REESTABLISHING OLYMPIA OYSTER POPULATIONS IN PUGET SOUND, WASHINGTON

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Puget Sound Restoration Fund

Sea Grant
Washington

For thousands of years, Olympia oysters provided sustenance for Washington's tribes and habitat for a host of marine organisms in the Pacific Northwest. Captain George Vancouver's naturalist Archibald Menzies described them as "plentifully strewn" across intertidal reaches of Washington's Discovery Bay when the expedition's ship reached land in 1792. During Vancouver's day, native oyster populations in Willapa Bay and south Puget Sound numbered in the billions.

Like so many natural resources in this fertile part of the world, Olympia oyster stocks were thought to be inexhaustible. However, history has proved this notion to be wrong. Pollution, over-harvesting and habitat loss have collectively taken their toll on populations in Puget Sound. Though greatly reduced in density, the West Coast's only native oyster can still be found in many intertidal areas. With help from the public and private sectors, government and Northwest tribes, Olympia oysters can reestablish themselves at sites throughout coastal Washington.

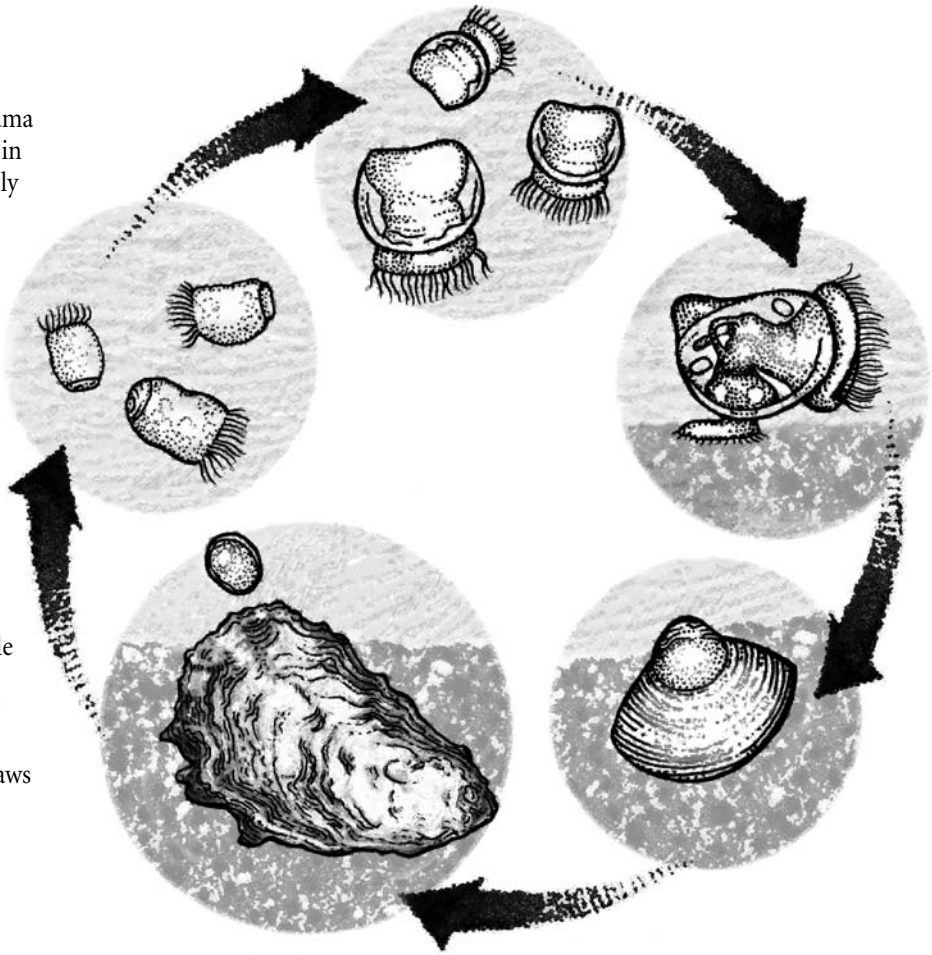
Private tideland owners are a critical piece of the reestablishment puzzle. With a full 75 percent of tidelands in Washington State owned privately, much of the best remaining habitat for Olympia oysters — and the persistent populations of oysters themselves — lies undiscovered across Puget Sound and Hood Canal. By working with the Puget Sound Restoration Fund and other organizations, tideland owners can identify those prime habitats and assist in the efforts to rebuild populations of the state's signature shellfish.

Olympia Oyster Ecology: The Basics

The Olympia oyster (*Ostreola conchaphila*) is the only oyster species native to the Pacific Northwest. It is reported to occur from Panama to Sitka, Alaska. Although some populations thrive in pure seawater, this oyster's preferred habitat is usually restricted to bays and estuaries with brackish water, with salinities no lower than 23 to 24 parts per thousand. In Washington state, prolific natural beds have historically existed in Willapa Bay, Samish Bay and throughout the maze of inlets in southern Puget Sound.

