EXECUTIVE SUMMARY

Healthy coastal habitats are not only important ecologically; they also support healthy coastal communities and improve the quality of people's lives. Despite their many benefits and values, coastal habitats have been systematically modified, degraded, and destroyed throughout the United States and its protectorates beginning with European colonization in the 1600's (Dahl 1990). As a result, many coastal habitats around the United States are in desperate need of restoration. The monitoring of restoration projects, the focus of this document, is necessary to ensure that restoration efforts are successful, to further the science, and to increase the efficiency of future restoration efforts.

WHAT IS RESTORATION MONITORING?

The science of restoration requires two basic tools: the ability to manipulate ecosystems to recreate a desired community, and the ability to evaluate whether the manipulation has produced the desired change (Keddy 2000). The latter is often referred to as restoration monitoring.

For this manual, the definition of restoration monitoring is as follows:

> "*The systematic collection and analysis of data that provides information useful for measuring restoration project performance at a variety of scales (locally, regionally, and nationally), determining when modification of efforts are necessary, and building long-term public support for habitat protection and restoration*."

Restoration monitoring contributes to the understanding of complex ecological systems (Meeker et al. 1996) and is essential in documenting restoration performance and adapting project and program approaches. When the results of monitoring restored coastal areas are disseminated and shared amongst practitioners, they can provide tools to help plan management strategies and improve future restoration practices and projects (Washington et al. 2000). Restoration monitoring can be used to determine whether project goals are being met and if mid-course corrections are necessary. Monitoring provides information on whether selected project goals are good measures for future projects and on how to do routine maintenance in restored areas (NOAA et al. 2002). Restoration monitoring also provides the basis for a rigorous review of the pre-construction project planning and engineering.

Without effective monitoring, restoration projects are exposed to several risks including:

- The inability to obtain early warnings indicating that a restoration project is not developing as expected
- The inability to assess whether specific project goals and objectives (both ecological and human dimensions) are being met
- The inability to determine what measures might need to be taken to better achieve those goals
- Increased difficultly in gauging how well a restoration site is functioning both before and after implementation, and
- Decreased project coordination and efficiency

To address these and other issues associated with restoration monitoring, NOAA has provided guidance to the public in two volumes. The first volume, *Science-Based Restoration Monitoring of Coastal Habitats, Volume One: A Framework for Monitoring Plans under the Estuaries and Clean Waters Act of 2000 (Public Law 160-457)* was released in 2003. It outlines the steps necessary to develop a monitoring plan for any coastal habitat restoration project. Experienced

restoration practitioners, biologists, and ecologists as well as those new to coastal habitat restoration and ecology can benefit from the step-by-step approach to designing a monitoring plan outlined in *Volume One*. *Volume Two*, *Tools for Monitoring Coastal Habitats* expands upon the information in *Volume One*. *Volume Two* is designed more for practitioners who do not have extensive experience in coastal ecology or social science than is *Volume One*. Professionals familiar with coastal habitats and their social and ecological aspects, however, may benefit from the annotated bibliographies, literature review, and other tools provided in *Volume Two*.

The first section of *Volume Two*, **Monitoring Progress Toward Goals** (Chapters 1-14) includes:

- An introduction to Volume Two
- Information on the structural and functional characteristics of coastal habitats that may be of use in restoration monitoring
- Annotated bibliographies of restoration-related literature and technical methods manuals for each habitat type, and
- A chapter concerning the human dimensions of coastal habitat restoration monitoring

The second section, **Context for Restoration** (Chapters 15-18) includes:

- A review of methods to select reference conditions
- A sample list of costs associated with restoration monitoring
- An overview of an online, searchable database of coastal monitoring projects from around the United States, and
- A review of federal legislation that supports restoration and restoration monitoring

Volume Two is intended to provide readers with information on and pertinent to monitoring of restoration activities and, in so doing, includes references to ecological and human dimensions characteristics and to restoration efforts. *Volume Two* is not intended, however, as a treatise on the ecology and social aspects of each of the habitats. Numerous texts and published documents that do this well are already available, particularly for the ecological characteristics. Likewise, detailed discussions of the restoration of the various habitats are also not presented; again, for many of the habitats, scientific publications on individual restoration methods and projects already exist.

