Monitoring Protocols to Gauge Living Shoreline Outcomes

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Abstract

Coastal wetlands and some other habitats are increasingly degraded, eroding, and drowning in the Delaware Estuary and vicinity. In response, many types of projects are being proposed or implemented to help stem these losses and impart coastal resilience, such as living shorelines, thin-layer sediment application, and hydrologic improvements. Despite growing interest in living shoreline and other tactics within the Delaware Estuary as a result of Hurricane Sandy, few projects have been locally installed and there are insufficient scientific studies concerning their performance and long-term viability. It is therefore important that outcomes from new projects are assessed in a standardized manner and that resulting data are intercomparable and sharable.

To address this assessment gap, a draft monitoring framework was developed by PDE and shared in April 2014. With help from local and regional partners, this framework is now being adapted to serve the diverse needs of agencies, academics, non-profits and the public. The framework recognizes that different users and project implementers may have vastly different goals, capacity and resources. Hence, recommended metrics and methods depend on these additional considerations. Metrics are parameters used to assess changes in key site features (e.g., physical, biological conditions), whereas methods are the techniques used to collect data per metric. In addition to helping select appropriate measures and methods, the framework provides recommendations for crafting a monitoring plan. The goal of the monitoring framework is to help assess and share understandable outcomes among the restoration community so that the design of future projects can continue to be improved based on past successes and lessons learned.

Definitions

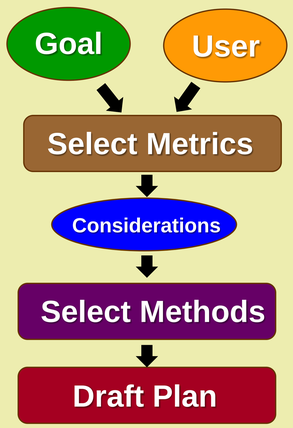
The term "Living Shoreline" represents a number of treatments and techniques that:

1) offer resilience to shorelines from wave, surge, tidal, or boat wake energies and/or rises in sea level;
2) utilizes predominantly natural materials and/or processes exclusively or in combination with structural components;
3) sustains, enhances, and/or restores ecological functions and connections between uplands and aquatic areas.

The focus of this monitoring framework is living shoreline projects, but it can be adapted for other types of coastal resilience and enhancement projects such as thin-layer sediment application and hydrological restoration.

Approach

There is a broad spectrum of monitoring options. Decisions regarding which metrics and methods to implement are selected based on goals, user sector, and additional considerations. The following model represents the step-wise procedure recommended for developing a suitable monitoring plan. The following sections describe each step.



Step 1. Identify Goals and Users

Goal

Monitoring should be tailored to assess whether a project achieves it's goals. Although many coastal resilience projects aim to stabilize erosion while enhancing environmental conditions, there may be other important objectives. Five example goals are shown in the green column in Table 1.

User

Different users groups may have disparate interests, expertise, and resources. Although standardization is to be encouraged, the actual selection of metrics and methods may vary widely. Four example user groups are shown in the orange row in Table 1.

Table 1. *A two-factor matrix showing twenty different User/Goal combinations.*

	Regulatory Agency	Science Group	Contractors	Public
Erosion Control	A1	A2	A3	A4
Water Quality	B1	B2	B3	B4
Fish & Wildlife	C1	C2	C3	C4
Contaminant	D1	D2	D3	D3
Economic	E1	E2	E3	E4
Social	F1	F2	F3	F4

To facilitate selection of recommended metrics and methods, self identify as one of the user groups and select your top goal(s). More than one combination may apply. Note the code(s) of any cells in the table and proceed to Step 2.

Step 2. Select Appropriate Metrics

Metrics

Metrics are specific parameters used to assess general features whereas **methods** are the actual techniques that are used to assess the metrics.

Once fully developed, the framework will recommend one or more metrics for each User/Goal pairing (from Table 1). Some metrics may be suggested for most or all users per goal, and some metrics may be suggested for most or all goals per user group.

Tables 2-4. Preliminary list of example metrics (column 4), grouped by major attributes: physical/chemical in Table 2, biological/structural in Table 3, and economic/social in Table 4. Group/user code recommendations have yet to be determined (TBD in column 3). Example methods options are shown in column 5.

