NOAA RESTORATION CENTER IMPLEMENTATION MONITORING

GUIDANCE FOR PROPOSING AND CONDUCTING TIER I MONITORING

1 Monitoring Plans and Reporting 2
1.1 Monitoring Plan Development 2
1.2 Monitoring Plan Structure 3
1.3 Reporting Monitoring Progress 3
2 Data and Publication Sharing Policy 3
2.1 Guidance 4
2.2 Templates and Examples 4
3 Tier I Monitoring Guidance 5
3.1 Fish Passage Barrier Removal 5
3.1.1 Site-Passability 6
3.1.2 Presence of Target Fish Species 7
3.1.3 Operating and Maintenance Costs 8
3.1.4 Public Safety 8
3.1.5 Community Enhancement 8
3.2 Coral Recovery 9
3.2.1 Management Plan Actions Implemented 9
3.2.2 Community Enhancement 10
3.2.3 Number of Target Species (Released or Planted) 10
3.2.4 Percent Survival (Plantings and Transplantings) 11
3.2.5 Presence/Absence of Ungulates 11
3.2.6 Percent Cover 11
3.2.7 Tons of Algae Removed 12
3.2.8 Density of Urchins 12
3.3 Hydrologic Reconnection 12
3.3.1 Land Elevations 13
3.3.2 Water Levels 13

December 2017

3.3.3 Operating and Maintenance Costs 14
3.3.4 Public Safety 15
3.3.5 Community Enhancement 15
3.4 Oyster Restoration 15
3.4.1 Reef Areal Dimensions 16
3.4.2 Reef Height 16
3.4.3 Oyster Density 17
3.4.4 Oyster Size Frequency Distribution/Mean Shell Height 17
3.4.5 Environmental Variables 18

Overview

The NOAA Restoration Center (RC) provides funding and technical assistance to help communities restore coastal habitats. Through our fisheries restoration grant programs (e.g. Community-based Restoration Program), the RC has identified the four most common project types: fish passage barrier removals, coral restoration, hydrologic reconnections, and oyster restoration. Specific metrics have been identified for these project types to consistently evaluate whether a project was implemented as designed and provides a basic level of effectiveness. These metrics provide quality assurance for project construction, and are required for all funded projects within these four project types. This "Tier I" monitoring occurs within the context of the RC's monitoring and evaluation framework. Tier I metrics for each project have a quantitative targets defined before project implementation. Typically, data are collected using the same methods pre- and post-implementation and compared with the target value.

Award recipients are expected to develop three monitoring-related documents during the course of their award—a Monitoring Plan, a Data Sharing Plan, and a final progress report including monitoring results.

1 MONITORING PLANS AND REPORTING

1.1 MONITORING PLAN DEVELOPMENT

A description of planned monitoring should be included in your project application, but a formal monitoring plan will be developed during award negotiations. The plans are intended to document how applicants will measure and report Tier I monitoring metrics listed in Section 2. NOAA staff, including Technical Monitors[1], can help applicants or recipients develop monitoring plans.

[1] NOAA Technical Monitors are restoration experts who participate in project oversight during the award. NOAA identifies them during the award negotiation process.

1.2 MONITORING PLAN STRUCTURE

Tier I monitoring plans will document how pre-and post-construction metrics will be assessed and should be completed during award negotiation to ensure that monitoring costs and award length are established correctly. The monitoring plan will include the following:

- Goals and objectives of the project;
- List of implementation monitoring metrics;
- Methods to assess and analyze the required pre- and post-construction metrics;
- Monitoring schedule (duration and frequency);
- Targets for each metric (or methods for determining targets); and
- References used to establish targets.

Guidance for required metrics, monitoring duration and frequency, and targets are provided in Section 3.

1.3 REPORTING MONITORING PROGRESS

Pre- and post-implementation data will be reported as part of the standard progress reporting schedule described in an award. The RC uses a progress report form that includes a narrative section and a table of Performance Measures, both of which may be used to report monitoring results. The final progress report should:

- describe the methods;
- interpret the monitoring data to determine whether the project was implemented as designed;
- provide an explanation/hypothesis regarding why the project didn't meet its targets;
- describe any deviations from the Monitoring Plan;
- include any recommendations for further investigation and monitoring; and
- include points of contact and data managers, in accordance with award conditions related to public access to data.

