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Restoring the Olympia Oyster, *Ostrea conchaphila*

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Introduction

Oysters are an integral part of North America's seafood supply, and have been since before European settlement. Archeological evidence and oral histories tell a story of subsistence and ceremonial harvest of oysters for most coastal Native Americans. On the West Coast, the gold rush in the mid-1800s fueled massive harvest and trade in the region's native oyster, *Ostrea conchaphila* (also *Ostrea lurida*), and greatly diminished its distribution and abundance. However, the native oyster is making a comeback, and the story is far from over. This edition of Habitat Connections is the 3rd in a series on oyster restoration in the United States, and it focuses on the 'Olympia' oyster, the only oyster native to the U.S. West Coast.

Fig. 1: Native Americans harvesting shellfish
(Photo courtesy of Northwest Indian Fish Commission)

History

The influx of gold miners and other settlers to California during the mid-1800s created a huge demand for delicacies such as the Olympia oyster. Although once plentiful in San Francisco Bay, the unabated appetite of the miners soon depleted local stocks. Not to be deterred from so fine a delicacy, they looked north to Oregon and Washington for more supply and by the late 1800s over-harvest began to take its toll on Olympia oysters. The decline was hastened in the early 20th century with the arrival of pulp and paper mills. Pollution from the discharge of sulfide liquor waste and logging debris on the bottom decimated oyster populations throughout southern Puget Sound (Fig. 2). Soon after, the industry began importing from Japan the Pacific oyster (*Crassostrea gigas*), which subsequently became the backbone of the northwest oyster industry.

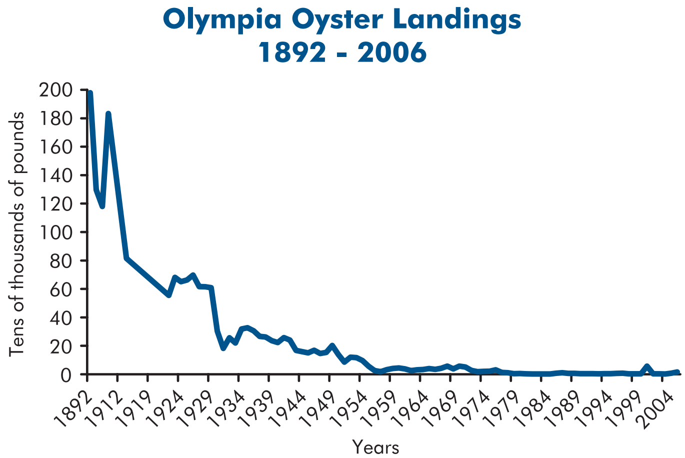

Fig. 2: Olympia oyster landings in Washington State, 1892-2004 *(Courtesy of Dr. Kay McGraw)*

In time, pollution problems caused by the pulp mills eased, and the Olympia oyster regained at least some of its previous status. Recent surveys indicate that populations are present throughout most of their historic range (Fig. 3), though in much less abundance than in pre-colonial times. As a result of a natural resurgence in the late 1990s, increased monitoring, and targeted restoration efforts, Olympia oysters are found in greater numbers today than post-gold rush days, but they do not yet exist in sufficient quantities outside of farmed areas to support consistent harvest. Any change in the current limited harvest regime would require changes to state rules or laws, depending on each state's particular management regime for shellfish harvesting. On the West Coast, all current oyster restoration projects funded by NOAA are aimed at restoring natural populations and habitat, and do not include a harvest component.

Species Description

Olympias tolerate brackish conditions, but prefer salinities above 22ppt. They do not generally survive if exposed to sub-freezing or extremely warm temperatures, and typically occupy lower tidal strata than the hardier Pacific oysters. Although they occur intertidally, Olympias in higher tidal ranges are often found in lagoons, areas of seepage, channels, or impounded tidal areas that offer minimal exposure to temperature extremes or predation.

What's in a Name?

