RESTORATION OF COASTAL HABITATS AND SPECIES IN THE GULF OF MAINE

Prepared for

Gulf of Maine
Council on the
Marine Environment

by

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EXECUTIVE SUMMARY

The Gulf of Maine is a dynamic system, complete with open ocean habitat, estuaries linking land and sea by way of rivers and tidal wetlands, and rocky shorelines and islands that are nesting grounds for thousands of migratory seabirds. This system, that has taken millennia to evolve, has taken humans only three centuries to degrade. Hundreds of dams now barricade salmon and herring spawning grounds, while diking and water control structures have converted over half of the marshes in the Bay of Fundy to agricultural lands. In Massachusetts, New Hampshire, and Maine, a majority of the salt marshes have been ditched and drained for mosquito control, while roads and coastal development have severed links between land and sea. With increased pressures and impacts on coastal habitats, waterfowl, seabird, and anadromous fish populations have plummeted. Less obvious impacts, such as poor water quality, have contaminated shellfish beds and decimated meadows of seagrass, which many species of fish and invertebrates depend upon for survival.

In an effort to reverse this destructive trend and strive toward a net gain in natural resources, environmentalists are looking more and more toward restoration as part of the solution. The term *restoration* as it is used here refers to the various ways in which humans are altering the existing environment in an effort to reverse cumulative impacts to habitats and their affiliated species. Efforts over the past few decades show promise and have included restoring tidal flow to salt marshes, transplanting seagrass, providing fish passage at dams and restoring spawning grounds, and building wetland habitat for waterfowl. Hundreds of government and non-government organizations, scientists, consultants, educators, and advocates are working toward the protection and restoration of coastal habitats and species in the Gulf. Sharing information and communication is increasingly important with this wide range of interest groups and the diversity of work being conducted. Improvements in communication will enable us to learn from our experiences, prevent duplication of efforts, identify restoration opportunities and funding partners, and form collaborations.

Project Overview

This report and an associated database of restoration projects are intended to increase the effectiveness of coastal habitat and species restoration in the Gulf of Maine by expanding coordination and facilitating information exchange. The project was initiated in October 1996 in accordance with one of the priority goals of the Gulf of Maine Council on the Marine Environment (GOMC): to "Identify, protect, and restore the Gulf’s terrestrial, coastal and marine habitats." GOMC is a collaborative organization formed by the states and provinces of the Gulf (Massachusetts, New Hampshire, Maine, New Brunswick, and Nova Scotia) that strives to maintain and enhance environmental quality in the Gulf of Maine to allow for sustainable resource use by existing and future generations.

Various types of information have been collected and are included in this report, including data on contacts (i.e., consultants, researchers, managers), bibliographic references, information on existing evaluative methodologies, and information on the restoration of tidal marshes, freshwater impoundment construction, tidal flats, seagrass, dunes, seabird populations, and anadromous fish. Information specific to past and current tidal marsh, freshwater impoundment, tidal flat, and seagrass restoration projects was entered into a database on coastal wetlands (Table 1). Although information on dunes and restoration of seabirds and anadromous fish is presented in this report, it was not included in the database, due to the types of data collected and because central sources for data already exist. The database was constructed using Microsoft Access™ and currently contains descriptive information such as project location, site and work descriptions, information on monitoring, and contact information.

During data collection, several sources of information on potential tidal marsh restoration projects were uncovered. These sources have identified approximately 350 sites in Massachusetts, New Hampshire, and Maine that have restoration potential. These sites were combined and added to the database to assist in future project implementation and to expose restoration opportunities (Table 2). Similar sources of information on potential projects were not found for Canada. The database, as well as this report, will be made available on the Gulf of Maine Council's Website at www.gulfofmaine.org.

Table 1 Number and Acreage of Current and Past Tidal Marsh, Impoundment, Tidal Flat, and Seagrass Projects

Project Type	**Number of Restoration Projects**					**Total Projects**	**Total Acres**
	MA	**NH**	**ME**	**NB**	**NS**		
Tidal marsh - mitigation	28	7	9	0	0	44	132
Tidal marsh - proactive	37	21	9	0	0	67	2,110
Freshwater impoundments	0	0	0	61	46	107	18,005
Tidal flat	1	1	2	0	0	4	10
Seagrass	1	2	0	0	0	3	10

Number and acreage represent those projects for which information was collected and entered into the database as of March 1998. Projects indicated are underway or complete. Acreage does not imply that the number of acres shown were "successfully" restored.

Table 2 Number and Estimated Acreage of Tidal Marsh Sites That Have Been Identified as Having Restoration Potential

Impacts Associated with Sites	**Number of Sites**			**Total Sites Identified**	**Total Acres Identified**	**Number of Sites Acreage Based on**
	MA	**NH**	**ME**			
Tidal restrictions	257	17	12	286	2,611	232
Ditched, diked, and/or drained	7	0	12	19	540	10
Filled	27	3	20	50	595	18

A total of 355 tidal marsh sites have been identified in Massachusetts, New Hampshire, and Maine as of April 1998. 3,746 acres were tallied for 260 of these sites. Since acreage is based on fewer than the total sites identified, acreage is underestimated. Sources of data and information are listed in Section 3.

Key Findings

Key findings are provided for each of the major categories for which information was collected. More detailed information is provided in the Sections to follow and in the Coastal Wetland Restoration Database.

Tidal Marshes

Restoration of tidal marshes may be conducted either to mitigate for permitted impacts or to compensate and offset cumulative or historical impacts through proactive efforts. For the 111 tidal marsh restoration projects listed in Table 1, including both mitigation and proactive projects, 45 involved tidal restrictions, 42 involved the removal of fill, 19 involved the creation of tidal marsh habitat, and 35 involved Open Marsh Water Management. Some projects may have involved more than one type of restoration work. Compensatory mitigation and proactive projects are very different in terms of project objectives, and, quite often, in the type of work conducted.

Mitigation

Compensatory mitigation projects aim to compensate for unavoidable adverse impacts through the restoration, creation, or enhancement of natural resources. The primary goal of these projects is to replace habitat functions and values lost during a permitted activity. These projects are often the least cost effective, especially those that involve habitat creation such as the conversion of an upland habitat to a tidal wetland. For example, it cost Logan Airport in Boston over $700,000 to construct a 1.3 acre salt marsh (Louis Berger & Assoc., 1997). This high cost reflects the high expense of permitting, planning, and construction often involved with compensatory mitigation projects.

As Table 2 shows, many opportunities for restoration have been identified. If restoration opportunities do not exist on-site for effective compensatory mitigation, resources should be allocated to support projects offsite. Mitigation banks are designed to pool money from mitigation and implement larger and more effective restoration projects. Restoration sites selected for mitigation banks may be located outside of the town where impacts occurred. This makes it difficult to convince local municipalities of the long-term ecological benefits. Information collected indicates that few mitigation projects are tracked and evaluated on a long-term basis and reveals the need for more rigorous tracking programs to enforce permit compliance and to document ecological changes. Existing permit tracking databases could be modified to include information on acres impacted versus acres restored and a brief description of the type and location of compensatory work. In addition, monitoring and assessment reports need to be written in a consistent manner and their submittal to regulatory agencies enforced.

Proactive

Proactive projects aim to restore degraded habitats to offset historical and cumulative impacts rather than compensate for permitted activities. These projects are becoming numerous and are often the most cost effective (other than conservation of existing habitats) due to the types of work involved and in-kind contributions of resources. By replacing a culvert or installing a self-regulating tide gate, tidal marshes can be restored at minimal cost. For example, restoring tidal flow to a 50 acre salt marsh in Rye, New Hampshire, was completed at a cost of

$40,000 (Louis Berger & Assoc., 1997). Other projects may involve the excavation of fill material and planting of vegetation or Open Marsh Water Management (OMWM). OMWM aims to restore ditched and drained wetlands and control mosquito populations. Resources need to be allocated toward initiatives that identify and evaluate restoration opportunities, and more importantly, toward those projects that have already been identified as having strong restoration potential. (See Table 2.)

Freshwater impoundments

Since Acadian settlement in the 1670s, over half of the tidal marshes in the Bay of Fundy have been lost to construction of dikes and conversion of marshes to agricultural land. Land acquisition, water level management, vegetation control, and impoundment construction are conducted as a means of increasing waterfowl numbers and freshwater wetland habitat on unused agricultural lands. These lands may not be reverted to salt marsh due to existing infrastructure and the need for flood protection. Over 100 impoundments, contributing to over 18,000 acres of wetland complexes, fall within the Gulf of Maine Watershed. Virtually all restoration work is conducted by Ducks Unlimited Canada and partners within the Eastern Habitat Joint Venture (EHJV) (Howell et al., 1991). The success of efforts underway by EHJV is based on annual waterfowl numbers for North America. Since the implementation of the North American Waterfowl Management Plan (NAWMP), numbers have increased from a low of 55 million birds in 1985 to approximately 90 million today. Goals of the NAWMP are ambitious and with additional resources, EHJV will be able to convert additional unused agricultural lands to wetland habitat and achieve NAWMP goals.

Tidal flats

Very little information was found on projects involving restoration of tidal flats. The few that have been and are being conducted are part of mitigation efforts in Revere, Massachusetts, and the Port Authority Expansion Project in Portsmouth, New Hampshire. One project in Maine near Beals Island involved the use of dredged materials in the construction of mud flat habitat. Restoration of shellfish beds was not included in this project on the premise that most of these projects aim to restore a fishery, rather than habitat. However, shellfish beds are a type of habitat, and their restoration for purposes other than human exploitation should be considered habitat restoration. No information on tidal flat restoration in Canada was found.

Seagrass

Although low in number, projects involving the restoration of seagrass exist. One experimental seagrass project has been conducted in Massachusetts, while several seagrass restoration projects have been conducted in New Hampshire's Great Bay Estuary. Additional projects have been conducted in Buzzards Bay and Narragansett Bay; however, they lie just outside the Gulf of Maine watershed. Techniques for transplanting and seeding seagrass are becoming more refined, and additional seagrass restoration projects and projects aimed at improving water quality will be necessary to compensate for historical losses.

Dunes

Dune restoration projects extend from Cape Cod to southern Maine. Most dune projects are relatively small in size and go undetected since they are often planted and maintained with the permission of the local conservation commission and without the need of a state or federal permit. Almost all of these plantings are for storm protection rather than habitat restoration. Several larger projects involving the construction of sacrificial dunes have been conducted in coastal communities such as Duxbury, Massachusetts. Sacrificial dunes are constructed primarily for storm protection rather than habitat restoration. If built in the wrong areas, dunes can have detrimental effects on nesting habitat for shoreline birds. However, if conducted in the right place and with proper considerations for rare and endangered species, dune restoration can have positive ecological, economic, and aesthetic benefits. These considerations are part of comprehensive dune management plans for approximately 11 barrier beaches, including Cape Cod National Seashore and the R. T.. Crane Jr. Memorial Reservation in Ipswich, Massachusetts.

Seabirds

Projects are underway to restore seabird populations on 10 Maine islands, including Matinicus Rock, Stratton and Bluff Islands, Jenny Island, Seal Island, Eastern Egg Rock, Metinic Island, Ship Island, Petit Manan Island, and Machias Seal Island. Projects are also underway at the Isles of Shoals (White and Seavey Islands) in New Hampshire and Monomoy Island in Massachusetts. The formation of the Gulf of Maine Seabird Working Group (GOMSWG) has encouraged Gulf-wide collaborations to effectively restore seabird populations. Restoration of tern populations along coastal Maine has been extremely successful. In 1997, GOMSWG counted 7,102 pairs of Common Terns, 3,976 pairs of Arctic Terns, and 237 pairs of Roseate Terns off coastal Maine. These numbers are close to population estimates made in the 1930s. Populations of other impacted species, including Atlantic Puffins, are also on the rise. GOMSWG is an excellent forum for coordinating seabird restoration efforts and is seeking increased participation by New Brunswick and Nova Scotia in order to address the issue Gulf-wide.

Anadromous fish

Efforts are underway throughout the Gulf to restore anadromous fish populations, including Atlantic salmon, river herring, shad, smelt, and sturgeon. These fish depend on various marine, estuarine, and freshwater habitats and have been impacted by dams, the loss of spawning habitat, and poor water quality. Projects address fish passage, fish populations, spawning habitat, and bordering riparian habitats. In the United States, projects focus on the Merrimack River in Massachusetts and New Hampshire and 12 significant rivers in Maine, including the Aroostook, St. Croix, Dennys, East Machias, Machias, Pleasant, Narraguagus, Union, Penobscot, Ducktrap, Sheepscot, Kennebec, Androscoggin, and Saco. Eight projects have been expanded over the past two years through funding provided by the recently formed Maine Atlantic Salmon Watersheds Collaborative (MASWC). It can be expected, with the drafting of the Maine Atlantic Salmon Conservation Plan and the petition to list the Atlantic salmon as an endangered species, that the number of projects in Maine will increase. In Canada, federal and provincial government agencies collaborate with non-government organizations to restore anadromous fish habitat on tributaries of the St. Croix, St. John, Petitcodiac, Kennebecasis, and Annapolis rivers. Work in Canada has primarily involved restoration of spawning habitat. Future projects should be part of watershed-based plans and should be modeled after projects like those initiated through the MASWC in Maine and the Trout Creek Model Watershed Project in Sussex, New Brunswick. Despite all restoration efforts to date, Atlantic salmon populations continue to decline in the Gulf of Maine for reasons that are still unclear.

Monitoring and Evaluation

Historically, there has been little monitoring data collected on restoration projects and inconsistencies in monitoring methods and data collection have persisted. As a result, evaluation of projects based on goals and objectives, and on ecological success, has been difficult. The need to monitor restoration projects in a consistent manner and the need to develop a central location for data storage has been identified repeatedly by individuals and organizations throughout the Gulf of Maine. Monitoring, whether it is used to evaluate and prioritize restoration opportunities or to evaluate restoration projects, must be conducted to maximize utilization of resources, learn from experience, and identify the most effective techniques. Several evaluation and monitoring methods are described in this report and a method recently implemented by the New Hampshire Coastal Program is presented as a model for other organizations seeking to implement consistent and economical monitoring programs.

Conclusions and Recommendations for Future Project Development

Restoration, together with habitat and species protection, is necessary to rebuild, replace, and preserve natural resources. The Gulf of Maine is rich in natural resources, and it is these resources that the economy is dependent upon. Coastal inhabitants rely on the commercial fisheries and tourism that many of the coastal habitats and species support. The opportunities for improving and increasing restoration of coastal habitats and species are numerous, and along with protection of resources, should be the top priority. However, the common limiting factor in implementing new projects and carrying on existing projects throughout the Gulf of Maine is funding. Until adequate resources allow for more elaborate forms of restoration, such as habitat creation, economical projects that provide the best ecological returns should be pursued. These projects might include acquisition of lands for conservation and restoration projects involving tidally restricted marshes.

There are numerous marshes impacted by tidal restrictions and, for relatively economical and highly effective habitat restoration, funding should be allocated to these projects. (See Table 2.) Support, both financial and in-kind, must be consistent and long-term. Past federal funding in Canada has enabled many non-government organizations to begin effective stream restoration programs. However, changing agency goals and diminishing funds have prevented the continuation of such work, thus devaluing the original restoration efforts. Allocation of money and resources must be based on economically and ecologically sound decisions. This reinforces the need to prioritize projects based on ecological, economic, and practical considerations, so that when money becomes available it can be allocated toward those projects that provide the most benefits.

The first step in prioritizing and implementing restoration projects is to collect baseline information on current and past restoration projects and to identify potential projects for future implementation. This report and the database represent this first step and provide significant information on coastal habitat and species restoration in the Gulf of Maine. However, information gaps remain, and changes to existing information are inevitable as the number of restoration projects increase and technologies are developed and refined. Data collection and dissemination need to be ongoing and information must be updated on a regular basis. It is recommended that the following next steps be taken to continue this project:

* Expand the database to include spatial data, data for prioritizing potential restoration projects, and data from consistent monitoring programs for use in long-term evaluation of ecological success.

* Interface the database with the Internet to allow online usage, encourage updates, and increase exposure and participation.

* Establish a permanent host that has adequate resources and commitment toward managing and updating the database and making it available to users.

* Obtain memoranda of understanding between major data providers to ensure ongoing participation and submittal of updates. Major sources of information include the Massachusetts Wetlands Restoration & Banking Program, New Hampshire Coastal Program, U.S. Fish and Wildlife Service Gulf of Maine Program, Gulf of Maine Seabird Working Group, United States Atlantic Salmon Assessment Committee, Fisheries and Oceans Canada, and Conservation Law Foundation.

* Develop, adopt, and distribute a standardized form (such as the one developed for this project) available in hard copy and on the Internet for submitting updates and information on new projects.

SECTION 1 - INTRODUCTION

Extending from Cape Cod Bay in Massachusetts to Cape Sable, Nova Scotia, the Gulf of Maine contains many significant coastal habitats, including salt marshes and tidal flats, dunes, rocky shorelines, and beds of seagrass. These habitats support many migratory species, hundreds of thousands of shorebirds, hundreds of species of fish and shellfish, and approximately 30 species of threatened or endangered plants and animals. Coastal habitats may be adversely impacted by sea-level rise, land subsidence, erosion, coastal development, decreased water quality, and even activities in upland areas such as logging (Thayer, 1992; Mathews and Minello, 1994).

Many projects are aimed at restoring degraded habitats and associated species to offset cumulative loss and degradation of habitat. In addition, restoration through permitted mitigation remains a common form of impact compensation along coastlines under heavy development pressures. In the Gulf of Maine, hundreds of projects involve the restoration of salt marshes, seagrass beds, or tidal flats. Many other projects focus on restoring populations of coastal species, including anadromous fish, seabirds and waterfowl.

Historically, sufficient information has not been compiled to adequately track these projects. The absence of baseline data, inconsistencies in data collection, and lack of spatial data has inhibited regional and long-term evaluation of restoration projects. These coastal habitat restoration projects, whether considered successes or failures, must be documented not only to assist with future project implementation and to learn from past experiences but for long-term evaluation of ecological success. Exchange of information, including funding sources, effective techniques, and monitoring methods, will promote more effective and consistent development of future restoration projects.

Initially, the primary objective of this project, entitled *Restoration of Coastal Habitats and Species in the Gulf of Maine*, was to evaluate the effectiveness of habitat and species restoration projects Gulf-wide. While investigating this enormous task, an even more important and necessary first step was identified - the need to collect and provide baseline information. During preliminary investigations, no one source could address the following questions on a regional scale:

* What is the status of restoration in the Gulf of Maine?
* Where are past, present, and potential restoration projects?
* How are projects being evaluated?
* Are projects being evaluated for long-term ecological success?
* Are restoration projects successful, and if so, which types of projects are most effective? Why?

Collection and organization of information that addresses these questions became the focus of this project. This final report, along with related products, including a Gulf of Maine Coastal Wetland Restoration Database, provides answers to many of these questions and provides information that is invaluable to improving restoration of our degraded habitats and associated species.

Goals and Objectives

The goal of this project is to increase the effectiveness of coastal habitat and species restoration in the Gulf of Maine by expanding coordination and facilitating information exchange among individuals and organizations active in the restoration of coastal habitats and associated species. This goal is consistent with one of the priority goals of the Gulf of Maine Council on the Marine Environment (GOMC); to "Identify, protect, and restore the Gulf's terrestrial, coastal and marine habitats". Objectives to achieve the project goal include the following:

* Collect project-specific information on the majority of potential, current, and completed coastal habitat and species restoration projects;

* Distribute information in various formats, including a database available on the Internet;

* Provide information on effective restoration techniques and evaluative methodologies; and

* Provide a unique regional perspective on coastal habitat and species restoration.

Definitions of Terms

While compiling information, it became immediately apparent that the interpretation of commonly used terms varies considerably. To prevent discrepancies, the following definitions have been adopted for the terms used in this report.

Restoration

The term restoration is used rather loosely throughout this text and refers to the various ways in which humans are altering the existing environment in an effort to compensate and offset cumulative and historical impacts. For specific projects, restoration has a more focused definition in order to differentiate among the many types of projects. Projects may involve the restoration, creation, enhancement, and/or management of habitats or the restoration of species. These terms are defined as follows:

* *Habitat restoration*: Efforts to return a habitat to a close approximation of its condition prior to disturbance (National Research Council, 1992).

* *Habitat creation:* Efforts to construct a habitat in an area where it did not previously exist (e.g., conversion of an upland area to a wetland).

* *Habitat enhancement*: Efforts to improve or increase an existing function and/or value of a habitat (e.g., expanding open water areas to increase waterfowl use).
* *Habitat management*: When a habitat is managed or controlled for specific objectives, such as mosquito control or flood protection, and as a result of management techniques, certain habitat functions and values are restored. *Open Marsh Water Management* is an example of habitat management.

* *Species restoration:* Efforts to restore historic populations of selected species in areas where they formerly existed and/or currently exist.

Coastal habitat

A habitat may be defined as a place where an organism lives, feeds and reproduces. A coastal habitat would therefore pertain to such places that are close to the coast. However, the term coastal may be perceived differently, depending on which attributes, such as physical, geological, or hydrological boundaries are considered when defining the coastal zone. According to the Coastal Zone Management Act, the term " coastal zone" means the coastal waters (including the lands therein and thereunder) and the adjacent shorelands (including the waters therein and thereunder), that are strongly influenced by each other and in proximity to the shorelines of coastal states, and include islands, transitional and intertidal areas, salt marshes, wetlands, and beaches.

* *Watershed*: A geographic area that contributes ground water or surface water to a receiving water body (e.g., the Gulf of Maine is the receiving waterbody for coastal watersheds in parts of Massachusetts, New Hampshire, Maine, New Brunswick, and Nova Scotia).

Mitigation

Process for minimizing impacts to habitats. Mitigation is employed to limit damages to valuable habitat and restore functions that are lost due to human activities (Kurland, 1991). Mitigation may involve any of the following:

1. Avoiding the impact.

2. Minimizing the impact.

3. Repairing or restoring the impacted habitat.

4. Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action.

5. Compensating for the impact by replacing or providing substitute resources or environments.

Information on projects involving the last three are included in this report and are lumped under the category "compensatory mitigation." It is emphasized that compensatory mitigation involving restoration or creation of habitat should not be equated with protection of undisturbed habitat and avoidance of the impact.

* *Mitigation bank*: In a mitigation bank, money is pooled from independent wetland impacts and applied to restore another habitat and/or area where it is used to compensate for unavoidable impacts (Massachusetts Wetland Restoration & Banking Program, 1996).

Other relevant definitions

* *No Net Loss/Net Gain Policy*: A policy that states that in the short term, there shall be no net loss of wetlands and that in the long-term there shall be an increase in the quantity and quality of wetland resources (Massachusetts Wetland Restoration & Banking Program, 1996).

* *Proactive restoration:* When an effort to restore a degraded habitat is conducted solely to improve the functions and values of the resource and not to directly compensate for permitted impacts.

* *Unplanned restoration:* When restoration of a degraded habitat is not planned or intended. For example, salt marshes may be impacted by restricted tidal flow. Tide gates that have been installed allow for runoff from the upland to move through the marsh seaward; however, the gates may also restrict tidal flow of salt water into the marsh causing degradation of the marsh. When tide gates break, or are not properly maintained, tidal flow may be restored and the salt marsh may begin to recover many of its functions.

* *Function*: Functions, as defined by the U.S. Army Corps of Engineers under section 404 of the Clean Water Act, are the self-sustaining properties of a wetland ecosystem that exist in the absence of society. Functions may result from both living and non-living components of a specific habitat (USACE, 1995).