As listed in Section 3, some project types may require particular analyses (e.g. hydrographs) or photographs as part of the data interpretation, which can be submitted as separate attachments. Site maps showing sampling locations may also be requested.

2 DATA AND PUBLICATION SHARING POLICY

Environmental data and information collected and/or created under NOAA grants and cooperative agreements must be made visible, accessible, and independently understandable to general users, free of charge or at minimal cost, in a timely manner (typically no later than two (2) years after the data are collected or created), except where limited by law, regulation, policy or security requirements. Failing to share environmental data and information in accordance with your Data Management Plan may lead to enforcement actions and be considered by NOAA when making future award decisions.

More information about the Data Sharing Policy is available on NOAA's Environmental Data Management Committee website at:
https://geo-ide.noaa.gov/wiki/index.php?title=Data_Sharing_for_NOAA_Grants_PD
This website includes:

- NOAA's Data and Publication Sharing Directive for Grants, Cooperative Agreements, and Contracts, including data management award conditions
- Frequently Asked Questions

The Data Management Plan you submit may be posted to the internet by NOAA, and serves to document how the recipient intends to comply with their award conditions related to collecting and making data available to the public. NOAA's National Centers for Environmental Information (NCEI) is one option for publicly archiving data. Information about archiving data at NCEI is available at https://www.ncdc.noaa.gov/customer-support/archiving-your-data-ncdc.

2.1 GUIDANCE

Each proposal submitted to NOAA should contain a Data Management Plan. These plans should include:

- the types of environmental data and information expected to be created during the course of the project;
- the tentative date by which data will be shared;
- the standards to be used for data/metadata format and content, including a quality control process;
- methods for providing data access;
- approximate total volume of data to be collected; and
- prior experience in making such data accessible.

2.2 TEMPLATES AND EXAMPLES

Template

The [project name (award #)], implemented by [applicant name] will generate environmental data and information, including [type(s) of data that will be collected]. Datasets will include [additional detail regarding data collection methods, quality control and metadata]. Data will be collected by [person/group collecting data] according to the procedures described in [application/manual/published article], and stored [location/method of data storage]. The data will be available [where/how] starting on [date no later than two years after data collected/created]. In the past, we have shared similar data by [past data sharing methods, if any]. All future sub-awardees not identified in this plan will have as a condition of their contract acceptance of this data sharing plan. Contact [name] at [phone/email] for more information.

Template Example:

The Salt Marsh Restoration Project, implemented by We Heart Marshes, will generate environmental information, including pre- and post-restoration assessments of the number of

acres/stream miles with improved tidal wetland hydrology. Topographic data will include pre- and post-restoration controlling bottom invert elevation, controlling top invert elevation, channel widths, and channel depths. Hydrographs documenting at least one full 28-day tidal cycle pre- and post-restoration will be collected. The number of acres/stream miles improved will be estimated by We Heart Marshes within one year of project implementation. Post-restoration topography data will be collected by the construction contractor or sub-contractor within one year of implementation. Topographic data will be collected via standard survey techniques and recorded electronically and in field notebooks. The hydrographs will be created using pressure transducers at locations upstream and downstream of the former tidal restriction. Measurements will be taken every 15 minutes.

Data collection will be supervised by We Heart Marshes' senior scientist, Mr. Spart Alterniflora. Our data collection and quality control processes are fully described within the proposal, and we will contact the National Centers for Environmental Information to confirm their ability to archive our data. The data will be available to the public by September 1, 2019. In the past, we have shared similar data through grant progress reports and presentations to our town Conservation Commission. Contact Spart Alterniflora at s.alterniflora@weheartmarshes.org or 123-456-7890 for more information.