Ostrea lurida* vs. *Ostrea conchaphila

Although both taxonomic names have been in use for about 150 years (*O. lurida* since 1864 and *O. conchaphila* since 1857), debate rages among fans of this little bivalve. Aside from pure loyalty and regional nomenclature, there are real scientific questions as to 1) the accurate taxonomical classification, and 2) the possibility that there are two separate species (or sub-species) of West Coast native oysters. Recent molecular evidence supports the hypothesis that two distinct species exist: *O. conchaphila* south of Sinaloa on mainland Mexico, and *O. lurida* north of San Quintin, Baja California, Mexico.

For the purposes of this publication, we will use *O. conchaphila*, but recognize that both taxonomic terms are in common use. (For a descriptive discussion on this topic, see Peabody, 2007).

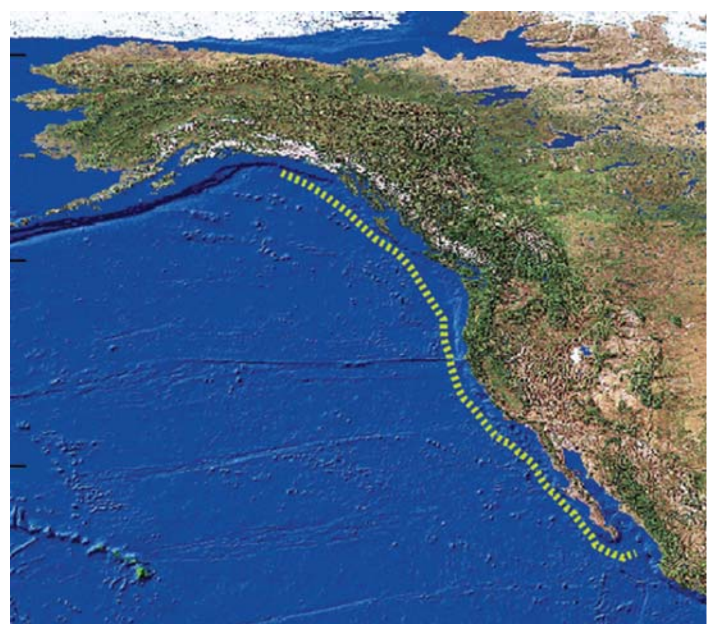

Fig. 3: Map depicting historic distribution of *O. conchaphila* (green dotted line). *(Courtesy of Dr. Kay McGraw).*

Olympias are hermaphroditic filter feeders, changing sexes throughout their lifespan. Spawning occurs at temperatures between 12.5 and 16 ºC (55-61 ºF), and takes place between late spring and into summer, depending on regional life history differences and local factors. Males expel sperm clusters, which disintegrate in seawater, 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 eggs are stored and fertilization occurs. Each female oyster broods about 250,000 larvae and several broods may be produced each year. The larvae spend 10-12 days developing through four stages inside the female oyster's mantle cavity. After being discharged into the water column, the free-swimming larvae spend anywhere from a few days to two weeks in the water column before settling onto oyster shell, a protected tideflat, rock, wood, or other suitable substrate.

The oysters grow to sexual maturity in about a year, and reach maximum size after approximately three years. Rarely are Olympia oysters found greater than about 7.5cm (3 inches) in shell length, although there have been reports of shell lengths up to 10cm (4 inches).

Ecosystem Services

In their natural state, *O. conchaphila* populations form sparse to dense beds in coastal bays and estuaries. They are not reef builders, like their East and Gulf Coast cousin, *Crassostrea virginica*. Olympia oyster beds have high biodiversity because they provide a physical habitat structure ideal for juvenile fish and crustaceans, worms, and foraging nekton and birds. Oyster beds also tend to stabilize sediment, possibly providing better opportunities for establishment of submerged aquatic vegetation (SAV). Light is the most common limiting factor for eelgrass (*Zostera marina*), and filtration by native oysters can help decrease plankton blooms, thereby increasing light penetration and opportunities for SAV growth. Further, a robust population of filter feeders can help modulate plankton blooms, potentially decreasing the likelihood of red tide events. In areas subject to high productivity levels from agricultural or residential runoff, filter feeders can help to maintain moderate levels of plankton productivity.

