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West Coast
Native Oyster Restoration
Workshop Proceedings

September 16-17, 2010
Suquamish, WA

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West Coast Native Oyster Restoration: 2010 Workshop Proceedings

September 16-17, 2010
Suquamish, Washington

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Foreword

The 2010 West Coast Native Oyster Restoration Workshop united 55 people spanning eight tribes, three states, and our Canadian neighbors in a full-on, 2-day exchange of current practices and research priorities for native oyster restoration efforts on the West Coast. Our thanks to the Suquamish Tribe for hosting the 2010 West Coast Native Oyster Workshop and to the other co-sponsors of the event, including National Oceanic and Atmospheric Administration, The Nature Conservancy, and the National Fish and Wildlife Foundation.

The goal of the workshop was to renew contact among practitioners and produce tangible outcomes that would guide native oyster restoration efforts along the West Coast. In addition to discussing current restoration practices and tools, monitoring methodologies, research priorities and natural aggregations, the goal of the workshop was to draft 10-year restoration goals for California, Oregon, Washington and British Columbia.

Agencies, tribes, NGOs and researchers along the West Coast have been undertaking native oyster restoration projects for over a decade. The drive to rebuild the West Coast's only native oyster (*Ostrea lurida*) takes place within the context of regional ecosystem recovery efforts and a national effort led by The Nature Conservancy, NOAA and National Fish and Wildlife Foundation to identify ecologically-meaningful goals for restoration.

The first annual West Coast Native Oyster Restoration Workshop was held in 2006 in Marin, California. This was followed by a 2007 workshop in Shelton, Washington and the 2010 workshop in Suquamish, Washington. A community of close-knit practitioners has developed over the years to advance restoration of the West Coast's only native oyster. The workshops ensure that disparate efforts have occasion to cross fertilize. Research conducted in Oregon coastal estuaries is shared with Washington and California. Methods and materials tested in Washington provide a template for projects beginning in Southern California. Populations in British Columbia may help supply brood oysters for restoration efforts in North Puget Sound. Recent efforts to identify 10-year and 50-year goals help drive more targeted strategies and cost estimates for undertaking larger-scale restoration in specific estuaries.

Native oyster restoration is driven by an ecological imperative. Structured oyster beds provide filtration services and complex habitat vital to estuary function. Oysters sequester both carbon and nitrogen in ways that can compensate for human inputs. But as we work to increase the scale of native oyster restoration efforts we are keenly aware that human-generated carbon emissions are changing the systems we are trying to restore. Oceans absorb approximately 25 percent of all the carbon dioxide (CO_2) we emit, which changes ocean chemistry over time, making seawater more acidic. Calcium-dependent organisms (including shellfish) are vulnerable to acidic conditions. Studies conducted over the past several years show a clear correlation between low pH and larval mortality in shellfish hatcheries. Though biological responses in the real world are as yet unproven, we know that over the long-run, the viability of native oyster restoration will depend on natural larval settlement. And we can surmise that the viability of human communities, in turn, may depend on our ability to maintain healthy marine systems. Such is our connected world.

As we continue our work to re-establish an iconic native species, we are mindful that we humans would do well to emulate the ways of the lowly mollusk. Native oysters give food and shelter to other creatures. They filter and cleanse the surrounding water. They are connected to the world around them—ingesting what the incoming tide has to offer, spawning according to the phases of the moon, alert to a shifting of the wind. To be truly grounded in one's world is a good and worthy thing.

Betsy Peabody
Puget Sound Restoration Fund

Tribal Welcome

Leonard Forsman, Chair of the Suquamish Tribal Council, welcomed the group to the Suquamish Tribe's new community house, called "House of Awakening." The tribe has been an active partner in efforts to rebuild native oyster populations within its usual and accustomed fishing ground. Native oyster restoration is part of a cultural awakening that includes hosting and participating in an annual tribal canoe journey, building the community house and the memorial up the hill, and re-connecting tribal members to traditional food sources and ways of life.

Proceedings Structure

The presentations and discussions of the 2010 workshop are summarized here, organized by session. A summary precedes each set of session abstracts. At the end of the workshop, "breakout sessions" were held in an effort to merge ideas and examine the future of Olympia oyster restoration. State-by-state 10-year goals were the result of these sessions and are summarized at the end of the proceedings.

We extend our sincere appreciation to the participants and sponsors of the 2010 workshop, including the Suquamish Tribe, Puget Sound Restoration Fund, NOAA, The Nature Conservancy, National Fish and Wildlife Foundation, and all those who helped plan and support the workshop. Thank you!

Session: Restoration Updates

Restoration Updates - Session Summary

Session Contributors:
Dick Vander Schaaf, The Nature Conservancy
Christopher S. Eardley, Oregon State University
Chela Zabin, Smithsonian Environmental Restoration Center
Rena Obernolte, Environ International
Paul Dinnel, Western Washington University
Brian L. Allen, Puget Sound Restoration Fund

The workshop began with a session focusing on Olympia oyster restoration over the past several years and current work in the field. While some projects are ongoing, others are incorporating new methods or new locations. Key questions for new and existing projects include:

1. What is a sustainable size and density for restored Olympia oyster beds?
2. Is the goal to restore current oyster beds or develop priority areas for restoration?
3. To what degree do we want to maintain a site over the long-term?

Through these presentations we learned of several limitations to oyster restoration and how they affect projects in the field. These included disease, sedimentation, eutrophication, and overgrowth of non-native fouling species. While different, these limitations can be examined in order to find similarities between regions or sub-regions and improve restoration efforts.

With a goal of restoring self-sustaining Olympia oyster populations to a level that provides ecosystem services, Dick Vander Schaaf tested spawning and setting of Olympia oyster spat in a hatchery and planted 800 cultch bags in Netarts Bay, Oregon, in 2010. His findings included a better understanding of eelgrass-oyster interactions and the effects of high pCO_2 (carbon dioxide partial pressure) events on spawning and setting success. He also observed that hatchery propagated Olympia oysters appear more resilient to varied pCO_2 than non-native Pacific oysters. The major challenge faced in this project was a *Vibrio tubiashi* bacteria outbreak in bay waters in 2007, which led to pCO_2 spikes and effects on shellfish.

Chris Eardley's project entitled, "Identifying limitations and requirements of native Olympia oysters (*Ostrea lurida*) to advise restoration efforts in the Yaquina Bay Estuary, Oregon," sought to improve understanding of native oyster populations in Yaquina Bay estuary and evaluate the feasibility of future restoration efforts. At the time of the workshop, recruitment had occurred in multiple locations in Yaquina Bay and post-metamorphic oysters had survived with survival rates and growth variable by location. Sedimentation appeared to be the limiting factor for both recruitment and survival.

Chela Zabin presented a project on behalf of Kerstin Wasson entitled, "Factors limiting native oyster distribution in Elkhorn Slough, CA." Restoration of Olympia oysters at Elkhorn Slough is critical due to its location between the northern and southern California Olympia oyster populations. The project has tracked recruitment for 3 years and found high variability. Some of the limiting factors detected include poor water quality (low dissolved oxygen from little tidal

exchange), competition with non-native species for substrate, and lack of appropriate substrate for settlement.

In a separate project, Chela Zabin was able to identify patterns in recruitment by examining competition and temporal and spatial variation of Olympia oysters in Tomales and San Francisco Bays. Zabin found that subtidal areas may be better for oysters if food levels are low or heat stress is high, while higher intertidal areas may be better for oyster restoration in locations where cover of competitors is high. Limiting factors included competition and recruitment.

Rena Obernolte's restoration objectives were to enhance ecosystem function in San Francisco Bay by creating habitat for native oysters, as well as migrating salmonids, and increasing understanding of salmon smolt migration. The primary challenges faced in this project were lack of habitat and community diversity. Project partners were able to construct two of the largest oyster reefs in San Francisco Bay, create benefits to salmonids, increase species diversity, and observe use of the habitat as nursery grounds.

Between 2008 and 2010, following several years of restoration activity, Paul Dinnel placed shell recruitment bags all along the shoreline of Fidalgo Bay, Washington, in an effort to document natural recruitment. Shell bags were planted in three different plots in the bay. In 2010, when the bags were recovered, heavy recruitment was observed, indicating successful spawning of the restored population.

