

S M A L L - S C A L E OYSTER FARMING FOR PLEASURE AND PROFIT IN WASHINGTON

Our region's oyster-farming heritage dates back the mid-1800s, three decades before President Benjamin Harrison declared Washington the 42nd state in the Union. Some historians have suggested that the abundance of native oysters may have inspired Washington's founding fathers to choose the city of Olympia as the state capital.

For many shoreline property owners or leaseholders in Washington, the appeal of rearing oysters is as strong as it was way back then. This publication offers practical advice to those individuals, to encourage the sustainable use of intertidal resources while keeping alive a time-honored tradition of oyster farming in our state.



THE BASICS

Oyster farming is structured to take advantage of the oyster's biology and life cycle. A basic understanding of these topics will greatly improve the productivity and marketability of one's product.

Oysters are mollusks—shelled invertebrates (or animals without backbones) in the same zoological phylum, Mollusca, as the mussel, clam, abalone, snail, octopus and squid. Oysters are also classified as bivalves. Their shells are in two parts, or “valves,” held together by an elastic ligament hinge. An oyster makes its own shell, secreting calcium and other materials from glandular tissue in its soft flesh. Worldwide, there are more than 100 living oyster species. Several of these are particularly well suited for culturing in Washington state.

A BRIEF HISTORY OF OYSTER FARMING IN WASHINGTON

The Washington oyster industry began in the mid-1800s to supply California's demand for oysters. The fishery focused on the native or Olympia oyster, which was harvested primarily from Willapa Bay and the southern portions of Puget Sound. Olympia oyster harvests peaked in the 1890s and declined sharply with almost no harvests by 1915. The decline was probably due to a variety of factors including over-harvesting in Willapa Bay and pollution from industry in Puget Sound.

In 1895, Washington's Legislature passed the Bush Act and the Callow Act, both of which allowed for sale of tidelands into private ownership. This private ownership of the tidelands, which is unique to Washington, is the foundation of the state's very successful shellfish industry.

With the decline of native oysters and consumers' desire for larger oysters, the eastern (or American) oyster was imported into Washington waters in the early 1900s. Although the oysters grew well, they experienced massive mortalities, with little subsequent harvest. In addition, the Pacific oyster was being considered for culture. Following successful trial plantings, the first shipment of Pacific oyster seed from Japan was received in 1922. After surviving the trans-Pacific crossing, Pacific oysters planted in Washington grew rapidly and were ready to harvest in two years.

Initially relying entirely on imported seed, Washington's Pacific oyster industry was later aided by natural seed sources in Willapa Bay and Dabob and Quilcena bays in Hood Canal. Imported seed from Japan continued to supplement the oyster industry through the 1970s, but hatchery-produced seed has now replaced the imports.

Wholly adapted for an aquatic existence, oysters have gills for breathing. As water is drawn across the gills, these feathery organs also collect particles of food from the water that surrounds them. Some species live in deep enough water to avoid being exposed to the air at low tide. Those that settle in shallower seas must deal periodically with exposure to the elements. For protection, they clamp their two-part shells tightly together, using their powerful adductor muscles to hold tight (the dark spots on the inside of an empty shell are the points where the ends of this muscle once adhered). Now sealed, the oyster can retain enough moisture to survive for hours, or, if necessary, several days out of water.

Members of the genus *Ostrea* and *Ostreola* (which includes the Olympia and European flat oysters) are hermaphroditic— that is, they have both male and female reproductive organs. They first mature into males (in about one year) and then change to the female state after spawning. A regular alternation of sexes apparently continues throughout life. Members of the genus *Crassostrea* (Pacific and Kumamoto oysters) also develop first as males. After the first year, the population divides into males and females, usually with no further sex reversals. However, an occasional hermaphrodite has been found.

Oysters in the genus *Crassostrea* shed sperm or eggs into the water, where fertilization, hatching and larval development take place. In Washington, this process occurs in mid-summer, when water temperatures reach about 70°F. However, with *Ostrea* oysters, the males release sperm into the water, but the eggs are fertilized within the branchial chamber (the space between the gills) of the female. The brood continues to develop for about ten days before being discharged into the water in the late spring when high-tide water temperatures reach about 55° F for the Olympia oyster (*Ostreola conchaphila*) and about 65° F for the European flat oyster (*Ostrea edulis*).

Once in the water, larvae become part of the planktonic community and gradually undergo several changes. After three to four weeks, the larvae metamorphose to the juvenile form and are ready to settle on and attach to suitable substrates. At this time, oyster growers place various kinds of material into the water to catch the larvae, in essence providing the young oysters with a home. This process is called “cultching.” The catching materials are referred to as “cultch” and the recently settled oysters are known as “spat.” Old shells from previously harvested oysters are commonly used as cultch.

FOUR COMMONLY FARMED OYSTERS IN WASHINGTON

Pacific Oyster

(*Crassostrea gigas*)

Distribution:

Originally introduced from Japan, this oyster is now the most important commercial species along the Pacific Coast of North America and may be most suitable for beginning growers. It has naturalized in Hood Canal, Willapa Bay and elsewhere in Washington waters.

Habitat:

Intertidal to shallow subtidal on rocks, soft mud, firm sand or gravel.

Shell characteristics:

Large, cup-like shells with coarse grayish-white exterior, sometimes with purple striations, strongly ridged and fluted at the growth lines. Shape is variable, depending on the environmental conditions.

Biological characteristics:

Pacific oysters are extremely hardy compared to native Olympia oysters. They grow rapidly, reaching lengths of about 4 to 6 inches in two to four years in most estuaries and embayments. This species exhibits a high tolerance to a range of temperature and salinity fluctuations. If left to grow beyond four years, Pacific oysters will attain considerably larger sizes.

Kumamoto Oyster

(*Crassostrea sikamea*)

Distribution:

Once considered a sub-species of the Pacific oyster; originally introduced from southern Japan's Kumamoto Prefecture.

Habitat:

Similar to the Pacific oyster.

Shell characteristics:

Small, cup-like shells that are round with coarse and widely spaced wavy ridges on the outside of the shell. The deep lower valve can contain a high ratio of meat weight to total weight.

Biological characteristics:

Like the Pacific oyster, the Kumamoto has a high tolerance for temperature and salinity fluctuations. Unlike the Olympia oyster, this species can't spawn in the comparatively colder waters of Puget Sound and the outer coast. As such, Washington growers must rely on hatchery stock. This drawback is offset by the fact that Kumamotos are available in all seasons, even in summer, when Olympia and Pacific oysters are spawning and unsuitable for harvest. It takes about three years for "Kumos" to reach a marketable size — about two inches across.

Olympia Oyster

(*Ostreola conchaphila*)

Distribution:

Native to the Pacific Coast of North America; once the dominant commercial species in Washington. Previously cultivated in diked ponds to minimize environmental fluctuations; currently found naturally in selective areas of Puget Sound and Willapa Bay.

Habitat:

On rocks near the low-tide line and in beds on mud flats and gravel bars (but prefers firm bottoms) in estuaries and bays.

Shell characteristics:

Elliptical or ovoid in shape and, generally, a blackish shade on the outside and gray to pale blue on the inside. Valves are symmetrical but variable in shape, with occasional purple-brown bands. Adults seldom exceed 3 inches in length.

Biological characteristics:

The Olympia oyster has a low tolerance to temperature, salinity and environmental fluctuations. It takes about four years for this species to reach a harvestable size. The Olympia is the original "cocktail oyster," and its flavor has been described as peculiarly sweet. Approximately 300 oyster meats comprise a pint.

European Flat (or Belon) Oyster

(*Ostrea edulis*)

Distribution:

Originally introduced from Europe; does not occur naturally but is grown commercially in Puget Sound.

