# Monitoring

## Why monitor?

Monitoring is an essential part of all restoration projects and consists of systematic data collection that indicates progress toward identified criteria, performance standards, and ecological goals. It entails measuring a number of attributes or parameters at regular intervals to record changes in the oyster reef or bed, and perhaps the water around the reef. The parameters measured at a project site should reflect the project objectives and target criteria, and monitoring results should be evaluated carefully to determine needed project adjustments or modifications and to track project success.

Betsy Peabody, Director, Puget Sound Restoration Fund, monitors oyster density in Liberty Bay, WA. Photo credit: Tristan Peter -Contesse.

Project managers or volunteers should perform monitoring before, during, and after restoration implementation to assess changes throughout the course of the project in order to:

☐ Evaluate the state of the habitat.
☐ Understand the functioning of the ecosystem.
☐ Characterize the interaction of organisms on and around the reefs.
☐ Evaluate the restoration technique.
☐ Evaluate stressors (e.g., low dissolved oxygen levels, currents, salinity, temperature, and disease).
☐ Evaluate sites proposed for restoration (e.g., natural spat set or recruitment, substrate conditions, and sediment loads).
☐ Facilitate adaptive management (e.g., monitoring the substrate in years after initial planting can indicate whether it is necessary to add more shell to provide clean settlement sites; monitoring recruitment may indicate the site is recruitment-limited and provide justification for brood stock enhancement).

## Oyster reef characteristics to monitor

Both structural and functional components of a habitat should be monitored. The structural components are those physical, chemical, and biological characteristics that define the habitat. Functional components are the processes occurring within and between habitats as a result of the structural components. Because returning functions to a habitat is the ultimate goal of a restoration effort, understanding these components is key to selecting the most relevant parameters for assessing project success (Thayer et al. 2003). For example, habitat created by animals - a biological structural characteristic - is considered to be the areal extent and complexity of the oyster reef. This characteristic is directly linked to some functional characteristics, such as the amount of attachment substrate and biodiversity of a reef. Some examples of structural and functional characteristics of oyster reefs and methods used to measure them are found in the tables below (adapted from Burrows et al. 2005).

To learn more about restoration monitoring, visit these sites:

- ☐ NOAA's Restoration Monitoring Planner
- ☐ NOAA's two-volume Science-Based Restoration Monitoring of Coastal Habitats

**Examples of structural characteristics to monitor on an oyster reef**

| Examples of Structural Characteristics of Oyster Reefs | | |
|---|---|---|
| **Characteristic** | **Parameter to measure** | **Methods used for measuring** |
| ***Biological Characteristics*** | | |
| Habitat created by animals (e.g., extent and complexity of reef) | Acreage of reef | Multiple image processing; photography; spectral clustering; digital texture analysis; aerial photography; side-scan sonar; video photography |
| **Physical Characteristics** | | |
| Topography | Vertical relief of reef | Side-scan sonar; acoustic seabed classification system (ASCS); underwater acoustic technology; acoustic profiler combined with fathometer and GPS |
| ***Hydrological Characteristic*** | | |
| Current velocity | Sheet flow of water | Acoustic Doppler flow meters; water velocity meter with turbo prop propellar; electromagnetic current meter. |
| ***Chemical Characteristics*** | | |
| Nutrient concentration | Phytoplankton diversity and abundance | Filter water for chlorophyll samples and analysis (spectrophotometer); phytoplankton net tows and microscopic examination |

**Examples of functional characteristics of oyster reefs to monitor**

| Examples of Functional Characteristics of Oyster Reefs | | |
|---|---|---|
| **Characteristic** | **Parameter to measure** | **Methods used for measuring** |
| ***Biological Characteristics*** | | |
| Provides substrate for | Recruitment and growth and | Spat collectors retrieved |

| | | |
|---|---|---|
| attachment | survival rates of oyster spat | and assessed on a regular basis; quadrat samples of oysters on reefs for density, number, and size of spat over time |
| Supports a complex trophic structure | Number of species and abundance of fish and invertebrates | For fish: gill nets; visual underwater census For invertebrates: 24 $m^2$ lift net for nekton; quadrats (fixed or transects) |
| Disease | Disease prevalence and intensity | Histological sections and histopathology; Ray's fluid thioglycolate medium (RFTM) for Perkinsus marinum; PCR (polymerase chain reaction) probe; immunoassay techniques |
| ***Hydrological Characteristics*** | | |
| Alters turbidity | Secchi disc depth | Secchi disc extinction point; turbidimeter; nephelometer |
| Modifies dissolved oxygen | Chlorophyll concentration; dissolved oxygen (DO) | Filter water for chlorophyll samples and analysis (spectrophotometer); DO-titration method; DO meter; fiber optic oxygen sensor |
| ***Chemical Characteristics*** | | |
| Supports nutrient cycling | Carbon, nitrogen, and phosphorus flow and flux on oyster reefs | Nitrogen and phosphorous measurements in water column, increased biomass of oysters, and release of ammonium; phytoplankton density |

Other parameters could include social or economic aspects the human dimensions of the restoration project on the local community or region, depending on the goals of the project. Regardless of the parameters chosen, the results from monitoring will indicate progress and dictate whether some adjustments should be made in the location of the project or the methods used.