In his restoration project entitled "Community level effects monitoring on stock restoration enhancements for *Ostrea lurida* on a structure limited beach in Puget Sound, Washington," Brian Allen examined the temporal gradient and sampled emergent substrate and epibenthic and benthic fauna. This project was located in Liberty Bay, Washington, where water quality issues have had a dramatic effect on shellfish harvest in past years. New sampling methods led to a substantial increase in sampling efficiency. These methods included reduced sample unit, the collection of emergent material samples in the field, and off-site data collection.

Perhaps the greatest lesson learned through past and current projects is the importance of community involvement. All projects presented in this session have had some level of community support whether it was financial or on-the-ground work. This aspect of a restoration project is invaluable in terms of generating program support, educating the public, and ensuring long-term success. There is no doubt that the people of a community, large or small, play an integral role in the recovery of the Olympia oyster.

Olympia oyster restoration challenges in Netarts Bay, Oregon

Dick Vander Schaaf - The Nature Conservancy

Restoration of the Olympia oyster (*Ostrea lurida*) in Netarts Bay, Oregon, has been challenged by several water-borne factors in recent years. In 2007-2008 an unusually strong and long lasting *Vibrio tubiashii* outbreak was initially blamed for recruitment and hatchery failures of all oyster larvae. The following years saw less of an influence on oyster larvae by *Vibrio* but a possibly even greater impact by low pH coastal waters that surged into the Bay. Prior to these events, restoration was beginning to post some successful results, was embraced by the local community and was being initiated at other sites in Oregon. The *Vibrio* outbreak directly impacted the commercial shellfish hatchery in Netarts Bay that has been used for 6 years to spawn and set Olympia oysters for the NOAA/TNC funded restoration project in the Bay. The causes of the outbreak are unknown but they now appear to be linked to a series of events that involved seasonal upwelling of deep oceanic waters that have certain characteristics. These include low oxygen, high salinity, high pCO2 and abundant nutrients. Strong upwelling events have been linked to climate change and are being implicated in the hypoxia zone offshore of the Oregon coast. It appears that the Olympia oyster is somewhat more resistant to high pCO2 values than non-native Pacific oysters. Adaptive restoration strategies may include modifying planting times for Olympia oysters and locating restoration activities in Netarts to sites that are less influenced by regular tidal flushing.

Presentation (PDF)

Identifying limitations and requirements of native Olympia oysters (*Ostrea lurida*) to advise restoration efforts in the Yaquina Bay Estuary, Oregon

Christopher Eardley - College of Oceanic and Atmospheric Sciences, Oregon State University
Dick Vander Schaaf - The Nature Conservancy
Matthew Gray - Coastal Oregon Marine Experiment Station, Hatfield Marine Science Center
Caleb Price - College of Oceanic and Atmospheric Sciences, Oregon State University
Presented by Christopher Eardley

Olympia or "Native" oysters (*Ostrea lurida*) were once abundant in estuaries throughout the Pacific Northwest. Over-exploitation, poor water quality, and habitat degradation are principle causes for a massive decline in native oyster abundance on the West Coast in the late 1800s through the mid-20th century. Despite negligible harvests and efforts to assist in native oyster recovery, *O. lurida* has not regained its former abundance.

Currently, restoration activities for *O. lurida* are taking place throughout Washington, Oregon and California. Evaluating existing populations, recruitment, and survivorship of *O. lurida* in Yaquina Bay will promote better understanding of habitat quality in this estuary, the status of this species locally and in Oregon, as well as help determine where regional restoration efforts should be focused.

In this study, we examined the recruitment rates and post-recruitment survival of *O. lurida* in various areas of the Yaquina Bay estuary. Our goal was to provide a baseline assessment of native oysters in this estuary and to evaluate if future restoration efforts are feasible and warranted. Additionally, we investigated recruitment and survival of recent recruits in Netarts Bay, Oregon, a location where *O. lurida* recruitment appears to be lacking despite six years of restoration efforts by the Nature Conservancy. Together, these efforts seek to help inform efficient future restoration efforts in these historic home bays of the Olympia oyster.

Presentation (PDF)

Factors limiting native oyster distribution in Elkhorn Slough, CA

Chela Zabin - Smithsonian Environmental Research Center & University of California, Davis
Kerstin Wasson - Elkhorn Slough National Estuarine Research Reserve
Presented by Chela Zabin

At Elkhorn Slough in Central California only about 5,000 Olympia oysters remain, and recruitment is near zero in some years, so this population is in danger of going locally extinct, which would have negative consequences for connectivity between northern and southern California populations. Oysters are absent from highly eutrophic sites, and appear to be excluded from lower intertidal and subtidal elevations by overgrowth of non-native fouling species. At sites with firm sediments, they grow on small natural bits of substrate (shells, gravel) and are thus not substrate limited, but at sites with muddy sediments, they only survive on larger artificial substrates (rip rap, pilings, etc.). So substrate limitation and sedimentation are inextricably linked. Recent restoration experiments are deploying native clamshells in modular, mobile reefs whose vertical and lateral position on the shore can be easily adjusted to optimize oyster recruitment and growth and minimize overgrowth by non-native fouling species.

Presentation (PDF)

Temporal and spatial variation in recruitment and the effects of competition in Tomales and San Francisco bays: lessons for restoration

Chela Zabin - Smithsonian Environmental Research Center & University of California, Davis
Anna Deck - University of California, Davis
Sarikka Attoe - University of California, Davis & Oregon State University
Caitlin Hulbert - University of California, Davis & San Francisco Bay National Estuarine Research Reserve
Brian Cheng - University of California, Davis
Edwin Grosholz - University of California, Davis
Presented by Chela Zabin

To date, native oyster restoration efforts in San Francisco and Tomales bays have relied solely on the provision of hard substrate as a means of increasing populations. Studies of recruitment dynamics over time, across potential restoration site locations, and at different tidal depths are essential to planning and evaluating the success of restoration efforts. In both bays, non-native fouling species may compete with native oysters on deployed substrate, potentially limiting recruitment and growth. Here we present the results of parallel studies in San Francisco and Tomales bays examining recruitment and growth over several years, at multiple sites and tidal depths, and with and without removal of other sessile organisms. Recruitment varied between years, more drastically so in Tomales Bay, and across sites and tidal heights. There was a trend toward lower recruitment and smaller recruit size when space competitors were allowed to settle, but this varied with site and tidal height. At least part of the explanation of this variability is likely the result of differences in the abundance and identity of other sessile organisms. Site-specific differences in numbers of recruits and in growth are also likely the result of other factors, such as water retention time, differences in abundance of food, and presence or absence of predators. These factors have been better studied in Tomales Bay, but information critical to restoration is still lacking in both locations. We discuss recommendations for further research, as well as for protection and enhancement of native oyster populations.

Presentation (PDF)

Native oyster and salmonid habitat restoration projects in San Francisco Bay

Rena Obernolte - Environ International

Two ¼ acre reefs have been constructed in San Francisco Bay to provide habitat for native oysters and foraging habitat for salmonid smolts. The reefs are community-based restoration projects that include education and outreach components. Both reefs are constructed of bagged Pacific oyster cultch and materials dredged from the Bay that are formed into concrete reef balls. Each site consists of areas with oyster reefs alone, areas planted with eelgrass alone, oyster reefs with eelgrass in between reefs and an equal sized area of open mudflats is used as an experimental control. The first site was constructed in 2008 and the second site was constructed in June 2010. Monitoring included water quality, utilization of Tuffy Pad amphipod collectors, bait fish traps, and Plexiglas Breeder traps. In addition, Vemco VR2W 69 KHz acoustic receivers were installed to detect acoustically tagged salmon, steelhead, green sturgeon, and sharks. Data collected by the acoustic receivers indicates salmonid smolts tend to linger in the reef area in contrast to steady movement through the control area. Preliminary results suggest that there is a greater diversity of fish and crustacean species in reef study site vs. the control site, with the study site being used as nursery grounds for several species.