Habitat:

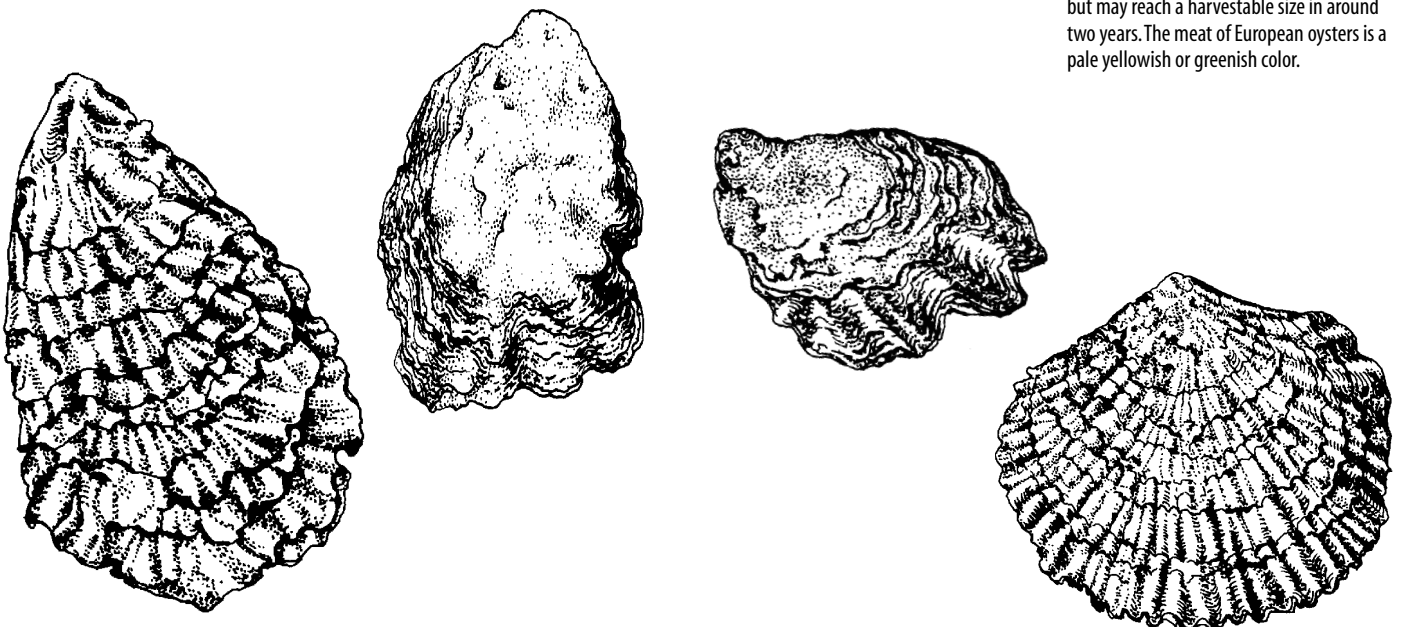
Inhabits ground below the low tide line in cold water of relatively high salinity. Due to concerns that the species may reproduce in the warmer waters of Hood Canal and compete with other species of shellfish, the Washington Department of Fish and Wildlife does not permit European Flat oysters to be cultivated there.

Shell characteristics:

Adult shell is circular with the left valve almost flat. Left valve is larger and deeper with 20 to 30 ribs and irregular concentric frills. Beak is poorly developed.

Biological characteristics:

Prized by ancient Romans and Gauls, European flat oysters were introduced to the Northwest in the mid-1970s. They are marketed today as Belon oysters, after their ancestral home, the coastal estuaries of Brittany in France. This species has a low tolerance to temperature, salinity and environmental fluctuations. It can grow to lengths of 4 inches in three to four years, but may reach a harvestable size in around two years. The meat of European oysters is a pale yellowish or greenish color.



BEACH CONSIDERATIONS

A tideland owner must first determine if a particular beach is suitable for oyster growing. While beaches vary considerably, certain criteria will help the prospective grower assess this.

Ownership

First, owners should have legal assurance of tideland rights. They should check the deeds and, if there is a question, contact either the Washington Department of Natural Resources (DNR) in Olympia, or the assessor's office in their county. DNR also leases state-owned tidelands for aquaculture activities, including subtidal grounds over which floating or hanging culture methods (described on pages 11 and 12) may be used.

Sanitation

Shellfish sanitation regulations were developed at a national level to address concerns regarding disease outbreaks.

Because oysters are often consumed raw, there is concern that bacteria or viruses could cause illnesses. The Washington Department of Health (DOH), Office of Food Safety and Shellfish Programs, or the local environmental health specialist should be contacted for information concerning water quality in a particular area. Regulations are in place to protect against sewage contamination from point (sewage outfalls, marinas, etc.) and non-point (failing septic tanks, etc.) pollution sources.

If a desired growing area is not already part of a current growing area, at least 30 water samples must be taken and a shoreline survey conducted by DOH to classify the beach for commercial harvests. DOH currently classifies growing areas as "Approved," "Conditionally Approved," "Restricted" or "Prohibited".

"Approved" growing areas are those where oysters may be directly harvested for commercial purposes.

"Conditionally Approved" areas meet the state public health standard, but requires closures when affected by predictable levels of pollution (rainfall closures, seasonal mooring areas, etc.).

"Restricted" areas are those where limited amounts of fecal coliform bacteria are present, indicating contamination that would make the shellfish unsafe to eat. Shellfish from these areas could be relayed to an "Approved" area for a period of time sufficient to cleanse the bacteria.

"Prohibited" areas are those where pollution conditions prohibit the harvest of shellfish for commercial consumption.

A commercial operator's permit also needs to be acquired before commercial shellfish can be harvested and transported (see section on "Legal Aspects").

Ground Elevation

Optimal tidal elevation for Pacific oyster (*Crassostrea gigas*) farming exists between +3-foot and 0-foot tides. This elevation provides convenient access to oyster beds during most low tide series and occurs below the "barnacle zone," reducing the amount of fouling by sponges, tunicates, algae, barnacles and other encrusting organisms (see section on "Fouling" for more information). In general, lower tide levels provide better growth potential and protection from destruction during warmer months. However, they may also provide for increased opportunities for predation by starfish and crabs, especially red rock crabs. Because Pacific oysters are intertidal organisms, they may benefit from brief periods of exposure to the air.

Ground Type

Through the utilization of different culture methods, oysters are grown in a variety of different substrate types. When beginning culture on a new beach, it is wise to experiment with different culture systems on a small scale to see which works best. Every location has its own unique set of variables that can affect the success of the crop. The most common substrate types and the culture methods used are described below.

Firm mud-sand is ideal for bed and off-bottom cultures. In general, these fine particulates are indicative of calm waters not subject to scouring currents and most often found in coves, bays, and heads of inlets.

Sandy ground suggests that the soil is unstable and easily moved by waves and currents. Nearby eroding bluffs are frequently sources of sandy, coarse materials. This type of ground will require some anchoring or, possibly, the use of rack or tray methods. Areas exposed to winds are also quite sandy.

Gravel to cobble beaches are indicative of heavy storm or current movement. These areas can provide for excellent growth, but planted oysters will very likely roll and move, particularly during windy periods. Generally, these kinds of beaches require some sort of anchoring, fencing, or bag method to contain the oysters on the property. Otherwise, the current movement may cause damage to the outer edges of the shell (known as the "bill"), which is the new-growth area of the shell. Also, oysters moved by waves and currents will tend to relocate on neighboring beaches and must be retrieved and re-spread.

