHROMATOGRAPHY; DEGRADATION
0694 CRUDE OIL; DEGRADATION; BACTERIA; PARAFFIN; GAS CHROMATOGRAPHY;
EMULSIFICATION
0695 CRUDE OIL; SHRIMP; TOXICITY; DETERGENTS; PALEOMONETES; PENAEUS
0647 CRUDE OIL; SALT GRASS; OYSTER
0707 CRUDE OIL; OIL POLLUTION; FLORA; FAUNA; BLACK SEA; DIESEL OIL
0702 CRUDE OIL; ZOOPLANKTON; TOXICITY; BLACK SEA; MINERAL OIL; ACARTIA;
PARACALANUS; PENILLIA; CENTROPAGES; OITHONA
0737 CRUDE OIL; PARAFFINS; FISH; JULIANA WRECK; SALMON; MULLET;
BLACK SEA BREAM; GAS CHROMATOGRAPHY
0648 CRUDE OIL; SALT GRASS; DISTICHLIS
0730 CRUDE OIL; SALMON; TOXICITY; PRUDHOE BAY; ALIPHATIC; AROMATICS;
CELL MEMBRANE PERMEABILITY
0736 CRUDE OIL; TAINTING; SCALLOPS; AROMATICS; PARAFFINS
0817 CRUDE OIL; ARCTIC; CRUSTACEA; ISOPODS; AMPHIPODS; BEHAVIOR;
ATTRACTION; REPULSION; TAINTING
0758 CRUDE OIL; CLAMS; UPTAKE; DEPURATION; CONTENT ANALYSIS; FUEL OIL #2;
SOLUBLE FRACTIONS; GAS CHROMATOGRAPHY
0847 CRUDE OIL; ALGAE; MARINE; PHYTOPLANKTON; FUEL OIL #2; GROWTH RATES
0807 CRUDE OIL; WATER SOLUBLE FRACTIONS; MICROALGAE; GROWTH RATE;
HYDROCARBON ANALYSIS; SEDIMENTS; WATERS; BIOTA;
SOUTH TEXAS OUTTER CONTINENTAL SHELF
0820 CRUDE OIL; ARCTIC; AMPHIPOD; COELENTERATE; LOCOMOTORY ACTIVITY;
SUBLETHAL EFFECTS; ONISIMUS; HALITHOLUS
0834 CRUDE OIL; IDOTEA; GAMMARUS; LONGEVITY; AMPHIPOD; ISOPOD;
OXYGEN CONSUMPTION
0804 CRUDE OIL; DEGRADATION; MARINE ENVIRONMENT; ZOOPLANKTON;
PHOTOCHEMICAL OXIDATION; SOLUBILITY; DISPERSION
0799 CRUDE OIL; TOXICITY; INTERTIDAL ORGANISMS; LIGHT TRANSMISSION;
TEMPERATURE; BOILING FRACTION
0819 CRUDE OIL; ARCTIC; MARINE; INVERTEBRATES; BEAUFORT SEA
0848 CRUDE OIL; SOUTH LOUISIANA CRUDE; KUWAIT CRUDE; FUEL OIL#2;
GROWTH RATE; PHOTOSYNTHESIS; MICROALGAE-TOXICITY; BLUE GREEN; DIATOM;

DINOFLAGELLATE
0818 CRUDE OIL; CRUSTACEA; BEHAVIOR; SEDIMENTS; AMPHIPOD; ONISIMUS; AVOIDANCE; WEATHERING
0942 CRUDE OIL; NAPTHALENE; WATER SOLUBLE FRACTION; CHLAMYDOMONAS; TOXICITY; GROWTH
0879 CRUDE OIL; MIDGES; CRICOTOPUS; FORT SIMPSON, NWT, CANADA; FIELD EXPERIMENTS; LARVAE; ARTIFICAL SUBSTRATES
0863 CRUDE OIL; SUPRALITTORAL; ARTHROPODS; LIMOSINA; ORCHESTIA; EFFLUENTS; TOXICITY; FLIES; AMPHIPODES
0929 CRUDE OIL; BRITAIN; LITTORAL COMMUNITY; TOXICITY; EMULSIFIER; MILFORD HAVEN; ESSO PORTSMOUTH SPILL; TORREY CANYON SPILL; LANDS END
0931 CRUDE OIL; PACIFIC HERRING; TOXICITY; ROE; HATCHING SUCCESS; MORPHOLOGICAL ANOMOLIES; HERRING; ALASKA
0935 CRUDE OIL; LAKES; ARCTIC; MACKENZIE DELTA; WATER COLUMN; SEDIMENTS; ZOOBENTHOS; DEGRADATION
0858 CRUDE OIL; CORAL; PANAMA; DIESEL MARINE; BUNKER C; TOXICITY; METABOLISM; FEEDING
0930 CRUDE OIL; TORREY CANYON SPILL; TOXICITY; SEA COMMUNITIES; SHORE COMMUNITIES; DETERGENT
0905 CRUDE OIL; PHOTOSYNTHESIS; ALGAE; DIFFUSION RATES
0869 CRUDE OIL; SALMON; ONCORHYNCHUS; EGGS; ALEVINS; FRY; TOXICITY; GROWTH
0912 CRUDE OIL; BIOINDICATORS; CLAMS; MACOMA BALTICA; MUD FLATS
0867 CRUDE OIL; PINK SALMON; TOXICITY; AVOIDANCE; JUVENILE; MIGRATION; AGE; CHEMORECEPTION
0941 CRUDE OIL; WATER SOLUBLE FRACTION; NAPHTHALENE; GREEN ALGAE; PHYSIOLOGY; MORPHOLOGY; FRESHWATER
0868 CRUDE OIL; TOXICITY; ACUTE; CHRONIC; COMPONENT; PHYSIOLOGY; BEHAVIOR; ARCTIC & SUBARCTIC ORGANISMS; TEMPERATURE; METABOLISM
0999 CRUDE OIL; PRODUCERS; CHEMORECEPTION; SUBLETHAL EFFECTS; WATER SOLUBLE FRACTION; INHIBITORS
1002 CRUDE OIL; SHRIMP; TOXICITY; CONTENT ANALYSIS; DEPURATION; FUEL OIL #2; BUNKER C; PALAEMONETES; TEMPERATURE; BENZENE; PHENOL; NAPHTHALENE
1038 CRUDE OIL; ALGAE; PHYSIOLOGY; HYDROCARBONS PETROLEUM; REVIEW; NAPHTHALENE; PHOTOSYNTHESIS; ATP; DISTILLATE FRACTIONS
1030 CRUDE OIL; BIESBOSCH TIDAL AREA; OIL SPILL INCIDENT; BIRDS-GEESE; MORTALITY; HOLLAND
0999 CRUDE OIL; PETROLEUM PRODUCTS; WATER QUALITY; FISH; AQUATIC LIFE &WILDLIFE
1159 CRUDE OIL; CAPITELLA; CORDGRASS; MANGROVES; MARSH; TEXAS; GULF OF MEXICO; ASSESSMENT OF SPILLS
1131 CRUDE OIL; MICROFLORA; PHYTOPLANKTON; ALGAE; FUEL OIL; TOXICITY; NAPHTHALENE; PHENANTHRENE; AROMATICS; ALGAE-GREEN; ALGAE-BLUE GREEN; DIATOMS; GROWTH
1140 CRUDE OIL; FUEL OIL; POLYCHAETES; TOXICITY; REPRODUCTION & DEVELOPMENT
1085 CRUDE OIL; FISH; TOXICITY; WATER SOLUBLE FRACTION
1151 CRUDE OIL; BIODEGRADATION; AROMATIC HC' S; BACTERIA
1129 CRUDE OIL; BIODEGRADATION; MICROOGANISMS; ARCTIC; TEMPERATURE; NUTRIENTS; OXYGEN REQUIREMENTS; AROMATICS; PARAFFINS; BEAUFORT SEA; CHUKCHI SEA
1160 CRUDE OIL; DISPERSANTS; COREXIT; ARCTIC; PHYTOPLANKTON; PRODUCTIVITY; ALGAE
1144 CRUDE OIL; BIRDS; HATCHING SUCCESS; EMBRYONIC DEVELOPMENT; EIDERS;

GULKS; MALLARDS; PATHOLOGICAL EFFECTS; FUEL OIL
1162 CRUDE OIL; CLAMS; BEHAVIOR; MORTALITY
1113 CRUDE OIL; DEGRADATION; BACTERIA; YEAST; FUNGI; SUBSTRATE; DISTRIBUTION
1133 CRUDE OIL; CRAB; CANCER; NAPHTHALENE; BENZENE; AROMATIC HC'S; TOXICITY; REPRODUCTION & DEVELOPMENT
1156 CRUDE OIL; FISHES; HISTOPATHOLOGICAL EFFECTS; TOXICITY
1174 CRUDE OIL; ESTUARIES; CANADA; SAENICH INLET; FUEL OIL; BIODEGRADATION; PHYTOPLANKTON; CEPEX; DIATOMS
1180 CRUDE OIL; BIODEGRADATION; DISPERSANTS
1189 CRUDE OIL; MICROORGANISMS; BACTERIA; FUNGI; YEASTS; BIODEGRADATION; NIGERIA
1207 CRUDE OIL; ALGAE; FUCUS; FUEL OIL #2; JET FUEL
1175 CRUDE OIL; ALGAE; ZOOPLANKTON; CRUSTACEANS; POLYCHAETES; MOLLUSCS; FISH; UPTAKE; RETENTION; DEPURATION; REVIEW; BENTHIC ORGANISMS
1219 CRUDE OIL; SEDIMENTS; WASHINGTON; INTERTIDAL ZONE; UPTAKE & DEPURATION; ASSESSMENT OF SPILLS; BENTHIC ORGANISMS; PUGET SOUND; RECRUITMENT
1190 CRUDE OIL; BIODEGRADATION; BUNKER C; MARINE DIESEL; MICROORGANISMS
1182 CRUDE OIL; CRAB; SHRIMP; ALASKA; EMBRYOGENESIS; GROWTH; COOK INLET
1196 CRUDE OIL; TOXICITY; REVIEW; BIOASSAY; MORTALITY; GROWTH STAGES
0097 CRUDE OIL FRACTIONS; COPEPOD; TOXICITY; GASOLINE; KEROSENE; TIGRIODUS
0289 CRUDE OIL FRACTIONS; PLANTS; TERRESTRIAL; CHRONIC TOXICITY; ACUTE TOXICITY
0068 CRUDE OIL- SWEDEN; ABUNDANCE; DISTRIBUTION; BIOINDICATOR; ENUMERATION; TEMPERATURE; LEVEL OF OIL; MICROORGANISMS; BIODEGRADATION; RARITAN BAY N.J.; GAS CHROMATOGRAPHY
0459 CRUDE OIL-ARABIAN LIGHT; TOXICITY; LITTORINA; MYTILUS; TIDL CYCLE; TEMPERATURE
1188 CRUDE OIL-NIGERIAN; BIODEGRADATION; NUTRIENTS; OXYGEN CONSUMPTION
0300 CRUDE OILS; OIL; MALLARDS; PHYSIOLOGY; INTESTINAL ABSORPTION; ANAS; MUCOSAL TRANSFER RATES; BOILING FRACTIONS
0318 CRUDE OILS; DEGRADATION; RESPIROMETRY; SEA WATER SOURCES; NITROGEN
1191 CRUDE OILS -IRANIAN & ARABIAN; AMOCO CADIZ SPILL; BRITTANY FRANCE
0580 CRUSTACEA; CRUDE OIL; BEHAVIOR; FEEDING; POLYAROMATIC HYDROCARBONS; ALIPHATIC; CHEMORECEPTION
0817 CRUSTACEA; ARCTIC; ISOPODS; AMPHIPODS; BEHAVIOR; ATTRACTION; REPULSION; TAINTING; CRUDE OIL
0818 CRUSTACEA; CRUSTACEA; BEHAVIOR; CRUDE OIL; SEDIMENTS; AMPHIPOD; ONISIMUS; AVOIDANCE; WEATHERING
0034 CRUSTACEANS; WATER SOLUBLE FRACTION; OIL IN WATER DISPERSION; FISH; TOXICITY; ESTUARINE; SOUTH LA. CRUDE; KUWAIT CRUDE; FUEL OIL #2; BUNKER C; CYPRINODON; MENIDIA; FUNDULUS; PENAEUS; PALEOMONETES; MYSIDOPSIS
0228 CRUSTACEANS; LITTORAL COMMUNITIES; FLORIDA KEYS; ROCKY PLATFORM; MANGROVE FRINGE; SEA GRASS FLATS; MANGROVE SWAMP; ECHINODERMS; RED MANGROVE; PEARL OYSTER; BLACK MANGROVE
0359 CRUSTACEANS; CRUDE OIL; DETERGENT; OCTOCORALS; MOLLUSCS; ECHINODERMS; FISH; TOXICITY; SUBLETHAL; DEVELOPMENTAL STAGES; RED SEA; FEEDING RATE; PHYSIOLOGY; BIOACCUMULATION; LIVER ENLARGEMENT; HEMATOCRIT
0532 CRUSTACEANS; HYDROCARBONS; BIOINDICATOR; BIOELECTRIC ACTION POTENTIALS; REMOTE ELECTRODES; ACTIVITY
0995 CRUSTACEANS; DISPERSANTS; EMULSIONS; TOXICITY; SUBLETHAL EFFECTS;

NUTRIENT ENRICHMENT
0001 DEGRADATION; HYDROCARBON; REVIEW
0226 DEGRADATION; BACTERIA; FUNGI; TEMPERATURE
0146 DEGRADATION; WEST FALMOUTH SPILL; WEATHERING; IDENTIFICATION; HYDROCARBON CONTENT; SEDIMENTS; SHELLFISH; OYSTERS; BUZZARD BAY
0189 DEGRADATION; BACTERIA; AEROBIC; ANAEROBIC; PHYSICAL CHANGE; CHEMICAL CHANGE
0144 DEGRADATION; BACTERIA; SEDIMENTS; PERSISTANCE; WEST FALMOUTH OIL SPILL; BUZZARD BAY
0205 DEGRADATION; BACTERIA; FUNGI; EMULSIONS; TOXICITY; TAINTING
0209 DEGRADATION; CRUDE OIL; BACTERIA
0225 DEGRADATION; BACTERIA; FUNGI; TEMPERATURE; OXIDATION; ASSIMILATION
0317 DEGRADATION; CRUDE OIL; SEA WATER; AUTO OXIDATION; BACTERIA; WEATHERING
0314 DEGRADATION; BACTERIA; ACTINOMYCETES; FILAMENTOUS FUNGI; YEAST; PHYCOMYCETES
0307 DEGRADATION; AROMATIC COMPOUNDS; BACTERIA
0318 DEGRADATION; RESPIROMETRY; CRUDE OILS; SEA WATER SOURCES; NITROGEN
0365 DEGRADATION; OUTBOARD OPERATION; TAINTING; WEATHERING; VOLATILITY
0429 DEGRADATION; BACTERIAL; TEMPERATURE
0389 DEGRADATION; REVIEW; INPUT; NON-BIOLOGICAL; BACTERIAL; BIOCHEMICAL
0428 DEGRADATION; BACTERIAL; OXYGEN UPTAKE; NUTRIENT LIMITATIONS; RESIDUE
0402 DEGRADATION; OXIDATION; HYDROCARBONS; BACTERIA; AEROBIC; ANAEROBIC
0390 DEGRADATION; CRUDE OIL; MARINE ENVIRONMENT; BACTERIAL; NON-BIOLOGICAL
0586 DEGRADATION; YEAST; TAXONOMY; HYDROCARBONS
0609 DEGRADATION; MARINE SEDIMENT; METABOLISM; MICROFAUNA; MEIOFAUNA; MACROFAUNA; POLYCHAETE WORMS; BIVALVES; BACTERIA; EXCRETION
0641 DEGRADATION; ESTUARIES; HYDROCARBON CONCENTRATIONS; SEDIMENTS; ZOOPLANKTON; PHYTOPLANKTON; CRUDE OIL; SALT MARSH PLANTS; DIVERSITY; POPULATIONS; FISH; MIGRATION; GAS CHROMATOGRAPHY
0680 DEGRADATION; CRUDE OIL; SANTA BARBARA; WEATHERING; SEQUENCE OF DEGRADATION; GAS CHROMATOGRAPHY
0701 DEGRADATION; BACTERIA; BLACK SEA; SELF-PURIFICATION
0667 DEGRADATION; ALGAE; MYXOTROPHIC GROWTH; HYDROCARBONS; SCENEDESMNS
0708 DEGRADATION; PURIFICATION; BLACK SEA; WATER; SEDIMENTS; BACTERIA
0705 DEGRADATION; BACTERIA; INDICATORS
0703 DEGRADATION; BACTERIA
0687 DEGRADATION; PETROLEUM; FUNGI
0694 DEGRADATION; BACTERIA; PARAFFIN; CRUDE OIL; GAS CHROMATOGRAPHY; EMULSIFICATION
0726 DEGRADATION; BACTERIA; MACROPHYTES; SPECIES COMPOSITION
0639 DEGRADATION; STREAMS; OXIDATION; SEDIMENTATION; OILY WASTE; TEMPERATURE; EMULSION
0844 DEGRADATION; BACTERIA; OXIDATION
0855 DEGRADATION; OIL; BIODEGRADATION; ENVIRONMENTAL FACTORS; ENERGY; BACTERIA; BUNKER C; CHEDABUCTO BAY; ARROW SPILL
0804 DEGRADATION; CRUDE OIL; MARINE ENVIRONMENT; ZOOPLANKTON; PHOTOCHEMICAL OXIDATION; SOLUBILITY; DISPERSION
0742 DEGRADATION; TEMPERATURE; BUNKER C; NOCARDIA; RATE LIMITING FACTORS
0828 DEGRADATION; BACTERIA; ESTUARY; BEACH; FUEL OIL; ENRICHMENT; RATE; NARRAGANSET BAY; HYDROCARBON CONCENTRATION; SEDIMENTS; MIGRATION
0741 DEGRADATION; BACTERIA; DISTRIBUTION; NORTHWEST ATLANTIC; COASTAL SEDIMENTS
0829 DEGRADATION; REVIEW; INPUT; FATE

0895 DEGRADATION; CELL MEMBRANES; AMOEBA; OIL; EMULSIFIERS; NARCOSIS; CYTOLOGY; BACTERIAL
0947 DEGRADATION; TORREY CANYON SPILL; ZOOPLANKTON; BACTERIA; LITTORAL; SUBLITTORAL; CLEAN UP
0939 DEGRADATION; BACTERIA; SELECTIVITY
0955 DEGRADATION; SALT MARSH; PLANTS; WEATHERED OIL; GAS EXCHANGE; RETENTION; BRITTANY; TORREY CANYON
0935 DEGRADATION; CRUDE OIL; LAKES; ARCTIC; MACKENZIE DELTA; WATER COLUMN; SEDIMENTS; ZOOBENTHOS
1051 DEGRADATION; CLADOSPORIUM; OXYGEN CONSUMPTION; COOXIDATION; TOLUENE; XYLENE; HEXADECANE
0997 DEGRADATION; POTENTIAL; SEAWATER; CHRONIC POLLUTION; BACTERIA; PETROLEUM HYDROCARBONS; SALINITY
1056 DEGRADATION; BACTERIA; FUNGUS; CLADOSPORIUM; WATER; SEDIMENTS; CHESAPEAKE BAY; HYDROCARBON CONCENTRATION
0988 DEGRADATION; POLNUCLEAR AROMATIC HYDROCARBONS; BENZOPYRENE; CARCINOGENSIS; SYNTHESIS; DISTRIBUTION
0984 DEGRADATION; BACTERIA; SOIL
1058 DEGRADATION; SOUTH LOUISIANA CRUDE; MASS SPECTROMETRY
1057 DEGRADATION; WATER; SEDIMENTS; CHESAPEAKE BAY; CLADOSPORIUM
1064 DEGRADATION; BACTERIA; SEDIMENTS; CHESAPEAKE BAY
1052 DEGRADATION; GROWTH POTENTIAL; BACTERIA; SEDIMENTS; NORTH ATLANTIC
1020A DEGRADATION; BACTERIA; LOW TEMPERATURE
1050 DEGRADATION; BACTERIA; MOTOR OIL; TREATMENT EFFLUENT; DISTRIBUTION; WATER COLUMN; SEDIMENTS
1036 DEGRADATION; BACTERIA; METABOLIC PATHWAYS
1055 DEGRADATION; FUNGUS; CLADOSPORIUM; OXIDIZING SYSTEM; PATHWAYS-METABOLIC; PESTICIDES; RADIOACTIVE TRACER EXPERIMENTS
1028 DEGRADATION; BUNKER C; SANDY BEACH; DISPERSION; SAN FRANCISCO; SAN FRANCISCO SPILL; BACTERIAL POPULATION &DIVERSITY
1110 DEGRADATION; BACTERIA; METHODS; RELATIVE OXIDIZABILITY; ASSUMLATION
1067 DEGRADATION; BACTERIA; SEDIMENTS; DEEP SEA; INORGANIC NUTRIENTS; GROWTH POTENTIAL
1109 DEGRADATION; BACTERIA; REVIEW
1114 DEGRADATION; CARCINOGENESIS; HYDROCARBONS; INPUT; METABOLISM; SYNTHESIS; BACTERIA
1111 DEGRADATION; REVIEW; MARINE OIL POLLUTION; INPUTS; FATES; BACTERIA
1113 DEGRADATION; CRUDE OIL; BACTERIA; YEAST; FUNGI; SUBSTRATE; DISTRIBUTION
0299 DEHYDRATION; BIRDS; MALLARDS; CRUDE OIL; PHYSIOLOGY; ANAS; MUCOSAL TRANSFER RATE; DISPERSANTS; INTESTINAL ABSORPTION
1091 DELAYED EFFECTS; DISPERSANT; TOXICITY; FISH; LARVAE; HERRING; PILCHARD; PLAICE; SOLE; LEMON SOLE; HADDOCK; BP1002; EMBRYOLOGY; BEHAVIORAL CHANGES
0548 DENMARK; BIRDS; MORTALITIES
0659 DEPOSITION; FISH; TAINTING; SEAWEED; PHENOLS; OILS; DETERGENTS
0361 DEPTH; CRUDE OIL; RED SEA; MACROFAUNA; TOXICITY; SUBLETHAL EFFECTS; PHYSIOLOGY; METABOLISM; BEHAVIOR; DISPERSANT
0360 DEPTH; TOXICITY; RABBIT FISH; CRUDE OIL; SIGANUS; DISPERSANT; STATIC ASSAY; FLOW THROUGH ASSAY; SALINITY
0553 DEPTH; CRUDE OIL; SAND; MICROBIAL DEGRADATION; OXYGEN AVAILABILITY
0260 DEPTH PROTECTION EFFECTS; CRUDE OIL; TOXICITY; CORALS; HETEROXENIA; RED SEA; SUBLETHAL EFFECTS; HYDROCARBON CONTENT ANALYSIS
0288 DEPURATION; HYDROCARBON CONCENTRATIONS; NAPHTHALENE; SHRIMP; CLAMS; OYSTERS; SEDIMENT; FUEL OIL#2

0333 DEPURATION; MUSSELS; MYTILUS; HYDROCARBON CONTENT; MONITOR; UPTAKE
0287 DEPURATION; FUEL OIL#2; SHRIMP; UPTAKE; MOUTHLY GROWTH
0355 DEPURATION; MYTILUS; MUSSELS; UPTAKE; BIOGENIC; PETROLEUM; AROMATICS; KIEL BIGHT
0278 DEPURATION; HYDROCARBONS; ZOOPLANKTON; FISH; TOXICITY; TAINTING; BEHAVIOR; UPTAKE; METABOLISM; ACCUMULATION
0254 DEPURATION; MYTILUS; UPTAKE; MUSSELS; HYDROCARBON CONTENT; PARAFFINS; PETROLEUM; TIDES
0277 DEPURATION; COPEPOD; UPTAKE; NAPHTHALENE; METABOLISM; CALANUS; FOOD WEB; WATER SOLUBLE FRACTION; DIETARY ROUTE OF ENTRY; RADIOACTIVE TRACERS
0410 DEPURATION; CLAM; RANGIA; NAPHTHALENES; TRINITY BAY, TEXAS; OIL SEPARATOR PLATFORM; UPTAKE; SEDIMENTS; HYDROCARBON ANALYSIS; GAS CHROMATOGRAPHY
0486 DEPURATION; RETENTION; COPEPOD; ZOOPLANKTON; CALANUS; EURYTEMORA; UPTAKE
0399 DEPURATION; HYDROCARBONS; CONTENT ANALYSIS; TEMPERATURE; MUSSELS; MYTILUS; LAGOON OF VENICE, ITALY
0400 DEPURATION; MYTILUS; UPTAKE; HYDROCARBON CONTENT ANALYSIS; PHYSIOLOGICAL STRESS; BIOLOGICAL MONITOR; MUSSELS; ACCUMULATION
0612 DEPURATION; METABOLISM; UPTAKE; RADIOACTIVE TRACERS; REVIEW
0611 DEPURATION; MYTILUS; CONTENT ANALYSIS; UPTAKE; RETENTION; MUSSEL; RADIOACTIVE TRACERS; AROMATIC HYDROCARBONS; PARAFFINS
0608 DEPURATION; ZOOPLANKTON; BENZPYRENE; UPTAKE; PACIFIC COAST; ARCTIC; AROMATIC HYDROCARBONS; NAPTHALENE; RADIOACTIVE TRACERS; CALANUS
0727 DEPURATION; BARNACLES; TAR BALL; CONTENT ANALYSIS; METABOLISM; UPTAKE
0816 DEPURATION; COMMUNITIES; ROCKY SHORES; DETERGENTS; NORMANDY, FRANCE; RECOVERY; MUSSELS
0758 DEPURATION; CLAMS; UPTAKE; CONTENT ANALYSIS; CRUDE OIL; FUEL OIL #2; SOLUBLE FRACTIONS; GAS CHROMATOGRAPHY
0759 DEPURATION; BENZ(A)PYRENE; UPTAKE; DISTRIBUTION; RADIO ASSAY; RANGIA; CLAMS
0881 DEPURATION; POLYCHAETE; NEANTHES; RADIOACTIVE TRACER EXPERIMENT; UPTAKE; RETENTION; METABOLISM; WATER SOLUBLE FRACTION; WATER; SEDIMENT; DETRITUS
0957 DEPURATION; OYSTER; CHRONIC EXPOSURE; PHSIOLOGICAL EFFECTS; RETENTION; CRASSOSTREA
0943 DEPURATION; NAPTHALENE; WATER SOLUBLE FRACTION; CHLAMYDOMONAS; PHOTOSYNTHESIS; GREEN ALGAE; UPTAKE
1004 DEPURATION; OYSTER; CRASSOSTREA; UPTAKE; RETENTION; PETROLEUM HYDROCARBONS
1002 DEPURATION; SHRIMP; TOXICITY; CONTENT ANALYSIS; CRUDE OIL; FUEL OIL #2; BUNKER C; PALAEMONETES; TEMPERATURE; BENZENE; PHENOL; NAPHTHALENE
0960 DEPURATION; OYSTER; CRASSOSTREA; UPTAKE; RETENTION; PETROLEUM FRACTIONS; LIPIDS; FAT CONTENT; METABOLISM
1161 DEPURATION; POLYNUCLEAR AROMATIC HYDROCARBONS; ESTUARINE; UPTAKE; RETENTION; BENTHIC ORGANISMS; SHELLFISH; BENZOPYRENE
1133 DEPURATION; FUEL OIL; CRASSOSTREA; QUAHOG; ESTUARINE; ALIPHATICS; MERCENARIA; CLAMS; OYSTERS; UPTAKE; RETENTION
1125 DEPURATION; REVIEW; SUBLETHAL EFFECTS; TOXICITY; UPTAKE; RETENTION; METHODS OF DETECTION OF HC'S IN ORGANISM; BIOINDICATORS
1137 DEPURATION; AUSTRALIA; UPTAKE; RETENTION; GAS CHROMATOGRAPHY; MYTILUS; MUSSEL; EFFECT ON ECOSYSTEM; BIOINDICATORS; TOXICITY

1143 DEPURATION; SOFT-SHELL CLAM; FUEL OIL; UPTAKE; RETENTION; BURROWING; MORTALITY; SEARSPORT-MAINE
1212 DEPURATION; SHRIMP; LARVAL GROWTH; UPTAKE; FUEL OIL #2; HATCHING SUCCESS; BEHAVIORAL EFFECTS
1175 DEPURATION; CRUDE OIL; ALGAE; ZOOPLANKTON; CRUSTACEANS; POLYCHAETES; MOLLUSCS; FISH; UPTAKE; RETENTION; REVIEW; BENTHIC ORGANISMS
1206 DEPURATION; CLAM; MYA; FUEL OIL #2; UPTAKE; RETENTION
0715 DESULFOVIBRIO; CORAL; PLATIGYRA; BACTERIA; STRESS; CRUDE OIL; MUCUS PRODUCTION; BEGGIATOA
0812 DETECTION; MIXED FUNCTION OXIDASES; ARYL HYDROCARBON HYDROXYLASE; PETROLEUM HYDROCARBON; METABOLISM; MONITORS; INVERTEBRATES; FISH
0227 DETERGENT; TOXICITY; STRIPED BASS; TRICON OIL SPILL ERADICATOR; ROCCUS
0359 DETERGENT; CRUDE OIL; OCTOCORALS; CRUSTACEANS; MOLLUSCS; ECHINODERMS; FISH; TOXICITY; SUBLETHAL; DEVELOPMENTAL STAGES; RED SEA; FEEDING RATE; PHYSIOLOGY; BIOACCUMULATION; LIVER ENLARGEMENT; HEMATOCRIT
0313 DETERGENT; OIL; REPRODUCTION
0311 DETERGENT; OLEOPHILIC "FLUFF"; OIL; TOXICITY; PORCELAIN CRAB; MECHANISM OF ACTION; BP1100
0513 DETERGENT; TORREY CANYON; LIMPETS; PLANKTON; FISHERIES; BIRDS; CRAIE DE CHAMPAGNE
0606 DETERGENT; TOXICITY; PLANKTON; COREXIT; CRANGON
0627 DETERGENT; CRUDE OIL; CORAL; TOXICITY
0798 DETERGENT; TORREY CANYON SPILL; OIL; INTERTIDAL; CORNWALL, ENGLAND
0930 DETERGENT; TORREY CANYON SPILL; TOXICITY; SEA COMMUNITIES; SHORE COMMUNITIES; CRUDE OIL
0972 DETERGENT; OIL; RECOLONIZATION; SETTLEMENT; ARTIFICAL SUBSTRATE
1090 DETERGENT; BP1002; SABELLARIA; LARVAE; TOXICITY; SUBSTRATE ABSORPTION
1093 DETERGENT; FISH; SOLE; PLAICE; HERRING; LARVAE; DEVELOPMENTAL ABNOMALITIES; BP1002; FINASOL; COREXIT
1089 DETERGENT; LONG TERM EFFECTS; LARVAE; SABELLERIA; TOXICITY
0043 DETERGENTS; TORREY CANYON; SINKING OIL; CLEANUP OF OIL SPILLS
0155 DETERGENTS; ALGAE; INTERTIDAL; SHORT TERM EFFECTS; LONG TERM EFFECTS; LITTORIAL COMMUNITY
0197 DETERGENTS; NUCELLA LAPILLUS; RESISTANCE; MORTALITY; POPULATION RECOVERY; RECOLONIZATION; ROCKY SHORE; LITTORAL
0283 DETERGENTS; MILFORD HAVEN; SALT MARSH; ROCKY SHORE; RECOVERY; EMULSIFIERS; CHRONIC EXPOSURE
0279 DETERGENTS; BARNACLES; TOXICITY; BEHAVIOR; LARVAE; BP1002; DASIC; ELMINIMS; SOLVENT; SURFACTANT
0438 DETERGENTS; OIL FRACTIONS; CELL MEMBRANE; AMOEBA
0659 DETERGENTS; FISH; TAINTING; SEAWEED; PHENOLS; OILS; DEPOSITION
0695 DETERGENTS; SHRIMP; TOXICITY; CRUDE OIL; PALEOMONETES; PENAEUS
0660 DETERGENTS; BP1002; ELECTROPHORESIS; ENZYNES; PROTEINS
0838 DETERGENTS; TOXICITY; SHORE CRAB; CARCINUS; BROWN SHRIMP; CRAGON; LARVAE; FISH
0822 DETERGENTS; LITTORINA; NUCELLA; BUCINNUM; GROWTH; MORTALITY; BP1002; TARSOLVENT
0816 DETERGENTS; COMMUNITIES; ROCKY SHORES; NORMANDY, FRANCE; RECOVERY; MUSSELS; DEPURATION
0763 DETERGENTS; REVIEW; MARINE LIFE
0924 DETERGENTS; OIL; SHELLFISH; TOXICITY; CLEAN UP PROCEDURES; TAINTING
1021 DETERGENTS; PHYTOPLANKTON; GROWTH

1069 DETERGENTS; TORREY CANYON SPILL; BIRDS; TOXICITY; INTERTIDAL; CHALK
0343 DETERMINATION TECHNIQUES; BENZO(A)PYRENE; CARCINOGENS; MONITORING; TISSUES; SEDIMENT; POLYCYCLIC AROMATICS; THIN-LAYER
1074 DETERMINATION TECHNIQUES; ALIPHATIC; AROMATIC; MARINE ORGANISMS; ETHER EXTRACTION; SILICA GEL CHROMATOGRAPHY; GAS CHROMATOGRAPHY; MASS SPECTROMETRY
0881 DETRITUS; POLYCHAETE; NEANTHES; RADIOACTIVE TRACER EXPERIMENT; UPTAKE; RETENTION; METABOLISM; DEPURATION; WATER SOLUBLE FRACTION; WATER; SEDIMENT
0522 DETROIT RIVER; WATERFOWL
0014 DEVELOPMENT; WATER SOLUBLE FRACTION; SEA URCHIN; FERTILIZATION; EGGS
0218 DEVELOPMENT; DISPERSANTS; OIL; FISH; SEA URCHINS; FERTILIZATION; TOXICITY; COREXIT
0337 DEVELOPMENT; PETROLEUM; TOXICITY; BARNACLES; LARVAE; PHOTOTAXIS
0370 DEVELOPMENT; FUNDULUS; FUEL OIL#2; WATER SOLUBLE FRACTION; HATCHING; HISTOPATHOLOGY
0592 DEVELOPMENT; CRUDE OIL; PETROLEUM FRACTIONS; HERRING; HATCHING; TOXICITY; EMULSIFICATION
0508 DEVELOPMENT; CRASSOSTREA; OYSTER; MERCENARIA; CLAM; SURFACTANT; LARVAE; GROWTH; SURVIVAL; TOXICITY
0596 DEVELOPMENT; EGGS; LARVAE
0634 DEVELOPMENT; DISPERSANTS; EGGS; SEA URCHIN; FISH; FERTILIZATION
0704 DEVELOPMENT; TOXICITY; FISH; PETROLEUM; EUGRAULIS; SCORPAENA; CRENILABRUS; BLACK OIL; SOLAR OIL
0635 DEVELOPMENT; OIL; DISPERSANTS; COREXIT; SEA URCHIN; FISH; EGGS; EMBRYO; FERTILIZATION
0884 DEVELOPMENT; FUEL OIL #2; NAPHTHALENE; ANNELIDS; POLYCHAETE; NEANTHES; UPTAKE &DEPURATION; MALE; FEMALE; EGGS; LARVAE
0864 DEVELOPMENT; DISPERSANT; SHELLFISH; LARVAE; SPERMATOZOA; TOXICITY; BIVALVES; OYSTERS; CRASSOSTREA; MUSSEL; FERTILIZATION
0994 DEVELOPMENT; SURFACTANTS; FISH; CRUSTACEANS; BIVALVES; TOXICITY; BEHAVIOR; ACTIVITY; BYSSUS THREAD; MOULTING
1154 DEVELOPMENT; ZOOPLANKTON; COPEPODS; NAPHTHALENE; AROMATIC HYDROCARBONS; PHYSIOLOGICAL EFFECTS; RETENTION
1093 DEVELOPMENTAL ABNOMALITIES; FISH; SOLE; PLAICE; HERRING; LARVAE; DETERGENT; BP1002; FINASOL; COREXIT
0865 DEVELOPMENTAL ABNORMALITIES; BIVALVES; TOXICITY; SPERMATOZOA; FERTILIZATION; PRUDHOE BAY CRUDE; KUWAIT CRUDE; NIGERIAN CRUDE
0359 DEVELOPMENTAL STAGES; CRUDE OIL; DETERGENT; OCTOCORALS; CRUSTACEANS; MOLLUSCS; ECHINODERMS; FISH; TOXICITY; SUBLETHAL; RED SEA; FEEDING RATE; PHYSIOLOGY; BIOACCUMULATION; LIVER ENLARGEMENT; HEMATOCRIT
0845 DIATOM; OIL; ALGAE; DINOFLAGELLATE; DUNALIELLA; FRAGILARIA; AXENIC CULTURES; GROWTH RATES
0848 DIATOM; CRUDE OIL; SOUTH LOUISIANA CRUDE; KUWAIT CRUDE; FUEL OIL#2; GROWTH RATE; PHOTOSYNTHESIS; MICROALGAE-TOXICITY; BLUE GREEN; DINOFLAGELLATE
0964 DIATOM; NAPHTHALENE; TOXICITY; PHOSPHORUS; SYNERGISM
0063 DIATOMS; MICROBIAL POPULATIONS; PROTOZOANS; BLUE GREEN ALGAE; DEGRADATION; YEAST; SPECIES DIVERSITY; GREEN ALGAE; NATURAL SEEPAGE; PRUDHOE CRUDE OIL; ARCTIC; ALASKA-PRUDHOE BAY; CAPE SIMPSON; NUTRIENT ENRICHMENT
0411 DIATOMS; REVIEW; SPREADING OF OIL; GASEOUS EXCHANGE; TOXICITY; TAINTING; OYSTERS; BLEED WATER; OFFSHORE DRILLING
0938 DIATOMS; SUBSTRATE SELECTION; TOXICITY OF END PRODUCTS;

DINOFLAGELLATES

1013 DIATOMS; ESTUARINE; GAS CHROMATOGRAPHY; SELECTIVE ABSORPTION

1094 DIATOMS; FUEL OIL #2; ALGAE; TOXICITY; PHENALEN-1-ONE; WAVELENGTH DEPENDENT; ALGAE-BLUE GREEN; ALGAE -GREEN

1131 DIATOMS; MICROFLORA; PHYTOPLANKTON; ALGAE; CRUDE OIL; FUEL OIL; TOXICITY; NAPHTHALENE; PHENANTHRENE; AROMATICS; ALGAE-GREEN; ALGAE-BLUE GREEN; GROWTH

1174 DIATOMS; ESTUARIES; CANADA; SAENICH INLET; CRUDE OIL; FUEL OIL; BIODEGRADATION; PHYTOPLANKTON; CEPEX

0236 DIESEL FUEL; PELAGIC LARVAE; ENCHINODERMATA; ANNELIDA; ARTHROPODA; TOXICITY; SYMPTOMS

0645 DIESEL FUEL; TROUT; TAINTING; SALMON

0906 DIESEL FUEL; FISH; PERIPHYTON; SEDIMENTS; STREAM; BOONE CREEK OIL SPILL; MACROINVERTEBRATES; HYDROCARBON ANALYSIS; SOUTH CAROLINA

0962 DIESEL FUEL, MARINE; TOXICITY; LONG TERM EFFECTS; INTERTIDAL; GASTROPODS; BIVALVES; ROCKY SHORE; FAUNA; LAMMA IS.; HONG KONG; DISPERSANTS; RECOVERY

0858 DIESEL MARINE; CRUDE OIL; CORAL; PANAMA; BUNKER C; TOXICITY; METABOLISM; FEEDING

0235 DIESEL OIL; ANACORTES; INTERTIDAL; INVERTEBRATES; MORTALITIES

0322 DIESEL OIL; ALGAE; GROWTH; EUGLENA; SCENEDESMUS; LUBRICATING OILS; PHOTOSYNTHETIC METABOLISM

0707 DIESEL OIL; OIL POLLUTION; FLORA; FAUNA; BLACK SEA; CRUDE OIL

0851 DIESEL OIL; OIL SPILL INCIDENT; DECEPTION BAY QUEBEC; GASOLINE; MYTILUS; FUCUS

0802 DIESEL OIL; BIOGENIC VS.PETROLEUM HYDROCARBON; LOBSTER; CHROMATOGRAPHY

0892 DIESEL OIL; PANAMA; S.S. WITWATER SPILL; TROPICS; INTERTIDAL; TERRESTRIAL PLANTS; LITTORAL; MANGROVE; REEF; MEIOFAUNA; SEA TURTLES; BIRDS; BUNKER C

1098 DIESEL SPILL; HONG KONG; MEIOFAUNA; SANDY BEACHES; INTERTIDAL; NEMATODES; HARPACTICOID COPEPODS

0277 DIETARY ROUTE OF ENTRY; COPEPOD; UPTAKE; DEPURATION; NAPHTHALENE; METABOLISM; CALANUS; FOOD WEB; WATER SOLUBLE FRACTION; RADIOACTIVE TRACERS

0905 DIFFUSION RATES; CRUDE OIL; PHOTOSYNTHESIS; ALGAE

0055 DIMETHYLNITROSAMINE -DEMETHYLASE; POLYNUCLEAR AROMATIC HYDROCARBONS; METABOLISM; ENZYME REPRESSION

0848 DINOFLAGELLATE; CRUDE OIL; SOUTH LOUISIANA CRUDE; KUWAIT CRUDE; FUEL OIL#2; GROWTH RATE; PHOTOSYNTHESIS; MICROALGAE-TOXICITY; BLUE GREEN; DIATOM

0845 DINOFLAGELLATE; OIL; ALGAE; DUNALIELLA; DIATOM; FRAGILARIA; AXEMIC CULTURES; GROWTH RATES

0938 DINOFLAGELLATES; SUBSTRATE SELECTION; TOXICITY OF END PRODUCTS; DIATOMS

0679 DIOGENES; DISPERSANTS; TOXICITY; FISH; SHRIMP; COREXIT; SUB-TROPICAL; CENTROPOGON; PALEOMONOTES; AMBASSIS

0806 DIPTERA; CHRONIC CONTAMINATION; AQUATIC ORGANISMS; FLIES; BIBLIOGRAPHY

0395 DIRECTORY; POLLUTION RESEARCHERS

0782 DIRECTORY

0932 DIRECTORY; BIBLIOGRAPHIES; POLLUTION MONITORING

0536 DIRECTORY-OCEAN WASTE DISPOSAL; BIBLIOGRAPHY

0394 DIRECTORY-POLLUTION RESEARCHES

0613 DISCHARGE; FISH; NAPTHALENE; BENZ(A)PYRENE; RADIOACTIVE TRACER; UPTAKE; METABOLISM; SCULPIN; OLIGOCOTTUS; GOBY; GILLICHTHYS; SAND DAB; CITHARICHTHYS
0482 DISCRIMINATION; FISH; ASSIMILATION; ALKANES; COD; HYDROCARBON CONTENT ANALYSIS
0859 DISCRIMINATION; FEEDING BEHAVIOR; COELENTERATA; RETENTION; PALYTHOA; CHEMORECEPTION; MARINE DIESEL; BUNKER C
0651 DISEASE INCIDENCE; OYSTER; CRASSOSTREA; LOUISIANA; OIL SPILL; MORTALITY; GROWTH; SET; TAINTING
0013 DISPERANTS AND EMULSIFIERS; WATERFOWL RESTORATION; TOXICITY; REVIEW-OIL SPILLS; AERIAL SURVEYS
0698 DISPERSAL; BIODEGRADATION
0024 DISPERSANT; CONFERENCE; TOXICITY; ECOLOGICAL EFFECTS
0362 DISPERSANT; CRUDE OIL; TOXICITY; STONY CORAL
0357 DISPERSANT; DRUPA GRANULATA; MYTILUS; PREDATION RATE; FECUNDITY; SUBLETHAL; CRUDE OIL; MUSSELS; RED SEA
0361 DISPERSANT; CRUDE OIL; RED SEA; MACROFAUNA; TOXICITY; DEPTH; SUBLETHAL EFFECTS; PHYSIOLOGY; METABOLISM; BEHAVIOR
0358 DISPERSANT; MACROFAUNA; RED SEA; TOXICITY; CRUDE OIL; CORAL; HETEROXENIA; GASTROPODS; MUSSELS; CHITON; SEA URCHIN; HERMIT CRAB; SHRIMP; GOATFISH; RABBITFISH
0360 DISPERSANT; TOXICITY; RABBIT FISH; CRUDE OIL; DEPTH; SIGANUS; STATIC ASSAY; FLOW THROUGH ASSAY; SALINITY
0484 DISPERSANT; LITTORINA; SUBLETHAL EFFECTS; BUNKER C; RESPIRATION; COREXIT; CRAWLING RATES
0864 DISPERSANT; SHELLFISH; LARVAE; SPERMATOZOA; TOXICITY; BIVALVES; OYSTERS; CRASSOSTREA; MUSSEL; FERTILIZATION; DEVELOPMENT
1091 DISPERSANT; TOXICITY; FISH; LARVAE; HERRING; PILCHARD; PLAICE; SOLE; LEMON SOLE; HADDOCK; BP1002; DELAYED EFFECTS; EMBRYOLOGY; BEHAVIORAL CHANGES
0108 DISPERSANTS; TOXICITY OF DISPERSANTS; CLEANUP AGENTS
0118 DISPERSANTS; TOXICITY; OIL
0073 DISPERSANTS; CRUDE OIL; BIVALVES
0217 DISPERSANTS; TOXICITY; BIODEGRADATION; BIRDS; OXYGEN TRANSPORT
0244 DISPERSANTS; BIRDS; MORTALITIES; BEACH SURVEYS; POPULATION; CHRONIC SPILLAGE; TREATMENT
0218 DISPERSANTS; OIL; FISH; SEA URCHINS; FERTILIZATION; DEVELOPMENT; TOXICITY; COREXIT
0299 DISPERSANTS; BIRDS; MALLARDS; CRUDE OIL; PHYSIOLOGY; ANAS; DEHYDRATION; MUCOSAL TRANSFER RATE; INTESTINAL ABSORPTION
0294 DISPERSANTS; TOXICITY; BP1002; RECOVERY ASSESSMENT
0296 DISPERSANTS; CHRYSSI P. GOULANDRIS SPILLAGE; TOXICITY; FINA NOVAGE SPILLAGE; TORREY CANYON SPILL; GULF REFINERY SPILL
0420 DISPERSANTS; CLEAN-UP; MORTALITIES; INTERTIDAL; THAMES ESTUARY, ENGLAND
0424 DISPERSANTS; OIL; TOXICITY; POLYCHAETE; GAMETE FORMATION; SPAWNING; GROWTH; MORTALITY; CIRRATULUS; CIRRIFORMIA; BP1002; COREXIT; ESSOLVENE
0475 DISPERSANTS; COREXIT 9527; SEA URCHIN; FERTILIZATION
0418 DISPERSANTS; CRUDE OIL; BIODEGRADATION; ECOSYSTEMS
0590 DISPERSANTS; REVIEW; NORTH SEA; FISH STOCKS; TAINTING
0604 DISPERSANTS; OIL; TOXICITY; METHODOLOGY; BIOASSAY
0594 DISPERSANTS; CRUDE OIL; FISH FRY; COD; GADUS; HERRING; CLUPEA; TOXICITY; EMBRYOLOGY; CHEMORECEPTION
0634 DISPERSANTS; EGGS; SEA URCHIN; FISH; FERTILIZATION; DEVELOPMENT

0635 DISPERSANTS; OIL; COREXIT; SEA URCHIN; FISH; EGGS; EMBRYO; FERTILIZATION; DEVELOPMENT
0629 DISPERSANTS; TOXICITY; CRUDE OIL; LARVAE; HERRING; CULPEA
0679 DISPERSANTS; TOXICITY; FISH; SHRIMP; COREXIT; SUB-TROPICAL; CENTROPOGON; DIOGENES; PALEOMONOTES; AMBASSIS
0633 DISPERSANTS; EMBRYOLOGY; SEA URCHIN; OIL; COREXIT; ULTRASTRUCTURE
0772 DISPERSANTS; REVIEW; INPUT; FATE; BIOLOGICAL EFFECTS; CLEANUP; OIL
0784 DISPERSANTS; EVALUATION; EFFECTIVNESS; TOXICITY; BIOASSAY; BOD; THRESHOLD ODOR
0790 DISPERSANTS; SANTA BARBARA SPILL; PRODUCTIVITY; PHYTOPLANKTON; OIL
0824 DISPERSANTS; BP1100X; SHELL DISPERSANT LT; FAUNA
0946 DISPERSANTS; COREXIT; OIL; TOXICITY
0915 DISPERSANTS; TOXICITY; TAINTING; FISHERIES; TESTING PROCEDURES; STATIC; FLOW THROUGH; BIOASSAY
0889 DISPERSANTS; TOXICITY; BIODEGRADABILITY
0916 DISPERSANTS; REVIEW; TYPES OF OILS; WEATHERING; TOXICITY; FISHERIES; MARINE ENVIRONMENT
0948 DISPERSANTS; OIL SPILL INICIDENT; PERSIAN GULF; MARINE FAUNA; COREXIT-7664; TARUT BAY, SAUDI ARABIA
0989 DISPERSANTS; TOXICITY; BP1002; BP1100; COCKLE-CERASTODERMA; LUGWORM-ARENICOLA; NERINE
1000 DISPERSANTS; TOXICITY; METHODOLOGY
1001 DISPERSANTS; DISPERSANTS; TOXICITY; STATIC BIOASSAY; STANDARDIZATION
0995 DISPERSANTS; EMULSIONS; TOXICITY; SUBLETHAL EFFECTS; ACTIVITY; MOTILITY; BIVALVES; CRUSTACEANS; FISH; BEHAVIOR; OIL EMULSION; CONTINUOUS FLOW; LOCOMOTION
0993 DISPERSANTS; TOXICITY; OIL; METHODOLOGY
0962 DISPERSANTS; TOXICITY; LONG TERM EFFECTS; INTERTIDAL; GASTROPODS; BIVALVES; DIESEL FUEL, MARINE; ROCKY SHORE; FAUNA; LAMMA IS.; HONG KONG; RECOVERY
1163 DISPERSANTS; CUNNER; HYPOXIA; RESPIRATION; COREXIT; BP1002; TRITON X-100; SODIUM LAURYL SULPHATE
1160 DISPERSANTS; COREXIT; CRUDE OIL; ARCTIC; PHYTOPLANKTON; PRODUCTIVITY; ALGAE
1092 DISPERSANTS; TOXICITY; METHODOLOGY
1192 DISPERSANTS; AMPHIPODS; ONISIMUS; RESPIRATION; TOXICITY; PHYSIOLOGICAL EFFECTS
1180 DISPERSANTS; BIODEGRADATION; CRUDE OIL
1216 DISPERSANTS; ALGAE; PORPHYRA; GROWTH; TOXICITY
1040 DISPERSED OIL; OIL; TOXICITY; EFFECTS; MARINE BIOTA
0464 DISPERSION; SEDIMENTS; SAN FRANCISCO; DISSOLUTION; WEATHERING; MICROBIAL DEGRADATION; BUNKER C; SAND COLUMN DISTRIBUTION
0804 DISPERSION; CRUDE OIL; DEGRADATION; MARINE ENVIRONMENT; ZOOPLANKTON; PHOTOCHEMICAL OXIDATION; SOLUBILITY
0860 DISPERSION; BIODEGRADATION; ARTHROBACTER; BACTERIA
1032 DISPERSION; FUEL OIL#2; INTERTIDAL COLONIES; SPECIES DIVERSITY; RELATIVE ABUNDANCE; NUMBERS OF SPECIES; INDIVIDUAL FREQUENCY OCCURANCE PATTERNS
1028 DISPERSION; BUNKER C; SANDY BEACH; DEGRADATION; SAN FRANCISCO; SAN FRANCISCO SPILL; BACTERIAL POPULATION &DIVERSITY
1079 DISPERSIONS; LOBSTER; HOMARUS; LARVAE; TOXICITY; BEHAVIOR; GROWTH; VENEZUELA CRUDE OIL; FOOD CONSUMPTION
0257 DISPOSAL; KELP; EFFLUENT; MACROCYSTIS
0464 DISSOLUTION; SEDIMENTS; SAN FRANCISCO; DISPERSION; WEATHERING; MICROBIAL DEGRADATION; BUNKER C; SAND COLUMN DISTRIBUTION

0885 DISSOLVED HYDROCARBONS; FUEL OIL # 2; WATER SOLUBLE FRACTION; NEANTHES; POLYCHAETE; HEMOGLOBIN; HYPOXIA; SOUTH LOUISIANA CRUDE; DISSOLVED OXYGEN; TOXICITY; SYNERGISM; NAPHTHALENES; RESPIRATION

1083 DISSOLVED ORGANIC CARBON; SALT MARSH; SEDIMENTS; MICROBIAL DEGRADATION; METABOLISM

0150 DISSOLVED ORGANIC MATTER(DOM); CLAMS; MERCENARIA; FILTER-FEEDING; UPTAKE; FUEL OIL#2

0885 DISSOLVED OXYGEN; FUEL OIL # 2; WATER SOLUBLE FRACTION; NEANTHES; POLYCHAETE; HEMOGLOBIN; HYPOXIA; SOUTH LOUISIANA CRUDE; TOXICITY; SYNERGISM; NAPHTHALENES; DISSOLVED HYDROCARBONS; RESPIRATION

0996 DISSOLVED OXYGEN; SHAD; ALOSA; TOXICITY; PETROLEUM PRODUCTS; SYNERGISM; GASOLINE; FUEL OIL; BUNKER OIL

0206 DISSOLVED PHASE; ARCTIC; BIODEGRADATION; RADIOACTIVE TRACER; GEOGRAPHIC DISTRIBUTION; EFFECT OF CLAY PARTICLES ON RATE; ENUMERATION; RATE

0401 DISTANCE FROM POLLUTION SOURCE; MUSSEL; MYTILUS; LAGOON OF VENICE, ITALY; HYDROCARBON CONTENT ANALYSIS; GAS CHROMATOGRAPHY; EXCHANGE WITH SEA

0648 DISTICHLIS; CRUDE OIL; SALT GRASS

1038 DISTILLATE FRACTIONS; ALGAE; PHYSIOLOGY; HYDROCARBONS PETROLEUM; REVIEW; NAPHTHALENE; PHOTOSYNTHESIS; ATP; CRUDE OIL

1141 DISTILLATES; TAINTING; HADDOCK; POTATO; VASCULAR PLANTS

0068 DISTRIBUTION; ABUNDANCE; BIOINDICATOR; ENUMERATION; CRUDE OIL- SWEDEN; TEMPERATURE; LEVEL OF OIL; MICROORGANISMS; BIODEGRADATION; RARITAN BAY N.J.; GAS CHROMATOGRAPHY

0163 DISTRIBUTION; BIRDS; OIL; BREEDING; STRANDINGS; WEATHER

0364 DISTRIBUTION; RINGED SEAL; NORMAN WELLS CRUDE OIL; UPTAKE; CLEARANCE

0469 DISTRIBUTION; BIODEGRADATION; BACTERIA; OIL-OXIDIZING BACTERIA; NORTH SEA; ABUNDANCE; WATER; SEDIMENT

0746 DISTRIBUTION; HYDROCARBON ANALYSIS; FATE & EFFECT

0740 DISTRIBUTION; BIODEGRADATION; MICROORGANISMS; NORTHWESTERN ATLANTIC

0759 DISTRIBUTION; BENZ(A)PYRENE; UPTAKE; DEPURATION; RADIO ASSAY; RANGIA; CLAMS

0741 DISTRIBUTION; DEGRADATION; BACTERIA; NORTHWEST ATLANTIC; COASTAL SEDIMENTS

0833 DISTRIBUTION; BIODEGRADATION; MICROORGANISMS OXIDIZING HC'S; NEVA INLET, RUSSIA; SEASONAL DISTRIBUTION; BACTERIA

1050 DISTRIBUTION; DEGRADATION; BACTERIA; MOTOR OIL; TREATMENT EFFLUENT; WATER COLUMN; SEDIMENTS

0988 DISTRIBUTION; POLNUCLEAR AROMATIC HYDROCARBONS; BENZOPYRENE; CARCINOGENSIS; SYNTHESIS; DEGRADATION

1113 DISTRIBUTION; CRUDE OIL; DEGRADATION; BACTERIA; YEAST; FUNGI; SUBSTRATE

1115 DISTRIBUTION; BIODEGRADATION; BACTERIA; SUBSTRATE; HYDROGEN ACCEPTOR; ABSORBENTS

0334 DISTRIBUTION IN BODY; NAPHTHALENE; FUNDULUS; STRESS BEHAVIOR

0117 DIVERSITY; CHRONIC POLLUTION; ACUTE POLLUTION; PHYTOMETRIC; PHYTOSOCIALOGY

0120 DIVERSITY; TOXICITY; BENTHIC ANIMALS; INTERTIDAL; RECOVERY; YORK RIVER; BUNKER C; FUEL OIL#6

0259 DIVERSITY; BACTERIA; BUNKER C; SAN FRANCISCO; POPULATIONS; BEACHES

0511 DIVERSITY; STREAM, VIRGINIA; SEDIMENT; MACROINVERTEBRATES; POPULATIONS

0535 DIVERSITY; PHYTOPLANKTON; COMPOSITION

0689 DIVERSITY; FUEL OIL#2; WEST FALMOUTH, WILD HARBOR, MASS.;

0492 DUCKS; OIL; BIRDS; REPRODUCTION; INGESTION; HATCHABILITY; COATING
0494 DUCKS; OIL; COATING; METABOLISM; TEMPERATURE; HEAT CONDUCTIVITY
1135 DUCKS; ESTUARINE; BIRDS; FISH; CHESAPEAKE BAY; HATCHING SUCCESS; TOXICITY
1142 DUCKS; HATCHABILITY; GROWTH; AROMATICS; EFFECTS ON ORGANISMS; REPRODUCTION & DEVELOPMENT
1124 DUCKS; FISH; FUEL OIL; BUNKER C; MUSKRATS; CATTAILS; ANALYSIS FOR HYDROCARBONS; ST. LAWRENCE RIVER; MARSHES
1173 DUCKS; MALLARDS; ANALYSIS FOR HYDROCARBONS; NAPHTHALENE; PHYSIOLOGICAL EFFECTS; SOUTH LOUISIANA CRUDE OIL
1211 DUCKS; FUEL OIL #2; EIDER; EGGS; HATCHING SUCCESS; GROWTH
0350 DUNALIALLA; PHYTOPLANKTON; AMPHIDINIUM; SKELETONEMA; CRICOSPHAERA; BENZENE; TOLUENE; XYLENE; FUEL OIL#2; GROWTH
0845 DUNALIELLA; OIL; ALGAE; DINOFLAGELLATE; DIATOM; FRAGILARIA; AXEMIC CULTURES; GROWTH RATES
0505 DYNAMIC HEAD SPACE SAMPLING; HYDROCARBONS CONTENT ANALYSIS; GAS CHROMATOGRAPHY; COUPLED-COLUMN LIQUID CHROMATOGRAPHY; MASS SPECTROMETRY
0664 EAST CHINA SEA; KUROSHIO; TAR BALLS; ATTACHED ORGANISMS; BLUE GREEN ALGAE; PENNATE DIATOMS; STONY CORALS; BRYOZOANS; BARNACLES; COPEPODS
0228 ECHINODERMS; LITTORAL COMMUNITIES; FLORIDA KEYS; ROCKY PLATFORM; MANGROVE FRINGE; SEA GRASS FLATS; MANGROVE SWAMP; CRUSTACEANS; RED MANGROVE; PEARL OYSTER; BLACK MANGROVE
0359 ECHINODERMS; CRUDE OIL; DETERGENT; OCTOCORALS; CRUSTACEANS; MOLLUSCS; FISH; TOXICITY; SUBLETHAL; DEVELOPMENTAL STAGES; RED SEA; FEEDING RATE; PHYSIOLOGY; BIOACCUMULATION; LIVER ENLARGEMENT; HEMATOCRIT
0951 ECHO SOUNDING; SANTA BARBARA SPILL; FISH; POPULATION; DIVERSITY; PELAGIC; ANCHOVY; ROCKFISH
1152 ECOLOGICAL; ORGANISMS; FISHERIES; ESTUARINE; COASTAL; TOXICITY; METHODOLOGY; PETROLEUM FRACTION; CLEANING AGENTS/DISPERSANTS
0241 ECOLOGICAL CONSEQUENCES; REVIEW
0224 ECOLOGICAL DAMAGE; OCEAN EAGLE SPILL; PUERTO RICO
0557 ECOLOGICAL DAMAGE; SANTA BARBARA SPILL
0024 ECOLOGICAL EFFECTS; CONFERENCE; DISPERSANT; TOXICITY
0027 ECOLOGICAL EFFECTS; REVIEW; TRAUMATIC OIL POLLUTION; VESSEL SOURCE
0153 ECOLOGICAL EFFECTS; REVIEW; COMMUNITIES; LONG TERM EFFECTS; EFFECTS OF CLEANING; PREVENTION
1006 ECOLOGICAL EFFECTS; REVIEW; OIL; OIL DISPERSANTS
0023 ECOLOGICAL IMPACT; ASSESSMENT TECHNIQUES REVIEW; WORKSHOP; OIL SPILL STRATEGIES AND TECHNIQUES
0543 ECOLOGICAL IMPACT; PUGET SOUND
0723 ECOLOGICAL IMPACT; HYPOTHETICAL SPILLS; ATLANTIC COAST; GULF OF ALASKA
0714 ECOLOGICAL IMPACT; OIL POLLUTION; NATURAL SEEPAGES; OVERVIEW
0789 ECOLOGICAL IMPACT; OCEAN EAGLE SPILL; PUERTO RICO; CLEANUP; OVERVIEW
0850 ECOLOGICAL IMPACT; INDIA; OIL SPILL INCIDENT; COSMOS PIONEER
0797 ECOLOGICAL IMPACT; TANKER DISCHARGES
1080 ECOLOGICAL IMPACT; WEST FALMOUTH OIL SPILL 1969; WEST FALMOUTH, MASS.; FUEL OIL #2; RECOVERY
0091 ECOLOGICAL IMPACTS; SALT MARSHES; ROCKY SHORES; OIL; EMULSIFIERS; TOXICITY
0514 ECOLOGICAL IMPACTS; SANTA BARBARA SPILL; CLEANUP; BIRDS; LITTORAL COMMUNITIES; KELP BEDS

0774 ECOLOGICAL IMPACTS; OFFSHORE PRODUCTION; GEORGES BANK; MONITORING
0280 ECOLOGICAL SURVEYS; OIL SPILLS; MILFORD HAVEN
0911 ECOLOGY; OFFSHORE PRODUCTION; LOUISIANA COAST; TIMBALIER BAY; ENVIRONMENTAL IMPACT
0215 ECONOMY; TANKER SINKINGS; WW 2; WILDLIFE
0977 ECOSYSTEM; SANTA BARBARA SPILL; RECUPERATIVE CAPACITY
1177 ECOSYSTEM; PUERTO RICO; OIL SPILLS; MANGROVE; CORAL REEFS; ESTUARIES; ANALYSIS FOR HYDROCARBONS; MULLET; OYSTER; CLAM; HISTOPATHOLOGY; REVIEW
1185 ECOSYSTEM; MARSH; PETROLEUM HYDROCARBON; LOUISIANA; ANALYSIS FOR HYDROCARBON; CORDGRASS; ESTUARIES
1183 ECOSYSTEM; PLANKTON; INVERTEBRATES; BIRDS; MAMMALS; TOXICITY; REVIEW; PETROLEUM HYDROCARBONS
0187 ECOSYSTEM IMPACT; TOXICITY; ACARTIA; HYPOTHETICAL; REVIEW; NIGERIAN CRUDE
0471 ECOSYSTEM IMPACT; METULA SPILL; STRAIT OF MAGELLAN; ARABIAN LIGHT CRUDE
0895 ECOSYSTEM IMPACT; OFFSHORE DRILLING; LOUISIANA
0976 ECOSYSTEM IMPACT; FACTORS AFFECTING DEGREE OF IMPACT
0090 ECOSYSTEMS; BEHAVIOR; WALES; REFINERY EFFLUENTS
0418 ECOSYSTEMS; CRUDE OIL; DISPERSANTS; BIODEGRADATION
0857 ECOSYSTEMS; REFINERY EFFLUENT; SOUTHERN CALIFORNIA
0599 ECOTOXICOLOGY; PRIMARY PRODUCTION; CRUDE OIL; EXPERIMENTAL ECOSYSTEM
0901 EDEMA; ARGO MERCHANT SPILL; HISTOPATHOLOGY; AMMODYTES; FLOUNDER (WINTER&YELLOWTAIL); ALEWIVES; CRABS(HERMIT); HYPERPLASIA; HEMOCYTES; CILIATES
0953 EDEMA; FUEL OIL#2; SOFT SHELL CLAM; MYA; EMULSION; TISSUE ABERRATIONS; HISTOPATHOLOGY; VACUOLATION; GLYCOGEN
0787 EEL; TAINTING; GREEN FISH; FUEL OIL-BOILER; CONTENT ANALYSIS; GIRELLA; ANGULLA
0788 EELS; FISH; PARIFFINS; GAS CHROMATOGRAPHY; ARABIAN LIGHT CRUDE OIL; TAINTING; ORGANIC SULFUR
0786 EELS; TAINTING; JAPANESE COAST; FISH; GAS CHROMATOGRAPHY; IR ABSORPTION; UV ABSORPTION; MASS SPECTRUM; TOLUENE; MIZUSHIMA, JAPAN; AROMATIC HYDROCARBONS; GASOLINE
0166 EFFECT; BIRDS; OIL; REVIEW; MORTALITIES; PHYSIOLOGY
0206 EFFECT OF CLAY PARTICLES ON RATE; ARCTIC; BIODEGRADATION; RADIOACTIVE TRACER; GEOGRAPHIC DISTRIBUTION; ENUMERATION; RATE; DISSOLVED PHASE
1137 EFFECT ON ECOSYSTEM; AUSTRALIA; UPTAKE; RETENTION; DEPURATION; GAS CHROMATOGRAPHY; MYTILUS; MUSSEL; BIOINDICATORS; TOXICITY
1132 EFFECT ON ORGANISMS; TOXICITY; PETROLEUM FRACTION/CLEANING AGENT; FUCUS; COPEPODS
0784 EFFECTIVNESS; DISPERSANTS; EVALUATION; TOXICITY; BIOASSAY; BOD; THRESHOLD ODOR
0030 EFFECTS; REVIEW; LABORATORY STUDIES; MARINE ORGANISMS
0452 EFFECTS; REVIEW; CONTINENTAL SHELF; ORGANISMS
0363 EFFECTS; OIL TANKER DISCHARGES
0637 EFFECTS; REVIEW; OCCURENCE; FATE
1040 EFFECTS; OIL; DISPERSED OIL; TOXICITY; MARINE BIOTA
1112 EFFECTS; REVIEW; INPUTS; FATES
0153 EFFECTS OF CLEANING; ECOLOGICAL EFFECTS; REVIEW; COMMUNITIES; LONG TERM EFFECTS; PREVENTION
0292 EFFECTS ON INTERTIDAL COMMUNITIES; EMULSIFIERS; OIL; FIELD EXPERIMENTS; EXPERIMENTAL SPILLS; ROCKY SHORE

0455 EIDERS; BIRDS; MORTALITY; TAY ESTUARY, SCOTLAND
1042 EIDERS; BIRDS; ALCIDS; INDICATOR SPECIES; AUKS; MURRS
1144 EIDERS; BIRDS; HATCHING SUCCESS; EMBRYONIC DEVELOPMENT; GULKS; MALLARDS; PATHOLOGICAL EFFECTS; FUEL OIL; CRUDE OIL
0660 ELECTROPHORESIS; DETERGENTS; BP1002; ENZYNES; PROTEINS
0279 ELMININS; BARNACLES; TOXICITY; BEHAVIOR; LARVAE; DETERGENTS; BP1002; DASIC; SOLVENT; SURFACTANT
1100 ELMINIUS; TOXICITY; RECOVERY; SURFACTANTS; BARNACLES; NAUPLII
0635 EMBRYO; OIL; DISPERSANTS; COREXIT; SEA URCHIN; FISH; EGGS; FERTILIZATION; DEVELOPMENT
0126 EMBRYO CELLS; CARCINOGENISIS
1127 EMBRYOGENESIS; ARGO MERCHANT SPILL; FUEL OIL; HATCHING SUCCESS; MORPHOLOGY; POLLOCK; CEPHALACHORDATA; AMPHIOXUS
1182 EMBRYOGENESIS; CRUDE OIL; CRAB; SHRIMP; ALASKA; GROWTH; COOK INLET
1172 EMBRYOGENSIS; FUEL OIL #2; SYNERGISTIC EFFECTS; TEMPERATURE; SALINITY; RESPIRATION; HORSESHOE CRAB; LIMULUS
0594 EMBRYOLOGY; CRUDE OIL; FISH FRY; DISPERSANTS; COD; GADUS; HERRING; CLUPEA; TOXICITY; CHEMORECEPTION
0633 EMBRYOLOGY; SEA URCHIN; OIL; DISPERSANTS; COREXIT; ULTRASTRUCTURE
1091 EMBRYOLOGY; DISPERSANT; TOXICITY; FISH; LARVAE; HERRING; PILCHARD; PLAICE; SOLE; LEMON SOLE; HADDOCK; BP1002; DELAYED EFFECTS; BEHAVIORAL CHANGES
1144 EMBRYONIC DEVELOPMENT; BIRDS; HATCHING SUCCESS; EIDERS; GULKS; MALLARDS; PATHOLOGICAL EFFECTS; FUEL OIL; CRUDE OIL
0207 EMBRYOS; MERCENARIA; TOXICITY; LARVAE; WATER SOLUBLE FRACTION; CRUDE; REFINED; WASTE; GROWTH
0986 EMBRYOS; BENZENE; HERRING; CULPEA; SPAWNING; OVARIAN EGGS; LARVAE; BEHAVIOR; RADIOACTIVE TRACER
0330 EMBRYOTOXICITY; DUCKS; MALLARDS; ANAS; CRUDE OIL; INGESTION; EGGS
0697 EMPIRE MIX CRUDE; MULLET; ESTUARY; FIN ROT
1102 EMPIRE MIX CRUDE; MULLET; PHSIOLOGICAL EFFECT; LIVER WEIGHT; ALKALINE PHOSPHATASE; B-GLUCURONIDASE; MALIC DEHYDROGENASE; AEROBIC METABOLISM; ACETYLCHOLINESTERASE
1171 EMPIRE MIX CRUDE; BIOINDICATORS; PROTOZOA; CILIATES; EUPLOTES; SAUDI ARABIAN CRUDE; MICROFAUNA; COMMUNITY DIVERSITY EXPERIMENTS
0386 EMULSIFERS; LITTORAL ORGANISMS; BP1002; BP1100; COCKLES; POLYCHAETE; PRAWN
0592 EMULSIFICATION; CRUDE OIL; PETROLEUM FRACTIONS; HERRING; HATCHING; DEVELOPMENT; TOXICITY
0694 EMULSIFICATION; DEGRADATION; BACTERIA; PARAFFIN; CRUDE OIL; GAS CHROMATOGRAPHY
0875 EMULSIFICATION; BIODEGRADATION; MICROORGANISMS; BACTERIA; ENHANCEMENT; SEEDING
1104 EMULSIFICATION; BIODEGRADATION; BUNKER C; BACTERIA
0185 EMULSIFIER; KUWAIT CRUDE; SURFACTANT; BP 1002; LICHENS; LICHINA; CARBON FIXATION
0719 EMULSIFIER; ALGAE; PLATYMONAS; TOXICITY; GROWTH RATES; FINE STRUCTURE; NANO PLANKTON; CRUDE OIL
0767 EMULSIFIER; MICRORESPIROMETRY; TOXICITY
0821 EMULSIFIER; TOXICITY; LITTORAL; INVERTEBRATES
0929 EMULSIFIER; BRITAIN; LITTORAL COMMUNITY; TOXICITY; CRUDE OIL; MILFORD HAVEN; ESSO PORTSMOUTH SPILL; TORREY CANYON SPILL; LANDS END
1019 EMULSIFIER; PHYTOPLANKTON; TOXICITY; SKELETONMEA; NITSCHIA
0084 EMULSIFIERS; SALT MARSH PLANTS; TOXICITY; KUWAIT CRUDE
0078 EMULSIFIERS; SALT MARSH PLANTS; TOXICITIES; CRUDE OIL