* *Value*: Societal benefits that derive from one or more functions and the physical characteristics associated with the habitat (USACE, 1995).

SECTION 2 - PROJECT SCOPE

This project, entitled *Restoration of Coastal Habitats and Species in the Gulf of Maine*, was designed to meet the objectives outlined above and was proposed by the three coastal programs in Massachusetts, New Hampshire, and Maine in collaboration with the Gulf of Maine Council on the Marine Environment. The primary objective of the project was to collect baseline information on habitat and species restoration in the Gulf of Maine. When the project began, in October 1996, it was decided that information would be collected for the following categories.

* *Tidal marshes, including salt, brackish, and fresh tidal marshes*
* *Freshwater impoundments*
* *Tidal flats*
* *Seagrass*
* *Dunes*
* *Seabirds*
* *Anadromous fish*

Projects under the above categories may involve restoration, enhancement, creation, and/or management of habitats and species. Although not all projects fall under the strict definition of "restoration", those included do address the issues of degraded habitats and species. Other types of habitats, such as freshwater non-tidal wetlands, were not included to keep the project scope and the amount of data collection feasible for the project's two-year timeline. In addition, restoration of shellfish beds is only briefly discussed in the tidal flat section. Information on this subject was not actively collected, on the premise that restoration of shellfish beds is conducted to restore a commercial fishery, rather than a habitat.

The Gulf of Maine watershed was used as the boundary for data collection (Figure 2-1).. However, references are occasionally made to efforts outside the region that provide useful information pertinent to the Gulf of Maine. This is most evident in the bibliographies provided for each of the above categories. These bibliographies are available on the Council's Website at www.gulfofmaine.org.

Figure 2-1 Gulf of Maine Watershed

SECTION 3 - DATA COLLECTION

Specific information was collected for past or current projects that have involved the restoration, creation, enhancement, or management of habitats (Figure 3-1). These habitats include tidal marshes, freshwater impoundments, tidal flats, seagrass, and dunes. In addition to data on coastal habitat restoration projects, information on the restoration of species, including seabirds and anadromous fish, was also collected. Existing information on potential projects was also compiled for assistance with future project development and implementation. In addition to project-specific information, other types of helpful information were collected, such as data on contacts (e.g., consultants, researchers, managers), bibliographic references, and existing methods for project evaluation.

Figure 3-1 Categories for Which Information was Collected

Information was collected through personal discussions with professionals throughout the five jurisdictions (Massachusetts, New Hampshire, Maine, New Brunswick, and Nova Scotia), including researchers, managers, and consultants. (See Appendix A.) Information was also collected through use of hard copy forms and electronic forms on the internet, access to permit files at various federal and state/provincial agencies, site visits, technical reports, and existing databases. Sample forms are provided in Appendix E.

Primary Sources of Information and Information Gaps

A significant amount of information on the categories in Figure 3-1 has been collected. However, information gaps have prevailed either because the desired information did not exist or existing information was unable to be collected. Despite various means for submitting information, few individuals participated on their own initiative, and instead most project-specific information was collected personally by going through permit files and picking up information from discussions, meetings, reports, and site visits. Collecting information from individuals, consultants, researchers, and managers, proved very difficult, and it is apparent that other priorities and limited staff time has prevented their participation. Primary sources for information and information gaps for each of the habitat and species types are discussed below.

Tidal marshes

Information on projects involving the restoration of tidal marshes was acquired from a variety of sources, including state and federal permit files, technical reports, articles, interviews, consultants, government agencies, and site visits. Information was also extracted and compiled from several existing "databases," including the following. The databases indicated by an asterisk (*) are in report form and are listed under references cited.

* *U.S. Army Corps of Engineers (USACE) database on compensatory mitigation projects*: The Policy, Analysis, and Technical Support Section is conducting qualitative assessments of mitigation projects that involve creation, restoration, or enhancement for both freshwater and coastal wetlands in Massachusetts, New Hampshire, and Maine. Site visits are made and comments on site successes and failures and recommendations for improvement are recorded. The information is entered into a database and is to be used as a baseline for determining special conditions for permits. Some information was acquired from this database and from USACE permit files. Contact Gail Clingerman for additional information (Appendix A).

* *Cape Cod Wetlands Investigation**:* This study was conducted by USACE to assist the Massachusetts Wetlands & Restoration Banking Program (WRBP) with the identification of tidal restrictions and evaluation of restorable marshes on Cape Cod. Fifty-six potentially degraded marshes were identified and six of these 56 were investigated comprehensively (USACE, 1996). Contact Christy Foote-Smith for additional information (Appendix A).

* *Neponset River Watershed Wetlands Restoration Plan*:* This preliminary report, produced by WRBP, includes information on 157 potential wetland restoration sites. One hundred and twenty-five of these sites have significant potential for habitat restoration. Most of these sites are freshwater wetlands, however, 14 sites representing approximately 960 acres have been identified as potentially restorable tidal marsh (WRBP, 1997). Contact Christy Foote-Smith for additional information (Appendix A).
* *Rumney Marshes Area of Critical Environmental Concern Wetland Restoration Database:* Through a multi-agency team organized by WRBP and Massachusetts Division of Environmental Management, approximately 25 tidal marsh restoration projects were identified, prioritized, and organized using a database and Geographic Information System (GIS). A plan is currently being developed to implement these projects. Some projects have already been conducted through the U.S. Fish and Wildlife Service's Partners for Wildlife Program, Coastal America, and as compensatory mitigation. Contact Christy Foote-Smith or Liz Sorenson for additional information (Appendix A).

* *Atlas of Tidally Restricted Marshes; North Shore of Massachusetts*:* This map based document was compiled by USFWS in cooperation with WRBP. It identifies and briefly describes approximately 190 tidally restricted wetlands (over 1400 acres) along the north shore of Massachusetts. The atlas is not a comprehensive inventory of all degraded marshes within the North Shore and only identifies those that were able to be identified through remote sensing and ground truthing (WRBP, 1997). Contact Christy Foote-Smith for additional information (Appendix A).

* *Tidal Crossings Inventory and Assessment*:* This database of tidal restrictions was compiled by the Parker River Clean Water Association for Eight Towns and the Bay Committee. This inventory, together with a follow-up addendum on additional sites, provide information on approximately 150 tidally restricted marshes. All sites fall within the area covered by the Atlas described above. However, this inventory includes more sites and greater detail than the Atlas (PRCWA, 1996). Contact Dr. David Mountain for additional information (Appendix A).

* *Evaluation of Restorable Salt Marshes in New Hampshire*:* Produced in 1994 by the Natural Resources Conservation Service, this database contains information on 50 tidal restrictions in New Hampshire. The restrictions impact approximately 1300 acres of tidal marsh habitat. Included in the report and database are information on the type(s) of restriction, restorable acres of tidal marsh, recommended corrective action, and estimated cost (USDA, 1994). The New Hampshire coastal Program and towns have used this database to prioritize and conduct restoration projects. Although many of the projects listed in the report have been completed, several remain to be implemented. Contact Dr. Alan

Amman for additional information (Appendix A).

* *US Fish and Wildlife Service Gulf of Maine Program:* USFWS has been compiling information on potentially restorable tidal marsh restoration sites in Maine. This information is to be put into a GIS database and will be used to implement and track restoration projects. This project is in its developmental stages. Contact Stewart Fefer for additional information (Appendix A).

* *Technology and success in restoration, creation, and enhancement of Spartina alterniflora marshes in the United States*:* This report includes a database of projects that have involved planting of *Spartina alterniflora* and was completed in 1994 by the National Oceanic and Atmospheric Administration. It identifies projects throughout the coastal United States, including several projects in Massachusetts, New Hampshire, and Maine (Matthews and Minello, 1994).

It is likely that many projects went undetected during the information collection process. Smaller projects conducted through local conservation commissions, older projects, or projects that have been initiated recently may not be documented in this report or within the database. Potential sites are numerous and remain to be identified in areas outside those covered by the above studies.

Freshwater impoundments

Information on projects involving the construction of freshwater impoundments in Canada was acquired from various partners in the Eastern Habitat Joint Venture, including Ducks Unlimited Canada (DUC) and several government agencies. DUC provided project specific information on all impoundment projects completed through 1997. Information on these projects is managed in a database at the DUC office in Amherst, Nova Scotia. Additional information was acquired from staff with Environment Canada and the Canadian Wildlife Service and Nova Scotia Department of Natural Resources. Detailed monitoring data are not organized within a central location and although sites are monitored on a yearly basis, there are no data regarding water quality, vegetation, etc. for most projects (Melanson, pers. com., 1998).

Tidal flats

Any information included on tidal flats in this report and in the database has been acquired from permit files or from personal communications with government agency personnel. During the early development of this project and determination of the project scope, it was decided that shellfish bed restoration would not be included. This was decided based on the premise that restoration of shellfish beds is conducted to increase/benefit the fishery, rather than restore habitat.

Seagrass

Information on seagrass restoration was obtained from researchers with the Jackson Estuarine Laboratory at the University of New Hampshire. Additional information on seagrass restoration associated with the Port Authority Expansion Project was pulled from permit files with the U.S. Army Corps of Engineers. Information on seagrass restoration in Massachusetts was acquired from staff with the U.S. Environmental Protection Agency (EPA) Region 1 and the New England Aquarium. EPA Region 1 holds an annual eelgrass meeting (usually in March), at which updates are given for seagrass restoration projects from Long Island Sound to Maine. Seagrass assessment and inventory projects, such as mapping efforts by Massachusetts Department of Environmental Protection and by the Maine Department of Marine Resources, have not been included in this project since they do not deal directly with seagrass restoration.

Dunes

Information on the restoration of dunes was acquired from Massachusetts Coastal Zone Management, the Department of Environmental Services in New Hampshire, and the Department of Environmental Protection in Maine. Dune projects, most of which may only be several hundred square feet in size, are numerous from Massachusetts to southern Maine. According to staff with Massachusetts Coastal Zone Management, most projects are permitted by the local conservation commission. Information in this report is based only on a select number of “model” projects. Hundreds of dune plantings have occurred but are not included in this report due to the number and small size of projects.

Seabirds

Information on seabird restoration efforts in the Gulf of Maine was collected primarily from reports and meeting minutes compiled by members of the Gulf of Maine Seabird Working Group (GOMSWG). GOMSWG is a gulf-wide group of non-government organizations, government agencies, and individuals that collaborate to conduct research, inventory seabird populations, and restore seabird populations. GOMSWG meets twice a year and produces meeting minutes that provide a summary of research results, census results, and updates on restoration progress. There are detailed reports produced for specific projects following each nesting season. Findings from these reports are summarized in the GOMSWG meeting minutes available from the National Audubon Society or the Maine Department of Inland Fisheries and Wildlife. Additional information was acquired through personal conversations with Dr. Stephen Kress of the National Audubon Society and from annual reports and a seabird database managed by Maine Department of Inland Fisheries and Wildlife. Because of the organization and participation of groups within GOMSWG, information is easily obtained on a regional scale and encompasses most seabird restoration efforts.

With the exception of restoration efforts on Machias Seal Island, no information was collected for the restoration of seabirds in New Brunswick and Nova Scotia. This information either does not exist or could not be located. Information on shorebirds, such as Piping Plovers, exists but is limited due to a lack of information received. Individuals to contact for information on Piping Plovers and other bird species are listed in Section 10.

Anadromous fish

Information on the restoration of anadromous fish and spawning habitat was acquired from several sources. For New Brunswick and Nova Scotia, information was acquired from individuals in the Habitat Management Division of Fisheries and Oceans Canada (DFO). DFO oversees community groups throughout the Maritime provinces that are working together to restore stream habitat. Detailed information on specific projects was acquired through contact with these community groups and from annual updates and reports.

In Maine, information on anadromous fish restoration efforts was provided by the US Fish and Wildlife Service's Gulf of Maine Program and the Maine Department of Marine Resources. In Massachusetts, information was provided by the Department of Fisheries, Wildlife & Environmental Law Enforcement, and the Massachusetts Division of Marine Fisheries. Information specific to stocking of Atlantic salmon was aquired from the Annual Report of the U.S. Atlantic Salmon Assessment Committee prepared annually for the North Atlantic Salmon Conservation Organization.

The wide breadth of anadromous fish restoration projects encompasses several types of work, including maintenance and restoration of fishways, stocking programs for several species of fish, and restoration of spawning and rearing habitat. For this report, information pertains primarily to the restoration of Atlantic salmon. Information on the Atlantic salmon and restoration efforts is relatively well organized and easily obtained on a state/provincial or even regional level. However, information gaps for this project exist for efforts to restore shad, herring, and other anadromous fish species. Most information on such things as the condition of fishways or the locations of important spawning habitat for these species resides with a handful of fisheries biologists, rather than annual reports, assessments, or databases. In addition, these projects are more spread out and are less detectable on a regional scale. Although information on specific projects for these species is not included, sources for information are provided at the end of Section 11.

SECTION 4 - DATA DISTRIBUTION AND THE COASTAL WETLAND RESTORATION DATABASE

All data and information collected for this project are posted on the Gulf of Maine Council on the Marine Environment's website. The website (www.gulfofmaine.org) serves as a regional clearinghouse for environmental information and data. At the site under "What's new?" or the " Library", one can obtain this report and/or bibliographies, and download a database containing specific information on coastal wetland restoration projects.

The database, entitled the Gulf of Maine Coastal Wetland Restoration Database (CWRD), was constructed using Microsoft Access™. Information on seabird projects and anadromous fish projects may be found in this report. However, this information is not included in the database due to the type of data collected and the presence of existing central sources of information and data. All appendices (except for appendix F) were generated using the database. The database is rather simple and includes data within a series of tables. Queries and reports in various formats may be constructed using the tables. Appendix A is an example of a report produced from the table containing contact information. Appendices B-D are examples of queries made from the tables containing project specific information. The sample printouts in Appendix E show the " form" view for the tables. As a form, tables are easier to read, and new data may be entered into the tables using the form.

The software used for the CWRD is widely used, is easily converted to other formats, allows input of graphics (e.g., maps), and has the potential of being implemented with GIS. Although the database currently does not contain monitoring data and spatial data, it is the first step in tracking restoration projects and can improve restoration in the following ways:

* *Research:* A database that identifies potential restoration sites, current projects underway, and projects that have been completed will allow scientists to identify and select sites to include in their research.

* *Identification of resources and assistance*: The database can assist managers with implementing a restoration project. Within the database, they can identify potential funding sources, funding partners, or perhaps review work conducted by consultants and contractors. They can also query the database based on such things as the type of degradation, estimated costs, and watershed. Information on contacts, including researchers, managers, and individuals experienced with permitting is also found in the database.

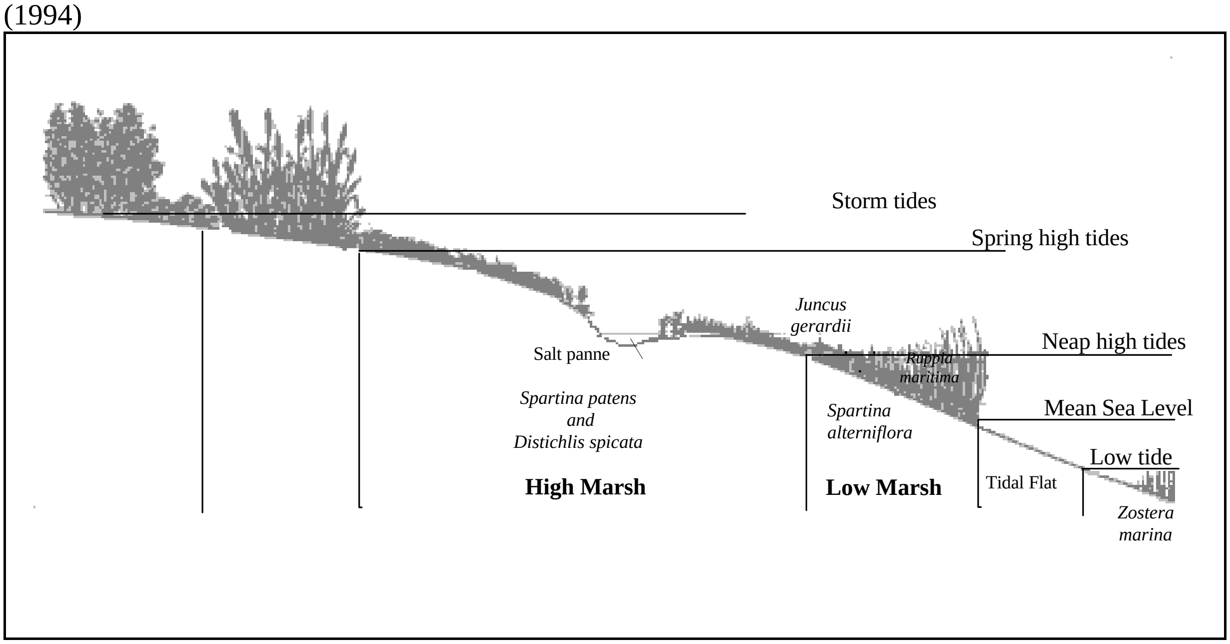
* *Lessons Learned:* When available, lessons learned through mistakes, failed projects, or unexpected outcomes were acquired and provided in the report and the database. Lessons learned are valuable and provide information important in future project implementation.

SECTION 5 - TIDAL MARSHES

Tidal marshes in the Gulf of Maine include salt, brackish, and freshwater marshes. Salt marshes are periodically exposed and flooded by salt water through tides and storms. Marshes located farther upriver may be brackish (<18 ppt) or even fresh (<0.5 ppt), showing clear differences in species diversity and composition (Dreyer and Niering, 1995). Projects included in this report and the database are primarily salt marsh.

Tidal marshes occurring within Massachusetts, New Hampshire, and southern Maine are referred to as the " New England" type, having been formed in drowned river valleys and containing significant deposits of peat (Figure 5-1). North of Penobscot Bay, ME, extreme tide ranges as large as 15 meters and shortened growing seasons give these marshes the classification as the "Fundy" type. Issues involving the restoration of Fundy marshes, explained in Section 6, are different than in the U.S., due to the tremendous tidal range, type of impact, and methods of restoration (Howell et. al., 1991; Dreyer and Niering, 1995).

Figure 5-1 Typical New England Salt Marsh
Figure adapted from MCZM (1994)



Tidal marshes are extremely productive habitats that perform numerous functions vital to the surrounding ecosystem (Table 5-1). Highly productive salt marsh plants, such as *Spartina alterniflora* and *Spartina patens*, trap, filter, and recycle nutrients. Tidal marshes support a complex food web through high primary production, the processing of nutrients that are made available to other forms or trophic levels, and structural heterogeneity. Many species of invertebrates, fish, shellfish, and wildlife rely on tidal marshes for food, nursery grounds, and refuge.

In addition to functions, tidal marshes also have values that derive from one or more functions and the physical characteristics associated with the marsh (USACE,1995). Tidal marshes provide a place for hunting, fishing, bird watching, and canoeing. They reduce flood damage by retaining water and stabilizing sediment-dominated environments. By dissipating wave energy, they provide protection from storms. In addition, tidal marshes filter contaminants and pathogens to improve water quality.

Table 5-1 Functions and Values of Tidal Marshes

Major Category	**Functions (F) and Values (V)**
Productivity	**F**: High primary productivity **-** Salt marsh plants, such as *Spartina alterniflora*, are among the most productive in the world. **F**: Food web support through organic matter accumulation in the form of nutrient rich detritus and peat. **F**: Habitat for invertebrates, fish, shellfish, and wildlife. **V**: Nursery ground and food chain support for many commercially important species. **V**: Hunting, fishing, and bird watching.
Hydrology	**F**: Water conservation during periods of drought. **V**: Water related activities, such as canoeing. **V**: Flood damage reduction by water retention and storm surge accommodation.
Geomorphological	**F**: Vegetation stabilizes sediment-dominated environments and dissipates wave energy providing a buffer that reduces wave damage. **V**: Erosion protection for uplands. **V**: Counteract sea level rise.
Biogeochemical	**F**: Vegetation and sediments trap, filter, and recycle nutrients, processing the nutrients into other forms or trophic levels. **F**: Retain toxicants and pathogens reducing or preventing the degradation of water quality. **F**: Organic matter storage and CO_2 sink. **V**: Improved water quality as a result of the above functions.
Heritage	**V**: Habitat for threatened and endangered species. **V**: Archaeological and historical sites. **V**: Unique areas for open space. **V**: Scientific study and outdoor education.

Information compiled from Race and Christie (1982), USACE (1995), Burdick (1996), and Short et al. (1998).

Like many of the habitats along the Gulf of Maine, tidal marshes are susceptible to human impacts. Miles of roads, highways, and railroad embankments bisect tidal marshes and prevent natural tidal exchange. These structures are equipped with culverts for water flow. The majority of these culverts, however, are undersized and are incapable of providing the tidal flushing necessary for the upstream marshes to function. Some culverts have one-way flap gates or slide gates for flood control and may completely prevent tidal flow into the marsh.

In addition to the construction of tide-restricting structures, tidal marshes were ditched and drained during through the 1930s in an effort to control mosquitoes. Approximately 13,000 acres of salt marshes along the Massachusetts North Shore region have been ditched, and it has been estimated that 9 out of every 10 acres of tidal marshes have been ditched throughout New England (Hruby and Montgomery, no date; WRBP, 1997). These ditches have disrupted the natural hydrological and ecological functions of tidal marshes. In addition, mud removed from the ditches was often piled alongside, forming linear mounds that are commonly covered with marsh elder (*Iva frutescens* L.) (Tiner, 1987). Disposal of material from larger dredge projects resulted in "spoil islands" that are now inhabited by upland vegetation and also disrupt tidal marsh hydrology. Other impacts to tidal marshes include filling for construction and dumping of garbage and debris. In Boston, over 2,000 acres of tidal marshes were filled for construction and development (Teal and Teal, 1969). The now abandoned I95 embankment in Revere filled over 200 acres of the Rumney marshes (Buchsbaum, 1997; Reiner, 1989). Storm water runoff and reduced water quality also affect tidal marshes. These various impacts along with techniques and methods employed to restore degraded tidal marshes are presented in Table 5-2.

Restoration of tidal marshes may be conducted to mitigate for a permitted impact or for public interest to restore a site that has become degraded due to cumulative impacts. In mitigation, the permit applicant is to avoid, minimize, or compensate for impacts. These steps are usually sequential and compensatory mitigation is only appropriate when impacts are absolutely unavoidable. Compensation may include restoration, creation, enchancement, and in some cases preservation of habitat.

Three federal laws provide the basis for protection and regulation of activities in coastal waters and wetlands of the U.S. These include the River and Harbor Act of 1899, Section 103 of the Marine Protection, Research, and Sanctuaries Act of 1792, and Section 404 of the Clean Water Act. Activities such as construction or placement of dredged or fill material into coastal waters and wetlands require a permit from the U.S. Army Corps of Engineers (USACE). If impacts caused during permitted activities are unavoidable, compensatory mitigation in the form of restoration, creation, enhancement, and/or preservation is commonly required.

Under the Fish and Wildlife Coordination Act, federal regulatory agencies must request comments on permit applications from the National Marine Fisheries Service and the U.S. Fish and Wildlife Service. Individuals from the U.S. Environmental Protection Agency (EPA) and the Natural Resource Conservation Service may also provide advice and technical assistance during permit review (Kurland, 1991).