Predators and Pests

Washington waters are host to a variety of predators and pests. Many are native to this region and others were inadvertently introduced along with eastern oysters (*Crassostrea virginica*) from the Atlantic Ocean and Pacific oyster seed from Japan.

Oyster drills are some of the most damaging pests found on oyster beds. These small marine snails have a rasp-like apparatus that drills a hole through the oyster shell to access oyster meat. The Japanese oyster drill (*Ceratostoma inornatum*) and the eastern drill (*Urosalpinx cinerea*) were both introduced into Washington waters. Once an area is infected with drills, it is almost impossible to get rid of them. Washington Department of Fish and Wildlife (DFW) has a shellfish transfer program that limits the transport of oysters from a drill-infested area to one that is drill-free. A special permit may be required for transferring oysters from one bed to another. Consult the booklet, *Guidelines and Requirements for the Import and Transfer of Shellfish, Including Oysters, Clams, and Other Aquatic Invertebrates in Washington State*, or contact DFW for more information.

Several sea star species are common predators on oyster beds, especially in lower intertidal areas. It can take less than 24 hours for a sea star to devour an adult oyster. In upper intertidal areas, they can be removed from oyster beds by hand and taken ashore for disposal. On the oyster beds, cutting sea stars into bits can be counterproductive, as pieces of a single sea star can regenerate lost limbs, creating several new sea stars from the original one. For this reason, it is illegal under DFW regulations to mutilate a sea star.

Three crustaceans common to Washington prey on oysters: Dungeness (*Cancer magister*), red rock (*C. productus*) and graceful (*Pugettia gracilis*) crabs. Although not a major problem in most areas, they can be destructive to smaller seed oysters. A fourth species, the European green crab (*Carcinus maenas*) has recently been seen in parts of the Northwest. It is illegal to possess or transport live European green crabs in the state of Washington without a permit; instead oyster growers are required to report any sightings to DFW. The other predatory crab species can be trapped or collected by hand and removed from the area.

Two species of burrowing pests — mud shrimp (*Upogebia pugettensis*) and ghost shrimp (*Neotrypaea californensis*) — are native to Washington waters. By burrowing, these shrimp can make the ground too soft, requiring methods other than beach culture for raising oysters. Ghost shrimp are particularly problematic and make the tideland generally unsuitable for any oyster culture system used today. If mud shrimp are present in moderate densities (less than 10 burrows per square meter), oyster culture may still be practical.

The flatworm (*Pseudostylochus ostreophagus*) was originally introduced from Japan with shipments of oyster seed. Each worm can feed on as many as 50 1-cm-diameter spat per month. Although this pest can be found sporadically, no widespread problems have been reported.

Fouling

Fouling occurs when organisms associated with oysters attach themselves to oysters or equipment. In some types of culture methods, fouling can seriously affect the growth and survival of the oysters by blocking water flow. The main fouling organisms include sponges, tunicates, mussels, algae and barnacles. These organisms are most commonly removed by scraping or scrubbing oyster bags and equipment with sea water.

Disease

Pacific oysters can periodically experience mass mortalities. Oyster growers refer to this as summer mortality, summer kill syndrome or heat kill, and stock losses of 70 percent or greater in a given year have been reported. Most scientists agree that the mortality stems from a combination of stress at or near spawning time and high summer temperatures, and it may also involve bacterial infections. Reducing air exposure time by transferring or growing oysters on lower ground, harvesting oysters at a smaller size, and/or avoiding heads of bays where water temperatures increase to higher levels will help to reduce or eliminate significant losses.

SELECTING SEED

There are many commercial sources of oyster seed (see “Seed Suppliers” on page 15). Beach characteristics and culture methods will determine which types of seed should be ordered and spread.

Seed Sources

The two primary sources of seed oysters in Washington are naturally occurring seed and hatchery seed. Natural spawning and setting occur together periodically in Washington waters. Collection of natural spat is accomplished by placing bags of clean oyster shell or other cultch material in the water prior to the forecasted settlement of the planktonic oyster larvae. The cultch is left in the water for several weeks. If the collection is successful, the spatting cultch is examined and transported to a nursery area. It is then handled similarly to hatchery cultch. It should be noted that the yearly setting frequency has always been unpredictable. In some years, catches exceed 50 spat per shell. In other years, no spat are caught.

Hatchery production includes the conditioning and spawning of adult oysters, setting the spat and growing the young oysters in nursery tanks. The majority of oyster hatcheries produce either bags of cultched oyster seed or single (cultchless) oyster seed. So-called “eyed” larvae, which are ready to settle onto cultch, can also be acquired from the hatcheries. A list of seed suppliers is provided in the appendix of this publication. Purchases of cultched and cultchless seed or eyed larvae from out-of-state suppliers require import permits from DFW.

To facilitate the process, growers can remotely set the eyed larvae onto cultch in their own settling tanks. This could decrease the cost of shipping bags of shell, but requires expensive tanks, heaters and other equipment. To be suitable for settling, tanks of seawater are aerated, heated to favorable levels, and filled with bags of clean shell to catch the seed. Oysters at the eyed-larvae stage are purchased from a shellfish hatchery and added to the tanks. After a few days, the oyster grower will have seed for the next crop of oysters. Many hatcheries also rear microalgae or purchase a phytoplankton slurry (usually referred to as algae paste) to feed the newly settled oysters until they are ready to be transported to a nursery area.

Triploid Oysters

Triploid oysters are genetically manipulated Pacific oysters with three sets of chromosomes in each body cell instead of the usual two. Like other triploid animals, this shellfish is incapable of producing eggs or sperm. Unlike the meat of ordinary Pacific oysters, which usually becomes runny or chalky during the reproductive season, the flesh of the so-called “sexless” oyster remain flavorful throughout the year.

Created from exposure to the chemical cytochalasin B or through cross-breeding with diploids (oysters with the usual

two sets of chromosomes) and tetraploids (four chromosome sets), triploid oysters are only available as seed from hatcheries. Today, about a third of all canned and jarred oysters are triploids.

Shellfish Introductions and Transfers

DFW controls the importation of shellfish into the state and between growing areas. Requests to import new species are reviewed by the DFW Import Advisory Committee. In addition, shellfish transfer permits are issued by DFW to monitor both in-state and out-of-state transfers of oysters. Essential details are presented in a DFW pamphlet, *Guidelines and Requirements for the Import and Transfer of Shellfish Including Oysters, Clams and Other Aquatic Invertebrates in Washington State*.

Nursery

The primary objective of the nursery phase is to ready the seed oysters for outdoor life. Newly settled spat are very small and vulnerable to a variety of predators and susceptible to siltation. Protection of the seed at this stage will increase the overall production. The seed are also vulnerable to exposure from the summer sun during low tides. However, exposure to fluctuating tides aids in a physical and physiological process termed “hardening” during which the oysters’ shell thickens and they become better suited for survival in the intertidal zones.

If a hatchery is nearby, bags of cultched seed can easily be acquired. Cultched seed is used for both bottom and off-bottom types of culture (See “Growing Methods” for more details). Spatted cultch is usually obtained in mesh bags, or in some instances can be purchased as shell threaded on longlines. The cultched seed may be held in the middle to lower intertidal area for up to several months prior to being spread.

Seed can range in size from 1/4 to 1/2 inch, but occasionally, larger seed will be available. Cultchless oysters need more nursery care than cultched oysters. To protect seed from both environmental factors and scattering. They are usually kept in containers, such as bags (described in the rack and bag section), lantern nets (suspended net section), or trays (floating culture section). The seed needs to be moved periodically and resorted to larger mesh bags and trays to allow for the increased growth and water flow. Particularly well protected and stable beaches can be seeded directly with single oysters.

