



OYSTER FARMING

CULTURING, HARVESTING, & PROCESSING A PRODUCT OF THE PACIFIC COAST AREA

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For several thousand years oysters have been the number one example of *mariculture* or *aquiculture*—farming the sea. Few people understand this succulent *mollusk*. Some people want to become oyster farmers, but many more simply ask questions about oysters.

You will notice that some words in this bulletin are *italicized*. Turn to the glossary on page 7 for definitions of these words.

This bulletin is intended to help people understand what oysters are, where and how they are grown, how an oyster lives, and the value of Pacific coast oyster farming.

HISTORY OF OYSTER FARMING

Prior even to beginning to hunt and fish, our ancestors gathered oysters for food from rocks on the sea edge. Thousands of years later, the oyster today still is the subject for developing advanced techniques of farming the sea.

Oysters are *bivalve* mollusks closely related to clams, scallops, mussels, and *pidlocks*. Indians of the Pacific Northwest used the native oysters and clams as a staple food. In the 1860's, sailing schooners dredged Puget Sound, Washington, and Yaquina Bay, Oregon, for oysters to grace the tables of San Francisco's elite. The native oyster, sensitive to such pressure, soon was nearly gone: not able to withstand unregulated harvest and water pollution. A few survive today in southern



A cluster of year-old Pacific (Miyagi) oysters. Oysters remain attached to a "mother shell" from post-larval stage to harvest.

Puget Sound and in Netarts and Yaquina bays in Oregon, but not enough grow to supply the trade with more than a few thousand gallons of *shucked* meats each year.

In the early 1900's a search began for a hardy, fast-growing oyster to utilize the substantial estuarine growing areas on the northeast Pacific rim. Several hundred cases of Hiroshima oyster *seed* were planted near Bellingham, Washington, with little success. Pacific (Miyagi) oysters from Matsushima Bay, Japan, destined to form the base for the Pacific coast oyster industry, first came to Puget Sound about 1919. By the mid-20's, Pacifics were in commercial production in Samish Bay in northern Puget Sound. In 1930 Pacific oyster plantings had spread to Tillamook Bay, Oregon. Now, forty years later, Tillamook Bay dominates Oregon production, but oystermen are also active in Yaquina, Coos, and Netarts bays. Oregon production is substantial at times. The Puget Sound and Willapa areas of Washington and Humboldt Bay in northern California are the more important volume oyster production areas on the Pacific coast, however.

KINDS OF OYSTERS

The term "oyster" has been applied to more than 400 different mollusks world-wide, including such non-food species as the pearl oyster. Edible varieties include some 70 species. Only a small percentage of these are grown commercially.

The native east coast oyster (American oyster) *Crassostrea virginica* is the major species farmed on the Atlantic and Gulf coasts. The native west coast oyster (Olympia or Yaquina oyster) *Ostrea lurida* historically was found from southeastern Alaska to northern California. Now small acreages of west coast native oysters are farmed on Puget Sound near Olympia and in Yaquina Bay.

Over the years commercial oysters have been transplanted widely. In the Pacific Northwest, two varieties of oysters are imported from Japan—the Pacific and the Kumamoto oyster. Both are believed to be races of one species, *Crassostrea gigas*. The Pacific oyster has been very successful. Oyster farmers on the west coast grow nearly 10 million pounds annually. The Kumamoto oyster is grown by a handful of oystermen in coastal bays of Oregon and Washington, primarily for the restaurant trade. Another exotic oyster, the European, *Ostrea edulis*, is valued as gourmet food in Europe and may someday be farmed on the west coast. Experimental plantings of the European oyster have been made in California and Oregon.

WHERE CAN OYSTERS BE GROWN?

Most major bays in the Pacific Northwest contain some areas suitable for oyster culture. Oregon estuaries used for oyster farming include Tillamook, Coos, Yaquina, and Netarts bays. About 5,000 acres in these four bays may be usable for oyster culture as judged by measurements of salinity, temperature, currents, and tide level. However, only an oyster can really determine whether it can survive in a given area of a bay. Because habitat conditions vary over time, good oyster land this year may not be productive next year or ten years from now.