State agencies, including the Massachusetts Department of Environmental Protection, New Hampshire Department of Environmental Services, and Maine Department of Environmental Protection coordinate with Federal Agencies and local conservation commissions to enforce mitigation requirements on the state level. Other agencies, including coastal programs in each of the states and the Massachusetts Wetlands Restoration & Banking Program, review projects, provide technical assistance, and assist communities with proactive restoration projects.

Non-government organizations (NGOs) are primarily involved with proactive projects. Roles of these organizations vary and include education and public awareness, coordinating, research, project implementation, and funding. The number of NGOs involved continues to grow with the increase in public interest in restoring degraded habitats. Audubon societies in Maine and New Hampshire are involved with citizen monitoring for identifying and evaluating potential salt marsh restoration sites. In Massachusetts, Audubon researchers participate in the assessment of habitat restoration projects, including salt marshes and anadromous fish passage. The Parker River Clean Water Association has been involved with the identification and evaluation of potential restoration sites throughout the North Shore of Massachusetts. Many NGOs also have funding and grant programs for restoring and protecting coastal habitats. These include (but are not limited to) Ducks Unlimited's Private Lands Program, Isaak Walton League of America's Save our Streams Program, National Fish and Wildlife Foundation Grants, Nature Conservancy projects, and the Wildlife Habitat Enhancement Council and its Waterways for Wildlife Program (Coastal America, 1996).

In addition to non-profit NGOs, there are consultants and contractors involved with the engineering, planning, construction, and monitoring of projects. New England companies that frequently conduct tidal marsh restoration projects include Northeast Wetland Restoration, Rowley, Massachusetts; Great Meadow Farm Wetland Contractors, Rowley, Massachusetts; Lelito Environmental Consultants, Falmouth, Massachusetts; Sverdrup Corporation, Boston, Massachusetts; The BSC Group, Boston, Massachusetts; Normandeau Associates, Inc., Bedford, New Hampshire; Swamp, Inc., York, Maine; and Environmental Concern, St. Michaels, Maryland (See Appendix A for contacts).

Current/Past Projects

Projects in Massachusetts, New Hampshire, and Maine may be categorized according to the type of work conducted to restore, create, enhance, and/or manage a degraded salt marsh. These efforts, depending on the corrective action taken, fall within one or more of the following categories based on impacts and methods of restoration:

* *Tidal restrictions:* Projects involving tidally restricted marshes. Restoration usually involves installation of properly sized culverts, the removal of tide gates, dikes, and other tide-restricting structures and mechanisms, or the installation of self-regulating tidegates in order to restore the hydrological functions of the marsh. Self-regulating tidegates provide flood protection while allowing a controlled amount of tidal flushing.

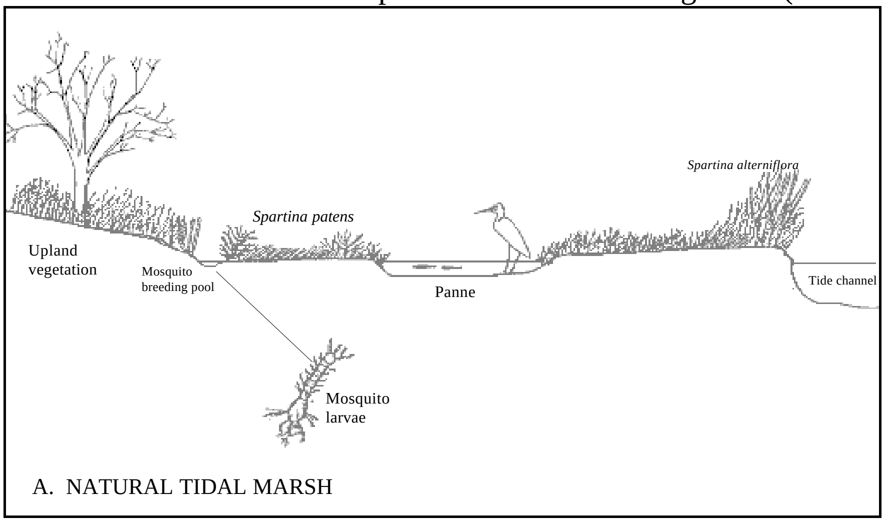
* *Fill*: Projects involving salt marshes impacted by filling activities or where elevation or nature of the substrate has impacted the marsh. Work involves removing and disposing of fill and grading of the substrate to bring elevations down to natural tidal marsh elevations.

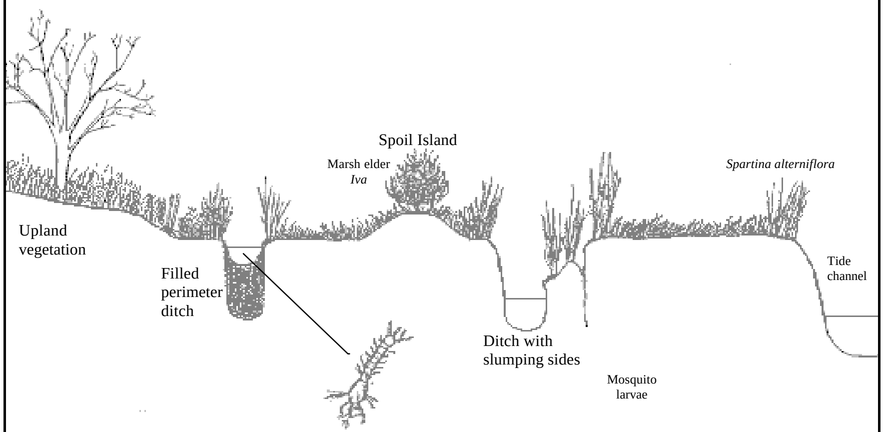
* *Vegetation:* Projects that are based on reestablishing native salt marsh vegetation through control of invasive species such as common reed *(Phragmites australis)* or purple loosestrife *(Lythrum salicaria)*.

* *Ditched marshes and Open Marsh Water Management*: A majority of the tidal marshes throughout the northeast were ditched through the 1930s in an attempt to control mosquitoes and in some cases for farming of salt hay. Restoring these sites usually involves filling in ditches and restoring the natural hydrology. Open Marsh Water Management (OMWM) aims to control mosquito populations and may result in the enhancement of previously ditched wetlands. OMWM techniques include plugging of ditches, the formation of pannes and creeks, and

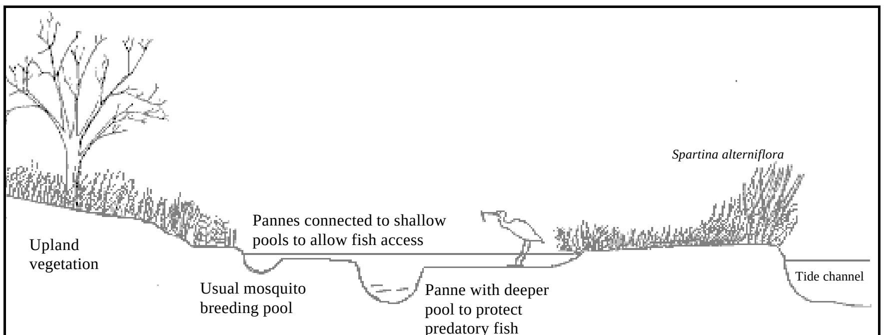
rotary ditching to connect deeper pools with shallow standing water (Figure 5-2).

Figure 5-2 Natural Marsh (Top), Ditched Marsh (Middle), and Open Marsh Water Management (Bottom)





B. DITCHED TIDAL MARSH



C. OPEN MARSH WATER MANAGEMENT

Figure adapted from Hruby and Montgomery (1988).

The amount of information collected for each specific project ranged from simply a name for a site to having the actual permit, locus maps, and photographs of a site. Information was collected for both compensatory mitigation and proactive projects (Figure 5-3). Individual projects that have been completed or are underway are listed in Table 5-3 and in Appendix B. It is apparent that the number of projects is higher in Massachusetts than the other two states. This may be due to higher development pressures in Massachusetts. Although Maine has protected many of their tidal marshes, those degraded from tidal restrictions, ditching, and fill, are just beginning to be identified. In addition, Maine's form of compensation has leaned heavily toward preservation of existing habitats rather than restoration (MDEP, 1998). Bath Iron Works and Sears Island mitigation projects are examples of large scale restoration projects that have recently been proposed.

Table 5-3 Number and Acreage of Current/Past Tidal Marsh Restoration Projects

Project Type	Number of Projects by State			Total Projects	Total Acres
	MA	NH	ME		
Tidal marsh - mitigation	28	7	9	44	132
Tidal marsh - proactive	37	21	9	67	2,110

Number and acreage of current (in progress) or completed tidal marsh restoration projects for which information was collected as of March, 1998. Acreage does not imply that the number of acres shown were "successfully" restored. Information on individual projects is in the Coastal Habitat Restoration Database.

For the 111 tidal marsh restoration projects listed in Table 5-3, including both mitigation and proactive projects, 45 involved tidal restrictions, 42 involved the removal of fill, 19 involved planting of vegetation and creation of tidal marsh habitat, and 35 involved Open Marsh Water Management. It should be noted that the number of projects involving OMWM is higher than 35. For this study, OMWM projects that were conducted adjacent to one another were grouped into the same project. See Appendix B for a list of projects and the Coastal Habitat Restoration Database for additional information on specific projects.

Potential/Future Projects

Several initiatives by the Massachusetts Wetland Restoration & Banking Program, including the North Shore Atlas, the Cape Cod Study, and the Neponset River Watershed Wetlands Restoration Plan, have involved the identification of degraded tidal marshes (See Section 3). These sites have been identified as having "potential" for restoration. The North Shore Atlas and the Parker River Clean Water Association Study together identify approximately 200 tidal restrictions that are impacting 1,400 acres of restorable marsh along the north shore of Massachusetts. The number of tidal marshes, the impacts associated with each of the sites, and the acreage identified as of April, 1998, for Massachusetts, New Hampshire, and Maine are summarized in Table 5-4. The locations of study areas for Massachusetts and New Hampshire and specific locations for potential projects in Maine are provided in Figure 5-4. Boxes in Massachusetts and New Hampshire identify the location of study areas where potentially degraded tidal marshes were identified. Points in Maine represent individual sites that have been identified as having restoration potential. The studies indicated are described in Section 3.

Table 5-4 Number and Acreage of Tidal Wetlands Identified as Having Restoration Potential

Impacts Associated with Sites	Number of Sites			Total Sites Identified	Total Acres Identified	Number of Sites Acreage Based on
	MA	NH	ME			
Tidal restrictions	262	17	12	291	2,176	133
Ditched, diked, and/or drained	9	0	12	21	540	8
Filled	24	3	20	46	595	18
Other (Dumping, clearing, stormwater, mowing)	9	0	0	9	15	5

The number and estimated acreage of tidal wetlands identified as being affected by various types of impacts. 367 tidal wetland sites were identified as of April, 1998. 3,326 acres were tallied for 164 of these sites. Since acreage is based on only half of the total sites identified, acreage is largely underestimated. Sources of data and information are listed in Section 3.

Information on potential sites, listed in Appendix C, may be found in the Coastal Habitat Restoration Database. Appendix C is not a comprehensive list of all potential tidal marsh restoration sites in the Gulf of Maine. With ongoing and new initiatives to identify and evaluate degraded habitats, the number of potentially restorable sites will continue to increase in number.

Evaluation and Monitoring

Evaluation of tidal marshes may be conducted for several reasons: (1) to assess functions and values for use in wetland regulation, (2) to identify, evaluate, and prioritize potential sites for future project implementation, and (3) to evaluate a project's success following restoration. Most all methods require data collection or monitoring, and may be used or modified to address more than one of the above applications (Table 5-5). Normandeau Associates, Inc., provides an extensive description of many of the methods listed in Table 5-5, as well as additional ones, in the report *Identification and Evaluation of Coastal Habitat Evaluation Methodologies* (Bowen and Small, 1992). Several of these methods, such as the U.S. Army Corp's Wetland Evaluation Technique (WET) and more recent Highway Methodology, were designed for regulatory purposes to identify and quantify impacts to wetlands and establish permit conditions under Section 404 of the Clean Water Act.

Other methods, including those described in the Parker River Clean Water Association's Tidal Crossing Handbook, the New Hampshire Coastal Method, and the Maine Citizens Tidal Marsh Guide, have been developed to identify and evaluate a site's potential for restoration. With such a large number of potential sites being identified using these methods, there is a need to evaluate sites and effectively prioritize their importance. Prioritization is especially important during the planning process since money and resources are short. The Massachusetts Wetland Restoration & Banking Program has been evaluating and prioritizing sites within the Rumney Marshes Area of Critical Environmental Concern in Revere, Massachusetts. Evaluations are based on ecological, societal, economic, and practical considerations, and although primarily qualitative, the method provides a means of implementing projects in an effective and efficient manner.

Once a project has begun, evaluating its success is a complicated issue that has received a considerable amount of attention by researchers, permitting agencies, and resource managers throughout the country. To accurately evaluate a project's success, careful monitoring using scientifically sound methods is required both before and after restoration work. Evaluation and monitoring is especially important for mitigation projects in order to maintain high levels of compliance and to ensure that any loss of habitat functions and values have been compensated for. Evaluation and monitoring is equally important for proactive restoration projects in order to learn from experience and to predict as well as maximize benefits of future restoration efforts. In addition, if public agencies, money, and resources are used to restore a habitat, having data to support the effectiveness and benefits of restoration will assist with gaining support for future project implementation. Whatever type of monitoring program is chosen, whether simple or complex, Zedler (1996) emphasizes that "monitoring programs should be adaptive, responding to new information as it is gathered and to new management needs as they develop".

To a large extent, methods of evaluation are project-specific and are usually based on restoration goals and a set of success criteria. Monitoring is designed to provide data that allows one to evaluate the project based on these established project goals and success criteria. The parameters measured, sampling location, data type, and sampling frequency may differ from project to project. In addition, the duration of monitoring following project completion will vary. For example, managers who conduct Open Marsh Water Management in Massachusetts monitor the sites for two years following completion (Hruby and Montgomery, 1988). Some researchers argue that certain functions are not fully restored for many years, if not decades, so many recommend a monitoring

program as long as 10 or even 20 years (Pacific Estuarine Research Laboratory, 1990; Burdick, 1996; Short et al., 1998).

Monitoring programs written into project plans for compensatory mitigation projects, explained below, range from three to five years, and in rare cases more than five years. Monitoring for the Port Authority Expansion Project in Portsmouth, New Hampshire, is planned for 15 years. This is an exception to the norm and is a result of combining regulatory compensation work with the development of monitoring and restoration technologies by the Jackson Estuarine Laboratory at the University of New Hampshire.

Evaluation and monitoring of proactive tidal marsh restoration projects

For proactive projects, monitoring programs must be effective and economical so that money can be allocated for the planning, site selection, and construction involved with restoring the marsh. Furthermore, monitoring must be long-term and consistent in order to evaluate restoration success and to study the development of projects on various temporal and spatial scales.

At a minimum, it is recommended that a monitoring program include maps that show vegetation patterns and identify water structures (e.g., tidal creeks, pannes, etc.) before and after restoration. These maps should be constructed from aerial photos. In addition, hydrological information, including amplitude of the tide above and below each restriction, and salinity of surface waters and of the soil should be required. Information on fish populations provides valuable information on habitat. It has been suggested that trained volunteers could easily assess whether mosquito larvae are present in the marsh. Methods for sampling fish might include minnow traps to assess fish diversity and fyke nets to assess fish productivity.

Spatial information on any data collected must also be acquired if monitoring data is to be used for long-term evaluation of ecological success. Spatial data would include GPS coordinates for sampling locations. These locations and site-specific information could then be organized in a Geographic Information System.

A consistent monitoring program that includes the above types of parameters has been developed by the New Hampshire Coastal Program. Massachusetts has also begun the process of developing a similar program. In Maine, no consistent monitoring program has been implemented for evaluating the effectiveness of restoration projects. The consistent monitoring program recently implemented by the New Hampshire Coastal Program is presented below as a model.

In 1992, Normandeau Associates, Inc., drafted *A Manual for Monitoring Mitigation and Restoration Projects on New Hampshire's Salt Marshes* for the New Hampshire Coastal Program (Normandeau Assoc., 1992) . This manual was intended for implementation with restoration projects funded by the New Hampshire Office of State Planning and the New Hampshire Coastal Program (NHCP). NHCP has standardized a simplified version of this method and requires its implementation for projects funded through their grant program. By establishing a long-term and consistent monitoring program statewide, NHCP hopes to track projects and use data for ecological evaluation of restoration projects. The following is an abbreviated description of the pre- and post-restoration monitoring requirements. For more detailed information on this program, contact Ted Diers, NHCP (Appendix A).

Pre-restoration monitoring requirements

1. *Accumulate existing information*, such as rare and endangered species information.

2. *Map* the following using aerial photographs or if resources permit, GIS.
Vegetation.
Water bodies such as salt pannes and tidal creeks.
Structures that may impact restoration.
Surrounding land uses.
Soils using county soil survey information.
Permanent photo locations.
Restoration work location and description of work.
Elevations at creek bottoms, high marsh and low marsh.
Salinity and vegetation sampling locations.

3. *Sample vegetation* using either a stratified random sampling method, or if resources permit, a transect method.

4. *Sample salinity*.

5. *Assess wildlife* including fish and migratory birds using observation, and if possible, collect data on mosquito larvae.

6. *Measure Tidal elevations.*

Post-restoration monitoring requirements

Immediately after construction, sites are evaluated as to whether restoration plans were followed as planned. Maps are then corrected if "as-built" is different from the planned work. Using the same techniques and parameters monitored during pre-restoration monitoring, five monitoring periods are conducted at as-built, and at peaks of first, second, third and fifth growing season. Monitoring is to include the following

1. Description of post-restoration management activities.

2. If plantings were included, estimation of the survival of seedlings.

3. *Sample vegetation* -- same method and sample stations used in pre-monitoring.

4. *Take photographs* from permanent photo locations.

5. *Assess wildlife* as in pre-monitoring.

6. *Sample salinity* as in pre-monitoring.

7. *Measure tidal elevations* as in pre-monitoring.

The NHCP suggests that a hired consultant run the monitoring program for the initial year and then train the local conservation commission so that they can assume responsibility for the following years. It is estimated that the above monitoring program should cost a town between $2,000 and $3,500 for the first year, depending on the project size, and less for monitoring during subsequent years.

Evaluation and monitoring of compensatory mitigation projects

Evaluation of functions of all habitats at risk from a proposed project are required during the permitting process to identify and determine the extent of impacts. Evaluation prior to construction can help avoid and minimize impacts. Furthermore, by assessing the functions and values of the habitat that will be lost to unavoidable impacts, terms for compensation can be accurately determined. Any impacts to wetlands caused during a project require compensatory mitigation and replacement of lost functions and values.

Monitoring and submission of reports by the permittee is required by USACE to track projects and enforce permit compliance. The permittee submits a project plan for review to USACE in which they design and present their own monitoring methods, and determine the content of their reports. Guidance is provided by the USACE Regulatory Branch for developing monitoring methods and reports. The types of parameters monitored are dependent on project goals and on the special conditions outlined by the assigned USACE project manager. Some projects, such as the Port Authority Expansion Project in Portsmouth, New Hampshire, include extensive monitoring for multiple wetland functions, such as vegetation, hydrology, soils, and wildlife habitat. However, the majority of project plans and monitoring reports in USACE permit files only included vegetation and qualitative assessments of other functions and values. In addition, monitoring reports were rarely available in these files (pers. obs. 1997). Mathews and Minello (1994) identified 787 marshes nationwide in which *Spartina alterniflora* was planted. Of these projects, only 106 had monitoring data available (Mathews and Minello, 1994). This lack of project evaluation reinforces the need to improve permit compliance and monitoring programs.

In a comprehensive evaluation of ten compensatory mitigation projects, Reiner (1989) concluded that most projects could have been more effective if they had been sufficiently monitored and enforced. In several of the projects reviewed by Reiner (1989), no state or federal agency was aware of the permittee's failure to compensate for lost salt marsh habitat. Reiner (1989) and others within USACE attribute the inability to enforce compliance to insufficient staff and the large number of incoming permit applications. Reiner's work indicates a lack of communication and coordination between and among the federal and state agencies. In reviewing permit files for this project, it was evident that compliance to permit conditions is rarely enforced, and in some cases projects were never followed up on (pers. obs. 1997).

Simply enforcing consistency in reporting data and monitoring results requires significant staff time and resources, and tracking the projects is equally as difficult. USACE and staff within the Regulatory Branch have recognized the need to require a more consistent and thorough method for tracking projects and evaluating long-term success. In general, monitoring must anticipate, identify, and correct factors that threaten permit compliance or jeopardize successful mitigation. Staff within the Policy, Analysis, and Technical Support Section have recommended minimum requirements for permit compliance and monitoring and continue to develop monitoring requirements as part of an ongoing process (Clingerman, pers. com. 1997). Requirements for monitoring remain project specific and may include additional and/or different requirements then the following general requirements:

* All mitigation sites shall have at least 35 percent site survival for vegetation within 75 percent of planting cells.

* All mitigation sites shall have at least 80 percent cover by non-invasive vegetation.

* Monitoring reports must be submitted at the end of each growing season for the first three years after construction.

* Monitoring reports should include at a minimum the following:
    - Vegetation cover percentages. This includes details on invasive species and native vegetation.
    - A detailed landscaping plan showing location and extent of vegetation, including the location of community types.
    - Photographs taken from fixed locations.

Minimal components of the post-construction assessment after 5 years include:

* Original or modified mitigation goals and the level of attainment of these goals at each mitigation site.

* Lessons learned.

* Identification of procedures or policies that may have unnecessarily encumbered the implementation of effective designs.

* Recommendations for similar projects in the future.

The above monitoring and reporting is to be required once every year for the first three years following construction. At the end of five years, an overall assessment report is provided. Failure to comply to permit conditions may require that the permittee address the problem in order to bring the project back into compliance. However, as identified in a comprehensive evaluation of mitigation projects, Reiner (1989) revealed that little, if any, permit compliance is enforced. The duration and requirements of monitoring for compensatory mitigation projects are geared toward expediting management and permit compliance, rather than evaluating long-term ecological success.

Monitoring frequently during the first few years is important for correcting problems with the project. However, long-term monitoring is necessary to accurately determine a project's ecological success. Determining a project's success based on three years of vegetation data may be premature (Kentula, 1998). This is supported by Hogan (1998), whose long-term conclusions of success agreed with only 50% of the short-term conclusions established by Reiner (1989). In addition, vegetation alone may be an inadequate indicator of success. Hogan (1998) found that both created and natural marshes failed to meet a 75 percent threshold for plant cover; both, however, met other criteria for ecological health, such as high numbers of epibenthic invertebrates, detritus decomposition, and molluscs. Differences in plant cover and animal populations between and among created and natural marshes reinforces the need to carefully select performance standards that accommodate natural variability (Hogan, 1998). The lack of long-term data and progress reports suggest that the rate of success for mitigation projects based on ecological considerations remains unknown and that the complexity of tidal marsh systems and natural variability reinforces the need to establish adaptive methodologies for determining a project's success, both for performance standards and ecology. Hogan (1998) recommends that simple measurements for surface elevations and hydrology be included in permit conditions. Surface elevations are identified as an important parameter to monitor both before and after a project since they are critical in the success of tidal marsh projects (Reiner, 1989; Mathews and Minello, 1994; Zedler, 1996; Hogan, 1998).