GROWING METHODS

Some of the more popular methods of culture are detailed in this section. Each has advantages and disadvantages associated with it (Table 1). The methods used to grow oysters can be divided into bottom and off-bottom culture methods.

Table 1. Some advantages and disadvantages associated with bottom and off-bottom oyster culture techniques

BOTTOM CULTURE	
Selected Advantages	Selected Disadvantages
Less labor to maintain and stage seed for stocking grow-out areas	Higher percentage of mortality from predators and pests
Lower capital and maintenance expenses as no nursery or grow-out structures are required	Higher potential for siltation
Less labor in moving shellstock to new areas because structures are not involved	Spat usually survive only on one side of the mother shell
Generally, fewer permits are required for bottom culture than off-bottom culture	Public resistance to many predator control methods
Usually less negative visual impact at nursery and grow-out sites	
OFF-BOTTOM CULTURE	
Selected Advantages	Selected Disadvantages
Less impact from predators and pests	More public resistance to visual impact of culture structures
Significantly less chance for problems resulting from siltation	Potential conflict with recreational boating
Use of total water column by three-dimensional culture techniques	Fouling organisms severely impact some container systems
Spat survival on both sides of the mother shell	Labor intensive in initial set-up
Less expensive equipment required for harvest	Capital cost and maintenance of nursery and grow-out structures

Source: Conte et al. 1994

Table 2 shows the tidal levels of a beach and the different culture methods that could be utilized.

Growers have the choice of producing single oysters or what is referred to as shellstock. Single oysters can be sold by the dozen in uniform sizes for the halfshell trade, whereas shellstock is sold to processors for opening and packing. Shellstock producers are usually paid according to the yield of meat obtained from one bushel of oysters, and the price will reflect the size and condition of oysters brought to the plant. One gallon of meat per bushel of shellstock is the industry standard. The number of oysters in a one gallon container is standardized for the entire industry (Table 3).

Table 3. FDA specifications for the number of shucked oysters per one-gallon container

SIZE	MORE THAN	NOT MORE
THAN		
Large	0	64
Medium	64	96
Small	96	144
X-small	144	
*Yearling	240	300
*Petite	300	400
*Cocktail	400	600

*Indicates industry standards.

Source: *Fishery Market News*, National Marine Fisheries Service, Statistics and Market News, Seattle, WA

Table 2. Intertidal zones and oyster culture activities frequently associated within a range of water depth

TIDAL TO SUBTIDAL ZONE	CULTURE ACTIVITY
+3 feet to -2.5 feet	Bottom culture on a suitable substrate
+1 foot to -5 feet	Stake culture (individual pieces of cultch attached to low stakes or longline culture (strings of cultch supported by stakes); low racks supporting bags, baskets or trays, bags longlined on the bottom
-2 feet to -8 feet	Rack culture supporting strings of cultch or stacks of trays containing individual oysters. Longline, buoyed lines supporting bags, lantern nets and other containers used to grow individual shellfish

Source: Conte et al. 1994

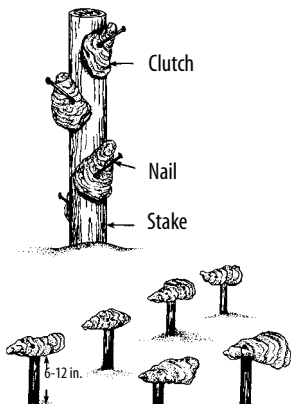


Figure 1. Stake culture

Smaller stakes extending 6 inches to 12 inches out of the bottom may also be used. In this case, one piece of cultch is attached to the top of the stake. Stakes should be installed about 2 feet apart in rows spaced to allow free movement during maintenance or harvesting.

Bottom Culture

Bottom culture is the most common method of oyster farming because of the low maintenance and simple preparation requirements. Cultched seed is placed onto beds, then harvested when the oysters reach appropriate (most likely medium) size. The best areas for this technique are protected bays or inlets with firm mud bottoms where currents and waves are not excessive.

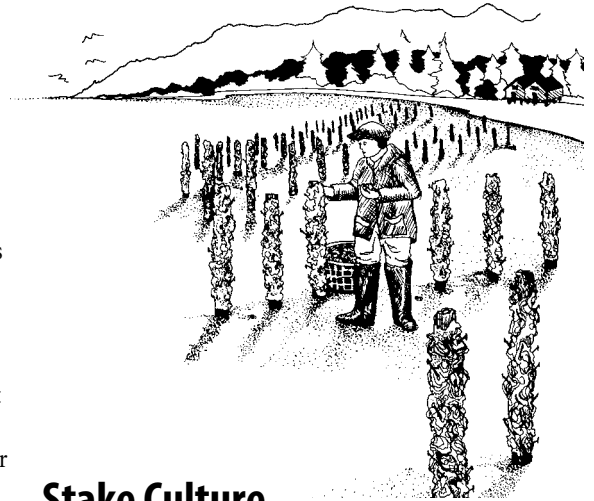
As a rule-of-thumb, the cultched shell should be spread about every one to two feet to allow for adequate growth. The seed should be allowed to grow until oysters are about two inches long. If too many oysters are clumped on the cultch, they may be separated to reduce crowding and poor growth. To reduce crowding, strike the base of the oyster clump with a metal object such as a railroad spike or hammer. Some oysters may be lost in this process, however, overall it will improve crop yield, as breaking reduces stunting and promotes individual oyster growth.

Each grower must learn how many oysters his or her ground will produce. Yields average between 800 to 1,000 gallons per acre, but certain grounds in Puget Sound have produced as many as 3,000 gallons per acre.

About 12,000 spat are needed to produce 20 gallons of medium-sized oyster meats. This means that, on average, 600,000 spat will be required to produce at the rate of 1,000 gallons per acre. Seed are commonly sold by the shell-bag, and such bags are available in several sizes. Assuming that a bag contains 150 shells and each shell has 20 spat, the bag would contain 3,000 spat. At this rate, one would need to purchase 200 bags per acre to attain the given planting rate. If yields begin to diminish, over-planting is probably the cause.

The price received for shellstock will be determined by the yield of meat at processing. For example, if the processor gets one gallon of meat for every bushel delivered, the grower will probably receive maximum price. In general, good plump oysters of medium size will receive the best prices. In recent years this has ranged from \$10 to \$15 per bushel FOB processing plant. With a delivery of 100 bushels, which yields 100 gallons of meat, the grower may receive up to \$1,500. However, if the yield from 100 bushels is only 50 gallons of meat, payment may be only \$500 to \$750.

The cultch bags of seeded oyster shells should be moved from the nursery area to the growing area. When the seed is roughly 1/2 inch in size, it should be removed from the bag and planted before it grows out through the bagging material. The shells are scattered so that each piece of shell will result in a cluster of oysters as a final product. In the intertidal area, this is accomplished at low tide. The bags should be split open and the oyster shells scattered evenly over the beach. The beach should be routinely monitored for predators or other problems. At low tide, the predators can be removed or the clusters can be broken if there are too many oysters per shell.



Stake Culture

This simple attachment method can be readily adapted to most beaches (Figure 1). It is particularly useful in bay areas with extremely muddy bottoms or hard grounds unsuitable for bed culture. The procedure involves hanging oysters on precut stakes that are driven into the bottom. Stakes should be from 30 inches to 36 inches in length and should be driven to a depth of 15 inches to 18 inches to keep them in place. The top of the stakes should be no higher than the 3.0-foot tide level. It is advisable to apply a wood preservative to the stakes. Cultch are hung on galvanized nails that have been driven in at an angle of about 45° before installation.

Smaller stakes extending 6 inches to 12 inches out of the bottom may also be used. In this case, one piece of cultch is attached to the top of the stake. Stakes should be installed about 2 feet apart in rows spaced to allow free movement during maintenance or harvesting.