0091 EMULSIFIERS; SALT MARSHES; ROCKY SHORES; OIL; ECOLOGICAL IMPACTS; TOXICITY
0056 EMULSIFIERS; REVIEW-OIL POLLUTION; LITTORAL ENVIRONMENT
0156 EMULSIFIERS; ALGAE; PRASINOLADUS; BP 1002; TOXICITY; TEMPERATURE
0283 EMULSIFIERS; MILFORD HAVEN; SALT MARSH; ROCKY SHORE; RECOVERY; DETERGENTS; CHRONIC EXPOSURE
0298 EMULSIFIERS; LITTORAL COMMUNITIES; BP1100; CHRONIC EFFLEUNT
0292 EMULSIFIERS; OIL; EFFECTS ON INTERTIDAL COMMUNITIES; FIELD EXPERIMENTS; EXPERIMENTAL SPILLS; ROCKY SHORE
0413 EMULSIFIERS; OIL; FUCUS; PLANTS; PHOTOSYNTHESIS; NET PRODUCTIVITY; METABOLISM
0423 EMULSIFIERS; MILFORD HAVEN, WALES; INTERTIDAL; LIMPETS
0469 EMULSIFIERS; BACTERIA; OIL-DEGRADING; POPULATIONS; TORREY CANYON; FIELD STUDY; BEACHES
0591 EMULSIFIERS; CRUDE OIL; TOXICITY; FRESH WATER; SALT WATER
0589 EMULSIFIERS; FISHERIES; TAINTING
0771 EMULSIFIERS; ESTUARINES; OIL POLLUTION; SPILLS; CHRONIC; SALT MARSH; ROCKY SHORE; CLEANING
0852 EMULSIFIERS; TORREY CANYON; COASTAL HABITATS; PLANTS; CORNWALL; BRITTANY
0895 EMULSIFIERS; CELL MEMBRANES; AMOEBA; OIL; NARCOSIS; CYTOLOGY; DEGRADATION; BACTERIAL
1020 EMULSIFIERS; ALGAE; BIOASSAY; TOXICITY; GROWTH; POPULATION; TISSUES; LAVER; PORPHYRA
1018 EMULSIFIERS; PHYTOPLANKTON; TOXICITY; SKELETONEMA
0398 EMULSION; SOUTH LA.CRUDE; LOBSTER; LARVAE; FLOW THROUGH SYSTEM; FEEDING; MOULTING; PIGMENTATION; HYDROCARBON ANALYSIS
0639 EMULSION; DEGRADATION; STREAMS; OXIDATION; SEDIMENTATION; OILY WASTE; TEMPERATURE
0953 EMULSION; FUEL OIL#2; SOFT SHELL CLAM; MYA; TISSUE ABERRATIONS; HISTOPATHOLOGY; EDEMA; VACUOLATION; GLYCOGEN
0205 EMULSIONS; DEGRADATION; BACTERIA; FUNGI; TOXICITY; TAINTING
0995 EMULSIONS; DISPERSANTS; TOXICITY; SUBLETHAL EFFECTS; ACTIVITY; MOTILITY; BIVALVES; CRUSTACEANS; FISH; BEHAVIOR; OIL EMULSION; CONTINUOUS FLOW; LOCOMOTION
1078 EMULSIONS; LOBSTER; TOXICITY; SUBLETHAL EFFECTS; LARVAE
0236 ENCHINODERMATA; DIESEL FUEL; PELAGIC LARVAE; ANNELIDA; ARTHROPODA; TOXICITY; SYMPTOMS
0855 ENERGY; OIL; DEGRADATION; BIODEGRADATION; ENVIRONMENTAL FACTORS; BACTERIA; BUNKER C; CHEDABUCTO BAY; ARROW SPILL
0336 ENGLAND; OLYMPIC ALLIANCE-DOVER STRAITS 1975; BIRD MORTALITY; CORMORANT; AUKS; OIL SPILL INCIDENT
0854 ENGLAND; BIRDS; OIL POLLUTION
0454 ENGLAND/SCOTLAND; BIRDS; MORTALITIES; BEACHED BIRDS COUNTS
0524 ENHANCEMENT; ARCTIC; TERRESTRIAL PLANTS; MICROBIAL DEGRADATION
0690 ENHANCEMENT; BACTERIAL DEGRADATION; SLICK-SEEDING; ADDITIVES; MICROBIAL SEEDING; BOD; TOTAL ORGANIC CARBON; NUTRIENT SALT
0791 ENHANCEMENT; BIODEGRADATION; FERTILIZER
0875 ENHANCEMENT; BIODEGRADATION; MICROORGANISMS; BACTERIA; EMULSIFICATION; SEEDING
0550 ENIWETOK ATOLL; CORAL; TOXICITY; AIR EXPOSURE; OIL
0576 ENRICHMENT; CRUDE OIL; BACTERIAL DEGRADATION; CHAIN LENGTH
0828 ENRICHMENT; DEGRADATION; BACTERIA; ESTUARY; BEACH; FUEL OIL; RATE; NARRAGANSET BAY; HYDROCARBON CONCENTRATION; SEDIMENTS; MIGRATION
0240 ENTERITIS; BIRDS; CLEANING; FEATHER WETTING; REHABILITATION

0794 ESTUARIES; CHRONIC POLLUTION; REVIEW; FIELD STUDIES;
OFFSHORE PRODUCTION; REFINERIES; SUBLETHAL EFFECTS; NATURAL SEEPS
0888A ESTUARIES; REVIEW
1049 ESTUARIES; BACTERIA; TOXICITY
1174 ESTUARIES; CANADA; SAENICH INLET; CRUDE OIL; FUEL OIL;
BIODEGRADATION; PHYTOPLANKTON; CEPEX; DIATOMS
1177 ESTUARIES; PUERTO RICO; OIL SPILLS; ECOSYSTEM; MANGROVE; CORAL REEFS;
ANALYSIS FOR HYDROCARBONS; MULLET; OYSTER; CLAM; HISTOPATHOLOGY;
REVIEW
1217 ESTUARIES; BIODEGRADATION; TEMPERATURE; MICROORGANISMS
1164 ESTUARIES; BENZOPYRENE; MOLLUSCS; BIVALVES; OREGON;
POLYCYCLIC AROMATICS; CARCINOGENS
1185 ESTUARIES; MARSH; ECOSYSTEM; PETROLEUM HYDROCARBON; LOUISIANA;
ANALYSIS FOR HYDROCARBON; CORDGRASS
0034 ESTUARINE; WATER SOLUBLE FRACTION; OIL IN WATER DISPERSION;
CRUSTACEANS; FISH; TOXICITY; SOUTH LA. CRUDE; KUWAIT CRUDE;
FUEL OIL #2; BUNKER C; CYPRINODON; MENIDIA; FUNDULUS; PENAEUS;
PALEOMONETES; MYSIDOPSIS
0691 ESTUARINE; PELAGIC LARVAE; BENTHIC INVERTEBRATES; TOXICITY
0761 ESTUARINE; TOXICITY; AROMATICS; PHENATHRENES; BENTHIC; OCEANIC;
LARVAE; JUVENILES; RESPIRATION; GROWTH; SUBLETHAL
0739 ESTUARINE; BIBLIOGRAPHY; MARINE; OIL POLLUTION
1013 ESTUARINE; DIATOMS; GAS CHROMATOGRAPHY; SELECTIVE ABSORPTION
1133 ESTUARINE; FUEL OIL; CRASSOSTREA; QUAHOG; ALIPHATICS; MERCENARIA;
CLAMS; OYSTERS; UPTAKE; RETENTION; DEPURATION
1135 ESTUARINE; BIRDS; DUCKS; FISH; CHESAPEAKE BAY; HATCHING SUCCESS;
TOXICITY
1161 ESTUARINE; POLYNUCLEAR AROMATIC HYDROCARBONS; UPTAKE; RETENTION;
DEPURATION; BENTHIC ORGANISMS; SHELLFISH; BENZOPYRENE
1152 ESTUARINE; ECOLOGICAL; ORGANISMS; FISHERIES; COASTAL; TOXICITY;
METHODOLOGY; PETROLEUM FRACTION; CLEANING AGENTS/DISPERSANTS
1186 ESTUARINE; BENZOPYRENE; CLAMS; MUSSELS; OYSTERS; OREGON; UPTAKE;
AROMATIC HYDROCARBONS; CARCINOGENS; MOLLUSCS
1178 ESTUARINE; COASTAL; MONITORING; SPILLS
1195 ESTUARINE; REVIEW; POLLUTION; BIOINDICATORS; MARINE; OIL POLLUTION
0035 ESTUARINE ANIMALS; UPTAKE AND DEPURATION; TOXICITY; RESPIRATION;
SOUTH LA. CRUDE; KUWAIT CRUDE; FUEL OIL #2; BUNKER C; MINNOW;
GRASS SHRIMP,PALAEMONTES; BROWN SHRIMP,PANAEUS;
WATER SOLUBLE FRACTION; OIL WATER DISPERSION; NAPHTHALENES
0827 ESTUARINE ORGANISMS; SUBLETHAL EFFECTS; MARINE ORGANISMS;
PHYSIOLOGICAL RESPONSE
1026 ESTUARINE POLLUTION; BIBLIOGRAPHY
0771 ESTUARINES; OIL POLLUTION; SPILLS; CHRONIC; SALT MARSH; ROCKY SHORE;
EMULSIFIERS; CLEANING
0127 ESTUARY; SALT MARSH; YORK RIVER; SOUTH LA. CRUDE;
HYDROCARBON ANALYSIS; CONTROLLED ECOSYSTEM; FUNDULUS; AROMATICS;
GAS CHROMATOGRAPHY; GC-MS
0563 ESTUARY; SALT MARSH; YORK RIVER; BACTERIA; FUNGI; LOUISIANA CRUDE;
SEDIMENTS; PETROLEUM DEGRADING
0674 ESTUARY; PHYTOPLANKTON; DIVERSITY; CHLOROPHYLL-A
0697 ESTUARY; MULLET; EMPIRE MIX CRUDE; FIN ROT
0828 ESTUARY; DEGRADATION; BACTERIA; BEACH; FUEL OIL; ENRICHMENT; RATE;
NARRAGANSET BAY; HYDROCARBON CONCENTRATION; SEDIMENTS; MIGRATION
0956 ESTUARY; EFFLUENT, REFINERY; SUBLETHAL EFFECTS; METABOLIC RATE;
OXYGEN CONSUMPTION RATE

1082 ESTUARY; MUD FLAT FAUNA; REFINERY EFFLUENT; MEDWAY ESTUARY; KENT, ENGLAND
1068 ESTUARY; BACTERIA; SUSCEPTIBILITY; FUNGI; TOXICITY; SOUTH LOUISIANA CRUDE OIL; FUEL OIL #2; CHESAPEAKE BAY; GROWTH
1074 ETHER EXTRACTION; ALIPHATIC; AROMATIC; DETERMINATION TECHNIQUES; MARINE ORGANISMS; SILICA GEL CHROMATOGRAPHY; GAS CHROMATOGRAPHY; MASS SPECTROMETRY
0322 EUGLENA; ALGAE; GROWTH; SCENEDESMUS; LUBRICATING OILS; DIESEL OIL; PHOTOSYNTHETIC METABOLISM
0704 EUGRAULIS; TOXICITY; FISH; DEVELOPMENT; PETROLEUM; SCORPAENA; CRENILABRUS; BLACK OIL; SOLAR OIL
0040 EUPLOTES; KUWAIT CRUDE; PROTOZOAN CILIATES; URONEMA; NEMATODE; INGESTION
1171 EUPLOTES; BIOINDICATORS; PROTOZOA; CILIATES; SAUDI ARABIAN CRUDE; EMPIRE MIX CRUDE; MICROFAUNA; COMMUNITY DIVERSITY EXPERIMENTS
0123 EURYTEMORA; COPEPOD; REPRODUCTION; NAPHTHALENE; EGG PRODUCTION; HEATING OIL; WATER SOLUBLE FRACTION
0487 EURYTEMORA; NAPHTHALENE; ACCUMULATION; COPEPOD; RADIOACTIVE; LONG TERM EXPOSURE; LOW LEVEL CONCENTRATIONS; MARINE ZOOPLANKTON; PERSISTENT EXPOSURE; UPTAKE/DEPURATION; CALANUS
0486 EURYTEMORA; RETENTION; COPEPOD; ZOOPLANKTON; CALANUS; UPTAKE; DEPURATION
0784 EVALUATION; DISPERSANTS; EFFECTIVNESS; TOXICITY; BIOASSAY; BOD; THRESHOLD ODOR
0119 EVENNESS INDEX; BIOLOGICAL INDICATORS; DIVERSITY INDICIES; SHANNON DIVERSITY INDEX
0401 EXCHANGE WITH SEA; MUSSEL; MYTILUS; LAGOON OF VENICE,ITALY; HYDROCARBON CONTENT ANALYSIS; GAS CHROMATOGRAPHY; DISTANCE FROM POLLUTION SOURCE
0276 EXCRETION; SPIDER CRAB; NAPHTHALENE; METABOLISM; MAIA
0609 EXCRETION; MARINE SEDIMENT; METABOLISM; MICROFAUNA; MEIOFAUNA; MACROFAUNA; DEGRADATION; POLYCHAETE WORMS; BIVALVES; BACTERIA
0598 EXPERIMENTAL ECOSYSTEM; ECOTOXICOLOGY; PRIMARY PRODUCTION; CRUDE OIL
0292 EXPERIMENTAL SPILLS; EMULSIFIERS; OIL; EFFECTS ON INTERTIDAL COMMUNITIES; FIELD EXPERIMENTS; ROCKY SHORE
0286 EXPERIMENTAL SPILLS; ROCKY SHORE; SALT MARSH; CHRONIC SPILLAGE; OIL PORT
0376 EXTRACTION TECHNIQUES; HYDROCARBON CONTENT; GAS CHROMATOGRAPHY
0976 FACTORS AFFECTING DEGREE OF IMPACT; ECOSYSTEM IMPACT
0960 FAT CONTENT; OYSTER; CRASSOSTREA; UPTAKE; RETENTION; DEPURATION; PETROLEUM FRACTIONS; LIPIDS; METABOLISM
0473 FATALITIES; BIRDS
0138 FATE; CRUDE OIL; WEATHER; MICROBIAL DEGRADATION; BIOLOGICALLY ACTIVE FRACTIONS; MARTHA'S VINEYARD; BERMUDA
0512 FATE; REVIEW ARTICLE; INPUT; BIOLOGICAL EFFECTS
0637 FATE; REVIEW; OCCURENCE; EFFECTS
0772 FATE; REVIEW; INPUT; BIOLOGICAL EFFECTS; CLEANUP; OIL; DISPERSANTS
0829 FATE; REVIEW; INPUT; DEGRADATION
0746 FATE & EFFECT; HYDROCARBON ANALYSIS; DISTRIBUTION
1226 FATE & EFFECTS; SYMPOSIUM; PETROLEUM HYDROCARBONS; MARINE ORGANISMS
1005 FATE &BEHAVIOR OF OIL; REVIEW; OIL POLLUTION; TOXICITY; BIRDS; BIODEGRADATION; FIELD STUDIES; BIBLIOGRAPHY
0005 FATE AND EFFECTS; REVIEW
0069 FATE AND EFFECTS; BIODEGRADATION; REVIEW-OIL POLLUTION; CONTROL OF OIL POLLUTION

0635 FERTILIZATION; OIL; DISPERSANTS; COREXIT; SEA URCHIN; FISH; EGGS; EMBRYO; DEVELOPMENT
0634 FERTILIZATION; DISPERSANTS; EGGS; SEA URCHIN; FISH; DEVELOPMENT
0777 FERTILIZATION; SAND DOLLAR; KUWAIT CRUDE; FUEL OIL #2; WATER SOLUBLE EXTRACTS; SPERM; EGG; RESPIRATION; MOBILITY OF SPERM; CLEAVAGE; LARVAL DEVELOPMENT
0864 FERTILIZATION; DISPERSANT; SHELLFISH; LARVAE; SPERMATOZOA; TOXICITY; BIVALVES; OYSTERS; CRASSOSTREA; MUSSEL; DEVELOPMENT
0865 FERTILIZATION; BIVALVES; TOXICITY; SPERMATOZOA; DEVELOPMENTAL ABNORMALITIES; PRUDHOE BAY CRUDE; KUWAIT CRUDE; NIGERIAN CRUDE
1158 FERTILIZATION; TROUT; HATCHING SUCCESS; REPRODUCTION & DEVELOPMENT; HISTOPATHOLOGICAL EFFECTS; MORPHOLOGY
0791 FERTILIZER; BIODEGRADATION; ENHANCEMENT
0031 FESTUCA; RECOVERY; CONTROLLED SPILLS; SHAEDA; JUNCUS; PLANTAGE; SPARTINA; SALT MARSH; PEMBROKE,WALES; KUWAIT CRUDE OIL; FLOWERING PLANTS; SEED PRODUCTION AND GERMINATION
0201 FIDDLER CRAB; HYDROCARBON CONTENT; METABOLISM; AROMATIC HYDROCARBON CONTENT; UCA; OXIDATION; CLEARANCE
0992 FIELD CROPS; PLANTS; TERRESTRIAL; PERSISTANCE; SOIL
0571 FIELD EXPERIMENT; PHYTOPLANKTON; CRUDE OIL; INHIBITED; STIMULATION; LABORATORY STUDIES; TOXICITY; PH; FRACTIONS; BENZENE; XYLENE; TOLUENE
0292 FIELD EXPERIMENTS; EMULSIFIERS; OIL; EFFECTS ON INTERTIDAL COMMUNITIES; EXPERIMENTAL SPILLS; ROCKY SHORE
0879 FIELD EXPERIMENTS; CRUDE OIL; MIDGES; CRICOTOPUS; FORT SIMPSON, NWT, CANADA; LARVAE; ARTIFICAL SUBSTRATES
0577 FIELD FENCING TECHNIQUES; REEF COMMUNITY; RESPIRATION; CALMING EFFECTS; GAS EXCHANGE; CRUDE OIL; TOXIXCTY; BEHAVIOR; HERON IS. GREAT BARRIER REEF AUSTRALIA
0969 FIELD SAMPLING; SANTA BARBARA SPILL; PROGRESS REPORT
0794 FIELD STUDIES; CHRONIC POLLUTION; REVIEW; OFFSHORE PRODUCTION; REFINERIES; ESTUARIES; SUBLETHAL EFFECTS; NATURAL SEEPS
1005 FIELD STUDIES; REVIEW; OIL POLLUTION; TOXICITY; FATE &BEHAVIOR OF OIL; BIRDS; BIODEGRADATION; BIBLIOGRAPHY
0468 FIELD STUDY; BACTERIA; OIL-DEGRADING; POPULATIONS; TORREY CANYON; EMULSIFIERS; BEACHES
0685 FIELDS STUDIES; CHRONIC POLLUTION; SANTA BARBARA SPILL; LAKE MARACAIBO, VENEZUELA; BERMUDA; TIMBALIER BAY, LA.; POPULATION LEVELS; DIVERSITY; SIZE; GROWTH RATE; REPRODUCTION; ABNORMAL GROWTHS; BIOMAGNIFICATION
0314 FILAMENTOUS FUNGI; DEGRADATION; BACTERIA; ACTINOMYCETES; YEAST; PHYCOMYCETES
0150 FILTER-FEEDING; CLAMS; MERCENARIA; DISSOLVED ORGANIC MATTER(DOM); UPTAKE; FUEL OIL#2
1048 FILTERING; MUSSEL; MYTILUS; PSEUDOFECES; PURIFICATION
0016 FILTERING ABILITY; MUSSEL; BEHAVIOR; BLACK SEA; TOLERANCE
0640 FILTERING RATE; OYSTERS; BLEED WATER; CRUDE OIL; WATER SOLUBLE FRACTION
0237 FILTRATION RATE; SINKING AGENTS; TOXICITY; CRUDE OIL; TOAD FISH; SHELLFISH
0697 FIN ROT; MULLET; ESTUARY; EMPIRE MIX CRUDE
0296 FINA NOVAGE SPILLAGE; DISPERSANTS; CHRYSSI P. GOULANDRIS SPILLAGE; TOXICITY; TORREY CANYON SPILL; GULF REFINERY SPILL
1093 FINASOL; FISH; SOLE; PLAICE; HERRING; LARVAE; DETERGENT;

DEVELOPMENTAL ABNOMALITIES; BP1002; COREXIT

0719 FINE STRUCTURE; ALGAE; PLATYMONAS; TOXICITY; GROWTH RATES; NANO PLANKTON; CRUDE OIL; EMULSIFIER

0936 FINLAND; BIRDS; PALVA; EIDER; SOMATERIA

0624 FINLAND COAST; EIDER DUCKS; MORTALITY; BALTIC SEA; PALVA 1969

0646 FIRTH OF CLYDE, SCOTLAND; N-ALKANES; HYDROCARBON CONTENT ANALYSIS; PLANKTON; FISH; FOOD CHAIN MAGNIFICATION

0121 FISH; SALT MARSH; YORK RIVER; ISOLATED ECOSYSTEM; SOUTH LA. CRUDE; WEATHERED OIL; PHYTOPLANKTON; PERIPHYTON; ATP; MARSH GRASS; BENTHIC FAUNA; POLYCHAETES; INSECT LARVAE; AMPHIPODS; OLIGOCHAETE

0002 FISH; TAINTING; WHITEFISH; ANALYSIS FOR PETROLEUM HYDROCARBONS

0111 FISH; BIOLOGICAL INDICATORS; SPECIES DIVERSITY INDICIES; GALVESTON BAY TEXAS

0041 FISH; ROAD OIL

0034 FISH; WATER SOLUBLE FRACTION; OIL IN WATER DISPERSION; CRUSTACEANS; TOXICITY; ESTUARINE; SOUTH LA. CRUDE; KUWAIT CRUDE; FUEL OIL #2; BUNKER C; CYPRINODON; MENIDIA; FUNDULUS; PENAEUS; PALEOMONETES; MYSIDOPSIS

0033 FISH; UPTAKE AND DEPURATION; SHRIMP; MOLLUSKS; FUEL OIL; NAPHTHALENES

0218 FISH; DISPERSANTS; OIL; SEA URCHINS; FERTILIZATION; DEVELOPMENT; TOXICITY; COREXIT

0141 FISH; TRACERS; PHYTOL; ZOOPLANKTON; ANALYSIS FOR HYDROCARBONS; OLEFINS; FOOD CHAIN; BIOGENIC VS. PETROLEUM

0129 FISH; UPTAKE; N-ALKANE

0301 FISH; REVIEW; OFFSHORE PRODUCTION; SHELLFISH; CONTINENTIAL SHELF

0278 FISH; HYDROCARBONS; ZOOPLANKTON; TOXICITY; TAINTING; BEHAVIOR; UPTAKE; METABOLISM; DEPURATION; ACCUMULATION

0359 FISH; CRUDE OIL; DETERGENT; OCTOCORALS; CRUSTACEANS; MOLLUSCS; ECHINODERMS; TOXICITY; SUBLETHAL; DEVELOPMENTAL STAGES; RED SEA; FEEDING RATE; PHYSIOLOGY; BIOACCUMULATION; LIVER ENLARGEMENT; HEMATOCRIT

0353 FISH; SANTA BARBARA

0323 FISH; TAINTING; YELLOWTAIL; CRUDE OIL; VAPOR ANALYSIS; SERIOLA; GAS CHROMATOGRAPHY

0442 FISH; R.C. STONER; REEF COMMUNITY; WAKE IS.

0415 FISH; CRUDE OIL; LESIONS; HISTOPATHOLOGY; MENIDIA; HYPERPLASIA

0482 FISH; ASSIMILATION; ALKANES; DISCRIMINATION; COD; HYDROCARBON CONTENT ANALYSIS

0426 FISH; HYDROCARBON CONTENT ANALYSIS; GAS CHROMATOGRAPHY; PARAFFINS; SQUID; SHRIMP

0539 FISH; OUTBOARD MOTORS; TAINTING; TOXICITY; FISH REPRODUCTION; BLUEGILLS; FATHEAD MINNOWS

0537 FISH; TOXICITY; OIL-REFINERY EFFLUENT; METABOLIC RATES; COMPARISION OF SPECIES; BIOASSAY; FRESH WATER

0602 FISH; INPUT; SHELLFISH; FOWL

0531 FISH; TAINTING; MICROBIAL INFESTATION; REVIEW

0613 FISH; NAPTHALENE; BENZ(A)PYRENE; RADIOACTIVE TRACER; UPTAKE; METABOLISM; DISCHARGE; SCULPIN; OLIGOCOTTUS; GOBY; GILLICHTHYS; SAND DAB; CITHARICHTHYS

0704 FISH; TOXICITY; DEVELOPMENT; PETROLEUM; EUGRAULIS; SCORPAENA; CRENILABRUS; BLACK OIL; SOLAR OIL

0654 FISH; SANTA BARBARA SPILL; POPULATION; PELAGIC

0659 FISH; TAINTING; SEAWEED; PHENOLS; OILS; DEPOSITION; DETERGENTS

0641 FISH; ESTUARIES; HYDROCARBON CONCENTRATIONS; SEDIMENTS; ZOOPLANKTON;

PHYTOPLANKTON; CRUDE OIL; SALT MARSH PLANTS; DIVERSITY; POPULATIONS;
MIGRATION; GAS CHROMATOGRAPHY; DEGRADATION

0635 FISH; OIL; DISPERSANTS; COREXIT; SEA URCHIN; EGGS; EMBRYO;
FERTILIZATION; DEVELOPMENT

0679 FISH; DISPERSANTS; TOXICITY; SHRIMP; COREXIT; SUB-TROPICAL;
CENTROPOGON; DIOGENES; PALEOMONOTES; AMBASSIS

0646 FISH; N-ALKANES; HYDROCARBON CONTENT ANALYSIS; PLANKTON;
FIRTH OF CLYDE, SCOTLAND; FOOD CHAIN MAGNIFICATION

0735 FISH; TAINTING; SALMON,CHUM

0700 FISH; REVIEW-OIL POLLUTION; LARVAE; SUBLETHAL EFFECTS; PRODUCTIVITY;
PHYTOPLANKTON; ZOOPLANKTON; EGGS; BIRDS; PLAICE

0634 FISH; DISPERSANTS; EGGS; SEA URCHIN; FERTILIZATION; DEVELOPMENT

0643 FISH; PARAFFIN; CRUDE

0658 FISH; TAINTING; OIL; PHENOL

0737 FISH; PARAFFINS; CRUDE OIL; JULIANA WRECK; SALMON; MULLET;
BLACK SEA BREAM; GAS CHROMATOGRAPHY

0811 FISH; BIOINDICATOR; BENZOPYRENE HYDROXYLASE; SUBLETHAL RESPONSE;
ENZYMES; MONITOR

0786 FISH; TAINTING; JAPANESE COAST; EELS; GAS CHROMATOGRAPHY;
IR ABSORPTION; UV ABSORPTION; MASS SPECTRUM; TOLUENE;
MIZUSHIMA, JAPAN; AROMATIC HYDROCARBONS; GASOLINE

0813 FISH; BENZOPYRENE; HYDROXYLASE INDUCTION;
POLYCYCLIC AROMATIC HYDROXYLASE; ARYL HYDROCARBON HYDROXYLASE;
BROWN TROUT; NEWFOUNDLAND; TAINTING; THIN-LAYER CHROMATOGRAPHY

0788 FISH; PARIFFINS; GAS CHROMATOGRAPHY; EELS; ARABIAN LIGHT CRUDE OIL;
TAINTING; ORGANIC SULFUR

0812 FISH; MIXED FUNCTION OXIDASES; ARYL HYDROCARBON HYDROXYLASE;
PETROLEUM HYDROCARBON; METABOLISM; DETECTION; MONITORS;
INVERTEBRATES

0838 FISH; DETERGENTS; TOXICITY; SHORE CRAB; CARCINUS; BROWN SHRIMP;
CRAGON; LARVAE

0904 FISH; OUTBOARD ENGINE EXHAUST; SPECIES ABUNDANCE; DIVERSITY;
PHYTOPLANKTON; ZOOPLANKTON; PERIPHYTON; BEHAVIOR; POPULATION

0893 FISH; FUNDULUS; LIVER; LIPOGENESIS; RADIOACTIVE TRACERS;
ULTRASTRUCTURE; METABOLIC PATHWAYS; GLYCOLYSIS

0914 FISH; HYDROCARBONS; GAS WASTES; TOXICITY; BEHAVIOR; ATTRACTION;
SUNFISH (ORANGE-SPOTTED)

0951 FISH; SANTA BARBARA SPILL; POPULATION; DIVERSITY; PELAGIC; ANCHOVY;
ROCKFISH; ECHO SOUNDING

0906 FISH; PERIPHYTON; SEDIMENTS; STREAM; DIESEL FUEL;
BOONE CREEK OIL SPILL; MACROINVERTEBRATES; HYDROCARBON ANALYSIS;
SOUTH CAROLINA

0870 FISH; TOXICITY; COOK INLET CRUDE; BIOASSAY; STATIC; INVERTEBRATES;
ALASKA

0994 FISH; SURFACTANTS; CRUSTACEANS; BIVALVES; TOXICITY; BEHAVIOR;
DEVELOPMENT; ACTIVITY; BYSSUS THREAD; MOULTING

0991 FISH; OUTBOARD MOTOR EXHAUST WASTE; BLUEGILL; TAINTING; LEAD

0999 FISH; CRUDE OIL; PETROLEUM PRODUCTS; WATER QUALITY;
AQUATIC LIFE &WILDLIFE

1017 FISH; KENT, ENGLAND; MARINE ALGAE PLANTS; BIRDS

1008 FISH; BIRDS; TAINTING; MOLLUSCS; BENZOPYRENE; ALGAE; TOXICITY;
TORREY CANYON SPILL

0995 FISH; DISPERSANTS; EMULSIONS; TOXICITY; SUBLETHAL EFFECTS; ACTIVITY;
MOTILITY; BIVALVES; CRUSTACEANS; BEHAVIOR; OIL EMULSION;
CONTINUOUS FLOW; LOCOMOTION

1134 FISH; ARCTIC; SUB ARCTIC; BAFFIN BAY; DAVIS STRAIT; LABRADOR SEA; ASSESSMENT OF SPILLS; PHYTOPLANKTON; ZOOPLANKTON; ZOOBENTHOS; MAMMALS; BIRDS
1124 FISH; FUEL OIL; BUNKER C; DUCKS; MUSKRATS; CATTAILS; ANALYSIS FOR HYDROCARBONS; ST. LAWRENCE RIVER; MARSHES
1091 FISH; DISPERSANT; TOXICITY; LARVAE; HERRING; PILCHARD; PLAICE; SOLE; LEMON SOLE; HADDOCK; BP1002; DELAYED EFFECTS; EMBRYOLOGY; BEHAVIORAL CHANGES
1135 FISH; ESTUARINE; BIRDS; DUCKS; CHESAPEAKE BAY; HATCHING SUCCESS; TOXICITY
1108 FISH; AROMATIC HYDROCARBON; POLYCYCLIC AROMATIC HC'S; CONTENT ANALYSIS; BUNKER C; CREOSOTE; SEALS; SHELLFISH; PAH; FLUOROMETRY; FUEL OIL
1093 FISH; SOLE; PLAICE; HERRING; LARVAE; DETERGENT; DEVELOPMENTAL ABNOMALITIES; BP1002; FINASOL; COREXIT
1085 FISH; CRUDE OIL; TOXICITY; WATER SOLUBLE FRACTION
1223 FISH; COOK INLET CRUDE OIL; FLOUNDER; CLAMS; CHRONIC CONCENTRATIONS; EGGS; LARVAE; HISTOPATHOLOGY; MORTALITY
1179 FISH; PETROLEUM HYDROCARBONS; MUTAGENESIS; PLANKTON; ARCTIC; METABOLISM
1204 FISH; LOS ANGELES HARBOR; SANSINEA SPILL; PRODUCTIVITY; ZOOPLANKTON; ASSESSMENT OF SPILLS; BIRDS; BENTHIC ORGANISMS; PHYTOPLANKTON
1208 FISH; URQUIOLA SPILL; SPAIN; PERSIAN GULF CRUDE OIL; BENTHIC MACROFAUNA; SPARTINA; TOXICITY
1175 FISH; CRUDE OIL; ALGAE; ZOOPLANKTON; CRUSTACEANS; POLYCHAETES; MOLLUSCS; UPTAKE; RETENTION; DEPURATION; REVIEW; BENTHIC ORGANISMS
0463 FISH BEHAVIOR; FISH PHYSIOLOGY; TOXICITY; SALMON; ENZYMES; SOLUBLE HYDROCARBONS; PRUDHOE BAY CRUDE OIL
0162 FISH CELLS IN VITRO; CYTOLOGICAL EFFECTS; HYDROCARBONS
0032 FISH EMBRYOS; HEART BEAT; HATCHING SUCCESS
0594 FISH FRY; CRUDE OIL; DISPERSANTS; COD; GADUS; HERRING; CLUPEA; TOXICITY; EMBRYOLOGY; CHEMORECEPTION
0463 FISH PHYSIOLOGY; FISH BEHAVIOR; TOXICITY; SALMON; ENZYMES; SOLUBLE HYDROCARBONS; PRUDHOE BAY CRUDE OIL
0539 FISH REPRODUCTION; OUTBOARD MOTORS; TAINTING; TOXICITY; FISH; BLUEGILLS; FATHEAD MINNOWS
0590 FISH STOCKS; REVIEW; NORTH SEA; DISPERSANTS; TAINTING
0320 FISH TAINTING; WAFRA SPILL; INTERTIDAL; SOUTH AFRICA; INTERTIDAL INVERTEBRATES
0636 FISH TAINTING; OUTBOARD MOTOR OPERATION; MICROORGANISM POPULATIONS
0109 FISHERIES; OFFSHORE PRODUCTION; VENEZUELA; LAKE MARACAIBO; NATURAL SEEPS
0233 FISHERIES; TORREY CANYON SPILL; BRITTANY
0174 FISHERIES; ARGO MERCHANT; FOOD CHAIN
0472 FISHERIES; OIL POLLUTION
0513 FISHERIES; TORREY CANYON; DETERGENT; LIMPETS; PLANKTON; BIRDS; CRAIE DE CHAMPAGNE
0589 FISHERIES; TAINTING; EMULSIFIERS
0618 FISHERIES; INDONESIA; CORAL REEF COMMUNITY; OFFSHORE PRODUCTION; REVIEW
0918 FISHERIES; ARGO MERCHANT SPILL; NANTUCKET SHOALS
0925 FISHERIES; TORREY CANYON SPILL
0915 FISHERIES; DISPERSANTS; TOXICITY; TAINTING; TESTING PROCEDURES; STATIC; FLOW THROUGH; BIOASSAY
0916 FISHERIES; REVIEW; TYPES OF OILS; WEATHERING; TOXICITY; DISPERSANTS;

MARINE ENVIRONMENT
0974 FISHERIES; SANTA BARBARA SPILL; SURVEY; BIRDS; MARINE MAMMALS; DIVERSITY; TAINTING
1007 FISHERIES; LAKE MARACAIBO, VENEZUELA; SEDIMENTS; WATER; BIOTA; HYDROCARBON CONTENT ANALYSIS; TOXICITY
1152 FISHERIES; ECOLOGICAL; ORGANISMS; ESTUARINE; COASTAL; TOXICITY; METHODOLOGY; PETROLEUM FRACTION; CLEANING AGENTS/DISPERSANTS
1147 FISHERIES; OUTER CONTINENTAL SHELF; SANTA BARBARA CHANNEL; CALIFORNIA
0324 FISHES; BERING SEA; TOXICITY; TEMPERATURE
1156 FISHES; HISTOPATHOLOGICAL EFFECTS; CRUDE OIL; TOXICITY
0149 FIXATION; OUTBOARD ENGINE EMMISSIONS; PHYTOPLANKTON; SPECIES DIVERSITY; CHLOROPHYLL; ZOOPLANKTON POPULATION DYNAMICS; BENTHIC MICROINVERTEBRATE COMMUNITY; GASOLINE
0600 FLAME IONIZATION DETECTION; PETRO SULFAR COMPOUNDS; AROMATIC HYDROCARBONS; MODIOLUS; CRASSOSTREA; RETENTION; FLAME PHOTOMETRIC DETECTION; GAS CHROMATOGRAPHY; GAS CHROMATOGRAPHY-MASS SPECTROMETRY
0600 FLAME PHOTOMETRIC DETECTION; PETRO SULFAR COMPOUNDS; AROMATIC HYDROCARBONS; MODIOLUS; CRASSOSTREA; RETENTION; FLAME IONIZATION DETECTION; GAS CHROMATOGRAPHY; GAS CHROMATOGRAPHY-MASS SPECTROMETRY
1073 FLAME PHOTOMETRIC DETECTOR; SULFUR CONTAINING PETROLEUM COMPONENTS; CONTENT ANALYSIS
0655 FLATFISH; PHSIOLOGICAL EFFECTS; SALMON; SPOTTED SHRIMP; UPTAKE AND DEPURATION; HISTOPATHOLOGY
0058 FLATWORM; CHEMOTAXIS; LOBSTERS; ALEWIVES; HORSESHOE CRAB; KEROSENE
0806 FLIES; CHRONIC CONTAMINATION; AQUATIC ORGANISMS; DIPTERA; BIBLIOGRAPHY
0863 FLIES; SUPRALITTORAL; ARTHROPODS; LIMOSINA; ORCHESTIA; EFFLUENTS; TOXICITY; CRUDE OIL; AMPHIPODES
0669 FLORA; PELAGIC HYDROCARBONS; TAR BALLS; ROCKY INTERTIDAL; FAUNA; BERMUDA; SPLASH ZONE; NODILITTORINA; TECTARIUS; HYDROCARBON ANALYSIS; ALGAE
0707 FLORA; OIL POLLUTION; FAUNA; BLACK SEA; CRUDE OIL; DIESEL OIL
0706 FLORA; OIL POLLUTION; FAUNA; BLACK SEA
0907 FLORIDA; BACTERIAL DEGREDATION; TEMPERATURE; PRESSURE; RATE
1225 FLORIDA; TURTLES; OIL SPILL; TAR
0228 FLORIDA KEYS; LITTORAL COMMUNITIES; ROCKY PLATFORM; MANGROVE FRINGE; SEA GRASS FLATS; MANGROVE SWAMP; CRUSTACEANS; ECHINODERMS; RED MANGROVE; PEARL OYSTER; BLACK MANGROVE
0529 FLOUNDER; BIOASSAY; CONTINUOUS FLOW; TOXICITY; SUBLETHAL EFFECTS; WATER SOLUBLE FRACTION; WHOLE OIL FRACTION; MINNOW; SHRIMP; SCALLOP; QUAHOG; MUSSEL; MUD SNAIL
1223 FLOUNDER; COOK INLET CRUDE OIL; FISH; CLAMS; CHRONIC CONCENTRATIONS; EGGS; LARVAE; HISTOPATHOLOGY; MORTALITY
1170 FLOUNDER; FUEL OIL; REPRODUCTION; HATCHING SUCCESS; GROWTH; EGGS; LARVAE; HISTOPATHOLOGY
0901 FLOUNDER (WINTER&YELLOWTAIL); ARGO MERCHANT SPILL; HISTOPATHOLOGY; AMMODYTES; ALEWIVES; CRABS(HERMIT); HYPERPLASIA; EDEMA; HEMOCYTES; CILIATES
0843 FLOW RATE IN CHEMOSTAT; BIODEGRADATION; RATES; BACTERIA; MECHANISM; TOXICITY OF METABOLIC AND PRODUCTS
0888 FLOW THROUGH; BIOASSAY; METHODOLOGY; SALMON
0915 FLOW THROUGH; DISPERSANTS; TOXICITY; TAINTING; FISHERIES;

TESTING PROCEDURES; STATIC; BIOASSAY
0360 FLOW THROUGH ASSAY; TOXICITY; RABBIT FISH; CRUDE OIL; DEPTH; SIGANUS; DISPERSANT; STATIC ASSAY; SALINITY
0399 FLOW THROUGH SYSTEM; SOUTH LA.CRUDE; LOBSTER; LARVAE; EMULSION; FEEDING; MOULTING; PIGMENTATION; HYDROCARBON ANALYSIS
0081 FLOWERING PLANTS; RECOVERY; CONTROLLED SPILLS; SHAEDA; JUNCUS; FESTUCA; PLANTAGE; SPARTINA; SALT MARSH; PEMBROKE,WALES; KUWAIT CRUDE OIL; SEED PRODUCTION AND GERMINATION
0902 FLUORESCENCE ANALYSIS; HYDROCARBON CONCENTRATION; SEDIMENTS; BENTHIC SPECIES; FOOD CHAIN CONCENTRATION; CHEDABUCTO BAY; FUEL OIL -BUNKER C; NOVA SCOTIA
0443 FLUORESCENCE SPECTROSCOPY; OIL SPILL, EXPERIMENTAL; HYDROCARBON ANALYSIS; WATER COLUMN; SEDIMENT; TAR BALLS
1037 FLUORESCENCE SPECTROSCOPY; ARROW SPILL; CHEDABUCTO BAY,NOVA SCOTIA; BUNKER C; MYA; KELP; HYDROCARBON CONTENT ANALYSIS
0749 FLUORESENT; BIOASSAY; SALT MARSH; MICROCOSM; GAS CHROMATOGRAPHY; SPECTROPHOTOMETRY; ULTRAVIOLET
1108 FLUOROMETRY; AROMATIC HYDROCARBON; POLYCYCLIC AROMATIC HC'S; CONTENT ANALYSIS; BUNKER C; CREOSOTE; SEALS; FISH; SHELLFISH; PAH; FUEL OIL
0048 FOOD CHAIN; TOXICITY; AROMATIC HYDROCARBONS; FATTY TISSUES
0141 FOOD CHAIN; TRACERS; PHYTOL; ZOOPLANKTON; FISH; ANALYSIS FOR HYDROCARBONS; OLEFINS; BIOGENIC VS. PETROLEUM
0139 FOOD CHAIN; HYDROCARBONS; CONTENT ANALYSIS; MARINE PHYTOPLANKTON; BIOGENIC VS. PETROLEUM; TRACER
0174 FOOD CHAIN; ARGO MERCHANT; FISHERIES
0676 FOOD CHAIN; REVIEW
0605 FOOD CHAIN ACCUMULATION; UPTAKE AND DEPURATION; TOXICITY; OFFSHORE PRODUCTION
0202 FOOD CHAIN CONCENTRATION; SALT MARSH ECOSYSTEM; CONTENT ANALYSIS; WEST FALMOUTH,MASS; FUEL OIL #2; HYDROCARBON CONTENT
0902 FOOD CHAIN CONCENTRATION; HYDROCARBON CONCENTRATION; FLUORESCENCE ANALYSIS; SEDIMENTS; BENTHIC SPECIES; CHEDABUCTO BAY; FUEL OIL -BUNKER C; NOVA SCOTIA
0151 FOOD CHAIN MAGNIFICATION; CHRONIC OIL POLLUTION; COASTAL ECOSYSTEM; SUBLETHAL EFFECTS; METABOLISM; BEHAVIOR; WETLANDS; ESTUARIES
0646 FOOD CHAIN MAGNIFICATION; N-ALKANES; HYDROCARBON CONTENT ANALYSIS; PLANKTON; FISH; FIRTH OF CLYDE, SCOTLAND
1214 FOOD CHAINS; PETROLEUM HYDROCARBONS; OIL SPILLS
1079 FOOD CONSUMPTION; LOBSTER; HOMARUS; LARVAE; TOXICITY; BEHAVIOR; GROWTH; VENEZUELA CRUDE OIL; DISPERSIONS
0277 FOOD WEB; COPEPOD; UPTAKE; DEPURATION; NAPHTHALENE; METABOLISM; CALANUS; WATER SOLUBLE FRACTION; DIETARY ROUTE OF ENTRY; RADIOACTIVE TRACERS
0275 FOOD WEB TRANSFER; POLYCYCLIC AROMATIC HYDROCARBONS; METABOLISM; UPTAKE; BIOSYNTHESIS
0879 FORT SIMPSON, NWT, CANADA; CRUDE OIL; MIDGES; CRICOTOPUS; FIELD EXPERIMENTS; LARVAE; ARTIFICAL SUBSTRATES
0602 FOWL; INPUT; FISH; SHELLFISH
0312 FRACTIONS; REVIEW; BIODEGRADATION; BACTERIA; CRUDE OIL; ENVIRONMENTAL FACTORS
0571 FRACTIONS; PHYTOPLANKTON; CRUDE OIL; FIELD EXPERIMENT; INHIBITED; STIMULATION; LABORATORY STUDIES; TOXICITY; PH; BENZENE; XYLENE; TOLUENE
0845 FRAGILARIA; OIL; ALGAE; DINOFLAGELLATE; DUNALIELLA; DIATOM;

AXEMIC CULTURES; GROWTH RATES
0012 FRANK BUCK - TANKER SPILL (1937); SPILLS; BIRDS; SAN FRANCISCO BAY; WEST COAST U.S.
0572 FRESH WATER; CHLORELLA VULGARIS; ALGAE; TOXICITY; GROWTH; PHOTOSYNTHESIS; BENZENE; XYLENE; TOLUENE; NAPTHALENE
0591 FRESH WATER; CRUDE OIL; TOXICITY; EMULSIFIERS; SALT WATER
0537 FRESH WATER; FISH; TOXICITY; OIL-REFINERY EFFLUENT; METABOLIC RATES; COMPARISION OF SPECIES; BIOASSAY
0878 FRESH WATER; OIL POLLUTION; BIOINDICATORS; CHIRONOMIDAE; TRAIL RIVER, NWT, CANADA; FRESHWATER; MIDGES
0582 FRESH WATER FISH; TOXICITY; AUFWUCHS (SURFACE GROWTH); JP4 FUEL; JP5 FUEL
0668 FRESH WATER FISH; PETROLEUM REFINERY EFFLUENT; SUNFISH,REDEAR; LEPOMIS; BEHAVIORAL SYMPTOMS; TOXICITY
0941 FRESHWATER; WATER SOLUBLE FRACTION; CRUDE OIL; NAPHTHALENE; GREEN ALGAE; PHYSIOLOGY; MORPHOLOGY
0878 FRESHWATER; OIL POLLUTION; BIOINDICATORS; CHIRONOMIDAE; FRESH WATER; TRAIL RIVER, NWT, CANADA; MIDGES
0869 FRY; CRUDE OIL; SALMON; ONCORHYNCHUS; EGGS; ALEVINS; TOXICITY; GROWTH
0413 FUCUS; OIL; EMULSIFIERS; PLANTS; PHOTOSYNTHESIS; NET PRODUCTIVITY; METABOLISM
0851 FUCUS; OIL SPILL INCIDENT; DECEPTION BAY QUEBEC; DIESEL OIL; GASOLINE; MYTILUS
1010 FUCUS; CHEDEBUCTO BAY, NOVA SCOTIA; BUNKER C; MORTALITIES; INTERTIDAL; ARROW SPILL; WINTER; CHRONIC POLLUTION; MYA; SPARTINA
1132 FUCUS; TOXICITY; PETROLEUM FRACTION/CLEANING AGENT; COPEPODS; EFFECT ON ORGANISMS
1207 FUCUS; ALGAE; CRUDE OIL; FUEL OIL #2; JET FUEL
0033 FUEL OIL; UPTAKE AND DEPURATION; SHRIMP; FISH; MOLLUSKS; NAPHTHALENES
0072 FUEL OIL; TOXICITY; ABSORBANTS; BENTHIC FLORA; BIODEGRADATION
0256 FUEL OIL; KELP; WASTE DISCHARGE
0405 FUEL OIL; TOXICITY; FUNDULUS; PIMEPHALES; ARTEMIA; KUWAIT; WEST TEXAS; MARINE DIESEL; LUBE OIL
0614 FUEL OIL; TOXICITY; ARCATIA; SPHAEROMA; AMPHITHOE; WATER SOLUBLE FRACTION
0828 FUEL OIL; DEGRADATION; BACTERIA; ESTUARY; BEACH; ENRICHMENT; RATE; NARRAGANSET BAY; HYDROCARBON CONCENTRATION; SEDIMENTS; MIGRATION
0891 FUEL OIL; TROUT; CADDIS FLY; OYSTER; SNAILS
0996 FUEL OIL; SHAD; ALOSA; TOXICITY; PETROLEUM PRODUCTS; DISSOLVED OXYGEN; SYNERGISM; GASOLINE; BUNKER OIL
1131 FUEL OIL; MICROFLORA; PHYTOPLANKTON; ALGAE; CRUDE OIL; TOXICITY; NAPHTHALENE; PHENANTHRENE; AROMATICS; ALGAE-GREEN; ALGAE-BLUE GREEN; DIATOMS; GROWTH
1130 FUEL OIL; CHESAPEAKE BAY; INVERTEBRATES; ASSESSMENT OF SPILLS; BARGE STC-101
1144 FUEL OIL; BIRDS; HATCHING SUCCESS; EMBRYONIC DEVELOPMENT; EIDERS; GULKS; MALLARDS; PATHOLOGICAL EFFECTS; CRUDE OIL
1127 FUEL OIL; ARGO MERCHANT SPILL; EMBRYOGENESIS; HATCHING SUCCESS; MORPHOLOGY; POLLOCK; CEPHALACHORDATA; AMPHIOXUS
1122 FUEL OIL; EIDER; TOXICITY; REPRODUCTIVE GROWTH; HATCHING SUCCESS
1143 FUEL OIL; SOFT-SHELL CLAM; UPTAKE; RETENTION; DEPURATION; BURROWING; MORTALITY; SEARSPORT-MAINE
1121 FUEL OIL; MALLARD; TOXICITY; PHYSIOLOGICAL EFFECTS; HATCHING SUCCESS;

PARAFFINS; GROWTH
1133 FUEL OIL; CRASSOSTREA; QUAHOG; ESTUARINE; ALIPHATICS; MERCENARIA; CLAMS; OYSTERS; UPTAKE; RETENTION; DEPURATION
1108 FUEL OIL; AROMATIC HYDROCARBON; POLYCYCLIC AROMATIC HC'S; CONTENT ANALYSIS; BUNKER C; CREOSOTE; SEALS; FISH; SHELLFISH; PAH; FLUOROMETRY
1123 FUEL OIL; EIDER DUCKS; TOXICITY; PHYSIOLOGICAL EFFECTS; HATCHING SUCCESS
1124 FUEL OIL; FISH; BUNKER C; DUCKS; MUSKRATS; CATTAILS; ANALYSIS FOR HYDROCARBONS; ST. LAWRENCE RIVER; MARSHES
1140 FUEL OIL; CRUDE OIL; POLYCHAETES; TOXICITY; REPRODUCTION & DEVELOPMENT
1169 FUEL OIL; CRABS; WEST FALMOUTH SPILL; MORTALITY; UPTAKE; BEHAVIOR; BURROWING; TOXICITY; CRAB-SALT MARSH; MASS.
1174 FUEL OIL; ESTUARIES; CANADA; SAENICH INLET; CRUDE OIL; BIODEGRADATION; PHYTOPLANKTON; CEPEX; DIATOMS
1193 FUEL OIL; ANTARCTIC; MACROBENTHOS; ASSESSMENT; BENTHIC ECOLOGY
1215 FUEL OIL; BUNKER C; CHEDABUCTO BAY; NOVA SCOTIA; ARROW SPILL; LONG TERM EFFECTS; CORDGRASS; MARSH; ALGAE; TOXICITY
1170 FUEL OIL; FLOUNDER; REPRODUCTION; HATCHING SUCCESS; GROWTH; EGGS; LARVAE; HISTOPATHOLOGY
0885 FUEL OIL # 2; WATER SOLUBLE FRACTION; NEANTHES; POLYCHAETE; HEMOGLOBIN; HYPOXIA; SOUTH LOUISIANA CRUDE; DISSOLVED OXYGEN; TOXICITY; SYNERGISM; NAPHTHALENES; DISSOLVED HYDROCARBONS; RESPIRATION
0886 FUEL OIL # 2; KUWAIT CRUDE; SOUTH LOUISIANA CRUDE; BUNKER C; TOXICITY; WATER SOLUBLE FRACTION; NAPHTHALENE; NEANTHES; CAPITELLA
1059 FUEL OIL # 2; BACTERIA; BIODEGRADATION; LIMITING EFFECTS; SOUTH LOUISIANA CRUDE
0877 FUEL OIL # 6; CHESAPEAKE BAY; SPILL INCIDENT; ENVIRONMENTAL ASSESSMENT; BIRDS; MORTALITIES; SHELL FISHERIES; MARSH GRASS
0034 FUEL OIL #2; WATER SOLUBLE FRACTION; OIL IN WATER DISPERSION; CRUSTACEANS; FISH; TOXICITY; ESTUARINE; SOUTH LA. CRUDE; KUWAIT CRUDE; BUNKER C; CYPRINODON; MENIDIA; FUNDULUS; PENAEUS; PALEOMONETES; MYSIDOPSIS
0035 FUEL OIL #2; ESTUARINE ANIMALS; UPTAKE AND DEPURATION; TOXICITY; RESPIRATION; SOUTH LA. CRUDE; KUWAIT CRUDE; BUNKER C; MINNOW; GRASS SHRIMP,PALAEMONTES; BROWN SHRIMP,PANAEUS; WATER SOLUBLE FRACTION; OIL WATER DISPERSION; NAPHTHALENES
0038 FUEL OIL #2; OYSTERS; CRUDE OIL; REFINED OILS; CRASSOSTREA; BIOASSAY; BUNKER C; SOUTH LA. CRUDE; KUWAIT CRUDE
0142 FUEL OIL #2; WEST FALMOUTH SPILL; PERSISTANCE; MORTALITIES; OYSTERS
0202 FUEL OIL #2; SALT MARSH ECOSYSTEM; CONTENT ANALYSIS; FOOD CHAIN CONCENTRATION; WEST FALMOUTH,MASS; HYDROCARBON CONTENT
0271 FUEL OIL #2; WATER ACCOMODATED FRACTION; MYTILUS; MUSSELS; STARFISH; ASTERIS; RESPIRATION; FEEDING; REPRODUCTION; BYSSAL THREAD PRODUCTION
0615 FUEL OIL #2; WATER SOLUBLE FRACTION; ZOOPLANKTON COASTAL; ZOOPLANKTON OCEANIC; TOXICITY; BEHAVIOR
0616 FUEL OIL #2; TOXICITY; CRUDE; AMPHIPODS; BREEDING; WATER SOLUBLE FRACTION
0510 FUEL OIL #2; BACTERIA; CRUDE OIL; BUNKER C; METABOLISM; INHIBITION; RADIOACTIVE TRACER; CONTROLLED ECOSYSTEM
0847 FUEL OIL #2; ALGAE; MARINE; PHYTOPLANKTON; CRUDE OIL; GROWTH RATES

0759 FUEL OIL #2; CLAMS; UPTAKE; DEPURATION; CONTENT ANALYSIS; CRUDE OIL; SOLUBLE FRACTIONS; GAS CHROMATOGRAPHY
0777 FUEL OIL #2; SAND DOLLAR; KUWAIT CRUDE; WATER SOLUBLE EXTRACTS; SPERM; EGG; RESPIRATION; MOBILITY OF SPERM; FERTILIZATION; CLEAVAGE; LARVAL DEVELOPMENT
0780 FUEL OIL #2; WATER SOLUBLE FRACTION; PHYTOPLANKTON; TOXICITY
0899 FUEL OIL #2; WEST FALMOUTH SPILL; BENTHOS; SPECIES DIVERSITY
0882 FUEL OIL #2; TOXICITY; POLYCHAETES; CRUDE; NAPHTHALENE; BUNKER C; WATER SOLUBLE FRACTION; NEANTHES; CAPITELLA; SOUTH LOUISIANA CRUDE; KUWAIT
0884 FUEL OIL #2; NAPHTHALENE; ANNELIDS; POLYCHAETE; NEANTHES; UPTAKE &DEPURATION; DEVELOPMENT; MALE; FEMALE; EGGS; LARVAE
0954 FUEL OIL #2; SOUTH LOUISIANA CRUDE; SOFT SHELL CLAM; MYA; TEMPERATURE; SUBLETHAL EFFECTS; MUCUS PRODUCTION; MUSCLE CONTRACTION
0883 FUEL OIL #2; TOXICITY; WATER SOLUBLE FRACTION; POLYCHAETE; NEANTHOS; LARVAE
1002 FUEL OIL #2; SHRIMP; TOXICITY; CONTENT ANALYSIS; DEPURATION; CRUDE OIL; BUNKER C; PALAEMONETES; TEMPERATURE; BENZENE; PHENOL; NAPHTHALENE
1035 FUEL OIL #2; BIOASSAY; CONTINUOUS FLOW; PETROLEUM; TECHNIQUE; METHODOLOGY
1034 FUEL OIL #2; BIOASSAY; COON STRIPE SHRIMP; TOXICITY
1033 FUEL OIL #2; COON STRIPE SHRIMP; TOXICITY; PROCEDURES
1080 FUEL OIL #2; WEST FALMOUTH OIL SPILL 1969; WEST FALMOUTH, MASS.; ECOLOGICAL IMPACT; RECOVERY
1068 FUEL OIL #2; BACTERIA; SUSCEPTIBILITY; FUNGI; TOXICITY; ESTUARY; SOUTH LOUISIANA CRUDE OIL; CHESAPEAKE BAY; GROWTH
1070 FUEL OIL #2; CATFISH; TOXICITY; FEEDING BEHAVIOR; HEART RATE
1094 FUEL OIL #2; ALGAE; TOXICITY; PHENALEN-1-ONE; WAVELENGTH DEPENDENT; ALGAE-BLUE GREEN; ALGAE -GREEN; DIATOMS
1207 FUEL OIL #2; ALGAE; FUCUS; CRUDE OIL; JET FUEL
1184 FUEL OIL #2; TOXICITY; AMPHIPODS; TEMPERATURE; WEATHERING
1212 FUEL OIL #2; SHRIMP; LARVAL GROWTH; UPTAKE; DEPURATION; HATCHING SUCCESS; BEHAVIORAL EFFECTS
1211 FUEL OIL #2; EIDER; EGGS; HATCHING SUCCESS; GROWTH; DUCKS
1199 FUEL OIL #2; SOUTH LOUISIANA CRUDE OIL; POLYCHAETE; HYPOXIA; HEMOGLOBIN COMPENSATION
1206 FUEL OIL #2; CLAM; MYA; UPTAKE; RETENTION; DEPURATION
1172 FUEL OIL #2; SYNERGISTIC EFFECTS; TEMPERATURE; SALINITY; EMBRYOGENSIS; RESPIRATION; HORSESHOE CRAB; LIMULUS
0902 FUEL OIL -BUNKER C; HYDROCARBON CONCENTRATION; FLUORESCENCE ANALYSIS; SEDIMENTS; BENTHIC SPECIES; FOOD CHAIN CONCENTRATION; CHEDABUCTO BAY; NOVA SCOTIA
1176 FUEL OIL# 2; ZOOPLANKTON; SHRIMP; RESPIRATION; TOXICITY; FEEDING BEHAVIOR; MOBILITY; NAPHTHALENE; BENZENE; PHENOL
0150 FUEL OIL#2; CLAMS; MERCENARIA; DISSOLVED ORGANIC MATTER(DOM); FILTER-FEEDING; UPTAKE
0161 FUEL OIL#2; NIGERIAN CRUDE; CRANKCASE OIL; BENTHIC ALGAL COMMUNITIES; PRIMARY PRODUCTIVITY; TOXICITY; RECOVERY; ALGAL BLUE GREEN
0287 FUEL OIL#2; SHRIMP; UPTAKE; DEPURATION; MOUTHLY GROWTH
0289 FUEL OIL#2; HYDROCARBON CONCENTRATIONS; NAPHTHALENE; SHRIMP; CLAMS; OYSTERS; SEDIMENT; DEPURATION
0350 FUEL OIL#2; PHYTOPLANKTON; AMPHIDINIUM; SKELETONEMA; CRICOSPHAERA; DUNALIALLA; BENZENE; TOLUENE; XYLENE; GROWTH
0366 FUEL OIL#2; NIANTIC BAY, CT.; BENTHIC COMMUNITIES; AMPHIPODS;

HERMIT CRABS; HYDROCARBON CONTENT ANALYSIS; GAS CHROMATOGRAPHY

0444 FUEL OIL#2; PHYTOPLANKTON; PHOTOSYNTHESIS;
BEDFORD BASIN, NOVA SCOTIA; NORTH WESTERN ATLANTIC; VENEZUELAN CRUDE;
FUEL OIL#6

0370 FUEL OIL#2; FUNDULUS; WATER SOLUBLE FRACTION; HATCHING; DEVELOPMENT;
HISTOPATHOLOGY

0670 FUEL OIL#2; OIL; JP5 FUEL; GAS CHROMATOGRAPHY; SEDIMENTS;
SEARSPORT SPILL

0688 FUEL OIL#2; WEST FALMOUTH, WILD HARBOR, MASS.; BENTHIC FAUNA;
SEDIMENTS; HYDROCARBON CONTENT; OPPORTINUSTIC SPECIES; RECOVERY;
GAS CHROMATOGRAPHY; DIVERSITY; POPULATIONS

0848 FUEL OIL#2; CRUDE OIL; SOUTH LOUISIANA CRUDE; KUWAIT CRUDE;
GROWTH RATE; PHOTOSYNTHESIS; MICROALGAE-TOXICITY; BLUE GREEN; DIATOM;
DINOFLAGELLATE

0871 FUEL OIL#2; SALMON, PINK; PRUDHOE BAY CRUDE; COOK INLET CRUDE;
WATER SOLUBLE FRACTION; RESPIRATION; COUGHING; UPTAKE & DEPURATION

0953 FUEL OIL#2; SOFT SHELL CLAM; MYA; EMULSION; TISSUE ABERRATIONS;
HISTOPATHOLOGY; EDEMA; VACUOLATION; GLYCOGEN

1032 FUEL OIL#2; DISPERSION; INTERTIDAL COLONIES; SPECIES DIVERSITY;
RELATIVE ABUNDANCE; NUMBERS OF SPECIES;
INDIVIDUAL FREQUENCY OCCURANCE PATTERNS

0120 FUEL OIL#6; TOXICITY; BENTHIC ANIMALS; INTERTIDAL; DIVERSITY;
RECOVERY; YORK RIVER; BUNKER C

0444 FUEL OIL#6; PHYTOPLANKTON; PHOTOSYNTHESIS;
BEDFORD BASIN, NOVA SCOTIA; NORTH WESTERN ATLANTIC; VENEZUELAN CRUDE;
FUEL OIL#2

0434 FUEL OIL#6; MYA; CARBON FLUX; CASCO BAY MAINE;
TAMANO-CASCO BAY MAINE 1972

0903 FUEL OIL-#2; TOXICITY; SHRIMP(GRASS); MINNOW; MUMMICHOG;
CATFISH(CHANNEL); BLUEGILL

0787 FUEL OIL-BOILER; TAINTING; GREEN FISH; EEL; CONTENT ANALYSIS;
GIRELLA; ANGULLA

0928 FUEL OIL-BUNKER C; BIRDS; MORTALITIES; SAN FRANCISCO BAY; AUTOPSIES

0255 FUEL OIL-NAVY SPECIAL; HYDROCARBON UPTAKE; COMMUNITIES; INTERTIDAL;
WASHINGTON STATE; GENERAL M.C. MEIGS SPILL

0249 FUEL OIL-NAVY SPECIAL; GENERAL M.C. MEIGS SPILL; CHRONIC; SURVEYS;
HYDROCARBON CONTENT; INTERTIDAL; WASHINGTON COAST; SEA URCHINS;
STRONGYLOCENTRUS

0034 FUNDULUS; WATER SOLUBLE FRACTION; OIL IN WATER DISPERSION;
CRUSTACEANS; FISH; TOXICITY; ESTUARINE; SOUTH LA. CRUDE;
KUWAIT CRUDE; FUEL OIL #2; BUNKER C; CYPRINODON; MENIDIA; PENAEUS;
PALEOMONETES; MYSIDOPSIS

0127 FUNDULUS; SALT MARSH; ESTUARY; YORK RIVER; SOUTH LA. CRUDE;
HYDROCARBON ANALYSIS; CONTROLLED ECOSYSTEM; AROMATICS;
GAS CHROMATOGRAPHY; GC-MS

0334 FUNDULUS; NAPHTHALENE; DISTRIBUTION IN BODY; STRESS BEHAVIOR

0405 FUNDULUS; TOXICITY; PIMEPHALES; ARTEMIA; KUWAIT; WEST TEXAS;
MARINE DIESEL; FUEL OIL; LUBE OIL

0370 FUNDULUS; FUEL OIL#2; WATER SOLUBLE FRACTION; HATCHING; DEVELOPMENT;
HISTOPATHOLOGY

0762 FUNDULUS; UPTAKE &DEPURATION; RANGIA; CRASSOSTREA; PENAEUS

0893 FUNDULUS; FISH; LIVER; LIPOGENESIS; RADIOACTIVE TRACERS;
ULTRASTRUCTURE; METABOLIC PATHWAYS; GLYCOLYSIS

0959 FUNDULUS; METABOLISM; INTERMEDIARY METABOLISM;
XENOBIOTIC METABOLISMS; LIPOGENISIS; STENOTOMUS;

MIXED -FUNCTION OXIDASES
0008 FUNGAL ECOLOGY; YEAST; MOLDS; BIODEGRADATION; UPTAKE
0065 FUNGI; PHOTOSYNTHESIS; RESPIRATION; NITROGEN FIXATION; BACTERIA; ALGAE; ARCTIC; CRUDE OIL; NATURAL GAS; MICROORGANISMS
0006 FUNGI; BIODEGRADATION; YEAST; GUPPY; LOUISIANA CRUDE OIL
0066 FUNGI; PROTOZOA; ALGAE; PLANTS; LICHENS; PSEUDOMONAS; ARCTIC; MICROORGANISMS; PRUDHOE CRUDE OIL; NATURAL OIL SEEPAGE; ALASKA-PRUDHOE BAY; CAPE SIMPSON
0225 FUNGI; DEGRADATION; BACTERIA; TEMPERATURE; OXIDATION; ASSIMILATION
0226 FUNGI; DEGRADATION; BACTERIA; TEMPERATURE
0205 FUNGI; DEGRADATION; BACTERIA; EMULSIONS; TOXICITY; TAINTING
0563 FUNGI; SALT MARSH; ESTUARY; YORK RIVER; BACTERIA; LOUISIANA CRUDE; SEDIMENTS; PETROLEUM DEGRADING
0687 FUNGI; DEGRADATION; PETROLEUM
1053 FUNGI; MICROORGANISMS; YEAST; BACTERIA; CHESAPEAKE BAY; SUBSTRATE SELECTION
1068 FUNGI; BACTERIA; SUSCEPTIBILITY; TOXICITY; ESTUARY; SOUTH LOUISIANA CRUDE OIL; FUEL OIL #2; CHESAPEAKE BAY; GROWTH
1113 FUNGI; CRUDE OIL; DEGRADATION; BACTERIA; YEAST; SUBSTRATE; DISTRIBUTION
1189 FUNGI; MICROORGANISMS; BACTERIA; YEASTS; BIODEGRADATION; CRUDE OIL; NIGERIA
0263 FUNGUS; BACTERIAL DEGRADATION; SEASONAL FLUCTUATION; SPECIES DISTRIBUTION; CHESAPEAKE BAY
0466 FUNGUS; GAS OIL; BIODEGRADATION
1055 FUNGUS; DEGRADATION; CLADOSPORIUM; OXIDIZING SYSTEM; PATHWAYS-METABOLIC; PESTICIDES; RADIOACTIVE TRACER EXPERIMENTS
1056 FUNGUS; DEGRADATION; BACTERIA; CLADOSPORIUM; WATER; SEDIMENTS; CHESAPEAKE BAY; HYDROCARBON CONCENTRATION
0367 FUTURE STUDY RECOMMENDATIONS; WASTE OIL; SHORT TERM IMPACT
0594 GADUS; CRUDE OIL; FISH FRY; DISPERSANTS; COD; HERRING; CLUPEA; TOXICITY; EMBRYOLOGY; CHEMORECEPTION
0354 GALVESTON BAY; OYSTERS; CRASSOSTREA; HYDROCARBON CONTENT; COLUMN CHROMATOGRAPHY; TLC; MASS SPECTA; UV SPECTRA
0111 GALVESTON BAY TEXAS; BIOLOGICAL INDICATORS; SPECIES DIVERSITY INDICIES; FISH
0036 GALVESTON BAY, TEXAS; OYSTERS; UPTAKE AND DEPURATION; ANALYTICAL METHODS (UV,GC); ANALYSIS FOR HYDROCARBONS; CRASSOSTREA; GULF OF MEXICO
0480 GALVESTON TEXAS; DEEPWATER PORT; ENVIRONMENTAL IMPACT
0424 GAMETE FORMATION; OIL; DISPERSANTS; TOXICITY; POLYCHAETE; SPAWNING; GROWTH; MORTALITY; CIRRATULUS; CIRRIFORMIA; BP1002; COREXIT; ESSOLVENE
0630 GAMMARUS; AMPHIPOD; TOXICITY; BEHAVIOR; LARVAE; FECUNDITY
0834 GAMMARUS; CRUDE OIL; IDOTEA; LONGEVITY; AMPHIPOD; ISOPOD; OXYGEN CONSUMPTION
0067 GAS CHROMATOGRAPHY; DEGRADATION; COMPONENT PREFERENCE; MASS SPEC.; RATE AND EXTENT; CO2 PRODUCTION; PREFERENTIAL DEGRADATION; MINERALIZATION; PARAFFINNIC CRUDE OIL; BACTERIA; BIODEGRADATION
0068 GAS CHROMATOGRAPHY; ABUNDANCE; DISTRIBUTION; BIOINDICATOR; ENUMERATION; CRUDE OIL- SWEDEN; TEMPERATURE; LEVEL OF OIL; MICROORGANISMS; BIODEGRADATION; RARITAN BAY N.J.
0127 GAS CHROMATOGRAPHY; SALT MARSH; ESTUARY; YORK RIVER; SOUTH LA. CRUDE; HYDROCARBON ANALYSIS; CONTROLLED ECOSYSTEM; FUNDULUS; AROMATICS; GC-MS