Restoration Effectiveness

Effectiveness, or project success, is based on project goals and objectives as well as a project's ability to restore habitat functions and values. For compensatory mitigation, success is based on whether or not the permittee met the conditions specified in the permit. Reiner (1989) measured success based on whether objectives written into the permits were achieved and on plant cover and elevations. He found that compensatory mitigation for three out of ten of the projects was never completed and the remaining projects had variable degrees of success. In a study eight years later, Hogan (1998) found that several of the projects deemed a success, or at least a "partial success", by Reiner (1989) developed into failures (according to performance standards). In all, creation and restoration of tidal marshes did not equal the amount of habitat lost during permitted projects. Reiner (1989) states, "impacts to salt marshes from permitted projects have not been adequately compensated for by salt marsh creation and restoration. This is in large part due to inadequate implementation of the projects by the permittee, a situation that could probably be corrected with more supervision of projects in progress and better communication between regulatory agencies."

Deficiencies of projects reviewed by Reiner (1989), and later by Hogan (1998), included the placement of unauthorized fill material during construction, incompatible substrates, and incorrect elevations and grading during construction. Correct elevations and the types and quality of substrates used in construction are identified as being critical components in tidal marsh restoration (Reiner, 1989; Zedler, 1996; Hogan, 1998). In a nationwide inventory of tidal marsh restoration projects involving planting of *Spartina alterniflora*, Mathews and Minello (1994) identified the following key factors to consider during tidal marsh projects:

* Young healthy plants should be used and obtained, if possible, near the site location;

* Planting should be conducted early in the growing season to allow the plants time to
establish prior to winter;

* Soils should be rich in nutrients;

* Correct elevations are critical;

* A gentle slope of 1-10 percent will provide sufficient width and drainage for the marsh;

* Good water flow and tidal exchange;

* Protection from waves to prevent erosion of new plants;

* Protection of plants from pests, such as herbivorous animals and humans;

* Protection from surrounding activities, such as coastal development and land uses.

To further improve compensatory mitigation projects, objectives must be clearly stated and an understanding of what is meant by functional replacement must be shared between the permitting agency and the permittee (Kentula, 1998). One way to ensure successful compensation is to require that all restoration work be conducted prior to the start of construction or impact. The Port Authority Expansion Project in Portsmouth, New Hampshire, was conducted in this manner. Once sufficient habitat was recreated and restored, construction commenced.

Reiner (1989) supports salt marsh restoration over creation and suggests that restoration of hydrologically restricted marshes and filled marshes is more successful than creating marsh habitat. He further states from his research and observations that restoration of low marsh habitat has been more successful than restoration of high marsh habitat. Low marsh is lower in elevation and is vegetated primarily by smooth cordgrass (*Spartina alterniflora*). High marsh has a higher diversity in vegetation including species such as salt hay grass (*Spartina patens*) and black grass (*Juncus gerardii*) and includes pannes and creeks.

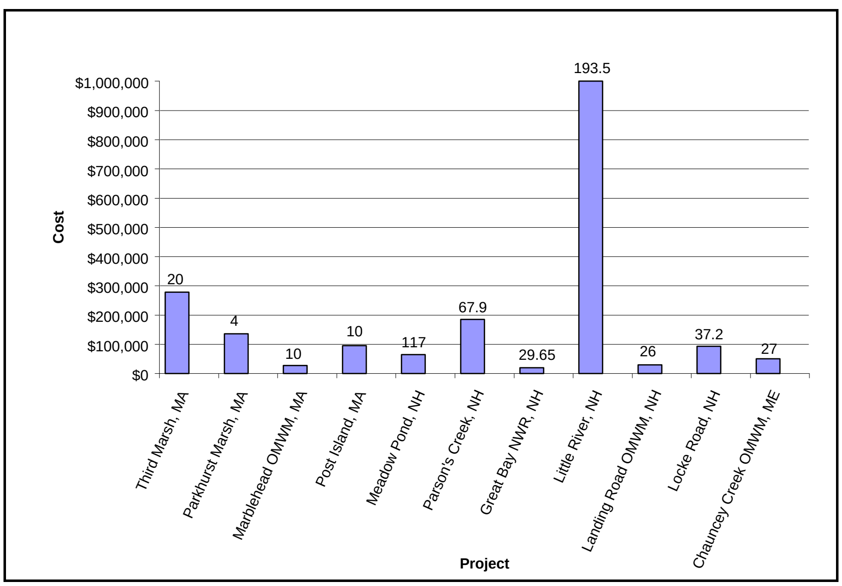
Personal observations during site visits and discussions with professionals suggest that certain types of projects are more likely to succeed and are more effective at replacing functions and values than other types. For example, creating a tidal marsh from upland habitat is difficult and has much greater room for error. On the other hand, removing an undersized culvert or tide gate can be extremely effective at restoring the hydrological functions and, with time, other ecological functions, of a tidal marsh (Rozsa and Orson, 1993; Burdick et al., 1997). Burdick et al. (1997) found that hydrologic restoration of unrestricted saltwater exchange at Mill Brook Marsh in New Hampshire led to relatively quick restoration of tidal marsh functions. Even Drake's Island Marsh, with only a partially restored tidal flow in the form of a lost tidegate, has large areas restored to salt marsh, although restoration is proceeding much more slowly than the Mill Brook site (Burdick, et al. 1997).

In addition to tidal restrictions, Open Marsh Water Management (OMWM) is gaining popularity as an accepted and effective restoration technique for ditch impacts to tidal marshes. OMWM projects were originally conducted in Northeast Massachusetts by the Essex County Mosquito Control Project and are now being implemented in New Hampshire and Maine and other parts of Massachusetts. The U.S. Fish and Wildlife Service views these projects as habitat restoration and has funded over 15 OMWM projects over the past four years in Massachusetts, New Hampshire, and Maine. According to Mike Morrison with S.W.A.M.P., Inc., and Walter Montgomery with Northeast Massachusetts Mosquito Control and Wetlands Management District, extensive monitoring data exists for OMWM projects. However, no reports or quantitative assessments have been completed using the data (Montgomery, pers. com., 1998; Morrison, pers. com., 1998).

Economic considerations should be included when determining the effectiveness of a restoration project. Restoration of tidally restricted marshes is economical in comparison to creation projects or projects involving the removal of fill (Figure 5-5) (U.S. Dept. Of Agriculture, 1994). Open Marsh Water Management projects may also restore tidal marsh functions at a relatively low cost - approximately one to two thousand dollars per acre (Montgomery and Scheirer, pers. com., 1997). Perhaps money spent on small, costly mitigation projects could be better spent if it was contributed toward habitat restoration efforts already in the planning stages, such as a mitigation bank. The permitting and planning process for a compensatory mitigation project can be extremely costly, as evidenced by the Logan Airport mitigation (Figure 5-6). The $700,000 spent on permitting, planning, and creating 1.3 acres of salt marsh at Boston's Logan Airport could have paid for many of the proactive projects in Figure 5-5. These other projects involved the restoration of over 200 acres of salt marsh and are far less expensive per acre since they involved restoring large areas of marsh simply by removing or enlarging a tide restricting structure. In addition, in-kind contributions of resources help keep costs low on many of these proactive projects.

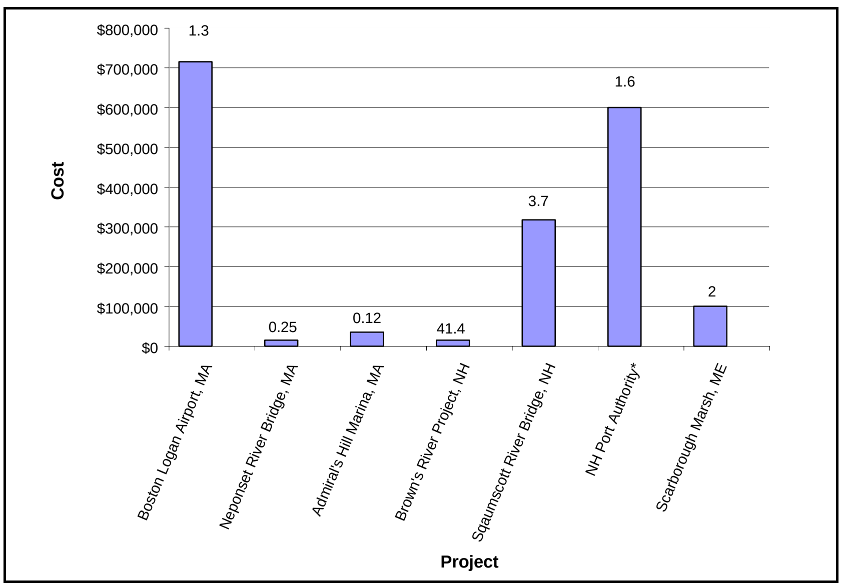
Although more expensive, it should be emphasized that compensatory mitigation projects are very different than tidal restriction projects in terms of project objectives and the final product. Mitigation projects are aimed at replacing habitat functions and values that were lost during construction. These projects often require the permittee to create an entirely new wetland, as was the case in the Logan Airport project, or perhaps remove fill material from an area that is no longer wetland. Restoration of tidally restricted marshes involves restoring an existing degraded wetland. It should also be mentioned that while mitigation projects often cost large sums of money, the permittee is the one required to pay for it. These high costs may encourage a permit applicant to carefully investigate ways to avoid any impacts to wetlands in the first place.

Figure 5-5 Costs for Proactive Tidal Marsh Restoration Projects



Data acquired from permit files and Louis Berger & Associates, Inc., 1997. Costs do not include in-kind contributions. Numbers at top of bars indicate acres.

Figure 5-6 Costs for Compensatory Mitigation Projects



Data acquired from permit files and Louis Berger & Associates, Inc., 1997. *The project for the New Hampshire Port Authority Expansion also included 6.8 acres of mud flat restoration and creation and approximately 6.2 acres of seagrass restoration. Costs shown here are for the creation of 1.6 acres of salt marsh habitat. Total cost for the project, including tidal marsh, mud flat and seagrass habitats was approximately $1,800,000 (Short, pers. com., 1998). Numbers on top of bars indicate acres.

Recommendations

Tidal marshes are a major focus of habitat restoration efforts in the Gulf of Maine. With numerous projects already completed, and even more having been identified for future restoration, the need to tighten standards and improve evaluation of our efforts continues to increase. The following recommendations are made to improve restoration effectiveness and evaluation and are based largely on personal experiences and on the literature.

* Permit tracking databases need to be modified and maintained by the U.S. Army Corps of Engineers (USACE) and appropriate regulatory state agencies. Databases that were queried, including those at USACE and Maine Department of Environmental Protection, did not provide useful information on work conducted for compensatory mitigation. The existing permitting tracking systems, however, could be easily modified to include additional fields. Simply adding whether or not compensatory work was conducted, a brief description and location of the project, and the number of acres impacted and restored, would prove very useful. If in a central location, this data would prevent "recounting" of the same acres and over estimates of restoration efforts when evaluating whether or not a "no net loss" of wetlands has been achieved.

* Consistent monitoring methods for project evaluation need to be developed, adopted, and implemented for all restoration projects.

* Reports or assessments based on data must be completed. For example, although OMWM techniques appear to rehabilitate a ditched wetland, there is little published data or quantitative assessments supporting OMWM as a form of habitat restoration in the Gulf of Maine. If the data are collected, they should be interpreted. Furthermore, if consulting firms and non-profit organizations do not have the resources or knowledge to make such assessments, then more money needs to be allocated to direct research. Submittal of assessment reports and/or

data to an established central source should be required for all projects.

* Multiple impacts to wetlands, no matter how small, have had long-term cumulative impacts on the landscape as a whole. A methodology to evaluate restoration of degraded systems must also be developed to assess effectiveness of restoration in a landscape context and for determining optimal places for restoration within watersheds (Kentula, 1998).

* Resources need to be allocated toward initiatives that identify, evaluate, and prioritize restoration opportunities.

* Resources need to be allocated toward those projects that have already been identified as having strong restoration potential.

* Outreach and communications with local communities and conservation commissions needs to be improved in order to promote restoration of tidal marshes and explain the importance of participation on the local level.

* For compensatory mitigation projects, consideration should be made for off-site mitigation through mitigation banking programs to ensure optimal habitat benefits for the watershed.

* For mitigation, one is to avoid, minimize, or compensate for impacts. These steps are usually sequential. Compensatory mitigation is only appropriate when impacts are absolutely unavoidable. Similar sequential steps should be taken when deciding what will be done for compensation. Protection of existing habitat should precede all other alternatives. Following protection of existing habitat, restoration of habitats should then be favored over creation of habitat. This is a general hierarchy, and it is apparent that one form of compensation may be more beneficial than another depending on the project and impacts.

* Vegetation is a good indicator of productivity, is easily measured, is economical, and as a result, is the most commonly monitored parameter. However, it is important to consider other functions and values of the marsh to fairly determine ecological success. Monitoring programs, both for compensatory and proactive projects, should include data on soils, fauna, and hydrology to better assess the long-term development of restoration projects (Kentula, 1998; Burdick et al., 1997).

Additional Information and Contacts

Additional information on individual projects listed in Appendices B and C may be found in the Coastal Wetland Restoration Database. The database, as well as a bibliography on coastal wetlands, may be downloaded from the Gulf of Maine Council's Website at www.gulfofmaine.org. (See Section 4.)

For information on tidal wetland restoration, or if you know of a degraded wetland that has potential for restoration, contact one of the following individuals. Detailed information on the following individuals and other contacts is provided in Appendix A.

In Massachusetts

Ed Reiner
U.S. Environmental Protection Agency - Region 1

Christy Foote-Smith
Massachusetts Wetland Restoration & Banking Program

Eric Hutchins (MA and NH)
National Marine Fisheries Service

In New Hampshire

Ted Diers
New Hampshire Coastal Program

In Maine

Stewart Fefer
Gulf of Maine Program
U.S. Fish and Wildlife Service

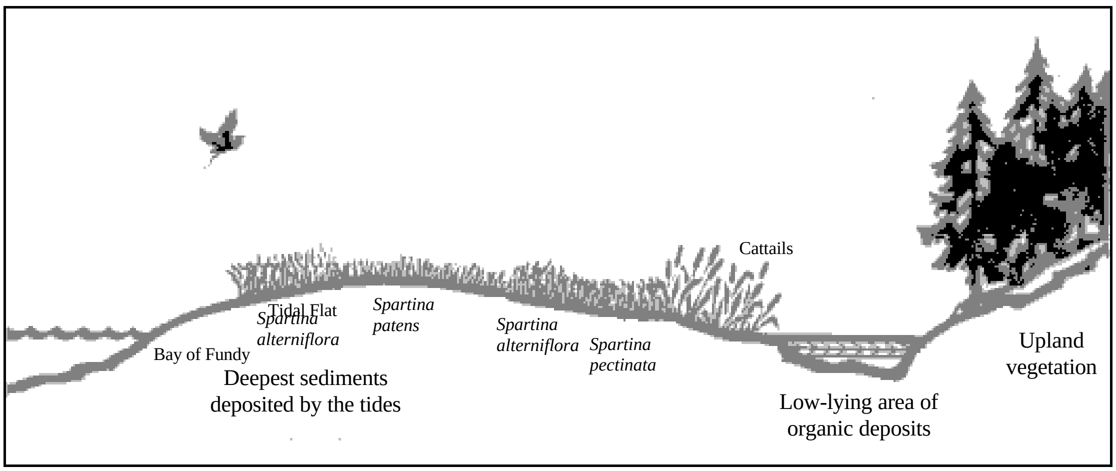
For Information on Open Marsh Water Management contact

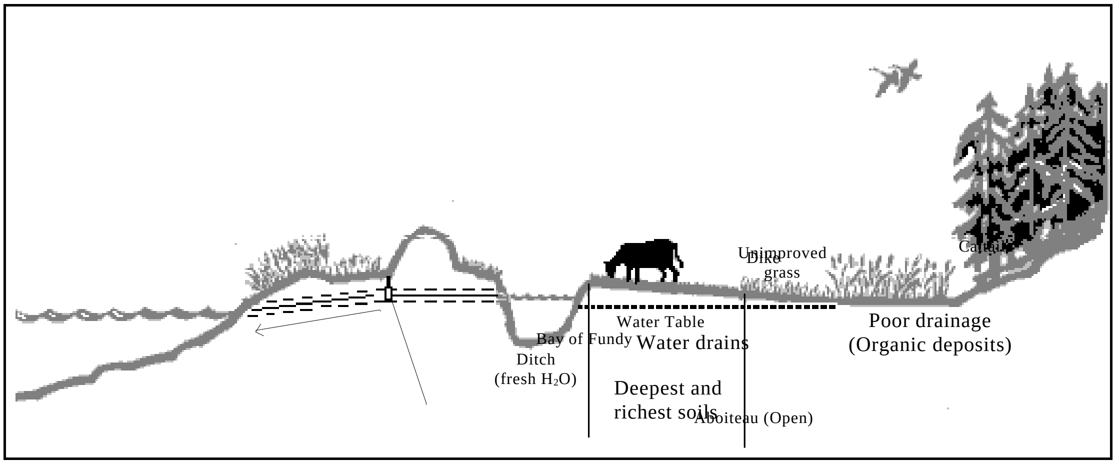
Walter Montgomery
Northeast Massachusetts Mosquito Control and Wetlands Management District

SECTION 6 - FRESHWATER IMPOUNDMENTS

Twice a day, the world's largest tides, as high as 50 feet/15 meters, flow in and out of the Chignecto Bay and Minas Basin in the upper Bay of Fundy. The repeated flush of water causes soft red sandstone to erode and form vast mud flats that over time give rise to extensive tidal marshes (Figure 6-1). These tidal marshes are referred to as the "Fundy" type and provide many functions and values similar to those in New England (See Table 5-1). Fundy tidal marshes are also susceptible to similar impacts (See Table 5-2). However, the most significant impact to Fundy tidal marshes was during the 1670s when Acadian settlers diked, drained, and converted the marshes to agricultural use. Today, approximately 300 km^2 of the original tidal marshes are now agricultural lands, or what are commonly called dikelands (Howell et al., 1991).

Figure 6-1 Landscape Sequence in an Undiked (Top) and Diked (Bottom) Tidal Marsh in the Upper Bay of Fundy





Modified from Howell et al. (1991).

From the 1700s to early 1900s, these lands were very important for the production of hay for local use and export to the United States. With the invention of the combustion engine in the early 1900s, the horse was replaced by tractors, trucks, and automobiles, reducing the demand for hay. Today, many of the dikelands are not actively being used for agricultural production. According to the Canadian Wildlife Service, conversion of these dikelands back to salt marshes is not practical because of existing infrastructure landward of the dikes and the need for flood control. Instead, an increasingly large number of freshwater impoundments are being constructed on unused dikelands in an effort to revitalize wetland habitat for waterfowl and other wildlife.

Drastic declines in waterfowl populations coupled with the great losses of wetlands instigated the adoption of the North American Waterfowl Management Plan (NAWMP) -- an international 15 year agreement between the United States, Canada, and recently Mexico that provides a framework for partnerships between governmental agencies and non-government organizations. The Plan addresses conservation and protection of critical wetland habitat through restoration, enhancement, and securement activities throughout North America.

The partnership in Eastern Canada is referred to as the Eastern Habitat Joint Venture (EHJV), and includes Environment Canada and the Canadian Wildlife Service, Wildlife Habitat Canada, New Brunswick's Department of Natural Resources and Energy, Nova Scotia's Department of Natural Resources, and Ducks Unlimited Canada (DUC). A portion of funding is made available through United States partners, including the U.S. Fish and Wildlife Service and U.S. non-government organizations such as the Nature Conservancy and Ducks Unlimited, Inc.

Private landowners also play a major role in EHJV projects and their assistance and input is often required in order to successfully implement a project. Once landowners involved with wetland enhancement are in agreement, permits required for enhancement work are applied for on the provincial level. Proposed projects are reviewed by the Provincial Departments of Environment, Natural Resources and Energy and Fisheries and Oceans Canada (Austin-Smith, 1994).

Land acquisition, water level management, vegetation control, and impoundment construction are the primary means of securing and enhancing wetland habitat on dikeland soils (Melanson, 1993). Earthen dikes and water control structures are used to maintain a constant water level within the impoundments. Level ditching is also being refined and used by DUC. This enhancement technique, similar to Open Marsh Water Management in the United States, involves connecting ponds with a series of channels and is done to prevent wetlands from drying during the brood rearing period. Additionally, a technique of ditching (using a "cookie cutter" type of machine) to improve water circulation and vegetation diversity within permanently flooded emergent areas has been proposed by DUC; however, it still was under evaluation as of 1994 (Austin-Smith, 1994). It should be emphasized that work conducted by DUC and the EHJV does not involve true "restoration" in the sense that a habitat is returned to a similar state prior to disturbance. Instead, these projects aim to build and enhance freshwater wetlands in areas that were historically tidal marsh and are done with the primary intent of increasing populations of waterfowl and other wetland dependent wildlife.

Current/Past Projects

Ducks Unlimited Canada (DUC), an action-oriented conservation corporation, has been enhancing waterfowl habitat in the Gulf of Maine watershed since 1965. Projects have been made possible through a combination of agreements with private landowners and more recently with land acquisition. Since the early work of DUC and the formation of the EHJV in 1989, over 100 wetland impoundments on nearly 20,000-acres/8065-hectares of land have been developed in the Gulf of Maine watershed. Costs of projects completed to date have averaged about $1,500 per acre and have included land acquisition and excavation of soil, both known to be expensive. These impoundments, along with their location and acreage, are listed in Appendix D and are shown in Figure 6-2.

At some sites, multiple freshwater impoundments have been integrated with agriculture and private land ownership. An example of this type of project is Belleisle Marsh, an 800-acre/323-hectare wetland complex located along the Annapolis River in Nova Scotia. Using the Belleisle project as its flagship, the EHJV hopes to encourage private landowners and farmers to develop similar projects on their land.

This approach is also underway in New Brunswick at the Hampton-Kennebecasis Marsh, a 4,960-acre/2,000-hectare wetland complex along the Kennebecasis River in Hampton and Quispamsis. At this site, freshwater impoundments, rough cover habitat (areas where dense vegetation is allowed to grow), and river and lake habitats, are managed alongside agricultural lands.

Ducks Unlimited Canada has developed four impoundments representing 278-acres/112-hectares within the Hampton-Kennebecasis Marsh. Along with the impoundments, approximately 130 nest boxes have been erected throughout the complex to provide shelter for species such as wood ducks and common goldeneye.

Potential/Future Projects

A 2,000-acre/806-hectare project is in the planning stages for the Tantramar Marsh near Sackville, New Brunswick. This project is modeled after the Belleisle and Hampton-Kennebecasis Marsh projects. With nearly 90 percent of the historical salt marshes in the Bay of Fundy having been converted to agricultural lands, potential for habitat enhancement is strong. Contacts listed below under additional information and contacts have the most recent information on future and potential sites. Like most restoration efforts, the opportunities are numerous, although money and resources remain a limiting factor.

Evaluation and Monitoring

According to staff with Nova Scotia Department of Natural Resources and Environment Canada, no monitoring or evaluation program exists for these impoundment projects. In general, projects are qualitatively assessed by an individual/expert, who may look to check whether or not the area is 50/50 vegetation to water. In addition, aerial photographs are used to evaluate sites.

The Belleisle Marsh project is an exception. At Belleisle, extensive monitoring data has been collected since 1991. Data collected includes waterfowl pair and brood surveys (primarily black duck), pheasant, waterfowl, and furbearers harvest surveys, passerine breeding pair surveys, and mammal, amphibian, and avian checklists. At Hampton-Kennebecasis Marsh, monitoring includes censuses for birds, invertebrates, and plants, as well as water chemistry. Questionnaires were also distributed to duck hunters and land owners to evaluate hunting conditions over time and to assess residential use of the marsh and trends in environmental attitudes toward the marsh. Reports that include monitoring results for the Belleisle and

Hampton-Kennebecasis projects have been produced (Austin-Smith, 1994; Pollard, 1996).