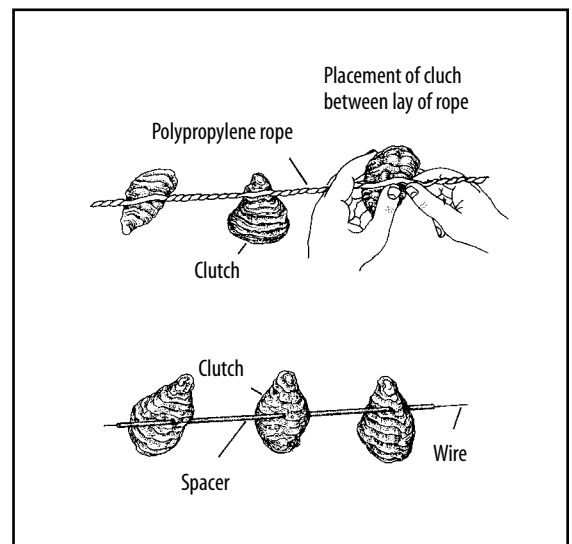


Figure 3. Basic Construction of Long lines

Longline Culture

This method involves spacing cultch at equal distances on a premeasured length of rope or wire. Once strung, the line can be submerged off a dock, anchored on hard bottoms, hung on a rack or elevated on stakes (Figure 2). In general, off-bottom techniques (such as the stake or longline methods) offer several advantages over bed culture for the small farmer. First, grounds not suitable for bed culture can be put into production. Second, these techniques reduce predation by sea stars and crabs, thereby increasing overall survival. Third, the use of any one of these methods can result in substantially higher yields than bed culture, as survival, growth and fatness will be increased.

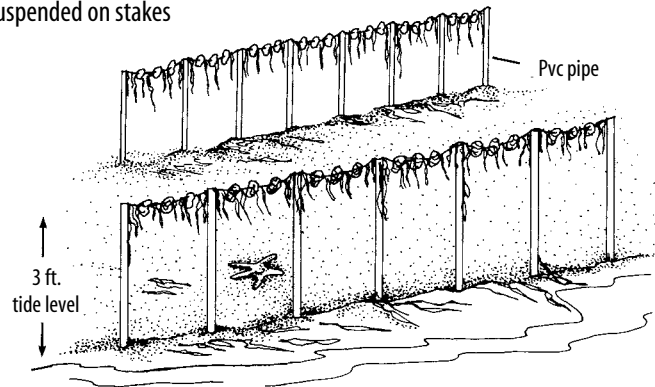
Off-bottom techniques do have certain disadvantages. Potential damage from storms, fouling by assorted animal life and seaweeds, and greater potential for vandalism because of increased visibility are the most serious problems associated with these rearing techniques. In addition, production costs are higher than for bed culture because of the need to buy stakes, pipes, lines and other equipment.

The newest longline systems are similar to the tensioned growing lines used by vineyards. Wire lines are generally preferred because, unlike rope lines, they are not chafed by wave action. They can be made of the following materials: 14-gauge galvanized wire, spacers made of PVC pipe or garden hose, and pre-punched cultch. If the cultch is not pre-punched, a hole can be made with a centerpunch or drill bit. Cultch should be spaced 8 inches to 10 inches apart (Figure 3).

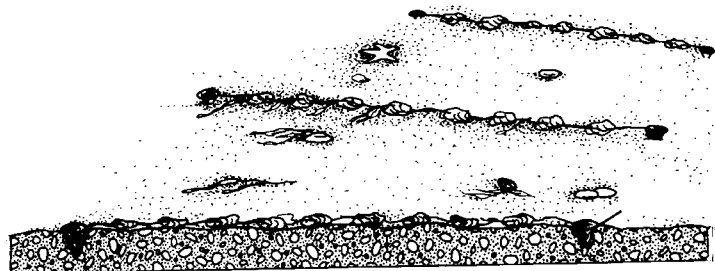
Elevating longlines in rows above the bottom with PVC pipe stakes is a successful commercial method pioneered in Grays Harbor near Westport, Washington. Lines are made by inserting cultch every 6 inches to 8 inches in 1/4-inch polypropylene laid rope. Stakes are cut in 30-inch lengths from 3/4-inch or 1-inch PVC pipe. The PVC pipe must be at least 200 psi or it will tend to shatter. The top of each stake is notched 1-1/4 inches with a power saw to insert and hold the line. Stakes are buried, notched side up, about halfway into the substrate. They should be spaced approximately two feet apart until the desired length of the row is attained. This spacing is required to allow for large weight increases from oyster growth (note a bushel of oysters will weigh from 40 to 65 pounds when out of water). A "T" handled pipe driver is a useful tool to drive the pipe in the beach and ensure pipes are all at the same elevation. These can be made using a 15-inch long, 1-inch diameter iron pipe with a cap on one end with a 20-inch 1/2" metal rod centered and welded across the cap to serve as the driver handle. Rows are spaced 8 feet apart to allow for optimum growth. Ideally, the top of the stakes will be at the 1.0- to 3.0-foot tide levels, relative to mean lower low water.

Figure 2. Longline applications for Pacific oysters

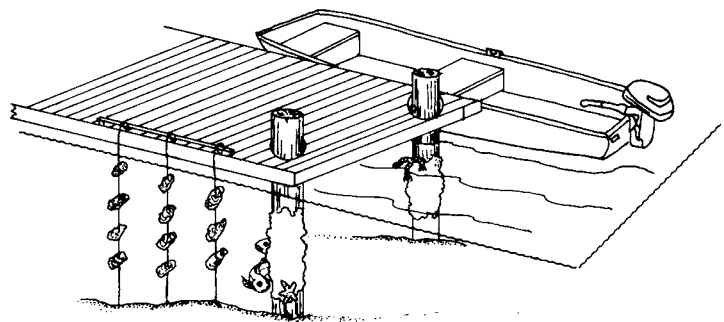
a. Suspended on stakes



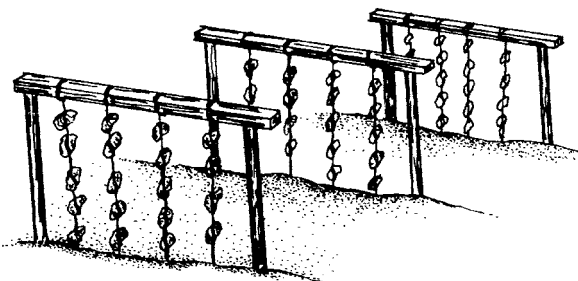
b. Anchored to bottom



c. Submerged from dock



d. Hanging from rack



Single Oyster Culture Methods

The resurgence of interest in freshly shucked oysters on the halfshell has invigorated the market for individual oysters called “singles.” Of uniform size and quality, these oysters usually command higher prices than do clusters of oysters, which must be manually broken apart to harvest the meats that are then frozen or jarred for later sale.

In producing single oysters, one may elect to use cultched seed or single seed. Cultched seed is usually available on whole oyster shell, and to produce singles, the shell must be broken after the oysters have grown about two inches. This procedure will result in the production of many single oysters, as well as some doubles and triples. Advantages of the method are significant: costs are minimal compared to those of caring for single seed; a certain proportion of single oysters will be produced; and the clustered oysters can be sold as shellstock.

Unless the beach is very protected and has few predators, large losses will occur if single seed is simply spread onto grounds. Rather, single oyster production requires trays, cages or plastic mesh bags. These culture devices, however, can be used in a variety of ways and on different ground types. They can be arranged on low-level racks, suspended from poles, hung from docks, used in floating culture or simply tied down to the ground. Because culture methods may be limited to those specified in a county’s shoreline management plan, it is important to check with the local jurisdiction (usually the county planning department) before choosing one.

