Department of the Interior, J. A. Krug, Secretary
Fish and Wildlife Service, Albert M. Day, Director

Fishery Leaflet 187

Washington, D. C. Rerun March 1949

THE OYSTER AND THE OYSTER INDUSTRY IN THE UNITED STATES

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GEOGRAPHIC DISTRIBUTION AND COMMERCIAL VALUE

The oyster industry in the United States is one of the very valuable fishery industries, yielding annually (1938-1942) from 75 to about 90 million pounds of oyster meat and giving to our fishermen an annual income varying from 7.5 to 11.8 million dollars. Three species are of commercial value: Ostrea virginica, the eastern oyster; O. lurida, so-called Olympia oyster of the Pacific Coast; and O. gigas, a Japanese oyster introduced into the United States.

The eastern oyster, O. virginica, is of primary importance because of its wide distribution and great abundance. It thrives in the inshore waters of our Atlantic and Gulf Coasts from Wellfleet, Mass., to the southern extremity of Texas, and was at one time found in large quantities on the coasts of Maine and New Hampshire. To the Indians and the Pilgrim colonists these northern oyster beds provided a most valuable food resource, but no industry exists there today, although a few scattered oysters are still found in the Sheepscott River, Maine, and in the Oyster River and Great Bay, New Hampshire. The eastern oyster thrives in sea water of reduced salinity (8 to 28 p.p.th.); it survives both in water of the open ocean (salinity 32-35 p.p.th.) and in greatly diluted coastal waters near the mouths of the rivers (salinity 3-7 p.p.th.) but never flourishes in these extremes of its range of tolerance. Successful propagation of this species takes place only in brackish water the summer temperature of which is not less than 65-70 F. Depletion, lack of cultivation, construction of dams which intercept the access of fresh water, harbor improvements and especially pollution of coastal waters by domestic sewage and various trade wastes have been responsible for the exhaustion or even complete destruction of large areas of natural oyster beds.

The native oyster of the Pacific Coast, O. lurida, is considerably smaller than the eastern oyster, seldom exceeding a length of 2½ inches. It is found from Charlotte Sound in British Columbia as far south as San Diego Harbor, Calif., occurring in greatest numbers, however, in the lower part of Puget Sound in the State of Washington, the leading West Coast State in oyster production.

In addition to the cultivation of the native oyster considerable attention is being given to the cultivation of O. gigas, imported as seed from Japan and grown in Puget Sound, Willapa Bay, and Gray's Harbor, Washington. Planted for the first time on a commercial scale in 1905, its production has rapidly increased and at present comprises about 12 percent of the total annual yield of oysters in the United States.

Production and values for the three species of oysters marketed in are given in Table 1.

NUTRITIVE VALUE

From the point of view of nutrition oysters are better balanced than possibly any other single food. Experimental data show that copper, iron, and manganese found in oyster meats are useful in preventing nutritional anemia. Of other elements calcium and phosphorus are necessary in bone growth, and iodine in the proper functioning of the thyroid gland. Oysters contain most of the essential vitamins; namely, vitamins A, B, C, D, and G, all necessary in the diet for the maintenance of a healthy body. The protein in oysters has an especially high nutritive value. Likewise, glycogen, a substance similar to starch, is found in a form readily digestible by the human body even when uncooked. Because of this high mineral, vitamin, protein, and glycogen content, oysters are considered one of our best balanced nutritive foods although their caloric value is rather low.

NATURAL HISTORY OF OYSTERS

Reproduction: The oyster is exceedingly prolific. It has been determined that an adult female eastern oyster may discharge from 15 million to 114 million eggs in one spawning. The amount of spawn produced varies greatly from year to year depending on local and climatic conditions. The Japanese species equals and may even exceed the eastern oyster in fecundity, but the native West Coast oyster, O. lurida, apparently does not produce over 250,000 to 300,000 eggs in one season.

Potential high fertility does not insure, however, high reproductive rate of oyster, for out of the multitude of eggs spawned by each female only a few specimens survive and reach adult stage.

