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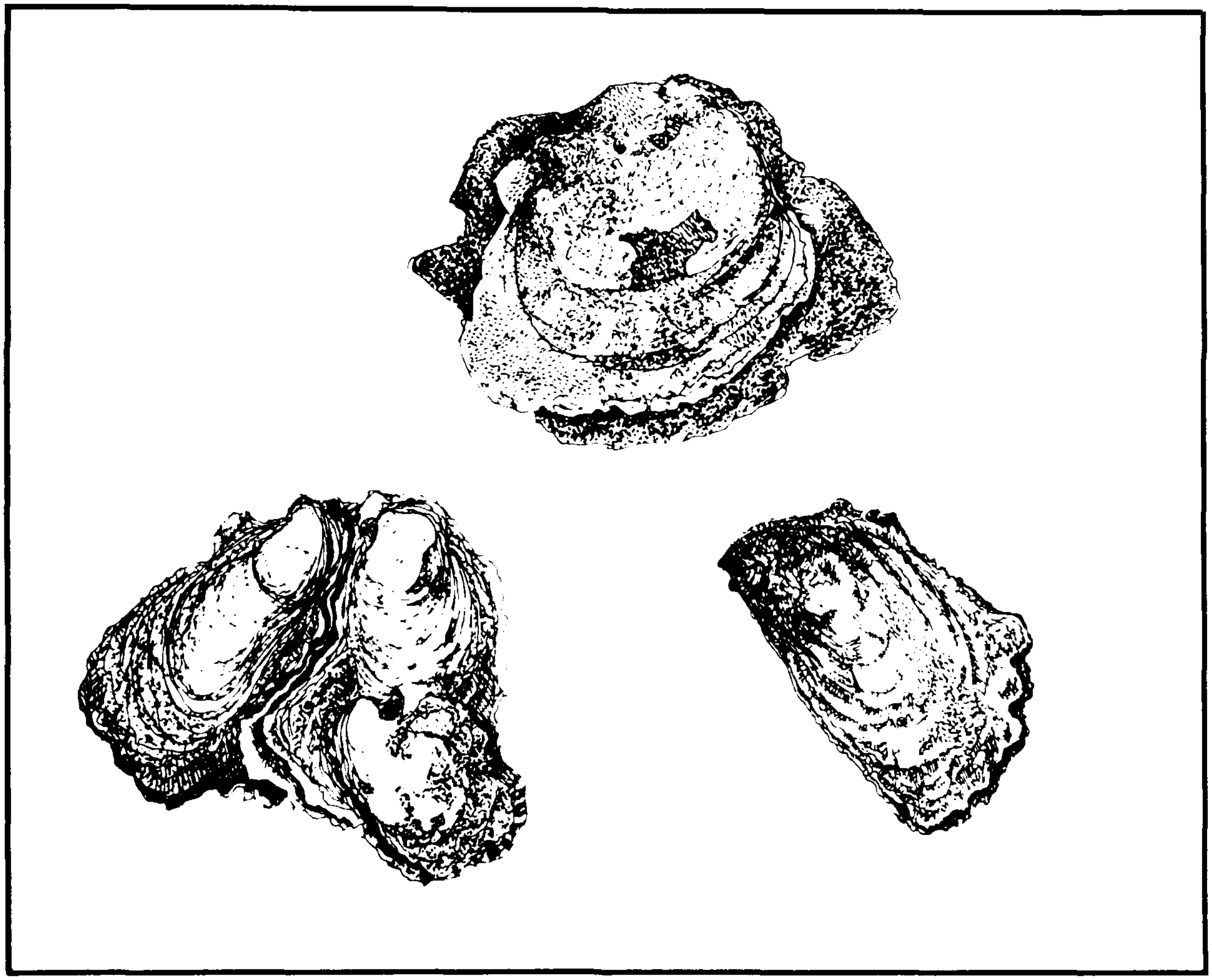
Biological Report 82(11.124)
December 1989

TR EL-82-4

Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (Pacific Northwest)