Seed is priced according to age, with the larger sizes (that is, the older seed) being more expensive. Obviously, larger seed will result in faster crop turnover. A backyard farmer may wish to pay more so that the crop can be harvested

within one year. Advantages of using single seed include increased survival (80 percent to 90 percent can be expected), uniformity of size and shape, production of plump, high-quality oysters, absence of processing, and rapid product turnover. Major disadvantages include considerably more labor, added time expended in planning, extra costs associated with devices, and higher seed cost.

Rack and Bag Culture

This culture method was developed for substrate types that do not support beach culture. Essentially, it involves growing single oysters in polyethylene grow-out bags that are clipped to rebar racks (Figure 4), designed to accommodate four bags laid side-by-side. With hard beach conditions, racks may not be needed, and the bags can be fastened directly to the ground. The bags have 1/8- to 1-inch mesh openings and measure about two feet by three feet. They are kept closed by sliding a 1/2-inch, 300 psi PVC pipe, cut along its length, over the ends or folding and, depending on the style of the bag, using plastic cable ties. Rubber straps or clips hold the bags to the racks.

Several steps are required in the growing procedure. First, small bags of 1/8-inch mesh should be used to nurse seed until the individual oysters are about 1/2-inch in size. Smaller mesh sizes will be required for smaller seed. These nursery bags can be inserted into the grow-out bags. The seed are allowed to grow until they can be transferred to a 1/4-inch mesh bag, which is then strapped to the racks. After a few months, the oysters will have grown enough to

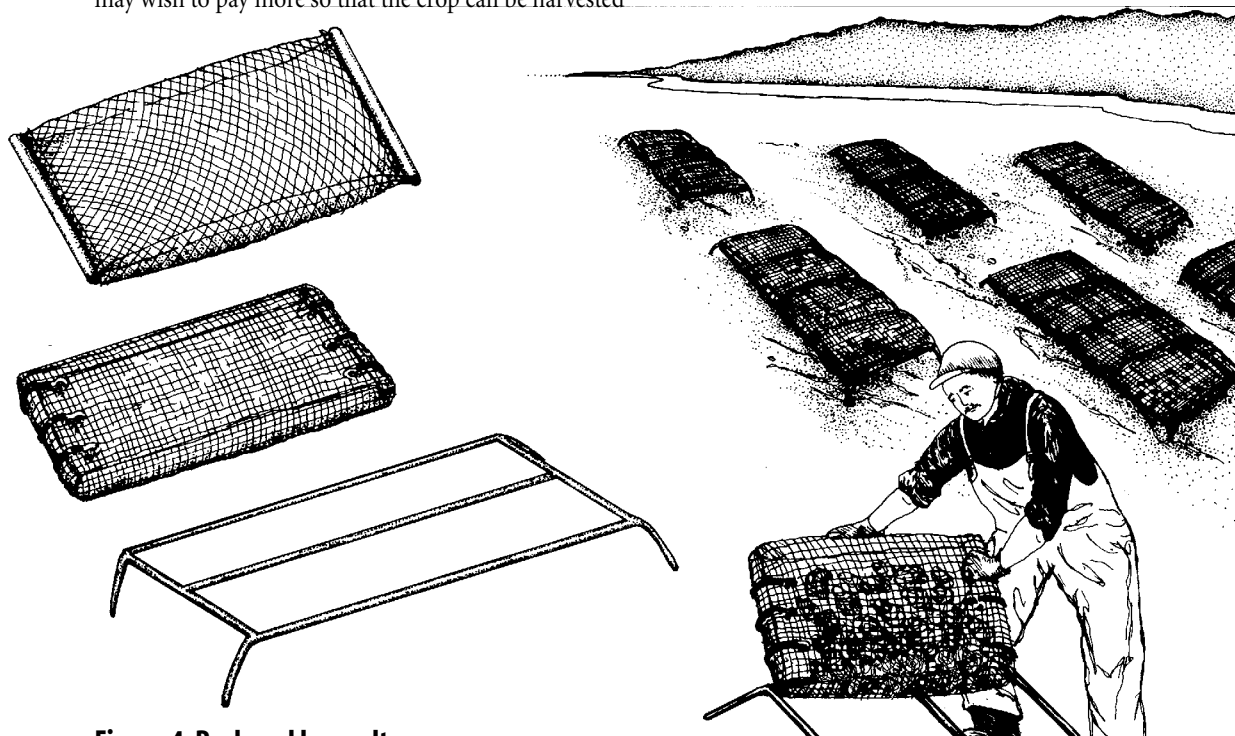


Figure 4. Rack and bag culture

be placed in the final grow-out bags, at about 200 oysters per bag. The same method using polyethylene cages is also being employed. The main difference is that the ends are closed by clips rather than by PVC pipe. Smaller mesh bags can be avoided by purchasing larger seed. The trade-off is that the larger seed is more expensive. The oyster-filled bags or cages are turned over at about two-week intervals to reposition the oysters and to reduce fouling effects.

OYSTERS AND HARMFUL ALGAL BLOOMS

In the past, harmful algal blooms (or HABs) have been inaccurately called “red tides.” This term is misleading because the color of the water does not indicate whether the algae that produce the harmful blooms are present. HABs in Puget Sound are unpredictable, usually occurring when environmental conditions and other factors are favorable to the growth of the algae and other organisms that produce marine biotoxins. All filter-feeding bivalves, including oysters, may concentrate the biotoxins in their bodies. The grower, through Department of Health (DOH) testing, routinely monitors harvests from commercial shellfish beds for biotoxins. If concentrations of biotoxins reach a minimum level, the growing area is closed to commercial harvests. If levels are significantly high, then a recall of product may be issued. The growing area is opened after subsequent testing by DOH indicates that the toxins are below the closure limit.

A microscopic planktonic organism called *Alexandrium catenella* produces the biotoxin that causes paralytic shellfish poisoning (or PSP). This biotoxin is concentrated by oysters and other shellfish that feed on it. While it does not harm the shellfish, the biotoxin can cause illness and death to humans and other warm-blooded mammals who eat these mollusks. PSP is a serious health problem whose symptoms include tingling of the lips, tongue and fingertips; numbness, nausea and vomiting; respiratory distress and death. When the plankton bloom is over, the shellfish purge the toxin and, once again, become safe to eat.

Biotoxins in *Pseudonitzschia*, another planktonic organism, cause domoic acid poisoning (DAP) or amnesic shellfish poisoning (ASP). Although this organism is found off the coast of Washington and the Strait of Juan de Fuca, no commercial shellfish closures have resulted from ASP in Puget Sound. DOH routinely monitors this biotoxin along with its sampling for PSP.

Floating Culture

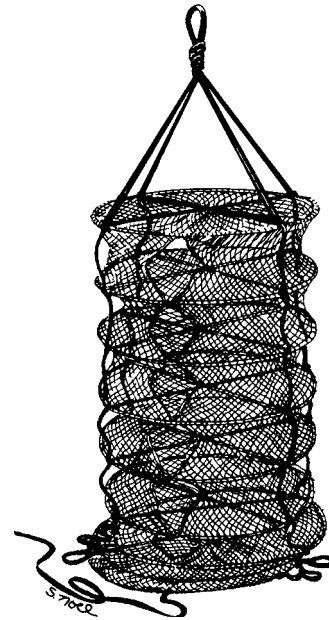
Floating culture uses the subtidal bottoms that are leased from the state, and application of this method is governed by local and state regulations. In this method, oyster grow-out trays or polyethylene cages may simply be stacked on the floor of a sink float, or the stack may be suspended from a raft or floating longline system in the water column. Of course, greater production levels per unit of surface area will result from the latter culture technique. If a float is used, one end should be tied to the anchor and the other end left free. This will allow the float always to swing against the tide, providing for better circulation through the culture devices.