Restoration Effectiveness

Belleisle, along with the other impoundment sites, are considered successes because they support considerable waterfowl populations. Indeed, some of the results from the Belleisle study are promising, including an increase of 20 avian species and three frog species not recorded prior to wetland development. In addition, an increase in furbearers, primarily muskrat, was observed (Pollard, 1996).

In general, numbers collected for waterfowl show the conversion of dikelands to fresh water wetlands to have a positive effect on wildlife. The Plan aims to restore continental waterfowl numbers to 100 million birds -- such numbers have not been seen since the 1970s. In 1996, North American waterfowl numbers were estimated at 90 million birds -- an increase of 35 million since 1985. Beyond ecological benefits, these projects have proven invaluable in improving communications between and among interest groups and government agencies.

Recommendations

The following general recommendations are based on personal observations made during this study.

* No information on tidal marsh restoration in New Brunswick or Nova Scotia was obtained during this project. If an inventory of potential tidal marsh restoration sites does not exist, an effort should be made to assess and inventory potential opportunities to restore tidal marshes in the Upper Bay of Fundy. Although freshwater impoundments provide significant wildlife habitat for visiting waterfowl and other species, a great resource has been lost, and every effort possible should be made to restore tidal marshes where it is feasible to do so.

* Comprehensive project evaluations that include multiple functions and values of freshwater impoundments are recommended. The monitoring could easily be modeled after one of the methods mentioned in Section 5. Data acquired from these assessments could then be organized within a central location, such as the existing database managed by Ducks Unlimited Canada. Such monitoring would of course need to be streamlined and economical and could prove valuable for the evaluation of past projects and in the design and implementation of future projects.

Additional Information and Contacts

General information on wetlands in Canada may be found on the Internet at www.wetlands.ca. Detailed information on the following individuals and other contacts is provided in Appendix A.

For general information on the Eastern Habitat Joint Venture and their projects contact

Jon Stone
Environment Canada
Reg Melanson
Canadian Wildlife Service

Keith McAloney
Ducks Unlimitted Canada

For information on the Hampton-Kennebecasis and Tantramar projects contact

Peter Austin-Smith
Canadian Wildlife Service

For information on projects in Nova Scotia contact

Randy Milton
Nova Scotia Department of Natural Resources

For information on evaluation/monitoring contact

Bruce Pollard
Ducks Unlimited Canada

SECTION 7 - TIDAL FLATS

In the United States, tidal flats account for more wetland acreage than all other intertidal wetlands (i.e., salt marsh) combined (Field et al., 1991). In Maine, tidal flats represent 48 percent of all marine intertidal and 66 percent of all estuarine intertidal wetlands (MSPO, 1988). Composed primarily of mud, sand, and/or gravel, tidal flats are sometimes referred to as mud flats, worm flats, or clam flats. Tidal flats are a place of high primary production by benthic algae. In addition, nutrient regeneration and recycling through high rates of decomposition occurs in the mud and sediments. Burrowing worms and clams filter and process detritus and in turn provide food for wading birds, shrimp, crabs, and fish. Tidal flats play a major role in fisheries and the economy, as they are habitat for commercially important species such as soft shelled clams and baitworms (Table 7-1) (Ray et al., 1994; Short et al., 1998).

Table 7-1 Functions and Values of Tidal Flats

Functions (F) and Values (V) of Tidal Flats
F: Epibenthic and benthic production
F: Primary production by benthic algae
F: Nutrient regeneration and recycling
F: Sediment filtration and trapping
V: Support of commercial and recreational fisheries
V: Improve water quality
V: Counters sea level rise

Contents from Short et al. (1998).

Tidal flats, often densely populated by beds of shellfish, are of both economic and ecological concern. Because of the economic importance of certain shellfish species, projects aimed at restoring tidal flats often focus on shellfish populations. Restoration of shellfish may focus on water quality and levels of contaminants, such as fecal coliforms. Shellfish may be thriving in a polluted area but are too contaminated for human consumption. Projects may also involve seeding of clams and mussels to increase population size. The primary objective of these types of projects is to restore the fishery. These projects were not documented since it was decided early on that they do not directly address restoration of habitat. However, projects that improve water quality should not be grouped solely with cleaning up shellfish beds, as many other benefits to the coastal environment are gained through improvements in water quality. In addition, projects involving the seeding of shellfish may not only be considered fishery restoration but also habitat restoration since many small fish and invertebrates, including crabs and shrimp, inhabit shellfish beds. Projects aimed at restoring shellfish "habitat" include the three tidal flat restoration projects described below.

Current/Past Projects

In 1988, an intertidal mud flat was constructed at Sheep Island near Jonesport, Maine using dredged material. This project involved the placement of 100,000 cubic yards of fine sands onto three acres of previously shallow sub-tidal sand and gravel. Dredged material was also disposed along nearby Beals Island in 1960. The primary goal of these projects was to provide for a beneficial use of disposed dredged material by creating habitat suitable for commercially important species. A thorough evaluation comparing these sites to reference sites was conducted in 1990, 1991, and 1992 to determine long-term conditions within the constructed flats. The use of dredge material for mud flat creation was determined to be a positive environmental alternative to other modes of dredge disposal (Ray et al., 1994).

Between 1993 and 1995, as part of the Port Authority Expansion Project in Portsmouth, New Hampshire, a degraded subtidal pond was converted to intertidal mud flat habitat and fringing salt marsh. The habitat was created by restoring tidal flow and deepening a channel. An additional one acre of mud flat was created by excavating upland habitat and regrading the elevation to make it intertidal. In all, 6.8 acres of mud flat was created and enhanced at a cost of approximately $500,000 (Louis Berger & Associates, Inc., 1997; Short and Short, 1997; Short, pers. com., 1998).

Potential/Future Projects

A project involving the restoration of a tidal creek and adjacent tidal flat is proposed for the Rumney Marshes in Revere, Massachusetts. This project is designed to compensate for impacts caused during the Roughans Point Coastal Flood Damage Reduction Project. As part of the mitigation, a two acre intertidal flat will be constructed using excavated material from the abandoned I-95 embankment that runs through the Rumney Marshes Area of Critical Environmental Concern. Part of the mitigation also includes the reestablishment of blue mussel beds on the Roughans Point revetment (USACE, 1998). Although the project will provide valuable habitat, its primary goal is to restore soft-shelled clams and other commercially valuable shellfish to the site. A major clam re-seeding project is proposed for Sears Island.

Evaluation and Monitoring

The project at Sheep Island in Maine was evaluated using data on sediment characteristics, such as grain size and organic content. Softshell clams and bait worms were inventoried at both the constructed sites and a reference site. In addition, infaunal communities were sampled for taxa richness and total abundance and compared between sites (Ray et al., 1994).

Scientists from the Jackson Estuarine Laboratory at University of New Hampshire are developing success criteria for evaluating the restoration of estuarine habitats associated with the Port Authority Expansion Project in Portsmouth, New Hampshire. The methodology can be modified to evaluate salt marsh, tidal flat, or seagrass habitats. Monitoring of all habitat types is long-term and will take place for 15 years. For the tidal flats, monitoring includes site elevations, tidal range, sediment characteristics (including grain size, organic content, and salinity), and benthic invertebrate populations (Short et al., 1997).

For the Roughans Point project in Rumney marsh, success will be based on site elevations, sediment characteristics, and the biomass, density, and size class structure of soft-shelled clams in comparison to nearby habitats.

Restoration Effectiveness

Projects at Sheeps Island and Beals Island demonstrate that dredged material can be used to create tidal flat habitat that closely resembles natural tidal flats. With time, the created sites resembled the reference sites in sediment characteristics, soft-shelled clam and baitworm abundance, and in benthic infaunal assemblages. These similarities were more evident as the sites aged, but significant clam and worm populations and infaunal diversity was observed at the Sheep Island site as early as two years following construction (Ray et al., 1994).

For the Port Authority Expansion Project, recruitment of soft-shelled clams and foraging by wading birds was observed within a year of construction (Short, pers. com., 1997). Long-term monitoring is currently underway and with time will provide information on effectiveness and project development.

Recommendations

As explained in Section 3, very little information was acquired for the restoration of tidal flats in the Gulf of Maine. The following general recommendations are based on the limited information and literature that was collected.

* If dredge material is used to create a mud flat habitat, assessments of existing habitats where the material is to be placed should be conducted to ensure that a net gain in habitat function and value will be achieved and that no existing valuable habitat is lost in the process.

* Shellfish restoration projects should aim to not only restore the fishery but also restore shellfish habitat. Once the fishery is restored, measures should be take to prevent over exploitation of shellfish to preserve habitat value.

Additional Information and Contacts

Detailed information on the following individuals and other contacts is provided in Appendix A.

For general information on tidal flat and shellfish restoration projects in the Massachusetts, New Hampshire, and Maine, contact

Jon Kurland
National Marine Fisheries Service

Paul Anderson
Maine Dept. Of Marine Resources

For information on the tidal flat restoration and evaluation for the Port Authority Expansion Project, contact

Dr. Fred Short
Jackson Estuarine Laboratory/University of New Hampshire

For information on shellfish and water quality, contact

Dr. Steve Jones
Jackson Estuarine Laboratory/University of New Hampshire

SECTION 8 - SEAGRASS

The most widely distributed species of seagrass within the Gulf of Maine is eelgrass (*Zostera marina*). A less common species in the Gulf of Maine is widgeon grass (*Ruppia maritima*). This grass is more commonly found in brackish waters and has limited distribution in the Gulf of Maine. Eelgrass, the focus of seagrass restoration efforts, forms dense beds that are essential habitat for both juvenile and adult fish and invertebrate species. Seagrass is an important primary producer in shallow marine and estuarine waters. In addition, the leaves, or " blades" provide a surface upon which epibionts, including larval forms of sea stars, snails, mussels, and plants, may adhere. These communities on the seagrass blades provide a food source for grazing fish and invertebrates. Fish, such as striped bass, pollock, winter flounder, Atlantic cod, tomcod, scup, tautog, white hake, and Atlantic herring also find food and cover within the seagrass. Commercially important invertebrate species such as lobster and bay scallops also utilize seagrasses at various life stages (Table 8-1) (Heck et al., 1989; Kurland, 1993; Chandler et. al., 1996).

Table 8-1 Functions and Values of Seagrass

Major Category	Functions (F) and Values (V)
Productivity	**F**: Primary production. **F**: O_2 production. **F**: Organic matter accumulation. **F**: Support of benthic and epibenthic secondary production and nearshore and offshore foodwebs. **F**: Habitat, refuge, and nursery for fish and invertebrates. **V**: Support of nearshore and offshore commercial fisheries. **V**: Recreational fishing.
Hydrological	**F**: Baffles wave energy and currents preventing resuspension of sediments. **V**: Erosion protection for shoreline and uplands.
Geomorphological	**F**: Sediment stabilization. **V**: Water quality improvement. **V**: Erosion protection for shoreline and uplands. **V**: Counters sea level rise.
Biogeochemical	**F**: Traps, filters, and recycles nutrients, processing the nutrients into other forms or trophic levels. **F**: Contaminant filtration. **F**: Organic matter storage. **V**: Water quality improvement.
Heritage	**V**: Habitat for threatened and endangered species. **V**: Recreation. **V**: Scientific study and outdoor education.

Contents compiled from Kurland (1993), Short and Wyllie-Echeverria (1996), and Short et al. (1998).

In addition to providing habitat for other plant and animal species, seagrass plays an important role in maintaining water quality. Seagrass beds, with a vast network of roots and rhizomes, effectively bind sediments, while dense blades trap and draw suspended sediments to the bottom. This prevents sediment resuspension and therefore ensures continued survival of the seagrass itself and other primary producers that depend on clear waters for photosynthesis. The roots and rhizomes also absorb nutrients and modify the organic matter and nitrogen content of the sediments (See Table 8-1) (Thayer et al. 1984; Short and Wyllie-Echeverria, 1996).

Seagrasses inhabit shallow coastal and estuarine waters throughout the Gulf of Maine and are therefore largely influenced by human activity. Any one of the following impacts, or any combination thereof, may contribute to the degradation of seagrass.

* *Coastal construction and dredging:* Filling or dredging within or in close proximity to a seagrass bed may bury or remove seagrass (Short and Wyllie-Echeverria, 1996).

* *Decreased water quality:* Nutrient overload and eutrophication cause a reduction in water clarity (through algal blooms) and nutrient-induced competition by macroalgae (Thorhaug, 1987; Short and Wyllie-Echeverria, 1996).

* *Damage from boating, fishing, and related activities:* Groundings of outboard engines and fishing gear (such as trawls, nets, and lobster traps) may dislodge sediments and uproot plants. Loose anchor lines for moorings can create bare spots as the chain scrapes along the bottom. If improperly built, docks and piers can shade seagrass and inhibit light penetration (Burdick and Short, 1995; Short and Wyllie-Echeverria, 1996).

Natural impacts not related to human activities, such as storms and disease, can have detrimental effects on the entire coastline and within bays and estuaries. One disease which can have catastrophic effects is wasting disease. This disease is caused by the slime mould *Labyrinthula zosterae* that infects and kills eelgrass (Short and Wyllie-Echeverria, 1996).

Valuable ecological resources, such as salt marshes and shellfish beds, have received an increasing degree of legal and regulatory protection from coastal development activities. In addition, public awareness of the importance of these habitat types has also increased. Unfortunately, appreciation of coastal habitats is often limited to those that are visible above the water, and only recently has the importance of restoring seagrass restoration begun to attract attention (Kurland, 1993; Short and Wyllie-Echeverria, 1996). It is apparent that an increased effort toward restoration of seagrass is warranted to offset the loss of seagrass in specific areas, such as Great Bay Estuary and Massachusetts Bays.

Current/Past Projects

Restoration of seagrass is still in an experimental phase. Seagrass grows in a complex environment and is influenced by many variables. In order to understand differences between natural variability and human impacts, baseline information must be compiled. Charlie Costello, Massachusetts Department of Environmental Protection, has spent the past few years mapping eelgrass beds in coastal Massachusetts. This information is available through MassGIS. Seth Barker, Maine Department of Marine Resources, has been mapping eelgrass in Maine and New

Hampshire. The New England Aquarium, in collaboration with the U.S. Environmental Protection Agency (EPA) and Massachusetts Audubon Society, has been studying the health and ecology of eelgrass beds throughout Massachusetts Bay for the past three years. Dr. Fred Short and researchers with the University of New Hampshire Jackson Estuarine Laboratory (JEL) have also done considerable research on the ecology and restoration of seagrass throughout the region.

There are several seagrass restoration projects that have been conducted in the Gulf of Maine. The most significant project, and the largest transplanting effort in the Northeast, is associated with the multi-habitat restoration for the Port Authority Expansion Project in Portsmouth, New Hampshire. As part of the mitigation to compensate for habitat lost during the expansion of pier facilities, Dr. Fred Short and JEL researchers successfully transplanted eelgrass in the Piscataqua River and Great Bay Estuary (Short, 1993). Total costs for transplanting 6.2 acres of eelgrass were approximately $700,000 (Louis Berger and Associates, 1997; Short, pers. com., 1998). This cost is partially inflated due to the construction of an 0.8 acre underwater terrace to provide suitable substrate and elevation for the transplanted seagrass.

The mitigation project was designed in an experimental format to meet permit requirements and to allow development of transplanting techniques and evaluative methodologies (Davis and Short, 1997). A great deal has been learned during this project and there have been considerable technologies developed that have proven effective. One such technology is a new transplanting technique referred to as the 'horizontal rhizome method'. This technique was shown to minimize impact to donor beds and was efficient, both in time and money (Davis and Short, 1997). Also developed during this project was a site selection model that considers physical characteristics, including bathymetry, water quality, sediment distribution, exposure, and proximity to other eelgrass beds, in identifying potential transplant sites (Short et al., 1998). Other projects that have recently been implemented in Great Bay Estuary under Dr. Fred Short include transplant sites at Rye Harbor, in Little Bay, and in North Mill Pond in the Piscataqua River.

A small experimental project was conducted in 1996 in Hingham Harbor, Massachusetts, by the New England Aquarium, the U.S. Environmental Protection Agency (EPA), and the Massachusetts Audubon Society. Although this transplanting project was unsuccessful in establishing a permanent bed, it provided valuable information on seagrass restoration. In addition, it was only a subset of a much larger effort to acquire baseline data on eelgrass beds in Massachusetts. Data and results from this ongoing assessment have provided extensive information on the productivity of eelgrass beds and the importance of eelgrass beds to commercial fisheries (Chandler et. al.,1996).

Considerable work in seagrass restoration has been conducted just outside of the Gulf of Maine. Joe Costa, Buzzards Bay Project National Estuary Program, has conducted several small projects in Buzzards Bay. Dr. Fred Short and Blaine Kopp with the Graduate School of Oceanography (GSO) at University of Rhode Island, have begun eelgrass restoration in New Bedford Harbor. At the New Bedford Harbor sites, a new technique called remote transplanting or "TERFS" (Transplanting Eelgrass Remotely with Frame Systems) is being used. TERFS was developed by UNH/JEL and involves attaching eelgrass to cages and setting the cages on the bottom. The cages are later removed once the eelgrass has rooted (Short, pers. com., 1998).

Researchers Scott Nixon, Blaine Kopp, and Steve Granger with the GSO have conducted several projects and studies on eelgrass restoration in Narragansett Bay between 1994 and 1997. The Narragansett Bay Project also collaborated with the GSO to conduct a project in 1994.

Other efforts in Narragansett Bay include those funded by NMFS and led by Mark Fonseca, and more recently a small seeding project conducted by Save the Bay. Further south, in the Chesapeake Bay area, researchers in Dr. Robert Orth's laboratory at Virginia Institute of Marine Science, have also conducted numerous experiments and projects involving restoration of eelgrass beds.

Potential/Future Projects

Dr. Fred Short and researchers at the Jackson Estuarine Laboratory have proposed additional seagrass restoration projects for North Mill Pond and Rye Harbor in the Great Bay Estuary. Projects have also been proposed for New Bedford Harbor, Massachusetts, which is outside of the Gulf of Maine watershed.

Evaluation and Monitoring

Methods for monitoring the health and distribution of seagrass in an effort to obtain baseline information have been developed and implemented. Large scale monitoring of seagrass primarily involves interpretation of aerial photography, and usually the measurement of physical parameters (e.g., temperature, salinity, turbidity), and measurement of biotic parameters (Beatty et. al., 1991).

In the Northeast, restoration of seagrass by transplanting is relatively new, and monitoring techniques for these projects have generally been developed on a project to project basis. For the multi-habitat restoration conducted for the Port Authority in Portsmouth, JEL researchers have developed a methodology for evaluating restoration success. This methodology, referred to as the "Success Criteria Methodology", is being used to evaluate success of eelgrass transplant sites and is designed to be transferable to projects involving other estuarine habitats such as tidal flats and salt marsh (Short et al., 1998). In general, the methodology involves measuring specific criteria that are based on important ecosystem functions and then quantitatively comparing results of transplant sites to selected reference sites. Indicators measured are chosen based on their importance of ecosystem function and their cost effectiveness. Indicators chosen for evaluating the sites in Great Bay Estuary included leaf width, density, and biomass, and benthic invertebrate abundance and diversity. JEL researchers have also monitored fish diversity and fish use at transplant sites, and have assessed the continuity of grassbeds using aerial photographs. Similar data to that collected for the projects in New Hampshire was collected to evaluate the project in Hingham Harbor, Massachusetts (Chandler et al., 1996).

Fonseca (1989) provides a step by step approach for the planning, construction, and monitoring of seagrass restoration projects. Fonseca's methods for monitoring project success include measuring the survival of planting units, determining the numbers of shoots, and assessing bottom coverage. Unfortunately, data on distribution, growth rate, and coverage of seagrass along the Northeast coast is minimal. It is difficult to determine a projects success without this baseline information. Baseline data is especially important in order to objectively evaluate mitigation projects involving seagrass restoration. Fonseca (1989) recommends that projects be evaluated quarterly for the first year after planting and semiannually thereafter for two more years.

Restoration Effectiveness

The failure to establish a self-sustaining eelgrass bed in Hingham Harbor, Massachusetts, was most likely due to bioturbation by green crabs and also the time of year that the planting was conducted (Chandler et al., 1996). Of the 6.2 acres of eelgrass planted in the Piscataqua River and Little Bay, New Hampshire, approximately 3.1 acres had survived after two years. Additional acreage has since established as the beds continue to grow. It was determined from evaluation results that it took approximately three growing seasons for eelgrass biomass and density to achieve success, and about two years for the benthic species of the transplant sites to resemble those of reference sites (Short et al., 1998). Short et al. (1998) suggests that other seagrass functions, such as sediment trapping and organic matter accumulation, will most likely take longer to evaluate since detectable differences take time.

From the projects that have been conducted in the Northeast, proper site selection, transplant or seeding methods, and timing of planting, have been identified as important considerations for seagrass restoration projects (Chandler et al., 1996; Short et al., 1998). Reasons for failed attempts in the past include the following:

* Bioturbation (caused by green crabs, clam worms, spider crabs, and slipper shells)
* Poor water quality
* Depth at which seagrass was planted
* Storm damage
* Ice damage

Although there have been failed attempts, much has been learned about the ecology and restoration of seagrass. New knowledge from lessons learned and research and the development of more effective restoration technologies has already begun to improve restoration efforts in Great Bay Estuary and will prove useful for future restoration projects conducted elsewhere in the region.

Recommendations

The following recommendations are made based on discussions with researchers and personal experience during this study.

* Projects that address improvements in water quality should be considered part of the effort to restore seagrass. Improvements in water quality will assure greater success in future seagrass transplanting and seeding projects and will promote natural reestablishment of seagrass.

* Restoring seagrass is currently very labor intensive and very expensive. Research investigating more economical methods of restoration, such as seeding, or the recently developed horizontal rhizome method, is warranted.

* Awareness of the value of seagrass as a habitat (as well as other submerged habitats) needs to be promoted to the public and policy makers. Currently, the U.S. Environmental Protection Agency has organized a yearly meeting on seagrass in the Northeast. Although effective and well attended, these meetings primarily involve researchers. A larger regional conference that attracts many different parties involved could be organized in order to raise awareness and direct attention to the efforts currently underway.

Additional Information and Contacts

More detailed information on specific projects is included in the database. The database and a bibliography on seagrass is available on the Gulf of Maine Council's Website at www.gulfofmaine.org. (See Section 4.) For additional information on seagrass restoration in the Gulf of Maine contact one of the following individuals. Detailed information on these and other contacts is provided in Appendix A.

Fred Short
Jackson Estuarine Laboratory
University of New Hampshire

Seth Barker
Maine Department of Marine Resources

Charlie Costello
Massachusetts Department of Environmental Protection

Robert Buchsbaum
Massachusetts Audubon Society

Mark Chandler
New England Aquarium

In Southern Massachusetts, contact

Joe Costa
Buzzards Bay Project

SECTION 9 - DUNES

A dune is any natural hill, mound, or ridge of sediment landward of a coastal beach deposited by the wind or storm over-wash or by artificial means and providing storm damage prevention and flood control (MCZM, 1994). Protection and restoration of coastal dunes, an important component of barrier beach systems, is of both economic and ecological concern. Dunes, situated in the backshore of barrier beaches, protect interior habitats and, in many cases, public facilities and privately owned homes, from the onslaught of wind and waves. Dunes are effective barriers due to the stabilizing effects of beachgrasses, the most common of which is American beachgrass *(Ammophila brevigulata)*. Dune grasses bind the sand with their roots and rhizomes, while their leaves trap sand and promote dune expansion and growth. Without dune vegetation, winds and waves will regularly change the form and location of dunes (Berrill and Berrill, 1981). Even well vegetated, dunes are not permanent landforms and frequently change form and location. In addition to storm protection, dunes provide significant habitat for birds, small mammals, and rare and endangered plant species. Characteristics of dunes also add significant value to society, including aesthetic benefits for beach goers (Table 9-1).

