

## AQUACULTURE INDUSTRY METHODS

Species & Method	Seeding	Site Prep & Mtnc	Planting & Harvesting
<p><b><u>Oyster Culture:</u></b></p> <p>Longline</p>	<p>Mature larvae are placed in tanks where they are allowed to settle out onto screens or cultch. Seawater and microalgae are pumped to the newly set larvae (“seed”) to feed them. When the seed reaches a suitable size, depending upon species, the time of year and the end use, it is taken to a secondary nursery for further controlled growth, or delivered to farms for planting</p>	<p>Residual oysters (“drop offs”) dislodged from the lines during the previous growing cycle are removed from the ground prior to replanting</p> <p>Silt that has built up as a result of wave and wind action on the substrate may be leveled manually at the end of a growing cycle.</p> <p>Longlines are checked periodically during low tides to ensure that they remain secured to the PVC pipe and that the PVC pipe remains in place.</p>	<p>Stakes of metal or PVC pipe are placed by hand during low tides. Polypropylene or nylon lines with a piece of seeded oyster cultch attached approximately every foot are suspended above the ground.</p> <p>Oysters are allowed to grow out over two to three years. Hand harvest by cutting oyster clusters off lines at low tide. Clusters are picked up by a vessel and barged to shore. Smaller operations carry the tubs off the beach by hand.</p> <p>Mechanical harvesting uses buoys attached at intervals along the lines at low tide. Buoys are reeled onto the boat, barged to shore and transported to processing plants or market.</p>
<p><b><u>Oyster Culture:</u></b></p> <p>Rack-and-Bag</p>	<p>Single-set seed is placed in re-usable plastic net bags and placed on metal or wooden racks</p>	<p>Beds are prepared by removing debris such as small driftwood, and pests such as oyster drills. In some cases, substrate is hardened with crushed oyster shells and/or gravel. Ground may be marked with stakes for working purposes. Some operations install lines and PVC pipe or metal stakes on the bed to secure the bags. Wood or metal racks may be used to support the bags off the ground. Racks with legs may be placed directly on the bottom, or supports may be driven into the bottom</p>	<p>During harvest, bags are released from supports, if any, loaded into a boat or (during low tides) a wheelbarrow for transport to shore, and then transported to processing plants or market</p>
<p><b><u>Oyster Culture:</u></b></p> <p>Stake</p>	<p>Stakes can be seeded in hatchery setting tanks before being planted in the beds or bare stakes might be planted in</p>	<p>Beds are prepared during low tides by removing debris such as driftwood, and predators (drills and sea stars). In some areas, the substrate may</p>	<p>Stakes are left in place through a two to four year growing cycle</p>