In selecting a bay area for oyster production, several physical factors must be considered. Water for


oyster culture should contain 2 to 3 percent, by weight, dissolved salts (20 to 30 parts per thousand) compared with full-strength sea water which is near 31½ percent or 35 parts per thousand. Water temperatures between 40° and 70° F seem best suited for oysters. Oysters exposed temporarily to the summer sun at low tide often survive much warmer temperatures; those exposed briefly to freezing air in winter may also recover. Tidal and river currents are required to bring food and nutrients to the oyster plantation, but continuously strong eddying currents should be avoided.

Most oyster farmers in the Pacific Northwest use *ground culture* methods. Seed is planted in the bay at or near *mean lower low water*. Some bay areas can grow oysters up to the plus 2-foot tide level. Oysters can also be farmed sub-tidally at well below mean lower low tide water. More intensive methods of oyster farming involve the suspension from *rafts or trays, racks,* and strings of oysters to more fully utilize the water column. Rack and *stake culture* involves placement of oysters at a fixed depth above the bed of the estuary.



"... only an oyster can really determine whether it can survive . . ."

For all cultural methods, water quality must be good. Good quality includes low turbidity. That is, water must be clear enough to permit *phytoplankton* (algae, diatoms, dinoflagellates) production as food for the oysters. Oxygen concentration should be about 5 parts per million—a level that will support fish life such as salmon. The water should be relatively free of domestic and industrial wastes. Organic pollutants such as bark and sawdust should be kept away from oyster beds.

OYSTERS DISCUSSED IN THIS PUBLICATION	Scientific name	Common name(s)	Locality	Comments
	<i>Crassostrea virginica</i>	American	Native of east coast of United States	Farmed on Atlantic and Gulf coasts
	<i>Ostrea lurida</i>	Olympia, Yaquina	Native of west coast of United States	Small acreages farmed in Puget Sound and Yaquina Bay
	<i>Crassostrea gigas</i>	Pacific, Kumamoto	Japan, now in Pacific Northwest	
	<i>Ostrea edulis</i>	European	Europe	Experimental on west coast of North America

OYSTER CULTURE REGULATIONS AND SANITARY CERTIFICATION

While the land farmer produces crops in public air, the aquiculturist raises crops of human food in public waters. Water quality over shellfish reefs is monitored by state and federal health authorities. In Oregon, the state Board of Health is responsible for the sanitation certification of the clam and oyster shucking plants and the certification of shellfish-growing areas. When interstate shipment is involved, the Oregon Board of Health certifies to the federal Food and Drug Administration (FDA) that the processing plants and growing waters meet FDA standards. The Oregon Department of Environmental Quality (DEQ) provides water bacteriological data for shellfish-growing areas to the Board of Health. DEQ also monitors domestic and industrial waste sources which might contaminate shellfish.

Although some oystermen own the grounds on which oysters are grown and pay taxes on the land, most of them lease lands from the state. Lease fees are often paid on both an acreage and production basis—currently \$2 per acre per year plus five cents per gallon of production in Oregon. Laws governing artificial oyster plantations were completely revised and updated by the 1969 Oregon legislature. These laws are designated in the Oregon Revised Statutes as 509.425 through 509.510. Fish Commission of Oregon Administrative Rules relating to oysters are numbered 10-275 to 10-295.

Most of the obviously suitable land for oyster culture is already under lease. Nevertheless, newer cultural methods may make other portions of Oregon bays available for oyster plantations.

Regulations of the federal government since 1962 have specified that oystermen are farmers. Specifically, the Consolidated Farmers Home Administration Act provides that production loans may be made available for planting, cultivating, and growing oysters. As the oyster industry stabilizes, other agricultural production lenders will undoubtedly become interested in financing oyster enterprises.

HOW OYSTERS ARE GROWN

Oysters seem to thrive on tender loving care and affection. Carefully managed oyster farms out-produce public reefs. Of the many cultural methods, ground culture is by far the most common type of oyster farming operation in the Pacific Northwest. Let's take a ground culture oyster crop from the seed stage on through marketing.

Northwest bay waters are usually too cold to permit successful natural spawning of Pacific oysters. Most baby oysters, called seed or *spat*, are imported from the Sendai area of Honshu Island, Japan, at a latitude of 38° N. In the warm waters of Matsushima Bay, oysters spawn naturally in the late summer. These

free-swimming babies are caught on "mother-shell strings" (*cultch*) which have been placed there. The babies cement themselves to the mother-shell, remaining attached for the rest of their lives. In November, the strings are moved to *hardening grounds* where the seed is tempered in preparation for the trans-Pacific voyage the following spring. In February and March the strings are collected, inspected, and packed in boxes, about two bushels, or approximately 18,000 oysters, per case. The seed is inspected for pests, diseases, quality, and count by American industrial and government repre-



sentatives. Shiploads of seed leave Japan in early March, arriving on the Pacific coast in the first few days of April. Seed is distributed to growers and is usually planted during the first two weeks in April. Some growers hold the seed in cases, submerged, and plant in May or June.