Presentation (PDF)

Restoration of native oysters, *Ostrea lurida*, in Fidalgo Bay, Washington

Paul Dinnel - Western Washington University & Skagit County Marine Resources Committee

Skagit County Marine Resources Committee (Skagit MRC), working in cooperation with shellfish industry, tribal, and community partners, initiated a project to establish several native oyster beds in Fidalgo Bay near Anacortes, Washington. The project goal is creation of one or more self-sustaining native oyster beds. Thus, oysters on these beds must survive, grow, spawn and produce larvae that recruit to the beds and surrounding areas. Native oyster seed on Pacific oyster cultch were planted in Fidalgo Bay during 2002, 2003, 2004 and 2006. Survival and growth of planted seed has been excellent at one site (Trestle Site), but poor at a second location. With the addition of seed on cultch during four years and augmentation of the Trestle Site with five cubic yards of Pacific oyster shell in 2006, a structured oyster bed has been gradually emerging. Deployment of temperature sensors in 2006 showed that water temperatures easily reached the minimum temperature for gameteogenesis and spawning. Analyses of Pacific oyster shell cultch bags has shown that successful spawning and post larval recruitment has occurred in three of seven years since 2003, with a strong recruitment pulse in 2009. Several new sites within and around Fidalgo Bay are being evaluated for future restoration efforts.

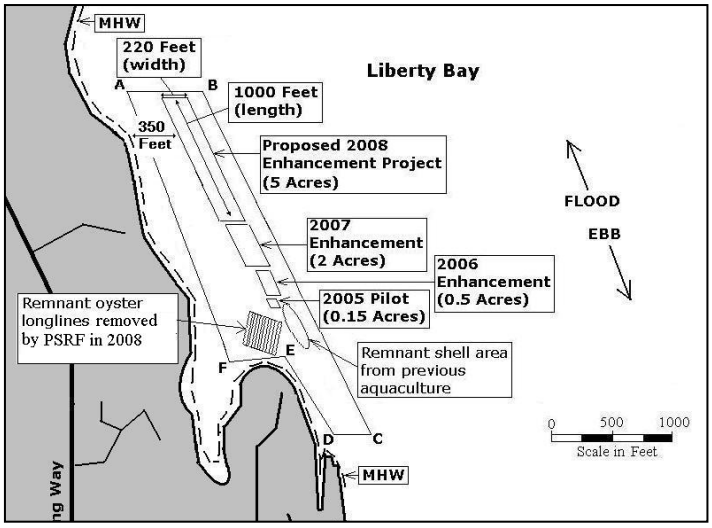
Presentation (PDF)

Community effects monitoring on restoration enhancements for *Ostrea lurida* on a structure-limited beach in Puget Sound, Washington

Jonathan P. Davis, Jordan Watson, Brian L. Allen, Annemarie K. Ansley - Puget Sound Restoration Fund
Presented by Brian Allen

A prime rationale for native oyster enhancement efforts in Washington State is the development of habitat types that may then be of benefit to native fishes, including salmonids, mobile invertebrates and decapod crustaceans. Habitat that increases overall complex structure likely increases the overall quantity and variety of microstructure. Enhanced habitat microstructure may be described as an increase in hard substrate area available for settlement, increased availability of edge or crevice habitat, increased variability in habitat with sediment accretional or depositional characteristics that are dependent on boundary layer flow characteristics that themselves vary on spatial and temporal scales. These features serve to increase the variety and amount of habitat suitable for small, epibenthic and infaunal animals to utilize for shelter or foraging.

In 2009, we specified a number of monitoring objectives for previous oyster habitat enhancements that included an evaluation of benthic conditions both before and following our manipulations. Shell enhancements were conducted over four consecutive years on an unstructured mudflat in Liberty Bay, Puget Sound.



The monitoring results and analysis presented here comes from the ongoing monitoring of temperature, larval retention, epibenthic meiofauna, benthic infauna, macro invertebrates and settlement by *Ostrea lurida*. The "condition" of the emergent shell is another important aspect of the enhancement, monitored to assess the application of this practice for stock recovery and to observe the community effect of shell enhancement.

Presentation (PDF)

Session: RESTORATION TOOLS

Restoration Tools – Session Summary

Session Contributors:
David Stick, Oregon State University
Brent Vadopalas, University of Washington
Nate Wight, Puget Sound Restoration Fund
Steve Rumrill, South Slough National Estuarine Research Reserve

While Olympia oyster restoration efforts proceed with varying levels of success, this session covers ongoing projects dedicated to the study of genetic analysis, hatchery-reared Olympia oysters, or factors that may be preventing population recovery. The primary purpose of this session was to discuss building blocks that can benefit other research and restoration efforts in order to improve effectiveness.

David Stick conducted an oyster genetics project entitled "Genetic structure among remnant populations of the threatened Olympia oyster (*Ostrea lurida*) at two spatial scales." He sampled almost 3,000 Olympia oysters from 40 locations between the northern tip of Vancouver Island, British Columbia, southward to Elkhorn Slough, California. The results of this study provide evidence that genetic structure exists at two scales for the Olympia oyster, between major geographical regions and within the larger, more complex Puget Sound and San Francisco Bay systems.

Brent Vadopalas presented on a collaborative effort between the Puget Sound Restoration Fund and The Nature Conservancy to rebuild a "core population" of Olympia oysters in Budd Inlet, located in south Puget Sound, Washington. Their goal was to mimic genetic diversity within the region using synthetic lines of Olympia oyster juveniles in order to restore effective populations of this species.

In his study "Hatchery propagation of restoration-grade Olympia oyster (*Ostrea lurida*) seed," Nate Wight set out to maximize genetic diversity of Olympia oyster seeded populations. Using broodstock from six embayments in south Puget Sound, Washington, this project was an approach to reestablishing oysters by means of hatchery production and outplanting of juveniles. Intensive hatchery propagation methods were utilized to ensure genetic diversity prior to outplanting in Budd Inlet.

Steve Rumrill presented on a joint project between the South Slough National Estuarine Research Reserve and the Oregon Department of Fish and Wildlife. This program focused on reproduction and larval ecology as essential factors in the recovery of Olympia oysters. Several hundred bags of Olympia oyster spat were transported into a grow-out area within the South Slough, Oregon. In addition, larval collector bags were deployed annually in Coos Bay, Oregon. Over time, genetic enhancement in small-scale experimental oyster restoration plots will be used to guide larger-scale oyster restoration efforts in South Slough and Coos Bay.

The information presented in this session will be useful to individuals designing future restoration projects and monitoring ongoing efforts. By identifying limiting factors and sharing information, practitioners up and down the West Coast can improve practices and focus on projects with the greatest promise.

Analyses of genetic structure within and among remnant populations of the Olympia oyster, *Ostrea lurida*

David A. Stick, Chris Langdon, Michael A. Banks, Mark D. Camara - Oregon State University
Presented by David Stick

The Olympia oyster, *Ostrea lurida* Carpenter 1864, is the only oyster species native to the United States Pacific Northwest. Historically, this species existed in densities capable of supporting both tribal subsistence fisheries and large commercial harvest operations throughout its range. Over-exploitation, habitat degradation, and competition and predation from non-native species have drastically depleted these densities and extirpated many local populations. Ecological benefits provided by oyster reef habitats and the species' historical significance has fueled numerous restoration/supplementation efforts of the Olympia oyster. However, these efforts are proceeding without a clear understanding of existing genetic structure among extant populations, which could be substantial as a consequence of limited dispersal and/or anthropogenic impacts resulting in localized genetic bottlenecks or population admixture due to historical commercial practices.

We developed and used eight *O. lurida* microsatellite DNA markers to investigate genetic differentiation among and within eight major geographical regions of the species' original range. A hierarchical Analysis of Molecular Variance revealed that 72% of the total molecular genetic variation is among the eight regions (F_{st}=0.017408, $p<0.01$). Sub-analyses of the genetic structure within Puget Sound and San Francisco Bay also found significant differentiation among sampled populations within these regions.

This research supports the hypothesis that there is currently limited gene flow among regions and among certain geographically separated Olympia oyster populations within those regions. An important implication of these data is that ongoing restoration efforts using hatchery-propagated oysters to supplement extant populations can both purposefully and inadvertently alter the genetic composition of recipient populations.