An outstanding characteristic of the oyster is its ability to change its sex from year to year, a phenomenon known as "sex reversal." Young oysters in their first year of life are generally male. The second year about a half of them will become females and a certain number will continue to alternate between the male and female phase. It has been found that about 10 percentof adult Long Island oysters, kept under observation at U. S. fishery biological laboratories, annually change their sex.

The time of spawning varies from year to year depending upon the water temperature and ripeness of the gonads. Eastern oysters may spawn, if fully ripe, at a temperature of 64° to 67° F., but spawning proceeds more copiously when the water is above 70° F. Somewhat higher temperatures actually have a stimulating effect, causing discharge of eggs by the female at about 77° F. Spawning may be induced, however, at low temperatures by the addition of sperm to the water. Since males can spawn at much lower temperatures than the females they usually initiate spawning. Under natural conditions the males spawn first and provide a chemical stimulation for spawning in the female. The oysterman may assist this process by stripping a few male oysters at the proper time and spreading the milt over the beds.

Insemination of eggs takes place in the water and in five to ten hours, depending on temperature, a small free-swimming oyster larva develops. In about two weeks it completes its development and at that time measures approximately 1/75 of an inch in diameter. The young oyster is now ready to <u>set</u> or <u>strike</u>, having previously developed a powerful foot for crawling and a large supply of sticky material by which it can cement itself to some clean hard object in the water. It attaches by the left valve and once secured must remain fixed for the rest of its life.

Reproduction in the West Coast oyster, <u>O. lurida</u>, is different in that the eggs are not discharged into the water as is the case with the Atlantic oyster but remain within special brood chambers in the mantle cavity of the female. They are fertilized by sperm brought in with the incoming current of water and remain inside for 12 to 16 days after which they are released and complete their development outside the mother organism. Similarly, as with the eastern oyster, they attach to shells, rocks and other hard objects found in the water.

In the life of the oyster the setting period is of prime importance for should young oysters find no suitable place of attachment they will die. It is possible to collect and save vast numbers which would otherwise

be lost by placing in the water shells and other materials to which they can attach.

Feeding: Feeding is accomplished in the oyster by opening the valves, drawing a current of water through the gill chambers and straining out the microscopic plants and animals. Changes in temperature greatly affect the feeding mechanism. It has been accurately determined that at 78° F., as much as 35 quarts may pass through the gill chambers of a single adult oyster in one hour. Food contained in the water consists largely of diatoms, peridinians, bacteria and other small organisms. Diatoms, simple plant forms are probably of greatest importance in the diet of the oyster.

Laboratory experiments conducted at the Service's laboratory at Milford, Conn., show that extreme abundance of food in the water causes the oysters to reduce the rate of feeding. In extreme cases the oysters cease feeding entirely and starve in the midst of superabundance of food.

Occasionally abnormally colored oysters, green, brown, and almost black are found in certain localities. Greening may be due to a certain variety of diatoms in the diet, in which case the color is usually limited to the gills. Green gilled oysters are of fine quality, and while not generally acceptable to the American public, are regarded in France as a superior product and special methods are used to grow them. Greening caused by an excess of copper in the tissues colors the entire body. It does not render the oysters inedible but gives them a coppery taste.

OYSTER CULTURE

Suitable locations for oyster farms: Under natural conditions oysters are found in brackish waters in depths ranging from half way between tide marks to 40 and 50 feet. Oysters can grow even in deeper water, but no commercially important beds occur below 40 feet. They are well adapted to withstand considerable fluctuations in temperature and salinity of water, thriving in the bays and estuaries where environmental conditions frequently change. In the Gulf of Mexico and on the flats of the inshore waters in southern States the temperature at oyster bottoms often reaches or even exceeds 90 F., whereas in the northern States nearly freezing temperatures occur every winter. Their tolerance to salt content is also very great. Natural oyster beds are usually located near river mouths and in bays where the salt content of the water is greatly reduced.