Real World Example:
The Mountain View Restoration Project, implemented by Ducks Unlimited, Inc., will generate environmental data and information, including data on sedimentation rates, vegetation cover, water quality, and fish. Datasets will include sedimentation rates; rate of vegetative colonization; water quality components such as dissolved oxygen, salinity, and specific conductance; and fish use of the newly restored site. Data will be collected by local researchers and compiled by the South Bay Salt Pond Restoration Project into an annual self-monitoring report. The data will be stored on the SBSP Restoration Project website (http://www.southbayrestoration.org/monitoring/). The data will be available to the public at this website no later than two years after it was collected, through 2050, or the end of the SBSP Restoration Project. Contact XXX (lead scientist for the project) at (phone number) or (email address) for more information or to make a data request outside of what is provided on the webpage. In the past, the SBSP Restoration project has shared similar data that you can find at the website. All future sub-awardees not identified in this plan will have as a condition of their contract acceptance of this data sharing plan. Any additional data sharing stipulations for future sub-awardees may be outlined at that time and described in their contract.

3 TIER I MONITORING GUIDANCE

3.1 FISH PASSAGE BARRIER REMOVAL

Tier I monitoring for fish passage barrier removal projects applies to projects removing dams and removing or replacing culverts. The metrics are:

1) Site Passability: channel width, channel slope, and jump height

2) Presence of Target Fish Species: presence/absence of diadromous fish species, life stage limited by barrier
3) Annual Operating and Maintenance Costs: annual for next five-year period
4) Safety Hazard: describe hazard diminished or eliminated
5) Community Enhancement: changes to infrastructure, utilities or recreational facilities

What follows is basic guidance for conducting Tier I fish passage monitoring.

3.1.1 SITE-PASSABILITY

Recipients are requested to provide project designs to NOAA Technical Monitors before implementation. The pre-implementation measurements for passability metrics (channel width, slope, and maximum jump height) should reflect existing conditions at the site and the target ranges should be based on project design plans that reflect regionally appropriate fish passage criteria as follows:

California: All projects should be designed to meet appropriate criteria defined in NMFS Southwest Fish Passage Guidelines.

Oregon and Washington: All projects should be designed to meet appropriate criteria defined in NMFS Northwest Fish Passage Guidelines.

Northeast and Southeast: Although there is not a single standard in the Northeast, recipients must describe and document how their design criteria for the target species were established, citing references if appropriate, and how their design meets these criteria. Design criteria should include flow velocities as they relate to the swimming abilities of the target species (including burst and sustained swimming speeds), jump heights, flow depths, channel width and slope. If necessary, hydraulic modeling should be used to verify whether the design will meet these criteria.

Passability Metrics

Channel width should be determined by taking the average of three measurements of the active channel width immediately within the barrier removal site. For culverts, these should be taken pre- and post-implementation just under the crossing and immediately upstream and downstream. For dams, pre-implementation measurements should be taken immediately upstream and downstream of the dam and across the spillway crest and repeated at these locations post-removal. Although channel widths are reported in progress report Section B "Performance Measures" as averages for each time period, the three measurements contributing to each average should be reported in the final progress report narrative described in Section 1.

Channel slopes should be determined by taking a longitudinal profile through the project reach, defined by the extent of barrier influence on channel and/or water surface slope. Determine the *average channel slope* from just upstream of the influence of the barrier to just downstream of its influence (i.e. below any scour pools). As such, pre- and post-implementation average channel slopes should be the same. Areas of *maximum channel slope* pre- and post-implementation should be identified visually from plotted longitudinal profiles and then computed. Maximum channel slopes should be identified and computed for channel distances greater than 5-10 feet (based on plot resolution). Significant changes in channel elevation over shorter distances should be considered as jump heights (see below).

Maximum jump height is the largest abrupt discontinuity in the channel slope that would require a fish to jump to transit the site. In the case of a dam removal, the dam itself would very often be the maximum jump height for the pre-implementation condition. Maximum jump heights should be identified visually from the pre-and post-implementation longitudinal profile plots and then measured.

Frequency/Duration of Sampling

A pre-implementation survey should be conducted at the site to document conditions before barrier removal. The post implementation survey should be conducted soon after project implementation to document as-built conditions.