Presentation (PDF)

Conservation genetics protocol for Olympia oyster restoration using hatchery methods

Brent Vadopalas - School of Aquatic and Fishery Sciences, University of Washington
Jonathan P. Davis, Brian L. Allen, Nate Wight - Puget Sound Restoration Fund
Brady Blake - Washington Department of Fish and Wildlife
Presented by Brent Vadopalas

Native oyster reefs have declined in abundance worldwide (Beck et al. 2009) and together with oyster fisheries have generally suffered from over-exploitation, pollution from human activities and loss of habitat (Brooks 1891; MacKenzie and Burrell 1997; Goulletquer and Heral 1997). At the same time there is increased recognition of the importance of reef or bed-forming bivalves that create habitat for other species in addition to important ecosystem services that large populations can provide. Olympia oysters (*Ostrea lurida*) in Washington State were formally abundant, with large beds of native oysters in both Willapa Bay and Puget Sound.

The scope of native oyster restoration activities in Puget Sound has expanded of late to include the perspectives of community ecology and conservation genetics to guide project development. In the interest of "doing no harm," recent restoration actions have relied on limited natural production, which also restricts stock rebuilding activities to water bodies with large, effective populations. Budd Inlet, in southern Puget Sound, historically hosted effective populations over large spatial scales at the head of the Inlet, what we refer to as a "core population," which has been extirpated locally.

In 2010, Puget Sound Restoration Fund began a project in Budd Inlet with The Nature Conservancy and other partners intended to rebuild a "core population" of Olympia oysters. Discussed here is the ongoing collaborative effort to mimic sub-regional genetic diversity with synthetic lines of Olympia oyster juveniles produced with our conservation genetics protocol. We are interested in the feasibility of utilizing synthetic lines, produced from sub-regional broodstock, as an option for restoration of effective populations.

Presentation (PDF)

Hatchery propagation of restoration-grade Olympia oyster (*Ostrea lurida*) seed

Nate Wight - Taylor Shellfish & Puget Sound Restoration Fund

There is increased interest in restoring Olympia oysters (*Ostrea lurida*) in parts of their native habitat where populations have either been reduced or are absent compared to their historical abundance. The goal of this study was to evaluate an approach to reestablishing oysters by means of hatchery production and outplanting of juveniles. The overarching goal is to maximize the genetic contribution of individuals selected for broodstock to therefore maximize the genetic diversity of seeded populations. Due to the larval brooding life history of Olympia oysters we could not utilize single pair matings. Therefore we used a partial factorial mating matrix composed of broodstock from six embayments in southern Puget Sound. In May 2010 broodstock oysters from each of six southern Puget Sound embayments were collected and combined into 24 single spawn groups of approximately 25 oysters. Broodstock oysters were maintained in flow-through 19L tanks over a 5 week period of spawning, fertilization, and brooding of larvae. Oyster larvae were captured on 100µm screens as they were released from females. Larvae were reared in 100L tanks and competent larvae were settled on to micro-cultch in downwellers to grow to seed. At each step the progeny from each of the 24 spawn groups were reared and maintained separately. Once the juvenile oysters were above 4mm in size they were moved to seed cylinders to await transfer to the field for further growth and overwintering.

Presentation (PDF)

Reproduction and larval ecology as essential factors in recovery of Olympia oysters (*Ostrea lurida*) in Coos Bay and the South Slough Estuary, Oregon

Steven S. Rumrill - South Slough National Estuarine Research Reserve
Scott Groth - Oregon Department of Fish and Wildlife, Marine Resources Program
Hans Klausner - South Slough National Estuarine Research Reserve

Olympia oysters (*Ostrea lurida*) became locally extinct in Coos Bay (OR) prior to written history in response to a combination of coastal fires, input of fine sediments, burial, and perhaps a large-scale tsunami. Small populations of *O. lurida* were re-established in Coos Bay in the 1950s when they were inadvertently re-introduced as hitch-hikers during commercial transport of Pacific oysters (*Crassostrea gigas*) from Willapa Bay, WA. However, it is likely that basin-wide re-colonization of *O. lurida* has been hampered by several limiting factors including habitat loss and alteration, dredging, decreased availability of shell substrata, diminished recruitment, predation, competition, and ecological interactions with native and non-native species. South Slough National Estuarine Research Reserve and the Oregon Department of Fish and Wildlife recently initiated a program to investigate factors that hamper population recovery, and to re-establish populations at several sites in Coos Bay and the South Slough. About 500 bags of Olympia oyster spat (produced by the Whiskey Creek Shellfish Hatchery) have been transported into a grow-out area within the South Slough. In addition, larval collector bags are deployed annually near the confluence of Isthmus Slough and Coalbank Slough (Coos Bay), and the natural recruits are also transported into South Slough. Larvae of *O. lurida* frequently settle on the shells of living Pacific oysters which are cultured extensively throughout the Coos Bay tideflats. Although the Pacific oysters are conducive to larval settlement and adult growth, harvests of *C. gigas* after 2-3 years may be an important source of incidental mortality for Olympia oysters.

Presentation (PDF)

Session: Population Surveys and Assessments

Population Surveys and Assessments – Session Summary

Session Contributors:
Brian Allen, Puget Sound Restoration Fund
Tammy Norgard, Department of Fisheries and Oceans, Canada
Brady Blake, Washington State Department of Fish and Wildlife

Discovering the dynamics of a healthy Olympia oyster population is of paramount importance in order to move forward with restoration. However, intact populations are becoming increasingly rare and are often located in remote areas. This session put the spotlight on natural, robust aggregations of Olympia oysters and sought to identify characteristics of natural beds that can be used to guide future restoration projects.

Brian Allen presented on 2008 and 2009 expeditions to Esperanza Inlet, Vancouver Island, in British Columbia. The first trip was a scoping trip to observe habitats and do preliminary assessment of the native Olympia oyster populations. The second trip focused on gathering quantitative data on the populations. Both trips were driven by the need to improve our understanding of natural native oyster beds (location, physical size and structure, population estimates, and habitat characteristics). Samples collected at one of the beaches in Port Eliza revealed a mean oyster density of over 600 oysters/m^2.

Tammy Norgard's presentation on "Current work on Olympia oysters in Canada" entailed exploratory surveys on 135 beaches in southern British Columbia in 2009 and 2010. This project was composed primarily of field verification of locations that were historically reported and identifying undocumented locations, developing survey protocols, and determining long-term research index sites. Results varied greatly, ranging from extensive Olympia oyster populations in some areas to no oysters in others. Historical knowledge of Olympia oyster populations also fluctuated depending on the location.

Brady Blake gave an overview of the current status of Olympia oyster populations in Puget Sound, Washington, as well as potential next steps for restoration. Lessons learned in this presentation include the frequency of Olympia oyster encounters in Puget Sound as well as the nature and characteristics of these sparse aggregations. He also addressed common challenges to oyster restoration, including tideland ownership, habitat alterations, resource availability and simple lack of recognition of the species. Several bays in North Puget Sound, including Samish Bay, Padilla Bay, Fidalgo Bay, and Chuckanut Bay, may provide opportunities for restoration in the future.

A common theme throughout these presentations is the call for continued data collection on natural oyster beds. Using these data to determine the ecological function of native oyster beds will provide invaluable knowledge in the following areas:

- Trophic dynamics
- Provision of habitat
- Fluxes of materials/nutrients

- Structural characteristics
- Oyster density and growth
- Spatial extent of beds
- Recruitment dynamics
- Vertical structure

Replicating these studies at a variety of sites and scales will help quantify the functions and services of Olympia oyster beds.

Structure and characterizations for robust populations of *Ostrea lurida* on Vancouver Island, B.C.'s West Coast

Brian L. Allen, Jonathan P. Davis - Puget Sound Restoration Fund
Presented by Brian Allen

A sizeable portion of our work in the Puget Sound is directed at stock recovery for the native Olympia oyster, *Ostrea lurida*. Our current practices include a focus on community ecology and efforts to understand the function of complex intertidal habitat like that found in a native oyster bed. As we learn more about the contemporary habitat requirements for these oysters, we have adapted our restoration practices. Our efforts include observing natural beds of native oysters whenever possible. By making assessments of these natural aggregations using the same measures we apply to our enhancement projects, we are able to compare our enhancements to the empirical microhabitat, community and population structure we find in a natural bed. One problem we face in Washington State, where the historic stocks of oysters were harvested in the early 20th century, is that we lack any sizeable examples in nature of undisturbed and sustained beds of native oysters.