Table 9-1 Functions and Values of Dunes

Functions (F) and Values (V) of Dunes
F: Sand storage and supply. Dunes store and supply sand to adjacent beaches.
F: Storm protection and flood control. The form and volume of dunes and the stabilizing effects of dune vegetation protect landward wildlife habitats, including salt marshes.
F: Significant wildlife habitat. Dunes provide habitat for birds, small mammals, amphibians, reptiles, and invertebrates.
V: Storm protection and flood control. The form, volume, and stabilizing effects of dune vegetation protect landward properties and infrastructure.
V: Aesthetic value. Dunes are aesthetically pleasing and attract naturalists and beach goers.

Contents from MCZM (1994).

In the Gulf of Maine, dunes are located between Cape Cod and Southern Maine. In Massachusetts, huge dunes as high as 100-feet and covering over 900-acres/363-hectares, may be found in the Province Lands dune fields at the tip of Cape Cod (CCNS, 1983). On the Cape, dunes are also found at Sandy Neck at Barnstable Harbor and on Monomoy Island. An extensive dune system, approximately six miles in length, may be found at the Parker River National Wildlife Refuge on Plum Island. This barrier beach system with extensive dunes provides storm protection for the most extensive salt marshes found in New England. The sites mentioned represent just a few of the 681 barrier beaches in Massachusetts (MCZM, 1994).

Dunes are also associated with many of the coastal towns and barrier beaches in New Hampshire, including a 56-acre/23-hectare dune complex adjacent to the Hampton-Seabrook estuary. In Maine, dunes are found at Ogunquit Beach, Scarborough Beach, and Popham Beach. Dunes in the Maritime Provinces are found outside the Gulf of Maine on Sable Island, and along the Gulf of Saint Lawrence (Berrill and Berrill, 1981).

Impacts to dunes began in the early 1700s, when cattle and horses were allowed to graze on dune grasses and the small shrubs and pines were used for firewood. On Cape Cod, laws were established as early as 1714 to protect dunes and associated vegetation (CCNS, 1983). Impacts to dunes include any activities that cause devegetation or direct erosion, such as off-road vehicles and direct development near and among dunes. Even foot traffic and trampling can significantly decrease both plant cover and the diversity of species. Natural processes, such as wave action, sea level rise, and storms also erode dunes (Carlson and Godfrey, 1989).

Dune restoration projects involve dune stabilization, protection, and management of public access. Dune stabilization is achieved through dune planting and revegetation programs. Blowouts (areas where wind action has removed sand and vegetation) are repaired by replenishing dune sand, planting vegetation, and installing snow fencing. Snow fencing is used to prevent people from walking on the dunes, and also assists in trapping sand. Control of access through the construction and maintenance of elevated boardwalks minimizes impacts by foot traffic. Interpretive signage is often used in an effort to raise public awareness. If not properly accounted for, methods to restore dunes and alter configurations may adversely impact rare and endangered species that depend on natural dune configurations and attributes, such as blowouts and washouts (Table 9-2) (OTA, 1995).

Table 9-2 Dune Construction and Protection of Property and Rare Species Habitat

Beach and Dune Characteristics	**Configuration to Protect Property**	**Configuration to Protect Rare Species Habitat**	**Possible Configuration to Meet Both Needs**
Beach width and shape	Wide and gently sloping	Wide and flat, or gently sloping	Wide and mixed gently to flat slope
Dune elevation	High	Low	Moderate
Dune volume	Large	Small	Moderate
Dune location and continuity	As far seaward as possible	No dune, or, when present, landward of shore	Inland, landward of high water line
Dune length	Long/continuous	Broken	Moderate length
Dune vegetation	Dense vegetation	Bare sand mixed with sparse vegetation	Minimum plantings needed for stabilization, or perhaps special patterns that leave bare areas
Dune fencing	Constructed in long rows	None	Minimum fencing for stabilization - use patterns of fencing that allow birds to move across beach and dunes

Configurations are relative and must be designed according to site-specific needs. Contents from OTA (1995).

Current/Past Projects

Numerous coastal development projects are permitted throughout Massachusetts, New Hampshire, and Maine that impact dunes. In Maine, these projects rarely involve any type of compensation (Mullen, pers. com., 1998). The majority of dune "restoration" projects are conducted solely to protect homes and other human infrastructure. Hundreds of these small scale projects are conducted annually by private homeowners. For example, it is estimated that approximately 50 to 100 residents currently conduct annual dune stabilization projects along Coffins Beach in Gloucester, Massachusetts (Haney, pers. com., 1998). Larger dune restoration projects have been conducted at Duxbury Beach by Duxbury Beach Reservation, Inc., and the town. Blowouts have been repaired, plantings conducted, and footpaths constructed along dunes in Seabrook, New Hampshire. According to permits issued by Maine Department of Environmental Protection, dune restoration projects were conducted at Fowler's Beach in Portland and on Long Island, Maine in 1991 and 1994, respectively.

Dune restoration may also include the construction of "sacrificial" dunes designed for flood control and short-term storm damage protection. Sacrificial dunes are supported by the Federal Emergency Management Agency and must be permitted by the U.S. Army Corps of Engineers. In Massachusetts, projects are reviewed by the U.S. Fish and Wildlife Service to ensure compliance with the Endangered Species Act and by Massachusetts Coastal Zone Management to ensure federal consistency with state coastal policies (MCZM, 1994).

Many dune restoration projects, whether they involve small plantings or construction of large sacrificial dunes, have been conducted amidst protest by environmentalists. Rare and endangered birds, such as Roseate Terns and Piping Plovers, nest on relatively flat shorelines free of dense dune vegetation. These nesting habitats can be impacted if the slope is altered by placing dunes of sand and vegetation in close proximity to nesting areas. In coastal towns such as Duxbury, Massachusetts, the construction of sacrificial dunes has resulted in controversy between homeowners and those looking to protect shorebird nesting habitat. Controversies and competing interests have prompted the drafting of comprehensive beach management plans that address both sides of the issue.

To assist in the management of barrier beaches, Massachusetts formed the Massachusetts Barrier Beach Task Force in 1992, which included members from local, state, and federal agencies, environmental organizations, beach managers, and beach users. The task force produced a document entitled *Guidelines for Barrier Beach Management* that provides barrier beach managers with a comprehensive overview of regulations and environmentally-based best management practices designed to foster responsible use and protection of barrier beaches (MCZM, 1994). The task force and the document strongly encourage the development of management plans for barrier beach areas.

In 1995, at the request of the U.S. Congress, the Office of Technology Assessment (OTA) organized a workshop that reviewed the feasibility of management technologies that allow protection of shoreline property and rare species habitat. According to OTA (1995), protectors of habitat seek to achieve beach and dune profiles that are nearly opposite those recommended for storm protection. However, configurations and design of dune projects can be modified to address both needs. (See Table 9-2.) If conducted in the right place and with proper considerations for rare and endangered species, dune restoration can have positive ecological, economic, recreational, and aesthetic benefits.

Potential/Future Projects

Potential for dune restoration lies wherever humans are impacting dunes. In addition, natural events, such as storms and sea level rise, will encourage continued restoration of dunes in areas of heavy coastal development. Such projects should take into consideration the natural surrounding habitat early in the planning stages and make the preservation of existing nesting habitat a primary concern.

Evaluation and Monitoring

There are no set criteria or methodologies for evaluating the effectiveness of dune restoration projects. However, ongoing monitoring of dunes is necessary as part of a management plan in order to assess, identify, and mitigate human impacts. In addition, surveys that include dune profiles must be conducted to determine changes in dune form, location, and volume. Monitoring and habitat evaluation was done extensively at Crane Reservation in Ipswich, Massachusetts, and included vegetation surveying and mapping along with field observations on land use practices of visitors and staff (Carlson and Godfrey, 1989).

Monitoring is a prerequisite for correctly evaluating the effectiveness of various methods of dune construction. In addition, in order to integrate storm protection with habitat protection, monitoring of rare species and coastline geomorphology is required. Such monitoring is necessary to establish management practices that respond to natural change, for ecosystem considerations, and to provide adequate storm protection (OTA, 1995). Preliminary assessments might include beach and dune profiles, tidal and storm elevations, location and elevation of infrastructure, and an aerial photograph or plan that indicates rare species habitat and areas for proposed dune construction or dune building enhancement projects, including proposed snow fence, beach grass, and sediment nourishment locations (MCZM, 1994).

Restoration Effectiveness

Dunes are naturally effective at protecting inland habitats and human infrastructure, and any attempts to protect, stabilize, and even construct human-made dunes will maintain and possibly improve this effectiveness. However, what should be determined is the effectiveness of these projects at protecting and restoring habitat. There are certain planting schemes and patterns that work best (See Table 9-2), and several consultants highly recommend the use of fertilizers in establishing vegetation (Lelito, pers. com., 1997). The plans developed for Crane Reservation in Ipswich, Massachusetts, proved to be effective at integrating protection and restoration practices with management plans (Carlson and Godfrey, 1989).

Recommendations

The following are general recommendations for dune restoration projects. A much more comprehensive list of recommendations may be found in the *Guidelines for Barrier Beach Management* distributed by Massachusetts Coastal Zone Management.

* In areas where numerous individual dune plantings are being conducted, comprehensive plans should be drafted to address storm protection, human uses and access, and most importantly, habitat.

* Prior to dune restoration, the existing habitat should be evaluated to determine functions and values that may be changed during and after construction or alteration of dunes and to minimize impacts to endangered species habitat.

Additional Information and Contacts

A bibliography for dunes is available on the Gulf of Maine Council's Website at www.gulfofmaine.org. (See Section 4.) Detailed information on the following individuals and other contacts is provided in Appendix A.

For information on dune restoration and impacts on rare and endangered species, contact

Dr. Scott Melvin
Massachusetts Division of Fisheries and Wildlife

For general and regulatory information contact:

Rebecca Haney
Massachusetts Coastal Zone Management

Nancy Beardsley
Maine Department of Environmental Protection

Frank Richardson
New Hampshire Department of Environmental Services

SECTION 10 - SEABIRDS

Seabirds that breed in the Gulf of Maine region include Atlantic Puffins, Black Guillemots, Thick-Billed and Common Murres, cormorants, gulls, eiders, Leach's Storm Petrels, Razorbills, and terns. Other types of birds associated with the coast, such as Piping Plovers, are protected in the Gulf of Maine, however, they are only briefly discussed. Certain species of seabirds such as terns and gulls are well distributed throughout the Gulf. However, other species, such as Atlantic Puffins and Razorbills, only nest on a few select Islands in Northern Maine and on Machias Seal Island.

In the Gulf of Maine, between the late 1800s and early 1900s, several seabird populations were nearly decimated by human exploitation and loss of nesting habitat. Seabirds were hunted for food and feathers and their eggs were gathered on many islands, the more bountiful of which earned names such as Eastern and Western Egg Rock. Other impacts that affect birds nesting along beaches, such as Least Terns and Piping Plovers, include coastal development, human disturbances such as off-road vehicles, and predation by foxes, raccoons, domestic dogs and cats, and other bird species (Melvin et al. 1991). Impacts to shorebird nesting habitat as a result of dune stabilization and construction projects are discussed in Section 9.

The Migratory Bird Treaty Act, passed by U.S. Congress in 1918, was established to protect all migratory bird species in the United States. However, seabird numbers still remained low, primarily due to the population explosion of Herring Gulls and Great Black-Backed Gulls, also protected by the Act, which compete with other species, particularly terns, for prime nesting sites and prey on eggs and chicks of other birds. Naturalists attribute the increased gull populations to increased food availability resulting from open dumping of garbage in land fills and exponential growth in the fishing industry. In 1996, researchers with the Department of Forestry and Wildlife at University of Massachusetts, Amherst, conducted a gull census of 313 islands along the Maine coast. A total of 15,800 pairs of Great Black-backed Gulls and 28,290 pairs of Herring Gulls were counted at 242 nesting colonies (Allen, 1997). In 1901, an estimated 14 nesting colonies of gulls occurred off coastal Maine (Schauffler, pers. com., 1997).

In 1984, in response to a 50 year decline in tern populations, Dr. Stephen Kress, manager of National Audubon Society's (NAS) Maine Coast Sanctuaries, and representatives from nearly 50 state, federal, and private organizations formed what is known as the Gulf of Maine Seabird Working Group (GOMSWG). GOMSWG works to restore populations of seabird species whose populations have been depleted by human activity. The group works on behalf of many seabird species including those listed in Table 10-1.

"Managing" bird habitat in an effort to restore historic numbers of seabird species includes controlling vegetation that has overgrown onto nesting beaches as a result of earlier agricultural practices, attracting species back to historical nesting sites, and making room for nesting seabirds by controlling gulls and relocating predatory species such as herons and owls. Controlling gulls may involve the use of avicides, the disruption of nests, predator exclosures, and removal by gunshot. These practices are often controversial. Members of GOMSWG, including the Audubon Society of New Hampshire, are experimenting with an alternative "non-lethal" method for controlling gulls. This method primarily involves maintaining human presence (often with dogs) at nesting sites to ward off invasive gulls. Other components of restoration projects include land acquisition and public awareness and education.

Table 10-1 Number of Nesting Pairs of Waterbirds and Number of Nesting Colonies in Maine (1976-1977 & 1994-1995)

	1976-1977		1994-1995	
SPECIES	**Pairs**	**Colonies**	**Pairs**	**Colonies**
Atlantic Puffin	125	1	195	4
Black-crowned Night Heron	117	8	109	7
Black Guillemot	2,668	115	12,341	167
Common Eider	22,390	241	28,384	322
Double-crested Cormorant	15,333	103	19,538	127
Glossy Ibis	75	3	141	3
Great Black-backed Gull	9,847	220	16,798	247*
Great Blue Heron	903	18	644	15
Great Cormorant	0	-	206	10
Great Egret	0	-	2	1
Herring Gull	26,037	223	16,819	189*
Laughing Gull	231	6	1,120	3
Leach's Storm-petrel	19,131	17	10,304	34
Little Blue Heron	4	2	9	2
Razorbill	25	2	250	3
Snowy Egret	90	4	182	5
Tricolored Heron	1	1	4	1

All data and information provided by the Maine Department of Inland Fisheries and Wildlife and the U.S. Fish and Wildlife Service. *Black Guillemot and Razorbill numbers are total counts of adult birds around nesting islands. Common Eider nesting data are an amalgamation of nesting records collected over several years. Herring and Great Black-Backed Gull and Double-Crested Cormorant numbers were derived from aerial counts. 1996 gull census results provided in the text above.

In addition to restoring seabird populations, members of GOMSWG collaborate on research including productivity, feeding, and reproductive studies. By counting and identifying the fish that seabirds consume during a season, researchers can predict future fishery productivity and can also monitor the birds for evidence of toxic substances in the environment, such as mercury, lead, and PCBs (Kress, pers. com., 1997). Future efforts by members of GOMSWG include continued research and continued management of nesting habitat.

Current/Past Projects

Active restoration of seabird colonies is being conducted on 12 islands (Table 10-2; Figure 10-1). GOMSWG members recently expanded efforts to Monomoy Island in Massachusetts, the Isles of Shoals (White and Seavey Islands) off Portsmouth, New Hampshire, and Machias Seal Island south of Grand Manan, New Brunswick. Work on these 12 islands includes gull control, research, censuses, and implementation of attraction techniques. Besides the work on these 12 islands, annual tern censuses are conducted on approximately 70 islands. In

1996, a census of Great Black-Backed Gulls and Herring Gulls was also conducted. All census data is maintained at the Maine Department of Inland Fisheries and Wildlife.

Mainland sites for tern censuses include Higgin's Beach and Reid State Park in Maine, Hampton Salt Marsh in New Hampshire, beaches along Cape Cod and Nantucket in Massachusetts, and Plymouth Beach, New Island, and Gray's Beach in Massachusetts. In addition, a small colony of Common Terns (~300 pairs) nests on an artificial platform constructed in Boston Harbor. Just outside the Gulf of Maine in Buzzards Bay, censuses are conducted on Bird, Ram, and Penikese Islands (Allen, 1997).

Protection and censuses are conducted for Piping Plovers at the Parker River National Wildlife Refuge and Crane Beach along the North shore of Massachusetts and on sections of Cape Cod National Seashore in Massachusetts. At Harding Beach in Chatham, Massachusetts, substantial plover nesting habitat was increased in the late 1980s using disposed dredged material (Melvin et al. 1991). In addition to censuses for terns and plovers, the USFWS, together with MDIFW, conducts a coast-wide census of 21 species of colonial waterbirds every 10 years (See Table 10-1). Nest counts are made for terns, Laughing Gulls, wading birds, Great Cormorants, and Atlantic Puffins (Allen, 1997). Aerial surveys are conducted to assess populations of Double-Crested Cormorants, Great Blue Herons, Herring Gulls, and Great Black-Backed Gulls.

Potential/Future Projects

With additional resources, including staff, volunteers, and monetary support, additional islands could be acquired and restored/protected to accommodate historical seabird numbers and diversity.

Evaluation and Monitoring

The success of seabird restoration is based on comparing current seabird numbers to estimates acquired prior to human disturbance. GOMSWG measures its success based on earlier estimates for Maine's coast during the 1930s.

Table 10-2 Seabird Nesting Islands Under Management/Restoration

Island	Organizations Involved	Observations in 1997

Monomoy NWR	US Fish and Wildlife Service (USFWS)	350 acre project area. Activities to restore tern nesting began in 1996. Gull control through use of poison has been limited. Common, Least, and Roseate Terns increasing.
White and Seavey Islands	Audubon Society of New Hampshire	7 acres of nesting habitat recently targeted for habitat management. Gulls controlled with human presence. Sound and attraction methods used. 6 Common Tern nests in 1997.
Stratton Island	National Audubon Society (NAS)	821 Common Tern nests, 56 Roseate Tern nests, and 6 Arctic Tern nests in 1997. Gulls allowed to nest in separate area. Common eiders and Black Crowned Night Herons also nest at Stratton. Feeding and productivity studies conducted. Blind constructed for island visitors.
Jenny Island	NAS	1068 Common Tern nests and 12 Roseate Tern nests in 1997. Common Eiders also nesting. Feeding and productivity studies conducted.
Pond Island	NAS	Restoration begun in 1996. 5 Common Tern nests in 1997. Common Eiders nesting on island. Eider productivity and courtship feeding study conducted.
Eastern Egg Rock	NAS	1441 Common Tern nests, 138 Roseate Tern nests, and 94 Arctic Tern nests in 1997. 22 pairs of puffins on island. Leaches-Storm Petrels also present. Feeding and productivity studies conducted.
Matinicus Rock	NAS	1024 Arctic Tern nests. 90 Common Tern nests. 144 puffin burrows (380 birds) observed with 54 chicks tagged in 1997. Efforts to attract and restore Common Murres continue. Chick provisioning study conducted.
Seal Island NWR	USFWS	1798 tern nests counted in 1997. 57% of these nests were estimated to be common terns and 43% of the nests were estimated to be Arctic Terns. One Roseate Tern nest was found in 1997. 333 Common Eider nests. 58 active Atlantic Puffin nests. Razorbill attraction conducted with decoys and sound recordings.

Contents from Allen (1997). See Figure 10-1 for island locations.

Table 10-2 Continued

Island	Organizations Involved	Observations in 1997

Metinic Island	NAS	Nesting low on North end of island, with 3 Arctic Tern nests, and 1 Common Tern nests. Approximately 95 nests on south end, of which, 80-85% were Arctic Tern nests.
Ship and Trumpet Islands	NAS	478 Common Tern nests. This is up from 41 nests in 1996. Productivity and feeding studies.
Petit Manan NWR	USFWS	1347 Common Tern nests, 359 Arctic Tern nests, and 29 Roseate Tern nests in 1997. Laughing Gull numbers up from previous year. 10 Atlantic Puffin nests and 8 Razorbill nests. Petit Manan NWR includes Outer Trumcap Island, a newly acquired 7.5 acre island that currently has no terns nesting on it.
Machias Seal	Environment Canada and USFWS	Census on island every other year. In 1997, 39 Common Tern nests and 70 Arctic Tern nests. 65 Atlantic Puffin nests and 58 Razorbill nests. Provisioning study conducted.

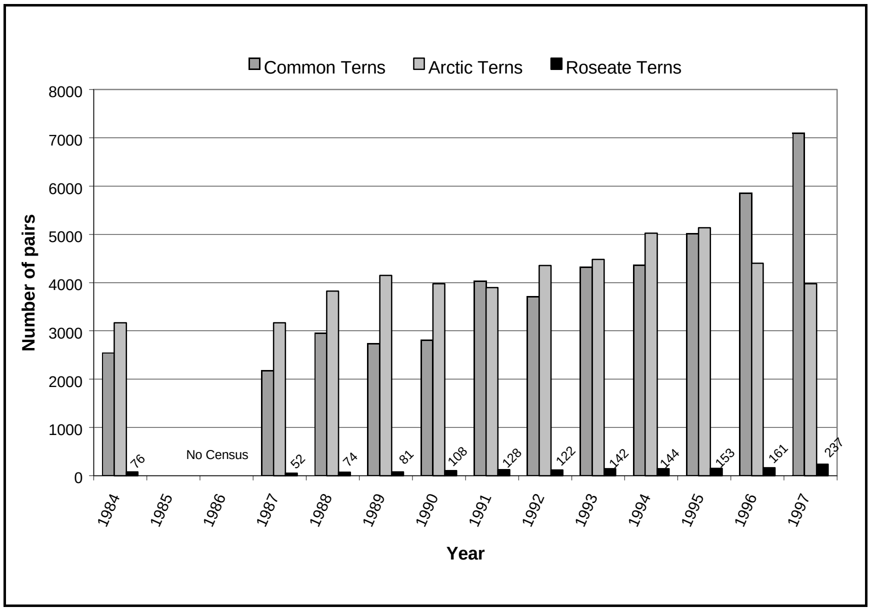
Contents from Allen (1997). See Figure 10-1 for island locations.

Restoration Effectiveness

GOMSWG aims to restore tern populations to the levels observed in the 1930s. Numbers from annual tern censuses conducted on Maine islands are provided in Figure 10-2. It is apparent that the restoration of terns along coastal Maine has been extremely successful. In 1997, GOMSWG counted 7,102 pairs of Common Terns, 3,976 pairs of Arctic Terns, and 237 pairs of Roseate Terns (Allen, 1997). Ralph Palmer, a Harvard University zoologist, estimated that in the 1930s as many as 8,000 pairs of Common Terns, 6,000 pairs of Arctic Terns, and 275 pairs of Roseate Terns nested along coastal Maine. Efforts on some islands, such as Stratton Island, have been extremely effective. On Stratton in 1995, there were approximately 260 nesting pairs of common terns. In 1998, numbers of nesting pairs rose to over 1,000. Roseate Terns have also increased on Stratton, from 1 pair in 1995 to 71 pairs in 1998 (Allen, 1997; Kress, pers. com., 1998). Results in 1997 suggest that Common Terns have recovered, Roseate Terns are close to their goal, and Arctic Terns need added attention over the next few years.