In selecting a location for oyster farming the foremost requirements are a protected area of hard or semi-hard but not shifting bottom of moderate depth, where water changes regularly with the tide; a place free from pollution; and an abundant supply of food. A very soft mud bottom may be reinforced with shell, gravel, slag, or similar material,

Table 1.—Production of Oysters in the United States

(Expressed in thousands of pounds and thousands of dollars; that is, 000 omitted)

	New England 1945		Middle Atlantic 1945		Chesapeake 1945		South Atlantic and Gulf 1945		Pacific Coast 1945	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Oysters, market:										
Eastern, public	45	17	418	190	16,388	5,737	11,889	3,305	-	-
Eastern, private	2,434	1,046	13,135	5,162	16,182	5,884	4,903	1,940	9	8
Pacific	-	-	-	-	-	-	-	-	10,074	1,706
Western	-	-	-	-	-	-	-	-	151	150
Total	2,479	1,063	13,553	5,352	32,570	11,621	16,792	5,245	10,234	1,864
Percent of total	3.0	4.2	18.0	21.3	43.0	46.2	22.0	20.9	14.0	7.4

so that oysters will not sink into the mud and be smothered. Sandy, shifting bottoms are entirely unsuitable and should be avoided.

Collection of seed: The task of an oyster farmer is first to prepare his ground by dredging and clearing away old shells, and natural enemies of the oyster. He then plants cultch or material on which to catch the set. For this purpose material such as gravel and the shells of oysters, clams and scallops are being used in different parts of the coast. To increase the area available for setting various spat collectors can be used. Cement coated tubes and poles have proved satisfactory for gathering seed in certain localities. Wire bags filled with shell are commonly used. A particularly efficient collector has been developed from the ordinary egg crate partition which, when coated with a mixture of lime and cement and placed in the water, affords a maximum area for "setting." In some places brush stacked in rows on mud flats can be used with great advantage. Set obtained on shell collectors may be left until the following fall or spring, but more often it is transplanted to growing grounds.

Growing of oysters: Good growing grounds are often located in deeper water where there is an abundant supply of food. In Long Island Sound oysters are usually transplanted several times before they are ready for market. An eastern oyster will take from two to five years to grow to marketable size, depending on the locality in which it lives. Oysters which are planted so that they have unrestricted space for growth acquire the most desirable shape, while oysters crowded excessively are thin and poorly flavored as well as ill-shaped. At the present time these oysters used chiefly for canning come from the overcrowded natural reefs of the southern States where they grow in great clusters. If properly cultivated, however, the same beds may produce oysters of better quality equally suitable for canning, shucking and the half-shell trade.

Special methods on the Pacific Coast: For the cultivation of the West Coast oyster, O. lurida, an elaborate system of dikes has been arranged whereby large areas of otherwise useless mud flats are converted into a series of pools. The system is so devised that the highest levels will be covered with water at low tide. Because of the great range of tide the enclosed tracts of about one acre each may be arranged at as many as five different levels. Oyster larvae when ready to attach strike near high tide line. Here they are allowed to remain for a year or two before they are transplanted to a lower level. Growth is slow in this species, from four to five years being required to reach marketable size.

The imported Pacific oyster, O. gigas, differs from our native oysters in appearance by its elongate and rather fragile shell. Imported as seed it arrives from Japan in February and March. It is then planted rather thickly and left undisturbed until the following spring. It may be transplanted several times but grows very rapidly attaining a marketable

length in less than two years. Attempts to propagate this species in American waters were successful, but setting cannot be expected to occur every year. It usually fails when summer temperature is low and water remains cold.

Because of its rapid growth and high glycogen content the Japanese oyster is considered well suited for canning. As to flavor and appearance it is decidedly interior to our eastern oyster and cannot take its place in half shell trade. Its very rapid growth may also contribute a serious handicap for the oyster often overgrows a marketable size and is not acceptable by trade. Failure to spawn presents another serious difficulty because the presence of large amounts of spawn in the oysters impairs their flavor and renders them unpalatable.

Enemies: Oysters have a number of natural enemies causing untold damage to the industry every year.