Upon learning of robust *O. lurida* beds near Espiranza Inlet, on Vancouver Island, B.C.'s west coast, the Puget Sound Restoration Fund and the Centre for Shellfish Research organized expeditions in 2008 and 2009 to find what we could learn from such populations. Our 2008 visit found beds of millions of oysters, where we characterized habitat and community fauna, and collected descriptive population statistics to represent relatively undisturbed and stable oyster beds. Tagged oysters were also deployed for growth trials.

In 2009 we returned to collect a suite of community and population data, employing GIS survey technology to incorporate microhabitat in a spatial analysis matrix. Tissue samples from separate year-class cohorts were collected to examine the stock structure within the water body. We will present the results and analysis of these collaborative efforts to describe these populations.

Presentation (PDF)

Current work on Olympia oysters in Canada

Tammy Norgard, Graham Gillespie and Sean MacConnachie - Department of Fisheries and Oceans, Canada
Presented by Tammy Norgard

Olympia oysters (*Ostrea lurida)* were harvested commercially from the late 1880's to 1930 when stock decline and shift in market preference ended the fishery in Canada. In 2000 they were designated as a species of special concern by the Committee on the Status of Endangered Wildlife in Canada and listed under the Canadian Species at Risk Act in 2003. Fisheries and Oceans Canada completed a Management Plan for Olympia oysters in 2009. This plan listed a number of management actions including protection of sites, zero harvest, informing the habitat referral process, mitigation of aquaculture impacts and invasive species impacts and community outreach. Research actions were also identified. These included development of survey protocols to measure relative population abundance, undertake surveys to document current species distribution, establishment of index sites for surveys every 5 years, habitat restoration, and the collection of samples for disease and genetics studies. In 2009 and 2010 investigators visited over 100 beaches in British Columbia surveying for the presence (live individuals and/or shells) of Olympia oysters. Olympia oysters were documented at over 75% of locations examined. In 2009 a survey protocol for Olympia oyster was developed. In 2010 investigators selected 13 representative index sites for long-term studies of which nine were surveyed.

Presentation (PDF)

The Olympia oyster (*Ostrea lurida*) in Puget Sound: lessons learned and the next steps for stock rebuilding

Brady Blake – Washington Department of Fish and Wildlife, Point Whitney Shellfish Lab

The Puget Sound occurrences of the Olympia oyster in oyster rich, large two-dimensional structured habitats, commonly referred to as beds, are primarily composed of relict shell and generations of living oysters. They have been greatly reduced, with an estimated 4% remaining of what historically existed (*ca* 1849). While the more recent focus on habitat enhancement or re-establishment through placement of oyster shell has shown excellent promise, it is recognized that native oyster rebuilding is unlikely to occur in portions of Puget Sound unless use of hatchery seed is included in the restoration tool box. Lessons learned over the past decade and an example of a proposed next step for native oyster restoration in Puget Sound along with roadblocks are presented to guide planning of future efforts.

Presentation (PDF)

Session: 10-Year Goal Setting

10-Year Goal Setting – Session Summary

Session Contributors:
Rob Brumbaugh, The Nature Conservancy
Marilyn Latta, California State Coastal Conservancy

The final session of the West Coast Native Oyster Restoration Workshop examined priorities and set forth goals. Given the major decline of oyster populations worldwide, the shared goal for West Coast efforts is to restore ecosystem services gained from oyster habitats and ensure long-term success. The two presenters in this session, Rob Brumbaugh and Marilyn Latta, provided a framework for the discussion.

The Nature Conservancy project, "Development of national-scale oyster reef restoration goals," seeks to develop a set of national restoration goals for oyster habitat that will work toward ecologically meaningful services and ensure long-term viability of management measures. Rob Brumbaugh described the details of this endeavor. With an ecosystem services approach, Brumbaugh encouraged restoration practitioners to ask the right questions and determine just how much oyster habitat is "enough" to accomplish our goals. Chesapeake Bay, Maryland, and Galveston Bay, Texas, were both used as oyster restoration examples and anticipated outcomes were also addressed.

Marilyn Latta presented on 50-year native oyster restoration goals in San Francisco Bay, California. This project focuses on restoring the sub-tidal habitats of the bay and their ecosystem services through a "precautionary adaptive management" approach. Latta defined three sets of goals for this project. Science goals seek information needed to improve protection and restoration, protection goals are based on the precautionary approach to protect habitat while data is gathered, and restoration goals focus on information from consultant reports and quantifiable and regionally specific targets. A five-phased restoration approach was then explained, which covers a basic site survey in phase one to a larger (one acre or more) restoration project in phase five.

Both of these planning efforts provide management measures that offer guidance for small and large restoration projects alike. However, scaling up to a region such as the Gulf Coast or Pacific Coast and then to the national scale suggests a new, larger context for restoration and new constituents for oyster habitat protection and restoration. Working at the national and regional scale would help create a long-term restoration plan, which would considerably improve the fate of the Olympia oyster.

As previously stated, the aim of the 2010 workshop was to create 10-year restoration goals for California, Oregon, Washington and British Columbia. Immediately following these final two presentations, workshop participants from each region gathered to discuss 10-year restoration goals. These goals are summarized in the section entitled, "State-by-State 10-year goals." The next step is to refine these goals with additional stakeholders and restoration practitioners.

Development of national-scale oyster reef restoration goals

Robert D. Brumbaugh – The Nature Conservancy Global Marine Team
Mark Spalding - The Nature Conservancy Global Marine Team and Conservation Science Group
Philine zu Ermgassen - Aquatic Ecology Group, Department of Zoology, University of Cambridge
Presented by Rob Brumbaugh

Oyster reefs are the most imperiled marine habitat on Earth, with a staggering 85% loss in just the past two centuries. A paradigm shift in the way we manage these critical coastal ecosystems is needed to ensure that they are restored and managed to sustain both human and ecological communities. Establishing restoration objectives that incorporate the full array of ecosystem services provided by oyster reefs could provide a much needed impetus for reversing course and maintaining these vital habitats. Ultimately, this is an important step toward creating a national-scale initiative for improving an important ecosystem that is, at present, significantly degraded and at continued risk of degradation or extirpation throughout the United States. With support from NFWF and NOAA, The Nature Conservancy and an external team of advisors is assembling data on the historic and recent spatial extent of reefs, oyster density and size distributions that, in turn, will be used to help estimate ecosystem services on an aerial basis (specifically water filtration, denitrification and fish production). Providing a framework for comparing past, present and potential future levels of services delivered through enhanced conservation and restoration will hopefully ensure that (1) shellfish ecosystems are restored to levels that deliver ecologically meaningful services such as filtration, denitrification, fish habitat and shoreline protection as well as shellfish fishery returns, and (2) that management measures are in place to ensure their long-term viability and ecological relevance of oyster reefs in the nation's estuaries.

Presentation (PDF)

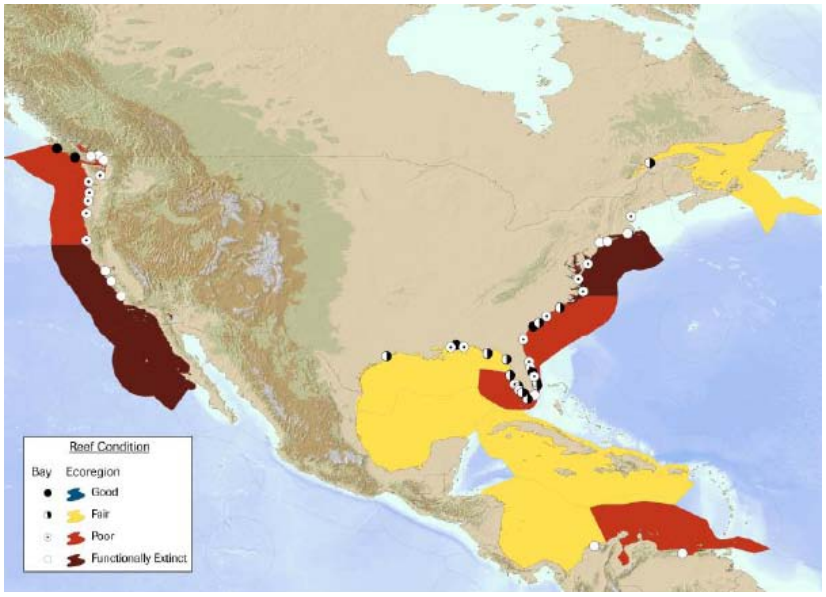
PROJECT SUMMARY

Development of national-scale oyster reef restoration goals

The Nature Conservancy, with input from scientists, restoration practitioners, managers and other partners, is working to develop a set of estuary-specific and ecoregional-scale restoration goals for oyster reef habitat in the United States. These goals will inform the Conservancy and others about the magnitude and geographic distribution of restoration that is needed to ensure the long term persistence of a globally imperiled marine habitat.