OLYMPIA OYSTER



Coastal Ecology Group
Waterways Experiment Station
U.S. Army Corps of Engineers

Fish and Wildlife Service
U.S. Department of the Interior

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Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (Pacific Northwest)

OLYMPIA OYSTER

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PREFACE

This species profile is one of a series on coastal aquatic organisms, principally fish, of sport, commercial, or ecological importance. The profiles are designed to provide coastal managers, engineers, and biologists with a brief comprehensive sketch of the biological characteristics and environmental requirements of the species and to describe how populations of the species may be expected to react to environmental changes caused by coastal development. Each profile has sections on taxonomy, life history, ecological role, environmental requirements, and economic importance, if applicable. A three-ring binder is used for this series so that new profiles can be added as they are prepared. This project is jointly planned and financed by the U.S. Army Corps of Engineers and the U.S. Fish and Wildlife Service.

Suggestions or questions regarding this report should be directed to one of the following addresses.

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CONVERSION TABLE

Metric to U.S. Customary

Multiply	*By*	*To Obtain*
miilimeters (mm)	0.03937	inches
centimeters (cm)	0.3937	inches
meters (m)	3.281	feet
meters	0.5468	fathoms
kilometers (km)	0.6214	statute miles
kilometers	0.5396	nautical miles
square meters (m^2)	10.76	square feet
square kilometers (km^2)	0.3861	square miles
hectares (ha)	2.471	acres
liters (l)	0.2642	gallons
cubic meters (m^3)	35.31	cubic feet
cubic meters	0.0008110	acre-feet
milligrams (mg)	0.00003527	ounces
grams (g)	0.03527	ounces
kilograms (kg)	2.205	pounds
metric tons (t)	2205.0	pounds
metric tons	1.102	short tons
kilocalories (kcal)	3.968	British thermal units
Celsius degrees (° C)	1.8 (° C) + 32	Fahrenheit degrees

U.S. Customary to Metric

inches	25.40	millimeters
inches	2.54	centimeters
feet (ft)	0.3048	meters
fathoms	1.829	meters
statute miles (mi)	1.609	kilometers
nautical miles (nmi)	1.852	kilometers
square feet (ft^2)	0.0929	square meters
square miles (mi^2)	2.590	square kilometers
acres	0.4047	hectares
gallons (gal)	3.785	liters
cubic feet (ft^3)	0.02831	cubic meters
acre-feet	1233.0	cubic meters
ounces (oz)	28350.0	milligrams
ounces	28.35	grams
pounds (lb)	0.4536	kilograms
pounds	0.00045	metric tons
short tons (ton)	0.9072	metric tons
British thermal units (Btu)	0.2520	kilocalories
Fahrenheit degrees (° F)	0.5556 (° F - 32)	Celsius degrees

CONTENTS

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We thank Kenneth Chew and Terry Nosho, University of Washington, for their reviews and William N. Shaw, Humboldt State University, for his review and allowing us to use his collection of rare publications.