0148 GAS CHROMATOGRAPHY; SEDIMENTS; OYSTERS; SCALLOPS; BIODEGRADATION;
TOXICITY; CONTENT ANALYSIS; WEST FALMOUTH OIL SPILL; BUZZARD BAY
0323 GAS CHROMATOGRAPHY; TAINTING; FISH; YELLOWTAIL; CRUDE OIL;
VAPOR ANALYSIS; SERIOLA
0253 GAS CHROMATOGRAPHY; N-PARAFFINS; COLUMN CHROMATOGRAPHY
0332 GAS CHROMATOGRAPHY; HYDROCARBON CONTENT ANALYSIS;
THIN LAYER CHROMATOGRAPHY; HIGH PRESSURE LIQUID CHROMATOGRAPHY;
SAN FRANCISCO BAY; SPONGE; MUSSEL; CRAB
0410 GAS CHROMATOGRAPHY; CLAM; RANGIA; NAPHTHALENES; TRINITY BAY, TEXAS;
OIL SEPARATOR PLATFORM; UPTAKE; DEPURATION; SEDIMENTS;
HYDROCARBON ANALYSIS
0366 GAS CHROMATOGRAPHY; FUEL OIL#2; NIANTIC BAY, CT.;
BENTHIC COMMUNITIES; AMPHIPODS; HERMIT CRABS;
HYDROCARBON CONTENT ANALYSIS
0376 GAS CHROMATOGRAPHY; HYDROCARBON CONTENT; EXTRACTION TECHNIQUES
0379 GAS CHROMATOGRAPHY; HYDROCARBON ANALYSIS;
PETROLEUM VS. BIOSYNTHESIZED HC'S
0426 GAS CHROMATOGRAPHY; HYDROCARBON CONTENT ANALYSIS; PARAFFINS; SQUID;
SHRIMP; FISH
0401 GAS CHROMATOGRAPHY; MUSSEL; MYTILUS; LAGOON OF VENICE,ITALY;
HYDROCARBON CONTENT ANALYSIS; DISTANCE FROM POLLUTION SOURCE;
EXCHANGE WITH SEA
0505 GAS CHROMATOGRAPHY; HYDROCARBONS CONTENT ANALYSIS;
DYNAMIC HEAD SPACE SAMPLING; COUPLED-COLUMN LIQUID CHROMATOGRAPHY;
MASS SPECTROMETRY
0504 GAS CHROMATOGRAPHY; HYDROCARBON CONTENT ANALYSIS;
ALASKA-PR. WILLIAM SOUND
0600 GAS CHROMATOGRAPHY; PETRO SULFAR COMPOUNDS; AROMATIC HYDROCARBONS;
MODIOLUS; CRASSOSTREA; RETENTION; FLAME IONIZATION DETECTION;
FLAME PHOTOMETRIC DETECTION; GAS CHROMATOGRAPHY-MASS SPECTROMETRY
0670 GAS CHROMATOGRAPHY; OIL; FUEL OIL#2; JP5 FUEL; SEDIMENTS;
SEARSPORT SPILL
0689 GAS CHROMATOGRAPHY; FUEL OIL#2; WEST FALMOUTH, WILD HARBOR, MASS.;
BENTHIC FAUNA; SEDIMENTS; HYDROCARBON CONTENT; OPPORTINUSTIC SPECIES;
RECOVERY; DIVERSITY; POPULATIONS
0694 GAS CHROMATOGRAPHY; DEGRADATION; BACTERIA; PARAFFIN; CRUDE OIL;
EMULSIFICATION
0738 GAS CHROMATOGRAPHY; N-PARAFFINS; SEDIMENTS; SOLVENT
0680 GAS CHROMATOGRAPHY; DEGRADATION; CRUDE OIL; SANTA BARBARA;
WEATHERING; SEQUENCE OF DEGRADATION
0641 GAS CHROMATOGRAPHY; ESTUARIES; HYDROCARBON CONCENTRATIONS; SEDIMENTS;
ZOOPLANKTON; PHYTOPLANKTON; CRUDE OIL; SALT MARSH PLANTS; DIVERSITY;
POPULATIONS; FISH; MIGRATION; DEGRADATION
0737 GAS CHROMATOGRAPHY; PARAFFINS; FISH; CRUDE OIL; JULIANA WRECK;
SALMON; MULLET; BLACK SEA BREAM
0681 GAS CHROMATOGRAPHY; HYDROCARBON CONTENT ANALYSIS
0692 GAS CHROMATOGRAPHY; HYDROCARBON CONTENT ANALYSIS; MULLET; SHRIMP;
OYSTER; LIQUID CHROMATOGRAPHY
0788 GAS CHROMATOGRAPHY; FISH; PARIFFINS; EELS; ARABIAN LIGHT CRUDE OIL;
TAINTING; ORGANIC SULFUR
0748 GAS CHROMATOGRAPHY; BIOASSAY; SALT MARSH; MICROCOSM;
SPECTROPHOTOMETRY; ULTRAVIOLET; FLUORESENT
0786 GAS CHROMATOGRAPHY; TAINTING; JAPANESE COAST; FISH; EELS;
IR ABSORPTION; UV ABSORPTION; MASS SPECTRUM; TOLUENE;
MIZUSHIMA, JAPAN; AROMATIC HYDROCARBONS; GASOLINE

0758 GAS CHROMATOGRAPHY; CLAMS; UPTAKE; DEPURATION; CONTENT ANALYSIS; CRUDE OIL; FUEL OIL #2; SOLUBLE FRACTIONS
0913 GAS CHROMATOGRAPHY; CLAM; MACOMA; PRUDHOE BAY CRUDE OIL; HYDROCARBON ANALYSIS; BEHAVIOR; BURROWING
0922 GAS CHROMATOGRAPHY; KEROSENE; MULLET; TAINTING; MUGIL
1013 GAS CHROMATOGRAPHY; ESTUARINE; DIATOMS; SELECTIVE ABSORPTION
0963 GAS CHROMATOGRAPHY; BIODEGRADATION; YEAST; TEMPERATURE; ACID PRODUCTION; SUBSTRATE SELECTION
1041 GAS CHROMATOGRAPHY; KUWAIT CRUDE OIL; SUSPENSION; COREXIT 7664; SPECTROFLUOROMETRY; COPEPOD; TOXICITY; LONG-TERM EFFECTS; REPRODUCTION; EGG PRODUCTION; HATCHING SUCCESS
1157 GAS CHROMATOGRAPHY; SOUTH LOUISIANA CRUDE OIL; OYSTERS; CRASSOSTREA; ANALYSIS FOR HYDROCARBONS; MORTALITY
1074 GAS CHROMATOGRAPHY; ALIPHATIC; AROMATIC; DETERMINATION TECHNIQUES; MARINE ORGANISMS; ETHER EXTRACTION; SILICA GEL CHROMATOGRAPHY; MASS SPECTROMETRY
1072 GAS CHROMATOGRAPHY; HYDROCARBON CONTENT ANALYSIS; SILICA GEL; TISSUE EXTRACTION
1075 GAS CHROMATOGRAPHY; ANACORTES; TRANSECTS; HYDROCARBON CONTENT ANALYSIS; DIVERSITY INIDICES; INTERTIDAL INVERTEBRATES
1095 GAS CHROMATOGRAPHY; MICROALGAE; WATER SOLUBLE FRACTION; HYDROCARBON ANALYSIS; MASS SPECTROMETRY; BAYTOWN; MONTANA; BATON ROUGE; NEW JERSEY
1137 GAS CHROMATOGRAPHY; AUSTRALIA; UPTAKE; RETENTION; DEPURATION; MYTILUS; MUSSEL; EFFECT ON ECOSYSTEM; BIOINDICATORS; TOXICITY
1167 GAS CHROMATOGRAPHY; CALIFORNIA; TAINTING; PETROLEUM; CLEANING AGENTS; ORGANOLEPTIC; BIODEGRADATION
1187 GAS CHROMATOGRAPHY; SCALLOPS; PECTEN; PARAFFINS; ANALYSIS FOR HYDROCARBONS
1194 GAS CHROMATOGRAPHY; THIN LAYER CHROMATOGRAPHY; ANALYSIS FOR HYDROCARBONS
0923 GAS CHROMATOGRAPHY- MASS SPECTROSCOPY; TAINTING; MULLET; MUGIL; KEROSENE; GAS LIGUID CHROMATOGRAPHY; INFRA RED SPECTROSCOPY; RADIOACTIVE TRACERS; UPTAKE; PROTON MAGNETIC RESONANCE SPECTROSCOPY
0600 GAS CHROMATOGRAPHY-MASS SPECTROMETRY; PETRO SULFAR COMPOUNDS; AROMATIC HYDROCARBONS; MODIOLUS; CRASSOSTREA; RETENTION; FLAME IONIZATION DETECTION; FLAME PHOTOMETRIC DETECTION; GAS CHROMATOGRAPHY
0577 GAS EXCHANGE; REEF COMMUNITY; RESPIRATION; CALMING EFFECTS; FIELD FENCING TECHNIQUES; CRUDE OIL; TOXIXCTY; BEHAVIOR; HERON IS. GREAT BARRIER REEF AUSTRALIA
0955 GAS EXCHANGE; SALT MARSH; PLANTS; WEATHERED OIL; DEGRADATION; RETENTION; BRITTANY; TORREY CANYON
0923 GAS LIGUID CHROMATOGRAPHY; TAINTING; MULLET; MUGIL; KEROSENE; GAS CHROMATOGRAPHY- MASS SPECTROSCOPY; INFRA RED SPECTROSCOPY; RADIOACTIVE TRACERS; UPTAKE; PROTON MAGNETIC RESONANCE SPECTROSCOPY
0251 GAS LIQUID CHROMATOGRAPHY; PARAFFINS; LIQUID-SOLID CHROMATOGRAPHY; TECHNIQUES
0559 GAS LIQUID CHROMATOGRAPHY; SANTA BARBARA SPILL; BACTERIAL POPULATIONS; SEDIMENTS; HYDROCARBON ANALYSIS
0466 GAS OIL; BIODEGRADATION; FUNGUS
0914 GAS WASTES; HYDROCARBONS; FISH; TOXICITY; BEHAVIOR; ATTRACTION; SUNFISH (ORANGE-SPOTTED)
0130 GAS-LIQUID CHROMATOGRAPHY; HYDROCARBON; ANALYSIS FOR PHC'S; N-ALKANE;

0893 GLYCOLYSIS; FISH; FUNDULUS; LIVER; LIPOGENESIS; RADIOACTIVE TRACERS; ULTRASTRUCTURE; METABOLIC PATHWAYS
0358 GOATFISH; MACROFAUNA; RED SEA; TOXICITY; CRUDE OIL; DISPERSANT; CORAL; HETEROXENIA; GASTROPODS; MUSSELS; CHITON; SEA URCHIN; HERMIT CRAB; SHRIMP; RABBITFISH
0613 GOBY; FISH; NAPTHALENE; BENZ(A)PYRENE; RADIOACTIVE TRACER; UPTAKE; METABOLISM; DISCHARGE; SCULPIN; OLIGOCOTTUS; GILLICHTHYS; SAND DAB; CITHARICHTHYS
0179 GOLDFISH; TOXICITY; OUTBOARD MOTOR EXHAUST; CONTINUOUS FLOW BIOASSAY; CARASSINS; TOLUENE; XYLENE; TRIMETHYLBENZENE
0800 GRAMMARUS; PATELLA; ROCKY SHORE
0035 GRASS SHRIMP,PALAEMONTES; ESTUARINE ANIMALS; UPTAKE AND DEPURATION; TOXICITY; RESPIRATION; SOUTH LA. CRUDE; KUWAIT CRUDE; FUEL OIL #2; BUNKER C; MINNOW; BROWN SHRIMP,PANAEUS; WATER SOLUBLE FRACTION; OIL WATER DISPERSION; NAPHTHALENES
0063 GREEN ALGAE; MICROBIAL POPULATIONS; PROTOZOANS; BLUE GREEN ALGAE; DIATOMS; DEGRADATION; YEAST; SPECIES DIVERSITY; NATURAL SEEPAGE; PRUDHOE CRUDE OIL; ARCTIC; ALASKA-PRUDHOE BAY; CAPE SIMPSON; NUTRIENT ENRICHMENT
0941 GREEN ALGAE; WATER SOLUBLE FRACTION; CRUDE OIL; NAPHTHALENE; PHYSIOLOGY; MORPHOLOGY; FRESHWATER
0943 GREEN ALGAE; NAPTHALENE; WATER SOLUBLE FRACTION; CHLAMYDOMONAS; PHOTOSYNTHESIS; UPTAKE; DEPURATION
0787 GREEN FISH; TAINTING; EEL; FUEL OIL-BOILER; CONTENT ANALYSIS; GIRELLA; ANGULLA
0573 GREEN SEA URCHIN; TOXICITY; VENEZUELAN CRUDE OIL; BEDFORD BASIN NOVA SCOTIA; OIL SPERSE
0316 GREY SEALS; PEMBROKESHIRE WEST WALES; BEHAVIOR; GROWTH; MORTALITY
0076 GROWTH; SALMON-CHINOOK; BENZENE
0037 GROWTH; OYSTERS; UPTAKE AND DEPURATION; CRASSOSTREA; ANALYSIS FOR HYDROCARBONS
0011 GROWTH; PETROLEUM PRODUCTS; BLUE GREEN ALGAE; APHANIZOMENON; SCENEDESMUS; MORPHOLOGY; PROTOCOCCAL ALGAE
0028 GROWTH; PETROLEUM HYDROCARBONS; MARINE ORGANISMS
0207 GROWTH; MERCENARIA; TOXICITY; EMBRYOS; LARVAE; WATER SOLUBLE FRACTION; CRUDE; REFINED; WASTE
0340 GROWTH; CLAMS; SURVIVAL
0322 GROWTH; ALGAE; EUGLENA; SCENEDESMUS; LUBRICATING OILS; DIESEL OIL; PHOTOSYNTHETIC METABOLISM
0316 GROWTH; GREY SEALS; PEMBROKESHIRE WEST WALES; BEHAVIOR; MORTALITY
0350 GROWTH; PHYTOPLANKTON; AMPHIDINIUM; SKELETONEMA; CRICOSPHAERA; DUNALIALLA; BENZENE; TOLUENE; XYLENE; FUEL OIL#2
0424 GROWTH; OIL; DISPERSANTS; TOXICITY; POLYCHAETE; GAMETE FORMATION; SPAWNING; MORTALITY; CIRRATULUS; CIRRIFORMIA; BP1002; COREXIT; ESSOLVENE
0483 GROWTH; MYTILUS; SANTA BARBARA SPILL; BODY WEIGHT
0567 GROWTH; CASPIAN SEA; BENTHOS; CRUDE OIL; REPRODUCTION; CHIRONOMUS; CERASTODERMA; NAIS; NEREIS; PYRGOHYDROBIA; ABRA
0508 GROWTH; CRASSOSTREA; OYSTER; MERCENARIA; CLAM; SURFACTANT; LARVAE; DEVELOPMENT; SURVIVAL; TOXICITY
0501 GROWTH; PHYTOPLANKTON; PHOTOSYNTHESIS; PLANTS; COMMUNITY EFFECTS; ARCTIC; PERIPHYTON; POPULATION COMPOSITION; SEASONAL SUCCESSION; MACKENZIE VALLEY NWT
0572 GROWTH; FRESH WATER; CHLORELLA VULGARIS; ALGAE; TOXICITY; PHOTOSYNTHESIS; BENZENE; XYLENE; TOLUENE; NAPTHALENE

0718 GROWTH; CHRONIC POLLUTION; OIL PORT; POMATOLEIOS; TOXICITY; KUWAIT; DIVERSITY; SUCCESSION

0651 GROWTH; OYSTER; CRASSOSTREA; LOUISIANA; OIL SPILL; MORTALITY; SET; DISEASE INCIDENCE; TAINTING

0710 GROWTH; ALGAE; PETROLEUM; TOXICITY

0761 GROWTH; TOXICITY; AROMATICS; PHENATHRENES; ESTUARINE; BENTHIC; OCEANIC; LARVAE; JUVENILES; RESPIRATION; SUBLETHAL

0822 GROWTH; LITTORINA; NUCELLA; BUCINNUM; DETERGENTS; MORTALITY; BP1002; TARSOLVENT

0942 GROWTH; CRUDE OIL; NAPTHALENE; WATER SOLUBLE FRACTION; CHLAMYDOMONAS; TOXICITY

0869 GROWTH; CRUDE OIL; SALMON; ONCORHYNCHUS; EGGS; ALEVINS; FRY; TOXICITY

1021 GROWTH; DETERGENTS; PHYTOPLANKTON

0985 GROWTH; BENZENE; HERRING; ANCHOVY; EGGS; LARVAE; TOXICITY; ABNORMALITIES; RESPIRATION; FEEDING

1020 GROWTH; ALGAE; EMULSIFIERS; BIOASSAY; TOXICITY; POPULATION; TISSUES; LAVER; PORPHYRA

1121 GROWTH; MALLARD; TOXICITY; PHYSIOLOGICAL EFFECTS; FUEL OIL; HATCHING SUCCESS; PARAFFINS

1142 GROWTH; DUCKS; HATCHABILITY; AROMATICS; EFFECTS ON ORGANISMS; REPRODUCTION & DEVELOPMENT

1079 GROWTH; LOBSTER; HOMARUS; LARVAE; TOXICITY; BEHAVIOR; VENEZUELA CRUDE OIL; FOOD CONSUMPTION; DISPERSIONS

1131 GROWTH; MICROFLORA; PHYTOPLANKTON; ALGAE; CRUDE OIL; FUEL OIL; TOXICITY; NAPHTHALENE; PHENANTHRENE; AROMATICS; ALGAE-GREEN; ALGAE-BLUE GREEN; DIATOMS

1088 GROWTH; BACTERIA; SUSCEPTIBILITY; FUNGI; TOXICITY; ESTUARY; SOUTH LOUISIANA CRUDE OIL; FUEL OIL #2; CHESAPEAKE BAY

1216 GROWTH; ALGAE; PORPHYRA; DISPERSANTS; TOXICITY

1170 GROWTH; FUEL OIL; FLOUNDER; REPRODUCTION; HATCHING SUCCESS; EGGS; LARVAE; HISTOPATHOLOGY

1182 GROWTH; CRUDE OIL; CRAB; SHRIMP; ALASKA; EMBRYOGENESIS; COOK INLET

1211 GROWTH; FUEL OIL #2; EIDER; EGGS; HATCHING SUCCESS; DUCKS

0725 GROWTH ENHANCEMENT; PLANTS, AQUATIC; BACTERIAL DEGRADATION; RIVERS

1052 GROWTH POTENTIAL; DEGRADATION; BACTERIA; SEDIMENTS; NORTH ATLANTIC

1067 GROWTH POTENTIAL; DEGRADATION; BACTERIA; SEDIMENTS; DEEP SEA; INORGANIC NUTRIENTS

0453 GROWTH RATE; CRUDE OIL; REFINED OIL; TOXICITY; BACTERIA; WATER SOLUBLE FRACTION; AROMATIC HYDROCARBONS; WEATHERING; MAXIMUIM CELL DENSITY

0685 GROWTH RATE; FIELDS STUDIES; CHRONIC POLLUTION; SANTA BARBARA SPILL; LAKE MARACAIBO, VENEZUELA; BERMUDA; TIMBALIER BAY, LA.; POPULATION LEVELS; DIVERSITY; SIZE; REPRODUCTION; ABNORMAL GROWTHS; BIOMAGNIFICATION

0848 GROWTH RATE; CRUDE OIL; SOUTH LOUISIANA CRUDE; KUWAIT CRUDE; FUEL OIL#2; PHOTOSYNTHESIS; MICROALGAE-TOXICITY; BLUE GREEN; DIATOM; DINOFLAGELLATE

0807 GROWTH RATE; WATER SOLUBLE FRACTIONS; CRUDE OIL; MICROALGAE; HYDROCARBON ANALYSIS; SEDIMENTS; WATERS; BIOTA; SOUTH TEXAS OUTTER CONTINENTAL SHELF

0570 GROWTH RATES; CRUDE OIL; CHLORELLA; WATER SOLUBLE FRACTIONS; TOXICITY; STIMULATION

0719 GROWTH RATES; ALGAE; PLATYMONAS; TOXICITY; FINE STRUCTURE; NANO PLANKTON; CRUDE OIL; EMULSIFIER

0845 GROWTH RATES; OIL; ALGAE; DINOFLAGELLATE; DUNALIELLA; DIATOM; FRAGILARIA; AXEMIC CULTURES
0947 GROWTH RATES; ALGAE; MARINE; PHYTOPLANKTON; CRUDE OIL; FUEL OIL #2
1020A GROWTH RATES; BACTERIA; DEGRADATION; LOW TEMPERATURE
1106 GROWTH STAGES; TOXICITY; REVIEW; CRUDE OIL; BIOASSAY; MORTALITY
0079 GROWTH STIMULATION; SALT MARSH; SALT MARSH GRASSES
0327 GUANICA; OIL SPILL; PUERTO RICO
0170 GUILLEMOTS; BIRDS; MORTALITIES; CONSERVATION
0171 GUILLEMOTS; PLUMAGE; WEARING
0172 GUILLEMOTS; TORREY CANYON; BIRDS; MORTALITIES; RAZORBILLS
0810 GUILLEMOTS; BIRDS; BREEDING COLONIES; OIL; WORLD WAR 2 OIL POLLUTION; PUFFINS
0165 GUILLIMOTS; BIRDS; GULLS; KITTIWAKES; BEHAVIOR
0723 GULF OF ALASKA; HYPOTHETICAL SPILLS; ATLANTIC COAST; ECOLOGICAL IMPACT
0036 GULF OF MEXICO; OYSTERS; UPTAKE AND DEPURATION; GALVESTON BAY, TEXAS; ANALYTICAL METHODS (UV,GC); ANALYSIS FOR HYDROCARBONS; CRASSOSTREA
0015 GULF OF MEXICO; OIL SPILL INCIDENT; OFFSHORE WELLS; CHEVRON OIL PLATFORM
0894 GULF OF MEXICO; LOW MOLECULAR WEIGHT HYDROCARBONS; OFFSHORE PRODUCTION; TOXICITY
1096 GULF OF MEXICO; PARAFFINS; PLANKTON
1159 GULF OF MEXICO; CAPITELLA; CORDGRASS; MANGROVES; CRUDE OIL; MARSH; TEXAS; ASSESSMENT OF SPILLS
0004 GULF OF ST. LAWRENCE; MAGDALEN IS.; LITTORAL COMMUNITY; CANADA
0236 GULF REFINERY SPILL; DISPERSANTS; CHRYSSI P. GOULANDRIS SPILLAGE; TOXICITY; FINA NOVAGE SPILLAGE; TORREY CANYON SPILL
1144 GULKS; BIRDS; HATCHING SUCCESS; EMBRYONIC DEVELOPMENT; EIDERS; MALLARDS; PATHOLOGICAL EFFECTS; FUEL OIL; CRUDE OIL
0165 GULLS; BIRDS; GUILLIMOTS; KITTIWAKES; BEHAVIOR
0717 GULLS; BIRDS; MORTALITIES; SAN FRANCISCO SPILL-1937; WATERFOWL
0006 GUPPY; BIODEGRADATION; YEAST; LOUISIANA CRUDE OIL; FUNGI
1091 HADDOCK; DISPERSANT; TOXICITY; FISH; LARVAE; HERRING; PILCHARD; PLAICE; SOLE; LEMON SOLE; BP1002; DELAYED EFFECTS; EMBRYOLOGY; BEHAVIORAL CHANGES
1141 HADDOCK; TAINTING; DISTILLATES; POTATO; VASCULAR PLANTS
0820 HALITHOLUS; ARCTIC; CRUDE OIL; AMPHIPOD; COELENTERATE; LOCOMOTORY ACTIVITY; SUBLETHAL EFFECTS; ONISIMUS
0558 HAMILTON TRADER SPILL; BIRDS; IRISH SEA
0425 HARP SEALS; RINGED SEALS; PHOCA; STRESS; INGESTION
0842 HARPACTICOID COPEPODS; ARGO MERCHANT SPILL; BENTHIC FAUNA; SPECIES DIVERSITY; POPULATION DENSITY; INTERTIDAL FAUNA; POLYCHAETES; AMPHIPODS
1098 HARPACTICOID COPEPODS; HONG KONG; DIESEL SPILL; MEIOFAUNA; SANDY BEACHES; INTERTIDAL; NEMATODES
0492 HATCHABILITY; OIL; BIRDS; DUCKS; REPRODUCTION; INGESTION; COATING
1142 HATCHABILITY; DUCKS; GROWTH; AROMATICS; EFFECTS ON ORGANISMS; REPRODUCTION & DEVELOPMENT
0370 HATCHING; FUNDULUS; FUEL OIL#2; WATER SOLUBLE FRACTION; DEVELOPMENT; HISTOPATHOLOGY
0592 HATCHING; CRUDE OIL; PETROLEUM FRACTIONS; HERRING; DEVELOPMENT; TOXICITY; EMULSIFICATION
0032 HATCHING SUCCESS; FISH EMBRYOS; HEART BEAT
0595 HATCHING SUCCESS; TOXICITY; EGGS; LARVAE; COD; BUNKER C; WATER SOLUBLE FRACTION

0931 HATCHING SUCCESS; PACIFIC HERRING; TOXICITY; ROE;
MORPHOLOGICAL ANOMOLIES; HERRING; CRUDE OIL; ALASKA
1041 HATCHING SUCCESS; KUWAIT CRUDE OIL; SUSPENSION; COREXIT 7664;
GAS CHROMATOGRAPHY; SPECTROFLUOROMETRY; COPEPOD; TOXICITY;
LONG-TERM EFFECTS; REPRODUCTION; EGG PRODUCTION
1122 HATCHING SUCCESS; EIDER; TOXICITY; REPRODUCTIVE GROWTH; FUEL OIL
1144 HATCHING SUCCESS; BIRDS; EMBRYONIC DEVELOPMENT; EIDERS; GULKS;
MALLARDS; PATHOLOGICAL EFFECTS; FUEL OIL; CRUDE OIL
1121 HATCHING SUCCESS; MALLARD; TOXICITY; PHYSIOLOGICAL EFFECTS; FUEL OIL;
PARAFFINS; GROWTH
1135 HATCHING SUCCESS; ESTUARINE; BIRDS; DUCKS; FISH; CHESAPEAKE BAY;
TOXICITY
1127 HATCHING SUCCESS; ARGO MERCHANT SPILL; FUEL OIL; EMBRYOGENESIS;
MORPHOLOGY; POLLOCK; CEPHALACHORDATA; AMPHIOXUS
1153 HATCHING SUCCESS; TROUT; FERTILIZATION; REPRODUCTION & DEVELOPMENT;
HISTOPATHOLOGICAL EFFECTS; MORPHOLOGY
1123 HATCHING SUCCESS; EIDER DUCKS; TOXICITY; PHYSIOLOGICAL EFFECTS;
FUEL OIL
1212 HATCHING SUCCESS; SHRIMP; LARVAL GROWTH; UPTAKE; DEPURATION;
FUEL OIL #2; BEHAVIORAL EFFECTS
1170 HATCHING SUCCESS; FUEL OIL; FLOUNDER; REPRODUCTION; GROWTH; EGGS;
LARVAE; HISTOPATHOLOGY
1211 HATCHING SUCCESS; FUEL OIL #2; EIDER; EGGS; GROWTH; DUCKS
0032 HEART BEAT; FISH EMBRYOS; HATCHING SUCCESS
1070 HEART RATE; FUEL OIL #2; CATFISH; TOXICITY; FEEDING BEHAVIOR
0494 HEAT CONDUCTIVITY; OIL; DUCKS; COATING; METABOLISM; TEMPERATURE
0374 HEAT FLUX; SEALS; OTTERS; METABOLIC RATE; DIVING BEHAVIOR
0123 HEATING OIL; COPEPOD; REPRODUCTION; NAPHTHALENE; EURYTEMORA;
EGG PRODUCTION; WATER SOLUBLE FRACTION
0451 HEAVY FUEL OIL; IRISH STARDUST - ALERT BAY 1973; ALERT BAY, CANADA;
RECOVERY; BIODEGRADATION
0359 HEMATOCRIT; CRUDE OIL; DETERGENT; OCTOCORALS; CRUSTACEANS; MOLLUSCS;
ECHINODERMS; FISH; TOXICITY; SUBLETHAL; DEVELOPMENTAL STAGES;
RED SEA; FEEDING RATE; PHYSIOLOGY; BIOACCUMULATION;
LIVER ENLARGEMENT
0901 HEMOCYTES; ARGO MERCHANT SPILL; HISTOPATHOLOGY; AMMODYTES;
FLOUNDER (WINTER&YELLOWTAIL); ALEWIVES; CRABS(HERMIT); HYPERPLASIA;
EDEMA; CILIATES
0985 HEMOGLOBIN; FUEL OIL # 2; WATER SOLUBLE FRACTION; NEANTHES;
POLYCHAETE; HYPOXIA; SOUTH LOUISIANA CRUDE; DISSOLVED OXYGEN;
TOXICITY; SYNERGISM; NAPHTHALENES; DISSOLVED HYDROCARBONS;
RESPIRATION
1199 HEMOGLOBIN COMPENSATION; FUEL OIL #2; SOUTH LOUISIANA CRUDE OIL;
POLYCHAETE; HYPOXIA
0358 HERMIT CRAB; MACROFAUNA; RED SEA; TOXICITY; CRUDE OIL; DISPERSANT;
CORAL; HETEROXENIA; GASTROPODS; MUSSELS; CHITON; SEA URCHIN; SHRIMP;
GOATFISH; RABBITFISH
0366 HERMIT CRABS; FUEL OIL#2; NIANTIC BAY, CT.; BENTHIC COMMUNITIES;
AMPHIPODS; HYDROCARBON CONTENT ANALYSIS; GAS CHROMATOGRAPHY
0577 HERON IS. GREAT BARRIER REEF AUSTRALIA; REEF COMMUNITY; RESPIRATION;
CALMING EFFECTS; GAS EXCHANGE; FIELD FENCING TECHNIQUES; CRUDE OIL;
TOXIXCTY; BEHAVIOR
0593 HERRING; WATER SOLUBLE FRACTION; COD; EGGS; LARVAE
0594 HERRING; CRUDE OIL; FISH FRY; DISPERSANTS; COD; GADUS; CLUPEA;
TOXICITY; EMBRYOLOGY; CHEMORECEPTION

0592 HERRING; CRUDE OIL; PETROLEUM FRACTIONS; HATCHING; DEVELOPMENT; TOXICITY; EMULSIFICATION
0629 HERRING; TOXICITY; CRUDE OIL; DISPERSANTS; LARVAE; CULPEA
0880 HERRING; AGONUS; TOXICITY
0931 HERRING; PACIFIC HERRING; TOXICITY; ROE; HATCHING SUCCESS; MORPHOLOGICAL ANOMOLIES; CRUDE OIL; ALASKA
0986 HERRING; BENZENE; CULPEA; SPAWNING; OVARIAN EGGS; EMBRYOS; LARVAE; BEHAVIOR; RADIOACTIVE TRACER
0985 HERRING; BENZENE; ANCHOVY; EGGS; LARVAE; TOXICITY; ABNORMALITIES; GROWTH; RESPIRATION; FEEDING
1093 HERRING; FISH; SOLE; PLAICE; LARVAE; DETERGENT; DEVELOPMENTAL ABNOMALITIES; BP1002; FINASOL; COREXIT
1107 HERRING; COKE OIL; MORTALITY; ROUTE OF UPTAKE; CLUPEA; NOVA SCOTIA
1091 HERRING; DISPERSANT; TOXICITY; FISH; LARVAE; PILCHARD; PLAICE; SOLE; LEMON SOLE; HADDOCK; BP1002; DELAYED EFFECTS; EMBRYOLOGY; BEHAVIORAL CHANGES
0975 HESPEROPHYCUS; SANTA BARBARA SPILL; BIRDS; INVERTEBRATES; ALGAE; MORTALITIES; RECOLONIZATION; SUBLETHAL EFFECTS; PHYLLOSPADIX; CHTHAMALUS; POLLICIPES
0358 HETEROXENIA; MACROFAUNA; RED SEA; TOXICITY; CRUDE OIL; DISPERSANT; CORAL; GASTROPODS; MUSSELS; CHITON; SEA URCHIN; HERMIT CRAB; SHRIMP; GOATFISH; RABBITFISH
0260 HETEROXENIA; CRUDE OIL; TOXICITY; CORALS; RED SEA; SUBLETHAL EFFECTS; DEPTH PROTECTION EFFECTS; HYDROCARBON CONTENT ANALYSIS
0910 HEXADECANE; BIODEGRADATION; RADIOACTIVE TRACER; TOKYO BAY; WATER COLUMN; BACTERIA
1051 HEXADECANE; DEGRADATION; CLADOSPORIUM; OXYGEN CONSUMPTION; COOXIDATION; TOLUENE; XYLENE
1060 HEXADECANE; BIODEGRADATION; POTENTIAL; MARINE; RADIOMETRY
0332 HIGH PRESSURE LIQUID CHROMATOGRAPHY; HYDROCARBON CONTENT ANALYSIS; GAS CHROMATOGRAPHY; THIN LAYER CHROMATOGRAPHY; SAN FRANCISCO BAY; SPONGE; MUSSEL; CRAB
0693 HIGH PRESSURE LIQUID CHROMATOGRAPHY; HYDROCARBON ANALYSIS TECHNIQUES
0191A HISTOLOGY; ARGO MERCHANT SPILL; LESIONS; PEARL FORMATION; CANCER; MODIOLUS; ZOOPLANKTON
1148 HISTOPATHOLOGICAL EFFECTS; QUAHOGS; PHENOL; TOXICITY; METHODOLOGY; CYTOLOGY; CLAMS
1156 HISTOPATHOLOGICAL EFFECTS; FISHES; CRUDE OIL; TOXICITY
1159 HISTOPATHOLOGICAL EFFECTS; TROUT; HATCHING SUCCESS; FERTILIZATION; REPRODUCTION & DEVELOPMENT; MORPHOLOGY
0100 HISTOPATHOLOGY; MERCENARIA; CLAMS; CANCER; TUMORS; NEOPLASM; SEARSPORT,MAINE
0098 HISTOPATHOLOGY; HYPERPLASIA; CLAMS; MYA; CARCINOGENISIS
0417 HISTOPATHOLOGY; OYSTER; SCALLOP; SILVERSIDES; MOTOR OIL; LESIONS
0415 HISTOPATHOLOGY; CRUDE OIL; LESIONS; FISH; MENIDIA; HYPERPLASIA
0495 HISTOPATHOLOGY; OIL; BIRDS; DUCKS; INGESTION; TOXICITY; PHYSIOLOGICAL EFFECTS
0370 HISTOPATHOLOGY; FUNDULUS; FUEL OIL#2; WATER SOLUBLE FRACTION; HATCHING; DEVELOPMENT
0655 HISTOPATHOLOGY; PHSIOLOGICAL EFFECTS; SALMON; FLATFISH; SPOTTED SHRIMP; UPTAKE AND DEPURATION
0901 HISTOPATHOLOGY; ARGO MERCHANT SPILL; AMMODYTES; FLOUNDER (WINTER&YELLOWTAIL); ALEWIVES; CRABS(HERMIT); HYPERPLASIA; EDEMA; HEMOCYTES; CILIATES
0953 HISTOPATHOLOGY; FUEL OIL#2; SOFT SHELL CLAM; MYA; EMULSION;

0410 HYDROCARBON ANALYSIS; CLAM; RANGIA; NAPHTHALENES; TRINITY BAY, TEXAS;
OIL SEPARATOR PLATFORM; UPTAKE; DEPURATION; SEDIMENTS;
GAS CHROMATOGRAPHY

0559 HYDROCARBON ANALYSIS; SANTA BARBARA SPILL; BACTERIAL POPULATIONS;
SEDIMENTS; GAS LIQUID CHROMATOGRAPHY

0669 HYDROCARBON ANALYSIS; PELAGIC HYDROCARBONS; TAR BALLS;
ROCKY INTERTIDAL; FLORA; FAUNA; BERMUDA; SPLASH ZONE; NODILITTORINA;
TECTARIUS; ALGAE

0749 HYDROCARBON ANALYSIS; PUERTO RICO; ZOE COLOCUTRONIS;
VENEZUELEN CRUDE; MANGROVE PROP COMMUNITY; TURTLE GRASS COMMUNITY;
SEDIMENTS; TROPICAL

0796 HYDROCARBON ANALYSIS; BACTERIA; SEDIMENTS; NORTH SEA; SEAWATER;
PELAGIC TAR

0807 HYDROCARBON ANALYSIS; WATER SOLUBLE FRACTIONS; CRUDE OIL; MICROALGAE;
GROWTH RATE; SEDIMENTS; WATERS; BIOTA;
SOUTH TEXAS OUTTER CONTINENTAL SHELF

0746 HYDROCARBON ANALYSIS; FATE & EFFECT; DISTRIBUTION

0913 HYDROCARBON ANALYSIS; CLAM; MACOMA; PRUDHOE BAY CRUDE OIL;
GAS CHROMATOGRAPHY; BEHAVIOR; BURROWING

0906 HYDROCARBON ANALYSIS; FISH; PERIPHYTON; SEDIMENTS; STREAM;
DIESEL FUEL; BOONE CREEK OIL SPILL; MACROINVERTEBRATES;
SOUTH CAROLINA

1016 HYDROCARBON ANALYSIS; SEDIMENTS; CHROMATOGRAPHY; MASS SPECTROMETRY;
UV FLUORESCENCE; PETROLEUM

1097 HYDROCARBON ANALYSIS; TRANSECT; INVERTEBRATES; TISSUES; SEDIMENT;
RECOLONIZATION; COBBLE BEACH; SPECTROPHOTOMETRY

1095 HYDROCARBON ANALYSIS; MICROALGAE; WATER SOLUBLE FRACTION;
GAS CHROMATOGRAPHY; MASS SPECTROMETRY; BAYTOWN; MONTANA; BATON ROUGE;
NEW JERSEY

0693 HYDROCARBON ANALYSIS TECHNIQUES; HIGH PRESSURE LIQUID CHROMATOGRAPHY

0728 HYDROCARBON CONCENTRATION; LIPIDS; SURFACE FILMS; ZOOPLANKTON

0828 HYDROCARBON CONCENTRATION; DEGRADATION; BACTERIA; ESTUARY; BEACH;
FUEL OIL; ENRICHMENT; RATE; NARRAGANSET BAY; SEDIMENTS; MIGRATION

0902 HYDROCARBON CONCENTRATION; FLUORESCENCE ANALYSIS; SEDIMENTS;
BENTHIC SPECIES; FOOD CHAIN CONCENTRATION; CHEDABUCTO BAY;
FUEL OIL -BUNKER C; NOVA SCOTIA

1056 HYDROCARBON CONCENTRATION; DEGRADATION; BACTERIA; FUNGUS;
CLADOSPORIUM; WATER; SEDIMENTS; CHESAPEAKE BAY

0288 HYDROCARBON CONCENTRATIONS; NAPHTHALENE; SHRIMP; CLAMS; OYSTERS;
SEDIMENT; FUEL OIL#2; DEPURATION

0641 HYDROCARBON CONCENTRATIONS; ESTUARIES; SEDIMENTS; ZOOPLANKTON;
PHYTOPLANKTON; CRUDE OIL; SALT MARSH PLANTS; DIVERSITY; POPULATIONS;
FISH; MIGRATION; GAS CHROMATOGRAPHY; DEGRADATION

0203 HYDROCARBON CONTENT; SARGASSUM COMMUNITY

0202 HYDROCARBON CONTENT; SALT MARSH ECOSYSTEM; CONTENT ANALYSIS;
FOOD CHAIN CONCENTRATION; WEST FALMOUTH,MASS; FUEL OIL #2

0201 HYDROCARBON CONTENT; METABOLISM; AROMATIC HYDROCARBON CONTENT;
FIDDLER CRAB; UCA; OXIDATION; CLEARANCE

0146 HYDROCARBON CONTENT; WEST FALMOUTH SPILL; WEATHERING; IDENTIFICATION;
SEDIMENTS; DEGRADATION; SHELLFISH; OYSTERS; BUZZARD BAY

0249 HYDROCARBON CONTENT; GENERAL M.C. MEIGS SPILL; CHRONIC; SURVEYS;
INTERTIDAL; WASHINGTON COAST; FUEL OIL-NAVY SPECIAL; SEA URCHINS;
STRONGYLOCENTRUS

0247 HYDROCARBON CONTENT; ORGANISMS; SEDIMENT; TECHNIQUES

0354 HYDROCARBON CONTENT; OYSTERS; CRASSOSTREA; GALVESTON BAY;

COLUMN CHROMATOGRAPHY; TLC; MASS SPECTA; UV SPECTRA
0254 HYDROCARBON CONTENT; MYTILUS; UPTAKE; DEPURATION; MUSSELS; PARAFFINS; PETROLEUM; TIDES
0252 HYDROCARBON CONTENT; PARAFFINS; PETROLEUM; MUSSELS; MYTILUS
0269 HYDROCARBON CONTENT; ARROW SPILL; ZOOPLANKTON; CHEDABUCTO BAY; BUNKER C; OIL INGESTION; SEDIMENTATION; FECES
0333 HYDROCARBON CONTENT; MUSSELS; MYTILUS; MONITOR; UPTAKE; DEPURATION
0376 HYDROCARBON CONTENT; EXTRACTION TECHNIQUES; GAS CHROMATOGRAPHY
0688 HYDROCARBON CONTENT; FUEL OIL#2; WEST FALMOUTH, WILD HARBOR, MASS.; BENTHIC FAUNA; SEDIMENTS; OPPORTINUSTIC SPECIES; RECOVERY; GAS CHROMATOGRAPHY; DIVERSITY; POPULATIONS
1106 HYDROCARBON CONTENT; TAINTING; AQUATIC ANIMALS; SPECTROFLUOROMETRY; BUNKER C
0196 HYDROCARBON CONTENT ANALYSIS; COLLECTING METHODS
0145 HYDROCARBON CONTENT ANALYSIS; WEST FALMOUTH OIL SPILL; RECOVERY; BUZZARD BAY
0332 HYDROCARBON CONTENT ANALYSIS; GAS CHROMATOGRAPHY; THIN LAYER CHROMATOGRAPHY; HIGH PRESSURE LIQUID CHROMATOGRAPHY; SAN FRANCISCO BAY; SPONGE; MUSSEL; CRAB
0260 HYDROCARBON CONTENT ANALYSIS; CRUDE OIL; TOXICITY; CORALS; HETEROXENIA; RED SEA; SUBLETHAL EFFECTS; DEPTH PROTECTION EFFECTS
0439 HYDROCARBON CONTENT ANALYSIS; SAMPLING AND ANALYTICAL METHODS
0482 HYDROCARBON CONTENT ANALYSIS; FISH; ASSIMILATION; ALKANES; DISCRIMINATION; COD
0400 HYDROCARBON CONTENT ANALYSIS; MYTILUS; UPTAKE; DEPURATION; PHYSIOLOGICAL STRESS; BIOLOGICAL MONITOR; MUSSELS; ACCUMULATION
0375A HYDROCARBON CONTENT ANALYSIS; TECHNIQUES
0379 HYDROCARBON CONTENT ANALYSIS; INTERCALIBRATION EXERCISES
0426 HYDROCARBON CONTENT ANALYSIS; GAS CHROMATOGRAPHY; PARAFFINS; SQUID; SHRIMP; FISH
0401 HYDROCARBON CONTENT ANALYSIS; MUSSEL; MYTILUS; LAGOON OF VENICE, ITALY; GAS CHROMATOGRAPHY; DISTANCE FROM POLLUTION SOURCE; EXCHANGE WITH SEA
0366 HYDROCARBON CONTENT ANALYSIS; FUEL OIL#2; NIANTIC BAY, CT.; BENTHIC COMMUNITIES; AMPHIPODS; HERMIT CRABS; GAS CHROMATOGRAPHY
0504 HYDROCARBON CONTENT ANALYSIS; ALASKA-PR. WILLIAM SOUND; GAS CHROMATOGRAPHY
0681 HYDROCARBON CONTENT ANALYSIS; GAS CHROMATOGRAPHY
0677 HYDROCARBON CONTENT ANALYSIS; TECHNIQUES
0646 HYDROCARBON CONTENT ANALYSIS; N-ALKANES; PLANKTON; FISH; FIRTH OF CLYDE, SCOTLAND; FOOD CHAIN MAGNIFICATION
0692 HYDROCARBON CONTENT ANALYSIS; MULLET; SHRIMP; OYSTER; LIQUID CHROMATOGRAPHY; GAS CHROMATOGRAPHY
0653 HYDROCARBON CONTENT ANALYSIS; ARGO MERCHANT SPILL; GLASS CAPILLARY GAS CHROMATOGRAPHY
1007 HYDROCARBON CONTENT ANALYSIS; LAKE MARACAIBO, VENEZUELA; FISHERIES; SEDIMENTS; WATER; BIOTA; TOXICITY
1012 HYDROCARBON CONTENT ANALYSIS; PRAWNS, SCARLET; PLESIOPENAEUS; BENTHIC OIL DEPOSIT; ARUBA WEST INDIES; ATTRACTION; BACTERIA; CHEMICAL ATTRACTIONS; METABOLISM
1003 HYDROCARBON CONTENT ANALYSIS; DEEP-SEA BENTHOS; RATTAIL; NEMATONURUS; HOLOTHURIANS
1037 HYDROCARBON CONTENT ANALYSIS; ARROW SPILL; CHEDABUCTO BAY, NOVA SCOTIA; BUNKER C; FLUORESCENCE SPECTROSCOPY; MYA; KELP

1115 HYDROGEN ACCEPTOR; BIODEGRADATION; BACTERIA; SUBSTRATE; DISTRIBUTION; ABSORBENTS
0813 HYDROXYLASE INDUCTION; BENZOPYRENE; FISH; POLYCYCLIC AROMATIC HYDROXYLASE; ARYL HYDROCARBON HYDROXYLASE; BROWN TROUT; NEWFOUNDLAND; TAINTING; THIN-LAYER CHROMATOGRAPHY
0098 HYPERPLASIA; CLAMS; HISTOPATHOLOGY; MYA; CARCINOGENISIS
0415 HYPERPLASIA; CRUDE OIL; LESIONS; HISTOPATHOLOGY; FISH; MENIDIA
0840 HYPERPLASIA; BRYOZOA; SCHIZOPORELLA; CARCINOGENS; OVICELLS; INDICATOR
0901 HYPERPLASIA; ARGO MERCHANT SPILL; HISTOPATHOLOGY; AMMODYTES; FLOUNDER (WINTER&YELLOWTAIL); ALEWIVES; CRABS(HERMIT); EDEMA; HEMOCYTES; CILIATES
0982 HYPERPLASIA; BRYOZOANS; OVICELL; CHRONIC EXPOSURE; NATURAL SEEPAGE
1166 HYPOTHERMIA; SEALS; PINNIPEDS; PRUDHOE BAY CRUDE OIL
0187 HYPOTHETICAL; TOXICITY; ACARTIA; ECOSYSTEM IMPACT; REVIEW; NIGERIAN CRUDE
0509 HYPOTHETICAL SPILL; OFFSHORE PRODUCTION; ARCTIC; BEAUFORT SEA
0538 HYPOTHETICAL SPILLS; ALASKA; COMPUTER MODELING
0723 HYPOTHETICAL SPILLS; ATLANTIC COAST; GULF OF ALASKA; ECOLOGICAL IMPACT
1155 HYPOTHETICAL SPILLS; COASTAL ENVIRONMENT; ALASKA; COOK INLET; VULNERABILITY INDEX
0885 HYPOXIA; FUEL OIL # 2; WATER SOLUBLE FRACTION; NEANTHES; POLYCHAETE; HEMOGLOBIN; SOUTH LOUISIANA CRUDE; DISSOLVED OXYGEN; TOXICITY; SYNERGISM; NAPHTHALENES; DISSOLVED HYDROCARBONS; RESPIRATION
1163 HYPOXIA; DISPERSANTS; CUNNER; RESPIRATION; COREXIT; BP1002; TRITON X-100; SODIUM LAURYL SULPHATE
1199 HYPOXIA; FUEL OIL #2; SOUTH LOUISIANA CRUDE OIL; POLYCHAETE; HEMOGLOBIN COMPENSATION
0921 ICE; OIL; BACTERIA; ALGAE; OTTAWA
0136 IDENTIFICATION; REVIEW; PETROLEUM; ANALYSIS; MONITORING
0146 IDENTIFICATION; WEST FALMOUTH SPILL; WEATHERING; HYDROCARBON CONTENT; SEDIMENTS; DEGRADATION; SHELLFISH; OYSTERS; BUZZARD BAY
0834 IDOTEA; CRUDE OIL; GAMMARUS; LONGEVITY; AMPHIPOD; ISOPOD; OXYGEN CONSUMPTION
0599 ILLUMINATION; TOXICITY; KUWAIT CRUDE; COREXIT 8666; PHYTOPLANKTON; PHAEODACTYLUM TRICORNUTUM; PRIMARY PRODUCTION
0422 IMMERSION; CRUDE OIL; SEALS; BEHAVIOR; PATHOLOGICAL EFFECTS; COATING; INGESTION
0850 INDIA; OIL SPILL INCIDENT; ECOLOGICAL IMPACT; COSMOS PIONEER
0840 INDICATOR; HYPERPLASIA; BRYOZOA; SCHIZOPORELLA; CARCINOGENS; OVICELLS
1042 INDICATOR SPECIES; BIRDS; ALCIDS; AUKS; MURRS; EIDERS
0705 INDICATORS; BACTERIA; DEGRADATION
1032 INDIVIDUAL FREQUENCY OCCURANCE PATTERNS; FUEL OIL#2; DISPERSION; INTERTIDAL COLONIES; SPECIES DIVERSITY; RELATIVE ABUNDANCE; NUMBERS OF SPECIES
0618 INDONESIA; FISHERIES; CORAL REEF COMMUNITY; OFFSHORE PRODUCTION; REVIEW
0923 INFRA RED SPECTROSCOPY; TAINTING; MULLET; MUGIL; KEROSENE; GAS LIGUID CHROMATOGRAPHY; GAS CHROMATOGRAPHY- MASS SPECTROSCOPY; RADIOACTIVE TRACERS; UPTAKE; PROTON MAGNETIC RESONANCE SPECTROSCOPY
0661 INFRA-RED SPECTROMETRY; BIOGENIC VS. PETROLEUM HYDROCARBONS; CRUDE OIL; SEDIMENTS
0040 INGESTION; KUWAIT CRUDE; PROTOZOAN CILIATES; EUPLOTES; URONEMA;

NEMATODE
0330 INGESTION; DUCKS; MALLARDS; ANAS; CRUDE OIL; EGGS; EMBRYOTOXICITY
0425 INGESTION; RINGED SEALS; PHOCA; HARP SEALS; STRESS
0495 INGESTION; OIL; BIRDS; DUCKS; TOXICITY; PHYSIOLOGICAL EFFECTS; HISTOPATHOLOGY
0492 INGESTION; OIL; BIRDS; DUCKS; REPRODUCTION; HATCHABILITY; COATING
0491 INGESTION; BIRDS; OIL; MOBILITY; TOXICOLOGICAL EFFECTS; DUCKS
0422 INGESTION; CRUDE OIL; SEALS; BEHAVIOR; PATHOLOGICAL EFFECTS; COATING; IMMERSION
1210 INGESTION; BIRDS; EGGS; OIL
0571 INHIBITED; PHYTOPLANKTON; CRUDE OIL; FIELD EXPERIMENT; STIMULATION; LABORATORY STUDIES; TOXICITY; PH; FRACTIONS; BENZENE; XYLENE; TOLUENE
0510 INHIBITION; BACTERIA; CRUDE OIL; FUEL OIL #2; BUNKER C; METABOLISM; RADIOACTIVE TRACER; CONTROLLED ECOSYSTEM
0716 INHIBITION; BACTERIA; CHEMORECEPTION; HYDROCARBONS
0998 INHIBITORS; CRUDE OIL; PRODUCERS; CHEMORECEPTION; SUBLETHAL EFFECTS; WATER SOLUBLE FRACTION
1061 INOCULUM WASHES; BIODEGRADATION; MICROORGANISMS; ENUMERATION; CONCENTRATION; ANTIBIOTICS
1067 INORGANIC NUTRIENTS; DEGRADATION; BACTERIA; SEDIMENTS; DEEP SEA; GROWTH POTENTIAL
0793 INORGANIC SALTS; BIODEGRADATION; RATES; MIXED CULTURE; ORGANIC ENRICHMENT; AERATION
0389 INPUT; REVIEW; DEGRADATION; NON-BIOLOGICAL; BACTERIAL; BIOCHEMICAL
0512 INPUT; REVIEW ARTICLE; FATE; BIOLOGICAL EFFECTS
0498 INPUT; REVIEW; OIL POLLUTION; DAMAGE
0602 INPUT; FISH; SHELLFISH; FOWL
0829 INPUT; REVIEW; FATE; DEGRADATION
0772 INPUT; REVIEW; FATE; BIOLOGICAL EFFECTS; CLEANUP; OIL; DISPERSANTS
1114 INPUT; CARCINOGENESIS; HYDROCARBONS; METABOLISM; SYNTHESIS; DEGRADATION; BACTERIA
0753 INPUTS; REVIEW WORKSHOP; BIOLOGICAL EFFECTS; ANALYTICAL TECHNIQUES
1111 INPUTS; REVIEW; MARINE OIL POLLUTION; FATES; DEGRADATION; BACTERIA
1112 INPUTS; REVIEW; EFFECTS; FATES
0781 INPUTS, FAT EFFECTS; WORKSHOP; PETROLEUM
0121 INSECT LARVAE; SALT MARSH; YORK RIVER; ISOLATED ECOSYSTEM; SOUTH LA. CRUDE; WEATHERED OIL; PHYTOPLANKTON; FISH; PERIPHYTON; ATP; MARSH GRASS; BENTHIC FAUNA; POLYCHAETES; AMPHIPODS; OLIGOCHAETE
0373 INSECTS; POPULATION SURVEY; SANTA BARBARA; CREVICE FAUNA; LITTORAL; BEETLE; THALASSOTRECHUS
0378 INTERCALIBRATION EXERCISES; HYDROCARBON CONTENT ANALYSIS
0959 INTERMEDIARY METABOLISM; METABOLISM; XENOBIOTIC METABOLISMS; LIPOGENISIS; FUNDULUS; STENOTOMUS; MIXED -FUNCTION OXIDASES
0474 INTERSPECIFIC VARIABILITY; INTRASPECIFIC VARIABILITY; LITTORINA
0120 INTERTIDAL; TOXICITY; BENTHIC ANIMALS; DIVERSITY; RECOVERY; YORK RIVER; BUNKER C; FUEL OIL#6
0230 INTERTIDAL; SAN FRANCISCO SPILL; TRANSECTS; COMMUNITIES; MACROINVERTEBRATES; RECRUITMENT; RECOVERY
0231 INTERTIDAL; SAN FRANCISCO SPILL; INVERTEBRATES; COMMUNITIES; SMOTHERING; RECRUITMENT; RECOVERY; BUNKER C; TRANSECTS
0235 INTERTIDAL; DIESEL OIL; ANACORTES; INVERTEBRATES; MORTALITIES
0238 INTERTIDAL; SANTA BARBARA; COMMUNITY; CLUSTER ANALYSIS
0249 INTERTIDAL; GENERAL M.C. MEIGS SPILL; CHRONIC; SURVEYS; HYDROCARBON CONTENT; WASHINGTON COAST; FUEL OIL-NAVY SPECIAL;

SEA URCHINS; STRONGYLOCENTRUS
0155 INTERTIDAL; DETERGENTS; ALGAE; SHORT TERM EFFECTS; LONG TERM EFFECTS; LITTORIAL COMMUNITY
0319 INTERTIDAL; WAFRA SPILL; SOUTH AFRICA
0309 INTERTIDAL; PLANTS; TIDAL CYCLE; SHORE TYPE
0320 INTERTIDAL; WAFRA SPILL; FISH TAINTING; SOUTH AFRICA; INTERTIDAL INVERTEBRATES
0293 INTERTIDAL; MILFORD HAVEN,BRITAIN; SEDIMENTS; MACROFAUNA; SANDY AND MUDDY SHORES; TAINTING
0255 INTERTIDAL; HYDROCARBON UPTAKE; COMMUNITIES; WASHINGTON STATE; FUEL OIL-NAVY SPECIAL; GENERAL M.C. MEIGS SPILL
0423 INTERTIDAL; MILFORD HAVEN, WALES; LIMPETS; EMULSIFIERS
0404 INTERTIDAL; SANTA BARBARA; COMMUNITIES; SURF GRASS; BARNACLES
0420 INTERTIDAL; DISPERSANTS; CLEAN-UP; MORTALITIES; THAMES ESTUARY, ENGLAND
0421 INTERTIDAL; SUBLETHAL EFFECTS; POLYCHAETE; SOUTH HAMPTON, ENGLAND; CIRRATULUS; CIRRIFORMIA
0382 INTERTIDAL; PORT VALLEY, ALASKA; SEDIMENT; BACTERIA POPULATIONS; MEIOFAUNA; COPEPODS; MACOMA BALTHICA
0652 INTERTIDAL; PETROLEUM HYDROCARBONS; BASELINE INVESTIGATION; PUGET SOUND; SEDIMENTS; MUSSELS; SNAILS; THAIS
0773 INTERTIDAL; SANTA BARBARA; KELP; SUBTIDAL; OVERVIEW
0751 INTERTIDAL; TOXICITY; BALTIC SEA; LITTORAL ZONE; COREXIT; BEROL; BP1100; WATER BASE; OIL BASE; SOLVENT
0799 INTERTIDAL; TORREY CANYON SPILL; OIL; DETERGENT; CORNWALL, ENGLAND
0892 INTERTIDAL; PANAMA; S.S. WITWATER SPILL; TROPICS; TERRESTRIAL PLANTS; LITTORAL; MANGROVE; REEF; MEIOFAUNA; SEA TURTLES; BIRDS; DIESEL OIL; BUNKER C
0962 INTERTIDAL; TOXICITY; LONG TERM EFFECTS; GASTROPODS; BIVALVES; DIESEL FUEL, MARINE; ROCKY SHORE; FAUNA; LAMMA IS.; HONG KONG; DISPERSANTS; RECOVERY
1010 INTERTIDAL; CHEDEBUCTO BAY, NOVA SCOTIA; BUNKER C; MORTALITIES; ARROW SPILL; WINTER; CHRONIC POLLUTION; FUCUS; MYA; SPARTINA
0966 INTERTIDAL; SANTA BARBARA SPILL; SUBTIDAL; SURVEY; DIVERSITY; PLANTS; ALGAE; INVERTEBRATES; CHANNEL IS.
0971 INTERTIDAL; SANTA BARBARA SPILL; BREEDING RATES; BARNACLE; MUSSELS; CHTHAMALUS; BALANUS; POLLICIPES; MYTILUS
1098 INTERTIDAL; HONG KONG; DIESEL SPILL; MEIOFAUNA; SANDY BEACHES; NEMATODES; HARPACTICOID COPEPODS
1117 INTERTIDAL; AFRICAN COAST; CHRONIC
1069 INTERTIDAL; TORREY CANYON SPILL; BIRDS; TOXICITY; DETERGENTS; CHALK
1032 INTERTIDAL COLONIES; FUEL OIL#2; DISPERSION; SPECIES DIVERSITY; RELATIVE ABUNDANCE; NUMBERS OF SPECIES; INDIVIDUAL FREQUENCY OCCURANCE PATTERNS
0181 INTERTIDAL COMMUNITY; RINCON IS.,CALIF; OFFSHORE PRODUCTION
0678 INTERTIDAL FAUNA; DIVERSITY; REFINERY EFFLUENT
0842 INTERTIDAL FAUNA; ARGO MERCHANT SPILL; BENTHIC FAUNA; SPECIES DIVERSITY; POPULATION DENSITY; HARPACTICOID COPEPODS; POLYCHAETES; AMPHIPODS
0321 INTERTIDAL INVERTEBRATES; SOUTH AFRICA
0320 INTERTIDAL INVERTEBRATES; WAFRA SPILL; INTERTIDAL; FISH TAINTING; SOUTH AFRICA
1075 INTERTIDAL INVERTEBRATES; ANACORTES; TRANSECTS; HYDROCARBON CONTENT ANALYSIS; DIVERSITY INIDICES; GAS CHROMATOGRAPHY
0045 INTERTIDAL ORGANISMS; SANTA BARBARA SPILL; CLEANUP; COMMUNITY SURVEY;

0817 ISOPODS; ARCTIC; CRUSTACEA; AMPHIPODS; BEHAVIOR; ATTRACTION; REPULSION; TAINTING; CRUDE OIL
1139 ISOPODS; ARCTIC; BENTHIC INVERTEBRATES; AMPHOPOD; BEHAVIORAL EFFECTS; MORTALITY
0786 JAPANESE COAST; TAINTING; FISH; EELS; GAS CHROMATOGRAPHY; IR ABSORPTION; UV ABSORPTION; MASS SPECTRUM; TOLUENE; MIZUSHIMA, JAPAN; AROMATIC HYDROCARBONS; GASOLINE
1207 JET FUEL; ALGAE; FUCUS; CRUDE OIL; FUEL OIL #2
0582 JP4 FUEL; TOXICITY; FRESH WATER FISH; AUFWUCHS (SURFACE GROWTH); JP5 FUEL
0582 JP5 FUEL; TOXICITY; FRESH WATER FISH; AUFWUCHS (SURFACE GROWTH); JP4 FUEL
0670 JP5 FUEL; OIL; FUEL OIL#2; GAS CHROMATOGRAPHY; SEDIMENTS; SEARSPORT SPILL
0737 JULIANA WRECK; PARAFFINS; FISH; CRUDE OIL; SALMON; MULLET; BLACK SEA BREAM; GAS CHROMATOGRAPHY
0081 JUNCUS; RECOVERY; CONTROLLED SPILLS; SHAEDA; FESTUCA; PLANTAGE; SPARTINA; SALT MARSH; PEMBROKE,WALES; KUWAIT CRUDE OIL; FLOWERING PLANTS; SEED PRODUCTION AND GERMINATION
0530 JUVENILE; BIOASSAY; SOLUBLE FRACTION; TOXICITY; LARVAE; SUBLETHAL EFFECTS
0729 JUVENILE; TOXICITY; SALMON; OIL; TEMPERATURE; STRESS BEHAVIOR; WEATHERING
0867 JUVENILE; PINK SALMON; CRUDE OIL; TOXICITY; AVOIDANCE; MIGRATION; AGE; CHEMORECEPTION
0747 JUVENILES; TOXICITY; STRIPED BASS; MORONE; BENZENE
0761 JUVENILES; TOXICITY; AROMATICS; PHENATHRENES; ESTUARINE; BENTHIC; OCEANIC; LARVAE; RESPIRATION; GROWTH; SUBLETHAL
0046 KELP; SANTA BARBARA SPILL; COMMUNITY SURVEY; SCALLOPS; ASSESSMENT; BIRDS
0115 KELP; ALGAE
0256 KELP; WASTE DISCHARGE; FUEL OIL
0257 KELP; KELP; EFFLUENT; MACROCYSTIS; DISPOSAL
0773 KELP; SANTA BARBARA; INTERTIDAL; SUBTIDAL; OVERVIEW
0779 KELP; TAMPICO MARU SPILL; CHRONIC; SURF CONDITIONS; MORTALITIES; SUCCESSION; RECOVERY; BAJA, CALIF.; ANTHOPLEURA; PHOTOSYNTHESIS
1037 KELP; ARROW SPILL; CHEDABUCTO BAY,NOVA SCOTIA; BUNKER C; FLUORESCENCE SPECTROSCOPY; MYA; HYDROCARBON CONTENT ANALYSIS
0514 KELP BEDS; SANTA BARBARA SPILL; CLEANUP; ECOLOGICAL IMPACTS; BIRDS; LITTORAL COMMUNITIES
0430 KENT; BIRDS; OIL POLLUTION
1017 KENT, ENGLAND; MARINE ALGAE PLANTS; FISH; BIRDS
1082 KENT, ENGLAND; ESTUARY; MUD FLAT FAUNA; REFINERY EFFLUENT; MEDWAY ESTUARY
0058 KEROSENE; CHEMOTAXIS; LOBSTERS; ALEWIVES; HORSESHOE CRAB; FLATWORM
0059 KEROSENE; CHEMICAL SIGNALS; SNAIL,NASSARIUS; LOBSTERS
0097 KEROSENE; COPEPOD; TOXICITY; CRUDE OIL FRACTIONS; GASOLINE; TIGRIODUS
0265 KEROSENE; MULLET; TAINTING; AUSTRALIA; RIVER SEDIMENTS
0467 KEROSENE; TOXICOLOGY; ULTRAVIOLET SPECTROPHOTMETRY; BENZENE; ALKYLBENZENES; BLOOD
0541 KEROSENE; NASSARIUS; CHEMOTAXIS; WATER SOLUBLE FRACTION; CHEMORECEPTION
0540 KEROSENE; NASSARIUS (MARINE SNAIL); CHEMOTAXIS
0733 KEROSENE; BP1002; CHEMKLEEN; BARNACLE; BALANUS; ADULT; NAUPLIUS;

TOXICITY; CIRRAL ACTIVITY

0709 KEROSENE; TOXICITY; BLACK OIL; MARINE PLANKTONIC ALGAE; BENTHOPLANKTONIC ALGAE

0922 KEROSENE; MULLET; TAINTING; GAS CHROMATOGRAPHY; MUGIL

0923 KEROSENE; TAINTING; MULLET; MUGIL; GAS LIGUID CHROMATOGRAPHY; GAS CHROMATOGRAPHY- MASS SPECTROSCOPY; INFRA RED SPECTROSCOPY; RADIOACTIVE TRACERS; UPTAKE; PROTON MAGNETIC RESONANCE SPECTROSCOPY

1031 KEROSENE; TAINTING; MULLET; MUGIL; HISTOPATHOLOGY; CONTENT ANALYSIS; AUSTRALIA

0355 KIEL BIGHT; MYTILUS; MUSSELS; UPTAKE; DEPURATION; BIOGENIC; PETROLEUM; AROMATICS

0356 KIEL BIGHT, W. GERMANY; MYTILUS; CONTENT ANALYSIS; METABOLISM; PETROLEUM; BIOGENIC; MUSSELS; AROMATICS

0183 KING CRABS; ALASKA; SHRIMP; COON-STRIPE SHRIMP; COOK INLET CRUDE; TOXICITY; BIOASSAY; STATIC; WATER SOLUBLE FRACTION

0165 KITTIWAKES; BIRDS; GULLS; GUILLIMOTS; BEHAVIOR

0664 KUROSHIO; EAST CHINA SEA; TAR BALLS; ATTACHED ORGANISMS; BLUE GREEN ALGAE; PENNATE DIATOMS; STONY CORALS; BRYOZOANS; BARNACLES; COPEPODS

0405 KUWAIT; TOXICITY; FUNDULUS; PIMEPHALES; ARTEMIA; WEST TEXAS; MARINE DIESEL; FUEL OIL; LUBE OIL

0718 KUWAIT; CHRONIC POLLUTION; OIL PORT; POMATOLEIOS; GROWTH; TOXICITY; DIVERSITY; SUCCESSION

0882 KUWAIT; TOXICITY; POLYCHAETES; CRUDE; NAPHTHALENE; BUNKER C; FUEL OIL #2; WATER SOLUBLE FRACTION; NEANTHES; CAPITELLA; SOUTH LOUISIANA CRUDE

0035 KUWAIT CRUDE; ESTUARINE ANIMALS; UPTAKE AND DEPURATION; TOXICITY; RESPIRATION; SOUTH LA. CRUDE; FUEL OIL #2; BUNKER C; MINNOW; GRASS SHRIMP,PALAEMONTES; BROWN SHRIMP,PANAEUS; WATER SOLUBLE FRACTION; OIL WATER DISPERSION; NAPHTHALENES