The northernmost limit of the Olympia oyster's range is determined by water temperature, as the oyster cannot survive freezing and requires water of at least 12.5 degrees C (55 degrees F) to reproduce. In Puget Sound, spawning typically occurs at water temperatures between 13 and 16 degrees C (55 and 61 degrees F) — usually in late May and early June. The process begins when a male expels a sperm cluster into the water. The cluster disintegrates on contact with sea water, releasing billions of individual sperm cells. In the process of filtering water through its gills, the female oyster draws these cells into its mantle cavity, where its eggs are stored and fertilization occurs. Each female oyster broods about 250,000 developing larvae and several broods may be produced each year.

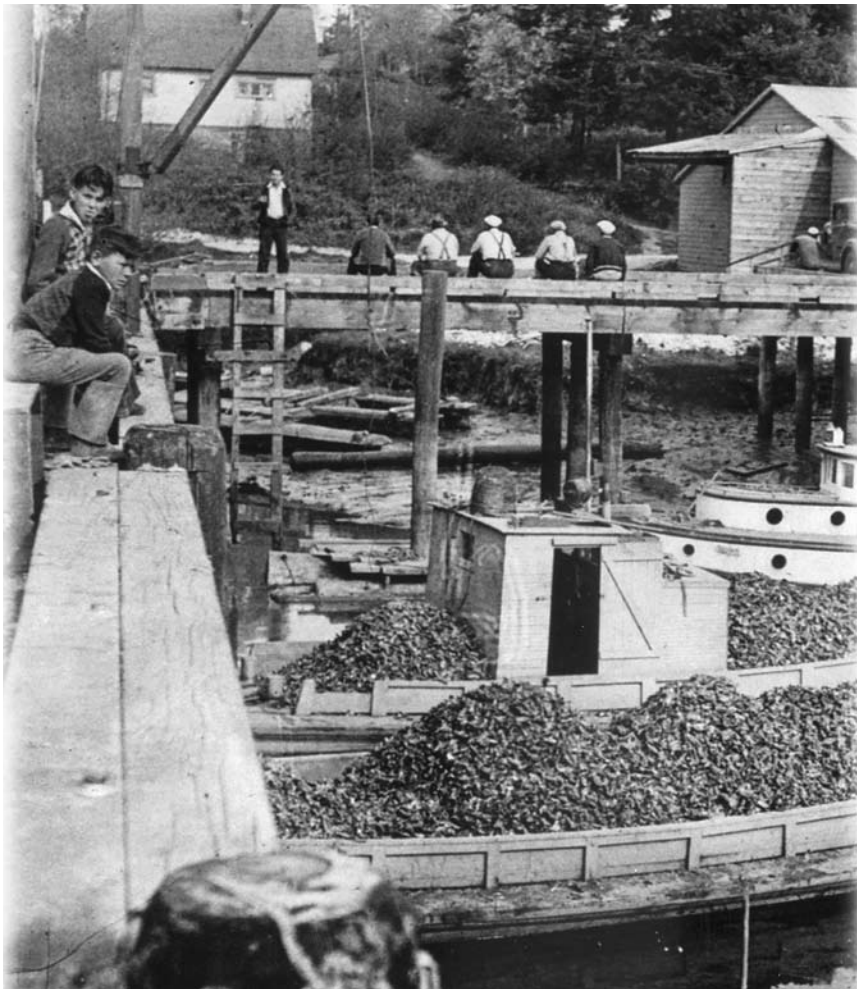
Fertilized eggs develop into larvae, remaining 10 to 12 days in the female oyster's mantle cavity. Here, the larvae go through four stages of development: a single-celled zygote; a trochophore with hair-like cilia for locomotion; a D-hinged larva with two thin shells, each vaguely reminiscent of the letter "D"; and an umbo larva, with the hinged part of the developing shell (or umbo) becoming more rounded. The umbo larvae are discharged into the surrounding sea water, where, as zooplankton, they are subject to tides, water currents and winds. The larvae remain in the water column for 10 to 14 days before settling on a suitable substrate — the surface of a rock, oyster shell or other hard material. The substrate type may influence the number of oysters that settle and how many survive. Each settling oyster secretes a special glue to hold itself in place and begins to filter nutrients from the sea water. The oyster can mature in less than a year and will attain an average shell length of 35 to 45 mm within three years; shell lengths of up to 10 cm have been reported. Little or no growth occurs after the third year, although the oyster's shell may develop a deeper cup. Adult Olympia oysters alternate between male and female reproductive modes.



Stages of an Olympia oyster's development (not to scale), clockwise from bottom: adult and zygote, trochophore stage, D-hinge stage, umbo stage and spat.