The great pest of the North Atlantic Coast from Cape Cod to Delaware Bay is the starfish, Asterius forbesi, which preys on an oyster by enclosing it in its arms, or rays, and exerting a steady pull to open the shell. The starfish then protrudes its stomach into the gaping valves and digests the meat. It is difficult to estimate the total losses due to the ravages of the starfish. It is known, however, that in Connecticut waters alone not less than 500,000 bushels are being destroyed annually. Great damages are suffered by the oystermen in Narragansett Bay, Rhode Island, and Buzzards Bay, Massachusetts. Protection of oyster bottoms in these waters is laborious and costly. The most commonly used mechanical device for the control of starfish is the star mop. This implement, which consists of an iron bar supporting a number of heavy rope mops, is dragged over the oyster beds and as the starfish become entangled it is brought to the surface and plunged into hot water. The oyster dredge and the suction dredge have also been used to remove starfish from the bottom. Since all mechanical methods of control are expensive various chemicals have been tested in an attempt to find a substance toxic to the starfish and yet harmless to other animals in association with it. Calcium oxide or quick lime has proved the most satisfactory. When spread over the bottom the lime settles on the starfish and inflicts wounds in the delicate tissue covering the animal, eventually causing its death.

Of equal importance as an enemy is the widely distributed screw borer or oyster drill, a snail which attacks oysters and other mollusks by boring small circular holes in the shell. The two species particularly destructive on the Atlantic Coast are Urosalpinx cinerea and Eupleura caudata. In Delaware Bay alone it is thought that more than one million dollars worth of oysters are killed every year by the drills. In Long Island Sound and certain parts of the Chesapeake region the destruction of seed often exceeds 70 percent. Drills can be removed from oyster bottoms with drill dredges or they may be taken in traps. Bags of shells made of chicken wire and baited with seed oysters make effective

traps. These can be removed easily from the water, cleaned and replanted whenever necessary. It is important to prevent the spreading of drills during transplantation of oysters from one area to another by forking, screening, or floating the stock. Additional information on oyster enemies is given in Memorandum I-99, Natural History and Methods of Control of the Common Oyster Drills; and Memorandum I-119, Natural History and Methods of Controlling the Starfish.

Another oyster enemy which does considerable harm, especially in South Carolina, is the boring sponge, Cliona celata. This animal bores into the shell of the oyster, forming small tunnels in which it lives. By this means the shell is gradually honeycombed and the oyster becomes thin and weak from its attempts to seal up the openings where the tunnels penetrate the shell completely. The sponge also spreads over the outside of the shell and may smother the oyster by its very size. In transport the sponge dies and decomposes very quickly, spoiling the meat of the oyster.

The wafer or "leech," a turbellarian worm, has been known to destroy great numbers of oysters in the South, and the "black drum" or drumfish occasionally attacks oyster beds. Mussels will smother and starve oysters by attaching to their shells in great numbers and exhausting the food supply. Similar damage on the Pacific Coast is done oysters by Crepidula fornicata, the slipper shell. Even ducks feed on small Olympia oysters of the Pacific Coast and cause heavy losses, especially during their migratory season.

Ownership of Oyster Beds: In the southern States on the Atlantic seaboard oysters are taken mostly from State-owned or public bottoms, while in the North they come almost entirely from privately leased beds, especially in New England and in the States of New York and New Jersey where oyster cultivation is most intensive. On the Pacific Coast oysters come mainly from privately owned beds in the Puget Sound and Willapa Bay regions of the State of Washington.

The Federal Government has no jurisdiction over fisheries in State waters. Licenses for the purpose of establishing oyster cultural operations or licenses for fishing in State waters must be obtained from the fishery authorities of the State in which the work is to be undertaken. Federal Government does, however, exercise control over oysters shipped in interstate commerce, which are subject to regulations on sanitation, adulteration, and mislabeling issued and enforced by the U. S. Department of Agriculture and U. S. Public Health Service.

Sanitary Control: Probably no other food product in this country is subject to more stringent sanitary regulations than the oyster. The beds from which oysters are taken for market are subjected to sanitary examinations by the health authorities of the various States in which

oysters are produced. If the bed meets certain bacteriological and chemical standards of purity a certificate is issued to the oyster growers by appropriate State authorities.

After the oyster has been extracted from the shell it is again subjected to rigid bacteriological examination and must meet certain standards of purity. Employees engaged in handling fresh oysters at the shucking plant are required to pass periodic medical examinations and any found suffering from contagious diseases are prohibited from engaging in this type of work. The shucking plant and its physical equipment also are given periodic examinations by various municipal and State health authorities.