Nutrient cycling is also an important role of native oysters. Feces and pseudofeces deposited by oysters enter the benthic nutrient cycle, and are converted to various forms of nitrogen and carbon. Some serves as a nutrient source for benthic infauna, some enters the microbial loop, and some re-enters the water column via nitrogen gas or other organic compounds. These nutrient pathways represent a crucial linkage between benthic and pelagic realms within the estuarine ecosystem.

Where Did You Come From, Where Did You Go?

During the gold rush years, Olympia oysters were routinely moved from bay to bay, and even deposited in various estuaries along the West Coast states, to store for subsequent transport to San Francisco. Although the precautionary principle dictates using only local broodstock, the historical mixing of stocks could mean that the 'original' population in any particular waterbody may actually not be the same today!

Restoration Techniques

There are two general strategies for re-establishing populations of Olympia oysters: adding new live oysters to a bay or estuary ('seeding'); and creating additional habitat by improving settling substrate.

Seeding

To restore depleted areas, oyster seed is obtained either from a hatchery or by providing suitable material to collect natural set wild seed (called "spat"). Hatchery production techniques include state of the art methods to stimulate spawning and subsequent larval settlement. Adult oysters (broodstock) are harvested from the wild, and brought to the hatchery for spawning. Bags of clean oyster shell (cultch) are used as settlement substrate for larval oysters. In the case of natural set production, cultch bags are suspended in the water column as a settlement substrate for larvae produced by existing populations. This seed-bearing cultch can then be moved to targeted restoration sites, which are usually in the same vicinity. These activities typically require state, local, and/or federal permits, so practitioners should check with state fish and wildlife agencies prior to embarking on a restoration activity.

For both hatchery and natural seed production, seed destined for a particular geographic area should be produced using oysters collected in the same geographic area in order to preserve genetic integrity (see text box). To further safeguard the genetic variability of offspring, hatcheries typically use hundreds of broodstock oysters to maintain genetic diversity. More advanced hatchery techniques will be needed in the future using families of paired crossings.

For the most part, seed planting methods involve spreading seeded cultch (hard material that spat is attached to) directly on tide flats. This is a traditional bottom culture technique used by commercial and small-scale growers. This basic bottom culture method was first used for restoration purposes in Oregon in the early 1990s, and spread to Washington in 1999 when a multifaceted effort was launched to reseed historic grounds spanning public, private, and tribal tidelands. Since then, in Puget Sound, 10 million oysters have been spread at 80 sites, re-establishing naturally spawning populations of Olympia oysters at eight sites and achieving a 29% - 95% survival rate at most sites three and four years after planting. Success appears largely driven by the suitability of habitat: If the right conditions exist, basic bottom culture is successful. To compensate for marginal habitat conditions, the seed can be protected in mesh grow-out bags during the first year to reduce predation prior to spreading. Transplanting adult oysters from one location to another can sometimes work well in conjunction with commercial shellfish operations that wish to remove *O. conchaphila* from a particular plot prior to planting a different bivalve species.

In addition to genetic safeguards employed in both hatchery and natural seed production, it is important to avoid spreading diseases or invasive species during the course of restoration. For instance, to avoid spreading drills, mature oysters that are taken from areas with Japanese oyster drills should be cleaned of any obvious oyster drills and egg cases, and only re-distributed to similarly infested areas. Transfer permits are required by Washington state for all hatchery-produced seed. In addition, to avoid the spread of diseases health certifications are required for all seed introduced to a hatchery and subsequently distributed. As an added precaution, the cultch shell used as a settlement substrate in seeding projects should also be cleaned and stored on land long enough to ensure that there are no viable non-native organisms or disease organisms on the shell.

Fig. 4: A handful of *O. conchaphila*

Habitat enhancement

Along the West Coast, habitat enhancement has been completed in areas that lack adequate settling substrate. As a restoration strategy, it is emerging as a common technique in Puget Sound, since it provides the means for larval oysters to recruit and re-colonize historically occupied habitats while also preserving the genetic integrity of any potential sub-populations. In areas with ample larval production but limited settling structure, oyster shell is distributed to a depth of 3-8 inches above existing substrate. At some sites, bagged oyster shell can be utilized in order to establish sites that are quantifiable (*i.e.*, in terms of substrate volume and surface area) and provide replicate samples for quantitative assessment of distribution. At other sites, it is more cost-effective to distribute cultch as loose shell. The shell material used in these types of projects needs to be free of fine sediments and marine organisms and certified accordingly, usually via state departments of health or fish and wildlife. Restoration efforts in California have consisted primarily of habitat enhancement, while Oregon has seen a mix of seeding as well as habitat enhancement.