3.1.2 Presence of Target Fish Species

Presence/absence metrics

Select one diadromous species and its life stage (*juvenile or adult*) that, if able to pass through the site, would represent adequate passage for all other species in the area. For example, if two diadromous species are likely to use the site, choose the species and life stage with the poorest swimming or jumping abilities. Use one of the following survey techniques to identify presence or absence for either adults or juveniles upstream of the project site, based on state or regional protocols for fish surveys[2]. For this metric, your target will be presence upstream after removal.

- Adults – upstream weirs, mark-recapture, spawner surveys, snorkel counts, videography at barrier location.
- Juveniles – mark-recapture, migrant traps, snorkel counts, electroshocking, videography at barrier location.

If a pre-implementation survey is not possible, report whether the barrier is a known full barrier or partial barrier for the target diadromous species. If no recent biological information is available, include surrogate information (e.g. last time the target species was seen above the barrier, a description of "completeness" of barrier, etc.).

[2] If unknown then refer to the following document: Roni, P. (Editor) 2005. Monitoring stream and watershed restoration. American Fisheries Society, Bethesda, Maryland, 350 p.

Frequency/Duration of Sampling

The frequency and duration of sampling should be related to the life history of the target species. At a minimum, this metric should be monitored once post-implementation, and at a maximum it could be monitored on an annual or seasonal basis.

- Monitoring for this measure is likely to yield meaningful results in the first 3 years after project implementation, although in some situations it may be valuable to monitor for the first 5 years.
- Once target fish presence is detected upstream of the project site post-implementation, monitoring for this measure is complete.

3.1.3 OPERATING AND MAINTENANCE COSTS

Changes in annual operations, maintenance and/or liability costs associated with the barrier removal should be documented.

- Pre-implementation: Calculate the expected average annual operating, maintenance, and/or liability costs over the next 5 year period if the barrier were to remain in place. Periodic or less frequent costs that may occur during this period (e.g. structural upgrades to meet safety or regulatory requirements) may be incorporated into the estimate.
- Post-implementation: Calculate the expected average annual operating, maintenance, and/or liability costs over the next 5 year period with the barrier removed.

3.1.4 PUBLIC SAFETY

Improved public safety associated with the barrier removal, if applicable.

- Pre-implementation: Describe the safety hazards caused by the barrier and how they will be eliminated or diminished through removal. Safety hazards may include barriers that serve as attractive nuisances and present swimming and boating dangers. Also, barriers that are structurally deficient, in danger of failure, or cause flooding may be considered public safety hazards
- Post-implementation: After implementation, confirm that the identified public safety hazard has been eliminated or diminished.

3.1.5 COMMUNITY ENHANCEMENT

Local civic enhancement projects associated with the barrier removal, if applicable.

- Pre-implementation: Determine whether or not there will be a local community, civic enhancement project associated with the barrier removal project. Local civic enhancement projects may include, but are not limited to, adjacent recreation enhancement, park development, and/or riverfront revitalization.
- Post-implementation: Confirm that the enhancement project(s) associated with the barrier removal was completed.

3.2 CORAL RECOVERY

The Restoration Center works to recover corals through three types of restoration actions: erosion control techniques; removing invasive species; and coral transplanting. There are eight potential metrics for coral projects, described below. They are listed here by project type.

Erosion control techniques:

- Management plan actions implemented-3.2.1
- Community enhancement-3.2.2
- Number of target species (plants)-3.2.3
- Percent survival (plants)-3.2.4
- Presence/absence of ungulates- 3.2.5

Removing invasive species:

- Management plan actions implemented-3.2.1
- Community enhancement-3.2.2
- Number of target species (urchins released)-3.2.3
- Percent cover (plant/algae, before/after)-3.2.6
- Tons of algae removed-3.2.7
- Density of urchins-3.2.8

Coral Transplanting:

- Management plan actions implemented-3.2.1
- Community enhancement-3.2.2
- Number of target species (corals transplanted)- 3.2.3
- Percent survival (of corals, including detachment rates)- 3.2.4

3.2.1 MANAGEMENT PLAN ACTIONS IMPLEMENTED

Techniques

Identify the name of the plan, include a web link for the plan, and work with the NOAA Technical Monitor to identify the number of actions the project will address. Clearly state the type of plan the actions are from. For example, an endangered species recovery plan, a watershed management plan, a conservation action plan, a regional plan, or a local plan.