Olympia oysters are filter feeders, with individuals capable of filtering eight to 12 gallons of water per day. Water is drawn into the oyster's interior, where gills retrieve oxygen from the water and release carbon dioxide and uric acid into the environment. The gills also serve as strainers, capturing small particles of food in the form of free-floating plants, called phytoplankton. Olympia oysters filter food particles that are smaller than those taken by Pacific oysters (*Crassostrea gigas*) and, thus, serve slightly different ecological roles in controlling phytoplankton blooms. A healthy Olympia oyster population — comprised of millions of shellfish — can provide filtration for huge volumes of water each day. Filter feeding can help to reduce the turbidity of sea water and may also promote nutrient balance. Although the input of nutrients in many parts of Puget Sound far exceeds the processing capacity of filter feeders, it stands to reason that increasing this capacity is a worthwhile endeavor.

Feast to Famine: A Brief History of Human / Oyster Interactions



Historically massive harvests of Olympia and Pacific oysters earned Willapa Bay the reputation as "Oyster Capital of the West."

For thousands of years, human communities have capitalized on Puget Sound's native oysters. Particularly in the south Sound, native tribes often sited their villages near large beds of Olympia oysters. Members of what is now known as the Squaxin Island Tribe recall the often densely concentrated shellfish as something akin to their "daily bread" — there for the taking any time the tide was out.

The first European settlers to the area gathered Olympia oysters from wild populations, primarily for sustenance and perhaps for local sale. In the 1850s, northern California's gold prospectors brought their appetites for oysters with them from the East Coast and often celebrated large strikes with enormous quantities of oysters and champagne. A plate of native oysters sold for as much as $20 — the equivalent of about $400 today. Overharvesting, pollution and sedimentation took their tolls on San Francisco Bay's oyster stocks, forcing seafood sellers to turn to Willapa Bay in the Washington Territory for relief. Merchants shipped Willapa Bay native oysters to San Francisco as fast as they could be harvested. As the oysters were shipped in their shells, however, the hard substrate necessary for larval settlement gradually disappeared. Overharvesting and the steady reduction of settling habitat spelled disaster. By the 1870s, Willapa's oyster stocks had been exhausted.

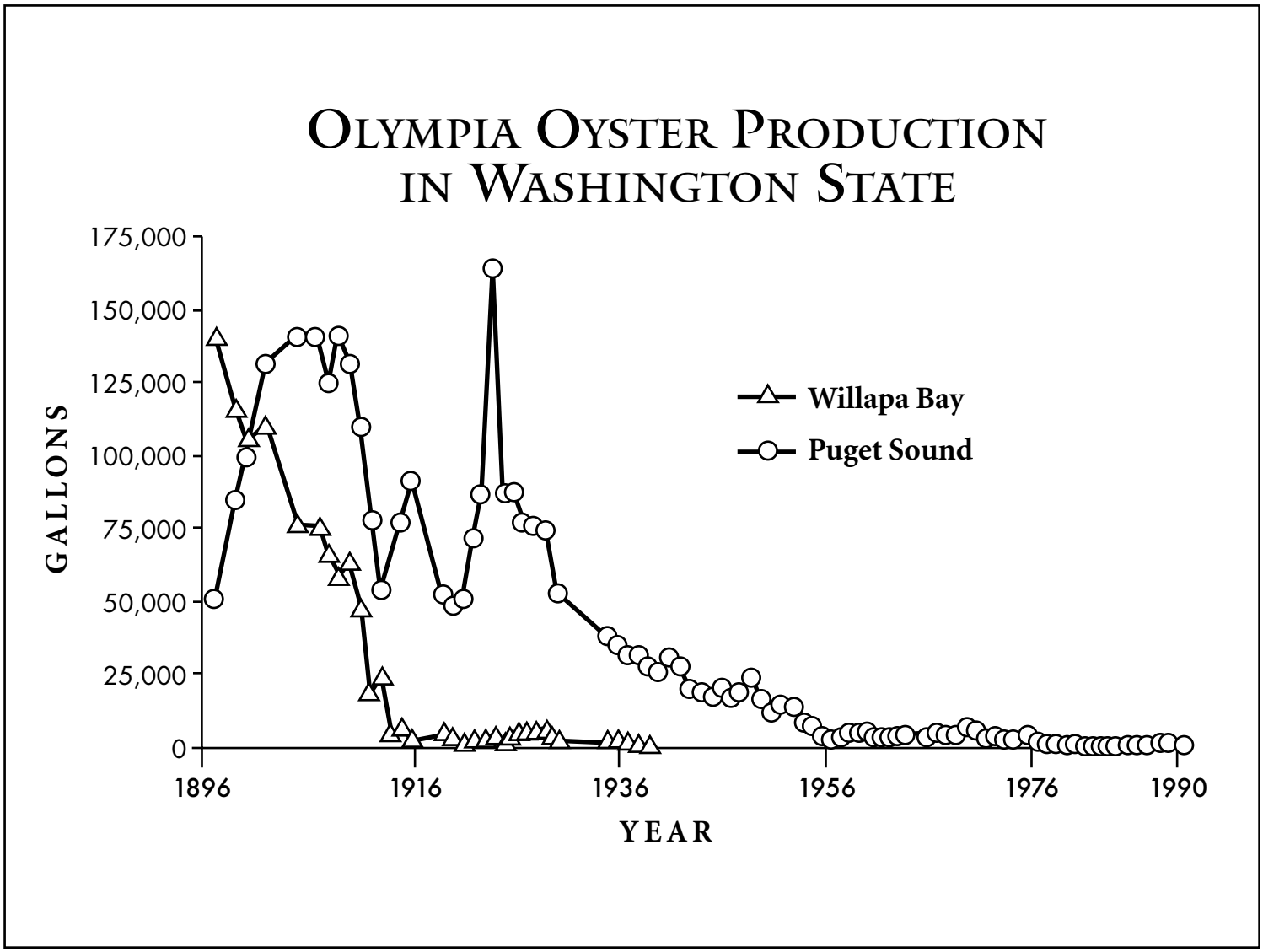
Olympia oysters in Puget Sound were initially spared the burden of overharvest, largely because oysters shipped by sea to San Francisco would spoil before they reached the city. Harvest was thus highly localized, and few instances of overharvest occurred before Washington's statehood in 1889. At that point, titles to all tidelands passed to the State of Washington. Six years later, state legislators passed laws allowing the sale of oyster beds to individuals already occupying adjacent land or cultivating natural oyster beds.