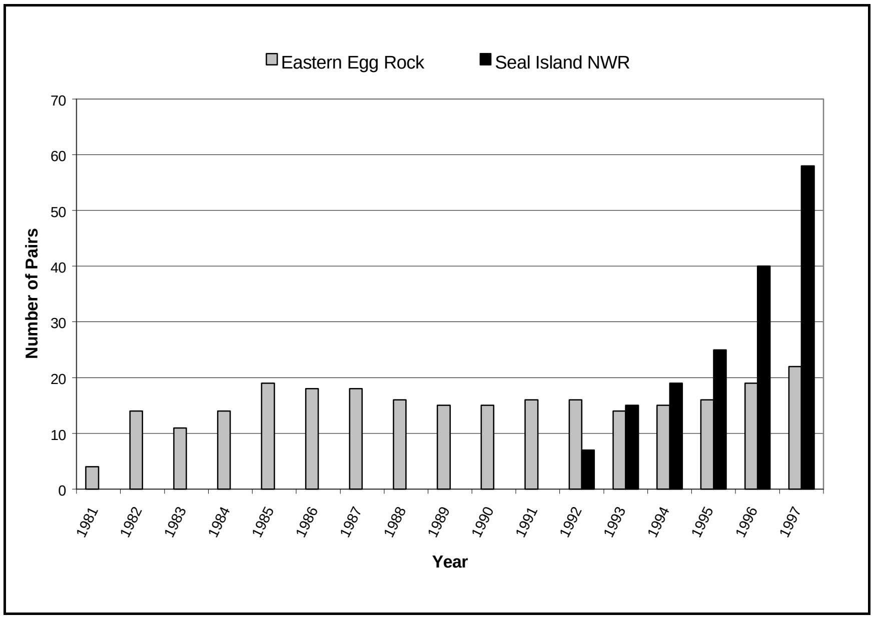
Although success is based on numbers for islands in Maine and Machias Seal Island, GOMSWG is gulf-wide and data collected from Massachusetts and New Hampshire is included in annual working group minutes. Totals in 1997 for Massachusetts nesting colonies within the Gulf of Maine included 8,327 Common terns, 22 pairs of Roseate Terns, and five pairs of Arctic Terns. Just outside of the Gulf of Maine, in Buzzards Bay, Massachusetts, approximately 3,200 pairs of Common Terns and 1,432 pairs of Roseate Terns nested on Bird and Ram Islands (Allen, 1997). Bird and Ram Islands represent the largest Roseate Tern nesting colonies in the Western Atlantic (Buchsbaum, pers. comm., 1998). Numbers for Common Terns remain high at Plymouth Beach (4,967 pairs). New Hampshire numbers for nesting terns are low but are expected to increase with the recently developed management program on the Isles of Shoals (Allen, 1997). Restoration of Atlantic Puffins also has proven effective over the past few years on Seal Island and Eastern Egg Rock (Figure 10-3). Overall, the restoration of seabird diversity has been extremely effective as population trends following restoration efforts demonstrate. (See Tables 10-1 and 10-2.)

Figure 10-2 Tern Census Results for Coastal Maine (1984-1997)



Data provided by Maine Dept. of Inland Fisheries and Wildlife and from annual GOMSWG Working Group minutes (Allen, 1997).

Figure 10-3 Atlantic Puffin Census Results for Eastern Egg Rock and Seal Island National Wildlife Refuge



Data provided by National Audubon Society.

Recommendations

Members of GOMSWG have been effective at restoring certain seabird species, such as Common Terns and Atlantic Puffins. However, at meetings and in discussions with seabird researchers, several recommendations were made to improve restoration efforts in the Gulf of Maine.

* At the August 1997 GOMSWG meeting, it was recommended that organized

seabird censuses go beyond terns, and that data on these species be collected in a consistent manner and entered onto a standardized seabird form.

* Census data, information on restoration activities, and results from research, should be placed and updated annually on the Internet or within a centralized location easily accessible by researchers, managers, and the public. With added resources, data could be organized by a member of GOMSWG, such as National Audubon Society or Maine Department of Inland Fisheries and Wildlife.

* Currently, GOMSWG has members from Massachusetts, New Hampshire, and Maine. With the exception of University of New Brunswick, New Brunswick and Nova Scotia are not represented at meetings. New Brunswick and Nova Scotia should be included and encouraged to attend, as these two provinces and their efforts are relatively unknown and should be a part of the Gulf-wide initiative to restore seabird populations. The need for their participation was expressed at the August 1997 GOMSWG meeting.

Additional Information and Contacts

More than 50 groups and agencies, including the following, have participated in the protection and restoration of seabird populations and are members of GOMSWG. Many of them would be able to provide additional information on their restoration efforts.

National Audubon Society
Damariscotta River Association
Maine Department of Inland Fisheries and Wildlife
University of New Brunswick
College of the Atlantic
The Nature Conservancy
The US Fish & Wildlife Service (USFWS)
Petit Manan National Wildlife Refuge
Monomoy Island National Wildlife Refuge
Keystone College
Massachusetts Division of Fish and Wildlife
Nokomis High School
Rutgers University
Audubon Society of New Hampshire
University of Maine, Orono
Maine Audubon Society
University of Massachusetts, Boston
University of Massachusetts, Amherst
Massachusetts Audubon Society

Primary contacts for information on restoration of seabirds, waterbirds, such as herons and eiders, and shorebirds, such as Piping Plovers, include the following. Detailed information on these and other contacts is provided in Appendix A. A bibliography for seabirds is accessible on the Gulf of Maine Council's website at www.gulfofmaine.org. (See Section 4.)

Dr. Stephen Kress or Rose Borzik
National Audubon Society

Brad Allen
Maine Department of Inland Fisheries and Wildlife

Jody Jones
Maine Audubon Society

Diane Deluca
Audubon Society of New Hampshire

Dr. Tony Diamond
University of New Brunswick

Stan Skutek
USFWS Petit Manan National Wildlife Refuge

Scott Melvin
Massachusetts Division of Fisheries and Wildlife

SECTION 11 - ANADROMOUS FISH

In North America, there are six species of anadromous salmonids that inhabit coastal waters and spawn in rivers and streams. Of these six species, only one, the Atlantic salmon (*Salmo salar*), inhabits the Gulf of Maine and its coastal watersheds (Murphy, 1995). Additional anadromous species that occur in the Gulf of Maine include sea run brook trout, brown trout (non-indigenous), river herring (blue-back herring and alewife), American shad, rainbow smelt, striped bass, sturgeon, and sea lamprey.

The restoration of Atlantic salmon, a species important to commercial and recreational fisheries, is the focus of many restoration efforts. Efforts to restore shad, river herring (blue-back herring and alewife), and smelt are underway in Massachusetts, New Hampshire, and Maine. Although these species have been severely impacted and are no less important than the Atlantic salmon, restoration efforts were not documented in detail for this report. (See Section 3.) It is apparent that efforts to restore spawning habitat for Atlantic salmon most likely benefit other anadromous fish species. However, fishways designed for Atlantic salmon may not be adequate to allow passage by other fish species, such as herring, shad, and sturgeon. Furthermore, species such as river herring may use smaller coastal waterways that aren't used by salmon. This emphasizes the need to consider the entire watershed and all species when developing restoration programs (Rutherford, pers. com., 1998).

Atlantic salmon live in the eastern part of the North Atlantic from the Arctic Ocean to Portugal, and in the western North Atlantic from Iceland, Greenland, and labrador, south to Connecticut. After feeding on alewife and herring in northern waters off the coast of Greenland, adult salmon return to their river of origin each fall to spawn. Inner Bay of Fundy salmon tend to stay within the GOM system, with the exception of St. John fish, which only go as far as Annapolis (Bob Rutherford, pers. com., 1998). Salmon follow currents and their source of food throughout their migration. In addition, scientists attribute the homing phenomenon to the salmon's ability to detect variations in the earth's electromagnetic field and to identify the distinctive "scent" of its home waters (Figure 11-1).

Traveling hundreds of kilometers upstream to spawn, salmon face many challenges, including water pollution, natural obstructions such as beaver dams, and human-made obstructions such as hydropower dams. Female salmon may spawn just above the point of tidal influence to small tributaries less than one meter wide. The female salmon deposits her eggs within a *redd* that she digs using her tail. Redds are usually located where the water is drawing down through the gravel, such as at the tail of a pool. After the male fertilizes them, the female covers the eggs with gravel. The eggs over-winter in the gravel and emerge as *fry* in the spring (Danie et al., 1984).

By late summer, the young salmon is called a *parr* or *fingerling.* In the spring of the 2nd or 3rd year, a salmon will develop into a *smolt*, a juvenile fish able to swim from its fresh water nursery downstream into the ocean. There, it matures rapidly into an adult. Unlike Pacific species that die after one reproductive cycle, Atlantic salmon are biologically capable of surviving to return the following year to spawn again (Danie et al., 1984). The term anadromous implies that the salmon reproduce in freshwater and live their adult lives primarily at sea.

For the past few decades, salmon populations have plummeted despite efforts including mass stockings of hatchery reared fry, parr, and smolts. Scientists attribute the decline to degradation of the multiple habitats that the salmon depend upon and a culmination of many factors over a long period of time. Many human perturbations have resulted in a decline of anadromous fish populations

and degradation of the upland, riparian, and stream habitats that they are dependent upon for survival. Forms of disturbances, along with methods for restoration, are summarized in Table 11-1.

Table 11-1 Various Human Activities and Their Impacts on Anadromous Fish Populations and Habitat

Impact	Result	Method of Restoration
Stormwater runoff and discharge of effluent	Results in poor water quality, including increased algae, low oxygen, and changes in temperature, and can effect health and rigor of fish	Watershed based restoration, storm water management
Over-fishing	Depletion in fish stocks	Strong regulations
Dams	Inhibits fish passage	Ladders, elevators, trucking of fish above/below dam
Garbage/debris and obstructions other than dams	Inhibits fish passage	Organized cleanups
Agriculture and forestry practices involving the removal of riparian vegetation	Can lead to streambank erosion, high siltation, straightening and widening of river, and can raise water temperatures	Planting of vegetation, enforcement of proper forest harvesting methods
Grazing of cattle	Increases streambank erosion and can cause water quality problems associated with animal waste	Fencing, establishment and maintenance of buffer zones
Roadway construction	Can restrict and alter river flow	Removal of unused roads, culverts, and outsloping road surfaces
Hatcheries and stocking	Can result in a poor gene pool by stocking of fry, smolt, or parr produced by fish from other river systems	Stock salmon fry, as apposed to smolt and parr, and only those that have been produced by adults collected in the same stream
Aquaculture	Escapees could enter gene pool and/or spread disease	Close monitoring of aquaculture pens and preventative maintenance

Contents from Koski (1992) and Murphy (1995).

The number and types of impacts in Table 11-1 show that any one project with a specific focus, such as stocking, will not fully address anadromous fish restoration. A holistic approach directed at the entire watershed is required in order to successfully restore anadromous fish habitat (Koski, 1992). Many watershed initiatives, such as The Trout Creek Model Watershed in New Brunswick, have been implemented throughout the Gulf of Maine and include the above types of projects.

Although issues such as water quality, upstream and downstream passage, and spawning habitat are important to the salmon’s survival, the number of Atlantic salmon returning to Gulf of Maine rivers remain low. Anadromous fish are dependent on many habitat types during various stages in their life cycle, including the open ocean, estuaries, and freshwater rivers and streams. Even if restoration on the mainland is successful, what is happening in the ocean may be working against restoration efforts.

In their North Atlantic feeding grounds, salmon fall victim to the Greenland fishing fleet. However, it should be emphasized that not all GOM salmon migrate to Greenland. Scientists also theorize that salmon populations may be influenced by warming ocean temperatures and changes in the food chain. Jon Greenwood with New Hampshire Fish and Game attributes poor returns from stocking on the Merrimack River to the resurgence of the striped bass population, which preys upon juvenile salmon. Still others blame the aquaculture industry and introduction of disease.

Holistic approaches to habitat and species protection both inland and in the ocean is crucial to restoring Atlantic salmon as well as other anadromous fish populations. Although the fate of salmon at sea remains unclear, efforts to restore freshwater salmon habitats should continue in order to provide healthy habitat for those that do return.

To better prepare salmon for life at sea, fry are most commonly stocked, compared to parr and smolts, in an effort to increase the number of well adapted salmon. When fry are stocked, they will be leaving the system as wild smolts and may have a better chance of survival. On most rivers, salmon populations have been interbred with hatchery raised fish, which has contributed to and altered the gene pool. Scientists are therefore encouraging river-specific management to promote local adaptation (Baum, pers. com. 1997). Although not a quick fix, stocking rivers with fry and smolts produced by wild salmon may be part of a long-term solution. It should be noted that stocking is ineffective if the habitat does not support juvenile salmon (Bob Rutherford, pers. com., 1998).

With the decline in Atlantic salmon populations, their protection and restoration has become a political issue. Efforts to restore Atlantic salmon have been fueled by a long lasting review to list the species under the Federal Endangered Species Act. As a compromise to listing the species, the USFWS accepted the implementation of a Maine Atlantic Salmon Conservation Plan. The plan focuses on major issues that affect salmon, including genetics, forestry, agriculture, recreational fishing, and aquaculture. This plan is specific to the state of Maine.

Current/Past Projects

The restoration of anadromous fish species and their habitats is a Gulf-wide issue. Primary areas of concern for managers and scientists in the Gulf of Maine include stock numbers, access to spawning habitat, and the condition of spawning habitat. Projects aimed at resolving these problems may be divided into one or more categories depending on their focus. These categories include fish passage, stream habitat, and stocking and transfer of fish to increase populations.

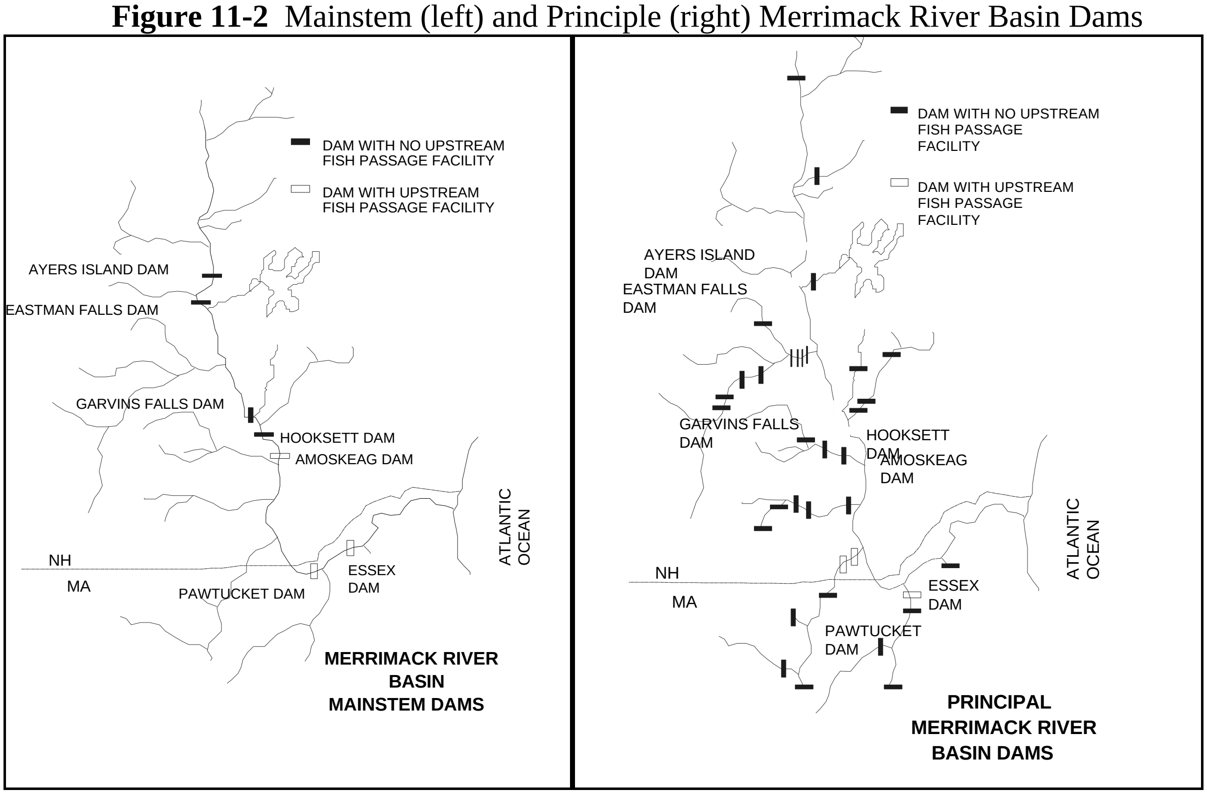
Fish Passage

Fish passage projects involve the construction, repair, operation, and maintenance of fishways to restore both upstream and downstream accessability. Projects may include the construction, assessment, and maintenance of fish ladders, and the removal of garbage and debris within the stream that may impact fish passage.

Massachusetts

Over 200 fishways on 100 coastal streams exist in Massachusetts. Figure 11-2 illustrates the number of dams that have been constructed on the Merrimack River. Fishways, unfortunately, are not constructed at every dam. Those that do exist in Massachusetts provide access to significant spawning areas for river herring (blue-back herring and alewives) and shad. With only three individuals assigned to manage these fishways, the Division of Marine Fisheries (DMF) and the Riverways Programs of the Department of Fisheries, Wildlife & Environmental Law Enforcement (DFWELE) innitiated a Fishway Stewardship Program in 1994. The program enables volunteers to assist in the assessment, management and restoration of herring runs and fishways. Stewards help keep streams and fishways clear of debris, ensure safe passage, and monitor fish populations. Groups active in the Fishway Stewardship Program are listed in Table 11-2.

Figure 11-2 Mainstem (left) and Principle (right) Merrimack River Basin Dams



From the 1998 U.S. Atlantic Salmon Assessment Committee report to NASCO (ASAC, 1998).

Table 11-2 Massachusetts Organizations Participating in the Fishway Stewardship Program

Organization	River/Stream
Coastal Conservation Association	Completed work on the North River tributaries in 1998.
Parker River Clean Water Association	Has piloted a project on the Parker River involving an annual herring count. Data collected by volunteers is extrapolated to estimate the number of returning adults.
SE Chapter of Trout Unlimitted	Palmer River
Wellfleet Anadromous Restoration Project and Environmental Detail (WARPED)	Herring River, Wellfleet
Cape Cod Chapter Trout Unlimitted	Marston Mills River
Orleans Anadromous Fish Council	Several small streams in Orleans
West Bridgewater Forestry and Park	Town River
Essex County Sportmens Association	Parker River
North and South Rivers Watershed Association	South River; Indian Head River
Barnstable Land Trust	Marstons Mill River, Barnstable; Santuit River, Mashpee
Cape Cod Harley Owners Group (HOG)	Herring River, Bournedale
The Gulf Association	Bound Brook, Cohasset
Westport Fish Committee	West branch of the Westport River
Red Lily Pond Project Association, Inc.	Red Lily Pond

Information acquired from Massachusetts Division of Marine Fisheries.

The Fishway Stewardship Program has proven effective at assessing and managing fishways and fish habitat on several rivers, including tributaries of the Merrimack, Ipswich, Parker, and Concord Rivers. However, information remains to be collected for many of the streams and fishways. In some cases, fishways are being worked on or managed by the local town, although such work is rarely reported to DFWELE or DMF. In other cases, no work has been done, and the condition of the fishway or the functionality of it is unknown. The last comprehensive study of anadromous fishways was completed in 1970 by DMF (Reback and DiCarlo, 1970). During the three year study, 147 coastal streams and salt ponds were assessed and 85 fishways were inspected. Staff with the Riverways Programs, Massachusetts Bays Program, the U.S. Environmental Protection Agency, and DMF are currently working together to update information collected during this earlier study. To assist in the effort, an intern has been charged with the task of conducting field observations of all the fishways and runs in Massachusetts. In addition to conducting assessments of fishways, the intern will establish town and volunteer contacts to assist in the expansion of the Fishway Stewardship Program.

Updated information on fishway condition, placement, fish use, and flow regime will be used to assist in the implementation of the Fishway Stewardship Program. In addition, the information will be added to a GISdatalayer on fishways that has been constructed by DFWELE. The datalayer, together with updated infomation on fishway condition, will prove to be a useful in managing and tracking fishways and projects in Massachusetts.

In addition to the Fishway Stewardship Program, the Riverways Programs administers an

Adopt-A-Stream Program. Within this program, residents, watershed association members, canoeists, hikers, sportsmen and anglers, riverine abutters and municipal officials join together in " Stream Teams" to conduct Shoreline Surveys (visual survey of the river) using data sheets and cameras. Following the Survey, Stream Teams determine priorities for action and create an action plan that lists (1) immediate action -- including reporting problems that need to be remedied to appropriate municipalities or state agencies, (2) short term projects for the Stream Team to undertake, and (3) long term actions that will take several years before environmental benefits will be realized. Adopt-A-Stream Program staff provide a leaders manual, interactive training with a slide show, facilitators for the action planning meeting, and support for implementing the plan (Kimball, pers. com., 1998).

The Stream Teams have also assisted the Massachusetts Wetlands Restoration & Banking Program in the identification of degraded wetlands. Over 30 stream teams and Watershed Associations, including those listed in Table 11.3, have completed the Shoreline Survey process and are working to implement their plans.

New Hampshire

Fishways exist on the Lamprey River and Cocheco rivers. Apparently, the Cocheco River fish ladder has not been operating in the fall due to a dispute between the Hydroelectric Development Corporations hydroelectric facility at the Cocheco Falls dam and the New Hampshire Fish and Game (NHFG) (ASAC, 1998). NHFG is currently working to resolve this problem as well as to modify the facility to better accommodate downstream passage. NHFG is also working with the USFWS and owners of the Wyandotte Hydroelectric dam on the Cocheco River to facilitate the installation of a downstream fishway (ASAC, 1998).

Maine

Probably the largest restoration effort underway in the Gulf of Maine watershed is the ordered removal of the Edwards Dam facility on the Kennebec River. Its removal has the potential to restore passage to 15 miles of river and stream habitats. This will benefit Atlantic salmon as well as many other species of anadromous fish.

During 1997, many new licenses containing provisions for fish passage have been issued to a number of existing hydroelectric projects in the Kennebec, Saco, Androscoggin, and Salmon Falls River drainage. These provisions will directly or indirectly benefit Atlantic salmon and other migratory species. In 1997, Central Maine Power Co. completed construction of new fish passage facilities at the Springs and Bradbury Dams on the lower Saco River. On the Penobscot River, construction of a new Basin Mills dam was denied. Other efforts to improve and evaluate fishway passage facilities is ongoing (ASAC, 1997; ASAC, 1998). The most recent comprehensive assesment of fishways in Maine was conducted in 1982 during the drafting of the Statewide River Fisheries management Plan (DMR, 1982)

New Brunswick and Nova Scotia

Maintenance of fishways is ongoing in Canada. However, detailed information was not acquired (See section 3).

Stream Habitat

Projects addressing stream habitat often involve instream construction and the use of “ digger logs” and “deflectors” and bank stabilization to restore natural spawning habitat. These projects may also involve planting of streambank vegetation and fencing to prevent cattle from entering the stream. Protection and restoration of riparian buffers are also crucial for water quality and shading purposes. “Stream habitat” includes not only adult spawning habitat but also juvenile habitats.

