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AN ANNOTATED BIBLIOGRAPHY OF MARINE FOULING FOR MARINE SCIENTISTS AND ENGINEERS

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INTRODUCTION

This annotated bibliography was compiled to provide information and guidance to the marine scientist or engineer who must contend with those animals and plants which attach themselves to man-made underwater objects, i.e., fouling organisms. The references selected for this bibliography are those which help answer one or more of the following questions: What kind of fouling can I expect to find in various parts of the world?; What are the factors which tend to promote or discourage the settlement and growth of fouling organisms?; and What are the effects of this settlement and growth on the performance of coatings, sensors, and hardware?

Not included in this bibliography are several classified reports. Also not included are references to marine borers, antifouling investigations, microscopic fouling communities, or basic studies of individual foulers. The literature of marine biological deterioration is extensive and the task of in toto annotation would be monumental. An excellent annotated bibliography of marine borers has already been compiled by Clapp and Kenk and published by the U.S. Office of Naval Research.

Each reference is follow[ed by a] brief abstract or outline of pertinent inform[ati]on, ignoring all other subjects which may also be discussed. Information concerning substrate material, test site environment, dates, depths, and length of exposure are included if possible. Important organisms are sometimes noted but exhaustive listings are not attempted.

A geographic index, an index of those factors affecting settlement and growth, and an index of fouling effects are appended. References are listed in alphabetical order by auther.

There are undoubtedly references which have been overlooked. Users of this annotated bibliography are invited to report any omissions to John R. DePalma, U.S. Naval Oceanographic Office, Washington, D.C. 20390.

ALEEM, ANWAR ABDEL., 1957. Succession of marine fouling organisms immersed in deep water at La Jolla, California. Hydrobiologia, Vol. 11 (1): 40-58.

La Jolla, California; March 1955 to June 1955. Wood, plexiglass, vinyl acetate, glass, brass, zinc, stainless steel, and copper panels were hung vertically in a bottom rack at 45 feet Organisms listed; also relative occurrence and sequence of occurrence.

Author introduces an arbitrary system for rating severity of fouling. Different organisms, once settled, tend not to be eliminated from the community but simply to vary in abundance.

ALEXANDER, A. L. and others, 1957. Corrosion of metals in tropical environments. Part I - Test methods etc. Report #4929. U. S. Naval Research Laboratory, Washington, D C

Oxygen concentration cell formation under barnacles and other foulers resulted in pitting of steel panels exposed at a pier on the Pacific end of the Panama Canal. Slight to large losses of metal and variable loss of strength were noted, depending on the numbers and distribution of closely adhering organisms. Organic decomposition may contribute to corrosion rate by producing aggressive materials such as acids, etc.

ALLEN, F. E., 1950. Investigations of underwater fouling. III - Note on the fouling organisms attached to naval mines in North Queensland waters. Australian Journal of Marine and Freshwater Research, Vol 1 (1): 106-109

Six minecases moored off the northeast coast of Australia during 1942-1947 were examined for fouling. Corals, mollusks, and encrusting bryozoans were the most abundant forms.

ALLEN, F. E. and E. J. WOOD., 1950. The biology of fouling in Australia. II - Result of a years research. Australian Journal of Marine and Freshwater Research. Vol. 1:92-105.

Australia, northeast coast, 1946 to present. Glass and perspex panels were exposed

at pierside for various periods of time. Organisms listed, no quantitative data.
Authors found evidence of true succession in fouling communities.

ALLUMBAUGH, W. L., 1964. Coatings for steel pilings in sea water. Materials Protection, Vol. [illegible]
Damage to bituminous coatings by fouling organisms was found to be excessive. After thirty months exposure, barnacles had penetrated coal tar, resulting in a [illegible]0% removal of the coating.

ANDREWS, J. D., 1953. Fouling organisms of Chesapeake Bay. Interim report [illegible], Inshore Survey Program Chesapeake Bay Institute, Johns Hopkins University.
Chesapeak Bay. 1952. Fouling on caissons and oyster clutch was examined. Distribution, habitat, settling characteristics, growth, and age at maturity for each fouling species were discussed.
The lower salinity limit for most fouling organisms was found to be 12-15 ppt. In lower salinities fouling may be intense but is limited to a few species.

ANTONY RAJA, B. T., 1959. Studies on the distribution and succession of sedentary organisms of the Madras harbour. Journal of the Marine Biological Association of India, Vol. 1 (2):180-197.
Madras, India; 1953-1955. Various materials, including wood, were exposed for two week periods at several depths beside a pier. Organisms listed and volume of biomass measured by the displacement method.
Maximum fouling occurred three to seven feet below the surface and decreased progressively to the bottom (twelve feet).
Pollution may be partially correlated with greater settlement and growth.

ARBUZOVA, K. S., 1961. The effect of fouling macroorganisms on the corrosion of steel in the Black Sea. Trudy Instituta Okeanologii, Vol 49:266-273.
Pitting of steel under barnacle bases was found to be correlated with their loose attachment, as a result of which electrochemical processes begin. Oxygen, pH, and metabolites were thought to be of little or no consequence in the corrosion of steel.

ARBUZOVA, K.S., 1963. Marine fouling in the southeastern part of the Baltic Sea. Marine Fouling and Borers. Trudy Instituta Okeanologii, Vol LXX:41-51.
Baltic Sea, 1960-61. Buoys exposed in shallow water for seven and eight month periods were examined for fouling. Organisms listed and weight of biomass per unit of surface given.
Fouling in the Baltic Sea was found to be generally insignificant (2400 grams per square meter per eight months). Mytilus is climax dominant.

ARIAS, E. and E. MORALES, 1963. Ecologia del puerto de Barcelona y desarrollo de adherencias organicas sobre embarcaciones. Investigacion Pesquera Vol. 24:139-157.
Mediterranean coast of Spain, 1961 and continuing. Metal panels exposed at three pierside stations for varying periods of time. List of organisms and weight of biomass given. Temperature, salinity, oxygen, nutrients, and plankton data collected on site.
Sponsored by OECD.
See also Morales and Arias, 1965.

AYERS, J.C., 1951. The average rate of fouling of surface and submerged objects on the waters adjacent to New York harbor. Unpublished report to the U.S. Navy Office of Naval Research. Cornell University, Ithaca, New York.
New York harbor approaches; 1937-1940. Buoys moored in depths of 10 to 234 feet for various periods up to fourteen months were examined for fouling organisms. Weight and thickness of biomass were no. d.
Severity of fouling was found to decrease with depth and distance from shore (at least to sixty miles offshore).

BARHAM, E. G., 1961. Effects of marine biological environment on compliant grating acoustic lenses. Research Report #1018, U. S. Naval Electronics Laboratory, San Diego, California.
Off San Diego, California; 1959. Examined the fouling attached to an acoustic lens exposed from July to August in forty feet of water.
The effects of fouling were not directly ascertained but the supposition was that the sound projector and receiver suffered serious acoustic energy losses.
The dominant organisms were hydroids and solitary tunicates (soft-bodied forms).

BARNARD, J. L., 1958. Amphipod crustaceans as fouling organisms in Los Angeles - Long Beach harbors, with reference to the influence of seawater turbidity. California Fish and Game, Vol. 44:161-170.
Long Beach, California; 1950-1951. Wooden blocks were exposed at fifteen pierside locations for one month periods. Organisms listed and relative occurrence noted. Temperature, oxygen, and transparency data collected on site.
Study showed that even within harbors, distinct assemblages of fouling organisms can be correlated with water transparency (turbidity).
See also Mohr, 1952.

BARNES, H. and H. T. POWELL, 1950. Some observations on the settlement of certain sedentary marine organisms. Journal of the Marine Biological Association of the U.K. Vol. 29 (2):299-302.
Hydroids did, barnacles and tubeworms didn't settle on fibrous glass cloth exposed in shallow water from March to June 1949. Material may be mechanically irritating to larvae.

BEAUMONT, W. L., 1900. The fauna and flora of Valencia harbour on the west coast of Ireland. VII - Report on the results of dredging and shore collecting. Proceedings, Royal Irish Academy, Vol. 5(3): 754-798.
Valencia Island, west coast of Ireland. Lists of organisms attached to wrecks and buoys in shallow water of harbor; in 1898. No quantitative data.

BECKNER, C. F., 1966. Marine fouling and corrosion of instrumentation at Argus Island. Unpublished IMR #0-55-65. U.S. Naval Oceanographic Office, Washington, D. C.
Off Bermuda, 1963-1965, observations of fouling on oceanographic instruments in water depths up to 192 feet.
Fouling attachment was found to affect calibration of wave staff and current meters.

BLAKE, J. W., 1966. Battelle Memorial Institute, William F. Clapp Laboratories, Inc. Duxbury, Massachusetts. Personal communication.
Duxbury, Massachusetts and Daytona Beach, Florida. Various materials are exposed in shallow water for biofouling and biodeterioration studies. Laboratory studies also conducted.
Data not yet reported.

BLICK, R. A. P. and B. WISELY, 1964. Attachment rates of marine invertebrate larvae to raft plates at a Sydney harbour site 1959-1960. Australian Journal of Science, Vol. 27(3): 84-85.
Garden Island, in Sydney harbour, 1947-1957. Perspex and bakelite panels were exposed biweekly and monthly beneath rafts at four shallow sites in harbour. Temperature and salinity data collected on site. Numbers of organisms per month listed.
Most fouling found on roughened, dark surfaces and during warm months.

CALLAME, B., 1954. Periodes de fixation de quelques organismes marins sessiles, en rapport avec les conditions du milieu, dans de port de La Pallice. Travaux de Centre de Recherches et D'Etudes Oceanographique, Vol. 5, 1(7).
La Pallice, France; 1950-1951. Metal panels were exposed at pierside for monthly and cumulative periods. Temperature, oxygen, and salinity data collected on site. Organisms listed; also season of maximum settlement noted.
OECD sponsored.

CASPERS, H., 1952. Der tierische bewuchs an Helgolander seetonnen. Helgolander Wissenschaftliche Meeresuntersuchunger, Vol. 4(2):138-160.
Helgoland, Germany; 1936-1939. Buoys from twelve stations were examined for fouling. List of species, percent coverage, and weight per square centimeter noted.

CHIMENZ, C., 1965. Sugli organismi incrostanti del cosiddetto "fouling" (Rivista sintetica). Annuario Inst. Mus. Zool. Univ. Napoli, Vol. 17(1): 1-33.
This report not seen.

CHITTLEBOROUGH, R. G., 1956. The settlement of marine organisms on submerged surfaces at Heard Island, 1949. Interim report #15 of Australian National Antarctic Research Expeditions, Department of External Affairs, Melbourne, Australia.
Atlas cove, Heard Island; 1949. Glass slides were exposed for one, three, and six month intervals under a buoy in eight feet of water. Temperature, oxygen, and phosphate data also collected on site. Thirty species of diatoms and eight other algae listed; also dry weights and seasonal occurrence.
Fouling was found to be minimal.