0038 KUWAIT CRUDE; OYSTERS; CRUDE OIL; REFINED OILS; CRASSOSTREA; BIOASSAY; FUEL OIL #2; BUNKER C; SOUTH LA. CRUDE

0040 KUWAIT CRUDE; PROTOZOAN CILIATES; EUPLOTES; URONEMA; NEMATODE; INGESTION

0084 KUWAIT CRUDE; SALT MARSH PLANTS; TOXICITY; EMULSIFIERS

0034 KUWAIT CRUDE; WATER SOLUBLE FRACTION; OIL IN WATER DISPERSION; CRUSTACEANS; FISH; TOXICITY; ESTUARINE; SOUTH LA. CRUDE; FUEL OIL #2; BUNKER C; CYPRINODON; MENIDIA; FUNDULUS; PENAEUS; PALEOMONETES; MYSIDOPSIS

0185 KUWAIT CRUDE; SURFACTANT; BP 1002; LICHENS; LICHINA; CARBON FIXATION; EMULSIFIER

0599 KUWAIT CRUDE; TOXICITY; COREXIT 8666; PHYTOPLANKTON; PHAEODACTYLUM TRICORNUTUM; PRIMARY PRODUCTION; ILLUMINATION

0848 KUWAIT CRUDE; CRUDE OIL; SOUTH LOUISIANA CRUDE; FUEL OIL#2; GROWTH RATE; PHOTOSYNTHESIS; MICROALGAE-TOXICITY; BLUE GREEN; DIATOM; DINOFLAGELLATE

0777 KUWAIT CRUDE; SAND DOLLAR; FUEL OIL #2; WATER SOLUBLE EXTRACTS; SPERM; EGG; RESPIRATION; MOBILITY OF SPERM; FERTILIZATION; CLEAVAGE; LARVAL DEVELOPMENT

0886 KUWAIT CRUDE; SOUTH LOUISIANA CRUDE; FUEL OIL # 2; BUNKER C; TOXICITY; WATER SOLUBLE FRACTION; NAPHTHALENE; NEANTHES; CAPITELLA

0865 KUWAIT CRUDE; BIVALVES; TOXICITY; SPERMATOZOA; FERTILIZATION; DEVELOPMENTAL ABNORMALITIES; PRUDHOE BAY CRUDE; NIGERIAN CRUDE

0081 KUWAIT CRUDE OIL; RECOVERY; CONTROLLED SPILLS; SHAEDA; JUNCUS; FESTUCA; PLANTAGE; SPARTINA; SALT MARSH; PEMBROKE,WALES;

PHYTOPLANKTON; ZOOPLANKTON; EGGS; BIRDS; PLAICE
0630 LARVAE; AMPHIPOD; TOXICITY; BEHAVIOR; GAMMARUS; FECUNDITY
0629 LARVAE; TOXICITY; CRUDE OIL; DISPERSANTS; HERRING; CULPEA
0838 LARVAE; DETERGENTS; TOXICITY; SHORE CRAB; CARCINUS; BROWN SHRIMP; CRAGON; FISH
0761 LARVAE; TOXICITY; AROMATICS; PHENATHRENES; ESTUARINE; BENTHIC; OCEANIC; JUVENILES; RESPIRATION; GROWTH; SUBLETHAL
0883 LARVAE; TOXICITY; WATER SOLUBLE FRACTION; FUEL OIL #2; POLYCHAETE; NEANTHOS
0864 LARVAE; DISPERSANT; SHELLFISH; SPERMATOZOA; TOXICITY; BIVALVES; OYSTERS; CRASSOSTREA; MUSSEL; FERTILIZATION; DEVELOPMENT
0879 LARVAE; CRUDE OIL; MIDGES; CRICOTOPUS; FORT SIMPSON, NWT, CANADA; FIELD EXPERIMENTS; ARTIFICAL SUBSTRATES
0884 LARVAE; FUEL OIL #2; NAPHTHALENE; ANNELIDS; POLYCHAETE; NEANTHES; UPTAKE &DEPURATION; DEVELOPMENT; MALE; FEMALE; EGGS
0986 LARVAE; BENZENE; HERRING; CULPEA; SPAWNING; OVARIAN EGGS; EMBRYOS; BEHAVIOR; RADIOACTIVE TRACER
0985 LARVAE; BENZENE; HERRING; ANCHOVY; EGGS; TOXICITY; ABNORMALITIES; GROWTH; RESPIRATION; FEEDING
1093 LARVAE; FISH; SOLE; PLAICE; HERRING; DETERGENT; DEVELOPMENTAL ABNOMALITIES; BP1002; FINASOL; COREXIT
1079 LARVAE; LOBSTER; HOMARUS; TOXICITY; BEHAVIOR; GROWTH; VENEZUELA CRUDE OIL; FOOD CONSUMPTION; DISPERSIONS
1089 LARVAE; LONG TERM EFFECTS; DETERGENT; SABELLERIA; TOXICITY
1078 LARVAE; LOBSTER; TOXICITY; SUBLETHAL EFFECTS; EMULSIONS
1091 LARVAE; DISPERSANT; TOXICITY; FISH; HERRING; PILCHARD; PLAICE; SOLE; LEMON SOLE; HADDOCK; BP1002; DELAYED EFFECTS; EMBRYOLOGY; BEHAVIORAL CHANGES
1090 LARVAE; BP1002; DETERGENT; SABELLARIA; TOXICITY; SUBSTRATE ABSORPTION
1170 LARVAE; FUEL OIL; FLOUNDER; REPRODUCTION; HATCHING SUCCESS; GROWTH; EGGS; HISTOPATHOLOGY
1223 LARVAE; COOK INLET CRUDE OIL; FLOUNDER; FISH; CLAMS; CHRONIC CONCENTRATIONS; EGGS; HISTOPATHOLOGY; MORTALITY
0447 LARVAE DEVELOPMENT; SURFACTANT; MUSSELS; FERTILIZATION
0777 LARVAL DEVELOPMENT; SAND DOLLAR; KUWAIT CRUDE; FUEL OIL #2; WATER SOLUBLE EXTRACTS; SPERM; EGG; RESPIRATION; MOBILITY OF SPERM; FERTILIZATION; CLEAVAGE
1212 LARVAL GROWTH; SHRIMP; UPTAKE; DEPURATION; FUEL OIL #2; HATCHING SUCCESS; BEHAVIORAL EFFECTS
1020 LAYER; ALGAE; EMULSIFIERS; BIOASSAY; TOXICITY; GROWTH; POPULATION; TISSUES; PORPHYRA
0991 LEAD; OUTBOARD MOTOR EXHAUST WASTE; FISH; BLUEGILL; TAINTING
1091 LEMON SOLE; DISPERSANT; TOXICITY; FISH; LARVAE; HERRING; PILCHARD; PLAICE; SOLE; HADDOCK; BP1002; DELAYED EFFECTS; EMBRYOLOGY; BEHAVIORAL CHANGES
0668 LEPOMIS; PETROLEUM REFINERY EFFLUENT; SUNFISH,REDEAR; BEHAVIORAL SYMPTOMS; TOXICITY; FRESH WATER FISH
0191A LESIONS; ARGO MERCHANT SPILL; HISTOLOGY; PEARL FORMATION; CANCER; MODIOLUS; ZOOPLANKTON
0415 LESIONS; CRUDE OIL; HISTOPATHOLOGY; FISH; MENIDIA; HYPERPLASIA
0417 LESIONS; OYSTER; SCALLOP; SILVERSIDES; MOTOR OIL; HISTOPATHOLOGY
0068 LEVEL OF OIL; ABUNDANCE; DISTRIBUTION; BIOINDICATOR; ENUMERATION; CRUDE OIL- SWEDEN; TEMPERATURE; MICROORGANISMS; BIODEGRADATION; RARITAN BAY N.J.; GAS CHROMATOGRAPHY

ANALYSIS FOR HYDROCARBON; CORDGRASS; ESTUARIES
0192 LOUISIANA BAY; BACTERIA; SEDIMENTS; OXIDATION; AEROBIC; ANAEROBIC
0911 LOUISIANA COAST; OFFSHORE PRODUCTION; TIMBALIER BAY; ECOLOGY; ENVIRONMENTAL IMPACT
0009 LOUISIANA CRUDE; YEAST; BIODEGRADATION; TRICHOSPORON
0563 LOUISIANA CRUDE; SALT MARSH; ESTUARY; YORK RIVER; BACTERIA; FUNGI; SEDIMENTS; PETROLEUM DEGRADING
0006 LOUISIANA CRUDE OIL; BIODEGRADATION; YEAST; GUPPY; FUNGI
0583 LOUISIANA CRUDE OIL; CRUDE OIL; PALATABILITY; BROWN SHRIMP; BLUE CRAB; TAINTING
0487 LOW LEVEL CONCENTRATIONS; NAPHTHALENE; ACCUMULATION; COPEPOD; RADIOACTIVE; LONG TERM EXPOSURE; MARINE ZOOPLANKTON; PERSISTENT EXPOSURE; UPTAKE/DEPURATION; CALANUS; EURYTEMORA
0394 LOW MOLECULAR WEIGHT HYDROCARBONS; OFFSHORE PRODUCTION; GULF OF MEXICO; TOXICITY
1020A LOW TEMPERATURE; BACTERIA; DEGRADATION; LOW TEMPERATURE
0405 LUBE OIL; TOXICITY; FUNDULUS; PIMEPHALES; ARTEMIA; KUWAIT; WEST TEXAS; MARINE DIESEL; FUEL OIL
0322 LUBRICATING OILS; ALGAE; GROWTH; EUGLENA; SCENEDESMUS; DIESEL OIL; PHOTOSYNTHETIC METABOLISM
0989 LUGWORM-ARENICOLA; TOXICITY; DISPERSANTS; BP1002; BP1100; COCKLE-CERASTODERMA; NERINE
0935 MACKENZIE DELTA; CRUDE OIL; LAKES; ARCTIC; WATER COLUMN; SEDIMENTS; ZOOBENTHOS; DEGRADATION
0328 MACKENZIE VALLEY CRUDE OIL; ARCTIC; ALGAE; PRIMARY PRODUCTIVITY; SPECIES COMPOSITION
0501 MACKENZIE VALLEY NWT; PHYTOPLANKTON; PHOTOSYNTHESIS; GROWTH; PLANTS; COMMUNITY EFFECTS; ARCTIC; PERIPHYTON; POPULATION COMPOSITION; SEASONAL SUCCESSION
0913 MACOMA; CLAM; PRUDHOE BAY CRUDE OIL; HYDROCARBON ANALYSIS; GAS CHROMATOGRAPHY; BEHAVIOR; BURROWING
1002A MACOMA; ALASKA; MUD FLATS; BEHAVIOR-BURROWING
1197 MACOMA; PRUDHOE BAY CRUDE OIL; NAPHTHALENE; CLAMS; UPTAKE; SEDIMENTS
1213 MACOMA; CLAM; PRUDHOE BAY CRUDE OIL; ALASKA; BURROWING; BEHAVIORAL EFFECTS
0332 MACOMA BALTHICA; PORT VALLEY, ALASKA; INTERTIDAL; SEDIMENT; BACTERIA POPULATIONS; MEIOFAUNA; COPEPODS
0912 MACOMA BALTICA; BIOINDICATORS; CLAMS; MUD FLATS; CRUDE OIL
0775 MACROALGAE; LITTORAL; ASSOCIATION INSTABILITY; CHRONIC EFFECTS; COAL OIL POINT; SANTA BARBARA SPILL
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1193 MACROBENTHOS; ANTARCTIC; ASSESSMENT; FUEL OIL; BENTHIC ECOLOGY
0257 MACROCYSTIS; KELP; EFFLUENT; DISPOSAL
0361 MACROFAUNA; CRUDE OIL; RED SEA; TOXICITY; DEPTH; SUBLETHAL EFFECTS; PHYSIOLOGY; METABOLISM; BEHAVIOR; DISPERSANT
0293 MACROFAUNA; MILFORD HAVEN, BRITAIN; INTERTIDAL; SEDIMENTS; SANDY AND MUDDY SHORES; TAINTING
0358 MACROFAUNA; RED SEA; TOXICITY; CRUDE OIL; DISPERSANT; CORAL; HETEROXENIA; GASTROPODS; MUSSELS; CHITON; SEA URCHIN; HERMIT CRAB; SHRIMP; GOATFISH; RABBITFISH
0609 MACROFAUNA; MARINE SEDIMENT; METABOLISM; MICROFAUNA; MEIOFAUNA; DEGRADATION; POLYCHAETE WORMS; BIVALVES; BACTERIA; EXCRETION
0673 MACROFAUNA; BUNKER C; RIVER; MUDDY RIVER, MASS.; BOD; PLANKTON;

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0199 MACROINVERTEBRATES; STREAMS; GASOLINE; ORTHOCLADIUS; RECOVERY; DIVERSITY INDEX
0230 MACROINVERTEBRATES; SAN FRANCISCO SPILL; TRANSECTS; COMMUNITIES; INTERTIDAL; RECRUITMENT; RECOVERY
0511 MACROINVERTEBRATES; STREAM, VIRGINIA; SEDIMENT; DIVERSITY; POPULATIONS
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1086 MACROINVERTEBRATES; STREAM; BENTHIC; OIL REFINERY EFFLUENT; DIVERSITY INDICES
0246 MACROORGANISMS; REVIEW; BIOLOGICAL FATES
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0004 MAGDALEN IS.; GULF OF ST. LAWRENCE; LITTORAL COMMUNITY; CANADA
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1014 MALIC DEHYDROGENASE; ARGO MERCHANT SPILL; WINTER FLOUNDER; YELLOW TAIL FLOUNDER; MODIOLUS; PLACOPECTEN; RESPIRATORY ENZYMES; OSMOLALITY; PYRUVATE REDUCTION; ANAEROBIOSIS
1102 MALIC DEHYDROGENASE; MULLET; EMPIRE MIX CRUDE; PHSIOLOGICAL EFFECT; LIVER WEIGHT; ALKALINE PHOSPHATASE; B-GLUCURONIDASE; AEROBIC METABOLISM; ACETYLCHOLINESTERASE
1121 MALLARD; TOXICITY; PHYSIOLOGICAL EFFECTS; FUEL OIL; HATCHING SUCCESS; PARAFFINS; GROWTH
0300 MALLARDS; OIL; PHYSIOLOGY; INTESTINAL ABSORPTION; ANAS; MUCOSAL TRANSFER RATES; CRUDE OILS; BOILING FRACTIONS
0299 MALLARDS; BIRDS; CRUDE OIL; PHYSIOLOGY; ANAS; DEHYDRATION; MUCOSAL TRANSFER RATE; DISPERSANTS; INTESTINAL ABSORPTION
0330 MALLARDS; DUCKS; ANAS; CRUDE OIL; INGESTION; EGGS; EMBRYOTOXICITY
1144 MALLARDS; BIRDS; HATCHING SUCCESS; EMBRYONIC DEVELOPMENT; EIDERS; GULKS; PATHOLOGICAL EFFECTS; FUEL OIL; CRUDE OIL
1224 MALLARDS; WATERFOWL; OIL SPILLS; REPRODUCTION; REVIEW; EGGS
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1134 MAMMALS; ARCTIC; SUB ARCTIC; BAFFIN BAY; DAVIS STRAIT; LABRADOR SEA; ASSESSMENT OF SPILLS; PHYTOPLANKTON; ZOOPLANKTON; ZOOBENTHOS; FISH; BIRDS
1183 MAMMALS; PLANKTON; INVERTEBRATES; BIRDS; TOXICITY; REVIEW; PETROLEUM HYDROCARBONS; ECOSYSTEM
0892 MANGROVE; PANAMA; S.S. WITWATER SPILL; TROPICS; INTERTIDAL; TERRESTRIAL PLANTS; LITTORAL; REEF; MEIOFAUNA; SEA TURTLES; BIRDS; DIESEL OIL; BUNKER C
1177 MANGROVE; PUERTO RICO; OIL SPILLS; ECOSYSTEM; CORAL REEFS; ESTUARIES; ANALYSIS FOR HYDROCARBONS; MULLET; OYSTER; CLAM; HISTOPATHOLOGY; REVIEW
0228 MANGROVE FRINGE; LITTORAL COMMUNITIES; FLORIDA KEYS; ROCKY PLATFORM; SEA GRASS FLATS; MANGROVE SWAMP; CRUSTACEANS; ECHINODERMS; RED MANGROVE; PEARL OYSTER; BLACK MANGROVE
0749 MANGROVE PROP COMMUNITY; PUERTO RICO; ZOE COLOCUTRONIS; VENEZUELEN CRUDE; TURTLE GRASS COMMUNITY; SEDIMENTS; HYDROCARBON ANALYSIS; TROPICAL
0228 MANGROVE SWAMP; LITTORAL COMMUNITIES; FLORIDA KEYS; ROCKY PLATFORM; MANGROVE FRINGE; SEA GRASS FLATS; CRUSTACEANS; ECHINODERMS; RED MANGROVE; PEARL OYSTER; BLACK MANGROVE

1159 MANGROVES; CAPITELLA; CORDGRASS; CRUDE OIL; MARSH; TEXAS;
GULF OF MEXICO; ASSESSMENT OF SPILLS
0193 MARINE; BIODEGRADATION; PETROLEUM FRACTIONS; BACTERIA
0768 MARINE; OIL POLLUTION; REVIEW
0347 MARINE; ALGAE; PHYTOPLANKTON; CRUDE OIL; FUEL OIL #2; GROWTH RATES
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0739 MARINE; BIBLIOGRAPHY; ESTUARINE; OIL POLLUTION
0770 MARINE; REVIEW; OIL; PLANTS; ANIMALS
1060 MARINE; BIODEGRADATION; POTENTIAL; RADIOMETRY; HEXADECANE
1195 MARINE; REVIEW; POLLUTION; BIOINDICATORS; ESTUARINE; OIL POLLUTION
1017 MARINE ALGAE PLANTS; KENT, ENGLAND; FISH; BIRDS
0649 MARINE BIOTA; REVIEW; OIL SPILLS; BRINE
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1040 MARINE BIOTA; OIL; DISPERSED OIL; TOXICITY; EFFECTS
0405 MARINE DIESEL; TOXICITY; FUNDULUS; PIMEPHALES; ARTEMIA; KUWAIT;
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0359 MARINE DIESEL; FEEDING BEHAVIOR; COELENTERATA; DISCRIMINATION;
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1190 MARINE DIESEL; BIODEGRADATION; BUNKER C; MICROORGANISMS; CRUDE OIL
0372 MARINE ECOSYSTEMS; REVIEW; CRUDE OIL; TOXICITY; LONG TERM EFFECTS
0147 MARINE ENVIRONMENT; REVIEW
0133 MARINE ENVIRONMENT; BIOLOGICAL EFFECTS; REVIEW
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0804 MARINE ENVIRONMENT; CRUDE OIL; DEGRADATION; ZOOPLANKTON;
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0916 MARINE ENVIRONMENT; REVIEW; TYPES OF OILS; WEATHERING; TOXICITY;
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0866 MARINE ENVIRONMENT; OIL POLLUTION; REVIEW
0177 MARINE FAUNA; REVIEW; BIRDS; PHYSIOLOGY; REHABILITATION
0948 MARINE FAUNA; OIL SPILL INICIDENT; PERSIAN GULF; DISPERSANTS;
COREXIT-7664; TARUT BAY, SAUDI ARABIA
0763 MARINE LIFE; REVIEW; DETERGENTS
0974 MARINE MAMMALS; SANTA BARBARA SPILL; SURVEY; BIRDS; DIVERSITY;
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0135 MARINE OIL POLLUTION; REVIEW
1111 MARINE OIL POLLUTION; REVIEW; INPUTS; FATES; DEGRADATION; BACTERIA
0028 MARINE ORGANISMS; PETROLEUM HYDROCARBONS; GROWTH
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0375 MARINE ORGANISMS; PETROLEUM; HYDROCARBON; CONTENT ANALYSIS;
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1226 MARINE ORGANISMS; SYMPOSIUM; PETROLEUM HYDROCARBONS; FATE & EFFECTS
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0609 MARINE SEDIMENT; METABOLISM; MICROFAUNA; MEIOFAUNA; MACROFAUNA;

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0801 MARINE TISSUES; POLYNUCLEAR AROMATIC HYDROCARBONS; ANALYTICAL METHODS; PETROLEUM OILS; BENZ(A)ANTHRACENE; BENZO(A)PYRENE
0487 MARINE ZOOPLANKTON; NAPHTHALENE; ACCUMULATION; COPEPOD; RADIOACTIVE; LONG TERM EXPOSURE; LOW LEVEL CONCENTRATIONS; PERSISTENT EXPOSURE; UPTAKE/DEPURATION; CALANUS; EURYTEMORA
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1185 MARSH; ECOSYSTEM; PETROLEUM HYDROCARBON; LOUISIANA; ANALYSIS FOR HYDROCARBON; CORDGRASS; ESTUARIES
1215 MARSH; FUEL OIL; BUNKER C; CHEDABUCTO BAY; NOVA SCOTIA; ARROW SPILL; LONG TERM EFFECTS; CORDGRASS; ALGAE; TOXICITY
0121 MARSH GRASS; SALT MARSH; YORK RIVER; ISOLATED ECOSYSTEM; SOUTH LA. CRUDE; WEATHERED OIL; PHYTOPLANKTON; FISH; PERIPHYTON; ATP; BENTHIC FAUNA; POLYCHAETES; INSECT LARVAE; AMPHIPODS; OLIGOCHAETE
0503 MARSH GRASS; CHESAPEAKE BAY; OIL SPILL INCIDENT; SALT MARSH; POPULATIONS; MUSSEL; OYSTERS; SNAIL
0877 MARSH GRASS; CHESAPEAKE BAY; SPILL INCIDENT; FUEL OIL # 6; ENVIRONMENTAL ASSESSMENT; BIRDS; MORTALITIES; SHELL FISHERIES
1099 MARSH SPRAY; MUSKRATS; WETTING; OIL; DDT
1124 MARSHES; FISH; FUEL OIL; BUNKER C; DUCKS; MUSKRATS; CATTAILS; ANALYSIS FOR HYDROCARBONS; ST. LAWRENCE RIVER
0138 MARTHA'S VINEYARD; CRUDE OIL; FATE; WEATHER; MICROBIAL DEGRADATION; BIOLOGICALLY ACTIVE FRACTIONS; BERMUDA
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0354 MASS SPECTA; OYSTERS; CRASSOSTREA; HYDROCARBON CONTENT; GALVESTON BAY; COLUMN CHROMATOGRAPHY; TLC; UV SPECTRA
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1058 MASS SPECTROMETRY; DEGRADATION; SOUTH LOUISIANA CRUDE
1074 MASS SPECTROMETRY; ALIPHATIC; AROMATIC; DETERMINATION TECHNIQUES; MARINE ORGANISMS; ETHER EXTRACTION; SILICA GEL CHROMATOGRAPHY; GAS CHROMATOGRAPHY
1095 MASS SPECTROMETRY; MICROALGAE; WATER SOLUBLE FRACTION; HYDROCARBON ANALYSIS; GAS CHROMATOGRAPHY; BAYTOWN; MONTANA; BATON ROUGE; NEW JERSEY
0786 MASS SPECTRUM; TAINTING; JAPANESE COAST; FISH; EELS; GAS CHROMATOGRAPHY; IR ABSORPTION; UV ABSORPTION; TOLUENE; MIZUSHIMA, JAPAN; AROMATIC HYDROCARBONS; GASOLINE
1200 MASS.; WEST FALMOUTH OIL SPILL; MACROBENTHOS; CAPITELLA; POPULATION; POPULATION DYNAMICS
1169 MASS.; CRABS; WEST FALMOUTH SPILL; MORTALITY; UPTAKE; BEHAVIOR; BURROWING; TOXICITY; FUEL OIL; CRAB-SALT MARSH
0458 MAXIMUIM CELL DENSITY; CRUDE OIL; REFINED OIL; TOXICITY; BACTERIA; WATER SOLUBLE FRACTION; AROMATIC HYDROCARBONS; WEATHERING; GROWTH RATE

OXYGEN CONSUMPTION RATE; ESTUARY
0537 METABOLIC RATES; FISH; TOXICITY; OIL-REFINERY EFFLUENT; COMPARISION OF SPECIES; BIOASSAY; FRESH WATER
0055 METABOLISM; POLYNUCLEAR AROMATIC HYDROCARBONS; DIMETHYLNITROSAMINE -DEMETHYLASE; ENZYME REPRESSION
0010 METABOLISM; POLYCYCLIC HYDROCARBONS; ENZYME SYSTEM; ARYL HYDROCARBON HYDROXYLASE; TROUT
0201 METABOLISM; HYDROCARBON CONTENT; AROMATIC HYDROCARBON CONTENT; FIDDLER CRAB; UCA; OXIDATION; CLEARANCE
0151 METABOLISM; CHRONIC OIL POLLUTION; COASTAL ECOSYSTEM; SUBLETHAL EFFECTS; BEHAVIOR; FOOD CHAIN MAGNIFICATION; WETLANDS; ESTUARIES
0132 METABOLISM; HYDROCARBONS; SHARK,BASKING; CENTROPAGES
0356 METABOLISM; MYTILUS; CONTENT ANALYSIS; PETROLEUM; BIOGENIC; MUSSELS; KIEL BIGHT, W. GERMANY; AROMATICS
0361 METABOLISM; CRUDE OIL; RED SEA; MACROFAUNA; TOXICITY; DEPTH; SUBLETHAL EFFECTS; PHYSIOLOGY; BEHAVIOR; DISPERSANT
0277 METABOLISM; COPEPOD; UPTAKE; DEPURATION; NAPHTHALENE; CALANUS; FOOD WEB; WATER SOLUBLE FRACTION; DIETARY ROUTE OF ENTRY; RADIOACTIVE TRACERS
0276 METABOLISM; SPIDER CRAB; NAPHTHALENE; MAIA; EXCRETION
0266 METABOLISM; BENZPYRENE; ENZYME INDUCTION
0278 METABOLISM; HYDROCARBONS; ZOOPLANKTON; FISH; TOXICITY; TAINTING; BEHAVIOR; UPTAKE; DEPURATION; ACCUMULATION
0275 METABOLISM; POLYCYCLIC AROMATIC HYDROCARBONS; UPTAKE; FOOD WEB TRANSFER; BIOSYNTHESIS
0494 METABOLISM; OIL; DUCKS; COATING; TEMPERATURE; HEAT CONDUCTIVITY
0413 METABOLISM; OIL; EMULSIFIERS; FUCUS; PLANTS; PHOTOSYNTHESIS; NET PRODUCTIVITY
0612 METABOLISM; UPTAKE; DEPURATION; RADIOACTIVE TRACERS; REVIEW
0613 METABOLISM; FISH; NAPTHALENE; BENZ(A)PYRENE; RADIOACTIVE TRACER; UPTAKE; DISCHARGE; SCULPIN; OLIGOCOTTUS; GOBY; GILLICHTHYS; SAND DAB; CITHARICHTHYS
0555 METABOLISM; HYDROCARBONS; MICROFLORA; BREAKDOWN; METHODS; BIOSYNTHESIS; TERRESTRIAL
0510 METABOLISM; BACTERIA; CRUDE OIL; FUEL OIL #2; BUNKER C; INHIBITION; RADIOACTIVE TRACER; CONTROLLED ECOSYSTEM
0609 METABOLISM; MARINE SEDIMENT; MICROFAUNA; MEIOFAUNA; MACROFAUNA; DEGRADATION; POLYCHAETE WORMS; BIVALVES; BACTERIA; EXCRETION
0727 METABOLISM; BARNACLES; TAR BALL; CONTENT ANALYSIS; UPTAKE; DEPURATION
0812 METABOLISM; MIXED FUNCTION OXIDASES; ARYL HYDROCARBON HYDROXYLASE; PETROLEUM HYDROCARBON; DETECTION; MONITORS; INVERTEBRATES; FISH
0881 METABOLISM; POLYCHAETE; NEANTHES; RADIOACTIVE TRACER EXPERIMENT; UPTAKE; RETENTION; DEPURATION; WATER SOLUBLE FRACTION; WATER; SEDIMENT; DETRITUS
0868 METABOLISM; TOXICITY; ACUTE; CHRONIC; CRUDE OIL; COMPONENT; PHYSIOLOGY; BEHAVIOR; ARCTIC & SUBARCTIC ORGANISMS; TEMPERATURE
0959 METABOLISM; INTERMEDIARY METABOLISM; XENOBIOTIC METABOLISMS; LIPOGENISIS; FUNDULUS; STENOTOMUS; MIXED -FUNCTION OXIDASES
0858 METABOLISM; CRUDE OIL; CORAL; PANAMA; DIESEL MARINE; BUNKER C; TOXICITY; FEEDING
1012 METABOLISM; PRAWNS, SCARLET; PLESIOPENAEUS; BENTHIC OIL DEPOSIT; ARUBA WEST INDIES; ATTRACTION; HYDROCARBON CONTENT ANALYSIS; BACTERIA; CHEMICAL ATTRACTIONS

1039 METABOLISM; AROMATICS; CYCLO-ALKANE; SEDIMENTS; BUNKER C;
BEACH SEDIMENTS; CHEDABUCTO BAY, NOVA SCOTIA; ARROW SPILL; MOLLUSCS;
MYA; OSTREA; MYTILUS; ARYL HYDROCARBON HYDROXYLASE; BENZOPYRENE;
RADIOACTIVE TRACER
0960 METABOLISM; OYSTER; CRASSOSTREA; UPTAKE; RETENTION; DEPURATION;
PETROLEUM FRACTIONS; LIPIDS; FAT CONTENT
1083 METABOLISM; SALT MARSH; SEDIMENTS; DISSOLVED ORGANIC CARBON;
MICROBIAL DEGRADATION
1114 METABOLISM; CARCINOGENESIS; HYDROCARBONS; INPUT; SYNTHESIS;
DEGRADATION; BACTERIA
1179 METABOLISM; PETROLEUM HYDROCARBONS; MUTAGENESIS; PLANKTON; FISH;
ARCTIC
0604 METHODOLOGY; OIL; DISPERSANTS; TOXICITY; BIOASSAY
0631 METHODOLOGY; SEA URCHIN; EGG; TOXICITY
0628 METHODOLOGY; BIOASSAY; BEHAVIOR; TOXICITY
0836 METHODOLOGY; TOXICITY TESTING; TAINTING
0888 METHODOLOGY; BIOASSAY; FLOW THROUGH; SALMON
0993 METHODOLOGY; TOXICITY; OIL; DISPERSANTS
1035 METHODOLOGY; BIOASSAY; CONTINUOUS FLOW; PETROLEUM; TECHNIQUE;
FUEL OIL #2
1000 METHODOLOGY; DISPERSANTS; TOXICITY
1152 METHODOLOGY; ECOLOGICAL; ORGANISMS; FISHERIES; ESTUARINE; COASTAL;
TOXICITY; PETROLEUM FRACTION; CLEANING AGENTS/DISPERSANTS
1092 METHODOLOGY; TOXICITY; DISPERSANTS
1148 METHODOLOGY; QUAHOGS; PHENOL; TOXICITY; HISTOPATHOLOGICAL EFFECTS;
CYTOLOGY; CLAMS
0555 METHODS; HYDROCARBONS; MICROFLORA; BREAKDOWN; BIOSYNTHESIS;
METABOLISM; TERRESTRIAL
1110 METHODS; DEGRADATION; BACTERIA; RELATIVE OXIDIZABILITY; ASSUMLATION
0461 METHODS COMPARSION; HYDROCARBON ANALYSIS; CONTENT ANALYSIS;
COLUMN CHROMATOGRAPHY
1125 METHODS OF DETECTION OF HC'S IN ORGANISM; REVIEW; SUBLETHAL EFFECTS;
TOXICITY; UPTAKE; RETENTION; DEPURATION; BIOINDICATORS
1126 METHODS OF DETECTION OF HC'S IN ORGANISM; NAPHTHALENE; UPTAKE;
SIPUNCULID WORM; SPECTROPHOTOMETRY; PHASCOLOSOMA;
PRUDHOE BAY CRUDE OIL
0130 METHYLANAPHTHALENE; HYDROCARBON; ANALYSIS FOR PHC'S; N-ALKANE;
SHELLFISH; COLUMN CHROMATOGRAPHY; GAS-LIQUID CHROMATOGRAPHY
0471 METULA SPILL; STRAIT OF MAGELLAN; ARABIAN LIGHT CRUDE;
ECOSYSTEM IMPACT
0477 METULA SPILL; STRAIT OF MAGELLAN
0478 METULA SPILL; METULA SPILL
0479 METULA SPILL; METULA SPILL; STRAIT OF MAGELLAN; BEACHES; ESTUARIES
1209 METULA SPILL; STRAITS OF MAGELLAN; ASSESSMENT OF SPILL; MUSSELS;
KUWAIT CRUDE OIL
0523 MICHIGAN; WATERFOWL
0807 MICROALGAE; WATER SOLUBLE FRACTIONS; CRUDE OIL; GROWTH RATE;
HYDROCARBON ANALYSIS; SEDIMENTS; WATERS; BIOTA;
SOUTH TEXAS OUTTER CONTINENTAL SHELF
1095 MICROALGAE; WATER SOLUBLE FRACTION; HYDROCARBON ANALYSIS;
GAS CHROMATOGRAPHY; MASS SPECTROMETRY; BAYTOWN; MONTANA; BATON ROUGE;
NEW JERSEY
0848 MICROALGAE-TOXICITY; CRUDE OIL; SOUTH LOUISIANA CRUDE; KUWAIT CRUDE;
FUEL OIL#2; GROWTH RATE; PHOTOSYNTHESIS; BLUE GREEN; DIATOM;
DINOFLAGELLATE

0610 MICROBIAL DEGRADATION; RADIOACTIVE TRACERS; ESTUARIES; ABSORPTION TO PARTICLES; PETROLEUM COMPONENTS
0138 MICROBIAL DEGRADATION; CRUDE OIL; FATE; WEATHER; BIOLOGICALLY ACTIVE FRACTIONS; MARTHA'S VINEYARD; BERMUDA
0407 MICROBIAL DEGRADATION; ARCTIC; INVERTEBRATES; RECRUITMENT; BROODING; TEMPERATURE; RECOLONIZATION
0464 MICROBIAL DEGRADATION; SEDIMENTS; SAN FRANCISCO; DISPERSION; DISSOLUTION; WEATHERING; BUNKER C; SAND COLUMN DISTRIBUTION
0553 MICROBIAL DEGRADATION; CRUDE OIL; SAND; OXYGEN AVAILABILITY; DEPTH
0524 MICROBIAL DEGRADATION; ARCTIC; TERRESTRIAL PLANTS; ENHANCEMENT
1083 MICROBIAL DEGRADATION; SALT MARSH; SEDIMENTS; DISSOLVED ORGANIC CARBON; METABOLISM
0531 MICROBIAL INFESTATION; FISH; TAINTING; REVIEW
0063 MICROBIAL POPULATIONS; PROTOZOANS; BLUE GREEN ALGAE; DIATOMS; DEGRADATION; YEAST; SPECIES DIVERSITY; GREEN ALGAE; NATURAL SEEPAGE; PRUDHOE CRUDE OIL; ARCTIC; ALASKA-PRUDHOE BAY; CAPE SIMPSON; NUTRIENT ENRICHMENT
0690 MICROBIAL SEEDING; BACTERIAL DEGRADATION; SLICK-SEEDING; ADDITIVES; ENHANCEMENT; BOD; TOTAL ORGANIC CARBON; NUTRIENT SALT
0025 MICROBIOLOGY; PETROLEUM
0748 MICROCOSM; BIOASSAY; SALT MARSH; GAS CHROMATOGRAPHY; SPECTROPHOTOMETRY; ULTRAVIOLET; FLUORESENT
0609 MICROFAUNA; MARINE SEDIMENT; METABOLISM; MEIOFAUNA; MACROFAUNA; DEGRADATION; POLYCHAETE WORMS; BIVALVES; BACTERIA; EXCRETION
1171 MICROFAUNA; BIOINDICATORS; PROTOZOA; CILIATES; EUPLOTES; SAUDI ARABIAN CRUDE; EMPIRE MIX CRUDE; COMMUNITY DIVERSITY EXPERIMENTS
0304 MICROFLORA; SOFT-SHELL CLAM; MYA; BIODEGRADATION
0556 MICROFLORA; HYDROCARBON UTILIZATION; SOIL
0555 MICROFLORA; HYDROCARBONS; BREAKDOWN; METHODS; BIOSYNTHESIS; METABOLISM; TERRESTRIAL
1131 MICROFLORA; PHYTOPLANKTON; ALGAE; CRUDE OIL; FUEL OIL; TOXICITY; NAPHTHALENE; PHENANTHRENE; AROMATICS; ALGAE-GREEN; ALGAE-BLUE GREEN; DIATOMS; GROWTH
1129 MICROOGANISMS; BIODEGRADATION; ARCTIC; TEMPERATURE; NUTRIENTS; OXYGEN REQUIREMENTS; CRUDE OIL; AROMATICS; PARAFFINS; BEAUFORT SEA; CHUKCHI SEA
1150 MICROORANISMS; BIODEGRADATION; AROMATIC PETROLEUM PRODUCTS; XYLENE; BACTERIA; NOCARDIA
0636 MICROORGANISM POPULATIONS; OUTBOARD MOTOR OPERATION; FISH TAINTING
0068 MICROORGANISMS; ABUNDANCE; DISTRIBUTION; BIOINDICATOR; ENUMERATION; CRUDE OIL- SWEDEN; TEMPERATURE; LEVEL OF OIL; BIODEGRADATION; RARITAN BAY N.J.; GAS CHROMATOGRAPHY
0093 MICROORGANISMS; BIODEGRADATION; CRUDE OIL; NITRIFICATION; AMMONIA PRODUCTION
0066 MICROORGANISMS; PROTOZOA; ALGAE; FUNGI; PLANTS; LICHENS; PSEUDOMONAS; ARCTIC; PRUDHOE CRUDE OIL; NATURAL OIL SEEPAGE; ALASKA-PRUDHOE BAY; CAPE SIMPSON
0065 MICROORGANISMS; PHOTOSYNTHESIS; RESPIRATION; NITROGEN FIXATION; BACTERIA; ALGAE; FUNGI; ARCTIC; CRUDE OIL; NATURAL GAS
0062 MICROORGANISMS; ARCTIC; PRUDHOE BAY; VALDEZ; UMIAT; NATURAL SEEPAGES; ALASKA -PRUDHOE BAY; CAPE SIMPSON
0262 MICROORGANISMS; BIODEGRADATION; CHESAPEAKE BAY
0403 MICROORGANISMS; HYDROCARBONS; SUBSTRATES
0712 MICROORGANISMS; CORALS; RED SEA; CRUDE OIL; MUCUS PRODUCTION

0747 MORONE; TOXICITY; STRIPED BASS; BENZENE; JUVENILES
0931 MORPHOLOGICAL ANOMOLIES; PACIFIC HERRING; TOXICITY; ROE;
HATCHING SUCCESS; HERRING; CRUDE OIL; ALASKA
0011 MORPHOLOGY; PETROLEUM PRODUCTS; BLUE GREEN ALGAE; APHANIZOMENON;
SCENEDESMUS; GROWTH; PROTOCOCCAL ALGAE
0941 MORPHOLOGY; WATER SOLUBLE FRACTION; CRUDE OIL; NAPHTHALENE;
GREEN ALGAE; PHYSIOLOGY; FRESHWATER
1127 MORPHOLOGY; ARGO MERCHANT SPILL; FUEL OIL; EMBRYOGENESIS;
HATCHING SUCCESS; POLLOCK; CEPHALACHORDATA; AMPHIOXUS
1159 MORPHOLOGY; TROUT; HATCHING SUCCESS; FERTILIZATION;
REPRODUCTION & DEVELOPMENT; HISTOPATHOLOGICAL EFFECTS
0054 MORTALITIES; BIRDS; BEACH SURVEY
0244 MORTALITIES; BIRDS; BEACH SURVEYS; POPULATION; CHRONIC SPILLAGE;
TREATMENT; DISPERSANTS
0191 MORTALITIES; BIRDS; ARROW SPILL; IRVING WHALE SPILL; NOVA SCOTIA;
SPECIES ENDANGERMENT; NEWFOUNDLAND
0235 MORTALITIES; DIESEL OIL; ANACORTES; INTERTIDAL; INVERTEBRATES
0168 MORTALITIES; BIRDS; SPECIES ENDANGERMENT; CONSERVATION;
REHABILITATION
0172 MORTALITIES; TORREY CANYON; BIRDS; GUILLEMOTS; RAZORBILLS
0142 MORTALITIES; WEST FALMOUTH SPILL; FUEL OIL #2; PERSISTANCE; OYSTERS
0166 MORTALITIES; BIRDS; OIL; EFFECT; REVIEW; PHYSIOLOGY
0170 MORTALITIES; BIRDS; CONSERVATION; GUILLEMOTS
0190 MORTALITIES; BIRDS
0167 MORTALITIES; BIRDS; REVIEW
0175 MORTALITIES; BIRDS; ARROW SPILL; CHEDABUCTO BAY, NOVA SCOTIA
0194 MORTALITIES; WHALES; DOLPHINS
0420 MORTALITIES; DISPERSANTS; CLEAN-UP; INTERTIDAL;
THAMES ESTUARY, ENGLAND
0453 MORTALITIES; BIRDS; TAY ESTUARY, SCOTLAND
0445 MORTALITIES; OYSTERS; OFFSHORE OIL WELLS; SALT-BRINE
0454 MORTALITIES; BIRDS; ENGLAND/SCOTLAND; BEACHED BIRDS COUNTS
0548 MORTALITIES; BIRDS; DENMARK
0619 MORTALITIES; BALTIC; BIRDS; WASTE OIL
0717 MORTALITIES; BIRDS; SAN FRANCISCO SPILL-1937; WATERFOWL; GULLS
0650 MORTALITIES; OYSTERS; CRASSOSTREA; SEDIMENT HYDROCARBONS;
DRILLING OPERATIONS; TEMPERATURE; SALINITY
0626 MORTALITIES; BIRDS
0779 MORTALITIES; TAMPICO MARU SPILL; CHRONIC; SURF CONDITIONS;
SUCCESSION; RECOVERY; BAJA, CALIF.; ANTHOPLEURA; KELP;
PHOTOSYNTHESIS
0877 MORTALITIES; CHESAPEAKE BAY; SPILL INCIDENT; FUEL OIL # 6;
ENVIRONMENTAL ASSESSMENT; BIRDS; SHELL FISHERIES; MARSH GRASS
0873 MORTALITIES; BIRDS
0928 MORTALITIES; BIRDS; SAN FRANCISCO BAY; AUTOPSIES; FUEL OIL-BUNKER C
1010 MORTALITIES; CHEDEBUCTO BAY, NOVA SCOTIA; BUNKER C; INTERTIDAL;
ARROW SPILL; WINTER; CHROMIC POLLUTION; FUCUS; MYA; SPARTINA
0973 MORTALITIES; BIRDS; SANTA BARBARA SPILL
0975 MORTALITIES; SANTA BARBARA SPILL; BIRDS; INVERTEBRATES; ALGAE;
RECOLONIZATION; SUBLETHAL EFFECTS; PHYLLOSPADIX; CHTHAMALUS;
POLLICIPES; HESPEROPHYCUS
1084 MORTALITIES; SAN FRANCISCO SPILL; BIRDS; BIRD TREATMENT
0087 MORTALITY; REFINERY EFFLUENT; SPARTINA
0169 MORTALITY; TORREY CANYON; BIRDS
0214 MORTALITY; BIRDS; SANTA BARBARA

0195 MORTALITY; SEA LIONS; ZALOPHUS; SANTA BARBARA
0197 MORTALITY; DETERGENTS; NUCELLA LAPILLUS; RESISTANCE; POPULATION RECOVERY; RECOLONIZATION; ROCKY SHORE; LITTORAL
0316 MORTALITY; GREY SEALS; PEMBROKESHIRE WEST WALES; BEHAVIOR; GROWTH
0341 MORTALITY; OIL; CLAM; SEARSPORT MAINE; MYA
0335 MORTALITY; PANTHER SPILL; BIRDS
0455 MORTALITY; BIRDS; TAY ESTUARY, SCOTLAND; EIDERS
0424 MORTALITY; OIL; DISPERSANTS; TOXICITY; POLYCHAETE; GAMETE FORMATION; SPAWNING; GROWTH; CIRRATULUS; CIRRIFORMIA; BP1002; COREXIT; ESSOLVENE
0651 MORTALITY; OYSTER; CRASSOSTREA; LOUISIANA; OIL SPILL; GROWTH; SET; DISEASE INCIDENCE; TAINTING
0624 MORTALITY; EIDER DUCKS; BALTIC SEA; FINLAND COAST; PALVA 1969
0822 MORTALITY; LITTORINA; NUCELLA; BUCINNUM; DETERGENTS; GROWTH; BP1002; TARSOLVENT
0809 MORTALITY; BIRDS
0874 MORTALITY; BIODEGRADATION; ALASKA; TEMPERATURE; SALINITY; CHEMOTAXIS; COOK INLET; VALDEZ
1030 MORTALITY; BIESBOSCH TIDAL AREA; OIL SPILL INCIDENT; BIRDS-GEESE; HOLLAND; CRUDE OIL
1162 MORTALITY; CLAMS; CRUDE OIL; BEHAVIOR
1101 MORTALITY; BIRDS; SHETLAND IS., BRITAIN; OIL
1107 MORTALITY; COKE OIL; HERRING; ROUTE OF UPTAKE; CLUPEA; NOVA SCOTIA
1157 MORTALITY; SOUTH LOUISIANA CRUDE OIL; OYSTERS; CRASSOSTREA; ANALYSIS FOR HYDROCARBONS; GAS CHROMATOGRAPHY
1143 MORTALITY; SOFT-SHELL CLAM; FUEL OIL; UPTAKE; RETENTION; DEPURATION; BURROWING; SEARSPORT-MAINE
1138 MORTALITY; ARCTIC; BENTHIC INVERTEBRATES; AMPHOPOD; BEHAVIORAL EFFECTS; ISOPODS
1169 MORTALITY; CRABS; WEST FALMOUTH SPILL; UPTAKE; BEHAVIOR; BURROWING; TOXICITY; FUEL OIL; CRAB-SALT MARSH; MASS.
1196 MORTALITY; TOXICITY; REVIEW; CRUDE OIL; BIOASSAY; GROWTH STAGES
1223 MORTALITY; COOK INLET CRUDE OIL; FLOUNDER; FISH; CLAMS; CHRONIC CONCENTRATIONS; EGGS; LARVAE; HISTOPATHOLOGY
0872 MOSQUITO; CULEX; SUFFOCATION; TOXICITY
0125 MOSQUITO LARVAE; GASOLINE FRACTIONS; TOLUENE; XYLENE; BENZENE; TOXICITY; AEDES AEGYPTI; WATER SOLUBLE FRACTIONS
0689 MOSQUITOS; PETROLEUM FRACTIONS; TOXICITY; CULEX; AEDES; EGGS; LARVAE; PUPAE
0803 MOSQUITOS; AQUATIC; LAKE CHAMPLAIN
0995 MOTILITY; DISPERSANTS; EMULSIONS; TOXICITY; SUBLETHAL EFFECTS; ACTIVITY; BIVALVES; CRUSTACEANS; FISH; BEHAVIOR; OIL EMULSION; CONTINUOUS FLOW; LOCOMOTION
1220 MOTILITY; COPEPODS; CALANUS; ALGAE; MONOCHRYSIS; NAPHTHALENE; BEHAVIORAL EFFECTS
0417 MOTOR OIL; OYSTER; SCALLOP; SILVERSIDES; LESIONS; HISTOPATHOLOGY
1063 MOTOR OIL; BIODEGRADATION; CHESAPEAKE BAY; SEDIMENTS
1050 MOTOR OIL; DEGRADATION; BACTERIA; TREATMENT EFFLUENT; DISTRIBUTION; WATER COLUMN; SEDIMENTS
0398 MOULTING; SOUTH LA.CRUDE; LOBSTER; LARVAE; FLOW THROUGH SYSTEM; EMULSION; FEEDING; PIGMENTATION; HYDROCARBON ANALYSIS
0569 MOULTING; MUD CRAB; LARVAE; TOXICITY
0994 MOULTING; SURFACTANTS; FISH; CRUSTACEANS; BIVALVES; TOXICITY; BEHAVIOR; DEVELOPMENT; ACTIVITY; BYSSUS THREAD
0287 MOUTHLY GROWTH; FUEL OIL#2; SHRIMP; UPTAKE; DEPURATION

1185 LOUISIANA; MARSH; ECOSYSTEM; PETROLEUM HYDROCARBON;

0299 MUCOSAL TRANSFER RATE; BIRDS; MALLARDS; CRUDE OIL; PHYSIOLOGY; ANAS; DEHYDRATION; DISPERSANTS; INTESTINAL ABSORPTION
0300 MUCOSAL TRANSFER RATES; OIL; MALLARDS; PHYSIOLOGY; INTESTINAL ABSORPTION; ANAS; CRUDE OILS; BOILING FRACTIONS
0952 MUCUS BINDING; OIL; UPTAKE; ACCUMULATE; RATE OF ENTRY; MYA ARENARIA; DROPLETS; OIL DYE
0715 MUCUS PRODUCTION; CORAL; PLATIGYRA; BACTERIA; STRESS; CRUDE OIL; DESULFOVIBRIO; BEGGIATOA
0712 MUCUS PRODUCTION; CORALS; RED SEA; CRUDE OIL; MICROORGANISMS
0954 MUCUS PRODUCTION; FUEL OIL #2; SOUTH LOUISIANA CRUDE; SOFT SHELL CLAM; MYA; TEMPERATURE; SUBLETHAL EFFECTS; MUSCLE CONTRACTION
0569 MUD CRAB; LARVAE; TOXICITY; MOULTING
1082 MUD FLAT FAUNA; ESTUARY; REFINERY EFFLUENT; MEDWAY ESTUARY; KENT, ENGLAND
0912 MUD FLATS; BIOINDICATORS; CLAMS; MACOMA BALTICA; CRUDE OIL
1002A MUD FLATS; MACOMA; ALASKA; BEHAVIOR-BURROWING
0529 MUD SNAIL; BIOASSAY; CONTINUOUS FLOW; TOXICITY; SUBLETHAL EFFECTS; WATER SOLUBLE FRACTION; WHOLE OIL FRACTION; MINNOW; FLOUNDER; SHRIMP; SCALLOP; QUAHOG; MUSSEL
0673 MUDDY RIVER, MASS.; BUNKER C; RIVER; BOD; PLANKTON; TOXICITY; MACROFAUNA; NEW ENGLAND
0922 MUGIL; KEROSENE; MULLET; TAINTING; GAS CHROMATOGRAPHY
0923 MUGIL; TAINTING; MULLET; KEROSENE; GAS LIGUID CHROMATOGRAPHY; GAS CHROMATOGRAPHY- MASS SPECTROSCOPY; INFRA RED SPECTROSCOPY; RADIOACTIVE TRACERS; UPTAKE; PROTON MAGNETIC RESONANCE SPECTROSCOPY
1031 MUGIL; TAINTING; MULLET; KEROSENE; HISTOPATHOLOGY; CONTENT ANALYSIS; AUSTRALIA
0265 MULLET; TAINTING; KEROSENE; AUSTRALIA; RIVER SEDIMENTS
0500 MULLET; CRUDE OIL; ENZYMES; OYSTERS; SHRIMP
0737 MULLET; PARAFFINS; FISH; CRUDE OIL; JULIANA WRECK; SALMON; BLACK SEA BREAM; GAS CHROMATOGRAPHY
0697 MULLET; ESTUARY; EMPIRE MIX CRUDE; FIN ROT
0692 MULLET; HYDROCARBON CONTENT ANALYSIS; SHRIMP; OYSTER; LIQUID CHROMATOGRAPHY; GAS CHROMATOGRAPHY
0922 MULLET; KEROSENE; TAINTING; GAS CHROMATOGRAPHY; MUGIL
0923 MULLET; TAINTING; MUGIL; KEROSENE; GAS LIGUID CHROMATOGRAPHY; GAS CHROMATOGRAPHY- MASS SPECTROSCOPY; INFRA RED SPECTROSCOPY; RADIOACTIVE TRACERS; UPTAKE; PROTON MAGNETIC RESONANCE SPECTROSCOPY
1031 MULLET; TAINTING; MUGIL; KEROSENE; HISTOPATHOLOGY; CONTENT ANALYSIS; AUSTRALIA
1102 MULLET; EMPIRE MIX CRUDE; PHSIOLOGICAL EFFECT; LIVER WEIGHT; ALKALINE PHOSPHATASE; B-GLUCURONIDASE; MALIC DEHYDROGENASE; AEROBIC METABOLISM; ACETYLCHOLINESTERASE
1177 MULLET; PUERTO RICO; OIL SPILLS; ECOSYSTEM; MANGROVE; CORAL REEFS; ESTUARIES; ANALYSIS FOR HYDROCARBONS; OYSTER; CLAM; HISTOPATHOLOGY; REVIEW
0903 MUMMICHOG; TOXICITY; FUEL OIL-#2; SHRIMP(GRASS); MINNOW; CATFISH(CHANNEL); BLUEGILL
1042 MURRS; BIRDS; ALCIDS; INDICATOR SPECIES; AUKS; EIDERS
0954 MUSCLE CONTRACTION; FUEL OIL #2; SOUTH LOUISIANA CRUDE; SOFT SHELL CLAM; MYA; TEMPERATURE; SUBLETHAL EFFECTS; MUCUS PRODUCTION
1124 MUSKRATS; FISH; FUEL OIL; BUNKER C; DUCKS; CATTAILS; ANALYSIS FOR HYDROCARBONS; ST. LAWRENCE RIVER; MARSHES

1099 MUSKRATS; WETTING; OIL; MARSH SPRAY; DDT
0045 MUSSEL; SANTA BARBARA SPILL; CLEANUP; COMMUNITY SURVEY; BIRDS;
LIMPETS; BARNACLES; CHITONS; INTERTIDAL ORGANISMS
0016 MUSSEL; BEHAVIOR; FILTERING ABILITY; BLACK SEA; TOLERANCE
0178 MUSSEL; MYTILUS; SURFACTANT; PHYSIOLOICAL EFFECT; TISSUE SWELLING;
SEASONAL VARIATION; NORWAY
0154 MUSSEL; MYTILUS; UPTAKE
0232 MUSSEL; SAN FRANCISCO SPILL; RECRUITMENT; BUNKER C; BARNACLES;
BALANUS; CHTHAMALUS; MYTILUS; LIMPETS; COLLISELLA
0332 MUSSEL; HYDROCARBON CONTENT ANALYSIS; GAS CHROMATOGRAPHY;
THIN LAYER CHROMATOGRAPHY; HIGH PRESSURE LIQUID CHROMATOGRAPHY;
SAN FRANCISCO BAY; SPONGE; CRAB
0401 MUSSEL; MYTILUS; LAGOON OF VENICE,ITALY;
HYDROCARBON CONTENT ANALYSIS; GAS CHROMATOGRAPHY;
DISTANCE FROM POLLUTION SOURCE; EXCHANGE WITH SEA
0529 MUSSEL; BIOASSAY; CONTINUOUS FLOW; TOXICITY; SUBLETHAL EFFECTS;
WATER SOLUBLE FRACTION; WHOLE OIL FRACTION; MINNOW; FLOUNDER; SHRIMP;
SCALLOP; QUAHOG; MUD SNAIL
0503 MUSSEL; CHESAPEAKE BAY; OIL SPILL INCIDENT; SALT MARSH; POPULATIONS;
OYSTERS; SNAIL; MARSH GRASS
0611 MUSSEL; MYTILUS; CONTENT ANALYSIS; UPTAKE; DEPURATION; RETENTION;
RADIOACTIVE TRACERS; AROMATIC HYDROCARBONS; PARAFFINS
0864 MUSSEL; DISPERSANT; SHELLFISH; LARVAE; SPERMATOZOA; TOXICITY;
BIVALVES; OYSTERS; CRASSOSTREA; FERTILIZATION; DEVELOPMENT
0980 MUSSEL; SUBLETHAL EFFECTS; CHRONIC EXPOSURE; COAL OIL POINT, CALIF.;
SEDIMENTS; BENTHIC IN-FAUNA; ABALONE; BARNACLE
1048 MUSSEL; MYTILUS; FILTERING; PSEUDOFECES; PURIFICATION
1137 MUSSEL; AUSTRALIA; UPTAKE; RETENTION; DEPURATION; GAS CHROMATOGRAPHY;
MYTILUS; EFFECT ON ECOSYSTEM; BIOINDICATORS; TOXICITY
0110 MUSSELS; MYTILUS; BIOINDICATOR
0357 MUSSELS; DRUPA GRANULATA; MYTILUS; PREDATION RATE; FECUNDITY;
SUBLETHAL; CRUDE OIL; RED SEA; DISPERSANT
0345 MUSSELS; BENZO(A)PYRENE; CARCINOGENS; MONITOR; MYTILUS
0355 MUSSELS; MYTILUS; UPTAKE; DEPURATION; BIOGENIC; PETROLEUM; AROMATICS;
KIEL BIGHT
0271 MUSSELS; WATER ACCOMODATED FRACTION; MYTILUS; STARFISH; ASTERIS;
RESPIRATION; FEEDING; REPRODUCTION; BYSSAL THREAD PRODUCTION;
FUEL OIL #2
0347 MUSSELS; BENZO(A)PYRENE; MYTILUS; RELEASE
0348 MUSSELS; BENZO(A)PYRENE; CARCINOGENS; SOUTHERN CALIFORNIA; MYTILUS;
BASELINE; BIOGENIC
0346 MUSSELS; MYTILUS; MONITORING; BENZO(A)PYRENE; CARCINOGEN;
VANCOUVER HARBOR; CREOSOTED
0333 MUSSELS; MYTILUS; HYDROCARBON CONTENT; MONITOR; UPTAKE; DEPURATION
0344 MUSSELS; ACCUMULATOR ORGANISMS; MONITORING; CARCINOGENS; MYTILUS;
POLYCYCLIC AROMATIC HYDROCARBONS; BENZOPYRENE
0349 MUSSELS; MYTILUS
0252 MUSSELS; HYDROCARBON CONTENT; PARAFFINS; PETROLEUM; MYTILUS
0359 MUSSELS; MACROFAUNA; RED SEA; TOXICITY; CRUDE OIL; DISPERSANT; CORAL;
HETEROXENIA; GASTROPODS; CHITON; SEA URCHIN; HERMIT CRAB; SHRIMP;
GOATFISH; RABBITFISH
0254 MUSSELS; MYTILUS; UPTAKE; DEPURATION; HYDROCARBON CONTENT; PARAFFINS;
PETROLEUM; TIDES
0356 MUSSELS; MYTILUS; CONTENT ANALYSIS; METABOLISM; PETROLEUM; BIOGENIC;
KIEL BIGHT, W. GERMANY; AROMATICS

0440 MUSSELS; MONITORING
0399 MUSSELS; HYDROCARBONS; CONTENT ANALYSIS; DEPURATION; TEMPERATURE; MYTILUS; LAGOON OF VENICE, ITALY
0447 MUSSELS; SURFACTANT; FERTILIZATION; LARVAE DEVELOPMENT
0432 MUSSELS; MYTILUS; MODIOLUS; CARBON BUDGETS; CRUDE OIL; SALINITY; RESISTANCE
0433 MUSSELS; MYTILUS; MODIOLUS; CARBON BUDGET; SALINITY; CRUDE OIL; STRESS; RESISTANCE
0400 MUSSELS; MYTILUS; UPTAKE; DEPURATION; HYDROCARBON CONTENT ANALYSIS; PHYSIOLOGICAL STRESS; BIOLOGICAL MONITOR; ACCUMULATION
0561 MUSSELS; CALIFORNIA COAST; SANTA BARBARA CRUDE; TOXICITY
0652 MUSSELS; PETROLEUM HYDROCARBONS; BASELINE INVESTIGATION; PUGET SOUND; SEDIMENTS; SNAILS; THAIS; INTERTIDAL
0816 MUSSELS; COMMUNITIES; ROCKY SHORES; DETERGENTS; NORMANDY, FRANCE; RECOVERY; DEPURATION
0876 MUSSELS
0971 MUSSELS; SANTA BARBARA SPILL; BREEDING RATES; BARNACLE; CHTHAMALUS; BALANUS; POLLICIPES; MYTILUS; INTERTIDAL
1209 MUSSELS; METULA SPILL; STRAITS OF MAGELLAN; ASSESSMENT OF SPILL; KUWAIT CRUDE OIL
1186 MUSSELS; BENZOPYRENE; CLAMS; OYSTERS; OREGON; ESTUARINE; UPTAKE; AROMATIC HYDROCARBONS; CARCINOGENS; MOLLUSCS
1179 MUTAGENESIS; PETROLEUM HYDROCARBONS; PLANKTON; FISH; ARCTIC; METABOLISM
0098 MYA; HYPERPLASIA; CLAMS; HISTOPATHOLOGY; CARCINOGENISIS
0341 MYA; OIL; CLAM; MORTALITY; SEARSPORT MAINE
0304 MYA; SOFT-SHELL CLAM; MICROFLORA; BIODEGRADATION
0391 MYA; CRUDE OIL; HYDROCARBON; UPTAKE; RESPIRATION; LIQUID CONTENT; SOFT SHELL CLAM
0434 MYA; CARBON FLUX; FUEL OIL#6; CASCO BAY MAINE; TAMANO-CASCO BAY MAINE 1972
0954 MYA; FUEL OIL #2; SOUTH LOUISIANA CRUDE; SOFT SHELL CLAM; TEMPERATURE; SUBLETHAL EFFECTS; MUCUS PRODUCTION; MUSCLE CONTRACTION
0953 MYA; FUEL OIL#2; SOFT SHELL CLAM; EMULSION; TISSUE ABERRATIONS; HISTOPATHOLOGY; EDEMA; VACUOLATION; GLYCOGEN
1037 MYA; ARROW SPILL; CHEDABUCTO BAY,NOVA SCOTIA; BUNKER C; FLUORESCENCE SPECTROSCOPY; KELP; HYDROCARBON CONTENT ANALYSIS
1039 MYA; AROMATICS; CYCLO-ALKANE; SEDIMENTS; BUNKER C; BEACH SEDIMENTS; CHEDABUCTO BAY, NOVA SCOTIA; ARROW SPILL; METABOLISM; MOLLUSCS; OSTREA; MYTILUS; ARYL HYDROCARBON HYDROXYLASE; BENZOPYRENE; RADIOACTIVE TRACER
1010 MYA; CHEDEBUCTO BAY, NOVA SCOTIA; BUNKER C; MORTALITIES; INTERTIDAL; ARROW SPILL; WINTER; CHRONIC POLLUTION; FUCUS; SPARTINA
1206 MYA; CLAM; FUEL OIL #2; UPTAKE; RETENTION; DEPURATION
0952 MYA ARENARIA; OIL; UPTAKE; ACCUMULATE; RATE OF ENTRY; MUCUS BINDING; DROPLETS; OIL DYE
0034 MYSIDOPSIS; WATER SOLUBLE FRACTION; OIL IN WATER DISPERSION; CRUSTACEANS; FISH; TOXICITY; ESTUARINE; SOUTH LA. CRUDE; KUWAIT CRUDE; FUEL OIL #2; BUNKER C; CYPRINODON; MENIDIA; FUNDULUS; PENAEUS; PALEOMONETES
0110 MYTILUS; MUSSELS; BIOINDICATOR
0232 MYTILUS; SAN FRANCISCO SPILL; RECRUITMENT; BUNKER C; BARNACLES; BALANUS; CHTHAMALUS; MUSSEL; LIMPETS; COLLISELLA
0178 MYTILUS; MUSSEL; SURFACTANT; PHYSIOLOICAL EFFECT; TISSUE SWELLING; SEASONAL VARIATION; NORWAY

0154 MYTILUS; MUSSEL; UPTAKE
0348 MYTILUS; BENZO(A)PYRENE; CARCINOGENS; SOUTHERN CALIFORNIA; MUSSELS; BASELINE; BIOGENIC
0355 MYTILUS; MUSSELS; UPTAKE; DEPURATION; BIOGENIC; PETROLEUM; AROMATICS; KIEL BIGHT
0252 MYTILUS; HYDROCARBON CONTENT; PARAFFINS; PETROLEUM; MUSSELS
0345 MYTILUS; BENZO(A)PYRENE; CARCINOGENS; MUSSELS; MONITOR
0344 MYTILUS; ACCUMULATOR ORGANISMS; MONITORING; CARCINOGENS; MUSSELS; POLYCYCLIC AROMATIC HYDROCARBONS; BENZOPYRENE
0349 MYTILUS; MUSSELS
0346 MYTILUS; MONITORING; MUSSELS; BENZO(A)PYRENE; CARCINOGEN; VANCOUVER HARBOR; CREOSOTED
0357 MYTILUS; DRUPA GRANULATA; PREDATION RATE; FECUNDITY; SUBLETHAL; CRUDE OIL; MUSSELS; RED SEA; DISPERSANT
0333 MYTILUS; MUSSELS; HYDROCARBON CONTENT; MONITOR; UPTAKE; DEPURATION
0347 MYTILUS; BENZO(A)PYRENE; MUSSELS; RELEASE
0271 MYTILUS; WATER ACCOMODATED FRACTION; MUSSELS; STARFISH; ASTERIS; RESPIRATION; FEEDING; REPRODUCTION; BYSSAL THREAD PRODUCTION; FUEL OIL #2
0356 MYTILUS; CONTENT ANALYSIS; METABOLISM; PETROLEUM; BIOGENIC; MUSSELS; KIEL BIGHT, W. GERMANY; AROMATICS
0254 MYTILUS; UPTAKE; DEPURATION; MUSSELS; HYDROCARBON CONTENT; PARAFFINS; PETROLEUM; TIDES
0399 MYTILUS; HYDROCARBONS; CONTENT ANALYSIS; DEPURATION; TEMPERATURE; MUSSELS; LAGOON OF VENICE, ITALY
0401 MYTILUS; MUSSEL; LAGOON OF VENICE,ITALY; HYDROCARBON CONTENT ANALYSIS; GAS CHROMATOGRAPHY; DISTANCE FROM POLLUTION SOURCE; EXCHANGE WITH SEA
0400 MYTILUS; UPTAKE; DEPURATION; HYDROCARBON CONTENT ANALYSIS; PHYSIOLOGICAL STRESS; BIOLOGICAL MONITOR; MUSSELS; ACCUMULATION
0459 MYTILUS; TOXICITY; CRUDE OIL-ARABIAN LIGHT; LITTORINA; TIDL CYCLE; TEMPERATURE
0433 MYTILUS; MODIOLUS; CARBON BUDGET; SALINITY; CRUDE OIL; STRESS; RESISTANCE; MUSSELS
0432 MYTILUS; MODIOLUS; CARBON BUDGETS; CRUDE OIL; SALINITY; RESISTANCE; MUSSELS
0483 MYTILUS; SANTA BARBARA SPILL; GROWTH; BODY WEIGHT
0562 MYTILUS; TOLERANCE; NATURAL OIL SEEPS
0611 MYTILUS; CONTENT ANALYSIS; UPTAKE; DEPURATION; RETENTION; MUSSEL; RADIOACTIVE TRACERS; AROMATIC HYDROCARBONS; PARAFFINS
0851 MYTILUS; OIL SPILL INCIDENT; DECEPTION BAY QUEBEC; DIESEL OIL; GASOLINE; FUCUS
1039 MYTILUS; AROMATICS; CYCLO-ALKANE; SEDIMENTS; BUNKER C; BEACH SEDIMENTS; CHEDABUCTO BAY, NOVA SCOTIA; ARROW SPILL; METABOLISM; MOLLUSCS; MYA; OSTREA; ARYL HYDROCARBON HYDROXYLASE; BENZOPYRENE; RADIOACTIVE TRACER
1048 MYTILUS; MUSSEL; FILTERING; PSEUDOFECES; PURIFICATION
0978 MYTILUS; CHRONIC EXPOSURE; SIZE; REPRODUCTION
0971 MYTILUS; SANTA BARBARA SPILL; BREEDING RATES; BARNACLE; MUSSELS; CHTHAMALUS; BALANUS; POLLICIPES; INTERTIDAL
1137 MYTILUS; AUSTRALIA; UPTAKE; RETENTION; DEPURATION; GAS CHROMATOGRAPHY; MUSSEL; EFFECT ON ECOSYSTEM; BIOINDICATORS; TOXICITY
1116 MYTILUS; BIODEGRADATION; BACTERIA; SEDIMENTS; BARATARIA BAY; ANAEROBIC; BENZ(A)PYRENE; ACCUMULATION; WHITING; PICKEREL