Oyster reefs have declined dramatically in most U.S. coastal bays over the past two centuries, and in some locations these declines are nothing short of catastrophic. Even more troubling, findings from a TNC-led global analysis of condition of oyster reefs suggest that they are likely the most imperiled type o f marine habitat on earth. Globally, the loss of oyster reef habitat is estimated to be 85%, making them the most degraded and, by extension, most imperiled type of marine ecosystem on earth, surpassing coral reefs (20% loss), mangroves and marshes (50%) and sea grass (30%) in the magnitude and geographic extent of loss. In this global analysis, the following conventions were used to describe the condition of shellfish ecosystems at ecoregional scales:

- ***Functionally Extinct*:** functional shellfish reefs and beds are essentially absent from the ecoregion (< 1% of historic area of shellfish ecosystems remaining). Although there may be remnant populations, the structure and function of these as ecosystems is negligible.
- ***Poor Condition*:** 1 – 10% of functional shellfish reefs or beds remaining in the ecoregion, and are at densities that provide some measure of ecosystem services.
- ***Fair Condition*:** 11- 50% of functional shellfish reefs or beds remaining in the ecoregion, and are at densities that provide some measure of ecosystem services.
- ***Good Condition*:** > 50% of functional shellfish reefs or beds remaining in the ecoregion, and are at densities that provide some measure of ecosystem services.



North America and Caribbean Ecoregional Estimates of Condition

Restoration as a Priority Conservation Strategy

The Nature Conservancy (TNC) and the National Oceanic and Atmospheric Administration (NOAA) have since 2001 been engaged in a National Partnership to restore marine, estuarine and coastal river habitats throughout the United States. To date, more than 95 community-based restoration projects have been funded in 20 states, and many of these projects involve restoration of native oyster reefs. This particular emphasis on oyster reefs stems from a recognition that the large size and great historic abundance of oysters not only supported commercial and recreational fisheries of great cultural significance, but also enabled their role as critical 'ecosystem engineers'[1]. In this role, they likely control water quality and structurally are the temperate equivalent of tropical coral reefs, providing shelter for myriad other species and protecting shorelines from erosive effects of waves and rising sea level. The profound ecological importance of shellfish, not surprisingly, typically results in their selection as conservation targets in Marine Ecoregional Assessments (ERAs) and Conservation Action Plans (CAPs) prepared by TNC and its partners. Progress is being made to restore reefs on small scales and medium scales (e.g. several NOAA Recovery Act projects focus on larger-scale oyster reef restoration), but to restore oyster reefs to functional relevance will require a comprehensive set of goals for the estuaries and ecoregions of the U.S.

[1] The term 'ecosystem engineer' was coined by Jones et al (1994) to describe organisms that modify their physical, chemical or biological environment in ways that support other organisms. Oysters, for example, form three-dimensional reefs or complex beds that many other species use as nesting or foraging habitat. The shellfish included in this report filter substantial volumes of water as they feed on algae and other particulate matter, clarifying the ambient water and cycling nutrients to enable the growth of nearby seagrasses.

Long-term objectives: This project will set the stage for a national-scale strategy for improving an ecosystem that is, at present, significantly degraded and at continued risk of degradation toward ecologically relevant conservation status throughout the United States. TNC and partners will use the restoration goals created through this project to develop a national strategy for shellfish conservation and restoration to ensure that (1) shellfish ecosystems are restored to levels that deliver ecologically meaningful services such as filtration, fish habitat, shoreline protection as well as shellfish fishery returns, and (2) that management measures are in place to ensure their long-term viability and ecological relevance in the nation's estuaries.

Project Outcomes: This project will begin to address threats to oyster reefs by developing restoration and conservation goals for 8 marine ecoregions bounding the Continental U.S., through a process that is both science-based and engages a broad array of stakeholders. This will better ensure support for development of longer-term and appropriately scaled streams of restoration funding and action at multiple scales – from local to regional to national. Ultimately, this project is designed to achieve the following measurable results:

1) We will develop bay-specific estimates of reef loss based on historic and current estimates of abundance (area) and produce maps that help to illustrate the current condition at national and ecoregional scales.

2) will convene a team of external scientists to help us test the assumption that 10% of historic size/abundance is sufficient for maintaining viable populations and use our findings to recommend appropriate minimum conservation and management goals for maintaining oyster reef viability within U.S. estuaries. The science team will include members of TNC's global shellfish assessment team to help provide continuity with that effort and to capitalize on their familiarity with relevant data that will help to underpin this project.

3) We will work with the science team to develop ecologically-based conservation and restoration goals that meet both viability *and* ecological functionality criteria (e.g., sufficient water filtration, nutrient removal, fish production).

4) We will conduct outreach through professional forums (e.g., National Shellfisheries Association, International Conferences on Shellfish Restoration, Interstate Shellfish Sanitation Conference) to engage the most relevant management stakeholders (fisheries managers, marine habitat and water quality managers, shellfish sanitation programs) to encourage implementation of larger scale conservation and restoration projects designed for ecological relevance.

San Francisco Bay subtidal habitat goals project: setting 50-year restoration goals for native oysters amidst multiple data gaps

Marilyn Latta – California State Coastal Conservancy

The San Francisco Bay Subtidal Habitat Goals Project is an interagency, collaborative, regional planning effort to establish a comprehensive and long-term vision for research, restoration and protection of subtidal habitats of the San Francisco Bay. The Draft 50-Year Plan released in June 2010 is non-regulatory and was developed by four lead partner agencies (including the San Francisco Bay Conservation and Development Commission, National Oceanic and Atmospheric Association, State Coastal Conservancy, and the San Francisco Estuary Partnership); science advisor Wim Kimmerer from San Francisco State University; consultants from University of California at Davis, San Francisco State University, and the San Francisco Estuary Institute; and a broad group of scientists, resource managers, and restoration practitioners working in and around San Francisco Bay. The recommendations are based on identifying and addressing key research questions, increasing desired ecosystem services in San Francisco Bay, and moving forward with protection and restoration goals in a phased, adaptive management approach over the next 50 years.

Building off of local and West Coast native oyster workshops and meetings over the past five years, UC Davis researchers Chela Zabin and Ted Grosholz completed a report on Opportunities and Constraints for Native Oyster Restoration for the Subtidal Goals Project. The report recommends a phased approach towards a broad 50-year goal of 8,000 acres of native oyster restoration and enhancement. This presentation will briefly outline our planning, describe how we arrived at the 8,000 acre restoration goal, and discuss specific steps towards targeted restoration site opportunities in San Francisco Bay.

Presentation (PDF)

Link to Subtidal Habitat Goals Project: www.sfbaysubtidal.org

State-by-State 10-Year Goals

The goals listed for each state are preliminary and based solely on discussions from workshop participants.