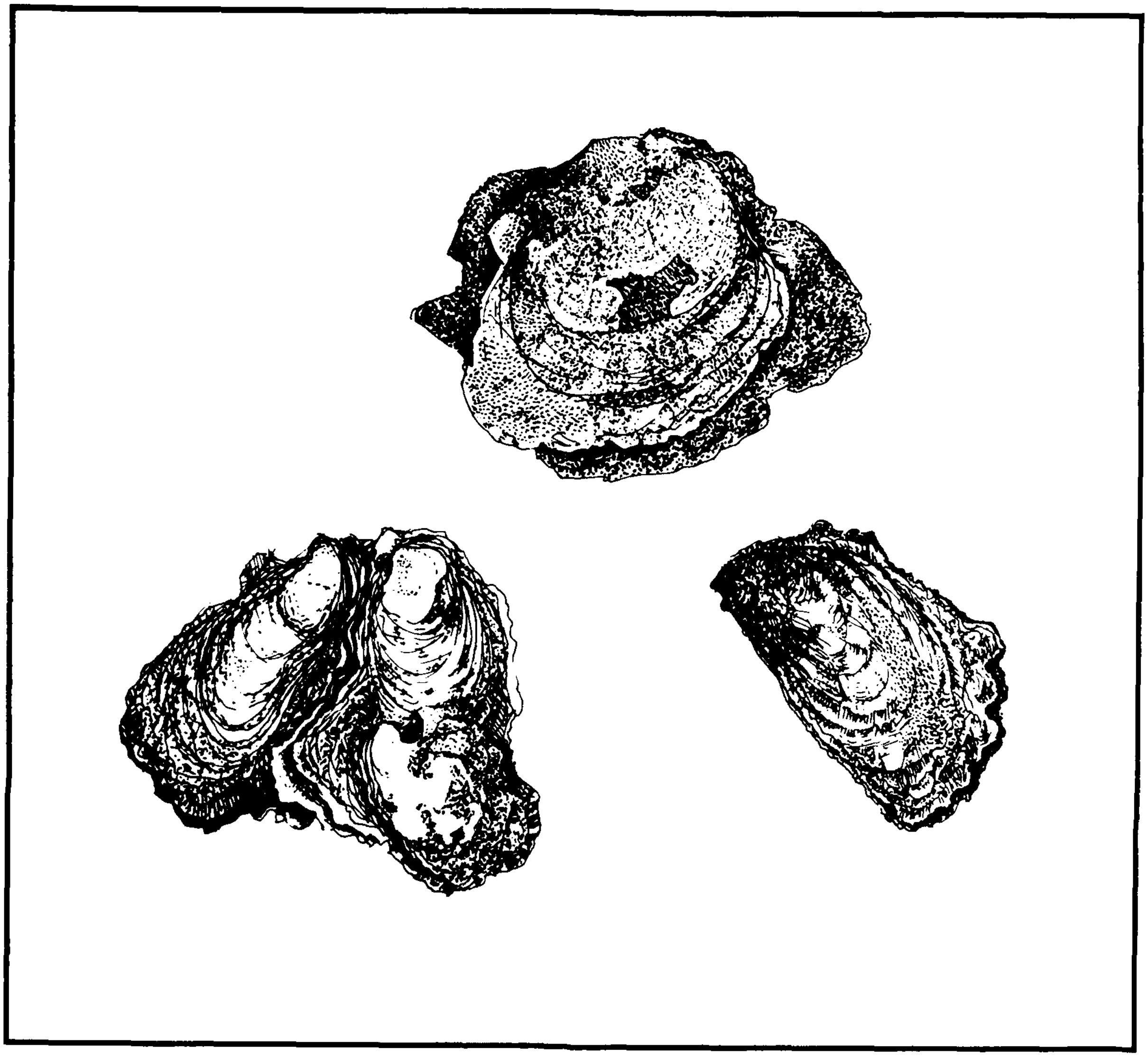

Figure 1. Olympia oyster. Single, top; cluster, bottom left; cultured, bottom right.

OLYMPIA OYSTER

NOMENCLATURE/TAXONOMY/RANGE

Scientific name .... *Ostrea lurida*
Preferred common name .... Olympia oyster (Figure 1)
Other common names .... California oyster, native oyster, shoalwater oyster, Yaquina Bay oyster, rock oyster.

Class .... Bivalvia
Order .... Pteroidea
Family .... Ostreidae

Geographic range: The Olympia oyster ranges from Southeast Alaska to Baja California--in tidal channels, estuaries, bays, and sounds; on the undersides of floats and on pilings (Fitch

1953) *in protected outer coast locations* (Allen 1976). Figure 2 shows its distribution in the Pacific Northwest.

MORPHOLOGY/IDENTIFICATION AIDS

The lower (left) valve is shallowly concave and the upper (right) valve fits into the raised margin of the opposite valve. Shell shape is extremely variable. Shells on substrate will conform to the shape of the substrate. The shells of free-growing oysters are ovate to elongate. The exterior of the shell is without a periostracum, varies from white to purplish black (Allen 1976), and may be striped with yellow or purplish brown (Hertlein 1959). The interior of the valves is white to olive green and the scar of the adductor muscle is not much darker than the rest of the shell's interior (Kozloff 1974).