0331 MYTILUS EDULIS; HYDROCARBON; SUSPENDED SEDIMENT
0667 MYXOTROPHIC GROWTH; ALGAE; HYDROCARBONS; SCENEDESMNS; DEGRADATION
0130 N-ALKANE; HYDROCARBON; ANALYSIS FOR PHC'S; METHYLANAPHTHALENE; SHELLFISH; COLUMN CHROMATOGRAPHY; GAS-LIQUID CHROMATOGRAPHY
0129 N-ALKANE; UPTAKE; FISH
0646 N-ALKANES; HYDROCARBON CONTENT ANALYSIS; PLANKTON; FISH; FIRTH OF CLYDE, SCOTLAND; FOOD CHAIN MAGNIFICATION
0253 N-PARAFFINS; COLUMN CHROMATOGRAPHY; GAS CHROMATOGRAPHY
0738 N-PARAFFINS; GAS CHROMATOGRAPHY; SEDIMENTS; SOLVENT
0567 NAIS; CASPIAN SEA; BENTHOS; CRUDE OIL; GROWTH; REPRODUCTION; CHIRONOMUS; CERASTODERMA; NEREIS; PYRGOHYDROBIA; ABRA
0719 NANO PLANKTON; ALGAE; PLATYMONAS; TOXICITY; GROWTH RATES; FINE STRUCTURE; CRUDE OIL; EMULSIFIER
0918 NANTUCKET SHOALS; ARGO MERCHANT SPILL; FISHERIES
0123 NAPHTHALENE; COPEPOD; REPRODUCTION; EURYTEMORA; EGG PRODUCTION; HEATING OIL; WATER SOLUBLE FRACTION
0289 NAPHTHALENE; HYDROCARBON CONCENTRATIONS; SHRIMP; CLAMS; OYSTERS; SEDIMENT; FUEL OIL#2; DEPURATION
0334 NAPHTHALENE; FUNDULUS; DISTRIBUTION IN BODY; STRESS BEHAVIOR
0277 NAPHTHALENE; COPEPOD; UPTAKE; DEPURATION; METABOLISM; CALANUS; FOOD WEB; WATER SOLUBLE FRACTION; DIETARY ROUTE OF ENTRY; RADIOACTIVE TRACERS
0276 NAPHTHALENE; SPIDER CRAB; METABOLISM; MAIA; EXCRETION
0487 NAPHTHALENE; ACCUMULATION; COPEPOD; RADIOACTIVE; LONG TERM EXPOSURE; LOW LEVEL CONCENTRATIONS; MARINE ZOOPLANKTON; PERSISTENT EXPOSURE; UPTAKE/DEPURATION; CALANUS; EURYTEMORA
0815 NAPHTHALENE; SEA GRASS; PHOTOSYNTHESIS; DODECANE; TOLUENE
0743 NAPHTHALENE; BACTERIAL DEGRADATION; PSEUDOMOMAS; METABOLIC PATHWAY
0760 NAPHTHALENE; ALKYLNAPHTHALENE; CONTENT ANALYSIS; ULTRAVIOLET SPECTROPHOTOMETRY; TECHNIQUES; TISSUES; SEAWATER
0882 NAPHTHALENE; TOXICITY; POLYCHAETES; CRUDE; BUNKER C; FUEL OIL #2; WATER SOLUBLE FRACTION; NEANTHES; CAPITELLA; SOUTH LOUISIANA CRUDE; KUWAIT
0941 NAPHTHALENE; WATER SOLUBLE FRACTION; CRUDE OIL; GREEN ALGAE; PHYSIOLOGY; MORPHOLOGY; FRESHWATER
0886 NAPHTHALENE; KUWAIT CRUDE; SOUTH LOUISIANA CRUDE; FUEL OIL # 2; BUNKER C; TOXICITY; WATER SOLUBLE FRACTION; NEANTHES; CAPITELLA
0884 NAPHTHALENE; FUEL OIL #2; ANNELIDS; POLYCHAETE; NEANTHES; UPTAKE &DEPURATION; DEVELOPMENT; MALE; FEMALE; EGGS; LARVAE
1002 NAPHTHALENE; SHRIMP; TOXICITY; CONTENT ANALYSIS; DEPURATION; CRUDE OIL; FUEL OIL #2; BUNKER C; PALAEMONETES; TEMPERATURE; BENZENE; PHENOL
1038 NAPHTHALENE; ALGAE; PHYSIOLOGY; HYDROCARBONS PETROLEUM; REVIEW; PHOTOSYNTHESIS; ATP; CRUDE OIL; DISTILLATE FRACTIONS
0964 NAPHTHALENE; TOXICITY; PHOSPHORUS; SYNERGISM; DIATOM
1145 NAPHTHALENE; NORMAL WELLS CRUDE OIL; SEALS; ARCTIC; RINGED SEALS; BENZENE; PATHOLOGICAL EFFECTS; UPTAKE & INGESTION
1139 NAPHTHALENE; CRUDE OIL; CRAB; CANCER; BENZENE; AROMATIC HC'S; TOXICITY; REPRODUCTION & DEVELOPMENT
1149 NAPHTHALENE; TEMPERATURE; SALINITY; CLAMS; SOUTHERN LOUISIANA CRUDE OIL; UPTAKE & DEPURATION; CLAM-BOREAL; CLAM-TEMPERATURE
1154 NAPHTHALENE; ZOOPLANKTON; COPEPODS; AROMATIC HYDROCARBONS; PHYSIOLOGICAL EFFECTS; RETENTION; DEVELOPMENT
1131 NAPHTHALENE; MICROFLORA; PHYTOPLANKTON; ALGAE; CRUDE OIL; FUEL OIL;

TOXICITY; PHENANTHRENE; AROMATICS; ALGAE-GREEN; ALGAE-BLUE GREEN;
DIATOMS; GROWTH

1126 NAPHTHALENE; METHODS OF DETECTION OF HC'S IN ORGANISM; UPTAKE;
SIPUNCULID WORM; SPECTROPHOTOMETRY; PHASCOLOSOMA;
PRUDHOE BAY CRUDE OIL

1173 NAPHTHALENE; DUCKS; MALLARDS; ANALYSIS FOR HYDROCARBONS;
PHYSIOLOGICAL EFFECTS; SOUTH LOUISIANA CRUDE OIL

1220 NAPHTHALENE; COPEPODS; CALANUS; ALGAE; MONOCHRYSIS;
BEHAVIORAL EFFECTS; MOTILITY

1176 NAPHTHALENE; FUEL OIL# 2; ZOOPLANKTON; SHRIMP; RESPIRATION; TOXICITY;
FEEDING BEHAVIOR; MOBILITY; BENZENE; PHENOL

1197 NAPHTHALENE; PRUDHOE BAY CRUDE OIL; CLAMS; MACOMA; UPTAKE; SEDIMENTS

0033 NAPHTHALENES; UPTAKE AND DEPURATION; SHRIMP; FISH; MOLLUSKS;
FUEL OIL

0035 NAPHTHALENES; ESTUARINE ANIMALS; UPTAKE AND DEPURATION; TOXICITY;
RESPIRATION; SOUTH LA. CRUDE; KUWAIT CRUDE; FUEL OIL #2; BUNKER C;
MINNOW; GRASS SHRIMP,PALAEMONTES; BROWN SHRIMP,PANAEUS;
WATER SOLUBLE FRACTION; OIL WATER DISPERSION

0410 NAPHTHALENES; CLAM; RANGIA; TRINITY BAY, TEXAS;
OIL SEPARATOR PLATFORM; UPTAKE; DEPURATION; SEDIMENTS;
HYDROCARBON ANALYSIS; GAS CHROMATOGRAPHY

0885 NAPHTHALENES; FUEL OIL # 2; WATER SOLUBLE FRACTION; NEANTHES;
POLYCHAETE; HEMOGLOBIN; HYPOXIA; SOUTH LOUISIANA CRUDE;
DISSOLVED OXYGEN; TOXICITY; SYNERGISM; DISSOLVED HYDROCARBONS;
RESPIRATION

0212 NAPHTHENIC ACID; TOXICITY; BLUEGILL SUNFISH; POND SNAIL;
WATER HARDNESS; TEMPERATURE

0613 NAPTHALENE; FISH; BENZ(A)PYRENE; RADIOACTIVE TRACER; UPTAKE;
METABOLISM; DISCHARGE; SCULPIN; OLIGOCOTTUS; GOBY; GILLICHTHYS;
SAND DAB; CITHARICHTHYS

0572 NAPTHALENE; FRESH WATER; CHLORELLA VULGARIS; ALGAE; TOXICITY; GROWTH;
PHOTOSYNTHESIS; BENZENE; XYLENE; TOLUENE

0581 NAPTHALENE; CRABS; OYSTERS; CHEMORECEPTION; SUBLETHAL EFFECTS;
BEHAVIOR; BIOASSAY

0609 NAPTHALENE; ZOOPLANKTON; BENZPYRENE; UPTAKE; DEPURATION;
PACIFIC COAST; ARCTIC; AROMATIC HYDROCARBONS; RADIOACTIVE TRACERS;
CALANUS

0942 NAPTHALENE; CRUDE OIL; WATER SOLUBLE FRACTION; CHLAMYDOMONAS;
TOXICITY; GROWTH

0943 NAPTHALENE; NAPTHALENE; WATER SOLUBLE FRACTION; CHLAMYDOMONAS;
PHOTOSYNTHESIS; GREEN ALGAE; UPTAKE; DEPURATION

0182 NARCOSIS; SALMON, CHINOOK; STRIPED BASS; BENZENE; RESPIRATORY RATES;
ONCORHYNCHUS; MORONE

0663 NARCOSIS; AMOEBA; PARAFFIN OILS; SITE OF ACTION

0895 NARCOSIS; CELL MEMBRANES; AMOEBA; OIL; EMULSIFIERS; CYTOLOGY;
DEGRADATION; BACTERIAL

0949 NARCOSIS; TOXICITY TESTING; SUBLETHAL EFFECTS; COPEPODS; TECHNIQUE;
DROPLETS

0092 NARCOTIZATION; DONNA MARIKA - SPILL 1973; LIMPETS; GASOLINE;
MILFORD HAVEN,WALES

0377 NARRAGANSET BAY; HYDROCARBON; CONTENT ANALYSIS; SEDIMENTS;
MERCENARIA; CLAMS; PETROLEUM; BIOGENIC

0828 NARRAGANSET BAY; DEGRADATION; BACTERIA; ESTUARY; BEACH; FUEL OIL;
ENRICHMENT; RATE; HYDROCARBON CONCENTRATION; SEDIMENTS; MIGRATION

0051 NARRAGANSETT BAY; CLAMS; CHARLESTOWN POND R.I.;

ANALYSIS OF HYDROCARBONS
1201 NARRAGANSETT BAY; PHYTOPLANKTON; HYDROCARBONS
1020A NARRAGANSETT BAY, R.I.; BACTERIA; DEGRADATION; LOW TEMPERATURE
0541 NASSARIUS; CHEMOTAXIS; KEROSENE; WATER SOLUBLE FRACTION; CHEMORECEPTION
0540 NASSARIUS (MARINE SNAIL); CHEMOTAXIS; KEROSENE
0065 NATURAL GAS; PHOTOSYNTHESIS; RESPIRATION; NITROGEN FIXATION; BACTERIA; ALGAE; FUNGI; ARCTIC; CRUDE OIL; MICROORGANISMS
0102 NATURAL OIL SEEP; ARCTIC; PHYTOPLANKTON; PRODUCTIVITY; OIL SEEP; ABUNDANCE; BACTERIA; ALASKA; CAPE SIMPSON; PHYTOPLANKTON PRODUCTIVITY; BACTERIA
0066 NATURAL OIL SEEPAGE; PROTOZOA; ALGAE; FUNGI; PLANTS; LICHENS; PSEUDOMONAS; ARCTIC; MICROORGANISMS; PRUDHOE CRUDE OIL; ALASKA-PRUDHOE BAY; CAPE SIMPSON
0562 NATURAL OIL SEEPS; MYTILUS; TOLERANCE
1205 NATURAL OIL SEEPS; SANTA BARBARA CHANNEL CALIFORNIA; ISLA VISTA OIL SEEP; BENTHIC FAUNA; POLYCHAETES; BIOMASS; TOXICITY
0303 NATURAL SEEP; CHEDABUCTO BAY, NOVA SCOTIA; CAPE SIMPSON, ALASKA; ARTHROBACTER; PSEUDOMONAS; TEMPERATURE
0063 NATURAL SEEPAGE; MICROBIAL POPULATIONS; PROTOZOANS; BLUE GREEN ALGAE; DIATOMS; DEGRADATION; YEAST; SPECIES DIVERSITY; GREEN ALGAE; PRUDHOE CRUDE OIL; ARCTIC; ALASKA-PRUDHOE BAY; CAPE SIMPSON; NUTRIENT ENRICHMENT
0982 NATURAL SEEPAGE; BRYOZOANS; HYPERPLASIA; OVICELL; CHRONIC EXPOSURE
0062 NATURAL SEEPAGES; ARCTIC; MICROORGANISMS; PRUDHOE BAY; VALDEZ; UMIAT; ALASKA -PRUDHOE BAY; CAPE SIMPSON
0714 NATURAL SEEPAGES; OIL POLLUTION; ECOLOGICAL IMPACT; OVERVIEW
0109 NATURAL SEEPS; OFFSHORE PRODUCTION; FISHERIES; VENEZUELA; LAKE MARACAIBO
0137 NATURAL SEEPS
0552 NATURAL SEEPS; REVIEW
0794 NATURAL SEEPS; CHRONIC POLLUTION; REVIEW; FIELD STUDIES; OFFSHORE PRODUCTION; REFINERIES; ESTUARIES; SUBLETHAL EFFECTS
0981 NATURAL SEEPS; SANTA BARBARA; SANTA BARBARA CHANNEL SPILL 1969
1100 NAUPLII; TOXICITY; RECOVERY; SURFACTANTS; BARNACLES; ELMINIUS
0733 NAUPLIUS; BP1002; KEROSENE; CHEMKLEEN; BARNACLE; BALANUS; ADULT; TOXICITY; CIRRAL ACTIVITY
0885 NEANTHES; FUEL OIL # 2; WATER SOLUBLE FRACTION; POLYCHAETE; HEMOGLOBIN; HYPOXIA; SOUTH LOUISIANA CRUDE; DISSOLVED OXYGEN; TOXICITY; SYNERGISM; NAPHTHALENES; DISSOLVED HYDROCARBONS; RESPIRATION
0886 NEANTHES; KUWAIT CRUDE; SOUTH LOUISIANA CRUDE; FUEL OIL # 2; BUNKER C; TOXICITY; WATER SOLUBLE FRACTION; NAPHTHALENE; CAPITELLA
0884 NEANTHES; FUEL OIL #2; NAPHTHALENE; ANNELIDS; POLYCHAETE; UPTAKE &DEPURATION; DEVELOPMENT; MALE; FEMALE; EGGS; LARVAE
0881 NEANTHES; POLYCHAETE; RADIOACTIVE TRACER EXPERIMENT; UPTAKE; RETENTION; METABOLISM; DEPURATION; WATER SOLUBLE FRACTION; WATER; SEDIMENT; DETRITUS
0882 NEANTHES; TOXICITY; POLYCHAETES; CRUDE; NAPHTHALENE; BUNKER C; FUEL OIL #2; WATER SOLUBLE FRACTION; CAPITELLA; SOUTH LOUISIANA CRUDE; KUWAIT
0883 NEANTHOS; TOXICITY; WATER SOLUBLE FRACTION; FUEL OIL #2; POLYCHAETE; LARVAE
0040 NEMATODE; KUWAIT CRUDE; PROTOZOAN CILIATES; EUPLOTES; URONEMA; INGESTION

1098 NEMATODES; HONG KONG; DIESEL SPILL; MEIOFAUNA; SANDY BEACHES; INTERTIDAL; HARPACTICOID COPEPODS

1003 NEMATONURUS; HYDROCARBON CONTENT ANALYSIS; DEEP-SEA BENTHOS; RATTAIL; HOLOTHURIANS

0100 NEOPLASM; MERCENARIA; CLAMS; CANCER; TUMORS; HISTOPATHOLOGY; SEARSPORT,MAINE

0567 NEREIS; CASPIAN SEA; BENTHOS; CRUDE OIL; GROWTH; REPRODUCTION; CHIRONOMUS; CERASTODERMA; NAIS; PYRGOHYDROBIA; ABRA

0989 NERINE; TOXICITY; DISPERSANTS; BP1002; BP1100; COCKLE-CERASTODERMA; LUGWORM-ARENICOLA

0413 NET PRODUCTIVITY; OIL; EMULSIFIERS; FUCUS; PLANTS; PHOTOSYNTHESIS; METABOLISM

0456 NETHERLANDS; OIL; BIRDS; CLEANING; FEATHER WETTING

0833 NEVA INLET, RUSSIA; BIODEGRADATION; MICROORGANISMS OXIDIZING HC'S; DISTRIBUTION; SEASONAL DISTRIBUTION; BACTERIA

0673 NEW ENGLAND; BUNKER C; RIVER; MUDDY RIVER, MASS.; BOD; PLANKTON; TOXICITY; MACROFAUNA

1095 NEW JERSEY; MICROALGAE; WATER SOLUBLE FRACTION; HYDROCARBON ANALYSIS; GAS CHROMATOGRAPHY; MASS SPECTROMETRY; BAYTOWN; MONTANA; BATON ROUGE

0103 NEW JERSEY COAST; BIODEGRADATION; METABOLIC PATHWAYS; TEMPERATURE; NUTRIENT MINERALS; BACTERIA -HYDROCARBON UTILIZING

0814 NEW YORK BIGHT; BENTHOS; CONTINENTAL SHELF

0191 NEWFOUNDLAND; BIRDS; MORTALITIES; ARROW SPILL; IRVING WHALE SPILL; NOVA SCOTIA; SPECIES ENDANGERMENT

0813 NEWFOUNDLAND; BENZOPYRENE; HYDROXYLASE INDUCTION; FISH; POLYCYCLIC AROMATIC HYDROXYLASE; ARYL HYDROCARBON HYDROXYLASE; BROWN TROUT; TAINTING; THIN-LAYER CHROMATOGRAPHY

0366 NIANTIC BAY, CT.; FUEL OIL#2; BENTHIC COMMUNITIES; AMPHIPODS; HERMIT CRABS; HYDROCARBON CONTENT ANALYSIS; GAS CHROMATOGRAPHY

1189 NIGERIA; MICROORGANISMS; BACTERIA; FUNGI; YEASTS; BIODEGRADATION; CRUDE OIL

0161 NIGERIAN CRUDE; FUEL OIL#2; CRANKCASE OIL; BENTHIC ALGAL COMMUNITIES; PRIMARY PRODUCTIVITY; TOXICITY; RECOVERY; ALGAL BLUE GREEN

0187 NIGERIAN CRUDE; TOXICITY; ACARTIA; ECOSYSTEM IMPACT; HYPOTHETICAL; REVIEW

0865 NIGERIAN CRUDE; BIVALVES; TOXICITY; SPERMATOZOA; FERTILIZATION; DEVELOPMENTAL ABNORMALITIES; PRUDHOE BAY CRUDE; KUWAIT CRUDE

0093 NITRIFICATION; BIODEGRADATION; CRUDE OIL; AMMONIA PRODUCTION; MICROORGANISMS

0104 NITROGEN; BACTERIA; TEMPERATURE; PHOSPHORUS; LIMITING FACTORS; BIODEGRADATION

0180 NITROGEN; BACTERIA; OXIDATION; SEAWATER; LIMITING FACTORS; PHOSPHORUS

0318 NITROGEN; DEGRADATION; RESPIROMETRY; CRUDE OILS; SEA WATER SOURCES

0621 NITROGEN; BIODEGRADATION; RATE ENHANCEMENT; PHOSPHORUS

0065 NITROGEN FIXATION; PHOTOSYNTHESIS; RESPIRATION; BACTERIA; ALGAE; FUNGI; ARCTIC; CRUDE OIL; NATURAL GAS; MICROORGANISMS

0071 NITROGEN FIXATION; ARCTIC; LICHENS; ALGAE-NASTOC; RESPIRATION; PHOTOSYNTHESIS; PRUDHOE CRUDE OIL

0584 NITROGEN FIXATION; SEDIMENT; ARCTIC; BACTERIA; ANEROBIC BACTERIA; PETROLEUM FRACTIONS; BEAUFORT SEA; ESKIMO LAKES NWT

1019 NITSCHIA; PHYTOPLANKTON; TOXICITY; EMULSIFIER; SKELETONMEA

0742 NOCARDIA; DEGRADATION; TEMPERATURE; BUNKER C; RATE LIMITING FACTORS

1150 NOCARDIA; BIODEGRADATION; AROMATIC PETROLEUM PRODUCTS; XYLENE; MICROORANISMS; BACTERIA

0272 NOCTILUCA; TORREY CANYON SPILL; CRAIE DE CHAMPAGNE
0669 NODILITTORINA; PELAGIC HYDROCARBONS; TAR BALLS; ROCKY INTERTIDAL; FLORA; FAUNA; BERMUDA; SPLASH ZONE; TECTARIUS; HYDROCARBON ANALYSIS; ALGAE
0389 NON-BIOLOGICAL; REVIEW; INPUT; DEGRADATION; BACTERIAL; BIOCHEMICAL
0390 NON-BIOLOGICAL; DEGRADATION; CRUDE OIL; MARINE ENVIRONMENT; BACTERIAL
0448 NONYPHENIL ETHOXYLATE; COD; SWEDEN; UPTAKE AND DEPURATION; PHYSIOLOGICAL
1146 NORMAL WELLS CRUDE OIL; RINGED SEALS; EFFECTS ON ORGANISMS; UPTAKE &EXCRETION; SEALS
1145 NORMAL WELLS CRUDE OIL; SEALS; ARCTIC; RINGED SEALS; BENZENE; NAPHTHALENE; PATHOLOGICAL EFFECTS; UPTAKE & INGESTION
1202 NORMAN WELLS & PEMBINA CRUDE OIL; ASSESSMENT OF SPILLS; MICROORGANISMS; BACTERIA; PROTOZOA; PHYTOPLANKTON; ZOOPLANKTON; ANALYSIS FOR PETROLEUM HYDROCARBONS; CANADA
0364 NORMAN WELLS CRUDE OIL; RINGED SEAL; UPTAKE; DISTRIBUTION; CLEARANCE
0816 NORMANDY, FRANCE; COMMUNITIES; ROCKY SHORES; DETERGENTS; RECOVERY; MUSSELS; DEPURATION
1052 NORTH ATLANTIC; DEGRADATION; GROWTH POTENTIAL; BACTERIA; SEDIMENTS
1054 NORTH CAROLINA; BIODEGRADATION; SEDIMENTS; ATLANTIC COAST
0469 NORTH SEA; BIODEGRADATION; BACTERIA; DISTRIBUTION; OIL-OXIDIZING BACTERIA; ABUNDANCE; WATER; SEDIMENT
0590 NORTH SEA; REVIEW; FISH STOCKS; DISPERSANTS; TAINTING
0796 NORTH SEA; BACTERIA; HYDROCARBON ANALYSIS; SEDIMENTS; SEAWATER; PELAGIC TAR
0305 NORTH SEA OIL; BIRDS; CROMARTY FIRTH,SCOTLAND
0444 NORTH WESTERN ATLANTIC; PHYTOPLANKTON; PHOTOSYNTHESIS; BEDFORD BASIN, NOVA SCOTIA; VENEZUELAN CRUDE; FUEL OIL#2; FUEL OIL#6
0545 NORTHEAST U.S.; OFF SHORE OIL; SPORT FISHERIES
0248 NORTHEASTERN PACIFIC OCEAN
0741 NORTHWEST ATLANTIC; DEGRADATION; BACTERIA; DISTRIBUTION; COASTAL SEDIMENTS
0740 NORTHWESTERN ATLANTIC; BIODEGRADATION; MICROORGANISMS; DISTRIBUTION
0178 NORWAY; MUSSEL; MYTILUS; SURFACTANT; PHYSIOLOICAL EFFECT; TISSUE SWELLING; SEASONAL VARIATION
0191 NOVA SCOTIA; BIRDS; MORTALITIES; ARROW SPILL; IRVING WHALE SPILL; SPECIES ENDANGERMENT; NEWFOUNDLAND
0902 NOVA SCOTIA; HYDROCARBON CONCENTRATION; FLUORESCENCE ANALYSIS; SEDIMENTS; BENTHIC SPECIES; FOOD CHAIN CONCENTRATION; CHEDABUCTO BAY; FUEL OIL -BUNKER C
1107 NOVA SCOTIA; COKE OIL; HERRING; MORTALITY; ROUTE OF UPTAKE; CLUPEA
1215 NOVA SCOTIA; FUEL OIL; BUNKER C; CHEDABUCTO BAY; ARROW SPILL; LONG TERM EFFECTS; CORDGRASS; MARSH; ALGAE; TOXICITY
0017 NOVOROSSIYSK BAY,RUSSIA; BIOCHEMICAL OXYGEN DEMAND; OXYGEN-DISSOLVED
0822 NUCELLA; LITTORINA; BUCINNUM; DETERGENTS; GROWTH; MORTALITY; BP1002; TARSOLVENT
0197 NUCELLA LAPILLUS; DETERGENTS; RESISTANCE; MORTALITY; POPULATION RECOVERY; RECOLONIZATION; ROCKY SHORE; LITTORAL
0310 NUCLEIC ACIDS; ALGAE
1032 NUMBERS OF SPECIES; FUEL OIL#2; DISPERSION; INTERTIDAL COLONIES; SPECIES DIVERSITY; RELATIVE ABUNDANCE; INDIVIDUAL FREQUENCY OCCURANCE PATTERNS
0049 NUTRIENT ADDITION; BIODEGRADATION; CLEANUP
0063 NUTRIENT ENRICHMENT; MICROBIAL POPULATIONS; PROTOZOANS;

BLUE GREEN ALGAE; DIATOMS; DEGRADATION; YEAST; SPECIES DIVERSITY;
GREEN ALGAE; NATURAL SEEPAGE; PRUDHOE CRUDE OIL; ARCTIC;
ALASKA-PRUDHOE BAY; CAPE SIMPSON

0428 NUTRIENT LIMITATIONS; DEGRADATION; BACTERIAL; OXYGEN UPTAKE; RESIDUE

0103 NUTRIENT MINERALS; BIODEGRADATION; METABOLIC PATHWAYS;
NEW JERSEY COAST; TEMPERATURE; BACTERIA -HYDROCARBON UTILIZING

0690 NUTRIENT SALT; BACTERIAL DEGRADATION; SLICK-SEEDING; ADDITIVES;
ENHANCEMENT; MICROBIAL SEEDING; BOD; TOTAL ORGANIC CARBON

0070 NUTRIENTS; BIODEGRADATION; OLEOPHILIC FERTILIZER;
CLEANUP OF OIL SLICKS

0427 NUTRIENTS; OXIDATION; CRUDE OIL

1129 NUTRIENTS; BIODEGRADATION; MICROOGANISMS; ARCTIC; TEMPERATURE;
OXYGEN REQUIREMENTS; CRUDE OIL; AROMATICS; PARAFFINS; BEAUFORT SEA;
CHUKCHI SEA

1188 NUTRIENTS; BIODEGRADATION; CRUDE OIL-NIGERIAN; OXYGEN CONSUMPTION

0189 NUTRIENTS-NITROGEN AND PHOSPHATE; BIODEGRADATION; METABOLIC PRODUCTS;
TOXICITY TO FISH

0496 NYLON NETS; PLANKTON; SAMPLING METHODS; CONTAMINATION

0637 OCCURENCE; REVIEW; EFFECTS; FATE

0224 OCEAN EAGLE SPILL; ECOLOGICAL DAMAGE; PUERTO RICO

0789 OCEAN EAGLE SPILL; PUERTO RICO; ECOLOGICAL IMPACT; CLEANUP; OVERVIEW

0761 OCEANIC; TOXICITY; AROMATICS; PHENATHRENES; ESTUARINE; BENTHIC;
LARVAE; JUVENILES; RESPIRATION; GROWTH; SUBLETHAL

0359 OCTOCORALS; CRUDE OIL; DETERGENT; CRUSTACEANS; MOLLUSCS; ECHINODERMS;
FISH; TOXICITY; SUBLETHAL; DEVELOPMENTAL STAGES; RED SEA;
FEEDING RATE; PHYSIOLOGY; BIOACCUMULATION; LIVER ENLARGEMENT;
HEMATOCRIT

0282 OENANTHE; REVIEW; CHRONIC POLLUTION; SALT MARSH; REFINERY EFFLUENT;
RECOVERY; SPARTINA; PUCCINELLIA

0545 OFF SHORE OIL; SPORT FISHERIES; NORTHEAST U.S.

0411 OFFSHORE DRILLING; REVIEW; SPREADING OF OIL; GASEOUS EXCHANGE;
TOXICITY; TAINTING; OYSTERS; DIATOMS; BLEED WATER

0672 OFFSHORE DRILLING; SPILL INCIDENT; MISSISSIPPI DELTA; WATER COLUMN;
SEDIMENT; WEATHERING; MIGRATES IN SEDIMENTS; DIVERSITY; POPULATIONS;
SHRIMP; BLUE CRABS; BENTHIC ORGANISMS

0896 OFFSHORE DRILLING; ECOSYSTEM IMPACT; LOUISIANA

0825 OFFSHORE OIL OPERATIONS; ENVIRONMENTAL IMPACT;
CONFERENCE PROCEEDINGS

0309 OFFSHORE OIL PORT; LOUISIANA

0445 OFFSHORE OIL WELLS; OYSTERS; MORTALITIES; SALT-BRINE

1181 OFFSHORE PLATFORMS; CONTINENTAL SHELF; CRABS; UPTAKE; CALIFORNIA;
ANALYSIS FOR HYDROCARBONS

0109 OFFSHORE PRODUCTION; FISHERIES; VENEZUELA; LAKE MARACAIBO;
NATURAL SEEPS

0181 OFFSHORE PRODUCTION; RINCON IS.,CALIF; INTERTIDAL COMMUNITY

0186 OFFSHORE PRODUCTION; TIMBALIER BAY,LA.; LONG TERM EFFECTS; SUMMARY

0301 OFFSHORE PRODUCTION; REVIEW; FISH; SHELLFISH; CONTINENTIAL SHELF

0509 OFFSHORE PRODUCTION; ARCTIC; BEAUFORT SEA; HYPOTHETICAL SPILL

0605 OFFSHORE PRODUCTION; UPTAKE AND DEPURATION; TOXICITY;
FOOD CHAIN ACCUMULATION

0588 OFFSHORE PRODUCTION; PRODUCED WATERS; CHRONIC SPILLAGE;
TIMBALIER BAY LA.; TEXAS BAYS

0618 OFFSHORE PRODUCTION; INDONESIA; FISHERIES; CORAL REEF COMMUNITY;
REVIEW

0794 OFFSHORE PRODUCTION; CHRONIC POLLUTION; REVIEW; FIELD STUDIES;

REFINERIES; ESTUARIES; SUBLETHAL EFFECTS; NATURAL SEEPS
0774 OFFSHORE PRODUCTION; ECOLOGICAL IMPACTS; GEORGES BANK; MONITORING
0911 OFFSHORE PRODUCTION; LOUISIANA COAST; TIMBALIER BAY; ECOLOGY; ENVIRONMENTAL IMPACT
0894 OFFSHORE PRODUCTION; LOW MOLECULAR WEIGHT HYDROCARBONS; GULF OF MEXICO; TOXICITY
0015 OFFSHORE WELLS; OIL SPILL INCIDENT; GULF OF MEXICO; CHEVRON OIL PLATFORM
0118 OIL; TOXICITY; DISPERSANTS
0091 OIL; SALT MARSHES; ROCKY SHORES; EMULSIFIERS; ECOLOGICAL IMPACTS; TOXICITY
0163 OIL; BIRDS; BREEDING; DISTRIBUTION; STRANDINGS; WEATHER
0166 OIL; BIRDS; EFFECT; REVIEW; MORTALITIES; PHYSIOLOGY
0218 OIL; DISPERSANTS; FISH; SEA URCHINS; FERTILIZATION; DEVELOPMENT; TOXICITY; COREXIT
0341 OIL; CLAM; MORTALITY; SEARSPORT MAINE; MYA
0292 OIL; EMULSIFIERS; EFFECTS ON INTERTIDAL COMMUNITIES; FIELD EXPERIMENTS; EXPERIMENTAL SPILLS; ROCKY SHORE
0311 OIL; OLEOPHILIC "FLUFF"; DETERGENT; TOXICITY; PORCELAIN CRAB; MECHANISM OF ACTION; BP1100
0313 OIL; DETERGENT; REPRODUCTION
0300 OIL; MALLARDS; PHYSIOLOGY; INTESTINAL ABSORPTION; ANAS; MUCOSAL TRANSFER RATES; CRUDE OILS; BOILING FRACTIONS
0460 OIL; BIRDS; CLEANING; PATHOLOGY; SANTA BARBARA CRUDE; POLYCOMPLEX A-11
0413 OIL; EMULSIFIERS; FUCUS; PLANTS; PHOTOSYNTHESIS; NET PRODUCTIVITY; METABOLISM
0494 OIL; DUCKS; COATING; METABOLISM; TEMPERATURE; HEAT CONDUCTIVITY
0424 OIL; DISPERSANTS; TOXICITY; POLYCHAETE; GAMETE FORMATION; SPAWNING; GROWTH; MORTALITY; CIRRATULUS; CIRRIFORMIA; BP1002; COREXIT; ESSOLVENE
0492 OIL; BIRDS; DUCKS; REPRODUCTION; INGESTION; HATCHABILITY; COATING
0495 OIL; BIRDS; DUCKS; INGESTION; TOXICITY; PHYSIOLOGICAL EFFECTS; HISTOPATHOLOGY
0456 OIL; BIRDS; CLEANING; NETHERLANDS; FEATHER WETTING
0493 OIL; WATERFOWL; TOXICOLOGY
0491 OIL; BIRDS; INGESTION; MOBILITY; TOXICOLOGICAL EFFECTS; DUCKS
0604 OIL; DISPERSANTS; TOXICITY; METHODOLOGY; BIOASSAY
0550 OIL; CORAL; TOXICITY; AIR EXPOSURE; ENIWETOK ATOLL
0549 OIL; CORAL REEF COMMUNITY
0670 OIL; FUEL OIL#2; JP5 FUEL; GAS CHROMATOGRAPHY; SEDIMENTS; SEARSPORT SPILL
0633 OIL; EMBRYOLOGY; SEA URCHIN; DISPERSANTS; COREXIT; ULTRASTRUCTURE
0729 OIL; TOXICITY; SALMON; TEMPERATURE; JUVENILE; STRESS BEHAVIOR; WEATHERING
0732 OIL; OYSTERS; HONG KONG
0658 OIL; TAINTING; PHENOL; FISH
0635 OIL; DISPERSANTS; COREXIT; SEA URCHIN; FISH; EGGS; EMBRYO; FERTILIZATION; DEVELOPMENT
0722 OIL; CRITICAL REVIEW; MARINE ORGANISMS
0810 OIL; BIRDS; BREEDING COLONIES; WORLD WAR 2 OIL POLLUTION; GUILLEMOTS; PUFFINS
0790 OIL; SANTA BARBARA SPILL; PRODUCTIVITY; PHYTOPLANKTON; DISPERSANTS
0798 OIL; TORREY CANYON SPILL; DETERGENT; INTERTIDAL; CORNWALL, ENGLAND
0845 OIL; ALGAE; DINOFLAGELLATE; DUNALIELLA; DIATOM; FRAGILARIA;

AXEMIC CULTURES; GROWTH RATES
0826 OIL; BIRDS; TREATMENT; WW2 TANKER SINKINGS
0855 OIL; DEGRADATION; BIODEGRADATION; ENVIRONMENTAL FACTORS; ENERGY; BACTERIA; BUNKER C; CHEDABUCTO BAY; ARROW SPILL
0772 OIL; REVIEW; INPUT; FATE; BIOLOGICAL EFFECTS; CLEANUP; DISPERSANTS
0770 OIL; REVIEW; MARINE; PLANTS; ANIMALS
0765 OIL; TAMPICO MARU SPILL; TORREY CANYON SPILL; MILFORD HAVEN, WALES; LITTORAL COMMUNITY; SHORE CLEANING
0895 OIL; CELL MEMBRANES; AMOEBA; EMULSIFIERS; NARCOSIS; CYTOLOGY; DEGRADATION; BACTERIAL
0946 OIL; DISPERSANTS; COREXIT; TOXICITY
0921 OIL; BACTERIA; ALGAE; OTTAWA; ICE
0924 OIL; SHELLFISH; TOXICITY; DETERGENTS; CLEAN UP PROCEDURES; TAINTING
0952 OIL; UPTAKE; ACCUMULATE; RATE OF ENTRY; MYA ARENARIA; MUCUS BINDING; DROPLETS; OIL DYE
0972 OIL; DETERGENT; RECOLONIZATION; SETTLEMENT; ARTIFICAL SUBSTRATE
1040 OIL; DISPERSED OIL; TOXICITY; EFFECTS; MARINE BIOTA
1006 OIL; REVIEW; ECOLOGICAL EFFECTS; OIL DISPERSANTS
0993 OIL; TOXICITY; DISPERSANTS; METHODOLOGY
0983 OIL; PROTOZOA; OIL SEWAGE TREATMENT
1101 OIL; BIRDS; MORTALITY; SHETLAND IS., BRITAIN
1099 OIL; MUSKRATS; WETTING; MARSH SPRAY; DDT
1210 OIL; BIRDS; EGGS; INGESTION
0751 OIL BASE; TOXICITY; INTERTIDAL; BALTIC SEA; LITTORAL ZONE; COREXIT; BEROL; BP1100; WATER BASE; SOLVENT
0134 OIL CONTAMINATION; REVIEW ARTICLE; BIOLOGICAL EFFECTS
0290 OIL DEPOT; CROMARTY FIRTH, SCOTLAND
0835 OIL DISPERSANTS; TOXICITY; CARDIUM; CRAGON
1006 OIL DISPERSANTS; REVIEW; ECOLOGICAL EFFECTS; OIL
0952 OIL DYE; OIL; UPTAKE; ACCUMULATE; RATE OF ENTRY; MYA ARENARIA; MUCUS BINDING; DROPLETS
0995 OIL EMULSION; DISPERSANTS; EMULSIONS; TOXICITY; SUBLETHAL EFFECTS; ACTIVITY; MOTILITY; BIVALVES; CRUSTACEANS; FISH; BEHAVIOR; CONTINUOUS FLOW; LOCOMOTION
0438 OIL FRACTIONS; DETERGENTS; CELL MEMBRANE; AMOEBA
0034 OIL IN WATER DISPERSION; WATER SOLUBLE FRACTION; CRUSTACEANS; FISH; TOXICITY; ESTUARINE; SOUTH LA. CRUDE; KUWAIT CRUDE; FUEL OIL #2; BUNKER C; CYPRINODON; MENIDIA; FUNDULUS; PENAEUS; PALEOMONETES; MYSIDOPSIS
0268 OIL INGESTION; ARROW SPILL; ZOOPLANKTON; HYDROCARBON CONTENT; CHEDABUCTO BAY; BUNKER C; SEDIMENTATION; FECES
0082 OIL POLLUTION; TRANSPIRATION; TRANSLOCATION; CELL MEMBRANE PERMEABILITY; PLANT PHYSIOLOGY; PHOTOSYNTHESIS AND RESPIRATION; CELLULAR DAMAGE
0095 OIL POLLUTION; BIRDS
0431 OIL POLLUTION; REVIEW
0430 OIL POLLUTION; BIRDS; KENT
0368 OIL POLLUTION; BIRDS; MIGRATION
0369 OIL POLLUTION; BIRDS; MIGRATION
0472 OIL POLLUTION; FISHERIES
0498 OIL POLLUTION; REVIEW; INPUT; DAMAGE
0707 OIL POLLUTION; FLORA; FAUNA; BLACK SEA; CRUDE OIL; DIESEL OIL
0706 OIL POLLUTION; FLORA; FAUNA; BLACK SEA
0714 OIL POLLUTION; NATURAL SEEPAGES; ECOLOGICAL IMPACT; OVERVIEW
0768 OIL POLLUTION; MARINE; REVIEW

0771 OIL POLLUTION; ESTUARINES; SPILLS; CHRONIC; SALT MARSH; ROCKY SHORE; EMULSIFIERS; CLEANING
0744 OIL POLLUTION; RECOVERY; ENVIROMENTAL EFFECTS
0739 OIL POLLUTION; BIBLIOGRAPHY; MARINE; ESTUARINE
0854 OIL POLLUTION; BIRDS; ENGLAND
0769 OIL POLLUTION; REVIEW; SHORE CLEANING; BIOLOGICAL CONSEQUENCES
0878 OIL POLLUTION; BIOINDICATORS; CHIRONOMIDAE; FRESH WATER; TRAIL RIVER, NWT, CANADA; FRESHWATER; MIDGES
0866 OIL POLLUTION; MARINE ENVIRONMENT; REVIEW
1005 OIL POLLUTION; REVIEW; TOXICITY; FATE &BEHAVIOR OF OIL; BIRDS; BIODEGRADATION; FIELD STUDIES; BIBLIOGRAPHY
1195 OIL POLLUTION; REVIEW; POLLUTION; BIOINDICATORS; ESTUARINE; MARINE
1103 OIL POLLUTION 1950-67; BIBLIOGRAPHY
0890 OIL POLLUTION EFFECTS; CONFERENCE PROCEDINGS
0003 OIL POLLUTION MARINE
1045 OIL POLLUTION OF BIRDS; BIRDS; BIBLIOGRAPHY
0286 OIL PORT; ROCKY SHORE; SALT MARSH; CHRONIC SPILLAGE; EXPERIMENTAL SPILLS
0295 OIL PORT; MILFORD HAVEN, BRITAIN; ROCKY SHORE; BARNACLES; TOP SHELL (MONDONTA); LITTORINA
0551 OIL PORT; ORKNEY IS., SCOTLAND; MONITORING
0719 OIL PORT; CHRONIC POLLUTION; POMATOLEIOS; GROWTH; TOXICITY; KUWAIT; DIVERSITY; SUCCESSION
0965 OIL PORTS; LOUISIANA
0338 OIL REFINERY EFFLUENT; TOXICITY; OXYGEN DEMAND; MINNOWS; PIMEPHALES
1086 OIL REFINERY EFFLUENT; STREAM; BENTHIC; MACROINVERTEBRATES; DIVERSITY INDICES
0102 OIL SEEP; ARCTIC; PHYTOPLANKTON; PRODUCTIVITY; ABUNDANCE; BACTERIA; ALASKA; CAPE SIMPSON; NATURAL OIL SEEP; PHYTOPLANKTON PRODUCTIVITY; BACTERIA
0410 OIL SEPARATOR PLATFORM; CLAM; RANGIA; NAPHTHALENES; TRINITY BAY, TEXAS; UPTAKE; DEPURATION; SEDIMENTS; HYDROCARBON ANALYSIS; GAS CHROMATOGRAPHY
0983 OIL SEWAGE TREATMENT; OIL; PROTOZOA
0573 OIL SPERSE; TOXICITY; GREEN SEA URCHIN; VENEZUELAN CRUDE OIL; BEDFORD BASIN NOVA SCOTIA
0327 OIL SPILL; PUERTO RICO; GUANICA
0724 OIL SPILL; LONG IS., N.Y.; PREDICTION
0651 OIL SPILL; OYSTER; CRASSOSTREA; LOUISIANA; MORTALITY; GROWTH; SET; DISEASE INCIDENCE; TAINTING
1225 OIL SPILL; TURTLES; FLORIDA; TAR
0019 OIL SPILL CONFERENCE 1969; CONFERENCE; PREVENTION AND CONTROL; AMER. PETROL. INST.
0020 OIL SPILL CONFERENCE 1973; CONFERENCE; PREVENTION AND CONTROL; AMER. PETROL. INST.
0021 OIL SPILL CONFERENCE 1975; CONFERENCE; PREVENTION AND CONTROL; AMER. PETROL. INST.
0022 OIL SPILL CONFERENCE 1977; CONFERENCE; PREVENTION AND CONTROL; AMER. PETROL. INST.
0015 OIL SPILL INCIDENT; GULF OF MEXICO; OFFSHORE WELLS; CHEVRON OIL PLATFORM
0336 OIL SPILL INCIDENT; OLYMPIC ALLIANCE-DOVER STRAITS 1975; BIRD MORTALITY; CORMORANT; AUKS; ENGLAND
0490 OIL SPILL INCIDENT; BIRDS; MEDWAY ESTUARY
0503 OIL SPILL INCIDENT; CHESAPEAKE BAY; SALT MARSH; POPULATIONS; MUSSEL;

AD-A064 196 COAST GUARD RESEARCH AND DEVELOPMENT CENTER GROTON CONN F/G 13/2
BIOLOGICAL EFFECTS OF OIL POLLUTION - A OMPREHENSIVE BIBLIOGRAP--ETC(U)
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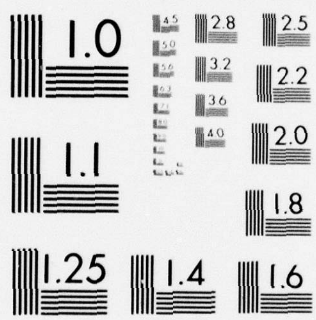

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

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0851 OIL SPILL INCIDENT; DECEPTION BAY QUEBEC; DIESEL OIL; GASOLINE; MYTILUS; FUCUS
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1224 OIL SPILLS; WATERFOWL; REPRODUCTION; REVIEW; MALLARDS; EGGS
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1123 PHYSIOLOGICAL EFFECTS; EIDER DUCKS; TOXICITY; HATCHING SUCCESS; FUEL OIL
1154 PHYSIOLOGICAL EFFECTS; ZOOPLANKTON; COPEPODS; NAPHTHALENE; AROMATIC HYDROCARBONS; RETENTION; DEVELOPMENT
1153 PHYSIOLOGICAL EFFECTS; SALMON; COHO; BENZOPYRENE; ARYL HYDROCARBON HYDROXYLASE; CYTOLOGICAL
1121 PHYSIOLOGICAL EFFECTS; MALLARD; TOXICITY; FUEL OIL; HATCHING SUCCESS; PARAFFINS; GROWTH
1192 PHYSIOLOGICAL EFFECTS; AMPHIPODS; ONISIMUS; RESPIRATION; TOXICITY; DISPERSANTS
1173 PHYSIOLOGICAL EFFECTS; DUCKS; MALLARDS; ANALYSIS FOR HYDROCARBONS; NAPHTHALENE; SOUTH LOUISIANA CRUDE OIL
0827 PHYSIOLOGICAL RESPONSE; SUBLETHAL EFFECTS; MARINE ORGANISMS; ESTUARINE ORGANISMS
0400 PHYSIOLOGICAL STRESS; MYTILUS; UPTAKE; DEPURATION; HYDROCARBON CONTENT ANALYSIS; BIOLOGICAL MONITOR; MUSSELS; ACCUMULATION
0177 PHYSIOLOGY; REVIEW; BIRDS; REHABILITATION; MARINE FAUNA
0166 PHYSIOLOGY; BIRDS; OIL; EFFECT; REVIEW; MORTALITIES
0300 PHYSIOLOGY; OIL; MALLARDS; INTESTINAL ABSORPTION; ANAS; MUCOSAL TRANSFER RATES; CRUDE OILS; BOILING FRACTIONS
0361 PHYSIOLOGY; CRUDE OIL; RED SEA; MACROFAUNA; TOXICITY; DEPTH; SUBLETHAL EFFECTS; METABOLISM; BEHAVIOR; DISPERSANT
0299 PHYSIOLOGY; BIRDS; MALLARDS; CRUDE OIL; ANAS; DEHYDRATION; MUCOSAL TRANSFER RATE; DISPERSANTS; INTESTINAL ABSORPTION
0359 PHYSIOLOGY; CRUDE OIL; DETERGENT; OCTOCORALS; CRUSTACEANS; MOLLUSCS; ECHINODERMS; FISH; TOXICITY; SUBLETHAL; DEVELOPMENTAL STAGES; RED SEA; FEEDING RATE; BIOACCUMULATION; LIVER ENLARGEMENT; HEMATOCRIT
0408 PHYSIOLOGY; AQUATIC ANIMALS; POLLUTANTS
0632 PHYSIOLOGY; COLLECTION OF PAPERS; POLLUTANTS; AQUATIC ORGANISMS
0941 PHYSIOLOGY; WATER SOLUBLE FRACTION; CRUDE OIL; NAPHTHALENE; GREEN ALGAE; MORPHOLOGY; FRESHWATER
0868 PHYSIOLOGY; TOXICITY; ACUTE; CHRONIC; CRUDE OIL; COMPONENT; BEHAVIOR; ARCTIC & SUBARCTIC ORGANISMS; TEMPERATURE; METABOLISM
1039 PHYSIOLOGY; ALGAE; HYDROCARBONS PETROLEUM; REVIEW; NAPHTHALENE; PHOTOSYNTHESIS; ATP; CRUDE OIL; DISTILLATE FRACTIONS
0178 PHYSIOLOICAL EFFECT; MUSSEL; MYTILUS; SURFACTANT; TISSUE SWELLING; SEASONAL VARIATION; NORWAY
0141 PHYTOL; TRACERS; ZOOPLANKTON; FISH; ANALYSIS FOR HYDROCARBONS; OLEFINS; FOOD CHAIN; BIOGENIC VS. PETROLEUM
0117 PHYTOMETRIC; CHRONIC POLLUTION; ACUTE POLLUTION; PHYTOSOCIALOGY; DIVERSITY
0101 PHYTOPLANKTON; CRUDE OIL; POND; ARCTIC; PHYSICAL PARAMETERS; VASCULAR PLANTS; CHIRONOMID; AQUATIC; PRUDHOE CRUDE OIL; ARCTIC -TUNDRA; ALASKA- BARLOW; BENTHIC ORGANISMS; PLANKTON
0102 PHYTOPLANKTON; ARCTIC; PRODUCTIVITY; OIL SEEP; ABUNDANCE; BACTERIA; ALASKA; CAPE SIMPSON; NATURAL OIL SEEP; PHYTOPLANKTON PRODUCTIVITY; BACTERIA
0121 PHYTOPLANKTON; SALT MARSH; YORK RIVER; ISOLATED ECOSYSTEM; SOUTH LA. CRUDE; WEATHERED OIL; FISH; PERIPHYTON; ATP; MARSH GRASS; BENTHIC FAUNA; POLYCHAETES; INSECT LARVAE; AMPHIPODS; OLIGOCHAETE

0149 PHYTOPLANKTON; OUTBOARD ENGINE EMMISSIONS; SPECIES DIVERSITY; FIXATION; CHLOROPHYLL; ZOOPLANKTON POPULATION DYNAMICS; BENTHIC MICROINVERTEBRATE COMMUNITY; GASOLINE

0250 PHYTOPLANKTON; PARAFFINS; ALGAE; ZOOPLANKTON; SEDIMENT; PRISTANE; BIOGENIC; PETROLEUM

0350 PHYTOPLANKTON; AMPHIDINIUM; SKELETONEMA; CRICOSPHAERA; DUNALIALLA; BENZENE; TOLUENE; XYLENE; FUEL OIL#2; GROWTH

0444 PHYTOPLANKTON; PHOTOSYNTHESIS; BEDFORD BASIN, NOVA SCOTIA; NORTH WESTERN ATLANTIC; VENEZUELAN CRUDE; FUEL OIL#2; FUEL OIL#6

0535 PHYTOPLANKTON; COMPOSITION; DIVERSITY

0501 PHYTOPLANKTON; PHOTOSYNTHESIS; GROWTH; PLANTS; COMMUNITY EFFECTS; ARCTIC; PERIPHYTON; POPULATION COMPOSITION; SEASONAL SUCCESSION; MACKENZIE VALLEY NWT

0571 PHYTOPLANKTON; CRUDE OIL; FIELD EXPERIMENT; INHIBITED; STIMULATION; LABORATORY STUDIES; TOXICITY; PH; FRACTIONS; BENZENE; XYLENE; TOLUENE

0620 PHYTOPLANKTON; CRUDE OIL; TEMPERATURE; TOXICITY

0599 PHYTOPLANKTON; TOXICITY; KUWAIT CRUDE; COREXIT 8666; PHAEODACTYLUM TRICORNUTUM; PRIMARY PRODUCTION; ILLUMINATION

0641 PHYTOPLANKTON; ESTUARIES; HYDROCARBON CONCENTRATIONS; SEDIMENTS; ZOOPLANKTON; CRUDE OIL; SALT MARSH PLANTS; DIVERSITY; POPULATIONS; FISH; MIGRATION; GAS CHROMATOGRAPHY; DEGRADATION

0700 PHYTOPLANKTON; REVIEW-OIL POLLUTION; LARVAE; SUBLETHAL EFFECTS; PRODUCTIVITY; FISH; ZOOPLANKTON; EGGS; BIRDS; PLAICE

0622 PHYTOPLANKTON; REFINERY WASTES; BIODEGRADATION; BACTERIA

0662 PHYTOPLANKTON; REVIEW; ATLANTIC COAST

0674 PHYTOPLANKTON; DIVERSITY; ESTUARY; CHLOROPHYLL-A

0682 PHYTOPLANKTON; CONTROLLED ECOSYSTEM; BACTERIAL POPULATIONS; CENTRATE DIATOMS; ZOOPLANKTON

0780 PHYTOPLANKTON; WATER SOLUBLE FRACTION; FUEL OIL #2; TOXICITY

0847 PHYTOPLANKTON; ALGAE; MARINE; CRUDE OIL; FUEL OIL #2; GROWTH RATES

0790 PHYTOPLANKTON; SANTA BARBARA SPILL; PRODUCTIVITY; OIL; DISPERSANTS

0904 PHYTOPLANKTON; OUTBOARD ENGINE EXHAUST; SPECIES ABUNDANCE; DIVERSITY; ZOOPLANKTON; PERIPHYTON; FISH; BEHAVIOR; POPULATION

1021 PHYTOPLANKTON; DETERGENTS; GROWTH

1018 PHYTOPLANKTON; EMULSIFIERS; TOXICITY; SKELETONEMA

0967 PHYTOPLANKTON; TOXICITY

1019 PHYTOPLANKTON; TOXICITY; EMULSIFIER; SKELETONMEA; NITSCHIA

1134 PHYTOPLANKTON; ARCTIC; SUB ARCTIC; BAFFIN BAY; DAVIS STRAIT; LABRADOR SEA; ASSESSMENT OF SPILLS; ZOOPLANKTON; ZOOBENTHOS; FISH; MAMMALS; BIRDS

1118 PHYTOPLANKTON; HYDROCARBONS; CHLOROPHYLL-A CORRELATION WITH; BIOGENIC VS. PETROLEUM; WEST AFRICA

1131 PHYTOPLANKTON; MICROFLORA; ALGAE; CRUDE OIL; FUEL OIL; TOXICITY; NAPHTHALENE; PHENANTHRENE; AROMATICS; ALGAE-GREEN; ALGAE-BLUE GREEN; DIATOMS; GROWTH

1160 PHYTOPLANKTON; DISPERSANTS; COREXIT; CRUDE OIL; ARCTIC; PRODUCTIVITY; ALGAE

1201 PHYTOPLANKTON; NARRAGANSETT BAY; HYDROCARBONS

1174 PHYTOPLANKTON; ESTUARIES; CANADA; SAENICH INLET; CRUDE OIL; FUEL OIL; BIODEGRADATION; CEPEX; DIATOMS

1204 PHYTOPLANKTON; LOS ANGELES HARBOR; SANSINEA SPILL; PRODUCTIVITY; ZOOPLANKTON; ASSESSMENT OF SPILLS; BIRDS; BENTHIC ORGANISMS; FISH

1202 PHYTOPLANKTON; NORMAN WELLS & PEMBINA CRUDE OIL; ASSESSMENT OF SPILLS; MICROORGANISMS; BACTERIA; PROTOZOA;

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0102 PHYTOPLANKTON PRODUCTIVITY; ARCTIC; PHYTOPLANKTON; PRODUCTIVITY; OIL SEEP; ABUNDANCE; BACTERIA; ALASKA; CAPE SIMPSON; NATURAL OIL SEEP; BACTERIA
0117 PHYTOSOCIALOGY; CHRONIC POLLUTION; ACUTE POLLUTION; PHYTOMETRIC; DIVERSITY
0306 PHYTOTOXICITY; HYDROCARBONS
1116 PICKEREL; BIODEGRADATION; BACTERIA; SEDIMENTS; BARATARIA BAY; ANAEROBIC; BENZ(A)PYRENE; ACCUMULATION; MYTILUS; WHITING
0398 PIGMENTATION; SOUTH LA.CRUDE; LOBSTER; LARVAE; FLOW THROUGH SYSTEM; EMULSION; FEEDING; MOULTING; HYDROCARBON ANALYSIS
1091 PILCHARD; DISPERSANT; TOXICITY; FISH; LARVAE; HERRING; PLAICE; SOLE; LEMON SOLE; HADDOCK; BP1002; DELAYED EFFECTS; EMBRYOLOGY; BEHAVIORAL CHANGES
0338 PIMEPHALES; TOXICITY; OIL REFINERY EFFLUENT; OXYGEN DEMAND; MINNOWS
0405 PIMEPHALES; TOXICITY; FUNDULUS; ARTEMIA; KUWAIT; WEST TEXAS; MARINE DIESEL; FUEL OIL; LUBE OIL
0867 PINK SALMON; CRUDE OIL; TOXICITY; AVOIDANCE; JUVENILE; MIGRATION; AGE; CHEMORECEPTION
1166 PINNIPEDS; SEALS; HYPOTHERMIA; PRUDHOE BAY CRUDE OIL
1014 PLACOPECTEN; ARGO MERCHANT SPILL; WINTER FLOUNDER; YELLOW TAIL FLOUNDER; MODIOLUS; RESPIRATORY ENZYMES; MALIC DEHYDROGENASE; OSMOLALITY; PYRUVATE REDUCTION; ANAEROBIOSIS
0700 PLAICE; REVIEW-OIL POLLUTION; LARVAE; SUBLETHAL EFFECTS; PRODUCTIVITY; FISH; PHYTOPLANKTON; ZOOPLANKTON; EGGS; BIRDS
1093 PLAICE; FISH; SOLE; HERRING; LARVAE; DETERGENT; DEVELOPMENTAL ABNOMALITIES; BP1002; FINASOL; COREXIT
1091 PLAICE; DISPERSANT; TOXICITY; FISH; LARVAE; HERRING; PILCHARD; SOLE; LEMON SOLE; HADDOCK; BP1002; DELAYED EFFECTS; EMBRYOLOGY; BEHAVIORAL CHANGES
0101 PLANKTON; CRUDE OIL; POND; ARCTIC; PHYSICAL PARAMETERS; PHYTOPLANKTON; VASCULAR PLANTS; CHIRONOMID; AQUATIC; PRUDHOE CRUDE OIL; ARCTIC -TUNDRA; ALASKA- BARLOW; BENTHIC ORGANISMS
0496 PLANKTON; SAMPLING METHODS; CONTAMINATION; NYLON NETS
0513 PLANKTON; TORREY CANYON; DETERGENT; LIMPETS; FISHERIES; BIRDS; CRAIE DE CHAMPAGNE
0606 PLANKTON; DETERGENT; TOXICITY; COREXIT; CRANGON
0646 PLANKTON; N-ALKANES; HYDROCARBON CONTENT ANALYSIS; FISH; FIRTH OF CLYDE, SCOTLAND; FOOD CHAIN MAGNIFICATION
0599 PLANKTON; STANDING CROP; COMMUNITY STRUCTURE; REFINERY EFFLUENT; HOLDING PONDS
0673 PLANKTON; BUNKER C; RIVER; MUDDY RIVER, MASS.; BOD; TOXICITY; MACROFAUNA; NEW ENGLAND
1096 PLANKTON; GULF OF MEXICO; PARAFFINS
1183 PLANKTON; INVERTEBRATES; BIRDS; MAMMALS; TOXICITY; REVIEW; PETROLEUM HYDROCARBONS; ECOSYSTEM
1179 PLANKTON; PETROLEUM HYDROCARBONS; MUTAGENESIS; FISH; ARCTIC; METABOLISM
0082 PLANT PHYSIOLOGY; TRANSPIRATION; TRANSLOCATION; CELL MEMBRANE PERMEABILITY; PHOTOSYNTHESIS AND RESPIRATION; CELLULAR DAMAGE; OIL POLLUTION
0083 PLANT TOXICITY; PHOTOSYNTHESIS; TRANSLOCATION; CELL DAMAGE; PETROLEUM COMPONENTS; RESPIRATION AND TRANSPIRATION
0081 PLANTAGE; RECOVERY; CONTROLLED SPILLS; SHAEDA; JUNCUS; FESTUCA; SPARTINA; SALT MARSH; PEMBROKE,WALES; KUWAIT CRUDE OIL;

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0065 PLANTS; PROTOZOA; ALGAE; FUNGI; LICHENS; PSEUDOMONAS; ARCTIC; MICROORGANISMS; PRUDHOE CRUDE OIL; NATURAL OIL SEEPAGE; ALASKA-PRUDHOE BAY; CAPE SIMPSON
0221 PLANTS; TOXICITY; SOYBEAN; MODULE DEVELOPMENT; STIMULATION
0289 PLANTS; CRUDE OIL FRACTIONS; TERRESTRIAL; CHRONIC TOXICITY; ACUTE TOXICITY
0308 PLANTS; INTERTIDAL; TIDAL CYCLE; SHORE TYPE
0285 PLANTS; SALT MARSH; TOLERANCE; RECOVERY; SOUTH WEST WALES
0413 PLANTS; OIL; EMULSIFIERS; FUCUS; PHOTOSYNTHESIS; NET PRODUCTIVITY; METABOLISM
0501 PLANTS; PHYTOPLANKTON; PHOTOSYNTHESIS; GROWTH; COMMUNITY EFFECTS; ARCTIC; PERIPHYTON; POPULATION COMPOSITION; SEASONAL SUCCESSION; MACKENZIE VALLEY NWT
0770 PLANTS; REVIEW; OIL; MARINE; ANIMALS
0852 PLANTS; TORREY CANYON; COASTAL HABITATS; EMULSIFIERS; CORNWALL; BRITTANY
0955 PLANTS; SALT MARSH; WEATHERED OIL; DEGRADATION; GAS EXCHANGE; RETENTION; BRITTANY; TORREY CANYON
0966 PLANTS; SANTA BARBARA SPILL; INTERTIDAL; SUBTIDAL; SURVEY; DIVERSITY; ALGAE; INVERTEBRATES; CHANNEL IS.
0992 PLANTS; TERRESTRIAL; PERSISTANCE; SOIL; FIELD CROPS
0725 PLANTS, AQUATIC; BACTERIAL DEGRADATION; RIVERS; GROWTH ENHANCEMENT
0715 PLATIGYRA; CORAL; BACTERIA; STRESS; CRUDE OIL; MUCUS PRODUCTION; DESULFOVIBRIO; BEGGIATOA
0719 PLATYMONAS; ALGAE; TOXICITY; GROWTH RATES; FINE STRUCTURE; NANO PLANKTON; CRUDE OIL; EMULSIFIER
1012 PLESIOPENAEUS; PRAWNS, SCARLET; BENTHIC OIL DEPOSIT; ARUBA WEST INDIES; ATTRACTION; HYDROCARBON CONTENT ANALYSIS; BACTERIA; CHEMICAL ATTRACTIONS; METABOLISM
0171 PLUMAGE; GUILLEMOTS; WEARING
0419 POLCYCLIC; BENZ(A)PYRENE; DNA BINDING; AROMATICS
0971 POLLICIPES; SANTA BARBARA SPILL; BREEDING RATES; BARNACLE; MUSSELS; CHTHAMALUS; BALANUS; MYTILUS; INTERTIDAL
0975 POLLICIPES; SANTA BARBARA SPILL; BIRDS; INVERTEBRATES; ALGAE; MORTALITIES; RECOLONIZATION; SUBLETHAL EFFECTS; PHYLLOSPADIX; CHTHAMALUS; HESPEROPHYCUS
1127 POLLOCK; ARGO MERCHANT SPILL; FUEL OIL; EMBRYOGENESIS; HATCHING SUCCESS; MORPHOLOGY; CEPHALACHORDATA; AMPHIOXUS
0408 POLLUTANTS; AQUATIC ANIMALS; PHYSIOLOGY
0632 POLLUTANTS; COLLECTION OF PAPERS; AQUATIC ORGANISMS; PHYSIOLOGY
1009 POLLUTANTS; REVIEW; EFFECTS ON MARINE LIFE
0934 POLLUTION; BIBLIOGRAPHY -DIRECTORY
1195 POLLUTION; REVIEW; BIOINDICATORS; ESTUARINE; MARINE; OIL POLLUTION
0932 POLLUTION MONITORING; DIRECTORY; BIBLIOGRAPHIES
0395 POLLUTION RESEARCHERS; DIRECTORY
0988 POLNUCLEAR AROMATIC HYDROCARBONS; BENZOPYRENE; CARCINOGENSIS; SYNTHESIS; DISTRIBUTION; DEGRADATION
0580 POLYAROMATIC HYDROCARBONS; CRUDE OIL; CRUSTACEA; BEHAVIOR; FEEDING; ALIPHATIC; CHEMORECEPTION
0424 POLYCHAETE; OIL; DISPERSANTS; TOXICITY; GAMETE FORMATION; SPAWNING; GROWTH; MORTALITY; CIRRATULUS; CIRRIFORMIA; BP1002; COREXIT; ESSOLVENE
0386 POLYCHAETE; EMULSIFERS; LITTORAL ORGANISMS; BP1002; BP1100; COCKLES; PRAWN

0421 POLYCHAETE; SUBLETHAL EFFECTS; INTERTIDAL; SOUTH HAMPTON, ENGLAND; CIRRATULUS; CIRRIFORMIA
0846 POLYCHAETE; ARENICOLA; BEHAVIOR; FEEDING; WEATHERING
0881 POLYCHAETE; NEANTHES; RADIOACTIVE TRACER EXPERIMENT; UPTAKE; RETENTION; METABOLISM; DEPURATION; WATER SOLUBLE FRACTION; WATER; SEDIMENT; DETRITUS
0883 POLYCHAETE; TOXICITY; WATER SOLUBLE FRACTION; FUEL OIL #2; NEANTHOS; LARVAE
0885 POLYCHAETE; FUEL OIL # 2; WATER SOLUBLE FRACTION; NEANTHES; HEMOGLOBIN; HYPOXIA; SOUTH LOUISIANA CRUDE; DISSOLVED OXYGEN; TOXICITY; SYNERGISM; NAPHTHALENES; DISSOLVED HYDROCARBONS; RESPIRATION
0884 POLYCHAETE; FUEL OIL #2; NAPHTHALENE; ANNELIDS; NEANTHES; UPTAKE &DEPURATION; DEVELOPMENT; MALE; FEMALE; EGGS; LARVAE
1199 POLYCHAETE; FUEL OIL #2; SOUTH LOUISIANA CRUDE OIL; HYPOXIA; HEMOGLOBIN COMPENSATION
0609 POLYCHAETE WORMS; MARINE SEDIMENT; METABOLISM; MICROFAUNA; MEIOFAUNA; MACROFAUNA; DEGRADATION; BIVALVES; BACTERIA; EXCRETION
0121 POLYCHAETES; SALT MARSH; YORK RIVER; ISOLATED ECOSYSTEM; SOUTH LA. CRUDE; WEATHERED OIL; PHYTOPLANKTON; FISH; PERIPHYTON; ATP; MARSH GRASS; BENTHIC FAUNA; INSECT LARVAE; AMPHIPODS; OLIGOCHAETE
0842 POLYCHAETES; ARGO MERCHANT SPILL; BENTHIC FAUNA; SPECIES DIVERSITY; POPULATION DENSITY; INTERTIDAL FAUNA; HARPACTICOID COPEPODS; AMPHIPODS
0882 POLYCHAETES; TOXICITY; CRUDE; NAPHTHALENE; BUNKER C; FUEL OIL #2; WATER SOLUBLE FRACTION; NEANTHES; CAPITELLA; SOUTH LOUISIANA CRUDE; KUWAIT
1140 POLYCHAETES; FUEL OIL; CRUDE OIL; TOXICITY; REPRODUCTION & DEVELOPMENT
1175 POLYCHAETES; CRUDE OIL; ALGAE; ZOOPLANKTON; CRUSTACEANS; MOLLUSCS; FISH; UPTAKE; RETENTION; DEPURATION; REVIEW; BENTHIC ORGANISMS
1205 POLYCHAETES; SANTA BARBARA CHANNEL CALIFORNIA; NATURAL OIL SEEPS; ISLA VISTA OIL SEEP; BENTHIC FAUNA; BIOMASS; TOXICITY
0460 POLYCOMPLEX A-11; OIL; BIRDS; CLEANING; PATHOLOGY; SANTA BARBARA CRUDE
1108 POLYCYCLIC AROMATIC HC'S; AROMATIC HYDROCARBON; CONTENT ANALYSIS; BUNKER C; CREOSOTE; SEALS; FISH; SHELLFISH; PAH; FLUOROMETRY; FUEL OIL
0158 POLYCYCLIC AROMATIC HYDROCARBONS; CARCINOGENISIS; RED ALGAE
0275 POLYCYCLIC AROMATIC HYDROCARBONS; METABOLISM; UPTAKE; FOOD WEB TRANSFER; BIOSYNTHESIS
0344 POLYCYCLIC AROMATIC HYDROCARBONS; ACCUMULATOR ORGANISMS; MONITORING; CARCINOGENS; MUSSELS; MYTILUS; BENZOPYRENE
0721 POLYCYCLIC AROMATIC HYDROCARBONS; MODEL; BIOLOGICAL EFFECTS; TOXICITY; SUBLETHAL EFFECTS; TAINTING; COATING; SOLUBLE AROMATIC HYDROCARBON DERIVITIES
0990 POLYCYCLIC AROMATIC HYDROCARBONS; PAH; BP; CARCINGENIC; BENZ(A)PYRENE
0813 POLYCYCLIC AROMATIC HYDROXYLASE; BENZOPYRENE; HYDROXYLASE INDUCTION; FISH; ARYL HYDROCARBON HYDROXYLASE; BROWN TROUT; NEWFOUNDLAND; TAINTING; THIN-LAYER CHROMATOGRAPHY
0343 POLYCYCLIC AROMATICS; BENZO(A)PYRENE; CARCINOGENS; MONITORING; DETERMINATION TECHNIQUES; TISSUES; SEDIMENT; THIN-LAYER
1164 POLYCYCLIC AROMATICS; BENZOPYRENE; MOLLUSCS; BIVALVES; ESTUARIES; OREGON; CARCINOGENS