COE, W. R., 1932. Season of attachment and rate of growth of sedentary marine organisms at a pier of Scripps Institute for Oceanography, La Jolla, California. Bulletin of Scripps Institute for Oceanography, Tech Serial 3(3): 37-86.
La Jolla, California; 1928-1932. Wood and concrete panels were exposed pierside for long and short intervals. Temperature data also collected on site. Organisms listed; also sequence of settlement and rates of growth.
Foulers were found to be most selective as to substrate during early swimming stages. Later the numbers tended to even up on different kinds of panel material.

COE, W. R. and W. E. ALLEN, 1937. Growth of sedentary organisms on experimental blocks and plates for nine years at Scripps pier. Bulletin of Scripps Institute for Oceanography, Tech Serial 4(4):101-136.

La Jolla, California; 1928-1936. Glass, Wood, and concrete panels were exposed pierside for long and short intervals. Organisms listed; also relative volumes, sequence of settlement and rates of growth.

Each of the nine years showed differences in time of settlement or abundance of some foulers.

Authors found true succession in fouling communities.

See also Coe, 1932.

CORLETT, J., 1948. Rates of settlement and growth of pile fauna of the Mersey Inlet. Proceedings and Transactions of the Liverpool Biological Society. Vol. 56:3-28.

Mersey River mouth, Liverpool, England; March 1946 to December 1947. Flooring tiles and scallop shells were exposed pierside for weekly, monthly, and cumulative periods up to fourteen months. Organisms listed; also relative numbers and screen of settlement.

Texture of substrate was found to have more influence on settlement of larvae than color or depth.

Author found that Balanus communities dominate in coastal environment, serpulid worms dominate in the estuary.

CORY, R. L., 1964. Environmental factors affecting attached macro organisms, Patuxent River estuary, Maryland. Articles 165. U.S. Geological Survey Professional Paper 475-D:D194-D197.

Patuxent River, Maryland; 1962 and continuing. Wood-asbestos panels were exposed under bridges at two sites in brackish river for monthly, quarterly, and yearly intervals. Temperature, salinity, and oxygen data collected on site. Organisms listed; also dry weight, ash weight, relative numbers, and depth preferences noted.

Fouling is studied in an effort to find a convenient index of organic production in an estuarine environment.

CORY, R. L., 1967. Epifauna of the Patuxent River estuary, Maryland, for 1963 and 1964. Chesapeake Science, Vol. 8(2): 71-89.

Patuxent River, Maryland; 1963, 1964 and continuing. Wood-asbestos panels exposed near surface and at depth at six sites for monthly, quarterly, and yearly intervals Temperature, salinity, and oxygen data collected on site. Forty organisms collected, of which seven were important Season of attachment, total numbers per panel, dry weight, and ash weight were noted

Stations extended from near the mouth to near the limit of salt water intrusion Comparison of dry weight measurements shows that the up river station was about eight times more productive than the station nearest the mouth.

CRISP, D. J. and J. S. RYLAND, 1960. The influence of filming and surface texture on the settlement of marine organisms. Nature, Vol. 185(4706):119.

In laboratory tests conducted in North Wales it was determined that no simple generalizations are applicable to reactions of settling larvae on filmed surfaces or on surface texture. Some prefer one surface, some another, some are indifferent.

DAHL, F., 1893. Untersuchungen uber die theirwelt der unterelbe. Jahresb. comm. wiss. unters. deuts. Meere Kiel Vol. 6(1887-1891):151-185.

Wooden blocks were exposed in the Elbe River to determine the time and rate of settlement of fouling organisms.

This was probably the first use of test panels for the collection of marine fouling organisms.

DANIEL, A., 1954. The seasonal variations and the succession of the fouling communities in the Madras harbour waters. Journal Madras University, Vol. 24B(2):189-212.

Madras harbour, India; 1950-1951. Teak panels were exposed pierside at three sites, mostly for periods of twenty-eight days. Temperature and salinity data also collected on site. Organisms listed and seasonal occurrence noted.

No well-defined seasonal settlement was observed because breeding occurs during all months. Successive stages in the fouling community development were noted.

Fewer species and numbers of foulers were found outside the harbor than inside, perhaps because of moderate pollution inside.

Twenty-eight days was found to be the ideal exposure period for determination of seasonal settlement; after this crowding occurs and numbers decline.

DAUGHERTY, F. M. JR., 1961. Marine biological fouling in the approaches to Chesapeake Bay. Technical Report #96, U.S. Navy Hydrographic Office, Washington, D. C.

Chesapeake Bay, off Norfolk, Virginia; April 1956 to November 1959. Steel panels and cylinders were exposed on the bottom at four sites for monthly and cumulatively longer periods, in water depths of thirty-eight to sixty-eight feet. Temperature and salinity data collected on site. Organisms listed by major groups; also season of settlement, relative occurrence, and wet weight of biomass noted.

Thirty-one to thirty-eight ounces of biomass per square foot per year accumulated on the test panels. Settlement occurred from April to November. Barnacles, mollusks and tubeworms seem to be the dominant forms.

See also Maloney, 1958.

DAVIES, I. E. and E. G. BARHAM, 1965. Fouling on a deep-anchored submarine hull. U.S. Naval Electronics Laboratory Report #1231, San Diego, California, 1965.

Off San Diego, California. A submarine was moored at 200 feet below the surface in 6,000 foot water depth from 1959 to 1964. The hull was subsequently examined for fouling organisms.

Tubeworms and bryozoans were found mostly on the bottom, other hardshelled forms and algae on the top.

DePALMA, J.R., 1962(a). Field results - Panama Canal Zone fouling project 0-11, 1957-1959. Unpublished IMR #0-33-62. U.S. Navy Hydrographic Office, Washington, D. C.

Balboa, Pacific end of the Panama Canal Zone; 1957-1959. Steel panels were exposed for one month and cumulatively longer periods to one year, near the bottom in fifty feet of water and at a shallow pier. Temperature and salinity data collected on site. Organisms listed by major groups; also season of attachment and preference for concave or convex test surfaces noted.

Settlement occurred during all seasons. Dominant organisms were barnacles, tubeworms, and encrusting bryozoans.

DePALMA, J. R., 1962(b). Field results of the first year of a bottom fouling study in Penobscot Bay, Maine. Unpublished IMR #0-34-62. U. S. Navy Hydrographic Office, Washington, D.C.

Penobscot Bay, off Rockland, Maine; May 1960 to May 1961. Steel panels were exposed for two months and cumulatively longer periods to one year, near the bottom in fifty feet of water. Temperature and salinity data collected on site. Organisms listed and season of attachment noted.

This study is continuing.

De PALMA, J. R., 1962(c). Marine fouling and boring organisms in the Tongue of the Ocean, Bahamas, Exposure II. Unpublished IMR #0-64-62. U.S. Naval Oceanographic Office, Washington, D.C.

Bahama Islands; April to July 1962. Wood, asbestos, and metal panels were exposed for 111 days at various depths to 1700 meters. Organisms listed; also relative occurrence with depth noted. Temperature and salinity data collected on site.

Fouling organisms occur in moderate amounts in the mixed laye. and near the bottom, with zero attachment in between.

This study is continuing.

DePALMA, J. R., 1963(a). Marine fouling and boring organisms off Fort Lauderdale, Florida. Unpublished IMR #0-70-62. U. S. Naval Oceanographic Office, Washington, D. C.

Fort Lauderdale, Florida; September 1961 to September 1962. Wood-asbestos panels were exposed for monthly and cumulative periods to one year at various depths to 100 meters. Temperature, salinity, and current data collected on site. Organisms listed; also season of attachment and dry weight of biomass noted.

Attachment of larvae occurs in all months. Maximum fouling was found at about twenty-seven meters and decreased with increasing depth.

The study is continuing.

DePALMA, J. R., 1963(b). Marine fouling and boring organisms off southern Sardinia. Unpublished manuscript, IMR #0-57-63. U. S. Naval Oceanographic Office, Washington, D. C.

Golgo di Palmas, Sardinia; January 1963 to July 1963. Wood-asbestos panels were exposed for six months at various depths to 180 feet. Organisms listed and relative occurrence with depth noted.

Settlement at the bottom was found to be five times greater (by weight and numbers of organisms) than near the surface.

DePALMA, J. R., 1966. A study of the marine fouling and boring organisms at Admiralty Inlet, Washington. Unpublished IMR #0-6-66. U. S. Naval Oceanographic Office, Washington, D. C.

Off Port Townsend, Washington; June 1963 to June 1965. Wood-asbestos panels were exposed near surface and near bottom for monthly and longer periods to one year, in depths to fifty feet. Temperature and salinity data collected on site. Organisms listed; also season of settlement, depth preferences, growth rates, and dry weights of biomass noted.

DEW, B. E. and E. J. F. WOOD, 1955. Observations on periodicity in marine invertebrates. Australian Journal Marine and Freshwater Research, Vol. 6:469-478.

Authors found that settlement of Hydroides norvegica on test panels seemed to be correlated with times of spring tides. For reasons not apparent, larvae of tubeworms and barnacles did not appear in plankton samples collected near test panels.

DEWOLF, P. and MEUTERSCHRIEL, 1963. The possibilities of exposure of antifouling paints in Curacao, Dutch Lesser Antilles. Report #56C. Netherland Research Centre T.N.O. for Shipbuilding and Navigation. Delft.

Fouling at pierside in Curacao harbor was considered inadequate for antifouling paint testing. Perspex panels were exposed for monthly intervals in 1960, 1961.

DOLGOPOL'SKAYA, M. A. 1959. The development of fouling in connection with the depth of submergence far off the Crimean coast in the Black Sea. (In Russian). Trudy Sevastopol'skoy Biologii Stantsii. Vol. 12:192-208.

Black Sea, off Sevastopol; September 1955 to October 1956. Steel panels and floats were exposed at several depths to 255 feet for three, five, ten, and thirteen months. Four arrays moored in 300 feet of water held the panels and floats. Organisms are listed and weights and occurrence with depth and time are noted.

Number of foulers was found to increase with depth until a maximum occurred at thirty feet below the surface; sizes and numbers then decreased to the bottom.

Corrosion of panels and floats resulted in a sloughing off of metal substrate and attached foulers, reducing the value of the data.

DOOCHIN, H. and F. G. WALTON SMITH, 1951. Marine boring and fouling in relation to velocity of water currents. Bulletin of Marine Science of the Gulf and Caribbean, Vol. 1(3):196-208.

Yellow pine discs were revolved at different speeds and settlement of fouling larvae noted. Some foulers were unable to attach at speeds as low as 0.8 knot. No foulers attached at speeds of 2.0 knots or higher.

DUNNINGTON, E. H. 1965. The effects of heat on attachment of fouling organisms. Minutes of 3rd Annual Conference on the Patuxent River estuary studies. Chesapeake Biol. Lab. Reference No. 65-23.

Plates heated to 50°C. every four hours (by incased heating elements) remained free of most fouling organisms. Only heat tolerant algae were able to remain attached. Control plates collected normal amounts of fouling.

EBERHARDT, R. L., 1964. Lockheed-California Co., San Diego, California. Personal communication.

Several inert mines have been moored off the coast of California in water depths up to 150 feet. These will be recovered periodically and the components will be examined for fouling degradation.

Data not yet reported.

EDMONDSON, C. H. 1944(a). Incidence of fouling in Pearl Harbor Honolulu, Hawaii. Occasional Papers of Bernice P. Bishop Museum. Vol. 18(1): 1-34.