The substrate material used for habitat enhancement projects is most often clean, whole Pacific oyster shell for two reasons: 1) not enough native oyster shell is currently available to support large-scale enhancement; and 2) habitats that lack sufficient settlement substrates are generally very muddy, requiring materials that can remain emergent long enough to re-establish a self-sustaining bed. In Puget Sound, alternative cultch materials are being discussed to test additional modes of creating functional habitat.

It is important to note that prior to embarking on a native oyster restoration project, an assessment should be completed to determine whether the proposed site is habitat-limited, recruitment-limited, or both. That determination will help indicate the restoration methods that should be employed.

Intertidal vs. Subtidal Enhancement

Most seeding and habitat enhancement efforts to date have been conducted either in intertidal habitats or in functionally subtidal habitats where the tidal regime has been altered in a way that excludes predators and creates optimal conditions for Olympia oysters. Examples include artificial lagoons and pools with tide gates that restrict or control inflow and outflow. Very little is known about the subtidal limit of successful enhancement beyond anecdotal observations of mortality below –2' MLLW, mostly because it is more difficult to monitor subtidally. Two schools of thought have emerged regarding the intertidal vs. subtidal question. Some scientists have indicated that establishment of a significant subtidal population of Olympia oysters is key to maintaining their long-term viability. Periodic episodes of extreme hot or cold periods and desiccation can cause intertidal populations to be completely wiped out. These could be reestablished if there were nearby subtidal populations to replenish affected intertidal habitats (TNC 2006; original comment by Alan Trimble, U. Washington).

On the other hand, in Puget Sound, there is little historical evidence that Olympia oysters occurred subtidally in significant numbers or distribution (Brady Blake, WDFW, personal communication). Washington Department of Fish & Wildlife conducted subtidal oyster surveys in North Bay adjacent to the largest known intertidal population of Olympia oysters in Puget Sound and found no evidence of subtidal presence. WDFW will continue to conduct other subtidal surveys in the future to assess the tidal range of Olympia oyster populations in Washington State. The Nature Conservancy, NOAA, and the Puget Sound Restoration Fund (PSRF) are also experimenting with subtidal oyster enhancement at select sites.

Monitoring

Monitoring is an essential part of all restoration projects and consists of systematic data collection that indicates progress toward identified criteria, performance standards, and ecological goals. In recent years, the PSRF has embraced monitoring objectives that reflect the growing practice of native oyster restoration involving oyster habitat enhancement. Monitoring programs for these restoration projects often begin prior to the enhancement itself and are aimed at specific questions and objectives. Examples of these are assessing the restoration area for larval availability, larval retention, spat recruitment and post-settlement mortality. Prior to the enhancement, it is also important to document the pre-manipulation condition of the area through observations of habitat, community species and benthic conditions. Following the enhancement effort, the monitoring program would evolve to include measuring the efficacy of the enhancement material at providing emergent oyster settlement substrate, specific habitat parameters and community species, and for juvenile oyster recruitment, oyster density and growth.

There is a significant seasonal influence to many of the measurements collected during native oyster monitoring programs. Care should be taken to collect repeat measures during the same month each year. Most PSRF monitoring programs are focused on collecting information twice annually, before and after the reproductive season.

What's Next?

In recent years, an increasing number of *O. conchaphila* populations have been found throughout Puget Sound and in other West Coast estuaries. Although not as close to demise as once thought, native oysters are clearly much more limited in numbers and distribution than 200 years ago. NOAA continues to support restoration efforts and the restoration and scientific communities are gaining the necessary experience and momentum to re-build oyster populations to increased levels. Scientists are working to identify locally distinct populations and refine restoration techniques; and the public is becoming more aware of the important role that Olympia oysters play in the ecology of our bays and estuaries. The history of the Olympia oyster on the West Coast is rich and captivating – with many chapters yet to be told.

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