REASON FOR INCLUSION IN SERIES

The Olympia oyster has been commercially exploited since the 1850's in the Pacific Northwest (Barrett 1963), and it is still produced in small quantities by oyster growers (Beattie et al. 1982). Habitat available to Olympia oysters, besides being naturally limited, has been adversely affected by human activities (Carlton 1979). Civil engineering projects in estuarine areas or in the upland watershed of the estuary can further damage Olympia oyster populations.

LIFE HISTORY

The life history of the Olympia oyster is similar to that of other oysters of the genus Ostrea. The oyster initially spawns as a male then alternates it functional gender between each spawning cycle (Coe 1932).

Spawning begins at water temperatures of 13 to 16 °C. In the southern portion of the oysters' range, spawning occurs from spring to fall, peaking in spring and to a lesser extent in fall (Coe 1932). In the central part of its range, spawning may be a prolonged period or *may consist of one or two spawning periods in* mid-summer (Hopkins 1937; Bonnot 1938). In the northern portion, there may be only one or two spawning periods in mid-summer (Hopkins 1937).

Spawning begins when males release clusters of sperm into the mantle cavity. These sperm balls, which are expelled from the body by contractions of the shell, disintegrate in seawater and release the spermatozoa. Spermatozoa are brought into the mantle cavity of the female with water pumped by the gills and the eggs are fertilized (Coe 1932). Presence of spermatozoa in seawater will stimulate synchronous spawning in Olympia oysters. The fertilized eggs develop into veliger larvae in the oyster's mantle chamber before they are discharged 10 to 12 days later. An average brood of larvae is 250,000 to 300,000 (Hopkins 1937). At discharge, the larvae are 185 to 187 μm long (Hopkins 1937). The veliger stage lasts 11 to 16 days (Imai et al. 1954).

The larvae develop an eyespot and foot and begin to crawl on hard substrate then metamorphose into spat. The preferred substrate is old oyster shells, but rocks, wood, metal, or any other hard material may be used as a setting surface (Fasten 1931). Olympia oyster spat most often set on the underside of horizontal surfaces. This is not a phototrophic response, but is attributed to the swimming position of the larvae in which the foot is held in a superior position (Hopkins 1937). The oyster crawls with the foot on the surface and glue is secreted from the byssus gland, which attaches the shell to the substrate (Galtsoff 1964).

Artificial spat collectors that create a turbulent waterflow, disrupting the normal swimming position of larvae, collect spat on the upper and underside of horizontal surfaces (Bonnot 1937). Artificial spat collectors, used to collect spat commercially, may be boards, pipes, or cardboard egg dividers covered with a slurry of hydrated lime, portland cement, and fine sand. Olympia oysters differ from other species in that the substrate on which they settle need not be particularly clean and may be