Depending on water temperature (near 70° F) in the Northwest, Willapa and Dabob bays in Washington and Pendrell Sound in British Columbia often produce oyster seed. Agencies such as the Washington Department of Fisheries keep close watch on oyster spawning conditions and alert the oystermen to place *garlands* of mother shell in the water at the precise time to catch the spat. This locally-produced seed is used to supplement imports. In the future, oyster seed hatcheries should help to stabilize quantities of seed available for planting. (Hatcheries are discussed in another section of this bulletin.)

PLANTING OYSTER SEED

Planting rates for ground culture vary. A good average may be a half million seed oysters per acre. The seed is transported by *dredge* and planted at high tide by hand-scattering. At a subsequent low tide the seed is more evenly distributed on the growing grounds.

Oysters seem to be colonial animals, growing faster in a close-knit community. But they can be too thick. When this happens, the oysters grow up rather than out, putting on more shell and less meat. Oysters are often thinned by hand, spread out to fill the blank spots on the bed so that individual growth can increase. When bottom conditions are soft, oystermen drag an English pasture harrow behind the work dredge to rake the

clusters of oysters out of the mud. Alder poles are used to mark the oyster claim boundaries.

As noted earlier, not just any piece of submerged land will grow oysters. Currents, bottom composition, salinity, pollution, and other factors determine whether a specific bed is suitable. One section of a bay may produce light-shelled, heavy-meated oysters that mature quickly, while another flat may grow all to shell with little meat and slow maturity. Growth rate varies. In most Oregon bays maturity to market size requires from two and a half to four years for Pacific oysters. On Tillamook Bay, oystermen usually start harvesting the crop 28 months after planting. They attempt to complete the crop harvest by the 36th month.

CULTURING PROBLEMS

Many problems and some catastrophes can occur during the three years of growth. Problems can be divided into four categories:

- 1. Physical:** Storms, floods, *tsunamis*, and siltation can bury the entire crop with a load of silt or wash the oysters off the beds. At other times, an excess of fresh water, heat exposure, or even freezing can harm the crop.
- 2. Biological predation:** Burrowing shrimp sometimes make the ground soft, allowing the oysters to sink and suffocate. In some bays, the Japanese oyster drill, a boring snail, preys upon young oysters. Starfish, crabs, skates, diving ducks, and even matted algae can be destructive. Predators can be two-legged. Not all clam diggers recognize that oysters are personal property like other "domesticated" animals. These rustlers on the shellfish range are called *half-sackers*.
- 3. Diseases and "mystery" problems:** Oysters are subject to diseases and parasites as are all living creatures. Most problems of this type can be handled by the animal, but some are very destructive. A "mystery" mortality problem now exists in some oyster-growing areas in the Northwest. Efforts to identify the causative agent, which can be fatal to 50 percent of the two- to three-year-old oysters, have not been successful. Several possible agents have been suggested. Some of these involve bacteria. At present the best solution hinges on attempts to "farm around" the problem.
- 4. Habitat destruction:** Probably the most serious threat to the future of oyster farming is harbor dredging, filling, and pollution of estuaries. When an oyster bed is covered with excavated dredge spoils, oysters are eliminated. When harbor development causes continual turbid water conditions, oyster food production is eliminated. When spoils are placed on the shallow plankton-producing tidal flats, the food nursery for oysters is eliminated. A partial solution to this is land- and