Floating culture requires considerable maintenance. During the summer months, oysters will be feeding at a maximum. This will result in a build-up of metabolites, which should be removed on a weekly basis. When oysters are grown in dense concentrations, fouling is reduced as the oysters filter the water. However, caution should be exercised, as too dense a concentration of oysters could result in stunting, irregular shells, clumping and increased mortality.

In September, the oysters should be transferred to the intertidal zones of a beach. These oysters will have nicely fluted shells that are extremely thin and brittle. The thin shells make the oyster susceptible to dehydration and temperature variations during transportation and in the marketplace, thereby reducing shelf-life. Because the adductor muscles of floating-culture oysters are not as strong as those of oysters exposed to the daily tide changes, the muscle will weaken and cause the oyster to gape. Also, the brittleness of the shells makes opening difficult, as the shells tend to shatter unless great care is exercised. Transferring the oysters to intertidal beds will help harden the shells, strengthen the adductor muscles and promote additional growth.

Suspended Nets

Japanese lantern net culture has been adapted to growing single oysters in Westcott Bay on San Juan Island. Essentially, the method involves suspending lantern nets (Figure 5) from an assembly of underwater longlines. This method involves a great deal of preparation and maintenance, but backyard farmers with access to floats or docks may find the technique very applicable to their needs. The desired number of lantern nets can be suspended from the dock or float with a rope bridle. If work is to be done by hand, each lantern net should consist of no more than five tiers because of weight considerations. This suspension method will produce oysters similar to those described in the previous section.



LEGAL ASPECTS

Federal, state, local and tribal programs work closely with oyster farmers to protect the environment, nurture the economy and safeguard human health. This section introduces some of those programs. A more detailed listing of relevant programs is contained in the “Resources” section of this document.

In April 1985, the Washington State Legislature declared aquaculture to be an agricultural endeavor, placing it under laws that apply to the advancement, benefit or protection of the agriculture industry. The Legislature further declared the Department of Agriculture to be the lead agency in all aquacultural matters. Currently, this agency provides a supportive framework and general marketing and promotional assistance for all aquaculture activities and products. However, issuing most licenses and permits is the responsibility of other agencies. For convenience, the principal requirements are itemized in the “Resources” section, but prospective growers should contact each agency for further details to ensure compliance with current regulations. Not all of the listed licenses or permits may be applicable to a particular project.

Under federal treaties of 1854 and 1855, Washington tribes reserved the right to harvest fish and shellfish at all usual grounds and stations. Recent court decisions have upheld the Puget Sound tribes’ rights to up to 50 percent of the sustainable yield from natural shellfish beds. The treaties included a shellfish proviso, in which the tribes are excluded from beds “staked and cultivated” by citizens. In 1994, Federal Circuit Court Judge Edward Rafeedie ruled that the beds staked and cultivated are defined in terms of the definitions of the day. He defined that “any beds staked and cultivated by citizens,” refers to artificial beds created by private citizens and are not subject to the treaty right. However, natural beds, including shellfish under artificial beds, are subject to the treaty right.

In 1995, Judge Rafeedie issued an Implementation Order, which included implementation of his decision on private, non-commercial tidelands and commercial grower’s shellfish beds. This Implementation Order included provisions for creation of new artificial beds as well. However, it contained several ambiguities that made it confusing to implement.

The Ninth Circuit Court of Appeals subsequently clarified that the tribes are entitled to half of the sustainable yield of natural beds where a commercial grower has cultivated a natural bed. Just “staking and cultivating” a beach is not adequate to exclude tribal harvest. The tribes, however, are not entitled to any portion of the harvest that is a result of the grower’s enhancement efforts.

In April 2002, a Stipulation and Order further clarified several of the implementation ambiguities. For the purposes of this guide, it is important to note that, if creating new artificial shellfish beds, you are required to notify any tribes with usual and accustomed fishing areas that include your beach. To determine which tribes must be notified, contact the Northwest Indian Fisheries Commission. If the artificial beds will coexist with natural beds, a plan must be developed with the tribe or tribes affected, to assure they are afforded the opportunity to harvest their share. Under the April 2002 Stipulation and Order, a matrix will be developed to establish minimum densities of shellfish in various regions of the Puget Sound that will constitute natural beds and, thus, trigger the sharing requirement.

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RESOURCES

State Agencies

Washington Department of Fish and Wildlife
Fish Program Licensing Division
Natural Resources Building
1111 Washington Street SE
Mailing address: 600 Capitol Way N.
Olympia, WA 98501-1091
360.902.2464
www.wa.gov/wdfw

Aquatic Farm Registration

Shellfish Transfer Permit required to move shellfish from beach-to-beach or from state-to-state, to control the spread of disease, pests or predators.

Hydraulic Project Approval required for floating structures such as docks or floats, or prior to any bulkhead construction or modification work on or adjacent to a beach. Not needed for ordinary aquaculture practices.

Wholesale Dealers License required only for companies handling products produced outside the state.

Department of Health,
Office of Food Safety and Shellfish Programs
PO Box 47824
Olympia, WA 98504-7824
360.236.3330 FAX: 360.236.2257
www.doh.wa.gov/ehp/sf/Commercial.htm

Shellfish Operation License and Certification required by all commercial shellfish operations: growers and harvesters, processors, wholesalers and repackers. Certification is required for growing areas and products. The agency will inspect growing grounds and adjacent uplands and will secure water and meat samples for fecal coliform analysis. The agency will also test shellfish samples for biotoxins. Fees are prorated and vary according to acreage. The agency further requires labeling and record-keeping for all product units and shipments.

Department of Natural Resources
Aquatic Resources Division
Natural Resources Building
1111 Washington Street SE
Mailing address: PO Box 47027
Olympia, WA 98504-7027
360.902.1100
www.wa.gov/dnr/htdocs/aqr/

Aquatic Land Lease required for the use of state-owned tidelands. Lease fees are established through competitive bidding or negotiation.

Department of Agriculture
Aquaculture Coordinator
Natural Resources Building
1111 Washington Street SE
Mailing address: 600 Capitol Way N.
Olympia, WA 98501-1091
360.902.1800

Identification of aquaculture products.

Required labeling and sale documentation to cover products produced by aquatic farmers.

Department of Ecology
300 Desmond Drive
Lacey, WA 98504
360.407.6000

Most small backyard oyster growers do not need to contact DOE, however they should check with this agency to determine whether it is necessary to apply for the following:

Statement of Consistency with Coastal Zone Management Act
Water Quality Certification
Water Quality Standards Modification
National Pollutant Discharge Elimination System permit

Washington State Attorney General
1125 Washington Street SE
PO Box 40100
Olympia, WA 98504-0100
Telephone: 360.753.6200 FAX: 360.586.7671
emailago@atg.wa.gov

Information on treaty rights to grower tidelands and property.

County/Local Agencies

Check with the local shorelines permit administrator to determine exact requirements. The contact person is usually with the county planning department. A Substantial Development Permit may be needed if the project has a total cost or fair market value exceeding \$2,500. Most small-scale oyster farms will not exceed this amount.

Federal Agencies

U.S. Army Corps of Engineers
Regulatory Branch
P.O. Box C-3755
Seattle, WA 98124
206.764.3742

Section 10 permit (River and Harbors Act) is required for any structure that will be put over navigable waters, including piers, docks, piles, rafts, etc.

U.S. Coast Guard
13th Coast Guard District
915 Second Avenue
Seattle, WA 98134-1067
800.982.8813
www.uscg.mil

Navigational markings, required for fixed or floating structures in or over water.