Pearl Harbor, Hawaii; 1940. Wooden, metal, and glass panels were exposed pierside at two sites for monthly and cumulative periods. Organisms listed and growth rates noted.

It was determined that in the fouling association, one organism is occasionally the limiting factor in the development of another. Tubeworms and tunicates were found to limit the settlement and subsequent growth of barnacles.

EDMONDSON, C. H., 1944(b). A report on the incidence of fouling on two similar units off the coast of Oahu, during a period of approximately six months preceding April 28, 1944. Unpublished enclosure to letter to the Chief, BUORD, File 063044 40035. U. S. Navy Bureau of Ordnance, Washington, D. C.

Pearl Harbor and Barbers Point, Hawaii; November 1943 to March 1944. Observation of fouling on minecases and chain moored in eighty feet of water. Organisms listed and occurrence with depth and site noted.

More species and numbers were found at the Barbers Point site. Amounts decreased from surface to bottom at both sites.

EDMONDSON, C. H. and W. M. INGRAM, 1939. Fouling organisms in Hawaii. Occasional Papers Bernice P. Bishop Museum, Vol. 14(14):251-300.

Kaneohe Bay, Hawaii; 1935-1939. Masonite, wood, metal, and glass panels were exposed pierside for two to four week periods. Organisms listed; also relative occurrence, seasonal preferences, [illegible] rates of growth noted.

Authors found that numbers of settling foulers decreased with lowered salinity.

See also Ingram, 1937.

FISH, C. F., 1945. The Mark VI moored minefield at Casablanca, French Morocco. U.S. Office of Naval Operations, Washington, D. C.

Moored mines were found to have dipped below effective depth after six months exposure off Casablanca because of the increased drag from fouling. K-mechanism failures were also the result of fouling attachment; calcareous tubeworms were responsible in two cases.

FITZGERALD, J. W., and others, 1947. Corrosion and fouling of sonar equipment. Part I. NRL Report #S2377. U.S. Naval Research Laboratory, Washington, D. C.

Sonar equipment was exposed for 165 and 300 days in Biscayne Bay, Florida. Soft-bodied forms (tunicates) on stainless-steel plates were found to have reduced the transmitting efficiency by 25 and 50 percent, respectively, at a frequency of about 25 kc. All energy loss was due to absorption by the 1.5 inch thick accumulation of foulers.

FORGESON, B. W. and others, 1958. Corrosion of metals in tropical environments Part III - Underwater corrosion of ten structural steels. Report #5153. U. S. Naval Research Laboratory, Washington, D. C.

A coating of fouling organisms on panels exposed off the Pacific end of the Panama Canal was found to inhibit corrosion of steel.

FOWLER, A. W., 1941. Underwater paint research. Comparative fouling test between Point Reyes and Yerba Buena, California. California Paint Laboratory, Mare Island, U.S. Navy Department.

Point Reyes and Yerba Buena, California; 1940. Glass and steel panels were exposed under floats in shallow water for thirty day periods. Temperature and salinity data were collected on site. No organisms listed; data simply reported as dry weight per month.

Yerba Buena was not recommended as an antifouling paint test site because of insufficient monthly accumulation of organisms.

FRASER, J. H., 1938. The fauna of fixed and floating structures in the Mersey estuary and Liverpool Bay. Proceedings and Transactions of the Liverpool Biological Society, Vol. 51:1-21.

Liverpool, England; 1936. Buoys, jetties, and pontoons at several sites were examined for fouling organisms. Organisms listed.

Author suggests that Zoothamnion marinum may be an indicator of untreated sewage.

FULLER, J. L., 1946. Season of attachment and growth of sedentary marine organisms at Lamoine, Maine. Ecology, Vol. 27(2):150-158.

Lamoine, Maine; May 1943 to October 1944. Asbestos panels were exposed pierside for short periods up to one year. Organisms listed; also weight of biomass and relative occurrence noted. Temperature data collected on site.

Dry weight of fouling was found to be approximately 27% of wet weight.

Maximum wet weight measured was only 50 grams per square foot per year

GANAPATI, P. N. and others. 1958. Biology of fouling in Vizagapatam Harbour. Andhra University Memoirs Oceanography. Serial 62. Vol. 2:193-209.

Vizagapatam Harbour, India; January through December 1955. Wood, glass, and asbestos-cement panels were exposed pierside for monthly periods. Temperature and salinity data collected on site. Organisms listed and season of occurrence noted.

Maximum settlement occurred from March to May; minimum in October. Barnacles and tubeworms (hard-shelled forms) were dominant.

Settlement decreased with decreasing salinity, increased with moderate pollution.

GAUL, R. D. and N. G. VICK, 1964. Sessile organism accumulation in a nearshore water column during a one year period. Project 286-D, Reference 64-10T, Texas A. and M. Department of Oceanography and Meteorology.

Off Panama City, Florida; 1963. Plastic floats were exposed at several depths from two offshore towers in depths to 140 feet for monthly and longer periods. Temperature, salinity, and current data collected on site. Organisms listed; also relative occurrence, abundance, and weights noted.

Hydroids impeded movement of current meter rotors after only sixty-three days, affecting the calibration.

GOODBODY, I., 1961. Inhibition of the development of a marine sessile community. Nature, Vol. 190:282-283.

Port Royal, Jamaica; October 1958 to September 1959. Tuffnol panels were exposed beneath rafts in shallow water for two month and occasionally longer periods. Organisms listed and relative occurrence noted.

In tropical waters, season of settlement is not important to climax community or seral stages on test panels.

Presence of already attached foulers inhibits attachment of new ones.

GOSNER, K. L., 1966. Newark Museum, Newark, N. J. Personal communication.

Periodic observations of navigation buoys in the Hudson River, from full salinity to fresh water, were made in 1965 and 1966.

It is hoped that changes in the fouling community can be used as an index of pollution.

Data not yet reported.

GRAHAM, H. W. and H. GAY, 1945. Season of attachment and growth of sedentary marine organisms at Oakland, California. Ecology, Vol. 26 (4):375-386.

Oakland, California, December 1940 to February

1942. Douglas fir panels were exposed under a bridge for monthly and cumulatively longer periods of time. Temperature and chlorinity data collected on site. Organisms listed; also relative occurrence, total volume, and growth rates noted.

Panels were clamped to a line and allowed to orient with the current. Four inch by four inch panels were found to give as reliable results as larger ones. Scrapings from panels were allowed to settle overnight in graduated cylinders, then measured.

Total volume curve was found to more closely approximate the temperature curve than the chlorinity curve.

GRAVE, B. H., 1933. Rate of growth, age of sexual maturity, and duration of life of certain sessile organisms at Woods Hole, Mass. Biological Bulletin of Woods Hole, Vol. 65(3):375-386.

Eel Pond, Woods Hole, Mass; 1923-1933. Mollusk shells, stones, bricks, and glass panels were exposed pierside for short periods of time during the summer months. Organisms listed; also relative accumulation and rates of growth noted.

GREAT BRITAIN ADMIRALTY CORROSION COMMITTEE, 1952. Fouling in deep water - H. M. S. AFFRAY. Report #ACC/F21/52. Antifouling Research Subcommittee, London, England.

Submarine hull submerged for six months at 280 feet in the English Channel was examined for attached organisms. Encrusting bryozoans were dominant.

GREAT BRITAIN ADMIRALTY CORROSION COMMITTEE, 1954. Season of settlement of sedentary marine organisms at Kuwait, Persian Gulf. Report of the Antifouling Research Subcommittee. London, England.

Persian Gulf; August 1950 to October 1953. Bakelite panels were exposed pierside for two week, one month, and three month periods. Temperature and salinity data collected on site. Organisms listed; also relative numbers, season of settlement, and rates of growth noted.

Settlement of larvae was found to be continuous throghout the year.

GRINBART, S. C., 1948. Investigation results on marine fouling on test panels in the Black Sea. Paatsi Odc..'k. Derzh. un-tu. Vol. 3(1).

This report not seen.

GUNTER, G. and R. A. GEYER 1955. Studies on fouling organisms of the northwest Gulf of Mexico. Publications of the Institute of Marine Science, Vol. 4(1):37-87.

Examination of the attached organisms on Humble Oil Company towers off the Texas and Louisiana coasts; also steel panels were hung from these towers at various depths to fifty feet for periods of three, six, and fourteen months, 1948-1949. Organisms listed; also depth preference and relative occurrence noted.

The authors conclude that the top to bottom distribution in the northwest Gulf of Mexico is a miniature of the horizontal distribution from estuary to open sea.

HARGIS, W., 1964. Virginia Institute of Marine Science, Gloucester Point, Virginia. Personal communication.

Fouling studies have been conducted on the James River, Virginia from Thimble Shoals to the Chickahominy River since 1963, as part of an exhaustive hydrographic study of the river. These data will be reported later by Sims, Behler, Wasser, or others.

HARRIS, J. E., 1946. Report on antifouling research, 1942-1944. Journal of the Iron and Steel Institute, No. 2:297-333.

Discusses "biological exclusion", the process by which certain species, by virtue of their growth habits or density of settlement, suppress both the later establishment of certain other forms and continued growth in existing populations.

HENTSCHEL, E., 1915. Biologische Untersuchungen uber den tierischen und pflanzlichen bewuchs in Hamburger Hafen. Mitt. Zool. Museum, Hamburg. Vol. 33:1-172.

Hamburg, Germany; 1914-1915. Glass panels were exposed pierside for weekly and cumulative periods. Dry weight of material noted.

HOSIAI, T., 1956. On the forming process of the marine sedentary community. Ecological Review, Vol. 14(2): 191-197.

Sendai, Japan; May to November 1954. Slate panels were exposed 1.5 meters below the surface in shallow water for short periods of time. Organisms listed; also preferences of organisms for north or south facing surfaces and for upper or under panel surfaces.

HOSIAI, T., 1964. Distribution of sessile animals in the intake duct of the cooling sea water of the Hachinohe thermal power station. Asamushi Marine Biological Station Bulletin, Vol. 12(1).

Hachinohe, Japan; 1961. Metal intake ducts and concrete blocks at a sea water cooled power station were examined for fouling organisms. Organisms listed and wet weights per square centimeter noted.

The biomass of sessile organisms decreased from the entrance toward the end of the intake duct. Mussels were the dominant form at the entrance; toward the end tubeworms replaced the mussels as dominants.

HUTCHINS, L. W., 1944. Progress in the investigation of the fouling of fixed installations. Unpublished report to BUSHIPS, Paper #21, Woods Hole Oceanographic Institution, Woods Hole, Mass.

Navigation buoys moored in depths of thirty to fifty feet in Hana Bay, Hilo Bay, Pearl Harbor, and off the coast of Kauai for one to eight months in 1943 were examined for fouling organisms. Organisms listed and weight and thickness of biomass noted.

Buoy fouling around Hawaii was found to be generally less severe than along the U. S. mainland.

HUTCHINS, L. W., 1949. Fouling in the Western Pacific. TR#6. Unpublished report to the U. S. Navy Office of Naval Research, Reference No. 49-11, Woods Hole Oceanographic Institution, Woods Hole, Massachusetts.