ALASKA -PRUDHOE BAY; CAPE SIMPSON
0730 PRUDHOE BAY; SALMON; TOXICITY; CRUDE OIL; ALIPHATIC; AROMATICS; CELL MEMBRANE PERMEABILITY
0871 PRUDHOE BAY CRUDE; SALMON, PINK; COOK INLET CRUDE; FUEL OIL#2; WATER SOLUBLE FRACTION; RESPIRATION; COUGHING; UPTAKE & DEPURATION
0865 PRUDHOE BAY CRUDE; BIVALVES; TOXICITY; SPERMATOZOA; FERTILIZATION; DEVELOPMENTAL ABNORMALITIES; KUWAIT CRUDE; NIGERIAN CRUDE
0463 PRUDHOE BAY CRUDE OIL; FISH PHYSIOLOGY; FISH BEHAVIOR; TOXICITY; SALMON; ENZYMES; SOLUBLE HYDROCARBONS
0913 PRUDHOE BAY CRUDE OIL; CLAM; MACOMA; HYDROCARBON ANALYSIS; GAS CHROMATOGRAPHY; BEHAVIOR; BURROWING
1011 PRUDHOE BAY CRUDE OIL; SALMON; WATER SOLUBLE FRACTION; RESPIRATORY RATE; STRESS
1126 PRUDHOE BAY CRUDE OIL; NAPHTHALENE; METHODS OF DETECTION OF HC'S IN ORGANISM; UPTAKE; SIPUNCULID WORM; SPECTROPHOTOMETRY; PHASCOLOSOMA
1166 PRUDHOE BAY CRUDE OIL; SEALS; PINNIPEDS; HYPOTHERMIA
1197 PRUDHOE BAY CRUDE OIL; NAPHTHALENE; CLAMS; MACOMA; UPTAKE; SEDIMENTS
1213 PRUDHOE BAY CRUDE OIL; CLAM; MACOMA; ALASKA; BURROWING; BEHAVIORAL EFFECTS
0564 PRUDHOE CRUDE; CRABS; CHIONOECETES; MOLTING
0066 PRUDHOE CRUDE OIL; PROTOZOA; ALGAE; FUNGI; PLANTS; LICHENS; PSEUDOMONAS; ARCTIC; MICROORGANISMS; NATURAL OIL SEEPAGE; ALASKA-PRUDHOE BAY; CAPE SIMPSON
0101 PRUDHOE CRUDE OIL; CRUDE OIL; POND; ARCTIC; PHYSICAL PARAMETERS; PHYTOPLANKTON; VASCULAR PLANTS; CHIRONOMID; AQUATIC; ARCTIC -TUNDRA; ALASKA- BARLOW; BENTHIC ORGANISMS; PLANKTON
0071 PRUDHOE CRUDE OIL; ARCTIC; LICHENS; ALGAE-NASTOC; RESPIRATION; PHOTOSYNTHESIS; NITROGEN FIXATION
0063 PRUDHOE CRUDE OIL; MICROBIAL POPULATIONS; PROTOZOANS; BLUE GREEN ALGAE; DIATOMS; DEGRADATION; YEAST; SPECIES DIVERSITY; GREEN ALGAE; NATURAL SEEPAGE; ARCTIC; ALASKA-PRUDHOE BAY; CAPE SIMPSON; NUTRIENT ENRICHMENT
1048 PSEUDOFECES; MUSSEL; MYTILUS; FILTERING; PURIFICATION
0743 PSEUDOMONAS; BACTERIAL DEGRADATION; NAPHTHALENE; METABOLIC PATHWAY
0066 PSEUDOMONAS; PROTOZOA; ALGAE; FUNGI; PLANTS; LICHENS; ARCTIC; MICROORGANISMS; PRUDHOE CRUDE OIL; NATURAL OIL SEEPAGE; ALASKA-PRUDHOE BAY; CAPE SIMPSON
0303 PSEUDOMONAS; CHEDABUCTO BAY, NOVA SCOTIA; CAPE SIMPSON, ALASKA; NATURAL SEEP; ARTHROBACTER; TEMPERATURE
0546 PSEUDOMONAS; BACTERIAL DEGRADATION; AROMATICS; METABOLIC PATHWAYS
1020A PSYCHROPHILIC; BACTERIA; DEGRADATION; LOW TEMPERATURE
0242 PUBLIC HEALTH; REVIEW; BIOLOGICAL CONSEQUENCES; BIRDS; COMMERCIAL FISHERIES; COASTAL FLORA AND FAUNA; ARCTIC
0281 PUCCINELLA; SALT MARSH; SPARTINA; CHRONIC; WEATHERING; RECOVERY; CORNWALL
0282 PUCCINELLIA; REVIEW; CHRONIC POLLUTION; SALT MARSH; REFINERY EFFLUENT; RECOVERY; SPARTINA; OENANTHE
0224 PUERTO RICO; OCEAN EAGLE SPILL; ECOLOGICAL DAMAGE
0327 PUERTO RICO; OIL SPILL; GUANICA
0749 PUERTO RICO; ZOE COLOCUTRONIS; VENEZUELEN CRUDE; MANGROVE PROP COMMUNITY; TURTLE GRASS COMMUNITY; SEDIMENTS; HYDROCARBON ANALYSIS; TROPICAL
0789 PUERTO RICO; OCEAN EAGLE SPILL; ECOLOGICAL IMPACT; CLEANUP; OVERVIEW
1177 PUERTO RICO; OIL SPILLS; ECOSYSTEM; MANGROVE; CORAL REEFS; ESTUARIES;

INORGANIC SALTS; AERATION
1003 RATTAIL; HYDROCARBON CONTENT ANALYSIS; DEEP-SEA BENTHOS; NEMATONURUS; HOLOTHURIANS
0172 RAZORBILLS; TORREY CANYON; BIRDS; MORTALITIES; GUILLEMOTS
0197 RECOLONIZATION; DETERGENTS; NUCELLA LAPILLUS; RESISTANCE; MORTALITY; POPULATION RECOVERY; ROCKY SHORE; LITTORAL
0234 RECOLONIZATION; ARCTIC; INVERTEBRATES; REPRODUCTION; RECOVERY
0407 RECOLONIZATION; ARCTIC; INVERTEBRATES; RECRUITMENT; BROODING; MICROBIAL DEGRADATION; TEMPERATURE
0972 RECOLONIZATION; OIL; DETERGENT; SETTLEMENT; ARTIFICAL SUBSTRATE
0975 RECOLONIZATION; SANTA BARBARA SPILL; BIRDS; INVERTEBRATES; ALGAE; MORTALITIES; SUBLETHAL EFFECTS; PHYLLOSPADIX; CHTHAMALUS; POLLICIPES; HESPEROPHYCUS
1097 RECOLONIZATION; TRANSECT; INVERTEBRATES; HYDROCARBON ANALYSIS; TISSUES; SEDIMENT; COBBLE BEACH; SPECTROPHOTOMETRY
0757 RECOMMENDED AREAS OF RESEARCH; REVIEW-OFFSHORE PETROL. INDUS.
0081 RECOVERY; CONTROLLED SPILLS; SHAEDA; JUNCUS; FESTUCA; PLANTAGE; SPARTINA; SALT MARSH; PEMBROKE,WALES; KUWAIT CRUDE OIL; FLOWERING PLANTS; SEED PRODUCTION AND GERMINATION
0088 RECOVERY; TOLERANCE; COMMUNITY SURVEY; SALT MARSH PLANTS; SUCCESSIVE OILINGS; GLAMORGAN,WALES
0120 RECOVERY; TOXICITY; BENTHIC ANIMALS; INTERTIDAL; DIVERSITY; YORK RIVER; BUNKER C; FUEL OIL#6
0085 RECOVERY; CLEANUP METHODS; SALT MARSH VEGETATION
0231 RECOVERY; SAN FRANCISCO SPILL; INVERTEBRATES; COMMUNITIES; SMOTHERING; RECRUITMENT; INTERTIDAL; BUNKER C; TRANSECTS
0234 RECOVERY; ARCTIC; INVERTEBRATES; REPRODUCTION; RECOLONIZATION
0230 RECOVERY; SAN FRANCISCO SPILL; TRANSECTS; COMMUNITIES; INTERTIDAL; MACROINVERTEBRATES; RECRUITMENT
0145 RECOVERY; WEST FALMOUTH OIL SPILL; BUZZARD BAY; HYDROCARBON CONTENT ANALYSIS
0199 RECOVERY; STREAMS; MACROINVERTEBRATES; GASOLINE; ORTHOCLADIUS; DIVERSITY INDEX
0161 RECOVERY; FUEL OIL#2; NIGERIAN CRUDE; CRANKCASE OIL; BENTHIC ALGAL COMMUNITIES; PRIMARY PRODUCTIVITY; TOXICITY; ALGAL BLUE GREEN
0229 RECOVERY; SAN FRANCISCO SPILL; ROCKY INTERTIDAL; TRANSECTS
0131 RECOVERY; OIL SPILL REMOVER; SURFACTANT; MEIOFAUNA; LONG-TERM EFFECTS
0282 RECOVERY; REVIEW; CHRONIC POLLUTION; SALT MARSH; REFINERY EFFLUENT; SPARTINA; PUCCINELLIA; OENANTHE
0281 RECOVERY; SALT MARSH; SPARTINA; PUCCINELLA; CHRONIC; WEATHERING; CORNWALL
0285 RECOVERY; SALT MARSH; PLANTS; TOLERANCE; SOUTH WEST WALES
0283 RECOVERY; MILFORD HAVEN; SALT MARSH; ROCKY SHORE; DETERGENTS; EMULSIFIERS; CHRONIC EXPOSURE
0451 RECOVERY; IRISH STARDUST - ALERT BAY 1973; ALERT BAY, CANADA; BIODEGRADATION; HEAVY FUEL OIL
0688 RECOVERY; FUEL OIL#2; WEST FALMOUTH, WILD HARBOR, MASS.; BENTHIC FAUNA; SEDIMENTS; HYDROCARBON CONTENT; OPPORTINUSTIC SPECIES; GAS CHROMATOGRAPHY; DIVERSITY; POPULATIONS
0625 RECOVERY; WESTERN NORTH ATLANTIC; CHEDABUCTO BAY,NOVA SCOTIA; ARROW SPILL; BUNKER C
0816 RECOVERY; COMMUNITIES; ROCKY SHORES; DETERGENTS; NORMANDY, FRANCE; MUSSELS; DEPURATION

0744 RECOVERY; ENVIROMENTAL EFFECTS; OIL POLLUTION
0779 RECOVERY; TAMPICO MARU SPILL; CHRONIC; SURF CONDITIONS; MORTALITIES; SUCCESSION; BAJA, CALIF.; ANTHOPLEURA; KELP; PHOTOSYNTHESIS
0962 RECOVERY; TOXICITY; LONG TERM EFFECTS; INTERTIDAL; GASTROPODS; BIVALVES; DIESEL FUEL, MARINE; ROCKY SHORE; FAUNA; LAMMA IS.; HONG KONG; DISPERSANTS
1100 RECOVERY; TOXICITY; SURFACTANTS; BARNACLES; NAUPLII; ELMINIUS
1080 RECOVERY; WEST FALMOUTH OIL SPILL 1969; WEST FALMOUTH, MASS.; FUEL OIL #2; ECOLOGICAL IMPACT
0294 RECOVERY ASSESSMENT; TOXICITY; DISPERSANTS; BP1002
0231 RECRUITMENT; SAN FRANCISCO SPILL; INVERTEBRATES; COMMUNITIES; SMOTHERING; INTERTIDAL; RECOVERY; BUNKER C; TRANSECTS
0232 RECRUITMENT; SAN FRANCISCO SPILL; BUNKER C; BARNACLES; BALANUS; CHTHAMALUS; MUSSEL; MYTILUS; LIMPETS; COLLISELLA
0230 RECRUITMENT; SAN FRANCISCO SPILL; TRANSECTS; COMMUNITIES; INTERTIDAL; MACROINVERTEBRATES; RECOVERY
0407 RECRUITMENT; ARCTIC; INVERTEBRATES; BROODING; MICROBIAL DEGRADATION; TEMPERATURE; RECOLONIZATION
1219 RECRUITMENT; CRUDE OIL; SEDIMENTS; WASHINGTON; INTERTIDAL ZONE; UPTAKE & DEPURATION; ASSESSMENT OF SPILLS; BENTHIC ORGANISMS; PUGET SOUND
0977 RECUPERATIVE CAPACITY; SANTA BARBARA SPILL; ECOSYSTEM
0158 RED ALGAE; CARCINOGENISIS; POLYCYCLIC AROMATIC HYDROCARBONS
0228 RED MANGROVE; LITTORAL COMMUNITIES; FLORIDA KEYS; ROCKY PLATFORM; MANGROVE FRINGE; SEA GRASS FLATS; MANGROVE SWAMP; CRUSTACEANS; ECHINODERMS; PEARL OYSTER; BLACK MANGROVE
0358 RED SEA; MACROFAUNA; TOXICITY; CRUDE OIL; DISPERSANT; CORAL; HETEROXENIA; GASTROPODS; MUSSELS; CHITON; SEA URCHIN; HERMIT CRAB; SHRIMP; GOATFISH; RABBITFISH
0357 RED SEA; DRUPA GRANULATA; MYTILUS; PREDATION RATE; FECUNDITY; SUBLETHAL; CRUDE OIL; MUSSELS; DISPERSANT
0361 RED SEA; CRUDE OIL; MACROFAUNA; TOXICITY; DEPTH; SUBLETHAL EFFECTS; PHYSIOLOGY; METABOLISM; BEHAVIOR; DISPERSANT
0260 RED SEA; CRUDE OIL; TOXICITY; CORALS; HETEROXENIA; SUBLETHAL EFFECTS; DEPTH PROTECTION EFFECTS; HYDROCARBON CONTENT ANALYSIS
0359 RED SEA; CRUDE OIL; DETERGENT; OCTOCORALS; CRUSTACEANS; MOLLUSCS; ECHINODERMS; FISH; TOXICITY; SUBLETHAL; DEVELOPMENTAL STAGES; FEEDING RATE; PHYSIOLOGY; BIOACCUMULATION; LIVER ENLARGEMENT; HEMATOCRIT
0712 RED SEA; CORALS; CRUDE OIL; MICROORGANISMS; MUCUS PRODUCTION
0892 REEF; PANAMA; S.S. WITWATER SPILL; TROPICS; INTERTIDAL; TERRESTRIAL PLANTS; LITTORAL; MANGROVE; MEIOFAUNA; SEA TURTLES; BIRDS; DIESEL OIL; BUNKER C
0442 REEF COMMUNITY; R.L. STONER; FISH; WAKE IS.
0577 REEF COMMUNITY; RESPIRATION; CALMING EFFECTS; GAS EXCHANGE; FIELD FENCING TECHNIQUES; CRUDE OIL; TOXIXCTY; BEHAVIOR; HERON IS. GREAT BARRIER REEF AUSTRALIA
0207 REFINED; MERCENARIA; TOXICITY; EMBRYOS; LARVAE; WATER SOLUBLE FRACTION; CRUDE; WASTE; GROWTH
0458 REFINED OIL; CRUDE OIL; TOXICITY; BACTERIA; WATER SOLUBLE FRACTION; AROMATIC HYDROCARBONS; WEATHERING; GROWTH RATE; MAXIMUIM CELL DENSITY
0042 REFINED OILS; TOXICITY STUDIES; SLUDGE OIL; SILVER SALMON FINGERLINGS; PETROLEUM PRODUCTS
0038 REFINED OILS; OYSTERS; CRUDE OIL; CRASSOSTREA; BIOASSAY; FUEL OIL #2;

BUNKER C; SOUTH LA. CRUDE; KUWAIT CRUDE
0794 REFINERIES; CHRONIC POLLUTION; REVIEW; FIELD STUDIES; OFFSHORE PRODUCTION; ESTUARIES; SUBLETHAL EFFECTS; NATURAL SEEPS
0087 REFINERY EFFLUENT; SPARTINA; MORTALITY
0291 REFINERY EFFLUENT; CHRONIC POLLUTION; LIMPETS; BARNACLES; TRANSECTS; ABUNDANCE
0282 REFINERY EFFLUENT; REVIEW; CHRONIC POLLUTION; SALT MARSH; RECOVERY; SPARTINA; PUCCINELLIA; OENANTHE
0273 REFINERY EFFLUENT; PHOTOSYNTHESIS; RESPIRATION
0544 REFINERY EFFLUENT; TOXICITY
0678 REFINERY EFFLUENT; DIVERSITY; INTERTIDAL FAUNA
0699 REFINERY EFFLUENT; STANDING CROP; COMMUNITY STRUCTURE; PLANKTON; HOLDING PONDS
0832 REFINERY EFFLUENT; PHENOL; BIODEGRADATION; ST. LAWRENCE RIVER
0861 REFINERY EFFLUENT; BENTHIC MARINE ANIMALS; LOS ANGELES HARBOR
0857 REFINERY EFFLUENT; ECOSYSTEMS; SOUTHERN CALIFORNIA
1082 REFINERY EFFLUENT; ESTUARY; MUD FLAT FAUNA; MEDWAY ESTUARY; KENT, ENGLAND
0090 REFINERY EFFLUENTS; BEHAVIOR; ECOSYSTEMS; WALES
0446 REFINERY EFFLUENTS; TOXICITY; LONG TERM
0274 REFINERY HOLDING PONDS; EFFLUENT; COMMUNITY METABOLISM; SEASONAL; ALGAL PRODUCTIVITY; RESPIRATION; LIGHT; TEMPERATURE
0622 REFINERY WASTES; BIODEGRADATION; BACTERIA; PHYTOPLANKTON
0114 REHABILITATION; BIRDS
0113 REHABILITATION; BIRDS
0168 REHABILITATION; BIRDS; MORTALITIES; SPECIES ENDANGERMENT; CONSERVATION
0240 REHABILITATION; BIRDS; CLEANING; FEATHER WETTING; ENTERITIS
0177 REHABILITATION; REVIEW; BIRDS; PHYSIOLOGY; MARINE FAUNA
0112 REHABILITATION AND CLEANING; BIRDS; TORREY CANYON; PATHOLOGICAL EFFECTS
1032 RELATIVE ABUNDANCE; FUEL OIL#2; DISPERSION; INTERTIDAL COLONIES; SPECIES DIVERSITY; NUMBERS OF SPECIES; INDIVIDUAL FREQUENCY OCCURANCE PATTERNS
1110 RELATIVE OXIDIZABILITY; DEGRADATION; BACTERIA; METHODS; ASSUMLATION
0347 RELEASE; BENZO(A)PYRENE; MUSSELS; MYTILUS
0532 REMOTE ELECTRODES; HYDROCARBONS; BIOINDICATOR; BIOELECTRIC ACTION POTENTIALS; CRUSTACEANS; ACTIVITY
0234 REPRODUCTION; ARCTIC; INVERTEBRATES; RECOVERY; RECOLONIZATION
0123 REPRODUCTION; COPEPOD; NAPHTHALENE; EURYTEMORA; EGG PRODUCTION; HEATING OIL; WATER SOLUBLE FRACTION
0313 REPRODUCTION; OIL; DETERGENT
0271 REPRODUCTION; WATER ACCOMODATED FRACTION; MYTILUS; MUSSELS; STARFISH; ASTERIS; RESPIRATION; FEEDING; BYSSAL THREAD PRODUCTION; FUEL OIL #2
0492 REPRODUCTION; OIL; BIRDS; DUCKS; INGESTION; HATCHABILITY; COATING
0567 REPRODUCTION; CASPIAN SEA; BENTHOS; CRUDE OIL; GROWTH; CHIRONOMUS; CERASTODERMA; NAIS; NEREIS; PYRGOHYDROBIA; ABRA
0685 REPRODUCTION; FIELDS STUDIES; CHRONIC POLLUTION; SANTA BARBARA SPILL; LAKE MARACAIBO, VENEZUELA; BERMUDA; TIMBALIER BAY, LA.; POPULATION LEVELS; DIVERSITY; SIZE; GROWTH RATE; ABNORMAL GROWTHS; BIOMAGNIFICATION
0978 REPRODUCTION; CHRONIC EXPOSURE; MYTILUS; SIZE
1041 REPRODUCTION; KUWAIT CRUDE OIL; SUSPENSION; COREXIT 7664; GAS CHROMATOGRAPHY; SPECTROFLUOROMETRY; COPEPOD; TOXICITY; LONG-TERM EFFECTS; EGG PRODUCTION; HATCHING SUCCESS

1224 REPRODUCTION; WATERFOWL; OIL SPILLS; REVIEW; MALLARDS; EGGS
1170 REPRODUCTION; FUEL OIL; FLOUNDER; HATCHING SUCCESS; GROWTH; EGGS; LARVAE; HISTOPATHOLOGY
1140 REPRODUCTION & DEVELOPMENT; FUEL OIL; CRUDE OIL; POLYCHAETES; TOXICITY
1153 REPRODUCTION & DEVELOPMENT; TROUT; HATCHING SUCCESS; FERTILIZATION; HISTOPATHOLOGICAL EFFECTS; MORPHOLOGY
1142 REPRODUCTION & DEVELOPMENT; DUCKS; HATCHABILITY; GROWTH; AROMATICS; EFFECTS ON ORGANISMS
1139 REPRODUCTION & DEVELOPMENT; CRUDE OIL; CRAB; CANCER; NAPHTHALENE; BENZENE; AROMATIC HC'S; TOXICITY
1122 REPRODUCTIVE GROWTH; EIDER; TOXICITY; HATCHING SUCCESS; FUEL OIL
0817 REPULSION; ARCTIC; CRUSTACEA; ISOPODS; AMPHIPODS; BEHAVIOR; ATTRACTION; TAINTING; CRUDE OIL
0665 RESEARCH NEEDS; ARGO MERCHANT SPILL
0428 RESIDUE; DEGRADATION; BACTERIAL; OXYGEN UPTAKE; NUTRIENT LIMITATIONS
0197 RESISTANCE; DETERGENTS; NUCELLA LAPILLUS; MORTALITY; POPULATION RECOVERY; RECOLONIZATION; ROCKY SHORE; LITTORAL
0433 RESISTANCE; MYTILUS; MODIOLUS; CARBON BUDGET; SALINITY; CRUDE OIL; STRESS; MUSSELS
0432 RESISTANCE; MYTILUS; MODIOLUS; CARBON BUDGETS; CRUDE OIL; SALINITY; MUSSELS
0035 RESPIRATION; ESTUARINE ANIMALS; UPTAKE AND DEPURATION; TOXICITY; SOUTH LA. CRUDE; KUWAIT CRUDE; FUEL OIL #2; BUNKER C; MINNOW; GRASS SHRIMP,PALAEMONTES; BROWN SHRIMP,PANAEUS; WATER SOLUBLE FRACTION; OIL WATER DISPERSION; NAPHTHALENES
0071 RESPIRATION; ARCTIC; LICHENS; ALGAE-NASTOC; PHOTOSYNTHESIS; NITROGEN FIXATION; PRUDHOE CRUDE OIL
0065 RESPIRATION; PHOTOSYNTHESIS; NITROGEN FIXATION; BACTERIA; ALGAE; FUNGI; ARCTIC; CRUDE OIL; NATURAL GAS; MICROORGANISMS
0274 RESPIRATION; EFFLUENT; REFINERY HOLDING PONDS; COMMUNITY METABOLISM; SEASONAL; ALGAL PRODUCTIVITY; LIGHT; TEMPERATURE
0273 RESPIRATION; REFINERY EFFLUENT; PHOTOSYNTHESIS
0271 RESPIRATION; WATER ACCOMODATED FRACTION; MYTILUS; MUSSELS; STARFISH; ASTERIS; FEEDING; REPRODUCTION; BYSSAL THREAD PRODUCTION; FUEL OIL #2
0391 RESPIRATION; CRUDE OIL; HYDROCARBON; UPTAKE; MYA; LIQUID CONTENT; SOFT SHELL CLAM
0484 RESPIRATION; LITTORINA; SUBLETHAL EFFECTS; BUNKER C; DISPERSANT; COREXIT; CRAWLING RATES
0577 RESPIRATION; REEF COMMUNITY; CALMING EFFECTS; GAS EXCHANGE; FIELD FENCING TECHNIQUES; CRUDE OIL; TOXIXCTY; BEHAVIOR; HERON IS. GREAT BARRIER REEF AUSTRALIA
0761 RESPIRATION; TOXICITY; AROMATICS; PHENATHRENES; ESTUARINE; BENTHIC; OCEANIC; LARVAE; JUVENILES; GROWTH; SUBLETHAL
0777 RESPIRATION; SAND DOLLAR; KUWAIT CRUDE; FUEL OIL #2; WATER SOLUBLE EXTRACTS; SPERM; EGG; MOBILITY OF SPERM; FERTILIZATION; CLEAVAGE; LARVAL DEVELOPMENT
0871 RESPIRATION; SALMON, PINK; PRUDHOE BAY CRUDE; COOK INLET CRUDE; FUEL OIL#2; WATER SOLUBLE FRACTION; COUGHING; UPTAKE & DEPURATION
0835 RESPIRATION; FUEL OIL # 2; WATER SOLUBLE FRACTION; NEANTHES; POLYCHAETE; HEMOGLOBIN; HYPOXIA; SOUTH LOUISIANA CRUDE; DISSOLVED OXYGEN; TOXICITY; SYNERGISM; NAPHTHALENES; DISSOLVED HYDROCARBONS
0985 RESPIRATION; BENZENE; HERRING; ANCHOVY; EGGS; LARVAE; TOXICITY;

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1176 RESPIRATION; FUEL OIL# 2; ZOOPLANKTON; SHRIMP; TOXICITY;
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1163 RESPIRATION; DISPERSANTS; CUNNER; HYPOXIA; COREXIT; BP1002;
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1172 RESPIRATION; FUEL OIL #2; SYNERGISTIC EFFECTS; TEMPERATURE; SALINITY;
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1192 RESPIRATION; AMPHIPODS; ONISIMUS; TOXICITY; DISPERSANTS;
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0083 RESPIRATION AND TRANSPIRATION; PHOTOSYNTHESIS; TRANSLOCATION;
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1014 RESPIRATORY ENZYMES; ARGO MERCHANT SPILL; WINTER FLOUNDER;
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1011 RESPIRATORY RATE; SALMON; PRUDHOE BAY CRUDE OIL;
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0182 RESPIRATORY RATES; SALMON, CHINOOK; STRIPED BASS; BENZENE; NARCOSIS;
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0319 RESPIROMETRY; DEGRADATION; CRUDE OILS; SEA WATER SOURCES; NITROGEN
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GAS CHROMATOGRAPHY; GAS CHROMATOGRAPHY-MASS SPECTROMETRY
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0881 RETENTION; POLYCHAETE; NEANTHES; RADIOACTIVE TRACER EXPERIMENT;
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0859 RETENTION; FEEDING BEHAVIOR; COELENTERATA; DISCRIMINATION; PALYTHOA;
CHEMORECEPTION; MARINE DIESEL; BUNKER C
0955 RETENTION; SALT MARSH; PLANTS; WEATHERED OIL; DEGRADATION;
GAS EXCHANGE; BRITTANY; TORREY CANYON
0957 RETENTION; OYSTER; CHRONIC EXPOSURE; PHSIOLOGICAL EFFECTS;
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0960 RETENTION; OYSTER; CRASSOSTREA; UPTAKE; DEPURATION;
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1004 RETENTION; OYSTER; CRASSOSTREA; UPTAKE; DEPURATION;
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1154 RETENTION; ZOOPLANKTON; COPEPODS; NAPHTHALENE; AROMATIC HYDROCARBONS;
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1161 RETENTION; POLYNUCLEAR AROMATIC HYDROCARBONS; ESTUARINE; UPTAKE;
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1125 RETENTION; REVIEW; SUBLETHAL EFFECTS; TOXICITY; UPTAKE; DEPURATION;
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1143 RETENTION; SOFT-SHELL CLAM; FUEL OIL; UPTAKE; DEPURATION; BURROWING;
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1133 RETENTION; FUEL OIL; CRASSOSTREA; QUAHOG; ESTUARINE; ALIPHATICS;
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1206 RETENTION; CLAM; MYA; FUEL OIL #2; UPTAKE; DEPURATION
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0030 REVIEW; LABORATORY STUDIES; MARINE ORGANISMS; EFFECTS
0031 REVIEW; PETROLEUM HYDROCARBON CONTAMINATION
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0167 REVIEW; BIRDS; MORTALITIES
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0153 REVIEW; ECOLOGICAL EFFECTS; COMMUNITIES; LONG TERM EFFECTS;
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0246 REVIEW; BIOLOGICAL FATES; MACROORGANISMS
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0242 REVIEW; BIOLOGICAL CONSEQUENCES; BIRDS; COMMERCIAL FISHERIES;
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0590 REVIEW; NORTH SEA; FISH STOCKS; DISPERSANTS; TAINTING
0531 REVIEW; FISH; TAINTING; MICROBIAL INFESTATION
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0612 REVIEW; METABOLISM; UPTAKE; DEPURATION; RADIOACTIVE TRACERS
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0916 REVIEW; TYPES OF OILS; WEATHERING; TOXICITY; FISHERIES; DISPERSANTS; MARINE ENVIRONMENT
1025 REVIEW; SPILL INCIDENTS
1038 REVIEW; ALGAE; PHYSIOLOGY; HYDROCARBONS PETROLEUM; NAPHTHALENE; PHOTOSYNTHESIS; ATP; CRUDE OIL; DISTILLATE FRACTIONS
1006 REVIEW; ECOLOGICAL EFFECTS; OIL; OIL DISPERSANTS
1009 REVIEW; EFFECTS ON MARINE LIFE; POLLUTANTS
1005 REVIEW; OIL POLLUTION; TOXICITY; FATE &BEHAVIOR OF OIL; BIRDS; BIODEGRADATION; FIELD STUDIES; BIBLIOGRAPHY
1024 REVIEW; MARINE POLLUTION
1071 REVIEW
1111 REVIEW; MARINE OIL POLLUTION; INPUTS; FATES; DEGRADATION; BACTERIA
1087 REVIEW; BIOLOGICAL EFFECTS OF OIL POLLUTION
1125 REVIEW; SUBLETHAL EFFECTS; TOXICITY; UPTAKE; RETENTION; DEPURATION; METHODS OF DETECTION OF HC'S IN ORGANISM; BIOINDICATORS
1112 REVIEW; INPUTS; EFFECTS; FATES
1109 REVIEW; DEGRADATION; BACTERIA
1077 REVIEW; FATE OF SPILLED OIL
1195 REVIEW; POLLUTION; BIOINDICATORS; ESTUARINE; MARINE; OIL POLLUTION
1221 REVIEW; ARCTIC; CONTINENTAL SHELVES; ASSESSMENT OF SPILLS; POTENTIAL OIL SPILLS
1183 REVIEW; PLANKTON; INVERTEBRATES; BIRDS; MAMMALS; TOXICITY; PETROLEUM HYDROCARBONS; ECOSYSTEM
1177 REVIEW; PUERTO RICO; OIL SPILLS; ECOSYSTEM; MANGROVE; CORAL REEFS;

EMULSIFIERS; CHRONIC EXPOSURE
0800 ROCKY SHORE; PATELLA; GRAMMARUS
0771 ROCKY SHORE; ESTUARINES; OIL POLLUTION; SPILLS; CHRONIC; SALT MARSH; EMULSIFIERS; CLEANING
0962 ROCKY SHORE; TOXICITY; LONG TERM EFFECTS; INTERTIDAL; GASTROPODS; BIVALVES; DIESEL FUEL, MARINE; FAUNA; LAMMA IS.; HONG KONG; DISPERSANTS; RECOVERY
0091 ROCKY SHORES; SALT MARSHES; OIL; EMULSIFIERS; ECOLOGICAL IMPACTS; TOXICITY
0816 ROCKY SHORES; COMMUNITIES; DETERGENTS; NORMANDY, FRANCE; RECOVERY; MUSSELS; DEPURATION
0931 ROE; PACIFIC HERRING; TOXICITY; HATCHING SUCCESS; MORPHOLOGICAL ANOMOLIES; HERRING; CRUDE OIL; ALASKA
1107 ROUTE OF UPTAKE; COKE OIL; HERRING; MORTALITY; CLUPEA; NOVA SCOTIA
0892 S.S. WITWATER SPILL; PANAMA; TROPICS; INTERTIDAL; TERRESTRIAL PLANTS; LITTORAL; MANGROVE; REEF; MEIOFAUNA; SEA TURTLES; BIRDS; DIESEL OIL; BUNKER C
1090 SABELLARIA; BP1002; DETERGENT; LARVAE; TOXICITY; SUBSTRATE ABSORPTION
1089 SABELLERIA; LONG TERM EFFECTS; LARVAE; DETERGENT; TOXICITY
1174 SAENICH INLET; ESTUARIES; CANADA; CRUDE OIL; FUEL OIL; BIODEGRADATION; PHYTOPLANKTON; CEPEX; DIATOMS
0360 SALINITY; TOXICITY; RABBIT FISH; CRUDE OIL; DEPTH; SIGANUS; DISPERSANT; STATIC ASSAY; FLOW THROUGH ASSAY
0432 SALINITY; MYTILUS; MODIOLUS; CARBON BUDGETS; CRUDE OIL; RESISTANCE; MUSSELS
0433 SALINITY; MYTILUS; MODIOLUS; CARBON BUDGET; CRUDE OIL; STRESS; RESISTANCE; MUSSELS
0650 SALINITY; OYSTERS; CRASSOSTREA; MORTALITIES; SEDIMENT HYDROCARBONS; DRILLING OPERATIONS; TEMPERATURE
0874 SALINITY; BIODEGRADATION; ALASKA; TEMPERATURE; MORTALITY; CHEMOTAXIS; COOK INLET; VALDEZ
0997 SALINITY; POTENTIAL; SEAWATER; CHRONIC POLLUTION; DEGRADATION; BACTERIA; PETROLEUM HYDROCARBONS
1149 SALINITY; TEMPERATURE; NAPHTHALENE; CLAMS; SOUTHERN LOUISIANA CRUDE OIL; UPTAKE & DEPURATION; CLAM-BOREAL; CLAM-TEMPERATURE
1172 SALINITY; FUEL OIL #2; SYNERGISTIC EFFECTS; TEMPERATURE; EMBRYOGENSIS; RESPIRATION; HORSESHOE CRAB; LIMULUS
0463 SALMON; FISH PHYSIOLOGY; FISH BEHAVIOR; TOXICITY; ENZYMES; SOLUBLE HYDROCARBONS; PRUDHOE BAY CRUDE OIL
0737 SALMON; PARAFFINS; FISH; CRUDE OIL; JULIANA WRECK; MULLET; BLACK SEA BREAM; GAS CHROMATOGRAPHY
0731 SALMON; TOXICITY; CRUDE OIL; ALIPHATICS; AROMATICS; CELL MEMBRANE PERMEABILITY
0729 SALMON; TOXICITY; OIL; TEMPERATURE; JUVENILE; STRESS BEHAVIOR; WEATHERING
0645 SALMON; TROUT; TAINTING; DIESEL FUEL
0655 SALMON; PHSIOLOGICAL EFFECTS; FLATFISH; SPOTTED SHRIMP; UPTAKE AND DEPURATION; HISTOPATHOLOGY
0730 SALMON; TOXICITY; CRUDE OIL; PRUDHOE BAY; ALIPHATIC; AROMATICS; CELL MEMBRANE PERMEABILITY
0888 SALMON; BIOASSAY; FLOW THROUGH; METHODOLOGY
0869 SALMON; CRUDE OIL; ONCORHYNCHUS; EGGS; ALEVINS; FRY; TOXICITY; GROWTH

1011 SALMON; PRUDHOE BAY CRUDE OIL; WATER SOLUBLE FRACTION;
RESPIRATORY RATE; STRESS
1153 SALMON; COHO; BENZOPYRENE; PHYSIOLOGICAL EFFECTS;
ARYL HYDROCARBON HYDROXYLASE; CYTOLOGICAL
1088 SALMON; TOXICITY; SURFACTANTS
0182 SALMON, CHINOOK; STRIPED BASS; BENZENE; RESPIRATORY RATES; NARCOSIS;
ONCORHYNCHUS; MORONE
0871 SALMON, PINK; PRUDHOE BAY CRUDE; COOK INLET CRUDE; FUEL OIL#2;
WATER SOLUBLE FRACTION; RESPIRATION; COUGHING; UPTAKE & DEPURATION
0735 SALMON,CHUM; TAINTING; FISH
0076 SALMON-CHINOOK; BENZENE; GROWTH
0647 SALT GRASS; CRUDE OIL; OYSTER
0648 SALT GRASS; CRUDE OIL; DISTICHLIS
0081 SALT MARSH; RECOVERY; CONTROLLED SPILLS; SHAEDA; JUNCUS; FESTUCA;
PLANTAGE; SPARTINA; PEMBROKE,WALES; KUWAIT CRUDE OIL;
FLOWERING PLANTS; SEED PRODUCTION AND GERMINATION
0080 SALT MARSH; CLEANING OF CRUDE OIL SPILL; WALES; MILFORD HAVEN;
PEMBROKESHIRE
0121 SALT MARSH; YORK RIVER; ISOLATED ECOSYSTEM; SOUTH LA. CRUDE;
WEATHERED OIL; PHYTOPLANKTON; FISH; PERIPHYTON; ATP; MARSH GRASS;
BENTHIC FAUNA; POLYCHAETES; INSECT LARVAE; AMPHIPODS; OLIGOCHAETE
0079 SALT MARSH; GROWTH STIMULATION; SALT MARSH GRASSES
0127 SALT MARSH; ESTUARY; YORK RIVER; SOUTH LA. CRUDE;
HYDROCARBON ANALYSIS; CONTROLLED ECOSYSTEM; FUNDULUS; AROMATICS;
GAS CHROMATOGRAPHY; GC-MS
0281 SALT MARSH; SPARTINA; PUCCINELLA; CHRONIC; WEATHERING; RECOVERY;
CORNWALL
0282 SALT MARSH; REVIEW; CHRONIC POLLUTION; REFINERY EFFLUENT; RECOVERY;
SPARTINA; PUCCINELLIA; OENANTHE
0283 SALT MARSH; MILFORD HAVEN; ROCKY SHORE; RECOVERY; DETERGENTS;
EMULSIFIERS; CHRONIC EXPOSURE
0285 SALT MARSH; PLANTS; TOLERANCE; RECOVERY; SOUTH WEST WALES
0286 SALT MARSH; ROCKY SHORE; CHRONIC SPILLAGE; OIL PORT;
EXPERIMENTAL SPILLS
0563 SALT MARSH; ESTUARY; YORK RIVER; BACTERIA; FUNGI; LOUISIANA CRUDE;
SEDIMENTS; PETROLEUM DEGRADING
0503 SALT MARSH; CHESAPEAKE BAY; OIL SPILL INCIDENT; POPULATIONS; MUSSEL;
OYSTERS; SNAIL; MARSH GRASS
0771 SALT MARSH; ESTUARINES; OIL POLLUTION; SPILLS; CHRONIC; ROCKY SHORE;
EMULSIFIERS; CLEANING
0748 SALT MARSH; BIOASSAY; MICROCOSM; GAS CHROMATOGRAPHY;
SPECTROPHOTOMETRY; ULTRAVIOLET; FLUORESENT
0955 SALT MARSH; PLANTS; WEATHERED OIL; DEGRADATION; GAS EXCHANGE;
RETENTION; BRITTANY; TORREY CANYON
1083 SALT MARSH; SEDIMENTS; DISSOLVED ORGANIC CARBON;
MICROBIAL DEGRADATION; METABOLISM
0202 SALT MARSH ECOSYSTEM; CONTENT ANALYSIS; FOOD CHAIN CONCENTRATION;
WEST FALMOUTH,MASS; FUEL OIL #2; HYDROCARBON CONTENT
0079 SALT MARSH GRASSES; SALT MARSH; GROWTH STIMULATION
0089 SALT MARSH PLANTS; MILFORD HAVEN,WALES; SHORT TERM EFFECTS;
LONG TERM EFFECTS
0084 SALT MARSH PLANTS; TOXICITY; EMULSIFIERS; KUWAIT CRUDE
0088 SALT MARSH PLANTS; RECOVERY; TOLERANCE; COMMUNITY SURVEY;
SUCCESSIVE OILINGS; GLAMORGAN,WALES
0078 SALT MARSH PLANTS; TOXICITIES; EMULSIFIERS; CRUDE OIL

0641 SALT MARSH PLANTS; ESTUARIES; HYDROCARBON CONCENTRATIONS; SEDIMENTS; ZOOPLANKTON; PHYTOPLANKTON; CRUDE OIL; DIVERSITY; POPULATIONS; FISH; MIGRATION; GAS CHROMATOGRAPHY; DEGRADATION

0086 SALT MARSH SOIL; SPARTINA; OXYGEN DIFFUSION

0085 SALT MARSH VEGETATION; CLEANUP METHODS; RECOVERY

0091 SALT MARSHES; ROCKY SHORES; OIL; EMULSIFIERS; ECOLOGICAL IMPACTS; TOXICITY

1081 SALT MARSHES; CLEAN-UP; SENSITIVITY TO OIL; SENSITIVITY TO CLEAN-UP

0591 SALT WATER; CRUDE OIL; TOXICITY; EMULSIFIERS; FRESH WATER

0445 SALT-BRINE; OYSTERS; MORTALITIES; OFFSHORE OIL WELLS

0105 SAMPLERS; MONITORING INSTRUMENTS; BIOLOGICAL SAMPLERS; SEDIMENT SAMPLERS; WATER SAMPLERS

0439 SAMPLING AND ANALYTICAL METHODS; HYDROCARBON CONTENT ANALYSIS

0052 SAMPLING METHODS; COLLECTION OF ABSTRACTS; ABSTRACTS; ANALYTICAL TECHNIQUES; BIOLOGICAL ASSESSMENT

0496 SAMPLING METHODS; PLANKTON; CONTAMINATION; NYLON NETS

0457 SAMPLING TECHNIQUES; CONTAMINATION

0465 SAN FRANCISCO BAY; BUNKER C; WATER SOLUBLE FRACTION; CRAB; PACHYGRAPSUS

0259 SAN FRANCISCO; BACTERIA; BUNKER C; POPULATIONS; DIVERSITY; BEACHES

0464 SAN FRANCISCO; SEDIMENTS; DISPERSION; DISSOLUTION; WEATHERING; MICROBIAL DEGRADATION; BUNKER C; SAND COLUMN DISTRIBUTION

1028 SAN FRANCISCO; BUNKER C; SANDY BEACH; DISPERSION; DEGRADATION; SAN FRANCISCO SPILL; BACTERIAL POPULATION &DIVERSITY

0012 SAN FRANCISCO BAY; SPILLS; BIRDS; FRANK BUCK - TANKER SPILL (1937); WEST COAST U.S.

0332 SAN FRANCISCO BAY; HYDROCARBON CONTENT ANALYSIS; GAS CHROMATOGRAPHY; THIN LAYER CHROMATOGRAPHY; HIGH PRESSURE LIQUID CHROMATOGRAPHY; SPONGE; MUSSEL; CRAB

0928 SAN FRANCISCO BAY; BIRDS; MORTALITIES; AUTOPSIES; FUEL OIL-BUNKER C

0232 SAN FRANCISCO SPILL; RECRUITMENT; BUNKER C; BARNACLES; BALANUS; CHTHAMALUS; MUSSEL; MYTILUS; LIMPETS; COLLISELLA

0230 SAN FRANCISCO SPILL; TRANSECTS; COMMUNITIES; INTERTIDAL; MACROINVERTEBRATES; RECRUITMENT; RECOVERY

0229 SAN FRANCISCO SPILL; ROCKY INTERTIDAL; TRANSECTS; RECOVERY

0231 SAN FRANCISCO SPILL; INVERTEBRATES; COMMUNITIES; SMOTHERING; RECRUITMENT; INTERTIDAL; RECOVERY; BUNKER C; TRANSECTS

1028 SAN FRANCISCO SPILL; BUNKER C; SANDY BEACH; DISPERSION; DEGRADATION; SAN FRANCISCO; BACTERIAL POPULATION &DIVERSITY

1084 SAN FRANCISCO SPILL; BIRDS; MORTALITIES; BIRD TREATMENT

0717 SAN FRANCISCO SPILL-1937; BIRDS; MORTALITIES; WATERFOWL; GULLS

0553 SAND; CRUDE OIL; MICROBIAL DEGRADATION; OXYGEN AVAILABILITY; DEPTH

0464 SAND COLUMN DISTRIBUTION; SEDIMENTS; SAN FRANCISCO; DISPERSION; DISSOLUTION; WEATHERING; MICROBIAL DEGRADATION; BUNKER C

0613 SAND DAB; FISH; NAPTHALENE; BENZ(A)PYRENE; RADIOACTIVE TRACER; UPTAKE; METABOLISM; DISCHARGE; SCULPIN; OLIGOCOTTUS; GOBY; GILLICHTHYS; CITHARICHTHYS

0777 SAND DOLLAR; KUWAIT CRUDE; FUEL OIL #2; WATER SOLUBLE EXTRACTS; SPERM; EGG; RESPIRATION; MOBILITY OF SPERM; FERTILIZATION; CLEAVAGE; LARVAL DEVELOPMENT

0293 SANDY AND MUDDY SHORES; MILFORD HAVEN,BRITAIN; INTERTIDAL; SEDIMENTS; MACROFAUNA; TAINTING

1028 SANDY BEACH; BUNKER C; DISPERSION; DEGRADATION; SAN FRANCISCO; SAN FRANCISCO SPILL; BACTERIAL POPULATION &DIVERSITY

1098 SANDY BEACHES; HONG KONG; DIESEL SPILL; MEIOFAUNA; INTERTIDAL;

NEMATODES; HARPACTICOID COPEPODS

1204 SANSINEA SPILL; LOS ANGELES HARBOR; PRODUCTIVITY; ZOOPLANKTON; ASSESSMENT OF SPILLS; BIRDS; BENTHIC ORGANISMS; FISH; PHYTOPLANKTON

0238 SANTA BARBARA; INTERTIDAL; COMMUNITY; CLUSTER ANALYSIS

0195 SANTA BARBARA; SEA LIONS; MORTALITY; ZALOPHUS

0214 SANTA BARBARA; BIRDS; MORTALITY

0353 SANTA BARBARA; FISH

0404 SANTA BARBARA; INTERTIDAL; COMMUNITIES; SURF GRASS; BARNACLES

0373 SANTA BARBARA; INSECTS; POPULATION SURVEY; CREVICE FAUNA; LITTORAL; BEETLE; THALASSOTRECHUS

0381 SANTA BARBARA; BENTHIC FAUNA

0680 SANTA BARBARA; DEGRADATION; CRUDE OIL; WEATHERING; SEQUENCE OF DEGRADATION; GAS CHROMATOGRAPHY

0773 SANTA BARBARA; KELP; INTERTIDAL; SUBTIDAL; OVERVIEW

0981 SANTA BARBARA; NATURAL SEEPS; SANTA BARBARA CHANNEL SPILL 1969

1147 SANTA BARBARA CHANNEL; OUTER CONTINENTAL SHELF; FISHERIES; CALIFORNIA

1205 SANTA BARBARA CHANNEL CALIFORNIA; NATURAL OIL SEEPS; ISLA VISTA OIL SEEP; BENTHIC FAUNA; POLYCHAETES; BIOMASS; TOXICITY

0981 SANTA BARBARA CHANNEL SPILL 1969; SANTA BARBARA; NATURAL SEEPS

0460 SANTA BARBARA CRUDE; OIL; BIRDS; CLEANING; PATHOLOGY; POLYCOMPLEX A-11

0561 SANTA BARBARA CRUDE; MUSSELS; CALIFORNIA COAST; TOXICITY

0107 SANTA BARBARA SPILL; REVIEW; CALIFORNIA COAST

0046 SANTA BARBARA SPILL; COMMUNITY SURVEY; KELP; SCALLOPS; ASSESSMENT; BIRDS

0045 SANTA BARBARA SPILL; CLEANUP; COMMUNITY SURVEY; BIRDS; LIMPETS; BARNACLES; MUSSEL; CHITONS; INTERTIDAL ORGANISMS

0483 SANTA BARBARA SPILL; MYTILUS; GROWTH; BODY WEIGHT

0559 SANTA BARBARA SPILL; BACTERIAL POPULATIONS; SEDIMENTS; HYDROCARBON ANALYSIS; GAS LIQUID CHROMATOGRAPHY

0514 SANTA BARBARA SPILL; CLEANUP; ECOLOGICAL IMPACTS; BIRDS; LITTORAL COMMUNITIES; KELP BEDS

0557 SANTA BARBARA SPILL; ECOLOGICAL DAMAGE

0654 SANTA BARBARA SPILL; FISH; POPULATION; PELAGIC

0675 SANTA BARBARA SPILL; ZOOPLANKTON

0685 SANTA BARBARA SPILL; FIELDS STUDIES; CHRONIC POLLUTION; LAKE MARACAIBO, VENEZUELA; BERMUDA; TIMBALIER BAY, LA.; POPULATION LEVELS; DIVERSITY; SIZE; GROWTH RATE; REPRODUCTION; ABNORMAL GROWTHS; BIOMAGNIFICATION

0790 SANTA BARBARA SPILL; PRODUCTIVITY; PHYTOPLANKTON; OIL; DISPERSANTS

0775 SANTA BARBARA SPILL; LITTORAL; MACROALGAE; ASSOCIATION INSTABILITY; CHRONIC EFFECTS; COAL OIL POINT

0776 SANTA BARBARA SPILL; INVERTEBRATES; MACROALGAE; COMMUNITY CHANGES

0900 SANTA BARBARA SPILL; OIL SPILL INCIDENT; BIRDS; CLEANUP

0951 SANTA BARBARA SPILL; FISH; POPULATION; DIVERSITY; PELAGIC; ANCHOVY; ROCKFISH; ECHO SOUNDING

0973 SANTA BARBARA SPILL; BIRDS; MORTALITIES

0966 SANTA BARBARA SPILL; INTERTIDAL; SUBTIDAL; SURVEY; DIVERSITY; PLANTS; ALGAE; INVERTEBRATES; CHANNEL IS.

0977 SANTA BARBARA SPILL; ECOSYSTEM; RECUPERATIVE CAPACITY

0969 SANTA BARBARA SPILL; BIOLOGICAL SURVEY

0971 SANTA BARBARA SPILL; BREEDING RATES; BARNACLE; MUSSELS; CHTHAMALUS; BALANUS; POLLICIPES; MYTILUS; INTERTIDAL

0975 SANTA BARBARA SPILL; BIRDS; INVERTEBRATES; ALGAE; MORTALITIES;

RECOLONIZATION; SUBLETHAL EFFECTS; PHYLLOSPADIX; CHTHAMALUS;
POLLICIPES; HESPEROPHYCUS
0970 SANTA BARBARA SPILL; BIOLOGY; BACTERIOLOGY
0969 SANTA BARBARA SPILL; FIELD SAMPLING; PROGRESS REPORT
0974 SANTA BARBARA SPILL; SURVEY; BIRDS; MARINE MAMMALS; DIVERSITY;
FISHERIES; TAINTING
0203 SARGASSUM COMMUNITY; HYDROCARBON CONTENT
1171 SAUDI ARABIAN CRUDE; BIOINDICATORS; PROTOZOA; CILIATES; EUPLOTES;
EMPIRE MIX CRUDE; MICROFAUNA; COMMUNITY DIVERSITY EXPERIMENTS
0417 SCALLOP; OYSTER; SILVERSIDES; MOTOR OIL; LESIONS; HISTOPATHOLOGY
0529 SCALLOP; BIOASSAY; CONTINUOUS FLOW; TOXICITY; SUBLETHAL EFFECTS;
WATER SOLUBLE FRACTION; WHOLE OIL FRACTION; MINNOW; FLOUNDER; SHRIMP;
QUAHOG; MUSSEL; MUD SNAIL
0046 SCALLOPS; SANTA BARBARA SPILL; COMMUNITY SURVEY; KELP; ASSESSMENT;
BIRDS
0148 SCALLOPS; SEDIMENTS; OYSTERS; BIODEGRADATION; TOXICITY;
CONTENT ANALYSIS; WEST FALMOUTH OIL SPILL; BUZZARD BAY;
GAS CHROMATOGRAPHY
0736 SCALLOPS; TAINTING; AROMATICS; PARAFFINS; CRUDE OIL
1187 SCALLOPS; PECTEN; PARAFFINS; GAS CHROMATOGRAPHY;
ANALYSIS FOR HYDROCARBONS
0667 SCENEDESMNS; ALGAE; MYXOTROPHIC GROWTH; HYDROCARBONS; DEGRADATION
0011 SCENEDESMUS; PETROLEUM PRODUCTS; BLUE GREEN ALGAE; APHANIZOMENON;
GROWTH; MORPHOLOGY; PROTOCOCCAL ALGAE
0322 SCENEDESMUS; ALGAE; GROWTH; EUGLENA; LUBRICATING OILS; DIESEL OIL;
PHOTOSYNTHETIC METABOLISM
0840 SCHIZOPORELLA; HYPERPLASIA; BRYOZOA; CARCINOGENS; OVICELLS;
INDICATOR
0704 SCORPAENA; TOXICITY; FISH; DEVELOPMENT; PETROLEUM; EUGRAULIS;
CRENILABRUS; BLACK OIL; SOLAR OIL
0613 SCULPIN; FISH; NAPTHALENE; BENZ(A)PYRENE; RADIOACTIVE TRACER; UPTAKE;
METABOLISM; DISCHARGE; OLIGOCOTTUS; GOBY; GILLICHTHYS; SAND DAB;
CITHARICHTHYS
0930 SEA COMMUNITIES; TORREY CANYON SPILL; TOXICITY; SHORE COMMUNITIES;
CRUDE OIL; DETERGENT
0815 SEA GRASS; PHOTOSYNTHESIS; DODECANE; TOLUENE; NAPHTHALENE
0228 SEA GRASS FLATS; LITTORAL COMMUNITIES; FLORIDA KEYS; ROCKY PLATFORM;
MANGROVE FRINGE; MANGROVE SWAMP; CRUSTACEANS; ECHINODERMS;
RED MANGROVE; PEARL OYSTER; BLACK MANGROVE
0195 SEA LIONS; MORTALITY; ZALOPHUS; SANTA BARBARA
0892 SEA TURTLES; PANAMA; S.S. WITWATER SPILL; TROPICS; INTERTIDAL;
TERRESTRIAL PLANTS; LITTORAL; MANGROVE; REEF; MEIOFAUNA; BIRDS;
DIESEL OIL; BUNKER C
0014 SEA URCHIN; WATER SOLUBLE FRACTION; FERTILIZATION; DEVELOPMENT; EGGS
0358 SEA URCHIN; MACROFAUNA; RED SEA; TOXICITY; CRUDE OIL; DISPERSANT;
CORAL; HETEROXENIA; GASTROPODS; MUSSELS; CHITON; HERMIT CRAB; SHRIMP;
GOATFISH; RABBITFISH
0475 SEA URCHIN; DISPERSANTS; COREXIT 9527; FERTILIZATION
0635 SEA URCHIN; OIL; DISPERSANTS; COREXIT; FISH; EGGS; EMBRYO;
FERTILIZATION; DEVELOPMENT
0633 SEA URCHIN; EMBRYOLOGY; OIL; DISPERSANTS; COREXIT; ULTRASTRUCTURE
0634 SEA URCHIN; DISPERSANTS; EGGS; FISH; FERTILIZATION; DEVELOPMENT
0631 SEA URCHIN; EGG; TOXICITY; METHODOLOGY
0218 SEA URCHINS; DISPERSANTS; OIL; FISH; FERTILIZATION; DEVELOPMENT;
TOXICITY; COREXIT

0249 SEA URCHINS; GENERAL M.C. MEIGS SPILL; CHRONIC; SURVEYS;
HYDROCARBON CONTENT; INTERTIDAL; WASHINGTON COAST;
FUEL OIL-NAVY SPECIAL; STRONGYLOCENTRUS
0317 SEA WATER; DEGRADATION; CRUDE OIL; AUTO OXIDATION; BACTERIA;
WEATHERING
0318 SEA WATER SOURCES; DEGRADATION; RESPIROMETRY; CRUDE OILS; NITROGEN
0908 SEADOCK; TEXAS; DEEP WATER PORT; ENVIRONMENTAL IMPACT
1023 SEADOCK; TEXAS CONTINENTAL SHELF; DEEP WATER PORT
0607 SEAL, ELEPHANT
0422 SEALS; CRUDE OIL; BEHAVIOR; PATHOLOGICAL EFFECTS; COATING; IMMERSION;
INGESTION
0374 SEALS; OTTERS; METABOLIC RATE; HEAT FLUX; DIVING BEHAVIOR
1146 SEALS; RINGED SEALS; NORMAL WELLS CRUDE OIL; EFFECTS ON ORGANISMS;
UPTAKE &EXCRETION
1108 SEALS; AROMATIC HYDROCARBON; POLYCYCLIC AROMATIC HC'S;
CONTENT ANALYSIS; BUNKER C; CREOSOTE; FISH; SHELLFISH; PAH;
FLUOROMETRY; FUEL OIL
1145 SEALS; NORMAL WELLS CRUDE OIL; ARCTIC; RINGED SEALS; BENZENE;
NAPHTHALENE; PATHOLOGICAL EFFECTS; UPTAKE & INGESTION
1166 SEALS; PINNIPEDS; HYPOTHERMIA; PRUDHOE BAY CRUDE OIL
0341 SEARSPORT MAINE; OIL; CLAM; MORTALITY; MYA
0670 SEARSPORT SPILL; OIL; FUEL OIL#2; JP5 FUEL; GAS CHROMATOGRAPHY;
SEDIMENTS
0100 SEARSPORT,MAINE; MERCENARIA; CLAMS; CANCER; TUMORS; NEOPLASM;
HISTOPATHOLOGY
1143 SEARSPORT-MAINE; SOFT-SHELL CLAM; FUEL OIL; UPTAKE; RETENTION;
DEPURATION; BURROWING; MORTALITY
0274 SEASONAL; EFFLUENT; REFINERY HOLDING PONDS; COMMUNITY METABOLISM;
ALGAL PRODUCTIVITY; RESPIRATION; LIGHT; TEMPERATURE
0833 SEASONAL DISTRIBUTION; BIODEGRADATION; MICROORGANISMS OXIDIZING HC'S;
DISTRIBUTION; NEVA INLET, RUSSIA; BACTERIA
0263 SEASONAL FLUCTUATION; BACTERIAL DEGRADATION; FUNGUS;
SPECIES DISTRIBUTION; CHESAPEAKE BAY
0501 SEASONAL SUCCESSION; PHYTOPLANKTON; PHOTOSYNTHESIS; GROWTH; PLANTS;
COMMUNITY EFFECTS; ARCTIC; PERIPHYTON; POPULATION COMPOSITION;
MACKENZIE VALLEY NWT
0178 SEASONAL VARIATION; MUSSEL; MYTILUS; SURFACTANT; PHYSIOLOICAL EFFECT;
TISSUE SWELLING; NORWAY
0180 SEAWATER; BACTERIA; OXIDATION; LIMITING FACTORS; NITROGEN;
PHOSPHORUS
0449 SEAWATER; BIODEGRADATION; BACTERIA; OXIDATION; HYDROCARBONS
0796 SEAWATER; BACTERIA; HYDROCARBON ANALYSIS; SEDIMENTS; NORTH SEA;
PELAGIC TAR
0760 SEAWATER; NAPHTHALENE; ALKYLNAPHTHALENE; CONTENT ANALYSIS;
ULTRAVIOLET SPECTROPHOTOMETRY; TECHNIQUES; TISSUES
0997 SEAWATER; POTENTIAL; CHRONIC POLLUTION; DEGRADATION; BACTERIA;
PETROLEUM HYDROCARBONS; SALINITY
0659 SEAWEED; FISH; TAINTING; PHENOLS; OILS; DEPOSITION; DETERGENTS
0247 SEDIMENT; HYDROCARBON CONTENT; ORGANISMS; TECHNIQUES
0250 SEDIMENT; PARAFFINS; ALGAE; ZOOPLANKTON; PHYTOPLANKTON; PRISTANE;
BIOGENIC; PETROLEUM
0343 SEDIMENT; BENZO(A)PYRENE; CARCINOGENS; MONITORING;
DETERMINATION TECHNIQUES; TISSUES; POLYCYCLIC AROMATICS; THIN-LAYER
0288 SEDIMENT; HYDROCARBON CONCENTRATIONS; NAPHTHALENE; SHRIMP; CLAMS;
OYSTERS; FUEL OIL#2; DEPURATION

0469 SEDIMENT; BIODEGRADATION; BACTERIA; DISTRIBUTION;
OIL-OXIDIZING BACTERIA; NORTH SEA; ABUNDANCE; WATER
0382 SEDIMENT; PORT VALLEY, ALASKA; INTERTIDAL; BACTERIA POPULATIONS;
MEIOFAUNA; COPEPODS; MACOMA BALTHICA
0443 SEDIMENT; OIL SPILL, EXPERIMENTAL; HYDROCARBON ANALYSIS;
WATER COLUMN; FLUORESCENCE SPECTROSCOPY; TAR BALLS
0511 SEDIMENT; STREAM, VIRGINIA; DIVERSITY; MACROINVERTEBRATES;
POPULATIONS
0584 SEDIMENT; NITROGEN FIXATION; ARCTIC; BACTERIA; ANEROBIC BACTERIA;
PETROLEUM FRACTIONS; BEAUFORT SEA; ESKIMO LAKES NWT
0672 SEDIMENT; OFFSHORE DRILLING; SPILL INCIDENT; MISSISSIPPI DELTA;
WATER COLUMN; WEATHERING; MIGRATES IN SEDIMENTS; DIVERSITY;
POPULATIONS; SHRIMP; BLUE CRABS; BENTHIC ORGANISMS
0881 SEDIMENT; POLYCHAETE; NEANTHES; RADIOACTIVE TRACER EXPERIMENT;
UPTAKE; RETENTION; METABOLISM; DEPURATION; WATER SOLUBLE FRACTION;
WATER; DETRITUS
1097 SEDIMENT; TRANSECT; INVERTEBRATES; HYDROCARBON ANALYSIS; TISSUES;
RECOLONIZATION; COBBLE BEACH; SPECTROPHOTOMETRY
0650 SEDIMENT HYDROCARBONS; OYSTERS; CRASSOSTREA; MORTALITIES;
DRILLING OPERATIONS; TEMPERATURE; SALINITY
0105 SEDIMENT SAMPLERS; MONITORING INSTRUMENTS; SAMPLERS;
BIOLOGICAL SAMPLERS; WATER SAMPLERS
1020A SEDIMENT VS.WATER COLUMN; BACTERIA; DEGRADATION; LOW TEMPERATURE
0268 SEDIMENTATION; ARROW SPILL; ZOOPLANKTON; HYDROCARBON CONTENT;
CHEDABUCTO BAY; BUNKER C; OIL INGESTION; FECES
0639 SEDIMENTATION; DEGRADATION; STREAMS; OXIDATION; OILY WASTE;
TEMPERATURE; EMULSION
0143 SEDIMENTS; PETROLEUM VS. INDIGENOUS HYDROCARBONS
0148 SEDIMENTS; OYSTERS; SCALLOPS; BIODEGRADATION; TOXICITY;
CONTENT ANALYSIS; WEST FALMOUTH OIL SPILL; BUZZARD BAY;
GAS CHROMATOGRAPHY
0192 SEDIMENTS; BACTERIA; LOUISIANA BAY; OXIDATION; AEROBIC; ANAEROBIC
0144 SEDIMENTS; DEGRADATION; BACTERIA; PERSISTANCE;
WEST FALMOUTH OIL SPILL; BUZZARD BAY
0146 SEDIMENTS; WEST FALMOUTH SPILL; WEATHERING; IDENTIFICATION;
HYDROCARBON CONTENT; DEGRADATION; SHELLFISH; OYSTERS; BUZZARD BAY
0293 SEDIMENTS; MILFORD HAVEN,BRITAIN; INTERTIDAL; MACROFAUNA;
SANDY AND MUDDY SHORES; TAINTING
0377 SEDIMENTS; HYDROCARBON; CONTENT ANALYSIS; MERCENARIA; CLAMS;
NARRAGANSET BAY; PETROLEUM; BIOGENIC
0410 SEDIMENTS; CLAM; RANGIA; NAPHTHALENES; TRINITY BAY, TEXAS;
OIL SEPARATOR PLATFORM; UPTAKE; DEPURATION; HYDROCARBON ANALYSIS;
GAS CHROMATOGRAPHY
0464 SEDIMENTS; SAN FRANCISCO; DISPERSION; DISSOLUTION; WEATHERING;
MICROBIAL DEGRADATION; BUNKER C; SAND COLUMN DISTRIBUTION
0559 SEDIMENTS; SANTA BARBARA SPILL; BACTERIAL POPULATIONS;
HYDROCARBON ANALYSIS; GAS LIQUID CHROMATOGRAPHY
0563 SEDIMENTS; SALT MARSH; ESTUARY; YORK RIVER; BACTERIA; FUNGI;
LOUISIANA CRUDE; PETROLEUM DEGRADING
0525 SEDIMENTS; BIODEGRADATION RATE; CONTINENTAL SHELF SEDIMENTS;
OXYGEN AVAILABILITY
0526 SEDIMENTS; HYDROCARBONS; CONTENT ANALYSIS; THIN LAYER CHROMATOGRAPHY;
ANALYTICAL TECHNIQUES
0661 SEDIMENTS; BIOGENIC VS. PETROLEUM HYDROCARBONS;
INFRA-RED SPECTROMETRY; CRUDE OIL

0738 SEDIMENTS; N-PARAFFINS; GAS CHROMATOGRAPHY; SOLVENT
0652 SEDIMENTS; PETROLEUM HYDROCARBONS; BASELINE INVESTIGATION;
PUGET SOUND; MUSSELS; SNAILS; THAIS; INTERTIDAL
0708 SEDIMENTS; PURIFICATION; BLACK SEA; DEGRADATION; WATER; BACTERIA
0688 SEDIMENTS; FUEL OIL#2; WEST FALMOUTH, WILD HARBOR, MASS.;
BENTHIC FAUNA; HYDROCARBON CONTENT; OPPORTINUSTIC SPECIES; RECOVERY;
GAS CHROMATOGRAPHY; DIVERSITY; POPULATIONS
0641 SEDIMENTS; ESTUARIES; HYDROCARBON CONCENTRATIONS; ZOOPLANKTON;
PHYTOPLANKTON; CRUDE OIL; SALT MARSH PLANTS; DIVERSITY; POPULATIONS;
FISH; MIGRATION; GAS CHROMATOGRAPHY; DEGRADATION
0670 SEDIMENTS; OIL; FUEL OIL#2; JP5 FUEL; GAS CHROMATOGRAPHY;
SEARSPORT SPILL
0807 SEDIMENTS; WATER SOLUBLE FRACTIONS; CRUDE OIL; MICROALGAE;
GROWTH RATE; HYDROCARBON ANALYSIS; WATERS; BIOTA;
SOUTH TEXAS OUTTER CONTINENTAL SHELF
0829 SEDIMENTS; DEGRADATION; BACTERIA; ESTUARY; BEACH; FUEL OIL;
ENRICHMENT; RATE; NARRAGANSET BAY; HYDROCARBON CONCENTRATION;
MIGRATION
0749 SEDIMENTS; PUERTO RICO; ZOE COLOCUTRONIS; VENEZUELEN CRUDE;
MANGROVE PROP COMMUNITY; TURTLE GRASS COMMUNITY;
HYDROCARBON ANALYSIS; TROPICAL
0818 SEDIMENTS; CRUSTACEA; BEHAVIOR; CRUDE OIL; AMPHIPOD; ONISIMUS;
AVOIDANCE; WEATHERING
0796 SEDIMENTS; BACTERIA; HYDROCARBON ANALYSIS; NORTH SEA; SEAWATER;
PELAGIC TAR
0935 SEDIMENTS; CRUDE OIL; LAKES; ARCTIC; MACKENZIE DELTA; WATER COLUMN;
ZOOBENTHOS; DEGRADATION
0902 SEDIMENTS; HYDROCARBON CONCENTRATION; FLUORESCENCE ANALYSIS;
BENTHIC SPECIES; FOOD CHAIN CONCENTRATION; CHEDABUCTO BAY;
FUEL OIL -BUNKER C; NOVA SCOTIA
0906 SEDIMENTS; FISH; PERIPHYTON; STREAM; DIESEL FUEL;
BOONE CREEK OIL SPILL; MACROINVERTEBRATES; HYDROCARBON ANALYSIS;
SOUTH CAROLINA
0917 SEDIMENTS; BIODEGRADATION; ANEROBIC CONDITIONS
1016 SEDIMENTS; HYDROCARBON ANALYSIS; CHROMATOGRAPHY; MASS SPECTROMETRY;
UV FLUORESCENCE; PETROLEUM.
1062 SEDIMENTS; BACTERIA; BIODEGRADATION; CHESAPEAKE BAY
1050 SEDIMENTS; DEGRADATION; BACTERIA; MOTOR OIL; TREATMENT EFFLUENT;
DISTRIBUTION; WATER COLUMN
1054 SEDIMENTS; BIODEGRADATION; ATLANTIC COAST; NORTH CAROLINA
1052 SEDIMENTS; DEGRADATION; GROWTH POTENTIAL; BACTERIA; NORTH ATLANTIC
0980 SEDIMENTS; SUBLETHAL EFFECTS; CHRONIC EXPOSURE;
COAL OIL POINT, CALIF.; BENTHIC IN-FAUNA; ABALONE; MUSSEL; BARNACLE
1056 SEDIMENTS; DEGRADATION; BACTERIA; FUNGUS; CLADOSPORIUM; WATER;
CHESAPEAKE BAY; HYDROCARBON CONCENTRATION
1057 SEDIMENTS; DEGRADATION; WATER; CHESAPEAKE BAY; CLADOSPORIUM
1039 SEDIMENTS; AROMATICS; CYCLO-ALKANE; BUNKER C; BEACH SEDIMENTS;
CHEDABUCTO BAY, NOVA SCOTIA; ARROW SPILL; METABOLISM; MOLLUSCS; MYA;
OSTREA; MYTILUS; ARYL HYDROCARBON HYDROXYLASE; BENZOPYRENE;
RADIOACTIVE TRACER
1064 SEDIMENTS; DEGRADATION; BACTERIA; CHESAPEAKE BAY
1007 SEDIMENTS; LAKE MARACAIBO, VENEZUELA; FISHERIES; WATER; BIOTA;
HYDROCARBON CONTENT ANALYSIS; TOXICITY
1063 SEDIMENTS; BIODEGRADATION; MOTOR OIL; CHESAPEAKE BAY
1116 SEDIMENTS; BIODEGRADATION; BACTERIA; BARATARIA BAY; ANAEROBIC;

BENZ(A)PYRENE; ACCUMULATION; MYTILUS; WHITING; PICKEREL

1067 SEDIMENTS; DEGRADATION; BACTERIA; DEEP SEA; INORGANIC NUTRIENTS; GROWTH POTENTIAL

1083 SEDIMENTS; SALT MARSH; DISSOLVED ORGANIC CARBON; MICROBIAL DEGRADATION; METABOLISM

1219 SEDIMENTS; CRUDE OIL; WASHINGTON; INTERTIDAL ZONE; UPTAKE & DEPURATION; ASSESSMENT OF SPILLS; BENTHIC ORGANISMS; PUGET SOUND; RECRUITMENT

1197 SEDIMENTS; PRUDHOE BAY CRUDE OIL; NAPHTHALENE; CLAMS; MACOMA; UPTAKE

0081 SEED PRODUCTION AND GERMINATION; RECOVERY; CONTROLLED SPILLS; SHAEDA; JUNCUS; FESTUCA; PLANTAGE; SPARTINA; SALT MARSH; PEMBROKE,WALES; KUWAIT CRUDE OIL; FLOWERING PLANTS