Tribal Information

Northwest Indian Fisheries Commission
Shellfish Coordinator
6730 Martin Way E
Olympia, WA 98516
Phone: 360-438-1180 Fax: 360.753.8659
contact@nwifc.org
www.nwifc.wa.gov/shellfish/

SHELLFISH SUPPLIERS

This list was compiled for the convenience of people interested in growing shellfish on a small scale. Additional seed sources may be found by checking with other local oyster farms. Also, some materials may be obtained from various marine hardware companies.

Washington Sea Grant Program does not endorse any of the companies or products listed.

Seed Suppliers

Coast Seafoods Co.
PO Box 327
1601 Linger Longer Road
Quilcene, WA 98376
Phone: 360.765-3345 FAX: 360.765-3045
coastquill@olympus.net

also

14711 NE 29th Place,
Suite 111 Bellevue, WA 98007
Phone: 425.702.8800 or 800.423.2303
FAX: 425.702.0400
info@coastseafoods.com
www.coastseafoods.com

Pacific oyster seed – seed and eyed larvae. Diploid and triploid oysters. Kumamoto oyster seed and larvae.
Minimum order: \$100.

Kuiper Mariculture, Inc.

PO Box 507
Bayside, CA 95524
Phone: 707.822.9057 FAX: 707.822.3652
kuimar@northcoast.com

Pacific oyster seed – singles, triploid and diploid; 2-3 mm to 35 mm. Minimum order: \$250.

Lummi Shellfish Hatchery

2616 Kwina Road
Bellingham, WA 98226
Phone: 360.384.2303 FAX: 360.380.1205
shellops@memes.com
Pacific oyster eyed larvae, single seed (1-30mm), bagged shells, (all oyster seed/larvae diploid or triploid), European flat larvae and seed. No minimum order. Special orders welcome.

Rock Point Oyster Co.

1733 Dabob Post Office Road
Quilcene, WA 98376
Phone: 360.765.4664 or 360.765.3765
FAX: 360.765.3676
rpoco@olympus.net
Pacific oyster seed in bags. Minimum order: \$100.

Taylor Shellfish Farms

130 SE Lynch Road
Shelton, WA 98584
Phone: 360.426.6178 FAX: 360.426.0327
orders@taylorshellfish.com
www.taylorshellfish.com
Pacific oyster seed – diploid and triploid; Specialty oysters – eastern, European flat, Olympia seed. Minimum order - Wholesale: 1M larvae, 100K seed. Seed sales days for backyard hobbyists, 3 days per year— check with the company for dates.

Whiskey Creek Shellfish Hatchery

2975 Netarts Bay Rd. W.
Tillamook, OR 97141
Phone: 503.815.8323 FAX: 503.842.6426
Pacific oyster larvae and single oyster seed – diploid and triploid. Minimum order 1M larvae, 100K seed.

Oyster Aquaculture Material Suppliers

Aqua-Pacific Wire Mesh & Supply Ltd.
2220 B McCullough Road
Nanaimo, BC
V9S 4M8 CANADA
Phone: 877.751.3772 or 250.751.3772
FAX: 250.756.3864
www.aquapacific@telus.net
www.aquapacificwire.com

Shellfish grow-out trays (PVC wire mesh), PVC wire mesh rolls, cages, longline baskets, beach handling baskets, larval tank baskets, algae tank frames, beach fencing, custom design, vexar, rope, bungee cord, electric rope knives, accessories.

Cards Aquaculture Products Ltd.

2551 Kenworth Road
Nanaimo, BC V9T 3M4 CANADA
Tel 250.758.2858
1.888.902.2737
Fax 250.758.2651
LeePoirer@cardsaqua.com
www.cardsaqua.com
Pearl nets, shellfish grow-out nets, plastic grow-out trays.

Coastal Aquaculture Supply

100 Glen Road,
P.O. Box 8066
Cranston, Rhode Island 02920
Phone: 401.467.9370
FAX: 401.461.9520
coastal@coastalaquacultural.com
www.coastalaquacultural.com
Rope, solar lights, upweller with power, Chinese hats (spat collectors), grow-out trays - "Dark Sea Tray," Aquatrays, custom racks to hold bags.

Del Star Technologies, Inc.

220 East St. Elmo Road
Austin, TX 78745-1218
Phone: 800.513.5112 / 512.447.7000
FAX: 512.447.7444
sales@naltex.com
www.delstarinc.com
Oyster trays, shellfish grow-out nets, cages, plastic netting.

Englund Marine

101 – 15th Street, P.O. Box 296
Astoria, OR 97103-3804
Phone: 800.228.7051 or 503.325.4341
englund@pacifier.com
also
123 Howerton Way
P.O. Box 426
Ilwaco, WA 98624
Phone: 360.642.2308 FAX: 360.642.0210
also
280 E. Wilson Ave. Westport, WA 98595
Phone: 206.268.9311
www.englundmarine.com
Oyster lay rope, developed especially for longlining. Oyster knives and "OysterTuff" hip boots.

Fablok Mills

140 Spring Street
Murray Hill, NJ 07974
Phone: 908.464.1950 FAX: 908.464.6520
info@fablok Mills.com
www.fablok Mills.com
Polyester and nylon netting in bulk rolls; mesh bags with different types of closures.

Fukui North America

PO Box 669
110-B Bonnechere St. W.
Eganville, ON, K0J 1T0 CANADA
Phone: 613.625.1704 FAX: 613.628.2688.
fukui@fukuina.com
www.fukuina.com
Lantern nets, shellfish grow-out nets, pearl nets, spat collectors, oyster bags, grow-out cages, floating upwell systems (FLUPSY), ropes, buoys, other supplies.

Norplex, Inc.

111 3rd Street NW
Auburn, WA 98002-4024
Mail: P.O. Box 814
Auburn, WA 98071-0814
Phone: 253.735.3431 FAX: 253.735.5056
norplex@aol.com
Oyster grow-out bags, plastic bird netting, oyster cultch netting, orange plastic safety net, ladder ties and plastic bags.

Seattle Marine and Fishing Supply

2121 W. Commodore Way
Seattle, WA 98199-1221
Phone: 206.285.5010 FAX: 206.285.7925

Summer Breeze Aquaculture Products

1034 Loma Linda Drive
Victoria, B. C.
V9C 4J9 Canada
Phone: 250.478.3518 Fax: 250.478.6390
Union Bay Phone: 250.335.3083/Fax: same
Bowser Phone: 250.757.9252 Fax: same
summerbreezeaqua@telus.net
www.aquacultureproducts.com
Plastic products: pouches, trays, nets, rope, etc. for growing.



This text is adapted by Derrick Toba from *Small-Scale Oyster Farming for Pleasure and Profit*, a 1989 publication by Terry Nosh, Washington Sea Grant Program's former aquaculture specialist. Special thanks are extended to the following individuals for their input and review of the manuscript: Drs. Kenneth Chew and Carolyn Friedman, University of Washington; Daniel P. Cheney, Pacific Shellfish Institute; Bill Dewey, Taylor Shellfish Company; Steve Harbell and Teri King, Washington Sea Grant Program; and Alex Bradbury and Russel Rogers, Washington Department of Fish and Wildlife, Point Whitney Shellfish Laboratory.

Illustrations by Sandra Noel

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WSG-AS 0203

November 2002
Revised 8/04

A Washington Sea Grant Program publication.
This report is published in part by Grant #NA76RG0119, Project A/PC-5, from the National Oceanic and Atmospheric Administration to Washington Sea Grant Program, University of Washington. The views expressed herein are those of the author(s) and do not necessarily reflect the views of NOAA or any of its subagencies.

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