A review of the information available on fouling of mines, ships, nets, test panels, etc. in the western Pacific. Author discusses and evaluates the various studies and attempts to relate this data to navy operations.

Tubeworms were found to prefer ships and test panels rather than mines or nets. Barnacles, mollusks, and corals were very common on mines. Mollusks were common on nets.

Fouling was thought to be not excessive in the western Pacific.

HUTCHINS, L. W. and E. S. DEEVEY, 1944. Estimation and prediction of the weight and thickness of mussel fouling on buoys. Unpublished Interim Report No. 1 submitted to the Bureau of Ships, U. S. Navy Department, Washington, D. C. by Woods Hole Oceanographic Institution, Woods Hole, Massachusetts.

U. S. Coast Guard buoys off the northeast coast of U. S. were examined for fouling organisms, 1937-1940.

Mytilus edulis was found to be the dominant form, and it was found to be active only at temperatures exceeding 44°F. Average weight of fouling was found to decrease with increasing distance from shore.

A rough estimate of Mytilus fouling can be predicted by comparing length of exposure with water temperature.

INGRAM, W. M., 1937. Fouling organisms in Kaneohe Bay and Pearl Harbor, Oahu. Unpublished Masters Thesis, University of Hawaii. Honolulu, Hawaii.

Kaneohe Bay and Pearl Harbor, Hawaii; September 1935 through March 1937. Masonite, wood, metal, and glass panels were exposed pierside for two week periods. Organisms listed; also relative occurrence, seasonal preference, rate of growth, and effects of light noted.

The fouling complex at Kaneohe Bay was similar in species and numbers to that found at Pearl Harbor. No clear cut breeding seasons were apparent; setting occurred year-round. Fouling was more abundant on shaded side of piers.

See also Edmondson and Ingram, 1939.

ITO, T., 1959. Marine sedentary communities with special reference to the succession in the Inland Sea of Japan. Bulletin of the Marine Biological Station of Asamushi, Tohoku University, Vol. 9 (4):161-165.

Inland Sea, Japan; 1955-1958. Concrete block panels were exposed at seven sites in water depths of eight meters to forty-five meters. Panels were recovered at one, two, and three year intervals by divers. Organisms are listed and relative occurrence noted.

Climax fouling community at the bottom in deep water progresses from tubeworm-bivalve to barnacle-bryozoan. Mytilus was climax community in shallow water.

Author suggests that the sere and climax of the sedentary communities in the sublittoral region may be more strongly influenced by the embayment degree (environmental factors) or by sequence of settlement than by true succession.

A submarine, salvaged from a depth of sixty-one meters after ten years, was found to be covered with barnacles, bryozoans, and tubeworms.

IYENGAR, S. R., and others, 1957. Studies on marine fouling organisms in Bombay harbour. Defense Science Journal, October 1957, pp. 123-139.

Bombay, India; 1953-1956. Bakelite panels were exposed for monthly periods at one and three feet below a raft moored at the entrance to the harbour. Temperature, salinity, and rainfall data collected on site. Organisms listed by major groups only; also wet weight of biomass measured and season of settlement noted.

The system generally used for rating antifouling panels is described and used.

The raft and panels were allowed to orient themselves with the current.

Fouling took place during all months except during the rainy season, when salinity fell below critical levels.

See also Rao, 1964.

IZUBUCHI, T., 1934. Increase in hull resistance through shipbottom fouling. Zosen Kiokai. Vol. 55.

Kobe, Yokosuka, Sasebo, Japan and the Pescadores; 1933. Glass panels were exposed for monthly intervals at shallow locations. Organisms listed and dry weights of biomass noted.

JEFFRIES, J. G. and A. M. NORMA, 1875. Submarine cable fauna. Annals and Magazine of Natural History. Vol. 15(4):169-176.

Submarine cable, exposed on the floor of the Atlantic between Falmouth and Lisbon in in water depths of 500 to 1200 feet was examined for foulers during recovery. Several groups of attached organisms are listed.

JOHNSON, M. W. and R. C. MILLER, 1935. The seasonal settlement of shipworms, barnacles, and other wharf-pile organisms at Friday Harbor, Washington. University of Washington Publications in Oceanography. Vol. 2(1):1-18. Seattle, Washington.

Friday Harbor, San Juan Islands, Washington; October 1928 to January 1930. Wooden panels were exposed quarterly at pierside. Organisms listed and season of settlement noted.

Authors pre-soaked test panels in boiled sea water before exposure.

No settlement of larvae occurred between January and March.

KALLIO, R. E. and C. A. EVANS, 1964. Construction and operation of a continuous environmental enrichment apparatus for marine microorganisms. Final Scientific Report, project NR103 502. University of Washington, Seattle, Washington.

An apparatus which will maintain sea water at a constant temperature and pH is discussed. One of the components is a Coulter Counter. Precise counts were difficult to achieve because of fouling on the vessel and on the orifice of the counter.

KATSUSHIGE, H. and M. TONOYAMA, 1962. Investigations on the animal fouling organisms in Tsukumo Bay. I. A preliminary study on the settlement of Spirorbis foraminosus on glass slide test panels. Annual Report of the Noto Marine Laboratory, University of Kanazawa. Vol. 2:9-14.

Tsukumo Bay Japan; June 1959 to December 1960. Colored glass slides were exposed at three depths pierside for ten day, one month, and three month periods.

More Spirorbis found at six meters and at three meters than at two-tenths of one meter below the surface.

Order of preference in color: red, black, pale blue and white.

Spirorbis occurred from June to September.

KAWAHARA, T., 1961. Regional differences in the composition of fouling communities in Ago Bay. Report of the Faculty of Fisheries, Prefectural University of Mie. Vol. 4(1):65-80.

Ago Bay, Japan; June to October 1958. Concrete blocks were exposed two meters below the surface beneath rafts for four months at ten stations in the bay. Temperature and rainfall data collected on site. Organisms listed and their relative occurrence noted.

Fouling communities in the central part of the bay had more species, are more complicated and more advanced than those in the far recesses of the bay. Complexity of community is determined by plotting rank of species by frequency of animals, then measuring angle of inclination which regression line makes with abscissa. Central part of bay has Balanus climax community; inner bay has Hydroides-Watersipora climax, is less well advanced.

Author found that the top to bottom distribution of sessile animals in Ago Bay was a miniature of the horizontal distribution from the estuary to open sea.

See also Kawahara and Iizima, 1960.

KAWAHARA, T., 1962. Studies on the marine fouling communities. I. Development of the fouling community. Report of the Faculty of Fisheries, Prefectural University of Mie, Vol. 4(2):27-41.

Tomioka, Japan; February to October 1946. Concrete block panels were exposed one meter below the surface under a raft moored in a depth of ten meters. Temperature data collected on site. Organisms listed and successive changes in numbers and species with time (five days) noted.

Author introduces the term "meso-fouling" to describe the primary film of bacteria, diatoms, and other microflora and fauna which usually proceeds macroscopic attaching organisms.

Author traces five stages in the development and decline of the fouling community.

KAWAHARA, T., 1963. Studies on the marine fouling communities. II. Differences in the development of the test block communities with reference to the chronological differences of their initiation. Report of the Faculty of Fisheries, Prefectural University of Mie, Vol. 4(3):391-418.

Tomioka, Japan; summer of 1944 and spring of 1946. Concrete block panels were exposed one meter beneath the surface under a raft moored in ten meters of water. Temperature data collected on site. Organisms listed and successive changes in species and numbers with time noted.

The life forms of fouling animals are divided into: block, erect, and encrusting. Generally speaking, encrusting forms have the shortest life span and block forms the longest. Speed of development is reversed in order, however.

KAWAHARA, T. 1965. Studies on the marine fouling communities. III. Seasonal changes in the initial development of test block communities. Report of the Faculty of Fisheries, Prefectural University of Mie. Vol. 5(2):319-364.

Tomioka, Japan; January 1947 to January 1948. Concrete block panels were exposed one meter below the surface under a raft moored in ten meters of water. Temperature data collected on site. Organisms listed and season of occurrence noted.

Author found three characteristic patterns of fouling in Tomioka: Leptoclinium-form in late spring, Bugula-form in early summer, and Balanus amphitrite-form in mid-summer.

KAWAHARA, T. and H. IIZIMA, 1960. On the constitution of marine fouling communities at various depths in Ago Bay. Report of the Faculty of Fisheries, Prefectural University of Mie, Vol. 3(3):582-594.

Ago Bay, Japan; July to August, 1958. Concrete blocks were exposed at 0.5, 2.0, 3.5, and 5.0 meters under a raft moored in ten meters of water. Temperature, chlorinity, and oxygen data collected on site. Organisms listed and numbers treated statistically for significance and complexity of community.

The upper layer was found to abound in numbers of animals but not species. The opposite was true for the lower layer. The communities in the upper layers were comparatively simple and arrested.

Accelerated development in the lower level communities is attributable to optimum temperature for growth.

See also Kawahara, 1961.

KAZIHARA, T. 1964. Ecological studies of marine fouling animals. Deep Sea Research, Vol. 13(2):333-335. (English abstract).

Nagasaki Bay and Sasebo Bay, Japan, 1950-61 and 1956-57. Nets and colored blocks exposed beneath rafts in shallow water at stations located throughout the bays.

The largest number of species was found in the middle parts of the bays, decreasing toward the head and the mouth. Author attempts to classify organisms by their size and growth form.

KINGCOME, J. C., 1961. Ships paints. Journal of the Oil and Col. Chemical Association. Vol. 44(4):237-255.

The fact that British cruisers were able to overtake the faster German pocket battleship "Graf Spee" in a running battle, was ascribed to the reduction in the battleships speed resulting from fouling on the hull.

KIRCHENPAUER, J. U., 1862. Die seetonnen der Elbmerndung. Abhandl. a.d. Gebiete'd. Naturwiss. her. v.d. naturwiss. Ver. in Hamburg. Vol. 4(4):1-59.

Elbe River, Germany. Lists eighty-four species of fouling organisms attached to navigation buoys in the river.

This was probably the first comprehensive study ever made of the marine fouling community.

KNIGHT-JONES, E. W. and D. J. CRISP, 1953. Gregariousness in barnacles in relation to the fouling of ships and to antifouling research. Nature, Vol. 171(4364):1109-1110.

Tests conducted in England demonstrate that larvae of barnacles and other foulers attach more readily to surfaces already settled by similar species.

KURIYAN, G. K. 1950. The fouling organisms of pearl oyster cages. Journal Bombay Natural History Society, Vol. 49.

Gulf of Mannar; September 1947 to August 1948. Wooden oyster cages were exposed for short periods of time in shallow water. Organisms listed and season of attachment noted.

KURIYAN, G. K., 1952. Notes on the attachment of marine sedentary organisms on different surfaces. Journal of the Zoological Society of India, Vol. 4(2):157-171.

Krusadi Island, Gulf of Mannar, India; January 1949 to January 1950. Wooden and glass panels and steel wire rope were exposed six feet below an oyster raft moored in shallow water.

Various organisms showed preference for different surfaces and/or materials.

KURIYAN, G. K., 1953. Biology of the fouling in the Gulf of Mannar; a preliminary account. Ecology. Vol. 34(4): 689-692.