Each shipper is supplied with a certificate countersigned by the U. S. Public Health Office showing that the oysters shipped in interstate commerce conform with the standards of purity and each shipment must be accompanied by a tag showing the name of the dealer and the origin of the oyster. In accordance with the law common carriers refuse to accept shipments of oysters not accompanied by these certificates.

The enforcement of these sanitary regulations assures the purity and wholesomeness of oysters delivered to the consumer.

The following publications contain further and more detailed information on the oysters and the oyster industry of the United States.

Churchill, E. P., Jr.

1919. The oyster and the oyster industry of the Atlantic and Gulf Coasts. Bureau of Fisheries Doc. 890. Appendix 8 to Rept. of Fish Commissioner for 1919. 51 pp., 29 pls., 5 text figs. (The illustrations include pictures of the anatomy of the oyster, oyster embryos, diatoms or oyster food, starfish attacking oyster, and other enemies of the oyster). 20 cents.

Galtsoff, Paul S.

1929. Oyster industry of the Pacific Coast of the United States. Bureau of Fisheries Doc. 1066. Appendix 8 to Rept. of Commissioner of Fisheries for 1929, pp. 367-400. Illus. Out of print.

1932. Introduction of Japanese oysters into the United States. Bureau of Fisheries Circular No. 12, August 1932. 16 pp. 5 illus. 5 cents.

1935. The biology of the oyster in relation to sanitation. American Journal of Public Health, Vol. 26, No.2, pp. 245-247. For copies address American Public Health Association, 347 Broadway, Albany, New York.

1938. Physiology of Reproduction of Ostrea virginica.
I. Spawning Reactions of the Female and Male. Biol. Bull. Vol. LXXIV, p. 461-486.

II. Stimulation of spawning in the Female Oyster. Ibid. p. 286-307.

1940. Stimulation of spawning in the male oyster. Biol. Bull. Vol. LXXVIII, pp. 117-135. For copies address the Wistar Institute, Philadelphia, Pa., or Marine Biol. Laboratory, Woods Hole, Mass.

1943. Increasing the production of oysters and other shellfish in the United States. United States Fish and Wildlife Service Fishery Leaflet No. 22.

Galtsoff, P. S., H. F. Prytherch, and H. C. McMillin
1930. An experimental study in production and collection of seed oysters. Bulletin of the U. S. Bureau of Fisheries, Vol. 46, Doc. 1088, 69 pp. illus. 30 cents.

Galtsoff, P. S., H. F. Prytherch, and J. B. Engle
1937. Natural History and methods of controlling the common oyster drills (Urosalpinx cinerea Say and Eupleura caudata Say). Bur. of Fish. Circular No. 25, pp. 1-24. 5 cents.

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1938. Preliminary report on the cause of the decline of the oyster industry of the York River, Va., and the effects of pulp mill pollution on oysters. Bur. of Fish., Investigational Rept. No. 37, 42 pp. 10 cents.

Hopkins, A. E.
1937. Experimental observations on spawning, larval development, and setting in the Olympia oyster, Ostrea lurida. Bur. of Fish. Bulletin No. 23, pp. 439-503. 25 cents.

Loosanoff, V. L. and J. B. Engle
1940. Spawning and setting of oysters in Long Island Sound in 1937 and discussion of the method for predicting the intensity and time of oyster setting. Bull. U. S. Bureau of Fisheries, No. 33, Vol. XLIX, pp. 217-255.

1942. Use of lime in controlling Starfish. United States Fish and Wildlife Service Research Report No. 2. 29 pp.

Prytherch, Herbert F.
1927. Oyster Farming. In Scientific Monthly, July 1927, Vol. 25, pp. 49-57. For copies address Science Press, Lancaster, Pa.

1930. Improved methods for the collection of seed oysters. Bur. of Fish. Doc. 1076, Appendix 4 to Rept. of Fisheries Commissioner.

Publications of the U. S. Bureau of Fisheries, which are not out of print, may be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C., at the prices mentioned. All publications of the Bureau of Fisheries may be consulted in libraries especially those which are Government Depositories.

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