Frequency/Duration of Sampling

The actions addressed should be assessed within 90 days of post-restoration.

Targets

The target is “Yes” actions from a management plan were implemented. The number of actions to be addressed should be in the monitoring plan.

3.2.2 COMMUNITY ENHANCEMENT

Techniques

Count the number of community enhancement components of the restoration project that will directly benefit the community, such as education, recreational infrastructure, or green infrastructure. For education and outreach opportunities, count the number of attendees or outreach material recipients. Examples of community enhancement activities by sector are provided. If you have questions on what to monitor, contact the NOAA Technical Monitor.

Education and Outreach

- Workshops, seminars, trainings, and manuals or brochures

Recreational Infrastructure

- Park, road, trail, or walkway development or enhancement
- Access to recreational opportunities

Green Infrastructure

- Raingardens, constructed wetlands, or bio-retention systems

Frequency/Duration of Sampling

Enhancement project metrics should be assessed every 6 months in the bi-annual report and in the final report.

Targets

The target will depend on the project type and should be recorded in the final scope of work.

3.2.3 NUMBER OF TARGET SPECIES (RELEASED OR PLANTED)

Techniques

As individuals are released or planted[3] in the upland, coastal, or marine environment, they should be counted and recorded by the scientific name (lowest reasonable taxon) of flora or fauna.

Frequency/Duration of Sampling

The individuals should be recorded by species as they are released or planted.

Targets

The target should be set to meet the purpose of the project. If you are unsure how to determine this, contact the NOAA Technical Monitor.

[3] NOAA RC only supports releasing or planting species native to the local geographic area, and from a verified source.

3.2.4 PERCENT SURVIVAL (PLANTINGS AND TRANSPLANTINGS)

Techniques

Permanent monitoring locations are preferred. Acceptable techniques include line-point intercept, belt transects, or quadrats. Consult the NOAA Technical Monitor for additional guidance.

Frequency/Duration of Sampling

This should be assessed at 90 days post-restoration.

Targets

Minimum target is 80% survival. The final target will be defined in the final design plans for the project. If the project area is hit by a natural disaster, such as a disease outbreak, bleaching event, or a hurricane, work with the NOAA Technical Monitor to reassess project metrics.

3.2.5 PRESENCE/ABSENCE OF UNGULATES

Techniques

Select one ungulate species (e.g. goats, pigs, etc.) and its life state (juvenile or adult) that if absent represents restoration of the project area. For example, projects focused on the removal of goats or pigs should choose the species and life stage with the greatest digging and jumping abilities. Ungulates can be detected using visual surveys (e.g. haphazard or random walk or aerial survey) of the project area for individual animals, scat, digging at the fence, or other animal signs or baited stations.

Frequency/Duration of Sampling

This should be completed prior to project implementation and once at 90 days post-restoration. If possible, it would be valuable to monitor the area on a regular basis over the first year to ensure the target species remains absent.

Targets

The target will be absence.

3.2.6 PERCENT COVER

Techniques

Permanent monitoring locations are preferred. Acceptable techniques include line-point intercept, belt transects, or quadrats. Consult the NOAA Technical Monitor for additional guidance.

Frequency/Duration of Sampling

Baseline percent cover should be assessed prior to restoration and assessed 90 days post-restoration.

Targets
Cover of invasive algae species should be 20% or less. Targets for all other species will be defined in the final scope of work.

3.2.7 TONS OF ALGAE REMOVED

Techniques
Algae removed should be weighed wet. The weight should be reported to NOAA as metric tons. For reference, 1 metric ton=1.1 U.S. tons=1,000kg = 2,204.6 lbs. If it is not possible to weigh the algae wet, then consistently weigh the materials for your project as wet or dry and note in your report, if the weight reported is a wet or dry weight.

Frequency/Duration of Sampling
The material should be weighed wet immediately after removal or as soon as practical.

Targets
The target will be defined in the final scope of work for the project.

3.2.8 DENSITY OF URCHINS

Techniques
For urchins, it is best to use a belt transect (25mx1m). Individual urchins along the belt should be counted to determine the number or urchins per square meter.

