A Guide to Olympia Oyster Restoration and Conservation

ENVIRONMENTAL CONDITIONS AND SITES THAT SUPPORT SUSTAINABLE POPULATIONS IN CENTRAL CALIFORNIA

Coastal Conservancy

NOAA

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California Department of Fish & Wildlife

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San Francisco State University




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This project was led by an interdisciplinary team from the San Francisco Bay and Elkhorn Slough National Estuarine Research Reserves, and has been developed in partnership with the University of California, Davis and the State Coastal Conservancy. The Smithsonian Environmental Research Center and the California Department of Fish and Wildlife are also partners in this effort. The management questions that we address have arisen directly from prior needs assessments of local and regional end-users: oyster restoration practitioners and the coastal decision-makers who set regional restoration policy and provide funding. The core project staff have worked for over ten years at the interface between science and estuarine management end-users, and have a successful track record of producing restoration planning tools which directly shape implementation of and policy for restoration projects. We are working in partnership with a range of local, state, and national partners.

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Synopsis

This guide identifies key environmental conditions that affect Olympia oysters in central California. Availability of hard substrate, abundance of phytoplankton, and relatively warm water temperatures are identified as important factors for supporting sustainable oyster populations. Low salinity, low dissolved oxygen, warm air temperatures and abundant predatory oyster drills are found to be the most important stressors negatively affecting oysters. In general, stressors already facing oysters today appear likely to exert more influence over Olympia oysters in coming decades than emerging climate-related stressors. Using data on oyster attributes and environmental conditions, the authors evaluated 21 sites in San Francisco Bay and Elkhorn Slough for their restoration and conservation potential.

Executive Summary

The Olympia oyster *(Ostrea lurida)* has declined at many estuaries in its native range along the Pacific coast from Baja California to British Columbia. In the past decade, efforts have begun to conserve, enhance or restore Olympia oyster populations in California, Oregon and Washington. The purpose of this guide is to inform these new initiatives, with emphasis on environmental conditions, including both supportive and stressful factors.

High densities of Olympia oysters at China Camp State Park.

Recommendations in this guide are based on new field monitoring and laboratory experiments conducted in central California, as well as on an extensive review of the published literature for Olympia oysters across their range. The authors comprise an interdisciplinary team with expertise in estuarine ecology and oyster restoration science, practice and policy, working closely with oyster restoration and conservation stakeholders, with major funding from NOAA's National Estuarine Research Reserve System Science Collaborative. Our two study locations are only 100 kilometers apart, yet they encompass a broad range of conditions. San Francisco Bay is urban, much larger than Elkhorn Slough, and receives significant amounts of freshwater in rainy seasons. Elkhorn Slough is surrounded by agricultural fields and experiences high nutrient inputs but relatively low amounts of fresh water. In addition, within each estuary, we selected sites along the estuarine gradient from high to low salinity.

Sustainable oyster populations exhibit a suite of attributes. We evaluated nine of these attributes for sites in San Francisco Bay (SF Bay) (Figure 1) and Elkhorn Slough (ES) (Figure 2), and specified desirable thresholds for each attribute. These attributes could be examined by other investigators at additional sites.

OYSTER POPULATION ATTRIBUTES

- Adult oyster density
- Population estimate
- Adult oyster size
- Diversity of size classes
- Recruit density
- Reliable recruitment
- Larvae exported
- Survival rate
- Growth rate

SUPPORTIVE ENVIRONMENTAL FACTORS

- Water Temperature
- Chlorophyll *a*

ENVIRONMENTAL STRESSORS

- Salinity range
- Oyster drill predation
- Risk of high air temperatures
- Low dissolved oxygen
- Risk of low salinity events

Olympia oysters and acorn barnacles.

We selected the following as important indicators of sustainable oyster populations: large adult population size, high density on hard substrates, high rate of juvenile recruitment, diversity of size classes, and high survival rate.

Numerous environmental factors affect the distribution and abundance of Olympia oysters. Based on results from field monitoring and laboratory experiments, combined with a thorough literature review and our own expert opinions, we have identified the factors that exert the strongest influence on Olympia oysters in our region. Some of these influences are positive.

