Science Foundation Chapter 3
Appendix 3.1 – Case Study
Oyster Beds and Reefs

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DESCRIPTION OF THE SPECIES

This case study focuses on the native Olympia oyster, *Ostrea lurida*. Much of the information herein was obtained from an Appendix to the Subtidal Habitat Goals report (Zabin et al. 2010).

CRITERIA FOR SELECTION OF THE SPECIES

Oyster beds can provide a variety of ecosystem services, although their current low abundance means they probably do not play a huge ecological role in today's estuary. Nevertheless, there is potential for restoration, particularly in living shorelines together with eelgrass for adaptation to higher sea level, protecting shorelines without increasing wave reflection. Oyster beds may be vulnerable to several aspects of long-term change in ways that could interact with marshes.

OTHER INFORMATION ABOUT THE SPECIES

These oysters are found mainly on hard substrates in the intertidal zone, although their abundance in the subtidal is poorly known. Artificial reefs have been installed at several pilot restoration sites, and oysters have recruited to the reefs in large numbers. Oysters occur throughout the more saline parts of the estuary although they are generally most abundant between the San Rafael and San Mateo bridges.

Native oysters do not build tall reefs but cement and expand existing hard structures and increase roughness. Thus they can be considered "ecosystem engineers" that create or alter habitat for themselves and other species.

The functions of oyster beds comprise those due to the physical structure and those due to the living oysters. Reefs that have been created for restoration typically have a taller profile than oyster beds that have grown on existing hard substrate such as rock and riprap. By altering bathymetry, these reefs can absorb energy from waves and tidal currents, trap sediments, and alter local mixing. The structures also increase physical heterogeneity, providing habitat for a wide variety of invertebrates and fish, particularly if the structures are physically complex. They can provide spawning substrate for herring.

The living oysters provide a food resource for other estuarine organisms. They filter the water and can locally reduce phytoplankton biomass. However, given the limited extent of their habitat they are unlikely to filter as much phytoplankton as the soft-bottom clams do, except in the immediate vicinity of dense oyster reefs with limited water circulation.

The principal link to marshes seems to be the reduction in wave energy and bottom stress that a constructed reef or living shoreline would provide, protecting an adjacent marsh from erosion. It is unclear whether the oysters themselves would play a major role in long-term maintenance and expansion of these constructed reefs. If they do, the outcome would require less maintenance than would be the case for largely abiotic reefs, which would need periodic cleaning and replacing degraded reef units.

The importance of oysters in the bay before European settlement is uncertain. However, here we are considering only future conditions and what role oyster reefs might play. The historical information would be of limited value for informing future actions given all the changes in the estuary.

REVIEW OF LONG-TERM EFFECTS

Oyster reefs may suffer negative effects from ocean acidification. Oyster shells are made of calcium carbonate which dissolves at low pH. The larval stages of oysters are particularly vulnerable to acidification (Hettinger et al. 2012). The key uncertainty is whether those effects override or are additive to the naturally high variation in pH in the estuary.

Changes in the distribution of salinity can affect oysters and if upstream hydrologic changes (e.g., reduced snowpack) produce more frequent floods the frequency of die-backs may be higher. Rising temperature may cause desiccation of oysters, particularly newly settled spat, high in the intertidal zone but not lower. Oyster fecundity is temperature dependent, and warmer springs might result in earlier spawning and larval release, but the population-level effects of earlier reproduction are not clear. Disease incidence in the Bay is currently low but incidence or its impacts may increase if oysters are already stressed. Reduced sediment supply might benefit oyster populations through reduced sedimentation on the reefs; however, sediment supply to particular locations may remain high because of local erosion and transport.

OTHER STRESSORS

Oyster drills can cause considerable mortality to native oysters, particularly small ones. Oyster drills, which in non-native in SF Bay, are found in high abundance in the South Bay and in Richardson Bay. Competition or overgrowth by fouling species (many of which are also non-native) may reduce recruitment and slow growth. Low levels of dissolved oxygen (DO) also appear to depress growth and increase mortality; although present levels of DO are high, this could change if the estuary becomes eutrophic in the future.

FACTORS THAT MAY AFFECT SPECIES RESILIENCE

Oyster populations rebounded quickly at a San Rafael restoration site after the 2006 floods. However, the overall resilience of the oyster populations can't be known without more information about their population structure. Although the larval period is long enough that oyster larvae should be broadly mixed within the estuary before settlement, there is some evidence of population structure. Although settlement of oysters onto newly implanted substrates has been rapid in restoration sites, ~40% of the suitable substrate surveyed by the UC Davis group is unoccupied, implying either a shortage of larvae or other processes inhibitingsettlement.

LIKELY CLIMATE CHANGE IMPACTS AND RISKS

Enumerated above.

MANAGEMENT ACTIONS TO BE CONSIDERED

The use of oyster reefs in living shorelines should continue to be investigated as part of an adaptation strategy for rising sea level and reduced sediment supply. Because of the lack of knowledge about oyster population dynamics, oyster restoration actions should be undertaken in an experimental framework so that the effort is not wasted and the knowledge necessary for continuing restoration can be accumulated.

UNCERTAINTY AND KNOWLEDGE GAPS

- The roles of the oysters themselves in the structure, function, and long-term resilience of artificial reefs.
- The function of the reefs in providing habitat and reducing shoreline erosion, and how this varies with location.
- Abundance of oysters in the subtidal
- Connectivity among oyster populations, including genetic variability as well as ecological connectivity (i.e. coherence in dynamics across the metapopulation).
- Population dynamics of oysters.
- The role of oyster reefs in providing substrate for introduced species.

LITERATURE CITED AND RESOURCES

Hettinger, A., E. Sanford, T. M. Hill, A. D. Russell, K. N. S. Sato, J. Hoey, M. Forsch, H. N. Page, and B. Gaylord. 2012. Persistent carry-over effects of planktonic exposure to ocean acidification in the Olympia oyster. Ecology **93:** 2758-2768.

Zabin, C.J., S. Attoe, E.D. Grosholz, and C. Coleman-Hulbert. 2010. Shellfish Conservation and Restoration in San Francisco Bay: Opportunities and Constraints. Appendix 7, Subtidal Habitat Goals Report. California Coastal Conservancy, Oakland.