<p><b><u>Oyster Culture:</u></b> Stake (Cont'd)</p>	<p>areas where there is a reliable natural seed set. Bare stakes might be planted during the prior winter to allow barnacles and other organisms to attach to the stakes, increasing the surface area available for setting oyster spat. An alternative method of seeding is to attach one to several pieces of seeded cultch to each stake.</p>	<p>occasionally be enhanced with crushed oyster shells to harden the ground, but usually soft mud or sand bottoms require little or no enhancement. During low tide, stakes made of hard-surfaced non-toxic materials, such as PVC pipe, are driven into the ground approximately 2 ft apart to allow good water circulation and easy access at harvest. Stakes are typically limited to 2 ft in height to minimize hazards to boaters.</p> <p>Bed maintenance takes place during harvest when stakes are repositioned, straightened, or replaced, and the oysters are thinned to relieve overcrowding. Stakes can be seeded in hatchery setting tanks before being planted in the beds or bare stakes might be planted in areas where there is a reliable natural seed set.</p> <p>Bare stakes might be planted during the prior winter to allow barnacles and other organisms to attach to the stakes, increasing the surface area available for setting oyster spat. An alternative method of seeding is to attach from one to several pieces of seeded cultch to each stake.</p>	<p>Oysters are selectively hand harvested during low tide by prying clusters from stakes, or removing the clusters and stakes, and placing them in baskets or buckets. The containers are tagged and either hand carried off the beach or loaded into a boat at a higher tide for transport to shore.</p> <p>Undersized single oysters from the clusters are transplanted to a special bed for grow-out, since they cannot reattach to the stakes, and are harvested using bottom culture methods when they reach market size. Oysters that fall from or are knocked off the stakes are harvested periodically using bottom culture methods. Market-sized drop-offs that have not settled into the mud are harvested along with those pried from the stakes, and those that have settled into the mud are periodically picked and transplanted to firmer ground to improve their condition for harvest at a later time.</p>
<p><b><u>Oyster Culture:</u></b> Bottom Culture</p>	<p>Seed oysters attached to cultch shell may be sprayed from the deck of barges or cast by hand onto marked beds at an even rate to achieve optimum densities. In some cases, farms rely solely on natural set of oyster seed on existing beds. If bottom culture is done with bags, single-set seed is placed in reusable plastic net bags closed with plastic ties or galvanized metal rings. The bags are placed in the intertidal zone directly on</p>	<p>Prior to planting a new crop of oysters, oyster beds may be cleaned of debris such as small driftwood and pests such as oyster drills by hand or by dragging a chain or net bag during a low tide. The bag removes any oysters remaining on the bed after a harvest as well as pests, debris and mud build-up. If the substrate is too soft or muddy and not naturally suitable for planting oysters, it may be hardened, typically by spraying crushed shell, often mixed with washed gravel</p> <p>Oysters may be moved from an initial growing area</p>	<p>During hand harvest, workers hand-pick oysters into bushel-sized containers at low tide. These may be emptied into large (10 to 30 bushel) containers equipped with ropes and buoys so they can be lifted with a boom crane onto the deck of a barge at high tide. Smaller containers are sometimes placed or dumped on decks of scows for retrieval at high tide or are carried off the beach at low tide.</p> <p>In mechanical harvest, a harvest bag is lowered from a barge or boat by boom</p>

<p><b><u>Oyster Culture:</u></b></p> <p>Bottom Culture (Cont'd)</p>	<p>the ground during a low tide.</p>	<p>to “fattening” grounds where higher levels of nutrients are found, allowing the oysters to grow more rapidly for market.</p> <p>In areas where the substrate is soft, the oysters may sink into the mud, usually in response to substrate bioturbation caused by ghost and mud shrimp. Unlike clams that live in the substrate, oysters must stay on the surface to survive. When this happens, the oysters must be dug with a harrow to periodically pull them up out of the mud. The harrow is a skidder with rake-like tines, towed along the bottom by a boat. The harrow penetrates the substrate by a few inches and moves the oysters back to the surface.</p>	<p>crane or hydraulic winch at high tide and pulled along the bottom to scoop up the oysters. Where feasible, the area may be hand harvested at low tide afterward to obtain any remaining oysters. After harvest, oysters are tagged and transported to processing plants.</p> <p>Single oysters cultured loose on the bottom are often hand harvested into mesh bags or baskets to minimize handling and damage to shells. When single oyster culture on the bottom is done in hard plastic mesh bags, the bags are simply loaded into a boat or (during low tide) a wheelbarrow for transport to shore, then transported to processing plants or market.</p>
<p><b><u>Oyster Culture</u></b></p> <p><b><u>Suspended Culture</u></b></p>	<p>Single set oyster seed is placed on the trays or in the bags and suspended in the water. Seed set on cultch is attached to the vertical ropes or wires.</p>	<p>Every three or four months the trays are pulled up, the stacks taken apart, oysters put through a hand or mechanical grading process, the trays restocked, stacks rebuilt and de-fouled and returned to the water. Oysters grown on vertical lines are in clusters and receive little attention between seeding and harvesting.</p> <p>Oysters grown using suspended culture may be transplanted to an intertidal bed for two to four weeks to “harden.” Hardening extends the shelf-life of suspended culture oysters by conditioning them to close their shells tightly when out of the water and retaining body fluids. Abrasion on the beach substrate literally hardens the shell making it less prone to chipping, breakage, and mortality during transport. If hardened, the oysters are re-harvested using bottom culture harvest methods. Alternatively oysters grown by suspended culture may be hung from docks when tidal cycles expose and harden them. This improves their shelf life as they are trained to close up tightly to survive between tidal cycles.</p>	<p>The nets, bags, trays, cages, or vertical ropes or wires are hung from the surface longlines under the floats or buoys, or from rafts</p> <p>A vessel equipped with davits and winches works along the lines, and the trays, nets or bags are detached from the line one by one and lifted into the boat. The gear is washed down as it is pulled aboard. Oysters are emptied from the gear and placed into tubs, then cleaned and sorted on board the harvest vessel, on an on-site work raft, or at an offsite processing facility.</p>