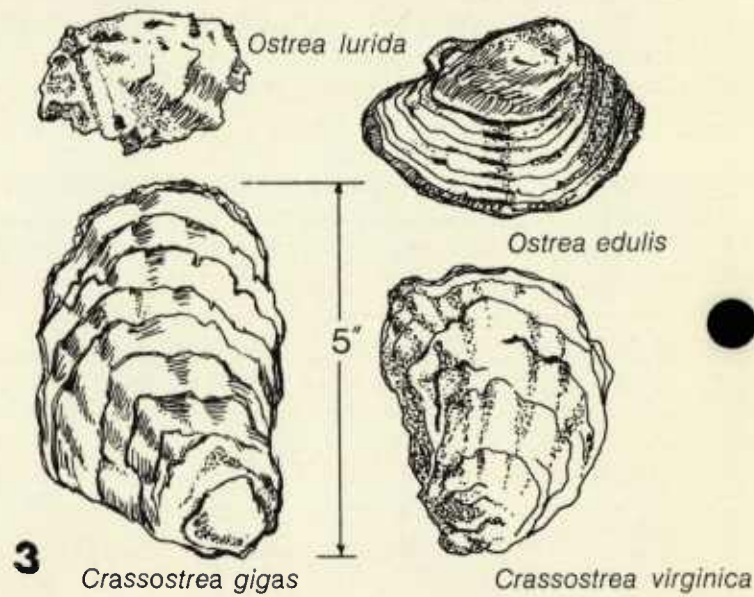


Photo (1), oyster farmer surveys crop of mature, ready-to-harvest oysters in estuary bed. (2) Oyster seed is transported by dredge and planted at high tide by hand-scattering. At a subsequent low tide the seed is more evenly distributed on the growing grounds. (3) Illustration shows four main kinds of oysters grown in America. (4) OSU marine scientist W. P. Breese checks "set" of oyster larvae on oyster shell cultch. Other types of cultch are tested at the hatchery in an effort to improve growth rates.

water-use planning and zoning in all estuarine areas. Excellent beginnings toward these ends are occurring in several Pacific Northwest estuaries. But more needs to be done.

In tray, rack, and stake culture, the oysters may grow faster, but require more handling. The investment in equipment usually increases also.

What kind of production can an oysterman expect from planting up to half a million baby oysters per acre? Much depends on the effects of storms and predation during the long growing period, but the oyster farmer hopes for 10 percent survival. Probably 600 bushels of Pacific oysters per acre at harvest time will put him above the break-even point.



HARVESTING OYSTERS

Hand harvesting methods of the past have been replaced by the use of dragline-like dredges mounted on oyster barges. The dredges are designed to move lightly on the bottom, collecting the shell stock with only moderate disturbance to the ground. Many oyster beds support natural crops of eel grass which help to solidify the bottoms and provide food for black brant and other waterfowl and habitat for clams and fish. The dredge barge moves in checkerboard fashion across the submerged reef with a dredge bag on both port and starboard sides. When full, bags are dumped on the barge deck. Modern oyster barges can hold from 150 to 350 bushels of shell stock. Each bushel should yield a gallon or more of shucked oyster meats.

This description of oyster growing and harvesting relates primarily to the Pacific (Miyagi) oyster. Techniques for other varieties vary somewhat. Kumamoto oysters are very small with light mothershell. They are normally planted in areas with mild currents or in trays. Kumamotos mature at approximately 18 to 24 months at a size of 600 to 1,000 per gallon. They are usually hand harvested, shucked, and sold in quarter- or half-pint jars at a premium price.

The few native oysters that reach the market are raised in *claires* or are *tonged* from natural reefs at about four years of age. They command a premium price, but are not widely available. A few seafood restaurants feature them.

PROCESSING OYSTERS FOR MARKET

The day's barge load of oysters is taken from the grounds to a shucking house for processing. Conveyers, with water jets for cleaning, transport the oysters from the barge to overhead bins. Oysters are hand-opened by shuckers. A good shucker can obtain about 25 gallons of Pacific oyster meats per day.

Efforts are continuing to develop mechanical methods of oyster shucking. Vacuum, electric shock, ultrasonic vibrations, and chemicals have been tried with limited success. Microwave energy now appears promising.

After they are shucked, the oyster meats are cleaned in a turbulence tank, flushed onto a *skimming* table, checked for cuts and size, and carefully hand packed. Fresh oysters are usually packed in 12- or 16-ounce glass jars. Oyster size grades relate to personal size preference, not to quality. Large oysters number 12 or less per pint, mediums 12 to 15, small 15 to 18, and extra small more than 18 oysters per pint.

Oyster shell has many uses. In the Northwest it is used as mother shell to catch spat, as ballast for roads, as poultry grit, or—ground—as lime flour for use in animal feed.