Washington's oyster farmers would soon discover diking, a method that eventually encompassed more than a thousand acres of tidelands. Oyster dikes — first made of logs and later built from concrete — took advantage of the native oyster's tendency to settle and thrive in areas consistently under water. At a time when natural beds of native oysters were beginning to be depleted, dikes offered a means by which growers could greatly expand available acreage for shellfish farming. Yields in the first years of Olympia oyster harvest in Puget Sound may have been as high as 100,000 bushels annually, but had dropped by 1910 to a mere 29,000 bushels. Over the next 15 years — a period of extensive diking — production once again increased to as many as 40,000 bushels per year.

A low point in Olympia oyster production occurred soon after 1927, the year that a sulfite pulp mill began operating in Shelton and discharging untreated sulphite waste liquor (SWL) into Oakland Bay. SWL is highly toxic and affected private and commercial oyster beds almost immediately, preventing oyster larvae from setting and killing most adult oysters. A series of experiments in the 1930s, 40s and 50s demonstrated that polluted wastewater from the mill circulated throughout southern Puget Sound. Other experiments established that SWL concentrations as low as eight parts per million were deleterious to oysters. By 1957, the year the pulp mill permanently closed, most Olympia oyster growers in southern Puget Sound had already switched over to cultivating the non-native Pacific oyster. Despite subsequent water quality improvements, the damage to native oyster stocks had been done. By 1960, overharvesting had nearly exterminated native oyster beds in Willapa and Samish bays, and pollution had wiped out most of south Puget Sound's once-thriving Olympia oyster populations.

Olympia oysters have survived in north and central Puget Sound, and populations in the south Sound and Hood Canal are, by some accounts, gradually recovering. Water quality has generally improved over the past 40 years, and strict regulations have alleviated harvest pressure on remaining wild oyster populations. Nonetheless, more than 150 years of habitat modification have taken their toll. Continued development around shorelines introduces silt to the ecosystem and the construction of bulkheads and dikes can scour beaches, damaging Olympia oyster beds that have only recently begun to recover.

Today, the Olympia oyster is a candidate for review as a possible state threatened, endangered or sensitive species, due to concern over low population levels. In 1998, the Washington Department of Fish and Wildlife (WDFW) developed the Olympia Oyster Stock Rebuilding Plan. More recent on-the-ground reestablishment efforts by the Puget Sound Restoration Fund (PSRF) have greatly assisted the Olympia oyster's return. As of this writing, PSRF has assisted in spreading over five million oysters at more than 80 experimental sites, with assistance from over 100 project partners.



Olympia oyster harvest peaked in the 1920s and, then, dropped substantially, reaching an all-time low in the 1960s, never to fully recover.

Source: Baker, P. 1995. Review of ecology and fishery of the Olympia oyster, *Ostrea lurida*, with annotated bibliography.

Preferred Habitat

Characteristics of suitable intertidal habitat for Olympia oysters include:

Firm substrate — composite areas of sand, mud, shell material and rock. Olympia oysters are prone to sinking when placed on soft substrate.

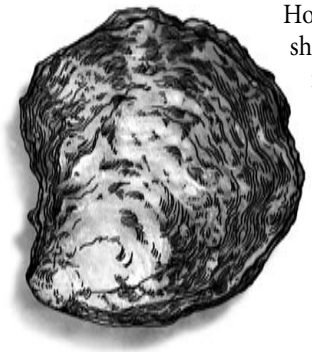
Few predators — For peak productivity, sites must be fairly free of oyster drills, sea stars, moon snails and other natural enemies of oysters. It should be noted that dense Olympia oyster populations are occasionally found co-occurring with dense populations of drills and other predators, suggesting the oysters may withstand intense predation pressure under some conditions.

High degree of protection — Estuaries, coves and bays may shelter Olympia oysters from movement and potential damage by currents and wave action.