Krusadi Island, Gulf of Mannar, India; 1949. Wooden panels were exposed six feet below a raft moored in shallow water. Organisms listed; also total volume of biomass and season of attachment noted.

LEBEDEV, Y. M. and others, 1963. The problem of fouling on panels in the Black Sea. Marine Fouling and Borers. Trudy Instituta Okeanologii, Vol. 70:270-275.

Off Sevastopol, in the Black Sea; August 1956 to August

1958. Plexiglass panels, some coated with coal tar, were exposed below a raft moored in shallow water. Organisms listed.
Barnacles cut through coal tar coatings, often in only a few weeks.

LUNZ, G. R. JR., 1940. Periodicity of fouling growths at Cavite, Philippines, and Guantanamo Bay, Cuba. Unpublished report to Bureau of Construction and Repair, U.S. Navy BUSHIPS Reference file S19-1-(3).2.
Cavite, Philippines and Guantanamo Bay, Cuba; August 1936 to August 1938. Metal panels were exposed pierside for monthly periods. Temperature data collected on site. Organisms listed by major groups; also dry weight, alcohol wet weight, percent coverage, and seasonal occurrence noted.
Maximum weights of biomass were found in summer months, there was no year-to-year agreement, however. Author found dry weight to be one third to one half that of alcohol wet weight.
Biomass at Cavite found to be about twenty times greater than at Guantanamo Bay.

LUNZ, G. R. JR., 1945. Report on damage to floating drydock in Charleston harbor, S.C., due to fouling organisms. Unpublished report to Bureau of Construction and Repair, U.S. Navy BUSHIPS, Washington, D.C.
A floating drydock moored in shallow was examined for fouling organisms. Organisms listed and displacement weight of biomass noted.
Salinity values for Charleston harbor range from 10 ppt. to 24 ppt.

MALONEY, W. E., 1958. A study of the types, seasons of attachment, and growth of fouling organisms in the approaches to Norfolk, Virginia. Technical Report #47, U.S. Navy Hydrographic Office, Washington, D.C.
Chesapeake Bay, off Norfolk, Virginia; April 1956 to April 1957. Steel panels were exposed for one month and cumulatively longer periods, near the bottom in thirty-eight feet of water. Temperature and salinity data were collected on site. Organisms listed; also season of attachment and wet weight of biomass noted.
Author suggests that clearly defined settlement times and smooth growth curves make tubeworms and jingleshells good immersion time indicator species.
See also Daugherty, 1961.

MANNING, J. H., 1952. Setting of oyster larvae and survival of spat in the St. Mary's River, Maryland, in relation to fouling of cultch. Papers Nat. Shellfish Association. 1952:74-78.
Bryozoans were found to have no influence on settlement of oyster spat; barnacles did, however. Oysters were found to be seventy-five percent more prevalent on cultch which was barnacle-free.

MAWATARI, S. 1965. Protection of power plants from biological fouling. (In Japanese). Misc. Reports of Research Institute for Natural Resources, Tokyo, Japan.
Near Nagoya, Japan. Test panels exposed for monthly and longer periods for about two years.
No attachment was found in current speeds of 4 to 7 meters/second.

MAWATARI, S. and S. KOBAYASHI, 1954. Seasonal settlement of animal fouling organisms in Ago Bay, middle part of Japan. I and II. Miscellaneous Reports of the Research Institute for Natural Resources, (35):37-47, (36):1-8.
Ago Bay, Japan; June 1952 to May 1953. Different colored glass panels exposed for ten day periods at 1.5 and 3.0 meters below a raft in shallow water. Temperature and chlorinity data also collected. Organisms listed; also seasonal occurrence and color preferences noted.
Maximum settlement of organisms occurred at temperatures of 17°C. to 22°C. Minimum settlement between 10°C. to 16°C. and between 26°C. and 29°C. Greatest settlement occurred on black and on orange panels, least on white. Maximum settlement in early summer and in fall, least in February.
Chlorinity values ranged from 16.5 to 19.2%, had negligible effect on fouling activity.

MAWATARI, S. and others, 1962. Biological approach to the water conduit fouling in littoral industrial districts along the coast of Japan. (I) and (2). Contributions from the Research Institute for Natural Resources, Vol. 58-59(1057):89-104.
Tokyo Bay, Japan; 1959-1961. Intake conduits and concrete blocks at four power stations were examined for fouling organisms. Organisms per square meter and growth rates and season of occurrence were noted. Temperature measurements were made at some stations.
Generally, mussels were the dominant form and they tended to be most abundant at the entrances of the conduits. At one station, however, (Tsurumi) they seemed to be evenly distributed throughout.

MC DOUGALL, K. D., 1943. Sessile marine invertebrates of Beaufort, N. C., a study of settlement, growth and seasonal fluctuations among pile dwelling organisms. Ecological Monographs. Vol. 13(3):321-374.
Beaufort, N.C.; February 1941 to February 1942. Hearth tiles, wooden blocks, and glass slides were exposed pierside at several depths in twelve feet of water for bi-weekly and cumulative periods. Organisms listed; also depth preferences, seasonal settlement, and tropistic response noted.
Various organisms showed difference preferences for depth, current speed, and angle of collecting surface.
Water temperature was found to be the most important influence on the breeding season of most foulers.
Hydroides hexagonus seemed to orient their tube openings toward light.

MC ENTEE, W., 1915. Variation of frictional resistance of ships with condition of wetted surface. Transactions, the Society of Naval Architects and Marine Engineers, Vol. 23:37-42.
Ship resistance due to fouling increased one half of one percent per day for as long as three months. In moderately fouled condition, frictional resistance of the hull was increased four times original.

MC MAHON, J. P., 1956. Steady and oscillatory flow forces on a Mark VI moored mine. Unpublished Masters thesis, U.S. Naval Post-graduate School, Monterey, California.
Cable drag was found to be the chief cause of mine dip when cable length exceeds fifty feet. Fouling causes increased drag and resultant mine dip, rather than by any increase in weight. Doubling the diameter of the cable (with fouling or otherwise), will double the drag.

MC NULTY, J. K., 1961. Ecological effects of sewage pollution in Biscayne Bay, Florida; sediments and the distribution of benthic and fouling macro-organisms. Bulletin of Marine Science of the Gulf and Caribbean, Vol. 11(3):394-447.
Biscayne Bay, Florida. Both harmful and fertilizing effects were observed. Harmful at zero to two hundred yards from the outfall, fertilizing from two hundred to six hundred yards.

MILLARD, N., 1952. Observations and experiments on fouling organisms in Table Bay harbour, South Africa. Transactions of the Royal Society of South Africa, Vol. 33(4):415-445.
Table Bay, South Africa; 1947 to 1949. Steel panels were exposed at pierside for monthly and cumulative periods. Temperature and salinity data collected on site. Organisms listed, also numbers per month, weights, percent coverage, and seasonal settlement noted.
Maximum settlement of larvae was found to occur in spring and fall.

MILLER, M. A. and others, 1948. The role of slime film in the attachment of fouling organisms. Biological Bulletin of Woods Hole, Vol. 94:143-157.
The presence of an algal-bacterial slime film on artificial surface seems to facilitate attachment of certain foulers.

MILNE, A., 1940. The ecology of the Tamar estuary. IV. The distribution of the fauna and flora on buoys. Journal of the Marine Biological Association of the U.K., Vol. 24:69-87.
Plymouth Sound, England; 1935-1937. Examination of fouling on navigation buoys placed in environments ranging from estuarine to open sea. Organisms listed; also weight of biomass and relative occurrence noted. Temperature, salinity, pH, and current data collected on site.
Changes in the fouling community from estuarine to open sea were due primarily to changing salinity.

MIYAZAKI, I., 1938. On fouling organisms in the oyster farm. Bulletin of the Japanese Society of Scientific Fisheries, Vol. 6(5):223-232.
Sagami Bay, Japan; April 1933 to April 1934 and February 1935 to March 1936. Calcareous plates were exposed pierside at three depths for monthly periods. Temperature data collected on site. Organisms listed and seasons of attachment noted.

MOHR, J. L., 1952. The relationship of the areas of marine borer attack to pollution patterns in Los Angeles-Long Beach harbors. Report of the Marine Borer Conference, ML 4719:I-1 through I-5. The Marine Laboratory, Miami, Florida.
Long Beach, California; 1950 to 1951 Douglas fir and glass panels were exposed at fifteen stations for one month periods. Temperature, oxygen, and transparency data collected on site. Organisms listed and relative occurrence noted.
Fouling organisms showed a differential sensitivity to pollutants. Degree of pollution can be gauged in a number of ways:
1. By actual quantitative measurement of the pollutants (impractical).
2. By measuring the effects of pollution; i.e., depression of DO, increased BOD, presence of H2S, etc. (difficult).
3. By observations of the plant-animal associations in various types of water (most generally reliable quick indicator, both of deterioration and recovery).

See also Barnard, 1958.

MORALES, E. and E. ARIAS, 1965. Ecology of the Barcelona harbor and fouling of submerged panels. Investigacion Pesqueras, Vol. 28:49-79.

Barcelona, Spain; 1961 and continuing. Metal panels were exposed pierside for varying periods of time. Temperature, salinity, oxygen, nutrients, and plankton data collected on site. Organisms listed and season of attachment noted.

Maximum settlement and growth occurred in summer months.

Organic production and the concentration of nutrients are believed to be important to the development of fouling communities.

See also Arias and Morales, 1963.

MORITZ, C. E., 1943. Interim report on recommendations regarding anticorrosive and antifouling measures for mines. NOLM #4145. U. S. Naval Ordnance Laboratory, Washington, D. C.

Acoustic devices and extenders were exposed at a depth of thirty feet off San Juan, Puerto Rico. After seventy-five days, acoustic reception was lowered to an undesireable degree by fouling organisms. After six months, complete retraction of an arming device failed because of fouling.

MORITZ, C. E., 1944. Mine warfare and marine fouling. Report #957. U. S. Naval Ordnance Laboratory, Washington, D. C.

San Juan, Puerto Rico; Oahu, Hawaii; Key West, Florida. Various materials and mine hardware were exposed in depths of 30 to 200 feet for periods up to six months.

More fouling was noted in the harbor of San Juan than outside because of moderate organic pollutants. More fouling at Pearl Harbor entrance than outside for the same reason. Little fouling at Key West because of the negligible nutrient runoff from coral islands.

Off Puerto Rico, a maximum of three inches of fouling accumulates after two years, although a one-eighth inch cable was found to have increased in diameter to two inches after only forty days, because of fouling.

MOSHER, L. M., 1961. Marine borers and fouling organisms and their prevalence in the vicinity of Bethlehem Steel Company shipyard properties. Annual Report, Bethlehem Steel Company, Quincy Massachusetts.

Boston, New York, Baltimore, and San Francisco; 1958-60. Wooden panels were exposed pierside for monthly and cumulative periods. Organisms listed by major groups only.

Year to year records are summarized to determine fluctuations in abundance of destructive organisms, usually marine borers.

MURAOKA, J. S., 1966. Deep-ocean biodeterioration of materials - Part III. Three years at 5,300 feet. TR-428. U. S. Naval Civil Engineering Laboratory, Port Hueneme, California.