MARKETING OYSTERS

Although a few oysters are sold in the shell, primarily at the oystermen's shucking house, most Pacific oysters go into the shucked fresh trade. Some companies specialize in producing canned oysters or oyster stew. Oysters produced in the Pacific Northwest usually find a ready market. A major increase in production, however, could require substantial market development efforts. Development of new markets presents an exciting challenge to oyster farmers.

Competition for markets from foreign importations is a sporadic problem that may become a persistent threat in the future. Japanese-grown oysters have invaded domestic markets for the last ten years. The South Koreans plan a strong export trade in the future. It is difficult to assess the impact that these plans may

have on the American market. It seems possible that domestic requirements in the Orient may siphon off much of the production planned for export to North America.

FOOD VALUE OF OYSTERS

Oysters grown in the Pacific Northwest are good to eat all through the year. Food values of oysters have been romanticized since ancient times. Many of the stories about high nutritive value are true. Oysters are a source of protein, several vitamins, sodium, iron, potassium, calcium, magnesium, iodine, and phosphorus plus 16 or more trace elements including gold. Oysters are high in protein and carbohydrates and low in fat. Thus, a "fat" oyster is not fat but contains an abundance of glycogen, an animal starch. Glycogen, in our oysters, is normally highest from October to June.



FEEDING AND REPRODUCTION

Adult oysters feed by filtering phytoplankton from the water. This requires little expenditure of energy and converts this primary food source into desirable animal protein. The plankton is strained from the water as it is pumped by the oyster through holes in the gills. Pacific oysters grow to lengths of 12 inches or more, but most are harvested at from 4 to 6 inches in length (a shucked size yielding 12 to 15 per pint).

Oysters reproduce in spring and summer when the water warms. Great quantities of eggs are produced—250,000 to 60 million—depending on species and size of the female. Fertilized eggs hatch within one or two days and larvae develop shells which enclose the body and a swimming organ called the *velum*. The larvae immediately start to feed on tiny (microscopic) phytoplankton. The young oysters are free-swimming for two to four weeks. When nearing the end of the free-swimming stage, larvae develop bumps, called *umboes* (near the point where the shells hinge together), a foot, and a *byssus gland*. Just before settlement, the larvae swim over a solid surface (an old oyster shell or rock) seeking a home spot. A drop of cement from the byssus gland allows the larvae to attach themselves to the surface. During the change which follows attachment, the *velum* is lost and young oysters assume the form of adults. They are now called spat or oyster seed.

THE FUTURE OF OYSTER FARMING

The opportunities for oyster farming are limited only by availability of land, imagination, industry, and the necessary research. Some estuarine areas in the Pacific Northwest not now producing oysters may become adaptable to oyster farming. Modified cultural methods, such as tray or raft culture, could bring more deep water areas into production.

Maintaining high water quality standards in estuaries is critical to the future growth of oyster farming. If pollution degrades the water, oyster farming will not be possible. The protection and preservation of our estuaries will determine the future of the oyster industry as well as the future of many other important seafoods, both commercial and recreational. Southeastern Alaska, with its high water quality, may become an important oyster-producing area.

A better, more reliable oyster seed source is needed. Research and development is progressing at the Oregon State University Marine Science Center to determine the commercial feasibility of seed hatcheries. In 1968, with support of Oregon oyster growers and a local development company, a pilot oyster hatchery was constructed. A team of university and Fish Commission of Oregon research biologists is activating hatchery techniques for producing seed from species presently farmed in the Northwest as well as other species of commercial potential such as the European oyster.

Animals cultured by man should eventually be domesticated. This suggests the capability of controlled breeding to achieve desirable characteristics. The present beef cattle breeds provide more meat than the Texas longhorns of a century ago. Modern chickens are, figuratively, "egg-laying machines." With the beginning of hatchery methods, perhaps oysters can be selectively bred for size, shape, disease resistance, rapid growth, and other characteristics desirable to the oyster producer and consumer.

A selective breeding study, to determine the heritable (as opposed to environmental) characteristics of oysters, is being conducted at the OSU pilot oyster hatchery. Financed by the Hill Family Foundation, this genetics project will also examine hybridization of oysters.

Future developments may include "oyster factories." With this concept, small areas, possibly near the estuaries rather than in them, could be used for intensive oyster culture in ponds, tanks, or raceways. Water could be recycled with new bay water added as necessary. Cultured or artificial food would be used. Another potential is the use of heated waste water from coastal steam electric stations to increase growth rate of stock in an "oyster factory."