Consistent sources of water — Unlike Pacific oysters, which can withstand periodic exposure at low tides, Olympia oysters are vulnerable to high and low temperatures if not covered by water.

Freshwater influences — Olympia oysters thrive in the brackish waters found near estuaries, stream outlets and the heads of bays.

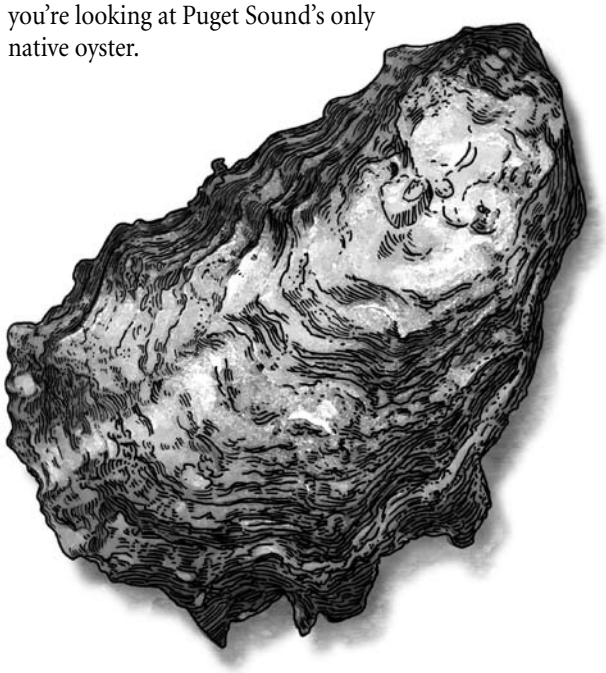
Olympia oysters have remarkable capacities to persist in suitable habitats throughout Puget Sound and Hood Canal. During spring and summer months, shellfish biologists from WDFW and partners in oyster reestablishment annually survey beaches thought to have extant populations of Olympia oysters. They often find evidence that Olympia oyster populations are maintaining themselves — and, in some instances, thriving — at locales from Budd Inlet to the northern San Juan Islands.



Adult Olympia oyster (full-sized)

In their habitats, Olympia oysters are not easily recognized by untrained eyes. Their shells are barely distinguishable from the colors and textures of rocks and vegetation surrounding them and they also are easily confused with non-native Pacific oysters in their juvenile stages. In addition, the shapes and sizes of Olympia oysters may vary considerably, depending on the environmental conditions of habitats in which the oysters settle and grow. Even seasoned field biologists must sometimes resort to genetic analysis to determine whether they have found native oysters or Pacific oysters.

In all life stages, Pacific oysters have thicker shells than Olympia oysters do. In addition, the insides of Olympia oyster shells are often pale purple tinged with green, while Pacific oyster shells are light gray or white. When attempting to identify an unknown oyster, keep in mind the characteristics of the habitat in which that oyster lives above all else. The majority of beaches in Puget Sound and Hood Canal — with exposure, heavy current, soft substrate, or little to no permanent water — simply do not provide the right kind of habitat for native oysters even though strewn with hardier Pacific oysters. If, however, you have discovered an unidentified oyster or two with morphology similar to the Olympia oyster characteristics described above, and have found that mollusk in likely habitat, chances are you're looking at Puget Sound's only native oyster.