Frequency/Duration of Sampling
The density of the target species should be assessed prior to release, as a baseline, upon release, and at 90 days post-restoration. If possible, it would be valuable to monitor the area on a regular basis over the first five years to ensure the target species remains.

Targets
Urchins should be released to achieve a target density of 1 urchin per m^2 across the restoration site at 90 days post-restoration.

3.3 HYDROLOGIC RECONNECTION

Tier I monitoring for hydrologic reconnection projects applies to fill removal, levee and dike removal/setback, tidal restriction removal, sediment replenishment, channel modification, and floodplain and off-channel habitat reconnection. The metrics are:

1) Land Elevations:
2) Water Levels: using hydrographs or photographs
3) Annual Operating and Maintenance Costs: estimated for the next five-year period
4) Public Safety: describe hazard diminished or eliminated
5) Community Enhancement: changes to infrastructure, utilities, or recreational facilities

3.3.1 LAND ELEVATIONS

Techniques

The RC will use restoration designs and post-construction as-built surveys or drawings to determine whether the restoration effort met its target elevations. Restoration designs should be prepared and stamped by a licensed professional engineer and show all relevant existing and proposed elevations and cross sections of structures, channels, wetlands, and floodplains. The as-built drawings should be prepared by a professional land surveyor and show the final elevations and cross sections of the structures, channels, and land installed or altered by the project. As-built drawings should be surveyed into a known elevation benchmark and referenced to a standard geodetic datum or the International Great Lakes Datum.

Frequency/Duration of Sampling

Only one post-restoration survey is needed. The survey can be immediately post-restoration, unless otherwise specified in the monitoring plan. This will be compared to engineered designs.

3.3.2 WATER LEVELS

Two basic methods of monitoring water levels are described, and the appropriate technique will depend on the project type. For project locations that are wetted at all times, such as tidal reconnection, lacustrine reconnection, and off/side-channel creation projects, water levels will be monitored using data loggers to create hydrographs. When data loggers can't be deployed effectively, photographs and measurements at staff gages can be used to document basic project effectiveness.

Techniques

Hydrographs - Pre-restoration and post-restoration hydrographs from both downstream and upstream of the project site should be obtained using data loggers. For tidal and lacustuary (Great Lakes) marsh restoration projects, recipients may need to purchase data loggers if they do not already have access to them. The only requirement is that the data logger collects water level information (usually a pressure transducer). Pre- and post-restoration hydrographs will be generated by collecting water elevations using at least three data loggers (upstream and downstream of water restrictions, and one to correct for atmospheric pressure) surveyed into the same elevation benchmark and datum as the as-built drawings and project plans. Nearby established water level gages may be substituted for project-specific gages with approval from NOAA. All loggers or gages should be surveyed into the same elevation benchmark (and tidal datum if appropriate) as the as-built drawings and restoration designs.

For freshwater side/off channel reconnection projects, the loggers will correlate the off/side channel feature inundation periods with the adjacent stream flow levels, and correct for atmospheric pressure, rather than measuring either side of a particular restriction.

Photographs - For freshwater floodplain reconnection projects, pre- and post-restoration photographs combined with measurements at multiple staff gages will be used to show floodplain inundation extent throughout the project area during peak flows. Staff gages and corresponding photo points along one or more transects should be surveyed. Flood elevations within the project area will be measured in tandem with existing gages on an adjacent river.

Frequency/Duration of Sampling

Hydrographs - For tidal locations, each monitoring period will occur over a single 28-day tidal cycle, and measurements should be taken every 15 minutes.

For lacustrine locations, the monitoring period should record water surface elevations over at least 30 days and attempt to capture at least one short-period water level fluctuation event (e.g. storm events, seiching) during those times of the year when the proposed connection is planned to be fully open.

For freshwater side/off channel reconnection, the post-project monitoring period should occur during the rainy season and should capture peak flows during the greatest extent of inundation, and may cover up to 8 months. Discuss whether there are benefits to conducting monitoring during a biologically relevant season for target fish species with your NOAA Technical Monitor.