Washington 10-Year Goals

GOALS:

Reestablish self-maintaining native oyster bed habitat which provides ecosystem services.
10-year Objective - Enhance 100 acres of native oyster habitat by 2020:

50 acres - Central Sound (Dyes Inlet, Sinclair Inlet, Gig Harbor, Miller Bay, Liberty Bay)

25 acres - South Sound (Budd Inlet, Henderson Inlet, Carr Inlet, Oakland Bay, Totten, LSK-Bishop, Wildcat Cove, Gallager Cove, Vaughn Bay in Case Inlet)

10 acres - North Sound (10 ½ acre test plots, Chuckanut, Samish, Fidalgo, Padilla, Drayton)

5 acres - Hood Canal (Wolfe Lagoon, Potlatch East, Dewato)

10 acres - Work with private tidelands owners in all basins to enhance native oyster beds

Restoration Practice

- Continue to improve and customize restoration techniques to suit different conditions.
- Define minimum footprint/density and other parameters to achieve self-maintaining habitat on a water body scale. Determine the tipping point regarding oyster abundance and scale for sustained maintenance of oyster bed habitat.
- Initiate long-term monitoring program of available natural oyster bed habitat aggregations.
- Research larval distribution and behavior in order to focus restoration efforts on re-building source populations that provide ongoing larval production services that benefit a larger geographic area.

Ecosystem Service:

- Identify and quantify ecosystem services provided by consolidated native oyster bed structure.
- On a bay-by-bay basis, estimate historic bed area, current bed areas and existing biomass. Given the water residence time within each bay, determine what filter feeding biomass is needed to filter the bay. Also, determine how many acres of near shore complex habitat (oyster bed) are needed to manage the bay for fish, crab and other fishery production. C. *gigas* and other filter feeding species (i.e. benthic clams) are providing filtration and similar ecosystem services; this needs to be included when calculating filter feeding biomass. Bay filtration and fish/crab production goals, in the context of existing filter feeding biomass, should guide acreage goals for native oyster bed re-establishment and restoration.

Conservation genetics/Hatchery Propagation:

- Develop hatchery propagation in order to scale up production of genetically diverse oyster seed that meet established conservation standards.
- Work with DFO Canada to identify broodstock collection sites in the Strait of Georgia that can support North Sound seed production.
- Seed production presents some inherent difficulties of scale
- Explore remote setting options. There may be options for *in situ* remote sets.
- Do we need to keep breeding groups separate after the larval stage?

Logistics & Project Development:

- Identify new sources of shell or alternative oyster habitat enhancement substrate in order to accomplish 10-year goals. Current *C. gigas* shell sources support 4-5 acres/yr.
- Lay the groundwork for reestablishing native oysters in historic areas currently occupied by eelgrass (Quilcene Bay, Belfair, Seal Rock, Samish Bay)
- Develop long-term partnerships with growers and other tideland owners to lay the groundwork for larger-scale restoration in the future (e.g. Samish Bay)
- Coordinate with Department of Health in order to pursue native oyster restoration in closed waters.
- Pursue longer-term opportunities on Navy tidelands in concert with remediation and nearshore restoration projects.
- Develop informal agreements with tribes and other stakeholders to identify no-harvest areas targeted for restoration.
- Work with Puget Sound Partnership to include native oyster restoration as part of regional recovery efforts.
- Core or source population reestablishment is approached in multiple steps. This benefits genetic diversity, budgets and long-term stakeholders.

RESEARCH QUESTIONS:

- What ecosystem services do native oyster beds provide that eelgrass doesn't? What is the special relationship and dynamic between these species? How are these different from other bivalves, nearshore complex structure and unstructured habitat?
- What is the expected loss of eelgrass habitat, spatially, in order to regain the habitat/filtration values of native oyster beds? Is there a net loss or gain of estuary function and habitat utilization as this ratio shifts within water bodies?
- Can oyster restoration efforts help mitigate the effects of ocean acidification?

- What is the larval distribution and behavior during peak activity within water bodies with substantial abundance of native oysters (>10 million)? Conduct experiments to examine larval competence and field assessment on comparing diurnal/tide exchange/water quality and larval behavior.
- Examine local adaptation within native oyster populations; conduct replicate common garden outplants in spatially discrete areas to examine local adaptation within the context of available data on gene flow.

ADDITIONAL DISCUSSION:

- We have work to do developing the mechanical tools for reestablishing oyster bed habitat, which is fundamentally different than oyster presence or aggregations. We understand and have had success with increasing local abundance where natural set is available. Acreage goals are made with the understanding that the techniques for reestablishing oyster bed habitat are still in development. We need to manage our process continually, incorporating regional information coming from continued monitoring and assessment of natural populations and production.

Oregon 10-Year Goals

GOALS:

Population Assessment and Characterization

An accurate, comprehensive, and quantitative survey of Olympia oyster populations has not yet been carried out for Oregon estuaries. The baseline survey should include information to describe the historic and current distribution of native oysters. This information can additionally be included in an oil spill contingency plans in case of a spill.

The effort to survey current native oysters should include:

- Quantitative assessments, rather than just presence/absence;
- Standardized protocols to make sites comparable and increase sampling rigor;
- Baseline reference sites for intensive, repeated assessments;
- Environmental and community ecology parameters;
- Information about interactions with eelgrass and commercially important species;
- Extent, reproductive output and importance of subtidal populations;
- Role of sedimentation and salinity in determining population depths.

Other activities should include:

- Complete a retrospective assessment of the historic distribution of Olympia oysters in Oregon estuaries.
- Assess potential oyster bed habitat in order to establish potential restoration goals- this provides an alternative method to goals based on percentage of historic population size.
- Project how population expansion will incorporate urban components of the estuarine shorelines.
- Incorporate the subtidal zone as potential oyster habitat.
- Use potential habitats to set goals of what's possible and what will provide measurable benefits to estuary.

Implementation:

-ODFW Marine Resources Program should be encouraged to:

- Recognize the status of Olympia oysters and perhaps create a species status report;
- Include Olympia oysters in the ongoing bivalve surveys conducted by the ODFW shellfish assessment/research team.

Statewide Regulatory Framework for Conservation and Mitigation

Establish statewide policy for no-net loss of Olympia oysters in Oregon:

- Limit activity that will be detrimental to existing intertidal and subtidal oyster beds;
- Require mitigation for unavoidable damage/destruction of Olympia oyster beds; and
- Establish a mitigation "bank" to consolidate repeated loss or destruction of small patches or clusters, and to create larger spatial blocks or plots of native oyster habitat

Develop a Bay-by-Bay Approach to Olympia Oyster Restoration
Oregon should develop and adopt a bay-by-bay approach to the conservation and restoration of Olympia oysters because the different estuaries exhibit a diversity of geomorphologies, habitat impacts, and ecological potentials for oyster recovery. It is unlikely that a "one size fits all" approach will be successful for estuaries as different as Netarts Bay, Yaquina Bay, and Coos Bay.

- Netarts: undeveloped, poor recruitment, but lots of potential area for native oyster beds;
- Yaquina: highly developed, consistent recruitment, and single commercial grower of *Crassostrea gigas*; and
- Coos: highly developed, consistent recruitment, and extensive tideflat acres used for commercial mariculture of *Crassostrea gigas* managed by four oyster farmers.

As surveys of Oregon estuaries are completed, the site-specific restoration goals and priorities for each bay can be developed.

Integrated Restoration and Enhancement of Genetic Diversity
- Develop an integrative restoration strategy that is tightly linked with the genetic broodstock program; and
- Expand common-garden experiments and/or genetic markers to investigate the potential ecological and genetic effects of local adaptation.

Ecosystem Emphasis on Olympia Oyster Restoration
- Develop a mechanism to link oyster restoration and population recovery to the management framework and ecosystem services that provide direct and indirect benefits to humans; and
- Encourage and integrate Olympia oyster recovery in concert with other wetlands and estuary restoration/conservation efforts.

Work Closely with Local *Crassostrea* Growers to Recover Olympia Oyster Populations
- Native Olympia oysters frequently settle on *Crassostrea* shells and are regularly harvested by *Crassostrea* growers. This situation provides a business opportunity that may increase interest in Olympia oyster restoration.
- Oregon / ODFW should not encourage recreational harvest of Olympia oysters (within the next 10 years) but should initially encourage development of harvest guidelines that can be followed by the existing commercial oyster farms.
- Oregon should strive to integrate Olympia oyster conservation and recovery with aquaculture to the greatest extent possible, and to place recovery of native oysters on the map in a broader framework (such as the state of MD oyster recovery plan).