- Availability of hard substrate in the low intertidal and shallow subtidal zone is a requirement for Olympia oysters, and in areas with deep mud, oysters only survive if large hard substrates are available.
- Phytoplankton is necessary to support suspension feeding; higher levels of chlorophyll *a* correlated with oyster attributes in our analysis.
- Warmer water temperatures also support growth and reproduction of Olympia oysters in this region.

Numerous environmental factors threaten oysters and serve as stressors. Some of these exert strong negative influences on oysters but only occur at certain sites. The expression of stressors is thus site-specific.

- Low salinity can very negatively affect oysters at sites with at least occasional high freshwater inflow.
- Predatory non-native Atlantic oyster drills *(Urosalpinx cinerea)* can have devastating consequences to oysters but are absent at many sites.
- Low oxygen (hypoxia) has negative effects but is only a problem at the most eutrophic sites in these estuaries.
- Warm air temperature during low tide exposure poses a potential threat at any site, but this threat is reduced at sites with more summer fog.

In contrast with our demonstration of strong negative effects by the above stressors, our work and that of others shows that other stressors are less important, at least during this study period and in this region. These include competition from non-native fouling species, sedimentation, contaminants, pathogens and disease, sea level rise and acidification of estuarine waters.

Olympia oysters face multiple environmental stressors due both to the natural dynamics of estuarine ecosystems and to anthropogenic modifications. We examined interactions between different stressors under laboratory conditions and found that the types of responses observed depended on the stressor and the timing of application. We documented some linear, additive relationships between stressors, and some that were non-linear and synergistic. It is clear that decreasing stressor levels through ecosystem management (such as reducing hypoxia resulting from nutrient loading) will support oysters, but it is hard to predict whether such stressor reduction will increase resilience to other stressors, such as those related to climate change.

Olympia oysters on hard substrate in SF Bay (top) and Elkhorn Slough (bottom).

Into the cold bay
Place oysters where they can best
Survive stressful times

We evaluated twenty-one sites according to the oyster attributes, supportive environmental factors and stressors described above and have summarized these results in a Site Evaluation Table. Of the sites we evaluated, the top-scoring sites for restoration in San Francisco Bay were Berkeley Marina (Shorebird Park area), Strawberry (Brickyard Cove), San Rafael Shoreline and Point Pinole Regional Shoreline; however, in Elkhorn Slough, only Kirby Park and South Marsh received a high restoration score and more sites received low scores at this estuary than in San Francisco Bay. All of the high-ranked restoration sites also ranked high as conservation sites, but several additional sites ranked high for conservation: Richmond (Point Orient), Loch Lomond Marina, and Sausalito (Dunphy Park) in SF Bay and Whistlestop in Elkhorn Slough. The Site Evaluation Table can be used as a framework to assess other sites with new data. Because the overall score is an average of all parameters, it is possible to score new sites even if data are not collected for as many parameters as were used here.

This approach to quantifying the relative conservation value and restoration potential of 21 sites in central California estuaries can be used to inform future management actions. Agencies, non-governmental organizations, citizen science groups or others considering the launch of a new restoration project can determine whether a particular site is likely to yield success. Funding agencies can use scores to help evaluate multiple restoration proposals and regulatory agencies can use the scores to direct policy protecting valuable existing populations.

Our identification of the stressors that exert the strongest influences on oysters in these estuaries also can help inform ecosystem management efforts. For instance, reduction of hypoxia and prevention of the spread of oyster drills to new regions are both clear management recommendations. In general, these current threats to oysters should be of more concern to managers than those posed by climate change; our investigation suggests warming water temperatures over coming decades may benefit oysters, and threats posed by acidification of surface waters and sea level rise are likely to be lower than those posed by existing stressors. However, our analysis also suggests that projected increases in air temperature and increased variation in precipitation may threaten oyster populations, through overheating during low tide exposure and through low salinity during extended rains.

In summary, this guide supports Olympia oyster conservation and restoration and by enhancing understanding of the attributes of sustainable oyster populations, the environmental conditions that fosters them, and the sites that best support them.