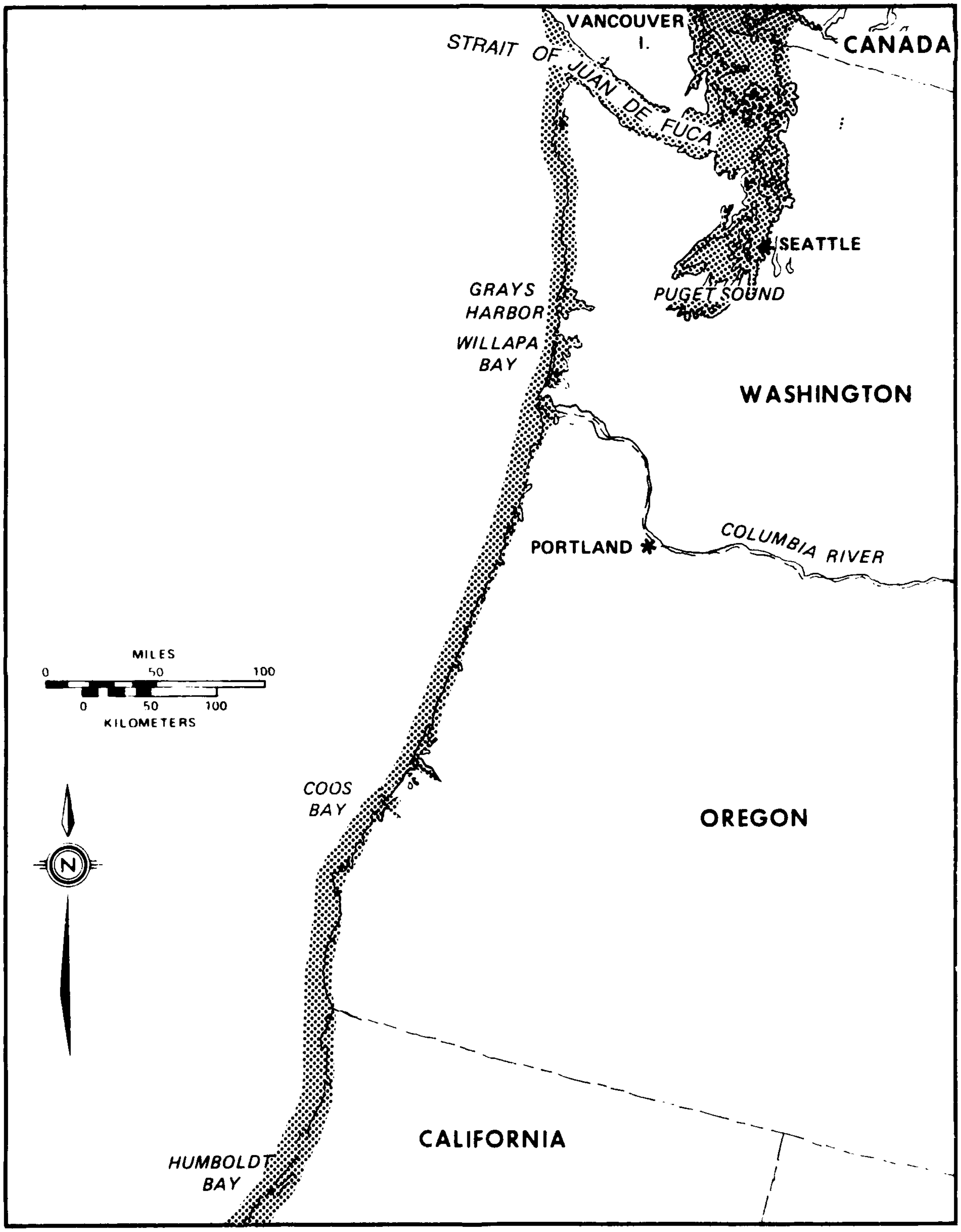

Figure 2. Distribution of the Olympia oyster (shaded area) in the Pacific Northwest region.

placed in the water in advance of spat settlement (Korringa 1976).

The Olympia oyster grows slowly, reaching shell heights of 35 to 45 mm in three years in Washington State and has little or no growth thereafter (K. Chew, Fisheries Department, University of Washington; pers. comm.). Shell height increased 2 mm per week at the Scripps Institute of Oceanography in southern California. Growth slows as the oysters mature but shell heights of 50 mm are sometimes reached in 30 weeks (Coe and Allen 1937). The maximum reported size of Olympia oysters is 75 mm (Hertlein 1959).

The maximum age of Olympia oysters has not been reported. In adults held in long-term bioassays, annual mortality was 34% in control groups (McKernan et al. 1949).

THE FISHERY

The Olympia oyster once supported an Indian sustenance fishery and a commercial fishery, and was used to establish a maricultural industry on the west coast of the United States. Examination of Indian kitchen middens near San Francisco Bay revealed Olympia oyster shells in sufficient quantities to establish the animals as an important food item of coastal tribes (Barrett 1963). Indians in the southern Puget Sound, Washington, region located their villages close to Olympia oyster populations (Steele 1957).