THE CHALLENGE

Through the years hundreds of people in the Pacific Northwest have attempted to become oyster farmers. Only a few have been successful. The hard work—often miserable working conditions, natural disasters, and feast-or-famine economics—have weeded out the timid, the lazy, and the unresourceful. Those that remain have been tempered and honed by hard-won success. They have learned to farm within the marine environment.

Oystermen of the future will face many of the same challenges. Research cooperation among industry, the universities, and management agencies will help to answer some of the key production problems. Nevertheless, the prime relationship of all farming—man in harmony with the land and water—will determine the oysterman's success.



TERMS OF MEASUREMENT USED BY OYSTERMEN

Japanese export seed case: slightly more than two bushels

Unbroken shell: about 12,000 spat per case

Broken shell: about 18,000 spat per case

Ren: 100 mother-shells on six foot wire—about 25 ren per case.

Mother-shell strings:

Dabob and Willapa Bay strings: usually 100 shells, six feet similar to Japanese ren.

Pendrell Sound string: typically 200 mother-shells, 10 feet long.

A bushel of shell stock (mature oysters) in good condition should yield one gallon of shucked oyster meats.

One gallon of shucked oyster meats weighs between eight and nine pounds.

One pound roughly equal to one pint.

GLOSSARY

Aquiculture—Farming in the water (mariculture).

Bivalve—A mollusk with two shells (clam, oyster, mussel).

Byssus—A hairy attachment structure.

Claire—An artificial pond for growing oysters.

Cultch—Material used to collect oyster spat.

Dredge—A powered work barge used to harvest, transport, culture, or plant oysters.

Garland—Strings of oyster shell or other cultch.

Ground culture—Farming oysters on the bottom of an estuary.

Hardening grounds—An area high in the tidal areas where oyster seed is conditioned for oversea shipment.

Half sackers—People who steal oysters from beds.

Mariculture—Farming in the water (aquiculture).

Mean lower low water—The average tidal level over an extended period of the lower of the two low tides occurring daily. Sometimes called “zero tide level.”

Mollusk—One of a group of soft, unsegmented animals (clam, snail, octopus).

Mother-shell strings—Strings of oyster shell used for collecting oyster spat.

Phytoplankton—Tiny free-drifting plants.

Piddock—Bivalve mollusk of genus *Pholas* or family *Pholadidae* having long ovate shells and burrowing in rocks or wood.

Rack culture—Farming oysters in fixed racks off bottom.

Raft culture—Farming oysters suspended from floats.

Seed—Young oysters.

Shucker, shucked—One who opens oysters and removes the meat from the shell; oyster meat removed from shell.

Skimming table—Shallow perforated stainless steel tray for washing, inspecting, and grading shucked oysters.

Spat—A newly settled or attached oyster; a post-larval oyster.

Stake culture—Farming oysters by attaching seed to small stakes about one foot above the mud.

Tong—Tool for manually gathering oysters in deep water.

Tsunami—A seismic sea wave.

Tray culture—Farming oysters off bottom in trays.

Umbo—The beak-like projection which represents the oldest part of a bivalve shell.

Velum—The ciliated locomotor organ of the molluscan larvae.

Zero tide level—The average of the lower low tides.

Cooperative Extension work in agriculture and home economics, Lee Kolmer, director, Oregon State University and the U.S. Department of Agriculture, cooperating. Printed and distributed in furtherance of the Acts of Congress of May 8 and June 30, 1914.

FOR MORE INFORMATION ON OYSTERS —READ THESE

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VISIT THE OSU MARINE SCIENCE CENTER IN NEWPORT, OREGON

Oregon State University's Marine Science Center in Newport, Oregon, is engaged in research, teaching, marine extension, and related activities. The center, located on Yaquina Bay, attracts thousands of visitors yearly to view the exhibits of oceanographic phenomena and aquaria of most of Oregon's marine fishes and invertebrates.

Scientists studying the basic characteristics of life in estuaries (including oysters) and in the ocean work in various laboratories at the center.

The center is home port for three OSU School of Oceanography vessels: the 180-foot Yaquina, 80-foot Cayuse (pictured below), and 33-foot Paiute.

The Oregon State University Sea Grant Marine Advisory Program issues educational material periodically that should be of value to students and teachers wishing to learn more about marine science. They are available at the Bulletin Mailing Office, Industrial Building, Oregon State University, Corvallis, Oregon 97331.