Conduct Research to Investigate Early Life History Events in Population Recovery
- Work with academic scientists to investigate the production of oyster larvae, the abundance and distribution of larval supplies within the estuaries, and the potential and realized larval dispersal;

- Conduct hydrodynamic modeling and particle tracking work to investigate the potential for larval retention and export from the Oregon bays and estuaries;
- Conduct laboratory and field experiments to document larval settlement preferences, delay of settlement, and patterns of juvenile recruitment within the different estuaries; and
- Document the survival of early juvenile stages that are subject to thermal stress, sedimentation, desiccation, differences in food availability, predation, and competition.

Investigate the Potential Impacts of Climate Change on Olympia Oyster Populations

- Estimate the vulnerability of oyster populations to different types of climate-change stressors. Ensure that the strategy taken by state of Oregon incorporates potential climate change effects, such as:
- sea level rise
- increased frequency and intensity of coastal storms
- changes in seawater temperature, salinity, dissolved oxygen
- ocean acidification, pCO2 and pH changes, calcification saturation states
- freshwater inputs

Public Education and Outreach

- More outreach, communication to the community;
- Workshops, multi-media approach, local events;
- Outreach efforts should be coordinated between groups;
- Training at different levels: volunteers, undergraduates, graduate students; and
- Collaboration between people working within Oregon on native oyster restoration.

Canada 10-Year Goals

GOALS:

Set up a more comprehensive monitoring plan for Olympia Oysters at long-term research sites:

- Spend more time reviewing the projects presented at the 2010 workshop in order to develop a 10-year plan.
- Obtain more data to inform the next management plan due in 2013.
- The Nature Conservancy of Canada, possibly working with Vancouver Island University, will explore the restoration of an ecologically damaged near shore marine site on Vancouver Island. The purpose of this restoration will be more holistic than simply restoring Olympia oysters, but the Olympia oyster will be a central focus of the project.
- One of the short-term goals is to have a meeting in October with the Canadian Olympia oyster research team to standardize data collection.
- Improve understanding of population dynamics and potential site dynamics before moving forward with restoration.

California 10-Year Goals*

*Please follow the link for the California State Coastal Conservancy's Subtidal Habitat Goals Project: www.sfbaysubtidal.org

Conclusions

Participants in the 2010 West Coast Native Oyster Restoration Workshop marched through a wide variety of presentations on tools and practices and successfully drafted 10-year goals for Washington, Oregon, California and British Columbia.

Each state, and for that matter, each estuary, is unique in its conditions (both environmental and regulatory). For instance, the methodologies, materials and strategies used to enhance oyster habitat in Netarts Bay, Oregon are shaped by the presence or absence of remnant populations, local habitat conditions, and larval availability. These conditions differ bay by bay and state by state. Other differences related to permit requirements and government support also make the standardization of practices difficult. But in spite of these differences, the overarching goals are held in common. Native oyster restoration is undertaken for the ecological benefits provided by complex bed structure and natural filtration.

Specific metrics for successful restoration efforts are still being developed and participants at the workshop spent time grappling with a number of ongoing questions. For instance, if our goal is to re-establish an effective population, what defines an effective population? What density and bed size are needed to achieve a self-sustaining population? Do these measures hold true across different bodies of water or does the size of a particular embayment or lagoon affect the size at which an oyster bed becomes self-sustaining? How many acres of native oyster habitat are sufficient to filter a particular bay or inlet? How many acres are needed to support fish production? These are questions that researchers, agencies and practitioners will need to answer in order to achieve longer-term, larger-scale enhancements.

In the wake of the 2010 West Coast Native Oyster Workshop, participants will go forth in pursuit of these various scientific inquiries knowing that science and ecological restoration are only part of the story. Native oyster restoration is also informed by a cultural movement to restore traditional food sources important to local tribes and the urge to renew human connections to coastal resources that have defined life along the West Coast for millennia. The 2007 and 2010 workshops were hosted by local tribes because native oyster restoration efforts need, always, to be anchored within this larger cultural context. We work to restore coastal resources because they sustain us. Tribal people understand these connections and are an important partner in native restoration efforts.

The 2012 West Coast Native Oyster Restoration Workshop will be hosted in Oregon at a place and time to be determined. Stay posted. In the meantime, The Nature Conservancy, NOAA and the National Fish and Wildlife Foundation will produce a report in 2011 quantifying historic and current oyster populations in coastal estuaries around the country and defining ecologically meaningful goals for the restoration of beds and reefs.

Appendices

Workshop Agenda

THURSDAY

Presenter	Time	Title
	7:00-8:00	**Breakfast (served in the Community House)**
Betsy Peabody *Puget Sound Restoration Fund*	8:00 – 8:15	Opening remarks/Introductions
Suquamish Tribe	8:15 – 8:30	Tribal Welcome
		Restoration Updates
Dick Vander Schaaf *The Nature Conservancy*	8:30 – 8:50	Olympia oyster restoration challenges in Netarts Bay, Oregon
Christopher Eardley *Oregon State University*	8:55 – 9:15	Identifying limitations and requirements of native oyster (*Ostrea lurida*) to advise restoration efforts in the Yaquina Bay Estuary, Oregon
Chela Zabin *Smithsonian Env. Rest. Ctr*	9:20 – 9:45	Factors limiting native oyster distribution in Elkhorn Slough, CA
Chela Zabin *Smithsonian Env. Rest. Ctr*	9:50 – 10:10	Temporal and spatial variation in recruitment and the effects of competition in Tomales and San Francisco bays: lessons for restoration
	10:15-10:30	**Break**
Paul Dinnel *Skagit County MRC*	10:35-10:55	Restoration of Native oysters, *Ostrea lurida*, in Fidalgo Bay, Washington
Brian Allen *Puget Sound Restoration Fund*	11:00-11:20	Community Effects Monitoring on Restoration Enhancements for *Ostrea lurida* on a structure-limited beach in Puget Sound, Washington
PSRF Staff	11:25-12:00	Discussion of key points for inclusion in 10-year goals

	12:00-1:00	**Lunch (served in the Community House)**
		Restoration Tools
David A.Stick *Oregon State University, COMES, HMSC Newport, OR*	1:00-1:20	Analyses of genetic structure within and among remnant populations of Olympia oysters, *Ostrea lurida*
Brent Vadopalas *University of Washington, SAFS*	1:25-1:40	Conservation genetics protocol for Olympia oyster restoration using hatchery methods
Nate Wight *Puget Sound Restoration Fund*	1:45-2:05	Hatchery propagation of restoration-grade Olympia oyster seed
Steve Rumrill *South Slough National Estuarine Research Reserve*	2:10-2:25	Reproduction and larval ecology as essential factors in recovery of Olympia oysters (*Ostrea lurida*) in Coos Bay and the South Slough Estuary, Oregon
PSRF Staff	2:30-3:00	Discussion of key points for inclusion in 10-year goals
	3:00-3:15	**Break**
		Population Surveys and Assessments
Brian Allen *Puget Sound Restoration Fund*	3:15-3:30	Structure and Characterizations for robust populations of *Ostrea lurida* on Vancouver Island, B.C.'s West Coast
Tammy Norgard *Dept. of Fisheries & Oceans, Canada*	3:35-3:50	Current work on Olympia oysters in Canada
Brady Blake *Washington Department of Fish & Wildlife*	3:55-4:15	Olympia oysters (*Ostrea lurida*) in Puget Sound: lessons learned, road blocks, next steps for stock rebuilding
PSRF Staff	4:20-5:00	Discussion of key points for inclusion in 10-year goals
	5:00 – 6:30	**Oyster Bar (Community House and nearby Pizzeria)**
	6:30 – 8:00	**Dinner (Community House)**

FRIDAY

	7:00 – 8:00	**Breakfast (served in the Community House)**
10-year Goal setting		
Rob Brumbaugh *The Nature Conservancy*	8:00 – 8:20	Setting ecologically meaningful goals for bays and sounds
Betsy Peabody *Puget Sound Restoration Fund*	8:20-8:30	Summary of 2009 NFWF workshops in Washington to develop 10-year business plan
	8:30-11:00	State-by-state discussion to develop 10-year goals for native oyster restoration Oregon leads: Steve Rumrill, Dick Vander Schaaf Washington lead: Betsy Peabody California lead: TBD British Columbia: Tammy Norgard
	11:30-12:00	State-by-state summaries of goal discussions
	12:00	**Adjourn**

2010 West Coast Native Oyster Restoration Workshop Attendees

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