0875 SEEDING; BIODEGRADATION; MICROORGANISMS; BACTERIA; ENHANCEMENT; EMULSIFICATION

1013 SELECTIVE ABSORPTION; ESTUARINE; DIATOMS; GAS CHROMATOGRAPHY

0939 SELECTIVITY; DEGRADATION; BACTERIA

0701 SELF-PURIFICATION; BACTERIA; BLACK SEA; DEGRADATION

1081 SENSITIVITY TO CLEAN-UP; SALT MARSHES; CLEAN-UP; SENSITIVITY TO OIL

1081 SENSITIVITY TO OIL; SALT MARSHES; CLEAN-UP; SENSITIVITY TO CLEAN-UP

0680 SEQUENCE OF DEGRADATION; DEGRADATION; CRUDE OIL; SANTA BARBARA; WEATHERING; GAS CHROMATOGRAPHY

0387 SEQUESTERING; BACTERIAL DEGRADATION; ACINETOBACTER; ULTRASTRUCTURE

0323 SERIOLA; TAINTING; FISH; YELLOWTAIL; CRUDE OIL; VAPOR ANALYSIS; GAS CHROMATOGRAPHY

0651 SET; OYSTER; CRASSOSTREA; LOUISIANA; OIL SPILL; MORTALITY; GROWTH; DISEASE INCIDENCE; TAINTING

0972 SETTLEMENT; OIL; DETERGENT; RECOLONIZATION; ARTIFICAL SUBSTRATE

0996 SHAD; ALOSA; TOXICITY; PETROLEUM PRODUCTS; DISSOLVED OXYGEN; SYNERGISM; GASOLINE; FUEL OIL; BUNKER OIL

0081 SHAEDA; RECOVERY; CONTROLLED SPILLS; JUNCUS; FESTUCA; PLANTAGE; SPARTINA; SALT MARSH; PEMBROKE,WALES; KUWAIT CRUDE OIL; FLOWERING PLANTS; SEED PRODUCTION AND GERMINATION

0119 SHANNON DIVERSITY INDEX; BIOLOGICAL INDICATORS; DIVERSITY INDICIES; EVENNESS INDEX

0132 SHARK,BASKING; HYDROCARBONS; METABOLISM; CENTROPAGES

0824 SHELL DISPERSANT LT; DISPERSANTS; BP1100X; FAUNA

0877 SHELL FISHERIES; CHESAPEAKE BAY; SPILL INCIDENT; FUEL OIL # 6; ENVIRONMENTAL ASSESSMENT; BIRDS; MORTALITIES; MARSH GRASS

0146 SHELLFISH; WEST FALMOUTH SPILL; WEATHERING; IDENTIFICATION; HYDROCARBON CONTENT; SEDIMENTS; DEGRADATION; OYSTERS; BUZZARD BAY

0130 SHELLFISH; HYDROCARBON; ANALYSIS FOR PHC'S; N-ALKANE; METHYLANAPHTHALENE; COLUMN CHROMATOGRAPHY; GAS-LIQUID CHROMATOGRAPHY

0237 SHELLFISH; SINKING AGENTS; TOXICITY; CRUDE OIL; TOAD FISH; FILTRATION RATE

0301 SHELLFISH; REVIEW; FISH; OFFSHORE PRODUCTION; CONTINENTIAL SHELF

0602 SHELLFISH; INPUT; FISH; FOWL

0527 SHELLFISH

0924 SHELLFISH; OIL; TOXICITY; DETERGENTS; CLEAN UP PROCEDURES; TAINTING

0864 SHELLFISH; DISPERSANT; LARVAE; SPERMATOZOA; TOXICITY; BIVALVES; OYSTERS; CRASSOSTREA; MUSSEL; FERTILIZATION; DEVELOPMENT

1161 SHELLFISH; POLYNUCLEAR AROMATIC HYDROCARBONS; ESTUARINE; UPTAKE; RETENTION; DEPURATION; BENTHIC ORGANISMS; BENZOPYRENE

1108 SHELLFISH; AROMATIC HYDROCARBON; POLYCYCLIC AROMATIC HC'S; CONTENT ANALYSIS; BUNKER C; CREOSOTE; SEALS; FISH; PAH; FLUOROMETRY; FUEL OIL

1101 SHETLAND IS., BRITAIN; BIRDS; MORTALITY; OIL

0839 SHIPS; REVIEW-OIL SPILLS

0769 SHORE CLEANING; REVIEW; OIL POLLUTION; BIOLOGICAL CONSEQUENCES

0765 SHORE CLEANING; TAMPICO MARU SPILL; TORREY CANYON SPILL; MILFORD HAVEN, WALES; LITTORAL COMMUNITY; OIL

0930 SHORE COMMUNITIES; TORREY CANYON SPILL; TOXICITY; SEA COMMUNITIES; CRUDE OIL; DETERGENT

0838 SHORE CRAB; DETERGENTS; TOXICITY; CARCINUS; BROWN SHRIMP; CRAGON; LARVAE; FISH

0308 SHORE TYPE; INTERTIDAL; PLANTS; TIDAL CYCLE

0089 SHORT TERM EFFECTS; SALT MARSH PLAMTS; MILFORD HAVEN,WALES; LONG TERM EFFECTS

0155 SHORT TERM EFFECTS; DETERGENTS; ALGAE; INTERTIDAL; LONG TERM EFFECTS; LITTORIAL COMMUNITY

0367 SHORT TERM IMPACT; WASTE OIL; FUTURE STUDY RECOMMENDATIONS

0033 SHRIMP; UPTAKE AND DEPURATION; FISH; MOLLUSKS; FUEL OIL; NAPHTHALENES

0183 SHRIMP; ALASKA; COON-STRIPE SHRIMP; KING CRABS; COOK INLET CRUDE; TOXICITY; BIOASSAY; STATIC; WATER SOLUBLE FRACTION

0358 SHRIMP; MACROFAUNA; RED SEA; TOXICITY; CRUDE OIL; DISPERSANT; CORAL; HETEROXENIA; GASTROPODS; MUSSELS; CHITON; SEA URCHIN; HERMIT CRAB; GOATFISH; RABBITFISH

0287 SHRIMP; FUEL OIL#2; UPTAKE; DEPURATION; MOUTHLY GROWTH

0289 SHRIMP; HYDROCARBON CONCENTRATIONS; NAPHTHALENE; CLAMS; OYSTERS; SEDIMENT; FUEL OIL#2; DEPURATION

0426 SHRIMP; HYDROCARBON CONTENT ANALYSIS; GAS CHROMATOGRAPHY; PARAFFINS; SQUID; FISH

0500 SHRIMP; CRUDE OIL; ENZYMES; OYSTERS; MULLET

0529 SHRIMP; BIOASSAY; CONTINUOUS FLOW; TOXICITY; SUBLETHAL EFFECTS; WATER SOLUBLE FRACTION; WHOLE OIL FRACTION; MINNOW; FLOUNDER; SCALLOP; QUAHOG; MUSSEL; MUD SNAIL

0692 SHRIMP; HYDROCARBON CONTENT ANALYSIS; MULLET; OYSTER; LIQUID CHROMATOGRAPHY; GAS CHROMATOGRAPHY

0672 SHRIMP; OFFSHORE DRILLING; SPILL INCIDENT; MISSISSIPPI DELTA; WATER COLUMN; SEDIMENT; WEATHERING; MIGRATES IN SEDIMENTS; DIVERSITY; POPULATIONS; BLUE CRABS; BENTHIC ORGANISMS

0679 SHRIMP; DISPERSANTS; TOXICITY; FISH; COREXIT; SUB-TROPICAL; CENTROPOGON; DIOGENES; PALEOMONOTES; AMBASSIS

0695 SHRIMP; TOXICITY; CRUDE OIL; DETERGENTS; PALEOMONETES; PENAEUS

1002 SHRIMP; TOXICITY; CONTENT ANALYSIS; DEPURATION; CRUDE OIL; FUEL OIL #2; BUNKER C; PALAEMONETES; TEMPERATURE; BENZENE; PHENOL; NAPHTHALENE

1182 SHRIMP; CRUDE OIL; CRAB; ALASKA; EMBRYOGENESIS; GROWTH; COOK INLET

1212 SHRIMP; LARVAL GROWTH; UPTAKE; DEPURATION; FUEL OIL #2; HATCHING SUCCESS; BEHAVIORAL EFFECTS

1176 SHRIMP; FUEL OIL# 2; ZOOPLANKTON; RESPIRATION; TOXICITY; FEEDING BEHAVIOR; MOBILITY; NAPHTHALENE; BENZENE; PHENOL

0903 SHRIMP(GRASS); TOXICITY; FUEL OIL-#2; MINNOW; MUMMICHOG; CATFISH(CHANNEL); BLUEGILL

0360 SIGANUS; TOXICITY; RABBIT FISH; CRUDE OIL; DEPTH; DISPERSANT; STATIC ASSAY; FLOW THROUGH ASSAY; SALINITY

0909 SILICA GEL; BACTERIAL DEGRADATION; VERTICAL DISTRIBUTION; MICROORGANISMS

1072 SILICA GEL; HYDROCARBON CONTENT ANALYSIS; GAS CHROMATOGRAPHY; TISSUE EXTRACTION

1074 SILICA GEL CHROMATOGRAPHY; ALIPHATIC; AROMATIC;
DETERMINATION TECHNIQUES; MARINE ORGANISMS; ETHER EXTRACTION;
GAS CHROMATOGRAPHY; MASS SPECTROMETRY
0042 SILVER SALMON FINGERLINGS; TOXICITY STUDIES; SLUDGE OIL;
REFINED OILS; PETROLEUM PRODUCTS
0417 SILVERSIDES; OYSTER; SCALLOP; MOTOR OIL; LESIONS; HISTOPATHOLOGY
0237 SINKING AGENTS; TOXICITY; CRUDE OIL; TOAD FISH; SHELLFISH;
FILTRATION RATE
0043 SINKING OIL; TORREY CANYON; DETERGENTS; CLEANUP OF OIL SPILLS
1126 SIPUNCULID WORM; NAPHTHALENE;
METHODS OF DETECTION OF HC'S IN ORGANISM; UPTAKE; SPECTROPHOTOMETRY;
PHASCOLOSOMA; PRUDHOE BAY CRUDE OIL
0663 SITE OF ACTION; AMOEBA; NARCOSIS; PARAFFIN OILS
0685 SIZE; FIELDS STUDIES; CHRONIC POLLUTION; SANTA BARBARA SPILL;
LAKE MARACAIBO, VENEZUELA; BERMUDA; TIMBALIER BAY, LA.;
POPULATION LEVELS; DIVERSITY; GROWTH RATE; REPRODUCTION;
ABNORMAL GROWTHS; BIOMAGNIFICATION
0978 SIZE; CHRONIC EXPOSURE; MYTILUS; REPRODUCTION
0350 SKELETONEMA; PHYTOPLANKTON; AMPHIDINIUM; CRICOSPHAERA; DUNALIALLA;
BENZENE; TOLUENE; XYLENE; FUEL OIL#2; GROWTH
1018 SKELETONEMA; EMULSIFIERS; PHYTOPLANKTON; TOXICITY
1019 SKELETONMEA; PHYTOPLANKTON; TOXICITY; EMULSIFIER; NITSCHIA
0690 SLICK-SEEDING; BACTERIAL DEGRADATION; ADDITIVES; ENHANCEMENT;
MICROBIAL SEEDING; BOD; TOTAL ORGANIC CARBON; NUTRIENT SALT
0042 SLUDGE OIL; TOXICITY STUDIES; REFINED OILS;
SILVER SALMON FINGERLINGS; PETROLEUM PRODUCTS
0231 SMOTHERING; SAN FRANCISCO SPILL; INVERTEBRATES; COMMUNITIES;
RECRUITMENT; INTERTIDAL; RECOVERY; BUNKER C; TRANSECTS
0503 SNAIL; CHESAPEAKE BAY; OIL SPILL INCIDENT; SALT MARSH; POPULATIONS;
MUSSEL; OYSTERS; MARSH GRASS
0057 SNAIL,NASSARIUS; LOBSTERS; BEHAVIOR
0059 SNAIL,NASSARIUS; CHEMICAL SIGNALS; LOBSTERS; KEROSENE
0652 SNAILS; PETROLEUM HYDROCARBONS; BASELINE INVESTIGATION; PUGET SOUND;
SEDIMENTS; MUSSELS; THAIS; INTERTIDAL
0891 SNAILS; FUEL OIL; TROUT; CADDIS FLY; OYSTER
0352 SNOW GEESE; BIRDS
1163 SODIUM LAURYL SULPHATE; DISPERSANTS; CUNNER; HYPOXIA; RESPIRATION;
COREXIT; BP1002; TRITON X-100
0391 SOFT SHELL CLAM; CRUDE OIL; HYDROCARBON; UPTAKE; MYA; RESPIRATION;
LIQUID CONTENT
0953 SOFT SHELL CLAM; FUEL OIL#2; MYA; EMULSION; TISSUE ABERRATIONS;
HISTOPATHOLOGY; EDEMA; VACUOLATION; GLYCOGEN
0954 SOFT SHELL CLAM; FUEL OIL #2; SOUTH LOUISIANA CRUDE; MYA;
TEMPERATURE; SUBLETHAL EFFECTS; MUCUS PRODUCTION; MUSCLE CONTRACTION
0304 SOFT-SHELL CLAM; MYA; MICROFLORA; BIODEGRADATION
1143 SOFT-SHELL CLAM; FUEL OIL; UPTAKE; RETENTION; DEPURATION; BURROWING;
MORTALITY; SEARSPORT-MAINE
0556 SOIL; MICROFLORA; HYDROCARBON UTILIZATION
0984 SOIL; DEGRADATION; BACTERIA
0992 SOIL; PLANTS; TERRESTRIAL; PERSISTANCE; FIELD CROPS
0704 SOLAR OIL; TOXICITY; FISH; DEVELOPMENT; PETROLEUM; EUGRAULIS;
SCORPAENA; CRENILABRUS; BLACK OIL
1093 SOLE; FISH; PLAICE; HERRING; LARVAE; DETERGENT;
DEVELOPMENTAL ABNOMALITIES; BP1002; FINASOL; COREXIT
1091 SOLE; DISPERSANT; TOXICITY; FISH; LARVAE; HERRING; PILCHARD; PLAICE;

TOXICITY; SYNERGISM; NAPHTHALENES; DISSOLVED HYDROCARBONS; RESPIRATION
0882 SOUTH LOUISIANA CRUDE; TOXICITY; POLYCHAETES; CRUDE; NAPHTHALENE; BUNKER C; FUEL OIL #2; WATER SOLUBLE FRACTION; NEANTHES; CAPITELLA; KUWAIT
0954 SOUTH LOUISIANA CRUDE; FUEL OIL #2; SOFT SHELL CLAM; MYA; TEMPERATURE; SUBLETHAL EFFECTS; MUCUS PRODUCTION; MUSCLE CONTRACTION
1058 SOUTH LOUISIANA CRUDE; DEGRADATION; MASS SPECTROMETRY
1059 SOUTH LOUISIANA CRUDE; BACTERIA; BIODEGRADATION; LIMITING EFFECTS; FUEL OIL # 2
1157 SOUTH LOUISIANA CRUDE OIL; OYSTERS; CRASSOSTREA; ANALYSIS FOR HYDROCARBONS; MORTALITY; GAS CHROMATOGRAPHY
1068 SOUTH LOUISIANA CRUDE OIL; BACTERIA; SUSCEPTIBILITY; FUNGI; TOXICITY; ESTUARY; FUEL OIL #2; CHESAPEAKE BAY; GROWTH
1199 SOUTH LOUISIANA CRUDE OIL; FUEL OIL #2; POLYCHAETE; HYPOXIA; HEMOGLOBIN COMPENSATION
1173 SOUTH LOUISIANA CRUDE OIL; DUCKS; MALLARDS; ANALYSIS FOR HYDROCARBONS; NAPHTHALENE; PHYSIOLOGICAL EFFECTS
0807 SOUTH TEXAS OUTTER CONTINENTAL SHELF; WATER SOLUBLE FRACTIONS; CRUDE OIL; MICROALGAE; GROWTH RATE; HYDROCARBON ANALYSIS; SEDIMENTS; WATERS; BIOTA
0285 SOUTH WEST WALES; SALT MARSH; PLANTS; TOLERANCE; RECOVERY
0766 SOUTH-WEST BRITAIN; MILFORD HAVEN, WALES; TORREY CANYON; TOXICITIES; COMMUNITY CHANGE; LITTORAL
0348 SOUTHERN CALIFORNIA; BENZO(A)PYRENE; CARCINOGENS; MUSSELS; MYTILUS; BASELINE; BIOGENIC
0357 SOUTHERN CALIFORNIA; REFINERY EFFLUENT; ECOSYSTEMS
1149 SOUTHERN LOUISIANA CRUDE OIL; TEMPERATURE; SALINITY; NAPHTHALENE; CLAMS; UPTAKE & DEPURATION; CLAM-BOREAL; CLAM-TEMPERATURE
0221 SOYBEAN; PLANTS; TOXICITY; MODULE DEVELOPMENT; STIMULATION
1208 SPAIN; URQUIOLA SPILL; PERSIAN GULF CRUDE OIL; BENTHIC MACROFAUNA; FISH; SPARTINA; TOXICITY
0081 SPARTINA; RECOVERY; CONTROLLED SPILLS; SHAEDA; JUNCUS; FESTUCA; PLANTAGE; SALT MARSH; PEMBROKE,WALES; KUWAIT CRUDE OIL; FLOWERING PLANTS; SEED PRODUCTION AND GERMINATION
0086 SPARTINA; SALT MARSH SOIL; OXYGEN DIFFUSION
0087 SPARTINA; REFINERY EFFLUENT; MORTALITY
0281 SPARTINA; SALT MARSH; PUCCINELLA; CHRONIC; WEATHERING; RECOVERY; CORNWALL
0282 SPARTINA; REVIEW; CHRONIC POLLUTION; SALT MARSH; REFINERY EFFLUENT; RECOVERY; PUCCINELLIA; OENANTHE
1010 SPARTINA; CHEDEBUCTO BAY, NOVA SCOTIA; BUNKER C; MORTALITIES; INTERTIDAL; ARROW SPILL; WINTER; CHROMIC POLLUTION; FUCUS; MYA
1208 SPARTINA; URQUIOLA SPILL; SPAIN; PERSIAN GULF CRUDE OIL; BENTHIC MACROFAUNA; FISH; TOXICITY
0424 SPAWNING; OIL; DISPERSANTS; TOXICITY; POLYCHAETE; GAMETE FORMATION; GROWTH; MORTALITY; CIRRATULUS; CIRRIFORMIA; BP1002; COREXIT; ESSOLVENE
0986 SPAWNING; BENZENE; HERRING; CULPEA; OVARIAN EGGS; EMBRYOS; LARVAE; BEHAVIOR; RADIOACTIVE TRACER
0904 SPECIES ABUNDANCE; OUTBOARD ENGINE EXHAUST; DIVERSITY; PHYTOPLANKTON; ZOOPLANKTON; PERIPHYTON; FISH; BEHAVIOR; POPULATION
0328 SPECIES COMPOSITION; ARCTIC; ALGAE; PRIMARY PRODUCTIVITY; MACKENZIE VALLEY CRUDE OIL
0726 SPECIES COMPOSITION; DEGRADATION; BACTERIA; MACROPHYTES

0778 SPILL INCIDENTS; REVIEW; BAJA, CALIF.; LONG TERM IMPACT; TAMPICO MARU SPILL
1025 SPILL INCIDENTS; REVIEW
0012 SPILLS; BIRDS; SAN FRANCISCO BAY; FRANK BUCK - TANKER SPILL (1937); WEST COAST U.S.
0152 SPILLS; CHRONIC LEAKAGE; BENTHIC ORGANISMS; BALTIMORE CANYON-MID ATLANTIC
0771 SPILLS; ESTUARINES; OIL POLLUTION; CHRONIC; SALT MARSH; ROCKY SHORE; EMULSIFIERS; CLEANING
1178 SPILLS; COASTAL; ESTUARINE; MONITORING
0887 SPIN-LABELING; HYDROCARBONS; MOLECULAR ACTION; MEMBRANE INTERACTION
0669 SPLASH ZONE; PELAGIC HYDROCARBONS; TAR BALLS; ROCKY INTERTIDAL; FLORA; FAUNA; BERMUDA; NODILITTORINA; TECTARIUS; HYDROCARBON ANALYSIS; ALGAE
0332 SPONGE; HYDROCARBON CONTENT ANALYSIS; GAS CHROMATOGRAPHY; THIN LAYER CHROMATOGRAPHY; HIGH PRESSURE LIQUID CHROMATOGRAPHY; SAN FRANCISCO BAY; MUSSEL; CRAB
0545 SPORT FISHERIES; OFF SHORE OIL; NORTHEAST U.S.
0243 SPORT FISHING
0655 SPOTTED SHRIMP; PHSIOLOGICAL EFFECTS; SALMON; FLATFISH; UPTAKE AND DEPURATION; HISTOPATHOLOGY
0411 SPREADING OF OIL; REVIEW; GASEOUS EXCHANGE; TOXICITY; TAINTING; OYSTERS; DIATOMS; BLEED WATER; OFFSHORE DRILLING
0426 SQUID; HYDROCARBON CONTENT ANALYSIS; GAS CHROMATOGRAPHY; PARAFFINS; SHRIMP; FISH
0832 ST. LAWRENCE RIVER; PHENOL; BIODEGRADATION; REFINERY EFFLUENT
1124 ST. LAWRENCE RIVER; FISH; FUEL OIL; BUNKER C; DUCKS; MUSKRATS; CATTAILS; ANALYSIS FOR HYDROCARBONS; MARSHES
1001 STANDARDIZATION; DISPERSANTS; TOXICITY; STATIC BIOASSAY
0699 STANDING CROP; COMMUNITY STRUCTURE; PLANKTON; REFINERY EFFLUENT; HOLDING PONDS
0271 STARFISH; WATER ACCOMODATED FRACTION; MYTILUS; MUSSELS; ASTERIS; RESPIRATION; FEEDING; REPRODUCTION; BYSSAL THREAD PRODUCTION; FUEL OIL #2
0183 STATIC; ALASKA; SHRIMP; COON-STRIPE SHRIMP; KING CRABS; COOK INLET CRUDE; TOXICITY; BIOASSAY; WATER SOLUBLE FRACTION
0915 STATIC; DISPERSANTS; TOXICITY; TAINTING; FISHERIES; TESTING PROCEDURES; FLOW THROUGH; BIOASSAY
0870 STATIC; TOXICITY; COOK INLET CRUDE; BIOASSAY; FISH; INVERTEBRATES; ALASKA
0360 STATIC ASSAY; TOXICITY; RABBIT FISH; CRUDE OIL; DEPTH; SIGANUS; DISPERSANT; FLOW THROUGH ASSAY; SALINITY
1001 STATIC BIOASSAY; DISPERSANTS; TOXICITY; STANDARDIZATION
0959 STENOTOMUS; METABOLISM; INTERMEDIARY METABOLISM; XENOBIOTIC METABOLISMS; LIPOGENISIS; FUNDULUS; MIXED -FUNCTION OXIDASES
0221 STIMULATION; PLANTS; TOXICITY; SOYBEAN; MODULE DEVELOPMENT
0571 STIMULATION; PHYTOPLANKTON; CRUDE OIL; FIELD EXPERIMENT; INHIBITED; LABORATORY STUDIES; TOXICITY; PH; FRACTIONS; BENZENE; XYLENE; TOLUENE
0570 STIMULATION; CRUDE OIL; CHLORELLA; GROWTH RATES; WATER SOLUBLE FRACTIONS; TOXICITY
0362 STONY CORAL; CRUDE OIL; DISPERSANT; TOXICITY
0664 STONY CORALS; EAST CHINA SEA; KUROSHIO; TAR BALLS; ATTACHED ORGANISMS; BLUE GREEN ALGAE; PENNATE DIATOMS; BRYOZOANS;

0060 SUBLETHAL EFFECTS; LOBSTER; CRUDE OIL
0151 SUBLETHAL EFFECTS; CHRONIC OIL POLLUTION; COASTAL ECOSYSTEM; METABOLISM; BEHAVIOR; FOOD CHAIN MAGNIFICATION; WETLANDS; ESTUARIES
0260 SUBLETHAL EFFECTS; CRUDE OIL; TOXICITY; CORALS; HETEROXENIA; RED SEA; DEPTH PROTECTION EFFECTS; HYDROCARBON CONTENT ANALYSIS
0361 SUBLETHAL EFFECTS; CRUDE OIL; RED SEA; MACROFAUNA; TOXICITY; DEPTH; PHYSIOLOGY; METABOLISM; BEHAVIOR; DISPERSANT
0484 SUBLETHAL EFFECTS; LITTORINA; BUNKER C; DISPERSANT; RESPIRATION; COREXIT; CRAWLING RATES
0421 SUBLETHAL EFFECTS; INTERTIDAL; POLYCHAETE; SOUTH HAMPTON, ENGLAND; CIRRATULUS; CIRRIFORMIA
0530 SUBLETHAL EFFECTS; BIOASSAY; SOLUBLE FRACTION; TOXICITY; LARVAE; JUVENILE
0581 SUBLETHAL EFFECTS; CRABS; OYSTERS; CHEMORECEPTION; NAPTHALENE; BEHAVIOR; BIOASSAY
0529 SUBLETHAL EFFECTS; BIOASSAY; CONTINUOUS FLOW; TOXICITY; WATER SOLUBLE FRACTION; WHOLE OIL FRACTION; MINNOW; FLOUNDER; SHRIMP; SCALLOP; QUAHOG; MUSSEL; MUD SNAIL
0721 SUBLETHAL EFFECTS; MODEL; BIOLOGICAL EFFECTS; TOXICITY; TAINTING; POLYCYCLIC AROMATIC HYDROCARBONS; COATING; SOLUBLE AROMATIC HYDROCARBON DERIVITIES
0683 SUBLETHAL EFFECTS; REVIEW; SPILL INCIDENTS; BIOASSAYS
0700 SUBLETHAL EFFECTS; REVIEW-OIL POLLUTION; LARVAE; PRODUCTIVITY; FISH; PHYTOPLANKTON; ZOOPLANKTON; EGGS; BIRDS; PLAICE
0827 SUBLETHAL EFFECTS; MARINE ORGANISMS; PHYSIOLOGICAL RESPONSE; ESTUARINE ORGANISMS
0820 SUBLETHAL EFFECTS; ARCTIC; CRUDE OIL; AMPHIPOD; COELENTERATE; LOCOMOTORY ACTIVITY; ONISIMUS; HALITHOLUS
0805 SUBLETHAL EFFECTS; MARINE BIOTA
0794 SUBLETHAL EFFECTS; CHRONIC POLLUTION; REVIEW; FIELD STUDIES; OFFSHORE PRODUCTION; REFINERIES; ESTUARIES; NATURAL SEEPS
0956 SUBLETHAL EFFECTS; EFFLUENT, REFINERY; METABOLIC RATE; OXYGEN CONSUMPTION RATE; ESTUARY
0954 SUBLETHAL EFFECTS; FUEL OIL #2; SOUTH LOUISIANA CRUDE; SOFT SHELL CLAM; MYA; TEMPERATURE; MUCUS PRODUCTION; MUSCLE CONTRACTION
0949 SUBLETHAL EFFECTS; TOXICITY TESTING; COPEPODS; TECHNIQUE; DROPLETS; NARCOSIS
0975 SUBLETHAL EFFECTS; SANTA BARBARA SPILL; BIRDS; INVERTEBRATES; ALGAE; MORTALITIES; RECOLONIZATION; PHYLLOSPADIX; CHTHAMALUS; POLLICIPES; HESPEROPHYCUS
0980 SUBLETHAL EFFECTS; CHRONIC EXPOSURE; COAL OIL POINT, CALIF.; SEDIMENTS; BENTHIC IN-FAUNA; ABALONE; MUSSEL; BARNACLE
0995 SUBLETHAL EFFECTS; DISPERSANTS; EMULSIONS; TOXICITY; ACTIVITY; MOTILITY; BIVALVES; CRUSTACEANS; FISH; BEHAVIOR; OIL EMULSION; CONTINUOUS FLOW; LOCOMOTION
0979 SUBLETHAL EFFECTS; CHRONIC EXPOSURE
0998 SUBLETHAL EFFECTS; CRUDE OIL; PRODUCERS; CHEMORECEPTION; WATER SOLUBLE FRACTION; INHIBITORS
1079 SUBLETHAL EFFECTS; LOBSTER; TOXICITY; LARVAE; EMULSIONS
1125 SUBLETHAL EFFECTS; REVIEW; TOXICITY; UPTAKE; RETENTION; DEPURATION; METHODS OF DETECTION OF HC'S IN ORGANISM; BIOINDICATORS
0811 SUBLETHAL RESPONSE; FISH; BIOINDICATOR; BENZOPYRENE HYDROXYLASE; ENZYMES; MONITOR
0947 SUBLITTORAL; TORREY CANYON SPILL; DEGRADATION; ZOOPLANKTON; BACTERIA;

DEVELOPMENT; GROWTH; SURVIVAL; TOXICITY
0994 SURFACTANTS; FISH; CRUSTACEANS; BIVALVES; TOXICITY; BEHAVIOR; DEVELOPMENT; ACTIVITY; BYSSUS THREAD; MOULTING
1088 SURFACTANTS; TOXICITY; SALMON
1100 SURFACTANTS; TOXICITY; RECOVERY; BARNACLES; NAUPLII; ELMINIUS
0966 SURVEY; SANTA BARBARA SPILL; INTERTIDAL; SUBTIDAL; DIVERSITY; PLANTS; ALGAE; INVERTEBRATES; CHANNEL IS.
0974 SURVEY; SANTA BARBARA SPILL; BIRDS; MARINE MAMMALS; DIVERSITY; FISHERIES; TAINTING
0755 SURVEY OR REVIEW-PETROL. POLLUTANTS; ENVIRONMENTAL IMPACT
0249 SURVEYS; GENERAL M.C. MEIGS SPILL; CHRONIC; HYDROCARBON CONTENT; INTERTIDAL; WASHINGTON COAST; FUEL OIL-NAVY SPECIAL; SEA URCHINS; STRONGYLOCENTRUS
0340 SURVIVAL; CLAMS; GROWTH
0508 SURVIVAL; CRASSOSTREA; OYSTER; MERCENARIA; CLAM; SURFACTANT; LARVAE; DEVELOPMENT; GROWTH; TOXICITY
1068 SUSCEPTIBILITY; BACTERIA; FUNGI; TOXICITY; ESTUARY; SOUTH LOUISIANA CRUDE OIL; FUEL OIL #2; CHESAPEAKE BAY; GROWTH
0331 SUSPENDED SEDIMENT; HYDROCARBON; MYTILUS EDULIS
1041 SUSPENSION; KUWAIT CRUDE OIL; COREXIT 7664; GAS CHROMATOGRAPHY; SPECTROFLUOROMETRY; COPEPOD; TOXICITY; LONG-TERM EFFECTS; REPRODUCTION; EGG PRODUCTION; HATCHING SUCCESS
0448 SWEDEN; COD; NONYPHENIL ETHOXYLATE; UPTAKE AND DEPURATION; PHYSIOLOGICAL
1203 SYMPOSIA; BIODEGRADATION; OILS
0018 SYMPOSIUM; SOURCES, EFFECTS, AND SINKS; HYDROCARBONS; AMER. INST. BIO.SCI.
0216 SYMPOSIUM; PACIFIC NW AND ALASKA COAST
0223 SYMPOSIUM; ARGO MERCHANT SPILL
0371 SYMPOSIUM
0393 SYMPOSIUM
0392 SYMPOSIUM
0518 SYMPOSIUM
0502 SYMPOSIUM
0565 SYMPOSIUM; PUGET SOUND
1226 SYMPOSIUM; PETROLEUM HYDROCARBONS; MARINE ORGANISMS; FATE & EFFECTS
0050 SYMPOSIUM-MARINE POLLUTION
0236 SYMPTOMS; DIESEL FUEL; PELAGIC LARVAE; ENCHINODERMATA; ANNELIDA; ARTHROPODA; TOXICITY
0885 SYNERGISM; FUEL OIL # 2; WATER SOLUBLE FRACTION; NEANTHES; POLYCHAETE; HEMOGLOBIN; HYPOXIA; SOUTH LOUISIANA CRUDE; DISSOLVED OXYGEN; TOXICITY; NAPHTHALENES; DISSOLVED HYDROCARBONS; RESPIRATION
0964 SYNERGISM; NAPHTHALENE; TOXICITY; PHOSPHORUS; DIATOM
0996 SYNERGISM; SHAD; ALOSA; TOXICITY; PETROLEUM PRODUCTS; DISSOLVED OXYGEN; GASOLINE; FUEL OIL; BUNKER OIL
1046 SYNERGISM; PHYSIOLOGICAL EFFECTS
1172 SYNERGISTIC EFFECTS; FUEL OIL #2; TEMPERATURE; SALINITY; EMBRYOGENSIS; RESPIRATION; HORSESHOE CRAB; LIMULUS
0988 SYNTHESIS; POLNUCLEAR AROMATIC HYDROCARBONS; BENZOPYRENE; CARCINOGENSIS; DISTRIBUTION; DEGRADATION
1114 SYNTHESIS; CARCINOGENESIS; HYDROCARBONS; INPUT; METABOLISM; DEGRADATION; BACTERIA
0528 TAIGA; ARCTIC; TERRESTRIAL PLANTS; TUNDRA
0002 TAINTING; FISH; WHITEFISH; ANALYSIS FOR PETROLEUM HYDROCARBONS

0205 TAINTING; DEGRADATION; BACTERIA; FUNGI; EMULSIONS; TOXICITY
0279 TAINTING; HYDROCARBONS; ZOOPLANKTON; FISH; TOXICITY; BEHAVIOR; UPTAKE; METABOLISM; DEPURATION; ACCUMULATION
0265 TAINTING; MULLET; KEROSENE; AUSTRALIA; RIVER SEDIMENTS
0323 TAINTING; FISH; YELLOWTAIL; CRUDE OIL; VAPOR ANALYSIS; SERIOLA; GAS CHROMATOGRAPHY
0293 TAINTING; MILFORD HAVEN,BRITAIN; INTERTIDAL; SEDIMENTS; MACROFAUNA; SANDY AND MUDDY SHORES
0365 TAINTING; OUTBOARD OPERATION; DEGRADATION; WEATHERING; VOLATILITY
0411 TAINTING; REVIEW; SPREADING OF OIL; GASEOUS EXCHANGE; TOXICITY; OYSTERS; DIATOMS; BLEED WATER; OFFSHORE DRILLING
0531 TAINTING; FISH; MICROBIAL INFESTATION; REVIEW
0590 TAINTING; REVIEW; NORTH SEA; FISH STOCKS; DISPERSANTS
0589 TAINTING; FISHERIES; EMULSIFIERS
0583 TAINTING; CRUDE OIL; PALATABILITY; BROWN SHRIMP; BLUE CRAB; LOUISIANA CRUDE OIL
0539 TAINTING; OUTBOARD MOTORS; TOXICITY; FISH; FISH REPRODUCTION; BLUEGILLS; FATHEAD MINNOWS
0659 TAINTING; FISH; SEAWEED; PHENOLS; OILS; DEPOSITION; DETERGENTS
0651 TAINTING; OYSTER; CRASSOSTREA; LOUISIANA; OIL SPILL; MORTALITY; GROWTH; SET; DISEASE INCIDENCE
0658 TAINTING; OIL; PHENOL; FISH
0721 TAINTING; MODEL; BIOLOGICAL EFFECTS; TOXICITY; SUBLETHAL EFFECTS; POLYCYCLIC AROMATIC HYDROCARBONS; COATING; SOLUBLE AROMATIC HYDROCARBON DERIVITIES
0645 TAINTING; TROUT; SALMON; DIESEL FUEL
0736 TAINTING; SCALLOPS; AROMATICS; PARAFFINS; CRUDE OIL
0735 TAINTING; FISH; SALMON,CHUM
0788 TAINTING; FISH; PARIFFINS; GAS CHROMATOGRAPHY; EELS; ARABIAN LIGHT CRUDE OIL; ORGANIC SULFUR
0813 TAINTING; BENZOPYRENE; HYDROXYLASE INDUCTION; FISH; POLYCYCLIC AROMATIC HYDROXYLASE; ARYL HYDROCARBON HYDROXYLASE; BROWN TROUT; NEWFOUNDLAND; THIN-LAYER CHROMATOGRAPHY
0817 TAINTING; ARCTIC; CRUSTACEA; ISOPODS; AMPHIPODS; BEHAVIOR; ATTRACTION; REPULSION; CRUDE OIL
0786 TAINTING; JAPANESE COAST; FISH; EELS; GAS CHROMATOGRAPHY; IR ABSORPTION; UV ABSORPTION; MASS SPECTRUM; TOLUENE; MIZUSHIMA, JAPAN; AROMATIC HYDROCARBONS; GASOLINE
0787 TAINTING; TAINTING; GREEN FISH; EEL; FUEL OIL-BOILER; CONTENT ANALYSIS; GIRELLA; ANGULLA
0836 TAINTING; TOXICITY TESTING; METHODOLOGY
0923 TAINTING; MULLET; MUGIL; KEROSENE; GAS LIGUID CHROMATOGRAPHY; GAS CHROMATOGRAPHY- MASS SPECTROSCOPY; INFRA RED SPECTROSCOPY; RADIOACTIVE TRACERS; UPTAKE; PROTON MAGNETIC RESONANCE SPECTROSCOPY
0922 TAINTING; KEROSENE; MULLET; GAS CHROMATOGRAPHY; MUGIL
0924 TAINTING; OIL; SHELLFISH; TOXICITY; DETERGENTS; CLEAN UP PROCEDURES
0897 TAINTING; CHRONIC POLLUTION; LOUISIANA; COASTAL OIL PRODUCTION; TOXICITY
0915 TAINTING; DISPERSANTS; TOXICITY; FISHERIES; TESTING PROCEDURES; STATIC; FLOW THROUGH; BIOASSAY
1008 TAINTING; BIRDS; FISH; MOLLUSCS; BENZOPYRENE; ALGAE; TOXICITY; TORREY CANYON SPILL
0974 TAINTING; SANTA BARBARA SPILL; SURVEY; BIRDS; MARINE MAMMALS; DIVERSITY; FISHERIES
0991 TAINTING; OUTBOARD MOTOR EXHAUST WASTE; FISH; BLUEGILL; LEAD

1031 TAINTING; MULLET; MUGIL; KEROSENE; HISTOPATHOLOGY; CONTENT ANALYSIS;
AUSTRALIA
1141 TAINTING; DISTILLATES; HADDOCK; POTATO; VASCULAR PLANTS
1106 TAINTING; HYDROCARBON CONTENT; AQUATIC ANIMALS; SPECTROFLUOROMETRY;
BUNKER C
1167 TAINTING; CALIFORNIA; PETROLEUM; CLEANING AGENTS; GAS CHROMATOGRAPHY;
ORGANOLEPTIC; BIODEGRADATION
0434 TAMANO-CASCO BAY MAINE 1972; MYA; CARBON FLUX; FUEL OIL#6;
CASCO BAY MAINE
0779 TAMPICO MARU SPILL; CHRONIC; SURF CONDITIONS; MORTALITIES;
SUCCESSION; RECOVERY; BAJA, CALIF.; ANTHOPLEURA; KELP;
PHOTOSYNTHESIS
0765 TAMPICO MARU SPILL; TORREY CANYON SPILL; MILFORD HAVEN, WALES;
LITTORAL COMMUNITY; OIL; SHORE CLEANING
0778 TAMPICO MARU SPILL; REVIEW; BAJA, CALIF.; SPILL INCIDENTS;
LONG TERM IMPACT
0797 TANKER DISCHARGES; ECOLOGICAL IMPACT
0215 TANKER SINKINGS; WW 2; WILDLIFE; ECONOMY
1225 TAR; TURTLES; FLORIDA; OIL SPILL
0727 TAR BALL; BARNACLES; CONTENT ANALYSIS; METABOLISM; UPTAKE;
DEPURATION
0443 TAR BALLS; OIL SPILL, EXPERIMENTAL; HYDROCARBON ANALYSIS;
WATER COLUMN; SEDIMENT; FLUORESCENCE SPECTROSCOPY
0507 TAR BALLS
0515 TAR BALLS; PETROLEUM LUMPS; ASSOCIATED BIOTA; AGE;
OXYGEN CONSUMPTION
0664 TAR BALLS; EAST CHINA SEA; KUROSHIO; ATTACHED ORGANISMS;
BLUE GREEN ALGAE; PENNATE DIATOMS; STONY CORALS; BRYOZOANS;
BARNACLES; COPEPODS
0669 TAR BALLS; PELAGIC HYDROCARBONS; ROCKY INTERTIDAL; FLORA; FAUNA;
BERMUDA; SPLASH ZONE; NODILITTORINA; TECTARIUS; HYDROCARBON ANALYSIS;
ALGAE
0831 TAR BALLS; ASSOCIATED ORGANISMS
0822 TARSOLVENT; LITTORINA; NUCELLA; BUCINNUM; DETERGENTS; GROWTH;
MORTALITY; BP1002
0948 TARUT BAY, SAUDI ARABIA; OIL SPILL INICIDENT; PERSIAN GULF;
DISPERSANTS; MARINE FAUNA; COREXIT-7664
0586 TAXONOMY; YEAST; DEGRADATION; HYDROCARBONS
0453 TAY ESTUARY, SCOTLAND; BIRDS; MORTALITIES
0455 TAY ESTUARY, SCOTLAND; BIRDS; MORTALITY; EIDERS
0047 TAY RIVER; BIRDS; VENEZUELAN CRUDE OIL
0949 TECHNIQUE; TOXICITY TESTING; SUBLETHAL EFFECTS; COPEPODS; DROPLETS;
NARCOSIS
1035 TECHNIQUE; BIOASSAY; CONTINUOUS FLOW; PETROLEUM; METHODOLOGY;
FUEL OIL #2
0247 TECHNIQUES; HYDROCARBON CONTENT; ORGANISMS; SEDIMENT
0251 TECHNIQUES; PARAFFINS; LIQUID-SOLID CHROMATOGRAPHY;
GAS LIQUID CHROMATOGRAPHY
0375A TECHNIQUES; HYDROCARBON CONTENT ANALYSIS
0677 TECHNIQUES; HYDROCARBON CONTENT ANALYSIS
0760 TECHNIQUES; NAPHTHALENE; ALKYLNAPHTHALENE; CONTENT ANALYSIS;
ULTRAVIOLET SPECTROPHOTOMETRY; TISSUES; SEAWATER
0669 TECTARIUS; PELAGIC HYDROCARBONS; TAR BALLS; ROCKY INTERTIDAL; FLORA;
FAUNA; BERMUDA; SPLASH ZONE; NODILITTORINA; HYDROCARBON ANALYSIS;
ALGAE

0068 TEMPERATURE; ABUNDANCE; DISTRIBUTION; BIOINDICATOR; ENUMERATION; CRUDE OIL- SWEDEN; LEVEL OF OIL; MICROORGANISMS; BIODEGRADATION; RARITAN BAY N.J.; GAS CHROMATOGRAPHY

0103 TEMPERATURE; BIODEGRADATION; METABOLIC PATHWAYS; NEW JERSEY COAST; NUTRIENT MINERALS; BACTERIA -HYDROCARBON UTILIZING

0064 TEMPERATURE; BIODEGRADATION; CRUDE OIL; SUBSTRATE COMPOSITION

0104 TEMPERATURE; BACTERIA; NITROGEN; PHOSPHORUS; LIMITING FACTORS; BIODEGRADATION

0225 TEMPERATURE; DEGRADATION; BACTERIA; FUNGI; OXIDATION; ASSIMILATION

0226 TEMPERATURE; DEGRADATION; BACTERIA; FUNGI

0212 TEMPERATURE; NAPHTHENIC ACID; TOXICITY; BLUEGILL SUNFISH; POND SNAIL; WATER HARDNESS

0156 TEMPERATURE; ALGAE; PRASINOLADUS; EMULSIFIERS; BP 1002; TOXICITY

0274 TEMPERATURE; EFFLUENT; REFINERY HOLDING PONDS; COMMUNITY METABOLISM; SEASONAL; ALGAL PRODUCTIVITY; RESPIRATION; LIGHT

0303 TEMPERATURE; CHEDABUCTO BAY, NOVA SCOTIA; CAPE SIMPSON, ALASKA; NATURAL SEEP; ARTHROBACTER; PSEUDOMONAS

0324 TEMPERATURE; FISHES; BERING SEA; TOXICITY

0459 TEMPERATURE; TOXICITY; CRUDE OIL-ARABIAN LIGHT; LITTORINA; MYTILUS; TIDL CYCLE

0494 TEMPERATURE; OIL; DUCKS; COATING; METABOLISM; HEAT CONDUCTIVITY

0429 TEMPERATURE; DEGRADATION; BACTERIAL

0407 TEMPERATURE; ARCTIC; INVERTEBRATES; RECRUITMENT; BROODING; MICROBIAL DEGRADATION; RECOLONIZATION

0399 TEMPERATURE; HYDROCARBONS; CONTENT ANALYSIS; DEPURATION; MUSSELS; MYTILUS; LAGOON OF VENICE, ITALY

0620 TEMPERATURE; PHYTOPLANKTON; CRUDE OIL; TOXICITY

0639 TEMPERATURE; DEGRADATION; STREAMS; OXIDATION; SEDIMENTATION; OILY WASTE; EMULSION

0671 TEMPERATURE; BIODEGRADATION; RATE; OXYGEN AVAILILITY; BOD

0650 TEMPERATURE; OYSTERS; CRASSOSTREA; MORTALITIES; SEDIMENT HYDROCARBONS; DRILLING OPERATIONS; SALINITY

0729 TEMPERATURE; TOXICITY; SALMON; OIL; JUVENILE; STRESS BEHAVIOR; WEATHERING

0799 TEMPERATURE; CRUDE OIL; TOXICITY; INTERTIDAL ORGANISMS; LIGHT TRANSMISSION; BOILING FRACTION

0742 TEMPERATURE; DEGRADATION; BUNKER C; NOCARDIA; RATE LIMITING FACTORS

0869 TEMPERATURE; TOXICITY; ACUTE; CHRONIC; CRUDE OIL; COMPONENT; PHYSIOLOGY; BEHAVIOR; ARCTIC & SUBARCTIC ORGANISMS; METABOLISM

0907 TEMPERATURE; BACTERIAL DEGREDATION; PRESSURE; RATE; FLORIDA

0874 TEMPERATURE; BIODEGRADATION; ALASKA; SALINITY; MORTALITY; CHEMOTAXIS; COOK INLET; VALDEZ

0954 TEMPERATURE; FUEL OIL #2; SOUTH LOUISIANA CRUDE; SOFT SHELL CLAM; MYA; SUBLETHAL EFFECTS; MUCUS PRODUCTION; MUSCLE CONTRACTION

1002 TEMPERATURE; SHRIMP; TOXICITY; CONTENT ANALYSIS; DEPURATION; CRUDE OIL; FUEL OIL #2; BUNKER C; PALAEMONETES; BENZENE; PHENOL; NAPHTHALENE

0963 TEMPERATURE; BIODEGRADATION; YEAST; GAS CHROMATOGRAPHY; ACID PRODUCTION; SUBSTRATE SELECTION

1020A TEMPERATURE; BACTERIA; DEGRADATION; LOW TEMPERATURE

1129 TEMPERATURE; BIODEGRADATION; MICROOGANISMS; ARCTIC; NUTRIENTS; OXYGEN REQUIREMENTS; CRUDE OIL; AROMATICS; PARAFFINS; BEAUFORT SEA; CHUKCHI SEA

1149 TEMPERATURE; SALINITY; NAPHTHALENE; CLAMS; SOUTHERN LOUISIANA CRUDE OIL; UPTAKE & DEPURATION; CLAM-BOREAL;

CLAM-TEMPERATURE
1172 TEMPERATURE; FUEL OIL #2; SYNERGISTIC EFFECTS; SALINITY; EMBRYOGENSIS; RESPIRATION; HORSESHOE CRAB; LIMULUS
1184 TEMPERATURE; FUEL OIL #2; TOXICITY; AMPHIPODS; WEATHERING
1217 TEMPERATURE; BIODEGRADATION; ESTUARIES; MICROORGANISMS
0258 TERNS; DRY TORTUGAS; BIRDS
0258 TERNS; DRY TORTUGAS; BIRDS
0289 TERRESTRIAL; PLANTS; CRUDE OIL FRACTIONS; CHRONIC TOXICITY; ACUTE TOXICITY
0555 TERRESTRIAL; HYDROCARBONS; MICROFLORA; BREAKDOWN; METHODS; BIOSYNTHESIS; METABOLISM
0992 TERRESTRIAL; PLANTS; PERSISTANCE; SOIL; FIELD CROPS
0524 TERRESTRIAL PLANTS; ARCTIC; MICROBIAL DEGRADATION; ENHANCEMENT
0528 TERRESTRIAL PLANTS; ARCTIC; TAIGA; TUNDRA
0892 TERRESTRIAL PLANTS; PANAMA; S.S. WITWATER SPILL; TROPICS; INTERTIDAL; LITTORAL; MANGROVE; REEF; MEIOFAUNA; SEA TURTLES; BIRDS; DIESEL OIL; BUNKER C
0915 TESTING PROCEDURES; DISPERSANTS; TOXICITY; TAINTING; FISHERIES; STATIC; FLOW THROUGH; BIOASSAY
0920 TETRACLITA; BARNACLES; CARCINOGENSIS; BENZ(A)PYRENE
1105 TETRACLITA; BARNACLES; CARCINOGENS; CONTENT ANALYSIS; BENZOPYRENE
0908 TEXAS; DEEP WATER PORT; SEADOCK; ENVIRONMENTAL IMPACT
1159 TEXAS; CAPITELLA; CORDGRASS; MANGROVES; CRUDE OIL; MARSH; GULF OF MEXICO; ASSESSMENT OF SPILLS
0588 TEXAS BAYS; OFFSHORE PRODUCTION; PRODUCED WATERS; CHRONIC SPILLAGE; TIMBALIER BAY LA.
1023 TEXAS CONTINENTAL SHELF; DEEP WATER PORT; SEADOCK
0652 THAIS; PETROLEUM HYDROCARBONS; BASELINE INVESTIGATION; PUGET SOUND; SEDIMENTS; MUSSELS; SNAILS; INTERTIDAL
0373 THALASSOTRECHUS; INSECTS; POPULATION SURVEY; SANTA BARBARA; CREVICE FAUNA; LITTORAL; BEETLE
0420 THAMES ESTUARY, ENGLAND; DISPERSANTS; CLEAN-UP; MORTALITIES; INTERTIDAL
0332 THIN LAYER CHROMATOGRAPHY; HYDROCARBON CONTENT ANALYSIS; GAS CHROMATOGRAPHY; HIGH PRESSURE LIQUID CHROMATOGRAPHY; SAN FRANCISCO BAY; SPONGE; MUSSEL; CRAB
0526 THIN LAYER CHROMATOGRAPHY; HYDROCARBONS; CONTENT ANALYSIS; SEDIMENTS; ANALYTICAL TECHNIQUES
1194 THIN LAYER CHROMATOGRAPHY; GAS CHROMATOGRAPHY; ANALYSIS FOR HYDROCARBONS
0343 THIN-LAYER; BENZO(A)PYRENE; CARCINOGENS; MONITORING; DETERMINATION TECHNIQUES; TISSUES; SEDIMENT; POLYCYCLIC AROMATICS
0813 THIN-LAYER CHROMATOGRAPHY; BENZOPYRENE; HYDROXYLASE INDUCTION; FISH; POLYCYCLIC AROMATIC HYDROXYLASE; ARYL HYDROCARBON HYDROXYLASE; BROWN TROUT; NEWFOUNDLAND; TAINTING
0784 THRESHOLD ODOR; DISPERSANTS; EVALUATION; EFFECTIVNESS; TOXICITY; BIOASSAY; BOD
0308 TIDAL CYCLE; INTERTIDAL; PLANTS; SHORE TYPE
0254 TIDES; MYTILUS; UPTAKE; DEPURATION; MUSSELS; HYDROCARBON CONTENT; PARAFFINS; PETROLEUM
0459 TIDL CYCLE; TOXICITY; CRUDE OIL-ARABIAN LIGHT; LITTORINA; MYTILUS; TEMPERATURE
0097 TIGRIODUS; COPEPOD; TOXICITY; CRUDE OIL FRACTIONS; GASOLINE; KEROSENE
0587 TIGRIOPUS; COPEPOD; OXYGEN TRANSFER; TOXICITY

0911 TIMBALIER BAY; OFFSHORE PRODUCTION; LOUISIANA COAST; ECOLOGY; ENVIRONMENTAL IMPACT
0588 TIMBALIER BAY LA.; OFFSHORE PRODUCTION; PRODUCED WATERS; CHRONIC SPILLAGE; TEXAS BAYS
0685 TIMBALIER BAY, LA.; FIELDS STUDIES; CHRONIC POLLUTION; SANTA BARBARA SPILL; LAKE MARACAIBO, VENEZUELA; BERMUDA; POPULATION LEVELS; DIVERSITY; SIZE; GROWTH RATE; REPRODUCTION; ABNORMAL GROWTHS; BIOMAGNIFICATION
0186 TIMBALIER BAY,LA.; OFFSHORE PRODUCTION; LONG TERM EFFECTS; SUMMARY
0953 TISSUE ABERRATIONS; FUEL OIL#2; SOFT SHELL CLAM; MYA; EMULSION; HISTOPATHOLOGY; EDEMA; VACUOLATION; GLYCOGEN
1072 TISSUE EXTRACTION; HYDROCARBON CONTENT ANALYSIS; GAS CHROMATOGRAPHY; SILICA GEL
0178 TISSUE SWELLING; MUSSEL; MYTILUS; SURFACTANT; PHYSIOLOICAL EFFECT; SEASONAL VARIATION; NORWAY
0343 TISSUES; BENZO(A)PYRENE; CARCINOGENS; MONITORING; DETERMINATION TECHNIQUES; SEDIMENT; POLYCYCLIC AROMATICS; THIN-LAYER
0760 TISSUES; NAPHTHALENE; ALKYLNAPHTHALENE; CONTENT ANALYSIS; ULTRAVIOLET SPECTROPHOTOMETRY; TECHNIQUES; SEAWATER
1020 TISSUES; ALGAE; EMULSIFIERS; BIOASSAY; TOXICITY; GROWTH; POPULATION; LAVER; PORPHYRA
1097 TISSUES; TRANSECT; INVERTEBRATES; HYDROCARBON ANALYSIS; SEDIMENT; RECOLONIZATION; COBBLE BEACH; SPECTROPHOTOMETRY
0354 TLC; OYSTERS; CRASSOSTREA; HYDROCARBON CONTENT; GALVESTON BAY; COLUMN CHROMATOGRAPHY; MASS SPECTA; UV SPECTRA
0237 TOAD FISH; SINKING AGENTS; TOXICITY; CRUDE OIL; SHELLFISH; FILTRATION RATE
0910 TOKYO BAY; BIODEGRADATION; HEXADECANE; RADIOACTIVE TRACER; WATER COLUMN; BACTERIA
0088 TOLERANCE; RECOVERY; COMMUNITY SURVEY; SALT MARSH PLANTS; SUCCESSIVE OILINGS; GLAMORGAN,WALES
0016 TOLERANCE; MUSSEL; BEHAVIOR; FILTERING ABILITY; BLACK SEA
0285 TOLERANCE; SALT MARSH; PLANTS; RECOVERY; SOUTH WEST WALES
0534 TOLERANCE; LIGHT ABSORPTION
0603 TOLERANCE; TOXICITY
0562 TOLERANCE; MYTILUS; NATURAL OIL SEEPS
0125 TOLUENE; GASOLINE FRACTIONS; XYLENE; BENZENE; TOXICITY; MOSQUITO LARVAE; AEDES AEGYPTI; WATER SOLUBLE FRACTIONS
0179 TOLUENE; TOXICITY; OUTBOARD MOTOR EXHAUST; GOLDFISH; CONTINUOUS FLOW BIOASSAY; CARASSINS; XYLENE; TRIMETHYLBENZENE
0350 TOLUENE; PHYTOPLANKTON; AMPHIDINIUM; SKELETONEMA; CRICOSPHAERA; DUNALIALLA; BENZENE; XYLENE; FUEL OIL#2; GROWTH
0571 TOLUENE; PHYTOPLANKTON; CRUDE OIL; FIELD EXPERIMENT; INHIBITED; STIMULATION; LABORATORY STUDIES; TOXICITY; PH; FRACTIONS; BENZENE; XYLENE
0572 TOLUENE; FRESH WATER; CHLORELLA VULGARIS; ALGAE; TOXICITY; GROWTH; PHOTOSYNTHESIS; BENZENE; XYLENE; NAPTHALENE
0815 TOLUENE; SEA GRASS; PHOTOSYNTHESIS; DODECANE; NAPHTHALENE
0786 TOLUENE; TAINTING; JAPANESE COAST; FISH; EELS; GAS CHROMATOGRAPHY; IR ABSORPTION; UV ABSORPTION; MASS SPECTRUM; MIZUSHIMA, JAPAN; AROMATIC HYDROCARBONS; GASOLINE
1051 TOLUENE; DEGRADATION; CLADOSPORIUM; OXYGEN CONSUMPTION; COOXIDATION; XYLENE; HEXADECANE
0295 TOP SHELL (MONDONTA); MILFORD HAVEN, BRITAIN; ROCKY SHORE; OIL PORT; BARNACLES; LITTORINA

0112 TORREY CANYON; BIRDS; REHABILITATION AND CLEANING; PATHOLOGICAL EFFECTS
0043 TORREY CANYON; SINKING OIL; DETERGENTS; CLEANUP OF OIL SPILLS
0116 TORREY CANYON; LITTORAL; SUB- LITTORAL; COMMUNITIES
0172 TORREY CANYON; BIRDS; MORTALITIES; GUILLEMOTS; RAZORBILLS
0164 TORREY CANYON
0209 TORREY CANYON
0169 TORREY CANYON; BIRDS; MORTALITY
0468 TORREY CANYON; BACTERIA; OIL-DEGRADING; POPULATIONS; FIELD STUDY; EMULSIFIERS; BEACHES
0513 TORREY CANYON; DETERGENT; LIMPETS; PLANKTON; FISHERIES; BIRDS; CRAIE DE CHAMPAGNE
0852 TORREY CANYON; COASTAL HABITATS; PLANTS; EMULSIFIERS; CORNWALL; BRITTANY
0853 TORREY CANYON; LICHEN
0766 TORREY CANYON; MILFORD HAVEN, WALES; TOXICITIES; COMMUNITY CHANGE; LITTORAL; SOUTH-WEST BRITAIN
0783 TORREY CANYON; BIRDS; AUKS; CORNWALL, ENGLAND
0955 TORREY CANYON; SALT MARSH; PLANTS; WEATHERED OIL; DEGRADATION; GAS EXCHANGE; RETENTION; BRITTANY
0925 TORREY CANYON SPILL; FISHERIES
0044 TORREY CANYON SPILL; CONTAINMENT AND CLEANUP OF OIL
0233 TORREY CANYON SPILL; FISHERIES; BRITTANY
0296 TORREY CANYON SPILL; DISPERSANTS; CHRYSSI P. GOULANDRIS SPILLAGE; TOXICITY; FINA NOVAGE SPILLAGE; GULF REFINERY SPILL
0272 TORREY CANYON SPILL; NOCTILUCA; CRAIE DE CHAMPAGNE
0435 TORREY CANYON SPILL
0765 TORREY CANYON SPILL; TAMPICO MARU SPILL; MILFORD HAVEN, WALES; LITTORAL COMMUNITY; OIL; SHORE CLEANING
0798 TORREY CANYON SPILL; OIL; DETERGENT; INTERTIDAL; CORNWALL, ENGLAND
0947 TORREY CANYON SPILL; DEGRADATION; ZOOPLANKTON; BACTERIA; LITTORAL; SUBLITTORAL; CLEAN UP
0945 TORREY CANYON SPILL; BIOLOGICAL EFFECTS
0929 TORREY CANYON SPILL; BRITAIN; LITTORAL COMMUNITY; TOXICITY; CRUDE OIL; EMULSIFIER; MILFORD HAVEN; ESSO PORTSMOUTH SPILL; LANDS END
0930 TORREY CANYON SPILL; TORREY CANYON SPILL; TOXICITY; SEA COMMUNITIES; SHORE COMMUNITIES; CRUDE OIL; DETERGENT
1008 TORREY CANYON SPILL; BIRDS; FISH; TAINTING; MOLLUSCS; BENZOPYRENE; ALGAE; TOXICITY
1069 TORREY CANYON SPILL; BIRDS; TOXICITY; DETERGENTS; INTERTIDAL; CHALK
0554 TORULOPSIS; YEAST; OXIDATION; METABOLIC PATHWAYS; ALKANES; GLYCOLIPIDS
0623 TORULOPSIS; YEAST; MARSEILLE, FRANCE; CANDIDA
0690 TOTAL ORGANIC CARBON; BACTERIAL DEGRADATION; SLICK-SEEDING; ADDITIVES; ENHANCEMENT; MICROBIAL SEEDING; BOD; NUTRIENT SALT
1168 TOXIC EFFECTS; CYTOLOGICAL EFFECT; PETROLEUM
0078 TOXICITIES; SALT MARSH PLANTS; EMULSIFIERS; CRUDE OIL
0766 TOXICITIES; MILFORD HAVEN, WALES; TORREY CANYON; COMMUNITY CHANGE; LITTORAL; SOUTH-WEST BRITAIN
0097 TOXICITY; COPEPOD; CRUDE OIL FRACTIONS; GASOLINE; KEROSENE; TIGRIODUS
0118 TOXICITY; OIL; DISPERSANTS
0048 TOXICITY; FOOD CHAIN; AROMATIC HYDROCARBONS; FATTY TISSUES
0013 TOXICITY; WATERFOWL RESTORATION; REVIEW-OIL SPILLS; AERIAL SURVEYS;

DISPERANTS AND EMULSIFIERS
0034 TOXICITY; WATER SOLUBLE FRACTION; OIL IN WATER DISPERSION; CRUSTACEANS; FISH; ESTUARINE; SOUTH LA. CRUDE; KUWAIT CRUDE; FUEL OIL #2; BUNKER C; CYPRINODON; MENIDIA; FUNDULUS; PENAEUS; PALEOMONETES; MYSIDOPSIS
0035 TOXICITY; ESTUARINE ANIMALS; UPTAKE AND DEPURATION; RESPIRATION; SOUTH LA. CRUDE; KUWAIT CRUDE; FUEL OIL #2; BUNKER C; MINNOW; GRASS SHRIMP,PALAEMONTES; BROWN SHRIMP,PANAEUS; WATER SOLUBLE FRACTION; OIL WATER DISPERSION; NAPHTHALENES
0091 TOXICITY; SALT MARSHES; ROCKY SHORES; OIL; EMULSIFIERS; ECOLOGICAL IMPACTS
0024 TOXICITY; CONFERENCE; DISPERSANT; ECOLOGICAL EFFECTS
0072 TOXICITY; ABSORBANTS; BENTHIC FLORA; BIODEGRADATION; FUEL OIL
0120 TOXICITY; BENTHIC ANIMALS; INTERTIDAL; DIVERSITY; RECOVERY; YORK RIVER; BUNKER C; FUEL OIL#6
0122 TOXICITY; WORKSHOP PROCEEDINGS
0084 TOXICITY; SALT MARSH PLANTS; EMULSIFIERS; KUWAIT CRUDE
0227 TOXICITY; DETERGENT; STRIPED BASS; TRICON OIL SPILL ERADICATOR; ROCCUS
0156 TOXICITY; ALGAE; PRASINOLADUS; EMULSIFIERS; BP 1002; TEMPERATURE
0125 TOXICITY; GASOLINE FRACTIONS; TOLUENE; XYLENE; BENZENE; MOSQUITO LARVAE; AEDES AEGYPTI; WATER SOLUBLE FRACTIONS
0218 TOXICITY; DISPERSANTS; OIL; FISH; SEA URCHINS; FERTILIZATION; DEVELOPMENT; COREXIT
0161 TOXICITY; FUEL OIL#2; NIGERIAN CRUDE; CRANKCASE OIL; BENTHIC ALGAL COMMUNITIES; PRIMARY PRODUCTIVITY; RECOVERY; ALGAL BLUE GREEN
0212 TOXICITY; NAPHTHENIC ACID; BLUEGILL SUNFISH; POND SNAIL; WATER HARDNESS; TEMPERATURE
0205 TOXICITY; DEGRADATION; BACTERIA; FUNGI; EMULSIONS; TAINTING
0221 TOXICITY; PLANTS; SOYBEAN; MODULE DEVELOPMENT; STIMULATION
0148 TOXICITY; SEDIMENTS; OYSTERS; SCALLOPS; BIODEGRADATION; CONTENT ANALYSIS; WEST FALMOUTH OIL SPILL; BUZZARD BAY; GAS CHROMATOGRAPHY
0183 TOXICITY; ALASKA; SHRIMP; COON-STRIPE SHRIMP; KING CRABS; COOK INLET CRUDE; BIOASSAY; STATIC; WATER SOLUBLE FRACTION
0207 TOXICITY; MERCENARIA; EMBRYOS; LARVAE; WATER SOLUBLE FRACTION; CRUDE; REFINED; WASTE; GROWTH
0187 TOXICITY; ACARTIA; ECOSYSTEM IMPACT; HYPOTHETICAL; REVIEW; NIGERIAN CRUDE
0217 TOXICITY; DISPERSANTS; BIODEGRADATION; BIRDS; OXYGEN TRANSPORT
0237 TOXICITY; SINKING AGENTS; CRUDE OIL; TOAD FISH; SHELLFISH; FILTRATION RATE
0213 TOXICITY; COOK INLET CRUDE OIL; WATER SOLUBLE FRACTION; BENZENE
0179 TOXICITY; OUTBOARD MOTOR EXHAUST; GOLDFISH; CONTINUOUS FLOW BIOASSAY; CARASSINS; TOLUENE; XYLENE; TRIMETHYLBENZENE
0236 TOXICITY; DIESEL FUEL; PELAGIC LARVAE; ENCHINODERMATA; ANNELIDA; ARTHROPODA; SYMPTOMS
0260 TOXICITY; CRUDE OIL; CORALS; HETEROXENIA; RED SEA; SUBLETHAL EFFECTS; DEPTH PROTECTION EFFECTS; HYDROCARBON CONTENT ANALYSIS
0362 TOXICITY; CRUDE OIL; DISPERSANT; STONY CORAL
0359 TOXICITY; CRUDE OIL; DETERGENT; OCTOCORALS; CRUSTACEANS; MOLLUSCS; ECHINODERMS; FISH; SUBLETHAL; DEVELOPMENTAL STAGES; RED SEA; FEEDING RATE; PHYSIOLOGY; BIOACCUMULATION; LIVER ENLARGEMENT; HEMATOCRIT

0311 TOXICITY; OLEOPHILIC "FLUFF"; DETERGENT; OIL; PORCELAIN CRAB; MECHANISM OF ACTION; BP1100
0329 TOXICITY; LIMPET
0278 TOXICITY; HYDROCARBONS; ZOOPLANKTON; FISH; TAINTING; BEHAVIOR; UPTAKE; METABOLISM; DEPURATION; ACCUMULATION
0279 TOXICITY; BARNACLES; BEHAVIOR; LARVAE; DETERGENTS; BP1002; DASIC; ELMINIMS; SOLVENT; SURFACTANT
0358 TOXICITY; MACROFAUNA; RED SEA; CRUDE OIL; DISPERSANT; CORAL; METEROXENIA; GASTROPODS; MUSSELS; CHITON; SEA URCHIN; HERMIT CRAB; SHRIMP; GOATFISH; RABBITFISH
0297 TOXICITY; LITTORAL
0337 TOXICITY; PETROLEUM; BARNACLES; LARVAE; DEVELOPMENT; PHOTOTAXIS
0294 TOXICITY; DISPERSANTS; BP1002; RECOVERY ASSESSMENT
0361 TOXICITY; CRUDE OIL; RED SEA; MACROFAUNA; DEPTH; SUBLETHAL EFFECTS; PHYSIOLOGY; METABOLISM; BEHAVIOR; DISPERSANT
0360 TOXICITY; RABBIT FISH; CRUDE OIL; DEPTH; SIGANUS; DISPERSANT; STATIC ASSAY; FLOW THROUGH ASSAY; SALINITY
0296 TOXICITY; DISPERSANTS; CHRYSSI P. GOULANDRIS SPILLAGE; FINA NOVAGE SPILLAGE; TORREY CANYON SPILL; GULF REFINERY SPILL
0324 TOXICITY; FISHES; BERING SEA; TEMPERATURE
0339 TOXICITY; BIOASSAY; EFFLUENT INDUSTRIAL WASTE; BIOASSAY TECHNIQUES
0338 TOXICITY; OIL REFINERY EFFLUENT; OXYGEN DEMAND; MINNOWS; PIMEPHALES
0458 TOXICITY; CRUDE OIL; REFINED OIL; BACTERIA; WATER SOLUBLE FRACTION; AROMATIC HYDROCARBONS; WEATHERING; GROWTH RATE; MAXIMUIM CELL DENSITY
0424 TOXICITY; OIL; DISPERSANTS; POLYCHAETE; GAMETE FORMATION; SPAWNING; GROWTH; MORTALITY; CIRRATULUS; CIRRIFORMIA; BP1002; COREXIT; ESSOLVENE
0372 TOXICITY; REVIEW; MARINE ECOSYSTEMS; CRUDE OIL; LONG TERM EFFECTS
0411 TOXICITY; REVIEW; SPREADING OF OIL; GASEOUS EXCHANGE; TAINTING; OYSTERS; DIATOMS; BLEED WATER; OFFSHORE DRILLING
0446 TOXICITY; LONG TERM; REFINERY EFFLUENTS
0495 TOXICITY; OIL; BIRDS; DUCKS; INGESTION; PHYSIOLOGICAL EFFECTS; HISTOPATHOLOGY
0463 TOXICITY; FISH PHYSIOLOGY; FISH BEHAVIOR; SALMON; ENZYMES; SOLUBLE HYDROCARBONS; PRUDHOE BAY CRUDE OIL
0459 TOXICITY; CRUDE OIL-ARABIAN LIGHT; LITTORINA; MYTILUS; TIDL CYCLE; TEMPERATURE
0405 TOXICITY; FUNDULUS; PIMEPHALES; ARTEMIA; KUWAIT; WEST TEXAS; MARINE DIESEL; FUEL OIL; LUBE OIL
0569 TOXICITY; MUD CRAB; LARVAE; MOULTING
0582 TOXICITY; FRESH WATER FISH; AUFWUCHS (SURFACE GROWTH); JP4 FUEL; JP5 FUEL
0537 TOXICITY; FISH; OIL-REFINERY EFFLUENT; METABOLIC RATES; COMPARISION OF SPECIES; BIOASSAY; FRESH WATER
0508 TOXICITY; CRASSOSTREA; OYSTER; MERCENARIA; CLAM; SURFACTANT; LARVAE; DEVELOPMENT; GROWTH; SURVIVAL
0614 TOXICITY; ARCATIA; SPHAEROMA; AMPHITHOE; FUEL OIL; WATER SOLUBLE FRACTION
0573 TOXICITY; GREEN SEA URCHIN; VENEZUELAN CRUDE OIL; BEDFORD BASIN NOVA SCOTIA; OIL SPERSE
0570 TOXICITY; CRUDE OIL; CHLORELLA; GROWTH RATES; WATER SOLUBLE FRACTIONS; STIMULATION
0575 TOXICITY; REVIEW; SOURCES; BIOLOGICAL EFFECTS; PERSISTANCE
0606 TOXICITY; DETERGENT; PLANKTON; COREXIT; CRANGON