<p><b><u>Littleneck, Manila, and Butter Clam:</u></b></p> <p>Bag Culture</p>	<p>Clam seed (typically 5-8 millimeters) is placed in reusable plastic net bags closed with plastic ties or galvanized metal rings. Substrate, consisting of pea gravel and shell fragments, may be added to the bags. Bags may be placed in shallow trenches during low tide and allowed to “siltin,” i.e., burrow into the substrate. Bags are monitored during low tides throughout the grow-out cycle to make sure they are properly secured, and turned occasionally to optimize growth.</p>	<p>Prior to planting clam seed on the tidelands, beds are prepared in a number of ways depending on the location. Bed preparation increases the chances of seed survival and allows for full use of available land. Types of preparatory work may include raking debris; adding gravel and/or crushed shell to the beach to create more suitable substrate; cleaning the beds of algae, mussel mats and other growth; and conducting environmental assessments of conditions, such as salinity and water quality. This work is done during low tide.</p> <p>When graveling, a method termed “frosting” is preferred where several light layers are placed over many days in order to minimize the “burying” impact on the benthic and epibenthic environment. Frosting is only performed in previously treated areas. In addition to these types of activities, other preparations may include laying down netting to protect against predators such as crabs and ducks; and marking boundaries. Many growers remove the predator netting within a few days of planting clam seed, giving the clams enough time to burrow sufficiently into the substrate to avoid most predators, while minimizing the chances that netting will escape into the environment</p>	<p>When the clams reach market size, the bags are removed from the growing area. Harvesting occurs when there is 1 to 2 ft of water, so that sand and mud that accumulated in the bags during grow-out can be sieved from the bags in place. Bags are brought to the processing site, and any added substrate is separated for later reuse.</p>
<p><b><u>Littleneck, Manila, and Butter Clam:</u></b></p> <p>Ground Culture</p>	<p>Typically, clam seed is planted in the spring and early summer. Most of the clam seed used comes from West Coast hatchery and nursery facilities; although in some areas natural sets of clams occur. Clam seed sizes and methods of seeding vary, depending on site-specific factors such as predators present and weather conditions. Planting methods include hand-spreading seed at low tide upon bare,</p>	<p>After each growing season, surveys and samplings are typically conducted during low tides to assess seed survival and spreading adequacy, and to estimate harvest yield for the upcoming year. Surveys determine whether additional seeding is required to supplement a natural set or poor hatchery seed survival. The goal is to maintain the optimum sustainable productivity of the growing ground.</p>	<p>Before harvesting begins, bed boundaries are typically staked and any remaining predator netting is folded back during a low tide. Harvesting crews typically hand-dig clams during low tides, using a clam rake. Each digger is responsible for going back and smoothing over the beach upon completion of the dig. Market-size clams are selectively harvested, put in buckets, bagged, and tagged, and transported to processing plants. Undersized clams are</p>