Off Port Hueneme, California; March 1962 to February 1965. Various materials were exposed for thirty-five months on the bottom in 5,300 feet.

Tubeworms and hydroids attached to nearly all materials in slight amounts. Wooden panels were destroyed by marine borers.

NAGABHUSHANAM, R., 1960. A note on the inhibition of marine wood-boring mollusks by heavy fouling accumulation. Science and Culture, Vol. 26:127-128.

Two sets of wooden panels were exposed in Vizagapatam harbour for three months in 1956. One set of panels was kept clean of fouling, the other not. Ratio of molluscan borers in cleaned panels was about nine times that of uncleaned panels.

NAIR, N. B., 1962. Ecology of marine fouling and boring organisms of Western Norway. Sarsia, Vol. 8:1-88.

Bergen, Norway and approaches, 1958. Wooden panels were exposed pierside at five stations for monthly and cumulative periods up to one year. Temperature and salinity data collected on site. Organisms listed; also vertical zonation and season of settlement noted.

Author found a correlation between abundance of larvae in the plankton and time of settlement.

Author feels that the fouling community advances through seral stages to climax (true succession).

NAZIROV, R. K. and others, 1960. Fouling of structures in marine oil fields and its prevention. Protection against Marine Growth, Academy of Sciences, USSR, Transactions of the Oceanographic Commission, Vol. 13:23.

Fouling on the legs of offshore oil rigs was found to cause an increase of 25 to 30% in the total wave pressure. This was determined with a cantilever and oscillograph, using fouled and unfouled tubes.

NIKITIN, V. N. and E. P. TURPAEVA, 1958. The process of incrustation in the Black Sea. Settling of larvae in the Gelendzhik region. Doklady Akademiia Nauk SSSR, Vol. 121(1):172-174.

Northeast Black Sea, Russia; 1954 through 1956. Glass panels were exposed pierside for ten day periods. Temperature data collected on site. Organisms listed.

ORTON, J. H., 1920. Sea temperature, breeding, and distribution in marine animals. Journal of the Marine Biological Association, Vol. 12:339-366.

Pago Pago, Samoa; May to June, 1919. Zinc panels were exposed below a wooden raft in the harbor. Attaching organisms listed.

ORTON, J. H., 1933. Some experiments on rate of growth in a Polar region (Spitzbergen), and in England. Nature, Vol. CXI:146.

Spitzbergen; June to August 1921. No fouling organisms settled on shells placed on the bottom in a wire cage. The water temperature was 4°C. at one point during the experiment.

PAUL, M. D., 1942. Studies on the growth and breeding of certain sedentary organisms in the Madras harbour. Proceedings of the Indian Academy of Science, Section B, Vol. 15:1-42.

Madras, India; December 1935 to February 1937. Concrete, steel, wooden, and glass panels were exposed pierside for short periods of time. Temperature, salinity, rainfall, tidal, and current data collected on site. Organisms listed; also season of attachment and growth rates noted.

Growth is continuous throughout the year.

PEQUEGNAT, W. E., 1965. A study of biofouling on protected and unprotected artificial substrates. Progress report 65-17T, Texas A and M Department of Oceanography and Meteorology.

Off Panama City, Florida; 1963 and continuing. Plastic floats are exposed at several depths from two offshore towers in depths to 140 feet for monthly and longer periods. Temperature, salinity, and current data collected on site.

PERSOONE, G., 1965. The importance of fouling in the harbour of Ostend in 1964. Helgolander Wissenschaftliche Meeresuntersuchengen, Vol. 12(4):444-448.

Ostend, Belgium; June 1964 to August 1964. Steel, wooden, and glass panels were exposed 1.5 meters below a raft at pierside. Organisms listed.

Testing was to determine qualitative and quantitative differences in fouling accumulation on different materials. Panels were so muddy after two months that detailed analysis was impossible.

PETUKHOVA, T. A., 1963. Settlement of larvae of fouling organisms and by marine borers (Teredinidae) in the Gelendzhik and Novorossesysk area. Marine Fouling and Borers. Trudy Instituta Okeanologii, Vol. 70:151-156.

Northeast Black Sea; 1960-1961. Glass and wooden panels were exposed pierside at two depths for one month, three months, six months and twelve months. Organisms listed; also relative occurrence, weight of biomass, and seasonal settlement noted.

Offshore winds were found to reduce the settlement of larvae on panels by driving away the planktonic larvae for reasons not stated.

PHELPS, A., 1941. Observations on fouling on test panels at Port Aransas, Texas. Unpublished Report to U.S. Navy BUSHIPS, Reference S19-1-(3).

This report not seen.

POMERAT, C. M. and E. R. REINER, 1942. The influence of surface angle and light on the attachment of barnacles and other sedentary organisms. Biological Bulletin of Woods Hole, Vol. 82(1):14-25.

Black, opal, and clear glass panels were exposed at different angles for short periods of time. Twice as many barnacles attached to black surfaces during daylight; little difference at night.

Surface angle was found to be important to some organisms but not to others.

POMERAT, C. M. and C. M. WEISS, 1946. The influence of texture and composition of surface on the attachment of sedentary marine organisms. Forty different structural materials were exposed to fouling attachment at a pier in Miami, Florida. Porous, fibrous material was found to collect the greatest numbers of larvae.

PYEFINCH, K., 1950. Studies on marine fouling organisms. Journal of the Iron and Steel Institute. June 1950:214-220.

Millport, Birkenhead, Caernarvon, Plymouth, and Chichester, England; 1942-1948. Metal panels were exposed under rafts in the various harbors for short periods of time. Temperature, salinity, currents, and light measured on site. Organisms listed; also season of attachment noted.

Barnacle settlement was deterred by already settled hydroids and algae and by water currents. Light, however, had little effect on settlement.

Balanus crenatus bases were shown to increase in size by 0.15 millimeter per day for several months if settlement occurred in the spring. If in the fall, growth was found to be negligible until spring.

Only one or two of thirteen thousand barnacle larvae live to be come adults.

RALPH, P. M. and D. E. HURLEY. 1952. The settling and growth of wharf-pile fauna in Port Nicholson, Wellington, New Zealand. Zoology Publications from Victoria University College. No. 19.

Queens Wharf, Port Nicholson, Wellington, New Zealand; March 1949 to April 1950. Wooden panels were exposed four feet below MLW at pierside for monthly and cumulative periods. Organisms listed; also season of settlement and rates of growth noted.

RAO, B. S., 1964. Studies on marine fouling organisms tolerant to low salinity and copper at Bombay harbour. Indian Journal of Technology. Vol. 2(4):142-146.

Bombay, India; June 1959 to December 1959. Plastic, bituminum, and steel panels exposed one and three feet below a raft moored at the entrance to the harbor. Salinity and rainfall data collected on site. Organisms listed and percent of test panels covered per month was noted.

Individual species preferences for low or normal salinity are indicated. Species of Membranipora were found to be resistant to copper toxins.

See also Iyengar and others, 1957.

RELINI, G., 1964. Andamento stagionale degli organismi sessili del porto di Genoa. Archivo di Oceanografia e Limnologia. Vol. 13(2):281-296.

Genoa, Italy; 1956-1958. Asbestos and cement panels were exposed under a raft in the harbor for monthly periods. Organisms listed by major group; also season of attachment and rates of growth.

RICHARDS, B. R. and W. F. CLAPP. 1944. A preliminary report on fouling characteristics at Ponce de Leon Inlet, Daytona Beach, Florida. Journal of Marine Research. Vol. 5(3):189-195.

Dayton Beach, Florida; 1942. Wooden panels exposed two feet below MLW at pierside for monthly periods. Temperature data also collected. Organisms listed.

The site was found to be satisfactory for use as a marine exposure station, i.e., adequate fouling and boring community and year-round settlement.

ROMANOVSKY, V., 1961. Hydrological conditions and biological conditions in testing stations: Vol. I - In Europe, and Vol. II - Outside Europe. Organization for Economic Cooperation and Development. Oceanographic Study and Research Center, Paris, France.

Test stations located at Portsmouth, England, Trondheim, Norway; Drobak, Norway; Cuxhaven, Germany; Der Helder, Netherlands; Ostend, Belgium; Cherbourg, France; La Pallice, France; Toulon, France; Marseille, France; Genoa, Italy, Rovinj, Yugoslavia; Haifa, Israel; Casablanca, Morocco; Abidjan, Ivory Coast; Sydney, Australia; Aukland, New Zealand; Duxbury, Massachusetts, Wrightsville Beach, North Carolina; Miami, Florida; and San Diego, California. Steel, wood, and plastic panels are exposed in shallow water for short periods, using standardized procedures.

Data will be reported independently by various authors.

RUSSELL, H. 1964. U.S. Naval Facilities Engineering Command Washington D.C. Personal communication.

Aircraft carriers docked at Norfolk, Virginia have been having problems with hydroids which enter water conduits as larvae and settle, seriously reducing the flow of water.

SAITO, T., 1931. Researches in fouling organisms of the ship's bottoms. Zosen Kiokai. Vol. 47:13-64.

Ominato, Maizuru, Kure, Yokosuka, Sasebo, Japan; Chinkai, Korea; and Bako, Fescadores; August 1925 to July 1927. Glass and steel panels were exposed for one year or one season in shallow water. Organisms listed and dry weight of biomass noted.

SCHEER, B. T., 1945. The development of marine fouling communities. Biological Bulletin of Woods Hole. Vol. 89:103-112.

Newport, California; February 1943 to March 1945. Glass and aluminum panels were exposed pierside for two week and longer periods. Temperature data collected on site. Organisms listed; also wet weight of biomass, seasonal occurrence, and percent coverage noted.

Six seral stages to climax are described, with the conclusion drawn that true succession occurs in the fouling community rather than seasonal progression.

SCHEER, B. T. and D. L. FOX, 1947. Attachment of sedentary marine organisms to petrolatum surfaces. Proceedings of the Society for Experimental Biology and Medicine. Vol. 65:92-95.

Fouling organisms were found to attach less readily to materials coated with petrolatum than to uncoated similar materials. The interface between the petrolatum and the water was found to have a negative charge, which may be important to its antifouling properties.

SKERMAN, T. M., 1958. Marine fouling at the port of Lyttleton. New Zealand Journal of Science. Fol. 1(2):224-257.

Lyttleton, South Island, New Zealoan, 1954-1955. Perspex panels were exposed one foot below ELWS at pierside for one month and longer periods. Temperature data collected on site. Organisms listed; also season of settlement and rates of growth noted.

Bugula colonies prevented settlement of barnacle, hydroid, and tubeworm larvae.

SKERMAN, T. M., 1959. Marine fouling at the port of Aukland. New Zealand Journal of Science. Vol. 2(1):57-94.

Aukland harbour, New Zealand; January 1954 to December 1955. Perspex panels were exposed one foot below ELWS at pierside for monthly and longer periods. Temperature data collected on site. Organisms listed; also season of settlement and rates of growth noted.

Author finds weights or volumes misleading when comparing the fouling of different ports or regions. More satisfactory characteristics would be: (1) length of season of settlement, (2) rates of growth, and (3) density of settlement.

