Monitoring Requirements Under the Estuary Restoration Act

The Estuary Restoration Act directs NOAA to develop standard monitoring protocols for estuary habitat restoration projects. This document summarizes NOAA's guidelines for evaluating the success of restoration activities in meeting project goals (posted at http://era.noaa.gov/htmls/era/era_monitoring.html). Because restoration project monitoring is often the responsibility of local project partners, the costs of monitoring and likely access of these parties to specialized equipment and technical expertise were considered in developing a set of standards that are both fiscally responsible and biologically pertinent. The supporting document *Science-based Restoration Monitoring of Coastal Habitats* (Thayer et al., 2003) contains additional information useful for preparing restoration monitoring plans.

A restoration monitoring plan must include information to allow for successful implementation and evaluation of the project over the long term. Because restoration science is still in development, restoration projects may not meet intended goals. Monitoring can provide information to explain why goals are not met, and data from these projects can help evaluate relative efficacy of different methods and improve restoration techniques and project designs for future efforts. The following five critical elements must be included in monitoring plans for projects supported by Estuary Restoration Act funds:

1. Monitoring parameters must be directly linked to the goals established for the project and/or the restoration of the watershed as a whole. Monitoring parameters should be driven by success criteria, which should be driven by project goals. They should be determined early in the restoration process and in conjunction with project planning and design. Success criteria may represent conditions at a reference site, or they may represent target conditions considering surrounding land use or other factors. Selected monitoring parameters must:

    - include at least one *structural* parameter (in addition to project acreage) to be monitored from the initiation/implementation of the restoration project,
    - include the addition of at least one *functional* parameter (in addition to project acreage) no later than one year from the initiation/implementation of the restoration project, and
    - continue to be measured until results (see #2) indicate a trend in whether or not the project is successful at meeting its goals (see #5 for recommended timeline). If a trend indicates that the project is not successfully meeting its goals, steps should be taken to determine why goals are not being met and determine whether mid-course corrections should occur (see item 5 below).

(See attached list of examples of commonly used structural and functional parameters)

2. Methods for evaluating results must be established (for example, statistical tests of hypotheses, trend analysis, or other quantitative or qualitative approaches) that directly relate to the goals for the project and/or watershed.

3. To establish initial conditions for each measure included in the monitoring plan, pre-construction or pre-design (baseline) monitoring must occur. Historical databases and other existing information about the study site and surrounding area can contribute to assessing baseline

conditions. Depending on the project site and ecosystem specifics, this may involve a one-time evaluation or multi-seasonal sampling.

4. Project sites should be compared to a reference site or historical data representing a reference condition in order to evaluate progress toward reaching goals. Ideally, reference sites would be monitored according to the same plan as the project site, so that natural variability and other regional fluctuations can be detected. Even if success criteria are not based on conditions at a reference site, reference sites provide useful information to interpret project performance.

5. Monitoring must be conducted in a timely fashion with a frequency and length of time appropriate to each parameter in the context of project goals and the status of the project. Immediately following construction it is imperative to intensively monitor those parameters that will drive the success of the project in order to allow for corrective measures. As the restored habitat matures, these measurements may become less frequent, while functional parameters may be more closely monitored.

   - Restoration projects must include provisions or contingency plans for adaptive management. Data must be provided in a timely fashion to project managers to allow for potential mid-course corrections.

   - The length of time over which monitoring is to be conducted should be driven by the project goals, success criteria, and monitoring parameters. Some impacts of a restoration project may be observed rather rapidly after construction, while others may take decades to fully appear. Five years should be considered a minimum for monitoring for projects with physical goals such as the stabilization of a shoreline. Any project including goals for organisms or ecological function should consider a longer monitoring period. If mid-course corrections occur, monitoring should continue, but is not required to continue for an additional five years after corrections are in place.

   - The monitoring schedule should be designed to measure each parameter at the most appropriate time of day, month and/or year; for example, according to wildlife activity levels, tidal cycles, migratory patterns, vegetation growing seasons, and other relatively predictable variations.