Attribute	Feature Subset	Goal/User Code	Metric	Method Options
Physical	Shoreline Stabilization	TBD	Elevation Change (Marsh Edge/Interior)	RTK-GPS
		TBD	Shoreline Slope/Contours	RTK-GPS
		TBD	Position of Shoreline	RTK-GPS
		TBD	Sediment Capture (Volume)	RTK-GPS
	Extent of Project	TBD	Changes Over Time	RTK-GPS Measuring Tape GIS Photographs
	Sedimentation	TBD	Sediment Accretion	Feldspar Marker Horizons
	Wave Climate	TBD	Wave Height/Amplitude	Water-level Loggers pressure gauges wave staffs range finders observations
	Energy	TBD	Mass Transport Rate	CETN/Fluo Balls
		TBD	Current Velocity	ADVs, ADCPs
		TBD	Current Direction	
	Sediment Character	TBD	Sediment Texture, Grain Size	Grab Sample Analysis
		TBD	Sediment Organic Content	Loss on Ignition
	Channelization	TBD	Channel Morphometry	RTK Survey Flagging
Chemical	Environmental Conditions	TBD	Temperature	YSI Measures
		TBD	Salinity	YSI Measures
	Water Quality	TBD	Particulate Matter	Water Samples
		TBD	Dissolved Oxygen	YSI Measures
		TBD	Particulate Pollutants	Water Samples
		TBD	Water Column Nutrients	Grab Sample Analysis
		TBD	Contaminants	Grab Sample Analysis
		TBD	Water Clarity	In-Situ Turbidity

Attribute	Feature Subset	Goal/User Code	Metric	Method Options
Economic	TBD	TBD	TBD	TBD
Social	Public Perception/ Interpretation	TBD	Visitation	TBD
		TBD	Environ. Education	TBD
		TBD	Perception of Community Resilience	TBD
		TBD	Recreational/Commercial Fishing	TBD

Tables 2-4 are still in development. Once these are completed, the next step will be to choose the methods from Column 5 that are most suited for your project (see Step 3).

Attribute	Feature Subset	Goal/User Code	Metric	Method Options
Biological	Submerged Aquatic Vegetation	TBD	SAV Coverage	Quadrat Surveys
	Vascular Plants	TBD	Vegetation Complexity	Horizontal Vegetation Obstruction Light Attenuation by Canopy
		TBD	Vegetation Integrity	Weight of Clippings
		TBD	Vegetation Robustness	Horizontal Vegetation Obstruction
		TBD	Aboveground Biomass	
		TBD	Belowground Biomass	Analysis of Cores
	Fauna	TBD	Extent of Bivalve Community	RTK-GPS, Lip Counts Quadrat Surveys
		TBD	Bivalve Density by Species	Quadrat Surveys
		TBD	Bivalve Demographics	Quadrat Surveys
		TBD	Bivalve Recruitment	Quadrat Surveys
		TBD	Bivalve Condition/Health	Physiological Condition Index
		TBD	Inhibition of Faunal Movement	Observations
		TBD	Gastropods (snails)	
		TBD	Crustaceans Burrowing (Fiddlers)	Quadrat Surveys
		TBD	Crustaceans/Blue Crabs -Motile	Seines, Traps, Nets
		TBD	Horseshoe Crabs	Observations
		TBD	Infauna	Quadrat Surveys
		TBD	Tubeworms (e.g. Sabellaria)	Quadrat Surveys
		TBD	Fish	Seines, Traps, Nets
		TBD	Avifauna	Observations
		TBD	Mammals	Observations
		TBD	Reptiles (e.g. terrapins)	Observations
		TBD	Vandalism	Observations
Disturbance	Anthropogenic	TBD	Trash	Observations
	Wildlife	TBD	Goose Foraging	Observations
		TBD	Fouling by Non-Target Organism	Quadrat Surveys
		TBD	Fouling by Invasives	Quadrat Surveys
Structural	Installed Materials (Coir, shellbags,WADs, Oyster Castles)	TBD	Crest Elevation	Observation Aerial Extent
		TBD	Position	Observation Aerial Extent
	Existing Materials (Existing Erosion Control	TBD	Crest Elevation	Observation Aerial Extent
		TBD	Position	Observation Aerial Extent

Step 3. Choose Methods

Before selecting methods to assess the chosen metrics, it is important to recognize any constraints or special circumstances that may guide choices. These additional considerations are briefly listed below.

Considerations

- **Technical Expertise.** Some methods require special training.
- **Budget/Resources.** Methods vary widely in cost, and some require special equipment.
- **Time Constraints**. Grant periods or other conditions may require expedited monitoring or otherwise limit the use of some methods and approaches.
- **Permitting**. Some monitoring methods may require special permits different from construction permits.
- **Scale.** Some methods are more suitable for larger or smaller scales of time and space.
- **Analysis**. The ideal design of monitoring plans (statistics, replication) may be constrained. For example, in cases where a comparative control is sought, one may not exist.