Volume Two is also not intended as a 'how to' or methods manual; many of these are already available on a regional or habitat specific basis[1]. *Volume Two* does not provide detailed procedures that practitioners can directly use in the field to monitor habitat characteristics, although it does mention or list many that are commonly used. The tremendous diversity of coastal habitats across the United States, the types and levels of impact to them, the differing scales of restoration activities, and variety of techniques used in restoration and restoration monitoring prevent the development of universal protocols. Thus, the authors of this volume have taken the approach of explaining, based on information found in the scientific literature, *what can be measured* during restoration monitoring, *why it is important*, and *what information it provides* about the progress of a restoration effort. Based on this information, the individual practitioner can then develop monitoring protocols suited to the goals of his or her particular restoration project.

AN INTRODUCTION TO THE CHAPTERS

Chapter 1: Introduction - Provides context for the publication of this document and the associated *Volume One*. Chapter 1 also describes the selection and organization of information in each of the following chapters, who the intended audience is as well as how they should use *Volume Two*. It

[1] Many 'how to' and sampling/monitoring methods manuals for specific habitats are listed in the second appendices of chapters 2-14.

is recommended that all readers, regardless of the habitat or social characteristics they are interested in monitoring, should read Chapter 1.

Chapter 2: Water Column - A conceptual volume of water extending from the water surface down to, but not including the substrate. The water column is unique among the habitats covered in *Volume Two* as characteristics of the water column will be a part of virtually all monitoring efforts. Therefore, those interested in any type of coastal habitat restoration should also read Chapter 2.

Chapter 3: Coral Reefs - Highly diverse ecosystems, found in warm, clear, shallow waters of tropical oceans worldwide. They are composed of marine polyps that secrete a hard calcium carbonate skeleton that serves as a base or substrate for the colony. Restoration of coral reefs can be challenging as water temperatures that may be outside of the control of restoration practitioners can directly affect corals.

Chapter 4: Oyster Reefs - Dense, highly structured communities of individual oysters growing on the shells of dead oysters. Oyster reefs can filter massive amounts of water, removing large amounts of suspended and dissolved material. It is partially the removal of historic oyster beds that has contributed to the decline in water quality in some estuaries such as the Chesapeake Bay.

Chapter 5: Soft Bottom - Loose, unconsolidated substrate characterized by fine to coarse-grained sediment. At first glance, soft bottoms may appear to be devoid of life. The soft, often organic, sediments are, however, teaming with organisms that live below the sediment surface and provide an important link in estuarine food webs.

Chapter 6: Kelp and other Macroalgae - Relatively shallow (less than 50m deep) subtidal and intertidal algal communities dominated by very large brown algae. Kelp and other macroalgae grow on hard or consolidated substrates forming extensive three-dimensional structures that support numerous plant and animal communities.

Chapter 7: Rock Bottom and Rocky Shoreline - Includes all wetlands, deepwater, and shoreline habitats with substrates having an aerial cover of stones, boulders, or bedrock 75% or greater and vegetative cover of less than 30% (Cowardin et al. 1979). Water regimes are restricted to subtidal, permanently flooded, intermittently exposed, and semi-permanently flooded. The rock bottom habitats addressed include bedrock and rubble.

Chapter 8: Soft Shoreline - Includes all habitats having three characteristics: (1) unconsolidated substrates with less than 75% aerial cover of stones, boulders, or bedrock; (2) less than 30% aerial cover of vegetation other than pioneering plants; and (3) any of the following water regimes: irregularly exposed, regularly flooded, irregularly flooded, seasonally flooded, temporarily flooded, intermittently flooded, saturated, or artificially flooded (Cowardin et al. 1979). This definition includes cobble-gravel, sand, and mud. Most commonly, these areas include beaches and mudflats used by people for recreation and shorebirds as feeding areas.

Chapter 9: Submerged Aquatic Vegetation (SAV; includes marine/brackish and freshwater) - Seagrasses (marine SAV) and other rooted aquatic plants grow on soft sediments in sheltered, shallow waters of estuaries, bays, and lagoons. Freshwater species are found in estuaries, rivers, and lakes and are adapted to the short- and long-term water level fluctuations typical of freshwater ecosystems. SAV along with kelp habitats can be thought of as underwater forests as they provided extensive, diverse vertical structure for animals and other plants to colonize.

Chapter 10: Marshes (marine/brackish and freshwater) - Transitional habitats between

terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is covered by shallow water tidally or seasonally. Freshwater species are adapted to the short- and long-term water level fluctuations typical of freshwater ecosystems. Coastal marshes are the kidneys of estuaries, filtering out sediments, nutrients, and other pollutants carried in runoff before they can impact downstream water quality.