0615 TOXICITY; WATER SOLUBLE FRACTION; FUEL OIL #2; ZOOPLANKTON COASTAL; ZOOPLANKTON OCEANIC; BEHAVIOR

0572 TOXICITY; FRESH WATER; CHLORELLA VULGARIS; ALGAE; GROWTH; PHOTOSYNTHESIS; BENZENE; XYLENE; TOLUENE; NAPTHALENE

0592 TOXICITY; CRUDE OIL; PETROLEUM FRACTIONS; HERRING; HATCHING; DEVELOPMENT; EMULSIFICATION

0604 TOXICITY; OIL; DISPERSANTS; METHODOLOGY; BIOASSAY

0519 TOXICITY; PRAWN

0561 TOXICITY; MUSSELS; CALIFORNIA COAST; SANTA BARBARA CRUDE

0539 TOXICITY; OUTBOARD MOTORS; TAINTING; FISH; FISH REPRODUCTION; BLUEGILLS; FATHEAD MINNOWS

0530 TOXICITY; BIOASSAY; SOLUBLE FRACTION; LARVAE; JUVENILE; SUBLETHAL EFFECTS

0568 TOXICITY; CRUDE OIL; CASPIAN SEA; CERASTODERMA; CHANGE; ABRA; PONTOGAMMARUS

0591 TOXICITY; CRUDE OIL; EMULSIFIERS; FRESH WATER; SALT WATER

0595 TOXICITY; EGGS; LARVAE; COD; BUNKER C; WATER SOLUBLE FRACTION; HATCHING SUCCESS

0544 TOXICITY; REFINERY EFFLUENT

0571 TOXICITY; PHYTOPLANKTON; CRUDE OIL; FIELD EXPERIMENT; INHIBITED; STIMULATION; LABORATORY STUDIES; PH; FRACTIONS; BENZENE; XYLENE; TOLUENE

0594 TOXICITY; CRUDE OIL; FISH FRY; DISPERSANTS; COD; GADUS; HERRING; CLUPEA; EMBRYOLOGY; CHEMORECEPTION

0605 TOXICITY; UPTAKE AND DEPURATION; OFFSHORE PRODUCTION; FOOD CHAIN ACCUMULATION

0616 TOXICITY; FUEL OIL #2; CRUDE; AMPHIPODS; BREEDING; WATER SOLUBLE FRACTION

0603 TOXICITY; TOLERANCE

0620 TOXICITY; PHYTOPLANKTON; CRUDE OIL; TEMPERATURE

0599 TOXICITY; KUWAIT CRUDE; COREXIT 8666; PHYTOPLANKTON; PHAEODACTYLUM TRICORNUTUM; PRIMARY PRODUCTION; ILLUMINATION

0529 TOXICITY; BIOASSAY; CONTINUOUS FLOW; SUBLETHAL EFFECTS; WATER SOLUBLE FRACTION; WHOLE OIL FRACTION; MINNOW; FLOUNDER; SHRIMP; SCALLOP; QUAHOG; MUSSEL; MUD SNAIL

0550 TOXICITY; CORAL; AIR EXPOSURE; OIL; ENIWETOK ATOLL

0587 TOXICITY; COPEPOD; OXYGEN TRANSFER; TIGRIOPUS

0704 TOXICITY; FISH; DEVELOPMENT; PETROLEUM; EUGRAULIS; SCORPAENA; CRENILABRUS; BLACK OIL; SOLAR OIL

0630 TOXICITY; AMPHIPOD; BEHAVIOR; LARVAE; GAMMARUS; FECUNDITY

0731 TOXICITY; SALMON; CRUDE OIL; ALIPHATICS; AROMATICS; CELL MEMBRANE PERMEABILITY

0631 TOXICITY; SEA URCHIN; EGG; METHODOLOGY

0709 TOXICITY; BLACK OIL; KEROSENE; MARINE PLANKTONIC ALGAE; BENTHOPLANKTONIC ALGAE

0679 TOXICITY; DISPERSANTS; FISH; SHRIMP; COREXIT; SUB-TROPICAL; CENTROPOGON; DIOGENES; PALEOMONOTES; AMBASSIS

0730 TOXICITY; SALMON; CRUDE OIL; PRUDHOE BAY; ALIPHATIC; AROMATICS; CELL MEMBRANE PERMEABILITY

0718 TOXICITY; CHRONIC POLLUTION; OIL PORT; POMATOLEIOS; GROWTH; KUWAIT; DIVERSITY; SUCCESSION

0729 TOXICITY; SALMON; OIL; TEMPERATURE; JUVENILE; STRESS BEHAVIOR; WEATHERING

0673 TOXICITY; BUNKER C; RIVER; MUDDY RIVER, MASS.; BOD; PLANKTON; MACROFAUNA; NEW ENGLAND

0702 TOXICITY; ZOOPLANKTON; BLACK SEA; CRUDE OIL; MINERAL OIL; ACARTIA; PARACALANUS; PENILLIA; CENTROPAGES; OITHONA
0689 TOXICITY; PETROLEUM FRACTIONS; MOSQUITOS; CULEX; AEDES; EGGS; LARVAE; PUPAE
0719 TOXICITY; ALGAE; PLATYMONAS; GROWTH RATES; FINE STRUCTURE; NANO PLANKTON; CRUDE OIL; EMULSIFIER
0691 TOXICITY; PELAGIC LARVAE; BENTHIC INVERTEBRATES; ESTUARINE
0710 TOXICITY; ALGAE; PETROLEUM; GROWTH
0663 TOXICITY; PETROLEUM REFINERY EFFLUENT; SUNFISH,REDEAR; LEPOMIS; BEHAVIORAL SYMPTOMS; FRESH WATER FISH
0628 TOXICITY; BIOASSAY; METHODOLOGY; BEHAVIOR
0695 TOXICITY; SHRIMP; CRUDE OIL; DETERGENTS; PALEOMONETES; PENAEUS
0686 TOXICITY; BENZENE; STRIPED BASS; CONTINUOUS FLOW
0627 TOXICITY; CRUDE OIL; DETERGENT; CORAL
0721 TOXICITY; MODEL; BIOLOGICAL EFFECTS; SUBLETHAL EFFECTS; TAINTING; POLYCYCLIC AROMATIC HYDROCARBONS; COATING; SOLUBLE AROMATIC HYDROCARBON DERIVITIES
0733 TOXICITY; BP1002; KEROSENE; CHEMKLEEN; BARNACLE; BALANUS; ADULT; NAUPLIUS; CIRRAL ACTIVITY
0629 TOXICITY; CRUDE OIL; DISPERSANTS; LARVAE; HERRING; CULPEA
0799 TOXICITY; CRUDE OIL; INTERTIDAL ORGANISMS; LIGHT TRANSMISSION; TEMPERATURE; BOILING FRACTION
0823 TOXICITY; PROCEDURES
0780 TOXICITY; WATER SOLUBLE FRACTION; FUEL OIL #2; PHYTOPLANKTON
0767 TOXICITY; MICRORESPIROMETRY; EMULSIFIER
0838 TOXICITY; DETERGENTS; SHORE CRAB; CARCINUS; BROWN SHRIMP; CRAGON; LARVAE; FISH
0821 TOXICITY; EMULSIFIER; LITTORAL; INVERTEBRATES
0784 TOXICITY; DISPERSANTS; EVALUATION; EFFECTIVNESS; BIOASSAY; BOD; THRESHOLD ODOR
0751 TOXICITY; INTERTIDAL; BALTIC SEA; LITTORAL ZONE; COREXIT; BEROL; BP1100; WATER BASE; OIL BASE; SOLVENT
0761 TOXICITY; AROMATICS; PHENATHRENES; ESTUARINE; BENTHIC; OCEANIC; LARVAE; JUVENILES; RESPIRATION; GROWTH; SUBLETHAL
0835 TOXICITY; OIL DISPERSANTS; CARDIUM; CRAGON
0747 TOXICITY; STRIPED BASS; MORONE; BENZENE; JUVENILES
0924 TOXICITY; OIL; SHELLFISH; DETERGENTS; CLEAN UP PROCEDURES; TAINTING
0865 TOXICITY; BIVALVES; SPERMATOZOA; FERTILIZATION; DEVELOPMENTAL ABNORMALITIES; PRUDHOE BAY CRUDE; KUWAIT CRUDE; NIGERIAN CRUDE
0839 TOXICITY; DISPERSANTS; BIODEGRADABILITY
0942 TOXICITY; CRUDE OIL; NAPTHALENE; WATER SOLUBLE FRACTION; CHLAMYDOMONAS; GROWTH
0916 TOXICITY; REVIEW; TYPES OF OILS; WEATHERING; FISHERIES; DISPERSANTS; MARINE ENVIRONMENT
0869 TOXICITY; CRUDE OIL; SALMON; ONCORHYNCHUS; EGGS; ALEVINS; FRY; GROWTH
0915 TOXICITY; DISPERSANTS; TAINTING; FISHERIES; TESTING PROCEDURES; STATIC; FLOW THROUGH; BIOASSAY
0872 TOXICITY; MOSQUITO; CULEX; SUFFOCATION
0870 TOXICITY; COOK INLET CRUDE; BIOASSAY; STATIC; FISH; INVERTEBRATES; ALASKA
0930 TOXICITY; TORREY CANYON SPILL; SEA COMMUNITIES; SHORE COMMUNITIES; CRUDE OIL; DETERGENT
0897 TOXICITY; CHRONIC POLLUTION; LOUISIANA; COASTAL OIL PRODUCTION;

TAINTING
0946 TOXICITY; DISPERSANTS; COREXIT; OIL
0883 TOXICITY; WATER SOLUBLE FRACTION; FUEL OIL #2; POLYCHAETE; NEANTHOS; LARVAE
0931 TOXICITY; PACIFIC HERRING; ROE; HATCHING SUCCESS; MORPHOLOGICAL ANOMOLIES; HERRING; CRUDE OIL; ALASKA
0882 TOXICITY; POLYCHAETES; CRUDE; NAPHTHALENE; BUNKER C; FUEL OIL #2; WATER SOLUBLE FRACTION; NEANTHES; CAPITELLA; SOUTH LOUISIANA CRUDE; KUWAIT
0903 TOXICITY; FUEL OIL-#2; SHRIMP(GRASS); MINNOW; MUMMICHOG; CATFISH(CHANNEL); BLUEGILL
0885 TOXICITY; FUEL OIL # 2; WATER SOLUBLE FRACTION; NEANTHES; POLYCHAETE; HEMOGLOBIN; HYPOXIA; SOUTH LOUISIANA CRUDE; DISSOLVED OXYGEN; SYNERGISM; NAPHTHALENES; DISSOLVED HYDROCARBONS; RESPIRATION
0863 TOXICITY; SUPRALITTORAL; ARTHROPODS; LIMOSINA; ORCHESTIA; EFFLUENTS; CRUDE OIL; FLIES; AMPHIPODES
0868 TOXICITY; ACUTE; CHRONIC; CRUDE OIL; COMPONENT; PHYSIOLOGY; BEHAVIOR; ARCTIC & SUBARCTIC ORGANISMS; TEMPERATURE; METABOLISM
0880 TOXICITY; HERRING; AGONUS
0894 TOXICITY; LOW MOLECULAR WEIGHT HYDROCARBONS; OFFSHORE PRODUCTION; GULF OF MEXICO
0867 TOXICITY; PINK SALMON; CRUDE OIL; AVOIDANCE; JUVENILE; MIGRATION; AGE; CHEMORECEPTION
0864 TOXICITY; DISPERSANT; SHELLFISH; LARVAE; SPERMATOZOA; BIVALVES; OYSTERS; CRASSOSTREA; MUSSEL; FERTILIZATION; DEVELOPMENT
0929 TOXICITY; BRITAIN; LITTORAL COMMUNITY; CRUDE OIL; EMULSIFIER; MILFORD HAVEN; ESSO PORTSMOUTH SPILL; TORREY CANYON SPILL; LANDS END
0858 TOXICITY; CRUDE OIL; CORAL; PANAMA; DIESEL MARINE; BUNKER C; METABOLISM; FEEDING
0886 TOXICITY; KUWAIT CRUDE; SOUTH LOUISIANA CRUDE; FUEL OIL # 2; BUNKER C; WATER SOLUBLE FRACTION; NAPHTHALENE; NEANTHES; CAPITELLA
0914 TOXICITY; HYDROCARBONS; GAS WASTES; FISH; BEHAVIOR; ATTRACTION; SUNFISH (ORANGE-SPOTTED)
1018 TOXICITY; EMULSIFIERS; PHYTOPLANKTON; SKELETONEMA
1008 TOXICITY; BIRDS; FISH; TAINTING; MOLLUSCS; BENZOPYRENE; ALGAE; TORREY CANYON SPILL
1041 TOXICITY; KUWAIT CRUDE OIL; SUSPENSION; COREXIT 7664; GAS CHROMATOGRAPHY; SPECTROFLUOROMETRY; COPEPOD; LONG-TERM EFFECTS; REPRODUCTION; EGG PRODUCTION; HATCHING SUCCESS
1033 TOXICITY; COON STRIPE SHRIMP; FUEL OIL #2; PROCEDURES
0995 TOXICITY; DISPERSANTS; EMULSIONS; SUBLETHAL EFFECTS; ACTIVITY; MOTILITY; BIVALVES; CRUSTACEANS; FISH; BEHAVIOR; OIL EMULSION; CONTINUOUS FLOW; LOCOMOTION
0993 TOXICITY; OIL; DISPERSANTS; METHODOLOGY
0964 TOXICITY; NAPHTHALENE; PHOSPHORUS; SYNERGISM; DIATOM
1001 TOXICITY; DISPERSANTS; STATIC BIOASSAY; STANDARDIZATION
1019 TOXICITY; PHYTOPLANKTON; EMULSIFIER; SKELETONMEA; NITSCHIA
0996 TOXICITY; SHAD; ALOSA; PETROLEUM PRODUCTS; DISSOLVED OXYGEN; SYNERGISM; GASOLINE; FUEL OIL; BUNKER OIL
1002 TOXICITY; SHRIMP; CONTENT ANALYSIS; DEPURATION; CRUDE OIL; FUEL OIL #2; BUNKER C; PALAEMONETES; TEMPERATURE; BENZENE; PHENOL; NAPHTHALENE
0962 TOXICITY; LONG TERM EFFECTS; INTERTIDAL; GASTROPODS; BIVALVES; DIESEL FUEL, MARINE; ROCKY SHORE; FAUNA; LAMMA IS.; HONG KONG; DISPERSANTS; RECOVERY

0967 TOXICITY; PHYTOPLANKTON
1007 TOXICITY; LAKE MARACAIBO, VENEZUELA; FISHERIES; SEDIMENTS; WATER; BIOTA; HYDROCARBON CONTENT ANALYSIS
0989 TOXICITY; DISPERSANTS; BP1002; BP1100; COCKLE-CERASTODERMA; LUGWORM-ARENICOLA; NERINE
1040 TOXICITY; OIL; DISPERSED OIL; EFFECTS; MARINE BIOTA
1049 TOXICITY; BACTERIA; ESTUARIES
1020 TOXICITY; ALGAE; EMULSIFIERS; BIOASSAY; GROWTH; POPULATION; TISSUES; LAVER; PORPHYRA
0985 TOXICITY; BENZENE; HERRING; ANCHOVY; EGGS; LARVAE; ABNORMALITIES; GROWTH; RESPIRATION; FEEDING
1034 TOXICITY; BIOASSAY; FUEL OIL #2; COON STRIPE SHRIMP
0994 TOXICITY; SURFACTANTS; FISH; CRUSTACEANS; BIVALVES; BEHAVIOR; DEVELOPMENT; ACTIVITY; BYSSUS THREAD; MOULTING
1005 TOXICITY; REVIEW; OIL POLLUTION; FATE &BEHAVIOR OF OIL; BIRDS; BIODEGRADATION; FIELD STUDIES; BIBLIOGRAPHY
1000 TOXICITY; DISPERSANTS; METHODOLOGY
1156 TOXICITY; FISHES; HISTOPATHOLOGICAL EFFECTS; CRUDE OIL
1090 TOXICITY; BP1002; DETERGENT; SABELLARIA; LARVAE; SUBSTRATE ABSORPTION
1092 TOXICITY; DISPERSANTS; METHODOLOGY
1131 TOXICITY; MICROFLORA; PHYTOPLANKTON; ALGAE; CRUDE OIL; FUEL OIL; NAPHTHALENE; PHENANTHRENE; AROMATICS; ALGAE-GREEN; ALGAE-BLUE GREEN; DIATOMS; GROWTH
1137 TOXICITY; AUSTRALIA; UPTAKE; RETENTION; DEPURATION; GAS CHROMATOGRAPHY; MYTILUS; MUSSEL; EFFECT ON ECOSYSTEM; BIOINDICATORS
1135 TOXICITY; ESTUARINE; BIRDS; DUCKS; FISH; CHESAPEAKE BAY; HATCHING SUCCESS
1069 TOXICITY; TORREY CANYON SPILL; BIRDS; DETERGENTS; INTERTIDAL; CHALK
1125 TOXICITY; REVIEW; SUBLETHAL EFFECTS; UPTAKE; RETENTION; DEPURATION; METHODS OF DETECTION OF HC'S IN ORGANISM; BIOINDICATORS
1089 TOXICITY; LONG TERM EFFECTS; LARVAE; DETERGENT; SABELLERIA
1122 TOXICITY; EIDER; REPRODUCTIVE GROWTH; HATCHING SUCCESS; FUEL OIL
1152 TOXICITY; ECOLOGICAL; ORGANISMS; FISHERIES; ESTUARINE; COASTAL; METHODOLOGY; PETROLEUM FRACTION; CLEANING AGENTS/DISPERSANTS
1139 TOXICITY; CRUDE OIL; CRAB; CANCER; NAPHTHALENE; BENZENE; AROMATIC HC'S; REPRODUCTION & DEVELOPMENT
1079 TOXICITY; LOBSTER; HOMARUS; LARVAE; BEHAVIOR; GROWTH; VENEZUELA CRUDE OIL; FOOD CONSUMPTION; DISPERSIONS
1132 TOXICITY; PETROLEUM FRACTION/CLEANING AGENT; FUCUS; COPEPODS; EFFECT ON ORGANISMS
1078 TOXICITY; LOBSTER; SUBLETHAL EFFECTS; LARVAE; EMULSIONS
1094 TOXICITY; FUEL OIL #2; ALGAE; PHENALEN-1-ONE; WAVELENGTH DEPENDENT; ALGAE-BLUE GREEN; ALGAE -GREEN; DIATOMS
1140 TOXICITY; FUEL OIL; CRUDE OIL; POLYCHAETES; REPRODUCTION & DEVELOPMENT
1091 TOXICITY; DISPERSANT; FISH; LARVAE; HERRING; PILCHARD; PLAICE; SOLE; LEMON SOLE; HADDOCK; BP1002; DELAYED EFFECTS; EMBRYOLOGY; BEHAVIORAL CHANGES
1085 TOXICITY; CRUDE OIL; FISH; WATER SOLUBLE FRACTION
1121 TOXICITY; MALLARD; PHYSIOLOGICAL EFFECTS; FUEL OIL; HATCHING SUCCESS; PARAFFINS; GROWTH
1070 TOXICITY; FUEL OIL #2; CATFISH; FEEDING BEHAVIOR; HEART RATE
1068 TOXICITY; BACTERIA; SUSCEPTIBILITY; FUNGI; ESTUARY;

MARINE ENVIRONMENT
0201 UCA; HYDROCARBON CONTENT; METABOLISM; AROMATIC HYDROCARBON CONTENT; FIDDLER CRAB; OXIDATION; CLEARANCE
0387 ULTRASTRUCTURE; BACTERIAL DEGRADATION; ACINETOBACTER; SEQUESTERING
0638 ULTRASTRUCTURE; YEAST; CANDIDA
0633 ULTRASTRUCTURE; EMBRYOLOGY; SEA URCHIN; OIL; DISPERSANTS; COREXIT
0893 ULTRASTRUCTURE; FISH; FUNDULUS; LIVER; LIPOGENESIS; RADIOACTIVE TRACERS; METABOLIC PATHWAYS; GLYCOLYSIS
0748 ULTRAVIOLET; BIOASSAY; SALT MARSH; MICROCOSM; GAS CHROMATOGRAPHY; SPECTROPHOTOMETRY; FLUORESENT
0467 ULTRAVIOLET SPECTROPHOTMETRY; TOXICOLOGY; BENZENE; ALKYLBENZENES; BLOOD; KEROSENE
0760 ULTRAVIOLET SPECTROPHOTOMETRY; NAPHTHALENE; ALKYLNAPHTHALENE; CONTENT ANALYSIS; TECHNIQUES; TISSUES; SEAWATER
0062 UMIAT; ARCTIC; MICROORGANISMS; PRUDHOE BAY; VALDEZ; NATURAL SEEPAGES; ALASKA -PRUDHOE BAY; CAPE SIMPSON
0009 UPTAKE; YEAST; MOLDS; FUNGAL ECOLOGY; BIODEGRADATION
0129 UPTAKE; N-ALKANE; FISH
0154 UPTAKE; MUSSEL; MYTILUS
0150 UPTAKE; CLAMS; MERCENARIA; DISSOLVED ORGANIC MATTER(DOM); FILTER-FEEDING; FUEL OIL#2
0277 UPTAKE; COPEPOD; DEPURATION; NAPHTHALENE; METABOLISM; CALANUS; FOOD WEB; WATER SOLUBLE FRACTION; DIETARY ROUTE OF ENTRY; RADIOACTIVE TRACERS
0355 UPTAKE; MYTILUS; MUSSELS; DEPURATION; BIOGENIC; PETROLEUM; AROMATICS; KIEL BIGHT
0287 UPTAKE; FUEL OIL#2; SHRIMP; DEPURATION; MOUTHLY GROWTH
0254 UPTAKE; MYTILUS; DEPURATION; MUSSELS; HYDROCARBON CONTENT; PARAFFINS; PETROLEUM; TIDES
0278 UPTAKE; HYDROCARBONS; ZOOPLANKTON; FISH; TOXICITY; TAINTING; BEHAVIOR; METABOLISM; DEPURATION; ACCUMULATION
0333 UPTAKE; MUSSELS; MYTILUS; HYDROCARBON CONTENT; MONITOR; DEPURATION
0275 UPTAKE; POLYCYCLIC AROMATIC HYDROCARBONS; METABOLISM; FOOD WEB TRANSFER; BIOSYNTHESIS
0391 UPTAKE; CRUDE OIL; HYDROCARBON; MYA; RESPIRATION; LIQUID CONTENT; SOFT SHELL CLAM
0486 UPTAKE; RETENTION; COPEPOD; ZOOPLANKTON; CALANUS; EURYTEMORA; DEPURATION
0400 UPTAKE; MYTILUS; DEPURATION; HYDROCARBON CONTENT ANALYSIS; PHYSIOLOGICAL STRESS; BIOLOGICAL MONITOR; MUSSELS; ACCUMULATION
0364 UPTAKE; RINGED SEAL; NORMAN WELLS CRUDE OIL; DISTRIBUTION; CLEARANCE
0410 UPTAKE; CLAM; RANGIA; NAPHTHALENES; TRINITY BAY, TEXAS; OIL SEPARATOR PLATFORM; DEPURATION; SEDIMENTS; HYDROCARBON ANALYSIS; GAS CHROMATOGRAPHY
0612 UPTAKE; METABOLISM; DEPURATION; RADIOACTIVE TRACERS; REVIEW
0608 UPTAKE; ZOOPLANKTON; BENZPYRENE; DEPURATION; PACIFIC COAST; ARCTIC; AROMATIC HYDROCARBONS; NAPTHALENE; RADIOACTIVE TRACERS; CALANUS
0611 UPTAKE; MYTILUS; CONTENT ANALYSIS; DEPURATION; RETENTION; MUSSEL; RADIOACTIVE TRACERS; AROMATIC HYDROCARBONS; PARAFFINS
0613 UPTAKE; FISH; NAPTHALENE; BENZ(A)PYRENE; RADIOACTIVE TRACER; METABOLISM; DISCHARGE; SCULPIN; OLIGOCOTTUS; GOBY; GILLICHTHYS; SAND DAB; CITHARICHTHYS
0727 UPTAKE; BARNACLES; TAR BALL; CONTENT ANALYSIS; METABOLISM; DEPURATION
0837 UPTAKE; MONITORING; PETROLEUM HYDROCARBONS

0758 UPTAKE; CLAMS; DEPURATION; CONTENT ANALYSIS; CRUDE OIL; FUEL OIL #2;
SOLUBLE FRACTIONS; GAS CHROMATOGRAPHY

0759 UPTAKE; BENZ(A)PYRENE; DEPURATION; DISTRIBUTION; RADIO ASSAY; RANGIA;
CLAMS

0952 UPTAKE; OIL; ACCUMULATE; RATE OF ENTRY; MYA ARENARIA; MUCUS BINDING;
DROPLETS; OIL DYE

0923 UPTAKE; TAINTING; MULLET; MUGIL; KEROSENE; GAS LIGUID CHROMATOGRAPHY;
GAS CHROMATOGRAPHY- MASS SPECTROSCOPY; INFRA RED SPECTROSCOPY;
RADIOACTIVE TRACERS; PROTON MAGNETIC RESONANCE SPECTROSCOPY

0943 UPTAKE; NAPTHALENE; WATER SOLUBLE FRACTION; CHLAMYDOMONAS;
PHOTOSYNTHESIS; GREEN ALGAE; DEPURATION

0958 UPTAKE; MEMBRANE DAMAGE; METABOLIC PATHWAYS; ENZYNE INDUCTION;
CELL INTEGRITY

0881 UPTAKE; POLYCHAETE; NEANTHES; RADIOACTIVE TRACER EXPERIMENT;
RETENTION; METABOLISM; DEPURATION; WATER SOLUBLE FRACTION; WATER;
SEDIMENT; DETRITUS

1004 UPTAKE; OYSTER; CRASSOSTREA; RETENTION; DEPURATION;
PETROLEUM HYDROCARBONS

0960 UPTAKE; OYSTER; CRASSOSTREA; RETENTION; DEPURATION;
PETROLEUM FRACTIONS; LIPIDS; FAT CONTENT; METABOLISM

1125 UPTAKE; REVIEW; SUBLETHAL EFFECTS; TOXICITY; RETENTION; DEPURATION;
METHODS OF DETECTION OF HC'S IN ORGANISM; BIOINDICATORS

1161 UPTAKE; POLYNUCLEAR AROMATIC HYDROCARBONS; ESTUARINE; RETENTION;
DEPURATION; BENTHIC ORGANISMS; SHELLFISH; BENZOPYRENE

1143 UPTAKE; SOFT-SHELL CLAM; FUEL OIL; RETENTION; DEPURATION; BURROWING;
MORTALITY; SEARSPORT-MAINE

1137 UPTAKE; AUSTRALIA; RETENTION; DEPURATION; GAS CHROMATOGRAPHY;
MYTILUS; MUSSEL; EFFECT ON ECOSYSTEM; BIOINDICATORS; TOXICITY

1126 UPTAKE; NAPHTHALENE; METHODS OF DETECTION OF HC'S IN ORGANISM;
SIPUNCULID WORM; SPECTROPHOTOMETRY; PHASCOLOSOMA;
PRUDHOE BAY CRUDE OIL

1133 UPTAKE; FUEL OIL; CRASSOSTREA; QUAHOG; ESTUARINE; ALIPHATICS;
MERCENARIA; CLAMS; OYSTERS; RETENTION; DEPURATION

1212 UPTAKE; SHRIMP; LARVAL GROWTH; DEPURATION; FUEL OIL #2;
HATCHING SUCCESS; BEHAVIORAL EFFECTS

1197 UPTAKE; PRUDHOE BAY CRUDE OIL; NAPHTHALENE; CLAMS; MACOMA; SEDIMENTS

1181 UPTAKE; CONTINENTAL SHELF; CRABS; CALIFORNIA; OFFSHORE PLATFORMS;
ANALYSIS FOR HYDROCARBONS

1206 UPTAKE; CLAM; MYA; FUEL OIL #2; RETENTION; DEPURATION

1169 UPTAKE; CRABS; WEST FALMOUTH SPILL; MORTALITY; BEHAVIOR; BURROWING;
TOXICITY; FUEL OIL; CRAB-SALT MARSH; MASS.

1186 UPTAKE; BENZOPYRENE; CLAMS; MUSSELS; OYSTERS; OREGON; ESTUARINE;
AROMATIC HYDROCARBONS; CARCINOGENS; MOLLUSCS

1175 UPTAKE; CRUDE OIL; ALGAE; ZOOPLANKTON; CRUSTACEANS; POLYCHAETES;
MOLLUSCS; FISH; RETENTION; DEPURATION; REVIEW; BENTHIC ORGANISMS

0871 UPTAKE & DEPURATION; SALMON, PINK; PRUDHOE BAY CRUDE;
COOK INLET CRUDE; FUEL OIL#2; WATER SOLUBLE FRACTION; RESPIRATION;
COUGHING

1149 UPTAKE & DEPURATION; TEMPERATURE; SALINITY; NAPHTHALENE; CLAMS;
SOUTHERN LOUISIANA CRUDE OIL; CLAM-BOREAL; CLAM-TEMPERATURE

1219 UPTAKE & DEPURATION; CRUDE OIL; SEDIMENTS; WASHINGTON;
INTERTIDAL ZONE; ASSESSMENT OF SPILLS; BENTHIC ORGANISMS;
PUGET SOUND; RECRUITMENT

1145 UPTAKE & INGESTION; NORMAL WELLS CRUDE OIL; SEALS; ARCTIC;
RINGED SEALS; BENZENE; NAPHTHALENE; PATHOLOGICAL EFFECTS

0762 UPTAKE &DEPURATION; RANGIA; CRASSOSTREA; FUNDULUS; PENAEUS
0884 UPTAKE &DEPURATION; FUEL OIL #2; NAPHTHALENE; ANNELIDS; POLYCHAETE;
NEANTHES; DEVELOPMENT; MALE; FEMALE; EGGS; LARVAE
1146 UPTAKE &EXCRETION; RINGED SEALS; NORMAL WELLS CRUDE OIL;
EFFECTS ON ORGANISMS; SEALS
0029 UPTAKE AND DEPURATION; PETROLEUM HYDROCARBONS; CLAMS; OYSTERS
0035 UPTAKE AND DEPURATION; ESTUARINE ANIMALS; TOXICITY; RESPIRATION;
SOUTH LA. CRUDE; KUWAIT CRUDE; FUEL OIL #2; BUNKER C; MINNOW;
GRASS SHRIMP,PALAEMONTES; BROWN SHRIMP,PANAEUS;
WATER SOLUBLE FRACTION; OIL WATER DISPERSION; NAPHTHALENES
0037 UPTAKE AND DEPURATION; OYSTERS; GROWTH; CRASSOSTREA;
ANALYSIS FOR HYDROCARBONS
0033 UPTAKE AND DEPURATION; SHRIMP; FISH; MOLLUSKS; FUEL OIL;
NAPHTHALENES
0036 UPTAKE AND DEPURATION; OYSTERS; GALVESTON BAY, TEXAS;
ANALYTICAL METHODS (UV,GC); ANALYSIS FOR HYDROCARBONS; CRASSOSTREA;
GULF OF MEXICO
0448 UPTAKE AND DEPURATION; COD; SWEDEN; NONYPHENIL ETHOXYLATE;
PHYSIOLOGICAL
0605 UPTAKE AND DEPURATION; TOXICITY; OFFSHORE PRODUCTION;
FOOD CHAIN ACCUMULATION
0655 UPTAKE AND DEPURATION; PHSIOLOGICAL EFFECTS; SALMON; FLATFISH;
SPOTTED SHRIMP; HISTOPATHOLOGY
0487 UPTAKE/DEPURATION; NAPHTHALENE; ACCUMULATION; COPEPOD; RADIOACTIVE;
LONG TERM EXPOSURE; LOW LEVEL CONCENTRATIONS; MARINE ZOOPLANKTON;
PERSISTENT EXPOSURE; CALANUS; EURYTEMORA
0040 URONEMA; KUWAIT CRUDE; PROTOZOAN CILIATES; EUPLOTES; NEMATODE;
INGESTION
1208 URQUIOLA SPILL; SPAIN; PERSIAN GULF CRUDE OIL; BENTHIC MACROFAUNA;
FISH; SPARTINA; TOXICITY
0375 UV; PETROLEUM; HYDROCARBON; CONTENT ANALYSIS; MARINE ORGANISMS;
CHROMATOGRAPHY-COLUMN GAS,THIN LAYER; SPECTROMETRY; IR
0786 UV ABSORPTION; TAINTING; JAPANESE COAST; FISH; EELS;
GAS CHROMATOGRAPHY; IR ABSORPTION; MASS SPECTRUM; TOLUENE;
MIZUSHIMA, JAPAN; AROMATIC HYDROCARBONS; GASOLINE
1016 UV FLUORESCENCE; SEDIMENTS; HYDROCARBON ANALYSIS; CHROMATOGRAPHY;
MASS SPECTROMETRY; PETROLEUM
0354 UV SPECTRA; OYSTERS; CRASSOSTREA; HYDROCARBON CONTENT; GALVESTON BAY;
COLUMN CHROMATOGRAPHY; TLC; MASS SPECTA
0953 VACUOLATION; FUEL OIL#2; SOFT SHELL CLAM; MYA; EMULSION;
TISSUE ABERRATIONS; HISTOPATHOLOGY; EDEMA; GLYCOGEN
0062 VALDEZ; ARCTIC; MICROORGANISMS; PRUDHOE BAY; UMIAT; NATURAL SEEPAGES;
ALASKA -PRUDHOE BAY; CAPE SIMPSON
0874 VALDEZ; BIODEGRADATION; ALASKA; TEMPERATURE; SALINITY; MORTALITY;
CHEMOTAXIS; COOK INLET
0346 VANCOUVER HARBOR; MYTILUS; MONITORING; MUSSELS; BENZO(A)PYRENE;
CARCINOGEN; CREOSOTED
0323 VAPOR ANALYSIS; TAINTING; FISH; YELLOWTAIL; CRUDE OIL; SERIOLA;
GAS CHROMATOGRAPHY
0101 VASCULAR PLANTS; CRUDE OIL; POND; ARCTIC; PHYSICAL PARAMETERS;
PHYTOPLANKTON; CHIRONOMID; AQUATIC; PRUDHOE CRUDE OIL;
ARCTIC -TUNDRA; ALASKA- BARLOW; BENTHIC ORGANISMS; PLANKTON
1141 VASCULAR PLANTS; TAINTING; DISTILLATES; HADDOCK; POTATO
0109 VENEZUELA; OFFSHORE PRODUCTION; FISHERIES; LAKE MARACAIBO;
NATURAL SEEPS

1079 VENEZUELA CRUDE OIL; LOBSTER; HOMARUS; LARVAE; TOXICITY; BEHAVIOR; GROWTH; FOOD CONSUMPTION; DISPERSIONS
0444 VENEZUELAN CRUDE; PHYTOPLANKTON; PHOTOSYNTHESIS; BEDFORD BASIN, NOVA SCOTIA; NORTH WESTERN ATLANTIC; FUEL OIL#2; FUEL OIL#6
0047 VENEZUELAN CRUDE OIL; TAY RIVER; BIRDS
0573 VENEZUELAN CRUDE OIL; TOXICITY; GREEN SEA URCHIN; BEDFORD BASIN NOVA SCOTIA; OIL SPERSE
0749 VENEZUELEN CRUDE; PUERTO RICO; ZOE COLOCUTRONIS; MANGROVE PROP COMMUNITY; TURTLE GRASS COMMUNITY; SEDIMENTS; HYDROCARBON ANALYSIS; TROPICAL
0809 VERTICAL DISTRIBUTION; BACTERIAL DEGRADATION; SILICA GEL; MICROORGANISMS
0027 VESSEL SOURCE; REVIEW; ECOLOGICAL EFFECTS; TRAUMATIC OIL POLLUTION
0365 VOLATILITY; OUTBOARD OPERATION; TAINTING; DEGRADATION; WEATHERING
1155 VULNERABILITY INDEX; COASTAL ENVIRONMENT; ALASKA; HYPOTHETICAL SPILLS; COOK INLET
0320 WAFRA SPILL; INTERTIDAL; FISH TAINTING; SOUTH AFRICA; INTERTIDAL INVERTEBRATES
0319 WAFRA SPILL; INTERTIDAL; SOUTH AFRICA
0442 WAKE IS.; R.C. STONER; REEF COMMUNITY; FISH
0080 WALES; SALT MARSH; CLEANING OF CRUDE OIL SPILL; MILFORD HAVEN; PEMBROKESHIRE
0090 WALES; BEHAVIOR; ECOSYSTEMS; REFINERY EFFLUENTS
1219 WASHINGTON; CRUDE OIL; SEDIMENTS; INTERTIDAL ZONE; UPTAKE & DEPURATION; ASSESSMENT OF SPILLS; BENTHIC ORGANISMS; PUGET SOUND; RECRUITMENT
0249 WASHINGTON COAST; GENERAL M.C. MEIGS SPILL; CHRONIC; SURVEYS; HYDROCARBON CONTENT; INTERTIDAL; FUEL OIL-NAVY SPECIAL; SEA URCHINS; STRONGYLOCENTRUS
0255 WASHINGTON STATE; HYDROCARBON UPTAKE; COMMUNITIES; INTERTIDAL; FUEL OIL-NAVY SPECIAL; GENERAL M.C. MEIGS SPILL
0207 WASTE; MERCENARIA; TOXICITY; EMBRYOS; LARVAE; WATER SOLUBLE FRACTION; CRUDE; REFINED; GROWTH
0256 WASTE DISCHARGE; KELP; FUEL OIL
0367 WASTE OIL; SHORT TERM IMPACT; FUTURE STUDY RECOMMENDATIONS
0619 WASTE OIL; BALTIC; BIRDS; MORTALITIES
0469 WATER; BIODEGRADATION; BACTERIA; DISTRIBUTION; OIL-OXIDIZING BACTERIA; NORTH SEA; ABUNDANCE; SEDIMENT
0708 WATER; PURIFICATION; BLACK SEA; DEGRADATION; SEDIMENTS; BACTERIA
0881 WATER; POLYCHAETE; NEANTHES; RADIOACTIVE TRACER EXPERIMENT; UPTAKE; RETENTION; METABOLISM; DEPURATION; WATER SOLUBLE FRACTION; SEDIMENT; DETRITUS
1056 WATER; DEGRADATION; BACTERIA; FUNGUS; CLADOSPORIUM; SEDIMENTS; CHESAPEAKE BAY; HYDROCARBON CONCENTRATION
1007 WATER; LAKE MARACAIBO, VENEZUELA; FISHERIES; SEDIMENTS; BIOTA; HYDROCARBON CONTENT ANALYSIS; TOXICITY
1057 WATER; DEGRADATION; SEDIMENTS; CHESAPEAKE BAY; CLADOSPORIUM
0271 WATER ACCOMODATED FRACTION; MYTILUS; MUSSELS; STARFISH; ASTERIS; RESPIRATION; FEEDING; REPRODUCTION; BYSSAL THREAD PRODUCTION; FUEL OIL #2
0751 WATER BASE; TOXICITY; INTERTIDAL; BALTIC SEA; LITTORAL ZONE; COREXIT; BEROL; BP1100; OIL BASE; SOLVENT
0443 WATER COLUMN; OIL SPILL, EXPERIMENTAL; HYDROCARBON ANALYSIS; SEDIMENT; FLUORESCENCE SPECTROSCOPY; TAR BALLS

0672 WATER COLUMN; OFFSHORE DRILLING; SPILL INCIDENT; MISSISSIPPI DELTA; SEDIMENT; WEATHERING; MIGRATES IN SEDIMENTS; DIVERSITY; POPULATIONS; SHRIMP; BLUE CRABS; BENTHIC ORGANISMS

0935 WATER COLUMN; CRUDE OIL; LAKES; ARCTIC; MACKENZIE DELTA; SEDIMENTS; ZOOBENTHOS; DEGRADATION

0910 WATER COLUMN; BIODEGRADATION; HEXADECANE; RADIOACTIVE TRACER; TOKYO BAY; BACTERIA

1050 WATER COLUMN; DEGRADATION; BACTERIA; MOTOR OIL; TREATMENT EFFLUENT; DISTRIBUTION; SEDIMENTS

0212 WATER HARDNESS; NAPHTHENIC ACID; TOXICITY; BLUEGILL SUNFISH; POND SNAIL; TEMPERATURE

0999 WATER QUALITY; CRUDE OIL; PETROLEUM PRODUCTS; FISH; AQUATIC LIFE &WILDLIFE

0105 WATER SAMPLERS; MONITORING INSTRUMENTS; SAMPLERS; BIOLOGICAL SAMPLERS; SEDIMENT SAMPLERS

0777 WATER SOLUBLE EXTRACTS; SAND DOLLAR; KUWAIT CRUDE; FUEL OIL #2; SPERM; EGG; RESPIRATION; MOBILITY OF SPERM; FERTILIZATION; CLEAVAGE; LARVAL DEVELOPMENT

0035 WATER SOLUBLE FRACTION; ESTUARINE ANIMALS; UPTAKE AND DEPURATION; TOXICITY; RESPIRATION; SOUTH LA. CRUDE; KUWAIT CRUDE; FUEL OIL #2; BUNKER C; MINNOW; GRASS SHRIMP,PALAEMONTES; BROWN SHRIMP,PANAEUS; OIL WATER DISPERSION; NAPHTHALENES

0034 WATER SOLUBLE FRACTION; OIL IN WATER DISPERSION; CRUSTACEANS; FISH; TOXICITY; ESTUARINE; SOUTH LA. CRUDE; KUWAIT CRUDE; FUEL OIL #2; BUNKER C; CYPRINODON; MENIDIA; FUNDULUS; PENAEUS; PALEOMONETES; MYSIDOPSIS

0014 WATER SOLUBLE FRACTION; SEA URCHIN; FERTILIZATION; DEVELOPMENT; EGGS

0207 WATER SOLUBLE FRACTION; MERCENARIA; TOXICITY; EMBRYOS; LARVAE; CRUDE; REFINED; WASTE; GROWTH

0123 WATER SOLUBLE FRACTION; COPEPOD; REPRODUCTION; NAPHTHALENE; EURYTEMORA; EGG PRODUCTION; HEATING OIL

0213 WATER SOLUBLE FRACTION; TOXICITY; COOK INLET CRUDE OIL; BENZENE

0183 WATER SOLUBLE FRACTION; ALASKA; SHRIMP; COON-STRIPE SHRIMP; KING CRABS; COOK INLET CRUDE; TOXICITY; BIOASSAY; STATIC

0277 WATER SOLUBLE FRACTION; COPEPOD; UPTAKE; DEPURATION; NAPHTHALENE; METABOLISM; CALANUS; FOOD WEB; DIETARY ROUTE OF ENTRY; RADIOACTIVE TRACERS

0370 WATER SOLUBLE FRACTION; FUNDULUS; FUEL OIL#2; HATCHING; DEVELOPMENT; HISTOPATHOLOGY

0414 WATER SOLUBLE FRACTION; TROUT; OVA; ALEVINS

0465 WATER SOLUBLE FRACTION; BUNKER C; CRAB; SAN FRANCISCO BAY; PACHYGRAPSUS

0453 WATER SOLUBLE FRACTION; CRUDE OIL; REFINED OIL; TOXICITY; BACTERIA; AROMATIC HYDROCARBONS; WEATHERING; GROWTH RATE; MAXIMUIM CELL DENSITY

0541 WATER SOLUBLE FRACTION; NASSARIUS; CHEMOTAXIS; KEROSENE; CHEMORECEPTION

0615 WATER SOLUBLE FRACTION; FUEL OIL #2; ZOOPLANKTON COASTAL; ZOOPLANKTON OCEANIC; TOXICITY; BEHAVIOR

0529 WATER SOLUBLE FRACTION; BIOASSAY; CONTINUOUS FLOW; TOXICITY; SUBLETHAL EFFECTS; WHOLE OIL FRACTION; MINNOW; FLOUNDER; SHRIMP; SCALLOP; QUAHOG; MUSSEL; MUD SNAIL

0595 WATER SOLUBLE FRACTION; TOXICITY; EGGS; LARVAE; COD; BUNKER C; HATCHING SUCCESS

0593 WATER SOLUBLE FRACTION; COD; HERRING; EGGS; LARVAE

0614 WATER SOLUBLE FRACTION; TOXICITY; ARCATIA; SPHAEROMA; AMPHITHOE;
FUEL OIL
0616 WATER SOLUBLE FRACTION; TOXICITY; FUEL OIL #2; CRUDE; AMPHIPODS;
BREEDING
0640 WATER SOLUBLE FRACTION; OYSTERS; FILTERING RATE; BLEED WATER;
CRUDE OIL
0780 WATER SOLUBLE FRACTION; FUEL OIL #2; PHYTOPLANKTON; TOXICITY
0871 WATER SOLUBLE FRACTION; SALMON, PINK; PRUDHOE BAY CRUDE;
COOK INLET CRUDE; FUEL OIL#2; RESPIRATION; COUGHING;
UPTAKE & DEPURATION
0883 WATER SOLUBLE FRACTION; TOXICITY; FUEL OIL #2; POLYCHAETE; NEANTHOS;
LARVAE
0881 WATER SOLUBLE FRACTION; POLYCHAETE; NEANTHES;
RADIOACTIVE TRACER EXPERIMENT; UPTAKE; RETENTION; METABOLISM;
DEPURATION; WATER; SEDIMENT; DETRITUS
0943 WATER SOLUBLE FRACTION; NAPTHALENE; CHLAMYDOMONAS; PHOTOSYNTHESIS;
GREEN ALGAE; UPTAKE; DEPURATION
0885 WATER SOLUBLE FRACTION; FUEL OIL # 2; NEANTHES; POLYCHAETE;
HEMOGLOBIN; HYPOXIA; SOUTH LOUISIANA CRUDE; DISSOLVED OXYGEN;
TOXICITY; SYNERGISM; NAPHTHALENES; DISSOLVED HYDROCARBONS;
RESPIRATION
0942 WATER SOLUBLE FRACTION; CRUDE OIL; NAPTHALENE; CHLAMYDOMONAS;
TOXICITY; GROWTH
0882 WATER SOLUBLE FRACTION; TOXICITY; POLYCHAETES; CRUDE; NAPHTHALENE;
BUNKER C; FUEL OIL #2; NEANTHES; CAPITELLA; SOUTH LOUISIANA CRUDE;
KUWAIT
0941 WATER SOLUBLE FRACTION; CRUDE OIL; NAPHTHALENE; GREEN ALGAE;
PHYSIOLOGY; MORPHOLOGY; FRESHWATER
0886 WATER SOLUBLE FRACTION; KUWAIT CRUDE; SOUTH LOUISIANA CRUDE;
FUEL OIL # 2; BUNKER C; TOXICITY; NAPHTHALENE; NEANTHES; CAPITELLA
0998 WATER SOLUBLE FRACTION; CRUDE OIL; PRODUCERS; CHEMORECEPTION;
SUBLETHAL EFFECTS; INHIBITORS
1011 WATER SOLUBLE FRACTION; SALMON; PRUDHOE BAY CRUDE OIL;
RESPIRATORY RATE; STRESS
1085 WATER SOLUBLE FRACTION; CRUDE OIL; FISH; TOXICITY
1095 WATER SOLUBLE FRACTION; MICROALGAE; HYDROCARBON ANALYSIS;
GAS CHROMATOGRAPHY; MASS SPECTROMETRY; BAYTOWN; MONTANA; BATON ROUGE;
NEW JERSEY
0125 WATER SOLUBLE FRACTIONS; GASOLINE FRACTIONS; TOLUENE; XYLENE;
BENZENE; TOXICITY; MOSQUITO LARVAE; AEDES AEGYPTI
0570 WATER SOLUBLE FRACTIONS; CRUDE OIL; CHLORELLA; GROWTH RATES;
TOXICITY; STIMULATION
0807 WATER SOLUBLE FRACTIONS; CRUDE OIL; MICROALGAE; GROWTH RATE;
HYDROCARBON ANALYSIS; SEDIMENTS; WATERS; BIOTA;
SOUTH TEXAS OUTTER CONTINENTAL SHELF
0493 WATERFOWL; OIL; TOXICOLOGY
0522 WATERFOWL; DETROIT RIVER
0523 WATERFOWL; WATERFOWL; MICHIGAN
0717 WATERFOWL; BIRDS; MORTALITIES; SAN FRANCISCO SPILL-1937; GULLS
1224 WATERFOWL; OIL SPILLS; REPRODUCTION; REVIEW; MALLARDS; EGGS
0013 WATERFOWL RESTORATION; TOXICITY; REVIEW-OIL SPILLS; AERIAL SURVEYS;
DISPERANTS AND EMULSIFIERS
0807 WATERS; WATER SOLUBLE FRACTIONS; CRUDE OIL; MICROALGAE; GROWTH RATE;
HYDROCARBON ANALYSIS; SEDIMENTS; BIOTA;
SOUTH TEXAS OUTTER CONTINENTAL SHELF

1094 WAVELENGTH DEPENDENT; FUEL OIL #2; ALGAE; TOXICITY; PHENALEN-1-ONE; ALGAE-BLUE GREEN; ALGAE -GREEN; DIATOMS
0171 WEARING; PLUMAGE; GUILLEMOTS
0163 WEATHER; BIRDS; OIL; BREEDING; DISTRIBUTION; STRANDINGS
0138 WEATHER; CRUDE OIL; FATE; MICROBIAL DEGRADATION; BIOLOGICALLY ACTIVE FRACTIONS; MARTHA'S VINEYARD; BERMUDA
0121 WEATHERED OIL; SALT MARSH; YORK RIVER; ISOLATED ECOSYSTEM; SOUTH LA. CRUDE; PHYTOPLANKTON; FISH; PERIPHYTON; ATP; MARSH GRASS; BENTHIC FAUNA; POLYCHAETES; INSECT LARVAE; AMPHIPODS; OLIGOCHAETE
0955 WEATHERED OIL; SALT MARSH; PLANTS; DEGRADATION; GAS EXCHANGE; RETENTION; BRITTANY; TORREY CANYON
0146 WEATHERING; WEST FALMOUTH SPILL; IDENTIFICATION; HYDROCARBON CONTENT; SEDIMENTS; DEGRADATION; SHELLFISH; OYSTERS; BUZZARD BAY
0317 WEATHERING; DEGRADATION; CRUDE OIL; SEA WATER; AUTO OXIDATION; BACTERIA
0281 WEATHERING; SALT MARSH; SPARTINA; PUCCINELLA; CHRONIC; RECOVERY; CORNWALL
0464 WEATHERING; SEDIMENTS; SAN FRANCISCO; DISPERSION; DISSOLUTION; MICROBIAL DEGRADATION; BUNKER C; SAND COLUMN DISTRIBUTION
0458 WEATHERING; CRUDE OIL; REFINED OIL; TOXICITY; BACTERIA; WATER SOLUBLE FRACTION; AROMATIC HYDROCARBONS; GROWTH RATE; MAXIMUIM CELL DENSITY
0365 WEATHERING; OUTBOARD OPERATION; TAINTING; DEGRADATION; VOLATILITY
0672 WEATHERING; OFFSHORE DRILLING; SPILL INCIDENT; MISSISSIPPI DELTA; WATER COLUMN; SEDIMENT; MIGRATES IN SEDIMENTS; DIVERSITY; POPULATIONS; SHRIMP; BLUE CRABS; BENTHIC ORGANISMS
0680 WEATHERING; DEGRADATION; CRUDE OIL; SANTA BARBARA; SEQUENCE OF DEGRADATION; GAS CHROMATOGRAPHY
0729 WEATHERING; TOXICITY; SALMON; OIL; TEMPERATURE; JUVENILE; STRESS BEHAVIOR
0818 WEATHERING; CRUSTACEA; BEHAVIOR; CRUDE OIL; SEDIMENTS; AMPHIPOD; ONISIMUS; AVOIDANCE
0846 WEATHERING; POLYCHAETE; ARENICOLA; BEHAVIOR; FEEDING
0916 WEATHERING; REVIEW; TYPES OF OILS; TOXICITY; FISHERIES; DISPERSANTS; MARINE ENVIRONMENT
1184 WEATHERING; FUEL OIL #2; TOXICITY; AMPHIPODS; TEMPERATURE
1118 WEST AFRICA; HYDROCARBONS; CHLOROPHYLL-A CORRELATION WITH; PHYTOPLANKTON; BIOGENIC VS. PETROLEUM
0012 WEST COAST U.S.; SPILLS; BIRDS; SAN FRANCISCO BAY; FRANK BUCK - TANKER SPILL (1937)
0302 WEST CORK, IRELAND; MECHANICAL DAMAGE; BEACHES
0145 WEST FALMOUTH OIL SPILL; RECOVERY; BUZZARD BAY; HYDROCARBON CONTENT ANALYSIS
0144 WEST FALMOUTH OIL SPILL; DEGRADATION; BACTERIA; SEDIMENTS; PERSISTANCE; BUZZARD BAY
0148 WEST FALMOUTH OIL SPILL; SEDIMENTS; OYSTERS; SCALLOPS; BIODEGRADATION; TOXICITY; CONTENT ANALYSIS; BUZZARD BAY; GAS CHROMATOGRAPHY
0898 WEST FALMOUTH OIL SPILL
1200 WEST FALMOUTH OIL SPILL; MASS.; MACROBENTHOS; CAPITELLA; POPULATION; POPULATION DYNAMICS
1080 WEST FALMOUTH OIL SPILL 1969; WEST FALMOUTH, MASS.; FUEL OIL #2; ECOLOGICAL IMPACT; RECOVERY
0142 WEST FALMOUTH SPILL; FUEL OIL #2; PERSISTANCE; MORTALITIES; OYSTERS
0146 WEST FALMOUTH SPILL; WEATHERING; IDENTIFICATION; HYDROCARBON CONTENT;

SEDIMENTS; DEGRADATION; SHELLFISH; OYSTERS; BUZZARD BAY
0899 WEST FALMOUTH SPILL; BENTHOS; FUEL OIL #2; SPECIES DIVERSITY
1169 WEST FALMOUTH SPILL; CRABS; MORTALITY; UPTAKE; BEHAVIOR; BURROWING; TOXICITY; FUEL OIL; CRAB-SALT MARSH; MASS.
1080 WEST FALMOUTH, MASS.; WEST FALMOUTH OIL SPILL 1969; FUEL OIL #2; ECOLOGICAL IMPACT; RECOVERY
0688 WEST FALMOUTH, WILD HARBOR, MASS.; FUEL OIL#2; BENTHIC FAUNA; SEDIMENTS; HYDROCARBON CONTENT; OPPORTINUSTIC SPECIES; RECOVERY; GAS CHROMATOGRAPHY; DIVERSITY; POPULATIONS
0202 WEST FALMOUTH,MASS; SALT MARSH ECOSYSTEM; CONTENT ANALYSIS; FOOD CHAIN CONCENTRATION; FUEL OIL #2; HYDROCARBON CONTENT
0405 WEST TEXAS; TOXICITY; FUNDULUS; PIMEPHALES; ARTEMIA; KUWAIT; MARINE DIESEL; FUEL OIL; LUBE OIL
1119 WESTERN ATLANTIC; HYDROCARBON; CHLOROPHYLL; FEED BACK
0625 WESTERN NORTH ATLANTIC; CHEDABUCTO BAY,NOVA SCOTIA; ARROW SPILL; BUNKER C; RECOVERY
0151 WETLANDS; CHRONIC OIL POLLUTION; COASTAL ECOSYSTEM; SUBLETHAL EFFECTS; METABOLISM; BEHAVIOR; FOOD CHAIN MAGNIFICATION; ESTUARIES
1099 WETTING; MUSKRATS; OIL; MARSH SPRAY; DDT
0194 WHALES; DOLPHINS; MORTALITIES
0002 WHITEFISH; FISH; TAINTING; ANALYSIS FOR PETROLEUM HYDROCARBONS
1116 WHITING; BIODEGRADATION; BACTERIA; SEDIMENTS; BARATARIA BAY; ANAEROBIC; BENZ(A)PYRENE; ACCUMULATION; MYTILUS; PICKEREL
0529 WHOLE OIL FRACTION; BIOASSAY; CONTINUOUS FLOW; TOXICITY; SUBLETHAL EFFECTS; WATER SOLUBLE FRACTION; MINNOW; FLOUNDER; SHRIMP; SCALLOP; QUAHOG; MUSSEL; MUD SNAIL
0215 WILDLIFE; TANKER SINKINGS; WW 2; ECONOMY
1010 WINTER; CHEDEBUCTO BAY, NOVA SCOTIA; BUNKER C; MORTALITIES; INTERTIDAL; ARROW SPILL; CHRONIC POLLUTION; FUCUS; MYA; SPARTINA
1014 WINTER FLOUNDER; ARGO MERCHANT SPILL; YELLOW TAIL FLOUNDER; MODIOLUS; PLACOPECTEN; RESPIRATORY ENZYMES; MALIC DEHYDROGENASE; OSMOLALITY; PYRUVATE REDUCTION; ANAEROBIOSIS
0437 WINTER QUARTERS; BIRDS; POPULATIONS; MIGRATION; BREEDING
0023 WORKSHOP; ECOLOGICAL IMPACT; ASSESSMENT TECHNIQUES REVIEW; OIL SPILL STRATEGIES AND TECHNIQUES
0781 WORKSHOP; INPUTS, FAT EFFECTS; PETROLEUM.
0122 WORKSHOP PROCEEDINGS; TOXICITY
0756 WORKSHOP-POLLUTANTS
0810 WORLD WAR 2 OIL POLLUTION; BIRDS; BREEDING COLONIES; OIL; GUILLEMOTS; PUFFINS
0215 WW 2; TANKER SINKINGS; WILDLIFE; ECONOMY
0826 WW2 TANKER SINKINGS; BIRDS; OIL; TREATMENT
0959 XENOBIOTIC METABOLISMS; METABOLISM; INTERMEDIARY METABOLISM; LIPOGENISIS; FUNDULUS; STENOTOMUS; MIXED -FUNCTION OXIDASES
0125 XYLENE; GASOLINE FRACTIONS; TOLUENE; BENZENE; TOXICITY; MOSQUITO LARVAE; AEDES AEGYPTI; WATER SOLUBLE FRACTIONS
0179 XYLENE; TOXICITY; OUTBOARD MOTOR EXHAUST; GOLDFISH; CONTINUOUS FLOW BIOASSAY; CARASSINS; TOLUENE; TRIMETHYLBENZENE
0350 XYLENE; PHYTOPLANKTON; AMPHIDINIUM; SKELETONEMA; CRICOSPHAERA; DUNALIALLA; BENZENE; TOLUENE; FUEL OIL#2; GROWTH
0571 XYLENE; PHYTOPLANKTON; CRUDE OIL; FIELD EXPERIMENT; INHIBITED; STIMULATION; LABORATORY STUDIES; TOXICITY; PH; FRACTIONS; BENZENE; TOLUENE
0572 XYLENE; FRESH WATER; CHLORELLA VULGARIS; ALGAE; TOXICITY; GROWTH;

PHOTOSYNTHESIS; BENZENE; TOLUENE; NAPTHALENE
1051 XYLENE; DEGRADATION; CLADOSPORIUM; OXYGEN CONSUMPTION; COOXIDATION; TOLUENE; HEXADECANE
1150 XYLENE; BIODEGRADATION; AROMATIC PETROLEUM PRODUCTS; MICROORANISMS; BACTERIA; NOCARDIA
0008 YEAST; MOLDS; FUNGAL ECOLOGY; BIODEGRADATION; UPTAKE
0063 YEAST; MICROBIAL POPULATIONS; PROTOZOANS; BLUE GREEN ALGAE; DIATOMS; DEGRADATION; SPECIES DIVERSITY; GREEN ALGAE; NATURAL SEEPAGE; PRUDHOE CRUDE OIL; ARCTIC; ALASKA-PRUDHOE BAY; CAPE SIMPSON; NUTRIENT ENRICHMENT
0006 YEAST; BIODEGRADATION; GUPPY; LOUISIANA CRUDE OIL; FUNGI
0009 YEAST; LOUISIANA CRUDE; BIODEGRADATION; TRICHOSPORON
0314 YEAST; DEGRADATION; BACTERIA; ACTINOMYCETES; FILAMENTOUS FUNGI; PHYCOMYCETES
0586 YEAST; TAXONOMY; DEGRADATION; HYDROCARBONS
0554 YEAST; OXIDATION; TORULOPSIS; METABOLIC PATHWAYS; ALKANES; GLYCOLIPIDS
0638 YEAST; ULTRASTRUCTURE; CANDIDA
0623 YEAST; MARSEILLE, FRANCE; CANDIDA; TORULOPSIS
0963 YEAST; BIODEGRADATION; GAS CHROMATOGRAPHY; TEMPERATURE; ACID PRODUCTION; SUBSTRATE SELECTION
1053 YEAST; MICROORGANISMS; BACTERIA; FUNGI; CHESAPEAKE BAY; SUBSTRATE SELECTION
1113 YEAST; CRUDE OIL; DEGRADATION; BACTERIA; FUNGI; SUBSTRATE; DISTRIBUTION
1189 YEASTS; MICROORGANISMS; BACTERIA; FUNGI; BIODEGRADATION; CRUDE OIL; NIGERIA
1014 YELLOW TAIL FLOUNDER; ARGO MERCHANT SPILL; WINTER FLOUNDER; MODIOLUS; PLACOPECTEN; RESPIRATORY ENZYMES; MALIC DEHYDROGENASE; OSMOLALITY; PYRUVATE REDUCTION; ANAEROBIOSIS
0323 YELLOWTAIL; TAINTING; FISH; CRUDE OIL; VAPOR ANALYSIS; SERIOLA; GAS CHROMATOGRAPHY
0120 YORK RIVER; TOXICITY; BENTHIC ANIMALS; INTERTIDAL; DIVERSITY; RECOVERY; BUNKER C; FUEL OIL#6
0121 YORK RIVER; SALT MARSH; ISOLATED ECOSYSTEM; SOUTH LA. CRUDE; WEATHERED OIL; PHYTOPLANKTON; FISH; PERIPHYTON; ATP; MARSH GRASS; BENTHIC FAUNA; POLYCHAETES; INSECT LARVAE; AMPHIPODS; OLIGOCHAETE
0127 YORK RIVER; SALT MARSH; ESTUARY; SOUTH LA. CRUDE; HYDROCARBON ANALYSIS; CONTROLLED ECOSYSTEM; FUNDULUS; AROMATICS; GAS CHROMATOGRAPHY; GC-MS
0563 YORK RIVER; SALT MARSH; ESTUARY; BACTERIA; FUNGI; LOUISIANA CRUDE; SEDIMENTS; PETROLEUM DEGRADING
1044 YUKON; BIRDS
0195 ZALOPHUS; SEA LIONS; MORTALITY; SANTA BARBARA
0749 ZOE COLOCUTRONIS; PUERTO RICO; VENEZUELEN CRUDE; MANGROVE PROP COMMUNITY; TURTLE GRASS COMMUNITY; SEDIMENTS; HYDROCARBON ANALYSIS; TROPICAL
0935 ZOOBENTHOS; CRUDE OIL; LAKES; ARCTIC; MACKENZIE DELTA; WATER COLUMN; SEDIMENTS; DEGRADATION
1134 ZOOBENTHOS; ARCTIC; SUB ARCTIC; BAFFIN BAY; DAVIS STRAIT; LABRADOR SEA; ASSESSMENT OF SPILLS; PHYTOPLANKTON; ZOOPLANKTON; FISH; MAMMALS; BIRDS
0141 ZOOPLANKTON; TRACERS; PHYTOL; FISH; ANALYSIS FOR HYDROCARBONS; OLEFINS; FOOD CHAIN; BIOGENIC VS. PETROLEUM
0191A ZOOPLANKTON; ARGO MERCHANT SPILL; HISTOLOGY; LESIONS;

PEARL FORMATION; CANCER; MODIOLUS
0268 ZOOPLANKTON; ARROW SPILL; HYDROCARBON CONTENT; CHEDABUCTO BAY; BUNKER C; OIL INGESTION; SEDIMENTATION; FECES
0250 ZOOPLANKTON; PARAFFINS; ALGAE; PHYTOPLANKTON; SEDIMENT; PRISTANE; BIOGENIC; PETROLEUM
0278 ZOOPLANKTON; HYDROCARBONS; FISH; TOXICITY; TAINTING; BEHAVIOR; UPTAKE; METABOLISM; DEPURATION; ACCUMULATION
0486 ZOOPLANKTON; RETENTION; COPEPOD; CALANUS; EURYTEMORA; UPTAKE; DEPURATION
0397 ZOOPLANKTON; MID-ATLANTIC BIGHT
0608 ZOOPLANKTON; BENZPYRENE; UPTAKE; DEPURATION; PACIFIC COAST; ARCTIC; AROMATIC HYDROCARBONS; NAPTHALENE; RADIOACTIVE TRACERS; CALANUS
0728 ZOOPLANKTON; LIPIDS; SURFACE FILMS; HYDROCARBON CONCENTRATION
0700 ZOOPLANKTON; REVIEW-OIL POLLUTION; LARVAE; SUBLETHAL EFFECTS; PRODUCTIVITY; FISH; PHYTOPLANKTON; EGGS; BIRDS; PLAICE
0702 ZOOPLANKTON; TOXICITY; BLACK SEA; CRUDE OIL; MINERAL OIL; ACARTIA; PARACALANUS; PENILLIA; CENTROPAGES; OITHONA
0682 ZOOPLANKTON; CONTROLLED ECOSYSTEM; BACTERIAL POPULATIONS; PHYTOPLANKTON; CENTRATE DIATOMS
0675 ZOOPLANKTON; SANTA BARBARA SPILL
0641 ZOOPLANKTON; ESTUARIES; HYDROCARBON CONCENTRATIONS; SEDIMENTS; PHYTOPLANKTON; CRUDE OIL; SALT MARSH PLANTS; DIVERSITY; POPULATIONS; FISH; MIGRATION; GAS CHROMATOGRAPHY; DEGRADATION
0804 ZOOPLANKTON; CRUDE OIL; DEGRADATION; MARINE ENVIRONMENT; PHOTOCHEMICAL OXIDATION; SOLUBILITY; DISPERSION
0830 ZOOPLANKTON; ARGO MERCHANT SPILL
0904 ZOOPLANKTON; OUTBOARD ENGINE EXHAUST; SPECIES ABUNDANCE; DIVERSITY; PHYTOPLANKTON; PERIPHYTON; FISH; BEHAVIOR; POPULATION
0947 ZOOPLANKTON; TORREY CANYON SPILL; DEGRADATION; BACTERIA; LITTORAL; SUBLITTORAL; CLEAN UP
0856 ZOOPLANKTON; CONTROLLED ECOSYSTEM
1154 ZOOPLANKTON; COPEPODS; NAPHTHALENE; AROMATIC HYDROCARBONS; PHYSIOLOGICAL EFFECTS; RETENTION; DEVELOPMENT
1134 ZOOPLANKTON; ARCTIC; SUB ARCTIC; BAFFIN BAY; DAVIS STRAIT; LABRADOR SEA; ASSESSMENT OF SPILLS; PHYTOPLANKTON; ZOOBENTHOS; FISH; MAMMALS; BIRDS
1175 ZOOPLANKTON; CRUDE OIL; ALGAE; CRUSTACEANS; POLYCHAETES; MOLLUSCS; FISH; UPTAKE; RETENTION; DEPURATION; REVIEW; BENTHIC ORGANISMS
1204 ZOOPLANKTON; LOS ANGELES HARBOR; SANSINEA SPILL; PRODUCTIVITY; ASSESSMENT OF SPILLS; BIRDS; BENTHIC ORGANISMS; FISH; PHYTOPLANKTON
1202 ZOOPLANKTON; NORMAN WELLS & PEMBINA CRUDE OIL; ASSESSMENT OF SPILLS; MICROORGANISMS; BACTERIA; PROTOZOA; PHYTOPLANKTON; ANALYSIS FOR PETROLEUM HYDROCARBONS; CANADA
1176 ZOOPLANKTON; FUEL OIL# 2; SHRIMP; RESPIRATION; TOXICITY; FEEDING BEHAVIOR; MOBILITY; NAPHTHALENE; BENZENE; PHENOL
0615 ZOOPLANKTON COASTAL; WATER SOLUBLE FRACTION; FUEL OIL #2; ZOOPLANKTON OCEANIC; TOXICITY; BEHAVIOR
0615 ZOOPLANKTON OCEANIC; WATER SOLUBLE FRACTION; FUEL OIL #2; ZOOPLANKTON COASTAL; TOXICITY; BEHAVIOR
0149 ZOOPLANKTON POPULATION DYNAMICS; OUTBOARD ENGINE EMMISSIONS; PHYTOPLANKTON; SPECIES DIVERSITY; FIXATION; CHLOROPHYLL; BENTHIC MICROINVERTEBRATE COMMUNITY; GASOLINE

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