For each metric, the framework will rank the various methods options as relatively low, medium or high per consideration. For example, cost is usually an important consideration, and so methods will be compared for their expense.

Methods

To facilitate choosing appropriate methods per metric (from column 5 in Tables 2-4), the comparative rankings of these additional considerations will be displayed using "stoplight coloration" when the tables are fully populated, similar to the example below.

Table 5. *Comparison of additional considerations in selection of methods (example).*

Method	Technical Expertise	Budget	Timetable	Permitting	Scale	Analysis
RTK GPS						
Core Sampling						
Light Attenuation						
Quadrat Sampling						
Vegetation Obstruction						
PVC Elevation Marker						
Transect Length Measurement						

Step 4. Prepare Monitoring Plan

The monitoring plan should identify the appropriate endpoints, or success criteria, that will allow the user to assess outcomes of the project. For example, are there thresholds that need to be met?

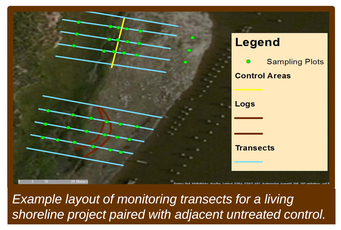
Consider how the selected metrics and methods need to be applied to gauge the endpoints. If the study is scientific or subject to the need for proof (e.g. mitigation), what are the statistical requirements?

Draft Plan

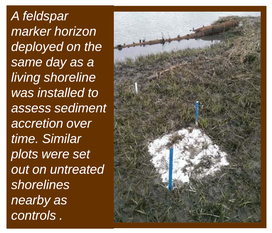
Monitoring plans will obviously vary widely, depending on the goals and users. At a minimum, they should identify the **goals, uses**, and **endpoints** for the project or program. They should summarize the metrics and methods, and discuss any additional considerations, such as timeline.

In cases where proof of performance is needed, or in comparative scientific studies, it is important to adopt an accepted statistical approach such as a Before-After-Control-Impact (BACI) design (see below). Where constrained, the BACI approach can be modified (B vs. A, or I vs. C). It can also be strengthened by comparing outcomes to reference stations (BACIR).

In addition to the statistical design (where appropriate), monitoring plans should describe the frequency, duration, and seasonality, of any sample collection. They should describe any plot layouts, replication, and cite or otherwise describe appropriate methods.



Example layout of monitoring transects for a living shoreline project paired with adjacent untreated control.



A feldspar marker horizon deployed on the same day as a living shoreline was installed to assess sediment accretion over time. Similar plots were set out on untreated shorelines nearby as controls .

State Efforts

- **Delaware.** The State of Delaware Living Shoreline Committee was formed in 2013. The Standards and Monitoring Subcommittee is working on a monitoring framework, which should be completed and ready for testing by the end of this year. To date, this framework aims specifically at living shoreline projects.
- **New Jersey.** The Partnership for the Delaware Estuary is working with the Nature Conservancy and New Jersey Department of Environmental Protection to outline a monitoring framework that can be applied to all coastal resilience projects. A statewide Living Shoreline Committee is also planned.
- **Pennsylvania.** No living shoreline projects or monitoring frameworks have been advanced as yet.

Fish visitation of living shorelines can be monitored intensively with seines and nets, or in some cases more simply with minnow pots.

Sediment capture (or erosion) can be tracked with 3-D GPS, or in some cases more simply by direct measures.

Water filtration benefits can be estimated from bivalve shellfish census data.

Next Steps

- Special Panel Session, Wed. 9:00-10:30, Crystal Ball Room
- Further development of monitoring frameworks per state
- Methods repository to promote consistency
- Identification/funding for pilot projects to test frameworks
- Derivations of frameworks may be needed for specific purposes (e.g. regulatory, citizen science)
- Interstate sharing of data and outcomes; project registry
- Adaptive management of frameworks as technology and understanding evolves

Acknowledgements

Support for this work has come from the Environmental Protection Agency via the National Estuary Program. Many individuals are contributing input on parallel, state-specific versions of monitoring frameworks. Specifically, we thank the following partners for their many intellectual contributions.

Delaware

- Doug Janiec, Sovereign Consulting
- Andy Howard, DNREC
- Alison Rogerson, DNREC
- Brian Boutin, Nature Conservancy
- Bart Wilson, USFWS

New Jersey

- Danielle Donkersloot, NJDEP
- Metthea Yepsen, Nature Conservancy
- Carl Alderson, NOAA
- Moses Katkowski, Nature Conservancy
- Martha Maxwell Doyle, Barnegat Bay P.
- Dorina Frizzera, NJDEP