Photographs - For freshwater floodplain reconnection projects, the post project monitoring period should occur during peak flows or during the greatest extent of inundation, and may cover up to 8 months in order to capture high flow periods. Discuss whether there are benefits to conducting monitoring during a biologically relevant season for target fish species with your NOAA Technical Monitor.

Targets

Hydrographs - There is no set target for comparing the pre- and post-restoration hydrographs. Instead, the RC is looking for a change that indicates progress towards the project's overall goals.

Photographs - There is no set target for comparing the pre- and post-restoration photographs. Instead, the RC is looking for evidence that the new flooding regime is in line with the project's overall goals.

3.3.3 OPERATING AND MAINTENANCE COSTS

Change in operations, maintenance and/or liability costs associated with restoration.

- Pre-implementation: Calculate the expected average annual operating, maintenance, and/or liability costs over the next 5-year period if the project were not completed. Periodic or less frequent costs that may occur during this period (e.g. structural upgrades to meet safety or regulatory requirements) may be incorporated into the estimate.

- Post-implementation: Calculate the expected operating, maintenance, and/or liability costs over the next 5-year period once the project is completed.

3.3.4 PUBLIC SAFETY

Improved public safety associated with the restoration, if applicable.

- Pre-implementation: Describe whether restoration will eliminate or diminish a public safety hazard. Safety hazards may include flooding or safety risks posed by unsafe infrastructure. Describe the safety hazards caused by the characteristics of the current sites and how they will be eliminated or diminished through restoration.
- Post-implementation: After implementation, confirm that the public safety hazard has been eliminated or diminished.

3.3.5 COMMUNITY ENHANCEMENT

Local civic enhancement projects associated with the restoration, if applicable.

- Pre-implementation: Determine whether there will be a local community, civic enhancement project associated with the restoration project. Local civic enhancement projects may include, but are not limited to, adjacent recreation enhancement, park development, and/or riverfront revitalization.
- Post-implementation: Confirm that the enhancement project(s) associated with the restoration project was completed.

3.4 OYSTER RESTORATION

The RC restores bivalve shellfish through a variety of techniques involving reef and bed construction, and seeding when restoration potential is limited by the availability of larvae. A major focus of our work is oyster habitat restoration. The RC and partners developed the Oyster Habitat Restoration Monitoring and Assessment Handbook to increase consistency in monitoring. The RC's Tier I metrics are described in the Handbook as "Universal" metrics and environmental variables. The Handbook provides guidance for collecting the RC's Tier I metrics for both eastern (*Crassostrea virginica*) and Olympia (*Ostrea lurida*) oysters. The latter is the only native oyster species found on the west coast of the U.S.
These metrics are:

1) Reef areal dimensions
    a) Project/Site footprint
    b) Reef area
2) Reef height (minimum, mean, and maximum)
3) Oyster density
    a) Mean live oyster density (including oyster recruits)
    b) Mean original (planted) oyster seed density (if applicable)
4) Oyster Size-Frequency Distribution (shell height) (recruit density may be extrapolated from this data);

5) Environmental Variables (annual minimum and maximum)
    a) Water Temperature
    b) Salinity
    c) Dissolved Oxygen (subtidal reefs only)

3.4.1 REEF AREAL DIMENSIONS

Techniques

The Handbook provides recommendations for techniques for both intertidal and subtidal reefs.

Frequency/Duration of Sampling

The "short-term" monitoring guidelines in the Handbook describe the appropriate sampling time frames for RC Tier I oyster restoration metrics. This includes pre-restoration monitoring, monitoring within 3 months of construction to document an as-built condition, and then a post-implementation monitoring point at one to two years post-construction to include at least two recruitment phases.

Targets

There are no targets or performance criteria for this metric, as changes in the reef footprint or area can be due to spreading of the original cultch material, rather than growth of the living reef.

3.4.2 REEF HEIGHT

Techniques

Reef height is measured in comparison to the immediately surrounding substrate, not the shoreline. The Handbook provides recommendations for techniques for both intertidal and subtidal reefs.