SMITH, F. G. W., 1946. The effects of water currents upon the attachment and growth of barnacles. Biological Bulletin of Woods Hole. Vol. 90 (1):51-70.

Larvae of different species of barnacles attempted to attach to a rotating disc. Some could not attach at speeds greater than 0.7 knot, others at greater than 0.9 knot, none at greater than 1.1 knots.

SMITH, F. G. W., and others, 1950. An ecological survey of the subtropical inshore waters adjacent to Miami. Ecology. Vol. 31 (1):119-146.

Miami, Florida; 1945-1946. Glass panels were exposed at several sites in the bay beneath rafts. Temperature, salinity, oxygen, and plankton data collected on site. Organisms listed; also relative occurrence and rates of growth noted.

Authors found neither a true succession nor a definite seasonal progression occurring. Changes in the communities of organisms appeared to be the result of interactions of a number of factors.

The pollutants of Biscayne Bay tended to have a stimulating effect on growth of foulers.

STAROSTIN, I. V., 1963. Marine fouling in technical conduits in our southern seas and some of the methods in fighting them. Marine Fouling and Borers. Trudy Instituta Okeanologii, Vol. 70:101-123.

Black Sea, Sea of Azov, and Caspian Sea; 1960-1961. Water conduits were examined and some iron panels exposed for unspecified periods. Organisms listed; also weight and seasonal occurrence noted.

Most of the foulers listed seem to be common to all three bodies of water.

STAROSTIN, I. V. and E. P. TURPAYEVA. 1963. Settlement on water intake structures of a metallurgical plant by larvae of fouling organisms (Sea of Azov). Marine Fouling and Borers. Trudy Instituta Okeanologii. Vol. 70:142-150.

Conduit walls examined and glass panels were exposed pierside at 0.7 and 1.3 meters below the surface from ten days to one year. Organisms listed; also weight and seasonal occurrence noted.

Different climax found on panels exposed for one year but commencing in different seasons.

There may be a correlation between abundance of plankton and the growth or decline of foulers.

STUBBINGS, H. G., 1964. The ecology of Chichester harbour, South England, with special reference to some fouling species. Internationale Revue Der Gesamten Hydrobiologie. Vol. 49(2):233-279.

Chichester, England; 1945-1949. Bakelite and steel panels were exposed in shallow water for weekly periods. Temperature and salinity data collected on site. Organisms listed; also seasonal occurrence and preference for shaded or unshaded panels noted.

TANITA, S. and S. SATO, 1953. Studies on the organisms attaching to raft cultured oysters. II. Seasonal variation. Bulletin of the Tohoku Regional Fisheries Research Laboratory. No. 2:56-66.

Onagawa Bay and Matsushima Bay, Japan; January 1951 to September 1952. Slate panels were exposed at one, three, and five meters below oyster rafts. Temperature data collected on site. Organisms listed; also season of occurrence and relative abundance noted.

More numbers at Onagawa Bay but more species at Matsushima Bay, for reasons not stated.

TARAMELLI, E. and C. CHIMENZ., 1965. Studi sperimentali e sistematici sul "fouling" nel porto di Civitavecchia. Rendic. Accad. Naz. dei XL(4) 16:1-37.

This report not seen.

TARASOV, N. I., 1961(a). Marine fouling - USSR. Zoologicheskiy Zhurnal, Vol. 40(4):447-489. Moscow.

Mostly a state-of-the-art report on current antifouling efforts in USSR. Principal macrofoulers are listed and their occurrence in USSR waters noted (Barents Sea, White Sea, Baltic Sea, Black Sea, Sea of Azov, Caspian Sea, Sea of Japan, Okhotsk Sea, Bering Sea).

TARASOV, N. I., 1961(5) Fouling in Soviet waters of the Sea of Japan. Trudy Instituta Okeanologii. Vol. 49:3-59.

Russian coast of the Sea of Japan; 1953-1956. Buoys were examined and steel panels exposed in shallow water for unspecified times. Organisms listed and weights of biomass noted

This is a summary of several fouling studies carried out during 1953-56.

TEEL, R. B. and W. F. FAIR, JR., 1957. Testing of coal tar coatings. Part III. Resistance of fouling and degradation by marine organisms. Corrosion. Vol. 13(F):493t-500t.

Barnacles were able to penetrate coal tar coatings. Encrusting bryozoans, hydroids, tunicates, mussels, and oysters were not.

THORSON, G., 1964. Light as an ecological factor. Ophelia, Vol. 1(167).

Investigations of the reactions of larvae of sedentary organisms leads him to the conclusion that most prefer shaded areas and dark surfaces for settlement and are attracted chemically by earlier settled populations of their own species. Strong light, increased temperature, and reduced salinity all combine to make larvae photo-negative, hence tend to keep numbers of species which settle in brackish intertidal habitat to a minimum.

TURNER, H. J., 1963. Deep ocean marine fouling. Oceanus, Vol. 10(2):2-7.

Wood-asbestos panels were exposed in deep water for forty-eight to fifty-seven days between Woods Hole and Bermuda.

Fouling in the open sea was found to be restricted to a few species in moderate numbers decreasing with depth, with no significant quantity below 500 meters.

Hydroids and stalked barnacles dominate

TURNER, R. D., 1966. Implications of recent research in the Teredinidae. Holz und Organismen - Internationales Symposium, Berlin, Germany, Vol. I:437-446.

"An early heavy settlement of filamentous bryozoans may prevent or greatly reduce the attack of shipworms, the larvae of the teredinids apparently being consumed by the fouling organisms before they can settle and penetrate"

U.S. NAVAL OCEANOGRAPHIC OFFICE, 1961. Research in progress, Penobscot Bay, Maine

After 120 days exposure in Penobscot Bay, Maine, during May to August 1961, the response of electrical conductivity cells was affected by fouling attachment, resulting in salinity errors of up to 4.93 parts per thousand. The electrodes were found to be coated with a film of diatoms and algal spores.

After cleaning, the conductivity cells again recorded salinity values within allowable limits

URICK, R. J., 1962. Acoustic effects of marine fouling on transducers. TR #62-145, U.S. Naval Ordnance Laboratory, Washington, D.C.

Chesapeake Bay, 1961. Hydrophones were exposed to fouling during the growing season. Measurements of beam pattern and receiving response were made both in the fouled condition and after the fouling had been cleaned off. Reductions of axial sensitivity ranging from zero to ten db were found in the frequency interval 1 to 20 kc.

VISSCHER, J. P., 1937. Report of fouling experiments at Pearl Harbor Navy yard, Honolulu, T. H. Unpublished report to Bureau of Construction and Repair, BUSHIPS library reference R-12 through R-21, U.S. Navy Bureau of Ships, Washington, D.C.

Coal Dock, Pearl Harbor, Hawaii, 1935 to 1937. Wooden panels were exposed at pierside for two weeks, one month, and two month periods. Organisms listed by major groups and wet and dry weights noted.

No regular trends in weights were found. Dry weight was found to be one-third to one-half that of wet weight.

VISSCHER, J. P. and R. H. LUCE, 1928. Reactions of the cyprid larvae of barnacles to light with special reference to spectral colors. Biological Bulletin of Woods Hole, Vol. 54:336-350

The larvae of barnacles and many other fouling organisms were found to be photonegative at the time of attachment, therefore preferred shaded or dark substrata

Light green might be a better color for ship bottoms than the more usual red.

VORSTMAN, A. G., 1935. Biologische notizen betreffs der sessilen fauna in hafen der stadt Amsterdam. Zool. Anz Vol. 109:76-80.

Amsterdam harbor, Netherlands; 1931-1934. Unknown material was exposed for monthly periods in shallow water. Organisms listed and rates of growth noted.

WALDRON, L. J. and others, 1961. Preliminary experiments on deep sea corrosion and corrosion prevention Memo Report 1242, U S Naval Research Laboratory, Washington, D C

Fouling attachment resulted in severe crevice corrosion, including penetration of one-eighth inch stainless steel (tenelon) panels, after 111 days of exposure at a shallow test site at Chincoteague, Virginia.

WEISS, C. M., 1948(a). The seasonal occurrence of sedentary marine organisms in Biscayne Bay, Florida. Ecology, Vol. 29(2):153-172.

Biscayne Bay, Miami, Florida; 1942-1945 Glass panels were exposed under rafts at three sites in the bay for one month periods. Temperature, salinity, pollution, and current data collected on site. Organisms listed and monthly and relative occurrence noted.

Barnacles were dominants because their larvae were available at all seasons in great numbers, especially at Beach Boat Slips where surrounding concrete walls provide a nearby brood stock and moderate pollution stimulated growth.

WEISS, C. M., 1948(b). Seasonal and annual variations in the attachment and survival of barnacle cyprids. Biological Bulletin of Woods Hole, Vol. 94(3):236-243.

Most barnacle cyprids were found to set within the temperature range of 18°C. to 27°C.

WEISS, C. M., 1948(c). An observation on the inhibition of marine wood destroyers by heavy fouling accumulation. Ecology, Vol. 29(1):120.

Experiments show that a heavy, early buildup of foulers will limit the depredations of marine borers, such as Teredo and Limnoria.

WHITTEN, H. L. and others, 1950. Invertebrate fauna of Texas coast jetties. Publications of the Institute for Marine Science, Vol. 1(2):53-87.

An ecological study of the fauna of rock jetties at Sabine Pass, Galveston, Freeport, Port Aransas, and Port Isabel, Texas; 1938-1940.

The annual range of salinities was found to be 15-35 parts per thousand; the annual range of temperatures was 9° - 30°C.

The fauna was dominated by barnacles, mussels, limpets, and anemones.

There was an indication of a north to south change in the relative abundance of these dominants, which might be correlated with mean annual salinity or wave action.

Organisms are listed for each area.

WISELY, B., 1959 Factors influencing the settling of the principal marine organisms in Sydney Harbour, Australia Australian Journal of Marine and Freshwater Research, Vol. 10 30-44.

Garden Island, in Sydney harbour, 1947-1957. Perspex and bakelite panels were exposed biweekly and monthly beneath rafts at four shallow sites in the harbor Temperature and salinity data collected on site. Organisms listed and relative occurrence noted.

Most fouling found on roughened, dark surfaces and during warm months.

WOOD, E. J. F., 1955. Effect of temperature and rate of flow on some marine fouling organisms. Australian Journal of Science, Vol. 18:34-37.

Author found that 32°C. was sufficient to kill Mytilus planulatus, Galeolaria caespitosa, Hydroides norvegica, and Ciona intestinalis.

Rate of flow also inhibited settlement of larvae. Hydroides norvegica would not settle on rotating discs at speeds greater than 1.2 knots. Balanus amphitrite would not settle at speeds greater than 2.0 knots.

WOODS HOLE OCEANOGRAPHIC INSTITUTION, 1952. Marine Fouling and its prevention. United States Naval Institute, Annapolis, Maryland, p. 344.

Tests made in Miami showed that panels oriented parallel with the tidal current resulted in a 3-% increase in the fouling population, compared to panels oriented at an angle of approximately thirty degrees to the current.

ZEVINA, G. B., 1962. Caspian fouling and its changes during the last ten years. 1951-1961. Okeanologii, Vol. 2(4):702-726.