Adult Pacific oyster

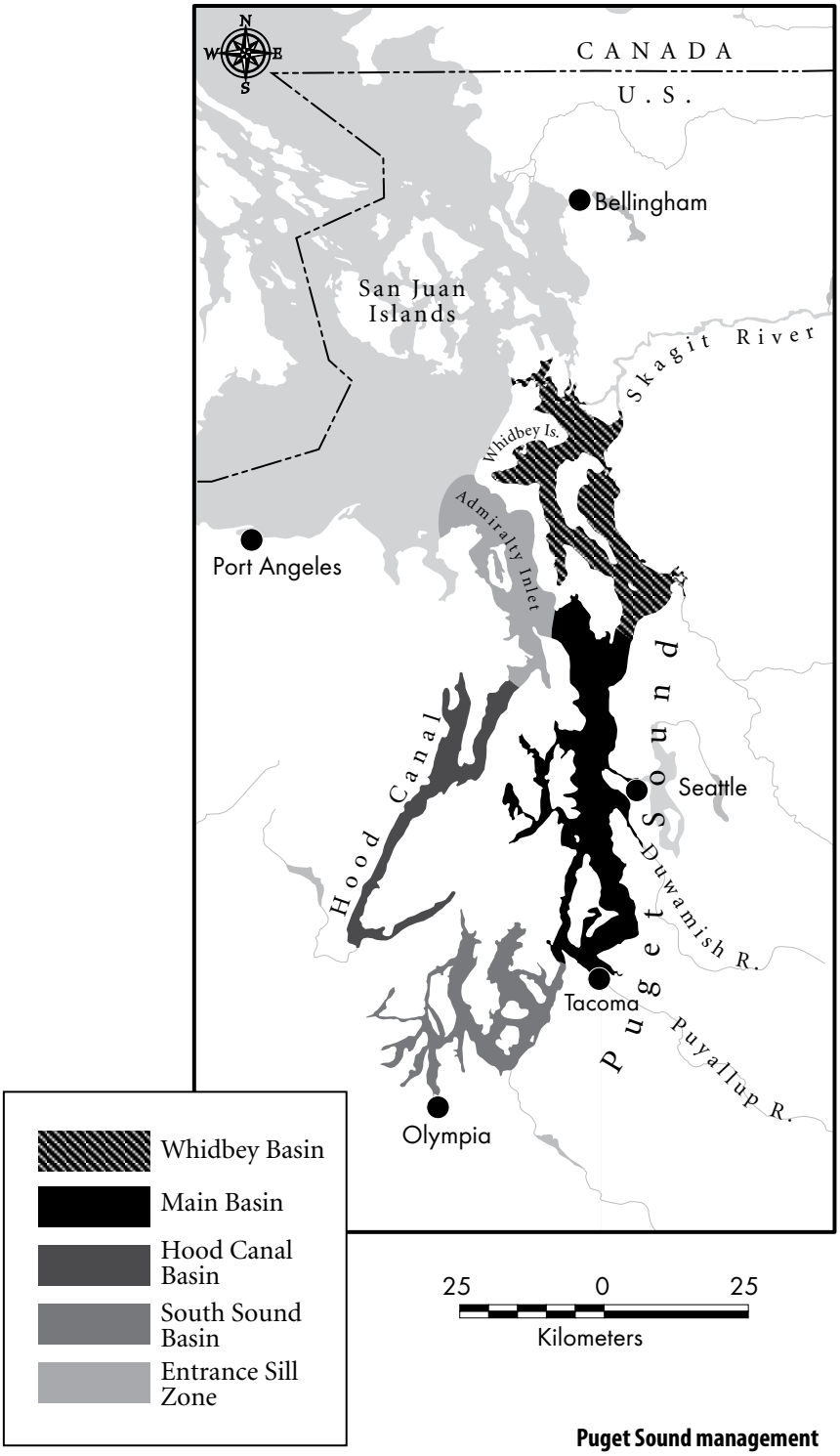
Reestablishment Considerations and Techniques

The discovery of suitable native oyster habitat is the first step toward a site-specific reestablishment project.

Intertidal areas with extant native oyster populations or those containing evidence of existing populations in the past are strong candidates for re-introduction efforts. Shell middens — historic mounds of oyster and clam shells discarded by Puget Sound tribes — provide evidence of prior shellfish abundances. However, the presence of middens does not necessarily prove the existence of Olympia oysters at a site, as the discarded shells may have been transported many miles from a harvest site. Regardless, all newly discovered middens should be protected from disturbance; property owners should report such finds to the nearest tribal authority or the Washington State Office of Archaeology & Historical Preservation.

After identifying areas where Olympia oysters may have thrived in the past, a plan should be formulated for securing a supply of juvenile Olympia oysters with which to seed the sites. Seed oysters can be acquired from a hatchery or by capitalizing on natural spawning and settling by wild stocks. Either form of acquisition will require broodstock — that is, natural populations of mature Olympia oysters.

Out of concern for preserving the genetic integrity of remaining Olympia oyster populations, WDFW suggests that brood oysters originate from the same Puget Sound management area in which their offspring will be spread (see map). Although it is currently unclear if Puget Sound's remaining Olympia oysters belong to one population, with essentially identical genetic materials, or whether there are a number of sub-populations with distinctly different genetic traits, WDFW's guidelines encourage Olympia oyster reestablishment project managers to "play it safe." Should future research indicate that all of Puget Sound's native oysters share most genetic material, brood oysters from one region — for example, the South Sound Basin — could be used to produce seed for projects in other parts of Puget Sound. If, however, significant genetic differences do exist among populations, it is exceedingly important that this localized variation be preserved with careful attention to seed production in each individual basin. The cautious action is to assume that differences between populations do exist and to design reestablishment projects accordingly.



Puget Sound management areas, as used by WDFW.

Tideland owners, biologists, resource managers and others who frequent Puget Sound's many miles of shoreline are usually among the first to report previously unknown populations of Olympia oysters. Currently, brood oysters are thought to be relatively plentiful in the South Sound and Hood Canal basins and somewhat less abundant in the other basins. As collecting oysters for seed production requires a permit from WDFW, it is a task ordinarily undertaken by non-profit organizations and commercial shellfish farming operations rather than individuals.