Frequency/Duration of Sampling

The "short-term" monitoring guidelines in the Handbook describe the appropriate sampling time frames for RC Tier I oyster restoration metrics. This includes pre-restoration monitoring, monitoring within 3 months of construction to document an as-built condition, and then a post-implementation monitoring point at one to two years post-construction to include at least two recruitment phases.

Targets

Target setting guidelines are provided in the "performance criteria" sections of the Handbook; for any given area or region, recipients should also rely on published data (e.g. state reports, peer-reviewed papers) for their location or region to help determine targets. Valuable information about targets may also be obtained by talking to oyster biologists and oyster

restoration practitioners who have conducted studies or restoration projects in the region previously.

3.4.3 OYSTER DENSITY

Techniques

Mean Live Oyster Density - This is the mean number of live oysters per square meter, including recruits.

Mean Original Oyster Seed Density (if applicable) - This is the mean number of live oysters per square meter planted onto the reef. The Handbook includes two methods for making this measurement.

Frequency/Duration of Sampling

Mean Live Oyster Density - The "short-term" monitoring guidelines in the Handbook describe the appropriate sampling time frames for RC Tier I oyster restoration metrics—one to two years post-restoration, in order to capture two recruitment cycles. The Handbook recommends sampling annually, at the end of the oyster growing season when newly settled oysters have grown to a size greater than 10mm for eastern oysters and 3 mm for Olympia oysters.

Mean Original Oyster Seed Density (if applicable) - The density of planted oysters should be determined within one week after deployment.

Targets

Target setting guidelines are provided in the "performance criteria" sections of the Handbook; for any given area or region, recipients should also rely on published data (e.g. state reports, peer-reviewed papers) for their location or region to help determine targets. Valuable information about targets may also be obtained by talking to oyster biologists and oyster restoration practitioners who have conducted studies or restoration projects in the region previously.

3.4.4 OYSTER SIZE FREQUENCY DISTRIBUTION/MEAN SHELL HEIGHT

Techniques

Report the mean shell height (mm) of live oysters, with SE. Submit size frequency distribution with final report as a chart.

Frequency/Duration of Sampling

0-3 months, 1 year, 2nd year if needed to catch a second recruitment cycle.
The "short-term" monitoring guidelines in the Handbook describe the appropriate sampling time frames for RC Tier 1 oyster restoration metrics; the minimum post-implementation

monitoring timeframe is one to two years post-construction and should include at least two recruitment phases.

Targets

Target setting guidelines are provided in the "performance criteria" sections of the Handbook; for any given area or region, recipients should also rely on published data (e.g. state reports, peer-reviewed papers) for their location or region to help determine targets. Valuable information about targets may also be obtained by talking to oyster biologists and oyster restoration practitioners who have conducted studies or restoration projects in the region previously. This is especially important for the Olympia oyster, which has a very different life history and environmental requirements than the eastern oyster. For example, Olympia oysters grow more slowly (only about 15 - 20 mm or ~1/2-3/4 inch per year) and have a smaller maximum size (about 75mm or 3 inches). The eastern oyster, in contrast, can reach 100 – 115 mm or ~ 4.0-4.5 inches during the first two years of life in the Gulf of Mexico and may attain sizes of 12 inches (35 cm) or more over 50 years in the Chesapeake Bay and the Gulf of Mexico.

3.4.5 ENVIRONMENTAL VARIABLES

Techniques

Please review the Oyster Habitat Restoration Monitoring and Assessment Handbook for suggestions regarding monitoring methodology.

Frequency/Duration of Sampling

Continuous data measurements are preferred, either from a monitoring station located near the project (ex: NOAA, USGS, EPA), or an in situ continuous monitor deployed by a practitioner. If continuous measurements are not possible, measurements may be made less frequently, with the understanding that as the frequency of measurements decreases, the usefulness of the data also decreases. To assess the limitations of the data, practitioners should report the frequency and timing (i.e., season, tidal stage, time of day) of sampling. Please see the Oyster Habitat Restoration Monitoring and Assessment Handbook for further information and suggestions when continuous monitoring isn't available.

Targets

There are no set targets for these Environmental Variables as they are meant to provide data to help explain potential impacts to the performance of restored reefs