<p><b><u>Littleneck, Manila, and Butter Clam:</u></b></p> <p>Ground Culture (Cont'd)</p>	<p>exposed substrate; hand-spreading seed on an incoming tide when the water is approximately 4 inches deep; hand-spreading seed on an outgoing tide when the water is approximately 2 to 3 ft deep; or spreading seed at high tide from a boat.</p>		<p>left in beds for future harvests. Harvested clams are generally left in net bags in wet storage, either in marine waters or in upland tanks filled with seawater, to purge sand for at least 24 hours.</p> <p>Technology has been developed to harvest clams mechanically, although only one or two growers use it. This technology may become more widely practiced due to labor and industry workforce concerns. Multiple crops may be in the ground at any time, depending upon the level of productivity of the ground. Beds may be dug annually, or as infrequently as once every four years.</p>
<p><b><u>Geoduck Culture</u></b></p>	<p>The most common method of culture currently in use consists of placing 10- to 12- inch-long sections of 4 to 6 inch diameter PVC pipe by hand into the substrate during low tide, usually leaving 2 to 3 inches of pipe exposed. Two to four seed clams are placed in each tube where they burrow into the substrate. The top of each pipe is covered with a plastic mesh net and secured with a rubber band to exclude predators. Additional netting may be placed over the tube field on beaches with heavy wind and wave action to prevent the tubes from becoming dislodged in storms. Some growers do not use the individual nets on tubes, and instead use nets that cover the</p>	<p>Prior to planting geoduck, bed preparation may include raking debris and cleaning the beds of algae, mussel mats and other growth. This work is done during low tide.</p>	<p>When geoducks reach market size, approximately 2 pounds in 4 to 7 years, the crop is harvested, either at low tide or, if at high tide, by divers. The geoduck, which have burrowed as far as 3 ft into the sand, are extracted by loosening the sand around each clam using approximately 20 gallons per minute of seawater delivered at approximately 40 pounds per square inch pressure via a hose and nozzle. The clam can then be pulled easily to the surface without damaging the animal. Small internal combustion engines are utilized to pump the seawater. These water pumps are typically located in a small boat just offshore of the harvest work. The water intakes of the pumps are fitted with intake screens to prevent entrainment of fish.</p>

<p><b><u>Littleneck, Manila, and Butter Clam:</u></b></p> <p>Ground Culture (Cont'd)</p>	<p>whole field of tubes.</p>		<p>After harvest, clams are brought to shore by boat on a flood tide and then transported to processing facilities.</p>
<p><b><u>Mussel Raft and Longline Culture</u></b></p> <p>(pertinent to Marine Deepwater, not Intertidal)</p>	<p>Naturally spawned mussel seed sets on lines or metal screen frames in net cages that are suspended in the water during the late spring spawning season. Hatchery seed is set on lines or screen frames at the nursery, and then transported to the mussel farm for planting. Once the seed reaches six to twelve mm it is scraped from the frames or stripped from the lines and sluiced into polyethylene net tubes. Concrete weights with stainless steel wire hooks are hung on the bottom end of each mussel sock for tension. The socks are then lashed to the raft, longlines or stakes, and suspended under the water.</p>	<p>When the mussels reach about one inch in length, the weights are often removed from the socks and saved for reuse. If the predator exclusion nets become fouled, blocking the flow of microalgae to the mussels, the nets may be removed, and shell or other debris cleaned off</p>	<p>Mussels are suspended from rafts or surface longlines anchored in subtidal waters. Raft sizes range from 30 by 34 feet, to 40 by 40 feet. Typically, two to three rafts are moored together to form a unit. Raft cultures may be enclosed by nets to exclude predators.</p> <p>Surface longlines are made of heavy polypropylene or nylon rope suspended by floats or buoys attached at intervals along the lines and anchored in place at each end. Anchors are made of concrete, and floats are either foam filled or recycled food-grade containers.</p> <p>Mussel culture may be performed at any time of the day and at any time of the year. They are not dependent on season or tides.</p> <p>When the mussels reach market size, socks or lines of mussels are freed from the longline, stake or raft structure for cleaning and grading. The mussels are stripped from the socks and bulk-bagged and tagged for transport to shore and the processing plant. Weights are reclaimed for re-use, and used socking and lines are recycled or disposed of at an appropriate waste facility.</p>

SOURCE: National Marine Fisheries Consultation, pages 7-15, dated 4/28/09, compiled by Dave Risvold/Pierce County Planning.