Examination of fouling on buoys in the Caspian Sea during 1951 to 1961 has shown an increase of 300 to 800 percent, because of changing hydrological conditions and the introduction of new species of animals, principally Balanus improvisus.

See also Zevina and others, 1963(b).

ZEVINA, G. B., 1963. Marine fouling in the White Sea. Marine Fouling and Borers, Trudy Instituta Okeanologii, Vol. 70:52-71.

Buoys exposed for five to six months in the White Sea were examined for fouling organisms. Organisms listed and relative frequency noted.

Quantative and qualitative differences in fouling for seven areas of the White Sea are discussed. Fouling settlement was more intense in coastal areas

ZEVINA, G. B and others 1963 The status of marine fouling in the Caspian Sea Marine Fouling and Borers. Trudy Instituta Okeanologii, Vol. 70:3-26.

Baltic Sea; 1951-1961. Buoys

were examined and test panels of unspecified material were exposed for short periods. Organisms listed and weights of biomass noted.

Many new organisms have shown up in the Caspian Sea, introduced from the Black Sea and the Mediterranean Sea. More biomass and more species are found in the Black Sea than in the Caspian Sea.

See also Zevina, 1962

ZINN, D. J. and others. 1957. Fouling project - final report. Unpublished report No. 57-6 from Narragansett Marine Laboratory to the Office of Naval Research, Washington, D.C.

Narragansett Bay, Rhode Island; March 1955 to March 1957. Glass panels and steel mine cases were exposed for short periods of time at three shallow stations. Temperature, salinity, and plankton measurements made on site. Organisms listed; also displacement volumes, and wet weights of biomass noted.

Total biomass was found to decrease with increasing distance from shore. Organisms attached to test panels and other artificial surfaces were found to be similar to those on natural substrates.

ZOBELL, C. E., 1939. The role of bacteria in the fouling of submerged surfaces. Biological Bulletin of Woods Hole, Vol. 77(2):302.

Primary films encourage the settlement of foulers by:

1. supplying a foothold for larvae and food for their development.
2. discoloring bright surfaces, for negatively phototropic forms.
3. insulating from toxic elements of the surface.
4. increasing the alkalinity of the surface, for $CaCO_3$ forms.
5. favoring the growth of algae by concentration of plant nutrients.

APPENDIX I

GEOGRAPHIC INDEX

AFRICA

French Morocco:
- Fish 1945
- Romanovsky 1961

Ivory Coast:
- Romanovsky 1961

South Africa:
- Millard 1952

ASIA

Bering Sea:
- Tarasov 1961(a)

India:
- Antony Raja 1959
- Daniel 1954
- Ganapati 1958
- Iyengar and others 1957
- Kuriyan 1950, 1952, 1953
- Nagabhushanam 1960
- Paul 1942
- Rao 1964

Israel:
- Romanovsky 1961

Japan:
- Hosiai 1958, 1964
- Ito 1959
- Izubuchi 1934
- Katsushige and Tonoyama 1960
- Kawahara 1961, 1962, 1963, 1965
- Kawahara and Iizima 1960
- Kawahara and Kobayashi 1954
- Kazihara 1964
- Mawatari and others 1962
- Miyazaki 1938
- Saito 1931
- Tanita and Sato 1953

Korea:
- Saito 1931

Kuwait:
- Great Britain Admiralty Corrosion Committee 1952

Okhotsk Sea:
- Tarasov 1961(a)

Sea of Japan:
- Tarasov 1961(a)

ATLANTIC OCEAN ISLANDS

Bahamas:
- DePalma 1962(c)

Bermuda:
- Beckner 1966
- Turner 1963

Spitsbergen:
- Orton 1933

AUSTRALIA AND NEW ZEALAND

Australia:
- Allen 1950
- Allen and Wood 1950
- Blick and Wisely 1964
- Romanovsky 1961
- Wisely 1959

New Zealand:
- Ralph and Hurley 1952
- Romanovsky 1961
- Skerman 1958, 1959

CENTRAL AMERICA AND WEST INDIES

Cuba:
- Lunz 1940

Curacao:
- DeWolf and Meuter-Schriel 1963

Jamaica:
- Goodboy 1961

Panama:
- DePalma 1962(a)
- Forgeson 1958

Puerto Rico:
- Moritz 1943, 1944

DEEP WATER SITES (100 meters or greater)

Bahamas:
- DePalma 1962(c)

Bermuda:
- Turner 1963

Black Sea:
- Dolgopal'skaya 1959

California:
- Muroaka 1966

Florida:
- DePalma 1963

EUROPE

Baltic Sea:
- Arbuzova 1963
- Tarasov 1961(a)
- Zevina and others 1963

Barents Sea:
- Tarasov 1961(a)

Belgium:
- Persoone 1965
- Romanovsky 1961

Black Sea:
- Dolgopol'skaya 1959
- Grinbart 1948
- Lebedev and others 1963
- Nikitin and Turpaeva 1958
- Petukhova 1963
- Starostin 1963
- Tarasov 1961(a)

Caspian Sea:
- Starostin 1963
- Tarasov 1961(a)
- Zevina 1962

France:
- Callame 1954
- Romanovsky 1961

Germany:
- Caspers 1952
- Dahl 1893
- Hentschel 1915
- Kirchenpauer 1862
- Romanovsky 1961

Great Britain:
- Beaumont 1900
- Corlett 1948
- Fraser 1938
- Great Britain Admiralty Corrosion Committee 1952
- Milne 1940
- Pyefinch 1950
- Romanovsky 1961
- Stubbings 1964

Italy:
- Chimenz 19[illegible]
- Relini 1964
- Romanovsky [illegible]
- Taramelli and Chimenz 1965

Netherlands:
- Romanovsky 1961
- Vorstman 1935

Norway:
- Nair 1962
- Romanovsky 1961

Sardinia:
- DePalma 1963(b)

Sea of Azov:
- Starotsin 1963
- Starotsin and Turpayeva 1963
- Tarasov 1961(a)

Spain:
- Arias and Morales 1963
- Morales and Arias 1965

White Sea:
- Tarasov 1961(a)
- Zevina 1963

Yugoslavia:
- Romanovsky 1961

NORTH AMERICA

California:
- Aleem 1957
- Barham 1961
- Barnard 1958
- Coe 1932
- Coe and Allen 1937
- Davies and Barham 1965
- Eberhardt 1964
- Fowler 1941
- Graham and Gay 1945
- Mohr 1952
- Mosher 1961
- Muroaka 1966
- Romanovsky 1961
- Scheer 1945

Florida:
- Blake 1966
- DePalma 1963(a)
- Fitzgerald and others 1917
- Gaul and Vick 1964
- McNulty 1961
- Pequegnat 1965
- Pomerat and Weiss 1946
- Richards and Clapp 1944
- Romanovsky 1961
- Smith 1950
- Weiss 1948(a), 1948(b)

Louisiana:
- Gunter and Geyer 1955

[Maine?]:
- DePalma [illegible]2(b)
- Fuller 1946

Massachusetts:
- Blake [illegible]
- Grave [illegible]33
- Hutchins and Deevey 19[illegible]
- Mosher 19[illegible]
- Romanovsky 19[illegible]

Maryland:
- Cory 1964, 1967
- Mosher 1961

New York:
- Ayers 1951
- Gosner 1966
- Hutchins and Deevey 1944
- Mosher 1961

North Carolina:
- McDougall 1943
- Romanovsky 1961

Rhode Island:
- Zinn and others 1957

South Carolina:
- Lunz 1945

Texas:
- Gunter and Geyer 1955
- Phelps 1941
- Whitten and others 1950

Virginia:
- Andrews 1953
- Daugherty 1961
- Hargis 1964
- Hutchins and Deevey 1944
- Maloney 1958
- Russell 1964

Washington:
- DePalma 1966
- Johnson and Miller 1935

PACIFIC AND INDIAN OCEAN ISLANDS

Hawaii:
- Edmondson 1944(a), 1944(b)
- Edmondson and Ingram 1939
- Ingram 1937
- Hutchins 1944
- Visscher 1937

Heard Island:
- Chittleborough 1956

Philippines:
- Lunz 1945

Samoa:
- Orton 1920

APPENDIX II

FACTORS AFFECTING THE SETTLEMENT AND GROWTH OF FOULERS

Bioinhibitors and Biostimulators:
- Edmondson 1944(a)
- Goodbody 1961
- Harris 1946
- Knight-Jones and Crisp 1953
- Manning 1952
- Nagabhushanam 1960
- Pyefinch 1950
- Skerman 1958
- Turner 1966
- Weiss 1948(c)

Color:
- Katsushige and Tonoyama 1962
- Mawatari and Kobayashi 1954
- Visscher and Luce 1928

Distance From Shore or Shoal Areas:
- Hutchins and Deevey 1944
- Zinn and others 1957

Light:
- Barnard 1958
- DePalma 1963(b)
- DeWolf and Meuter-Schriel 1963

Hosiai 1956
Ingram 1937
McDougall 1943
Pomerat and Reiner 1942
Pyefinch 1950
Stubbings 1964
Thorson 1964
Visscher and Luce 1928

Pollution and Nutrients:
Antony Raja 1959
Cory 1964
Daniel 1954
Fraser 1938
Ganapati and others 1958
Gosner 1966
McNulty 1961
Mohr 1952
Morales and Arias 1965
Moritz 1944
Smith and others 1950

Primary Film:
Crisp and Ryland 1960
Miller 1948
Zobell 1939

Salinity:
Andrews 1953
Edmondson and Ingram 1939
Ganapati and others 1958
McDougall 1943
Milne 1940
Rao 1964
Weiss 1948(a)
Whitten and others 1950

Substrate:
Barnes and Powell 1950
Blick and Wisely 1963
Coe 1932
Corlett 1948
Crisp and Ryland 1960
Hutchins 1949
Kuriyan 1952
Pomerat and Weiss 1946
Scheer and Fox 1947
Wisely 1959

Temperature:
Dunnington 1965
Graham and Gay 1945
Kawahara and Iizima 1960
Weiss 1948(b)
Wood 1955

Water Currents, Wind, Wave Action, and Tides:
Dew and Wood 1955
Doochin and Smith 1951
Mawatari 1965
McDougall 1943
Petukhova 1963
Pyefinch 1950
Smith 1946
Whitten and others 1950
Wood 1955
Woods Hole Oceanographic Institution 1952

APPENDIX III

EFFECTS OF FOULING

Effect on Acoustic Transmission and Reception:
Barham 1961
Fitzgerald and others 1947
Moritz 1943
Urick 1962

Effects on Coatings:
Alumbaugh 1964
Lebedev and others 1963

Effect on Corrosion:
Alexander and others 1957
Arbuzova 1961
Forgeson and others 1958
Waldron and others 1961

Effect on Instruments:
Beckner 1966
Eberhardt 1964
Fish 1945
Gaul and Vick 1964
Kallio and Evans 1964
U.S. Naval Oceanographic Office 1961

Effect on Water Movement:
Fish 1945
Kingcome 1961
McEntee 1915
McMahon 1956
Moritz 1944
Nazirov and others 1960
Russell 1964

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