Chapter 11: Mangrove Swamps - Swamps dominated by shrubs or trees that live between the sea and the land in areas that are inundated by tides and are of the genera *Avicennia*, *Rhizophora*, and *Laguncularia*. Mangroves thrive along protected shores with fine-grained sediments where the mean temperature during the coldest month is greater than 20º C, which limits their northern distribution. They serve many of the same functions as coastal salt marshes, which they often replace, at lower latitudes.

Chapter 12: Deepwater Swamps - Forested wetlands that develop along edges of lakes, alluvial river swamps, in slow-flowing strands, and in large coastal-wetland complexes. They can be found along the Atlantic and Gulf Coasts and throughout the Mississippi River valley. They are distinguished from other forested habitats by the tolerance of the dominant vegetation to prolonged flooding.

Chapter 13: Riverine Forests - Forests found along sluggish streams, drainage depressions, and in large alluvial floodplains. Although associated with deepwater swamps in the southeastern United States, riverine forests are found throughout the country in areas that do not have prolonged flooding. "Riparian" or "floodplain" forests are other terms that can be used to describe riverine forest habitats.

Chapter 14: Human Dimensions - Provides stakeholders engaged in restoration efforts with a basic understanding of the human dimensions issues in coastal restoration. A human dimensions approach to coastal restoration monitoring focuses on identifying and describing how people value, utilize, and benefit from the restoration of coastal habitats. Restoration projects that address diverse social values associated with coastal habitats, and that attempt to answer the questions *who cares about coastal restoration?* and *why it is important to them?*, are more likely to succeed in the long run. By incorporating human dimensions measures into their monitoring efforts, practitioners can increase public awareness of and support for restoration projects. As with Chapters 1 and 2, practitioners are encouraged to read and use the material and resources presented in Chapter 14, regardless of the particular habitat they are attempting to restore.

Chapter 15: Reference Conditions - Reviews methods available for choosing areas or conditions to which a restoration site may be compared both for the purpose of setting goals during project planning and for monitoring the development of the restored site over time. Examples of different methods that have been used in the past and lessons learned from them are provided.

Chapter 16: Cost Estimates - A listing of generalized costs associated with personnel, labor, and equipment to assist in the development of planning preliminary cost estimates of restoration monitoring activities. Some of this information will also be pertinent to estimating costs of conducting a restoration project as well.

Chapter 17: Review of Monitoring Programs - Provides a brief description of the online review of monitoring programs in the United States. The database can be accessed through the NOAA Restoration Portal (http://restoration.noaa.gov/). This database will allow interested parties to search restoration program databases by parameters and methodologies used in monitoring, contact

responsible persons, and provide examples that could serve as models for establishment or improvement of their own monitoring efforts.

Chapter 18: Review of Acts - A summary of the major United States Acts that support restoration monitoring. These resources may be used in documenting support for restoration and restoration monitoring activities.

Glossary - A listing and description of many of the technical terms found throughout *Volume Two* that may not be familiar to the reader.

References

Cowardin, L. M., V. Carter, F. C. Golet and E. T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States, 104 pp. FWS/OBS-79/31, U.S. Fish and Wildlife Service, Washington, D.C.

Dahl, T. E. 1990. Wetland loss in the United States 1780's to 1980's, United States Department of Interior, Fish and Wildlife Service, Washington, D.C.

Keddy, P. A. 2000. Wetland Ecology: Principles and Conservation. Cambridge University Press, Cambridge, United Kingdom.

Meeker, S., A. Reid, J. Schloss and A. Hayden. 1996. Great Bay Watch: A Citizen Water Monitoring Programpp. UNMP-AR-SG96-7, University of New Hampshire/University of Maine Sea Grant College Program.

NOAA, Environmental Protection Agency, Army Corps of Engineers, United States Fish and Wildlife Service and Natural Resources Conservation Service. 2002. An Introduction and User's Guide to Wetland Restoration, Creation, and Enhancement (pre-print copy), Silver Spring, MD.

Washington, H., J. Malloy, R. Lonie, D. Love, J. Dumbrell, P. Bennett and S. Baldwin. 2000. Aspects of Catchment Health: A Community Environmental Assessment and Monitoring Manual. Hawkesbury-Nepean Catchment Management Trust, Windsor, Australia.