Concern also exists over the movement or introduction of shellfish diseases via conservation efforts. Therefore, prior to seed production, shellfish pathologists must ensure that brood oysters are free of shellfish-borne diseases. Once a private or institutional shellfish pathology laboratory has certified that the broodstock are clear of contagious agents of infection, the oysters can be delivered to shellfish hatcheries. Because spawning readiness is determined by water temperature, hatchery technicians must condition the brood oysters for approximately one week in 55- to 61- degree F water. Immediately after the oysters are successfully spawned, their larvae are concentrated in small tanks, where they settle onto suitable substrate — often bits of Pacific oyster shell, known as cultch. The cultched larvae (called spat) may be bagged for shipping, with as many as 6,000 juvenile Olympia oysters per bag, or they may be kept in the hatchery and fed phytoplankton-rich water for several months. When each oyster is approximately the size of a pencil eraser — usually within three months of settling — the seed oysters are ready to be tested by a pathologist prior to being planted on the beach.

To reduce the risk of spreading disease, WDFW presently requires a transfer permit for any oyster moved from one site to another. This requirement applies to transport between beaches as well as to and from shellfish hatcheries.

Transporting oysters from a hatchery to a reestablishment site requires a degree of advanced planning. Like the adults, juvenile Olympia oysters are extremely susceptible to exposure to air, and extra care must be taken to ensure that they remain wet during transport. This is usually accomplished by layering damp blankets and tarps over the bags of cultch, often in the back of an open-air pickup truck.

At the site, several seeding methods can be employed. The choice of methods is based on a range of factors, including potential predation, size of seed, degree of exposure and substrate conditions. Traditional bottom culture involves scattering cultch across areas of suitable habitat.

Olympia oysters are not highly sensitive to crowding, so planters in reestablishment projects should not be concerned about evenly spacing the oysters they are spreading. Bottom culture is best employed at optimal sites with few known predators and sufficiently firm substrate. In marginal habitat, or when seed is of a size especially vulnerable to predation (typically smaller than a pencil eraser), other methods are best employed.

Particularly at sites where predation is a concern, seed can either be left in the mesh bags from the shellfish hatchery or transferred to rectangular, 1/8" to 1/4" mesh grow-out bags. If the bags are being employed to assist the seed in growing past the vulnerable stage (as opposed to compensation for marginal habitat), cultch shells can be removed from the bags and spread by bottom culture technique after three or four months in the water. If, however, bags are being used to augment less-than-ideal habitat, some care is required to give the oysters better odds at reaching spawning age. Heavy currents, wave action or other effects of beach exposure might require tidelands owners to stake their grow out bags to the beach with rebar or other material. Additionally, many shellfish growers recommend that bags be periodically flipped to minimize the impacts of siltation and the potential for smothering oysters on the bottoms of bags.

In places where habitat does not allow the placement of bags directly on the substrate, aspiring shellfish growers can suspend bags of cultch/seed from docks or other floating structures. Maintenance is required for suspended bags, as they tend to accumulate sponges, tunicates, seaweeds and other so-called fouling organisms. Pulling bags from the water and scrubbing them with a wire brush two or three times a year will substantially decrease growth on the bags, enabling many more oysters to reach maturity.

At sites where substrate is soft mud or silt and floating structures are unavailable for suspended bags, longline culture may be a viable option. Longlines are sections of braided rope attached to small posts, typically made from PVC pipe or wood. Each line contains either cultched shell or spat that has set on the longline itself. Longlines require periodic maintenance, ensuring that they do not sag into underlying mud or silt.

If the habitat is prone to siltation, raising juvenile oysters off the substrate by mounding the cultched shell can increase survival. For this method, cultched shell is concentrated in one or more areas, with multiple layers at heights that will facilitate adequate water coverage. Mounding can also be used on tidelands with suitable habitat, to minimize the impacts of predatory oyster drills.

Once seeding has been completed, the focus shifts to bi-annual monitoring of survival and growth of planted oysters. Project workers should first visit seeded sites no later than six months after planting, to scatter the juvenile oysters (where grow-out bags have been used) and to collect baseline data on the restored population. Standardized monitoring forms that have been developed by the Northwest Indian Fisheries Commission include spaces for notes on community ecology of the site, growth measurements, rates of mortality and the presence of predators or pests. These forms should be completed bi-annually — ideally once in April/May and again in September/October. If abnormal losses are observed, it is recommended that a pathologist is immediately contacted and live samples are sent on ice (but not frozen) overnight to the pathology lab for analysis.

As soon as a year after a site has been planted, but more typically in years two or three, monitoring may reveal evidence of natural reproduction. The most typical — and exciting — evidence of this is the presence of juvenile oysters that have set on the shells of mature ones. In this case, the young mollusks represent the first generation of what could eventually become a fully functional Olympia oyster bed, five or six oysters thick and teeming with crabs, anemones, salmon and other marine species. An abundance of juvenile oysters does not necessarily indicate *local* production, however, as the larvae could have originated from other locales. A well-designed monitoring program will assess recruitment over multiple years before seed or adult oysters are planted, to help measure any improvement in subsequent years.

Growing Olympia oysters for consumption is tantalizing; however, the immediate purpose of spreading seed throughout Puget Sound should be to increase the density of spawning adults. Thus, tideland owners who minimize the harvest of any oysters they plant are substantially aiding Sound-wide stock reestablishment efforts. In this regard, the best forms of assistance are those that supplement existing Olympia oyster populations and enhance habitat and water quality so that the planted oysters can thrive and expand on their own.