Olympia oysters harvested in the Pacific Northwest Region were marketed along the West Coast. Many were shipped to San Francisco on the decks of returning timber schooners (Barrett 1963), and those from southern Puget Sound were marketed locally or shipped to Seattle (Steele 1957). About 10,000 bushels of wild Olympia oysters were harvested in Washington in 1850 and annual production had reached 130,000 bushels by the 1890's; by 1910, however, production had declined to only 16,000 bushels a year (Beattie et al 1982). The harvests were similar in Oregon (Fasten 1931) and California (Barrett 1963)

The culture of Olympia oysters began in the 1890's, when oyster growers in southern Puget Sound claimed oyster producing tidelands under the Callow Act of 1890 which allowed private ownership of tidelands (Steele 1957). Early husbandry of the oysters was practiced by returning oyster shells to oyster reefs which provided substrate for new generations of oysters. In the early 1900's, the construction of dyked oyster beds, which held water at low tide and had gravel bottoms, marked a major development in oyster culture (Steele 1957). Oyster shells (cultch) were placed in locations favored for spat collection. Cultch containing Olympia oysters was spread in the dyked beds and left for 3.5 to 5 years until most of the oysters had reached a marketable size or 35-40 mm (Korringa 1976). These oysters were marketed as shucked meats rather than in the shell.

Olympia oyster production by oyster farmers peaked from 1897 to 1908, at 63,000 gallons of oyster meats a year. Production declined to 42,000 gallons a year in the 1920's and continued to fall to 10,000 gallons by the 1940's (Gunter and McKee 1960). Production in 1979 and 1980 was less than 600 gallons of meat a year (Solomon and Mills 1983). Oyster growers in southern Puget Sound would like to increase their production of Olympia oysters (Beattie et al. 1982). It takes 1,200 to 1,500 shucked Olympia oysters to make a gallon of meats (Matthiessen 1970). The 1986 market value of Olympia oyster meats was $200 a gallon (D. McMillin, Olympia Oyster Company, Shelton, Washington; pers. comm.), and $2.50 to $3.50 a dozen in the shell (K. Chew, pers. comm.).

The decline in cultured Olympia oyster production was attributed to urbanization and domestic pollution (Galtsoff 1930) and industrial pollution (Korringa 1976). The discharge of sulphite waste liquor from pulp mills has been especially destructive to oysters. Major growing grounds previously used for Olympia oysters are used to grow Pacific oysters (Crassostrea gigas) thus further reducing production of Olympia oysters (McKernan et al. 1949).

ECOLOGICAL ROLE

Olympia oysters survive in a broad range of habitats but are most abundant in estuaries small rivers and streams (Korringa 1976).

Olympia oyster reefs are formed in the subtidal zone and are bordered by mud flats at high elevations and by eel grass beds at low elevations. They are found at depths of 0 to 71 m (Hertlein 1959). Oysters may attach to the underside of rocks higher in the intertidal zone where the bottom is gravel or rock (Kozloff 1973).

Olympia oysters are filter feeders and rely on phytoplankton in the tidal waters as a food source. The ostia--gill openings through which water passes--are larger in the Olympia oyster than in the Japanese oyster. The large ostia result in the selection of larger food items and do not allow the Olympia oyster to consume nannoplankton (Elsey 1935).

The assemblage of invertebrates in bays of the Pacific coast is currently cosmopolitan, owing to the introduction of exotic species (Hedgepeth et al. 1981). Possibly some displacement of native species by invading exotic species has occurred (Carlton 1979).

Several introduced predators and parasites attack Olympia oysters. Two introduced invertebrate predators of Olympia oysters are the Japanese oyster drill Ocenebra japonica and the flatworm Pseudostylochus ostreophagus. These two species were introduced with regular sea shipments of Pacific oyster spat from Japan. The copepod Mytilicola orientalis ("red worm") lives in the anus of oysters, and oysters infected by it are usually in poor condition (Sinderman 1974); this species was also introduced from Japan. In southern Puget Sound, the slipper shell Crepidula fornicata may compete with Olympia oysters for food and space and is a major fouling organism on the oyster's shell. This slipper shell was introduced from the East Coast with the shipment of American oysters (Crassostrea virginica). Other pests are the ghost shrimp (Callianassa californiensis) and the blue mud shrimp (Upogebia pugettensis). The burrowing activity of these shrimp stirs up sediment and also weakens the dykes used for culturing oysters.