   - Monitoring results, both positive and negative, must be made available to others designing or managing restoration projects. Restoration practitioners are strongly encouraged to use the on-line National Estuary Restoration Inventory (www.neri.noaa.gov) to share project information, so that techniques can be selected and refined based on the collective experience of the restoration community.

Reference:
Thayer GW, TA McTigue, RJ Bellmer, FM Burrows, DH Merkey, AD Nickens, SJ Lozano, PF Gayaldo, PJ Polmateer, PT Pinit. 2003. Science-Based Restoration Monitoring of Coastal Habitats. Volume 1: A Framework for Monitoring Plans Under the Estuaries and Clean Waters Act of 2000 (Public Law 160-457). NOAA, National Ocean Service, National Centers for Coastal Ocean Science. 91 pages. http://coastalscience.noaa.gov/ecosystems/estuaries/restoration_monitoring.html

Examples of Restoration Monitoring Measurements

Listed below are examples of parameters that are indicators of habitat structure and function commonly monitored to evaluate restoration success. For more detailed information on selecting structural and functional parameters for specific habitat types, see *Science-based Restoration Monitoring of Coastal Habitats* (Thayer et al., 2003).

Indicators of Habitat Structure

Physical
Channel characteristics/Dimensions
Currents magnitude and timing/Water column current velocity
Fetch
Hydroperiod/tidal regime/Water level fluctuation over time
Inflow from upland sources/Sheet flow
Light penetration/Secchi/PAR
Pool/riffle ratio
Riverine water velocity and source
Temperature
Topography/Geomorphology/Basin elevations
Turbidity

Soil/Substrate
Bulk density
Moisture levels and drainage
Organic content
Redox potential
Sediment grain size/Percent sand, silt, clay, gravel, cobble
Sedimentation rate and quality

Vegetation
Algae species composition/percent cover
Basal area
Canopy areal extent and structure
Edge to area ratio
Epiphyte species composition/percent cover
Plant species composition/percent cover
Plant height
Ratio of vegetation to open water
Stem density
Woody debris

Fauna
Vertical relief of reef

Indicators of Habitat Function

Vegetation
Algae species composition/percent cover
Basal area
Biomass/Plant weight (above/below-ground parts)
Canopy areal extent and structure
Edge to area ratio
Epiphyte species composition/percent cover
Herbivory/Disease/Plant health
Invasives species composition/percent cover
Litter fall
Phytoplankton diversity/abundance
Plant species composition/percent cover
Plant height
Productivity rate
Rate of canopy closure
Seedling survival
Stem density
Woody debris

Fauna
Amphibians: species composition/abundance/life stage distribution/behavior
Animal health/disease
Birds: species composition/abundance/life stage distribution/behavior
Coral growth rate
Coral recruitment/survivorship
Fish: species composition/abundance/life stage distribution/behavior
Grazer density (for coral)
Invasives: species composition/abundance
Invertebrates: species composition/abundance/life stage distribution/behavior
Mammals: species composition/ abundance/life stage distribution/behavior
Reptiles: species composition/ abundance/life stage distribution/behavior
Shellfish disease/predation

Physical
Channel characteristics/Dimensions
Currents magnitude and timing/Water column current velocity
Hydroperiod/tidal regime/Water level fluctuation over time
Inflow from upland sources/Sheet flow
Light penetration/Secchi/PAR
Pool/riffle ratio
Riverine water velocity and source
Temperature
Topography/Geomorphology/Basin elevations
Turbidity

Chemical characteristics of water
Chlorophyll concentration
Dissolved oxygen
Nitrogen
Phosphorous
Salinity

Soil/Substrate
Bulk density
Moisture levels and drainage indicators
Nitrogen (pore water)
Phosphorous (pore water)
Organic content
Redox potential
Salinity (pore water)
Sediment grain size/Percent sand, silt, clay, gravel, cobble
Sedimentation rate and quality

Other
Trash
Fecal coliforms
Toxics