Olympia Oyster Predators

Oyster drills, several sea star species and many other marine invertebrates all prey on Olympia oysters. Drills, specifically, are one of the most damaging pests found on oyster beds. These small marine snails have rasp-like radulas that drill holes in the oyster shell, allowing this gastropod to gain access to the soft flesh within. Japanese oyster drills (*Ocinebrellus inornatus*) were accidentally introduced into Washington waters with the importation of Pacific oyster seed and can substantially impact local populations of Olympia oysters. Although not as widely distributed as the Japanese oyster drill, the eastern oyster drill (*Urosalpinx cinerea*) has an impact on Olympia oysters in Willapa and Samish bays. To slow or prevent the spread of drills, WDFW limits the transport of oysters from drill-infested areas to ones that are drill-free.

Several sea star species are common predators in oyster beds, especially in lower intertidal areas. It can take less than 24 hours for a sea star to devour an adult oyster. Unless present in unusually high densities, sea stars will have limited impacts on native oyster beds above —1 tidal elevations. Grow-out bags can minimize predation in areas where sea stars are a concern.

Predation by crabs is mostly confined to seed oysters. Dungeness crabs (*Cancer magister*), red rock crabs (*C. productus*) and graceful crabs (*C. gracilis*) are known predators of Olympia and Pacific oysters. Grow-out bags will deter most predation by crabs, allowing seed oysters to grow beyond a vulnerable stage.

Resources for Reestablishment Efforts

The Puget Sound Restoration Fund encourages individuals and groups to become involved in Olympia oyster reestablishment projects. People who are considering planting oyster seed on their beaches are urged to contact this organization, to discuss the feasibility of their projects and to identify any adverse impacts, such as the introduction of shellfish disease or non-native pests that might stem from such work.

Owners of waterfront property in southern Puget Sound (Henderson, Budd, Eld, Totten, Hammersley and Case inlets plus Pickering Passage and Oakland Bay) have unique opportunities to become involved in Olympia oyster reestablishment. Each year, Taylor Shellfish Company, based in Shelton, Washington, sells Olympia oyster seed during the spring and summer months. Prospective buyers should recognize that this company's seed comes from broodstock taken from south Puget Sound. To safeguard the genetic integrity of Olympia oysters throughout Puget Sound and Hood Canal, seed from this source should be spread only on tidelands south of the Tacoma Narrows Bridge.

Tidelands owners in northern Puget Sound and the Strait of Juan de Fuca, the San Juan Islands and all other marine areas north and west of the Entrance Sill Zone (identified on the map on page 5) can contact the Lummi Shellfish Hatchery. It should be noted that broodstock from the Northern Basin are extremely difficult to obtain. Tidelands owners with access to these stocks should notify the Lummi Shellfish Hatchery.

Tideland owners throughout Puget Sound, the Strait of Juan de Fuca and the San Juan Islands should also consider contacting the non-profit Puget Sound Restoration Fund organization. Additional assistance is also offered by any of the seven Marine Resources Committees — countywide volunteer groups created by the Northwest Straits Commission. The Marine Resources Committees in Clallam, Jefferson, San Juan and Skagit counties have been very active to date in Olympia oyster reestablishment projects and are additional resources for those seeking to get involved.

Washington's tribes are closely involved in efforts to rebuild stocks of Puget Sound's native oysters. Tideland owners considering the reestablishment or enhancement of Olympia oysters on their beaches are encouraged to contact local tribal shellfish biologists prior to any seeding efforts. Although the tribes have no claim to the oysters, native or otherwise, that are planted on privately owned or leased tidelands, they do have a right to 50 percent of the shellfish that existed prior to any stock enhancement efforts. Additional information can be obtained from the Northwest Indian Fisheries Commission in Olympia, Washington.

Individuals with access to docks or other floating structures have opportunities to produce Olympia oyster seed to aid in future reestablishment efforts. Oyster larvae from extant populations can be caught by a variety of methods, perhaps the most effective of which involves suspending mesh bags filled with Pacific oyster shell in the vicinity of spawning Olympia oyster populations. To determine whether a population of Olympia oysters exists in range of one's tidelands, one or two bags of shell should be suspended in the water during late May or early June. By late summer, the shell may be covered with juvenile Olympia oysters — firm proof that spawning and settlement have occurred. Typically, oysters settling in late spring will appear as semi-transparent brown specks, several millimeters in diameter, by the end of summer. Relatively inexpensive bags of cultch can be obtained from several shellfish growers in the Puget Sound area.

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Resources

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restorationfund.org
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Brinnon, WA 98320
wdwf.wa.gov
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Puget Sound Restoration Fund

Founded in 1997, Puget Sound Restoration Fund is a project-focused organization whose mission is to achieve on-the-ground restoration of Puget Sound habitats and native species. PSRF's projects are heralded as exemplars of cooperative conservation, with partnerships that effectively engage property owners, government, businesses, tribes, community organizations and citizen volunteers.

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