Olympia oysters have several natural predators. Some sea ducks (scaups and scoters) feed on Olympia oysters (Galtsoff 1930), and the rock crab Cancer productus is an important predator over much of the oyster's range. In California, the bat ray Myliobatis californica is an oyster predator (Matthiessen 1970). In Yaquina Bay, Oregon, histological examination of Olympia oysters has revealed a proliferative cellular disorder characterized by large, apparently abnormal cells that proliferate rapidly and cause death. The etiology of this disease is unknown (Mix 1976). Tissue examination of oysters from Puget Sound, Washington, collected after cold-water mortality showed the presence of Hexamita sp. and bacteria. Experimentation showed that Hexamita, a flagellated protozoan, could be transmitted to healthy oysters and act as a pathogen at low temperatures (Stein et al. 1961).

ENVIRONMENTAL REQUIREMENTS

Estuarine habitat along the Pacific coast is limited and has been adversely affected by human activities (Carlton 1979). Silt from highway construction has caused high mortality by smothering oysters in shallow areas of southern Puget Sound. Olympia oyster populations have never recovered to their pre-exploitation levels (Kincaid 1951).

Olympia oysters are sensitive to extreme high or low temperatures (Matthiessen 1970). Average water temperatures for southern Puget Sound are 6 to 9 °C in winter and 18 to 20 °C in summer (Hopkins 1937). In Olympia oysters held at Milford, Connecticut, through the winter, mortalities were 100% at -1.0 to 5.0 °C and 3% at 12.0 to 13.0 °C (Davis 1955).

Olympia oysters thrive at salinities above 25 ppt but tolerate occasional short exposure to lower salinities (Korringa 1976). Some oyster growers overcome predation from flatworms and drills by using oyster grounds which have flows of freshwater at low tide. The Olympia oysters can survive the salinity change but the flatworms and eggs of the drill cannot (D. McMillin, pers. comm.).

Pollution has also affected the Olympia oyster. The discharge of sulphite waste liquor from a pulp mill near Shelton, Washington, may have impacted Olympia oysters throughout the southern Puget Sound region. Spat production failed, and adult oysters failed to fatten normally (Korringa 1976). In Humboldt Bay, California, where the city of Arcata discharges its municipal wastewater about 1 km from the northern area of the State native oyster preserve (Barrett 1963), Olympia oysters still form a reef and have repopulated much of Humboldt Bay, allowing a sport harvest (California Department of Fish Game 1987).

Olympia oysters may be able to exclude small amounts of petroleum, including outboard motor wastes, for short periods by closing their shells (Clark et al. 1974). Exposure for 10 days caused some mortality, however. A conservative estimate of the portion of outboard motor fuel discharge into the water is about 10%.

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15. Supplementary Notes

*U.S. Army Corps of Engineers Report No. TR EL-82-4

16. Abstract (Limit: 200 words)

Species profiles are literature summaries of the taxonomy, morphology, range, life history, and environmental requirements of coastal aquatic species. They are designed to assist in environmental impact assessments. Olympia oysters initially spawn as males then alternate their functional genders. Spawning begins at 13-16 °C and occurs from spring to fall. After a short planktonic stage, larvae attach to the substrate. Olympia oysters thrive at salinities of 25 ppt or above; they are killed by freezing temperatures. Olympia oysters once supported large sustenance and commercial fisheries. Olympia oysters have not returned to pre-exploitation population levels which declined because of pollution and loss of habitat.

17. Document Analysis a. Descriptors

Estuaries	Life cycles	Feeding habits	Competition
Oysters	Pollution	Growth	
Salinity	Sediment	Water pollution	
Temperature	Suspended solids	Aquaculture	

b. Identifiers/Open-Ended Terms

Olympia oyster	Spat settlement
Ostrea lurida	Habitat loss
Spawning	

c. COSATI Field/Group

18. Availability Statement	19. Security Class (This Report)	21. No. of Pages
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