Massachusetts

Little work within streams has been done to restore degraded stream beds and shorelines in Massachusetts. Most efforts have concentrated on fishways, stocking/transfer programs, and watershed based initiatives. Through the Riverways Programs organized by DFWELE, Stream Teams conduct watershed based surveys and often hold stream cleanups where garbage and debris is removed from the stream bed to ensure safe fish passage. (See Table 11-3.) These surveys and cleanups provide valuable information toward remediating problems such as poorly functioning storm drains, degraded habitat, and dumping.

New Hampshire

No information was obtained for restoration projects focusing on stream habitat in New Hampshire. Information collected only pertained to stocking and fishways.

Maine

Several projects have been proposed and initiated though the Maine Atlantic Salmon Watersheds Collaborative (Table 11-4). Although not all projects involve "habitat restoration" work, they address the issue on a watershed basis. In 1998, the U.S. Fish and Wildlife Service accepted the State of Maine's *Atlantic Salmon Conservation Plan for Seven Maine Rivers* in lieu of listing the Atlantic Salmon under the Endangered Species Act. The projects funded through the Collaborative have been designed to meet the objectives of the Plan and have been designed to act as "model" projects for similar watershed based initiatives throughout the Gulf of Maine.

Other projects recently begun in Maine include two funded through Trout Unlimited's Embrace-A-Stream (EAS) Program in 1998. Approximately $10,000 was granted to the Trout Unlimited Merrymeeting Bay and St. Georges River Chapters in Maine to restore erosion sites that are causing sedimentation in Atlantic salmon spawing areas of the Sheepscot River. In addition, approximately $2,000 was granted to the Trout Unlimited Maine State Council to complete a survey of habitats in the Kennebec and Penobscot Rivers holding two genetically distinct populations of Atlantic salmon.

Table 11-4 Stream Habitat Projects Organized Through the Maine Atlantic Salmon Watersheds Collaborative

Waterway(s)	Organization	Comments
St. Croix River	St. Croix International Waterway Commission	Survey of Atlantic salmon spawning habitat and stocking of salmon parr.
Bond Brook Togus Stream	Friends of the Kennebec	Devopment and installation of educational signs. Removal of obstructions, including logs and debris dams, to provide accessible spawning grounds.
Dennys River	Nature Conservancy	Land acquisition within the Dennys River watershed. An 1,100 acre parcel is to be acquired in 1998. This project is part of a larger effort to develop a conservation corridor aimed at protecting salmon habitat.
Ducktrap River	Coastal Mountains Land Trust	Acquisition of approximately 236 acres of frontage property to protect salmon spawning and nursery habitat.
Ducktrap River watershed	Land for Maine's Future Board	Land acquisition
Sheepscot River	Sheepscot Valley Conservation Association	Funded a coordinator to develop and implement a watershed protection plan that includes water quality monitoring, restoration activities, developing landowner easements, and implementing a GIS system for the watershed.
Sheepscot River	Sheepscot Valley Conservation Association	Land acquisition along mainstem of the Sheepscot. Will complete a "forever wild" corridor.
Saco River	Saco River Salmon Club	Mapping of salmon habitat. GIS system to be developed and used to plan for stocking and informed land management decisions in the watershed.
Pleasant River	Downeast Salmon Federation	Streambank restoration and obstruction removal projects, water quality monitoring, watershed assessment, development of landowner contacts, easements, acquisitions, and stocking.
Penobscot River	Maine Council Atlantic Salmon Federation	Stream reconnaissance surveys will be conducted to identify and document habitat threats.

Projects listed are those approved for funding in 1997 and/or 1998. Information provided by U.S. Fish and Wildlife Service Gulf of Maine Program.

New Brunswick and Nova Scotia

Organizations involved with stream habitat restoration in New Brunswick and Nova Scotia are presented in Tables 11-5 and 11-6 and are shown geographically in Figure 11-3. These tables show only those projects within the Gulf of Maine Watershed. Most of these groups are public interest groups and volunteer their time to restoring stream habitat. The Department of Fisheries and Oceans (DFO) has jurisdiction over all work associated with anadromous fish, and therefore oversees all work done.

Work primarily has involved the installation of structures, such as rock deflectors, digger logs, and rock sills, to readjust the morphology of the stream, increase the rate of flow, and create deep pools. Streambank vegetation is planted to manage erosion and provide shading. In addition, fencing is installed to keep livestock out of the streams. Conducting stream cleanups maintains fish passage. To date, DFO estimates that 52 acres of stream habitat has been restored through the efforts described in Tables 11-5 and 11-6.

DFO's Habitat Management Division has developed stream restoration techniques and provides technical support to groups wishing to undertake restoration projects. The staff has been reduced to one individual that oversees projects for the entire region, of which the Gulf of Maine represents approximately 1/3. Funding assistance from DFO was available to groups during the past few years, however, it is no longer available. The Groups must now spend a considerable amount of their time searching for funding assistance from non-government sources.

Despite limited staff and resources, DFO has not delegated responsibility to the province level. However, the New Brunswick Department of Natural Resources and Energy (DNRE) and the Nova Scotia Department of Fisheries and Aquaculture (DFA) has stepped in to assist in restoration efforts (Toole, pers. com., 1997; Rutherford, pers. com., 1998). Much of the training and monitoring is conducted by staff from these agencies.

Some organizations, especially the ones that are not part of a larger partnership, have voiced difficulty in continuing their work due to lack of funds. Identification of funding sources and assistance with acquiring funding is needed for organizations involved with stream restoration in Canada. In Nova Scotia, DFO and DFA developed an Adopt-A-Stream Program, but it has had limited success due to a lack of support. ASF recently received 5 years worth of funding for the Adopt-A-Stream program to support stream restoration, however, funds must be matched with non-government money for any project. (Hinks, pers. com., 1997; Rutherford, pers. com., 1998). The Adopt-A-Stream program has produced a manual that provides information on how to start and run a project and fundraising tips.

Table 11-5 Anadromous Fish Habitat Restoration Projects in New Brunswick

Map No.	Waterway(s)	Organization/Contact	Comments
1	Nerepis River Sucker Brook	CFB Gagetown Oromocto, NB Kurt MacAllister	5 year plan being developed to improve logging and roadway construction and to restore fish habitat. Fording site erosion control structures installed and methods well documented.
2	Ayers Brook Two Mile Brook Sterling Brook	Fort Folly Native Band Sackville, NB Tim Robinson	Digger logs, deflectors installed. Improvements in channelized streams observed within first year according to DFO.
3	Sealy Brook	Maguadavic Watershed Management Association St. George, NB Jon Carr	Developed partnership; restoration project undertaken
4	Trout Creek Kennebecasis McLeod Brook Ward's Creek Mill Brook Musquash Brook Parsons Brook King Brook	Sussex Fish and Game Association, Fundy Model Forest, Universite de Moncton, and the Trout Creek Model Watershed Committee Sussex, NB Todd Byers	Efforts to date (since 1994) have been extensive and effective. Stream enhancement work, public education, and cooperative initiatives have resulted in the restoration of riparian zones, improvement of fish habitat, and furthering of baseline information.
5	Palmer's Brook Hammond River	Hammond River Angling Assoc. St. John, NB	Partnership formed and restoration conducted.
6	Keswick River and Jones Fork	Keswick River Society Burtt's Corner, NB Wayne Annis	Partnership formed and restoration conducted.
7	Indian and Murray brooks	Kingsclear Native Reserve Fredericton, NB Peter Birney	Partnership formed and restoration conducted.
8	Trout River Riviere Truite	Madawaska Fish and Game Edmunston, NB Steve Young	Partnership formed and restoration conducted.
9	Grande River	Fisheries and Oceans, New Brunswick Dept. Of Transportation Edmunston, NB Shayne McQuaid	Aquatic Habitat Technicians did work as part of highway compensation.
10	McQuarrie Brook, Meduxnekeag River, and Marven's Brook	Partners of the Meduxnekeag and Woodstock First Nation Woodstock, NB Wayne Annis	Partnership formed and restoration conducted. Digger logs, streambank stabilization, deflectors, stocking of Atlantic salmon. Made educational video on restoration.

11	Tantramar and Aulac Rivers; Joe's Brook	Sackville Rod and Gun Club Sackville, NB Charles Austin	50 km of tributaries surveyed to determine quality of fish habitat; Restoration project on Joe Brook - tributary of the Tantramar River.

Information obtained from the Habitat Management Division; Fisheries and Oceans Canada. Map numbers correspond to Figure 11-3.

Table 11-6 Anadromous Fish Habitat Restoration Projects in Nova Scotia

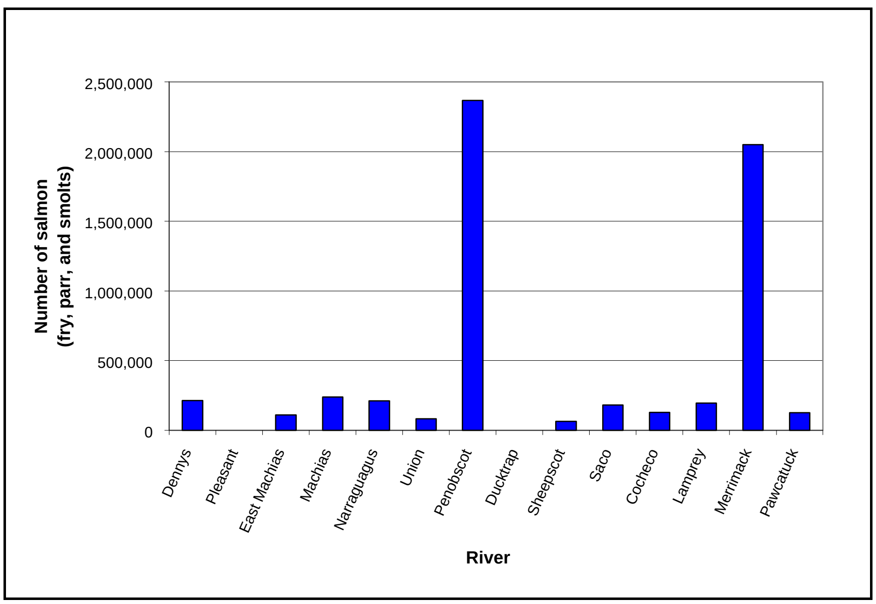
Map No.	Waterway(s)	Organization/Contact	Comments
12	Mill Brook Cornwall river Gaspereau	Friends of the Cornwallis River Society and Kings County Wildlife Federation Port Williams, NS Beth Lenentine	Digger logs placed in river, then removed per DFO request. Fencing installed to reduce impacts of livestock; also debris removal.
13	Millbrook Mclowers Brook	Millbrook Band Council Truro, NS William Sylliboy	Developed partnership; habitat restoration project undertaken.
14	South Branch of North River Tributary to Steel Run Steel Run	Cobequid Salmon Assoc. Truro, NS Rich Pryor	Aquatic Habitat Technicians did work as part of highway compensation. Cumberland river to have compensation work conducted.
15	North River (South Branch) - also referred to as Salmon River	Fisheries and Oceans, New Brunswick Dept. Of Transportation Truro, NS Shayne McQuaid	Project conducted as part of highway compensation. 4 aquatic technicians conducted work.
16	Little River South Hampton at Leamington East Branch - South Hampton	Cumberland County River Enhancement Assoc. Oxford, NS Peter Gay	Partnership formed and restoration conducted on several rivers.
17	Arcacia Valley Brook	Digby East Fish and Game Assoc. Digby Co., NS Steve Terialt	Partnership formed and restoration conducted. One of the only restoration efforts in Digby region due to acidification of waters.
18	Franklyn Brook Bear River	Bear River Native Band Bear River, NS Bonnie McEvan	Devoped partnership. Habitat restoration project on Franklyn Brook. Training program for native aquatic habitat technicians.
19	Annapolis River Black River	Clean Annapolis River Project Clemensport, NS Steve Hawboldt:	Partnership formed and restoration conducted on several rivers.
20	Indian Brook	Tobique Reserve Contact: NA	Partnership formed and restoration conducted.

Information obtained from the Habitat Management Division; Fisheries and Oceans Canada. Map numbers correspond to Figure 11-3.

Stocking/Transfer of Species

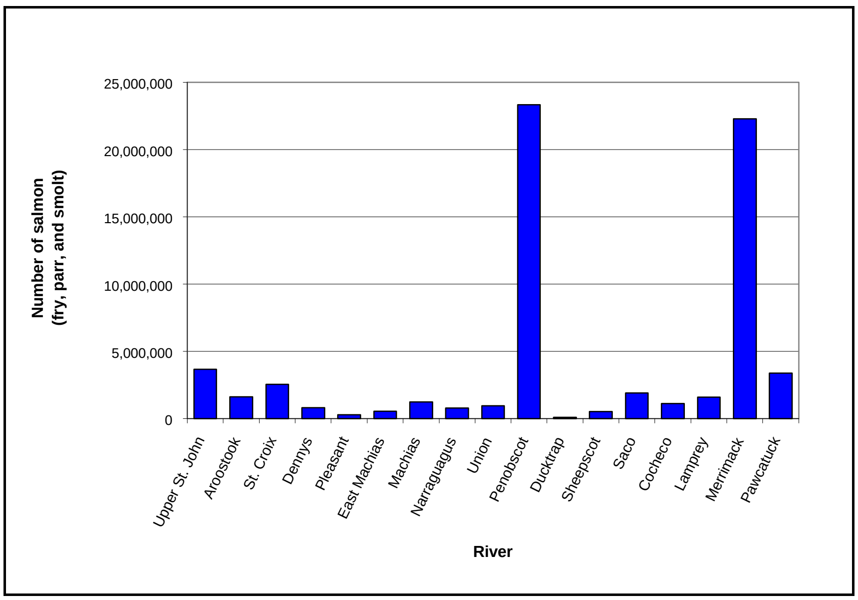
Many efforts to restore anadromous fish populations in the Gulf of Maine include the stocking or transfer of a species to an area where populations have declined. The following text makes references to Figures 11-4 through 11-6. These figures show stocking activity for Atlantic salmon rivers in the Gulf of Maine. Data used to make these figures was obtained from the U.S. Atlantic Salmon Assessment Committee's (ASAC) annual reports to the North Atlantic Salmon Conservation Organization (NASCO) and from Fisheries and Oceans Canada. Data for rivers in New Brunswick and Nova Scotia, other than the Saint Croix, Saint John, and Aroostook River, had to be presented in separate figures due to inconsistencies between United States and Canada data.

Figure 11-4 Total Salmon Stocked in Rivers in Massachusetts, New Hampshire, and Maine in 1997.



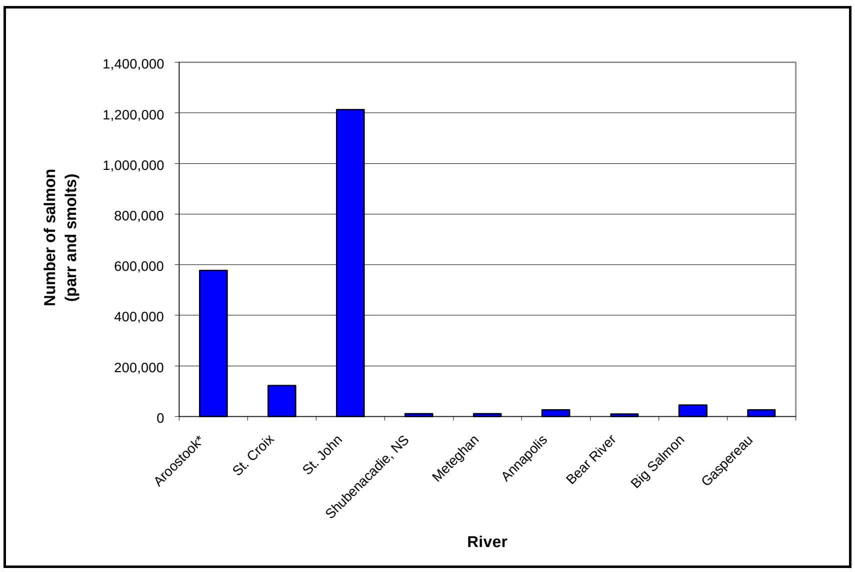
Numbers include fry, parr, and smolts.   Data aquired from ASAC (1998).

Figure 11-5 Total Salmon Stocked in Rivers in Massachusetts, New Hampshire, Maine, and New Brunswick Between 1970 and 1997 - By River



Numbers include all fry, parr, and smolts. St. John, Aroostook, and St. Croix rivers are in New Brunswick. Numbers for 1970-1997 not available for other New Brunswick and Nova Scotia rivers. Data aquired from ASAC (1998).

Figure 11-6 Total Salmon Stocked in Rivers in New Brunswick and Nova Scotia (within the GOM watershed) in 1997



Numbers include parr and smolts. Data acquired from Fisheries and Oceans Canada - Diadromous Fish Division. Data for Aroostook aquired from ASAC (1998).

Massachusetts

Each year, DMF and the Massachusetts Cooperative Fish Research Unit supervise the volunteer stocking of Atlantic Salmon. In 1997, two million fry were stocked within a three to four week period in April and May, primarily in the Merrimack River. Stocking of salmon also occurs at the following rivers/streams: Deerfield, Millers, Westfield, Fall, Mill, and Sawmill, as well as tributaries of the Connecticut rivers. Stocking activity for the Merrimack River in 1997 and between 1970-1997 is shown in Figures 11-4 and 11-5, respectively. Monitoring of the Atlantic salmon populations returning to the river is conducted each year. Extensive stocking/transfer programs exist for river herring, shad, and smelt and are conducted primarily by DMF staff and volunteer stream teams. River herring stocking is conducted almost entirely on Cape Cod (Buchsbaum, pers. com., 1998).

New Hampshire

Approximately 241,000 and 268,500 salmon fry were stocked into the Lamprey and Cocheco River systems in 1996 and 1997, respectively. (See Figures 11-4 and 11-5.) According to NHFG, anywhere from 50 to 100 volunteers helped out on stocking during the spring (ASAC, 1998).

Maine

In 1997, approximately 2 million fry and 600,000 smolts were released into rivers in Maine (ASAC, 1998). (See Figures 11-4 and 11-5.)

New Brunswick and Nova Scotia

Total salmon stocked between 1970 and 1997 for the Aroostook, St. Croix, and St. John Rivers is shown in Figure 11-5. Total salmon stocked in rivers in New Brunswick and Nova Scotia (within the GOM watershed) in 1997 are shown in Figure 11-6. Of the 2,044,931 salmon stocked, 578,000 were fry, 1,107,172 were parr, and 359,759 were smolts. Stocking data was provided by the Diadromous Fish Division of Fisheries and Oceans Canada and the 1998 U.S. Atlantic Salmon Assessment Committee report to NASCO.

Potential Projects

The scope and diversity of projects involved in restoring anadromous fish habitat are broad. There are many different types of projects that contribute to the restoration of fish populations and the habitats on which they depend. On any river or stream, potential for restoration exists due to continued pressures near and far from the waterway. Any type of project that addresses water quality, water quantity, shoreline erosion, deforestation, and protection of riparian habitat contributes to the restoration of anadromous fish populations. Potential projects have not been quantified or identified in this inventory. Contacts listed at the end of this section would have the most recent information on potential projects in their jurisdiction.

Evaluation and Monitoring

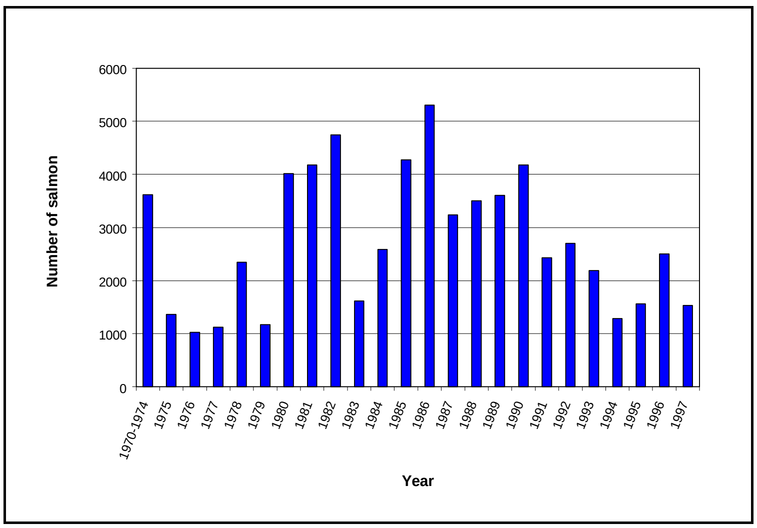
Projects aimed at restoring fish populations as well as their habitat should be evaluated on a watershed scale. Unfortunately, due to limited funds and resources, restoration groups cannot conduct extensive monitoring and instead are often limited to counting the number of returning fish (Rutherford, pers comm., 1998). Fish are counted using various types of weirs, visual counting at fish ladders, and electro-seining. Salmon returns are also estimated by counting the number of redds (spawning beds) created by female salmon within a river or stream. After acquiring data from various agencies, it has become apparent that there are inconsistencies in data collection. For example, salmon returns to rivers in New Brunswick and Nova Scotia are either documented or estimated. In addition, the origin of salmon is only known for a select number of rivers. Historical data similar to that provided in the NASCO reports was not found for Canada. Not having this baseline data makes measuring success of restoration efforts difficult. In addition, inconsistencies in data create problems when interpreting data on a Gulf-wide scale.

Other types of monitoring are essential to restoring anadromous fish populations. Many of the same community groups, stream teams, fishway stewards, and other groups mentioned in Tables 11-2 - 11-6, also conduct habitat surveys, monitor water quality and flow, and evaluate streams based on the suitability for spawning habitat.

Restoration Effectiveness

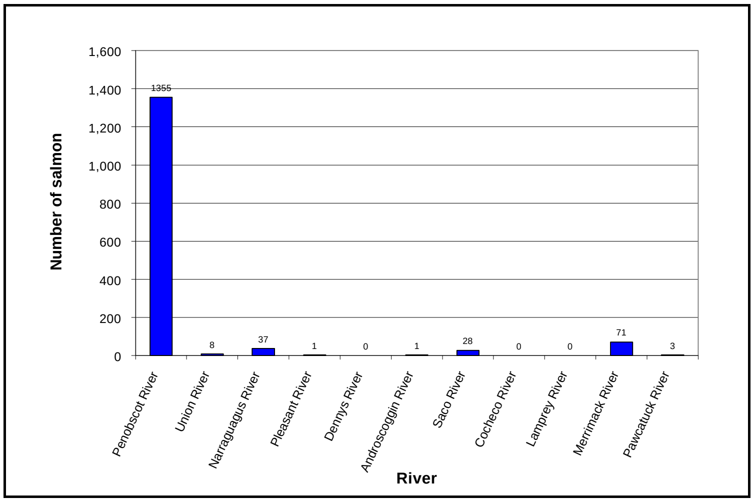
The following text makes references to Figures 11-7 through 11-10. These figures show numbers of returning adult Atlantic salmon for rivers in the Gulf of Maine. Data used to make these figures was obtained from the U.S. Atlantic Salmon Assessment Committee’s (ASAC) annual reports to the North Atlantic Salmon Conservation Organization (NASCO) and from Fisheries and Oceans Canada. Data for rivers in New Brunswick and Nova Scotia, other than the Saint Croix, Saint John, and Aroostook River, had to be presented in separate figures due to inconsistencies between United States and Canada data.

Figure 11-7 Total Salmon Returns in Rivers in Massachusetts, New Hampshire, Maine, and New Brunswick Between 1970-1997 - By Year



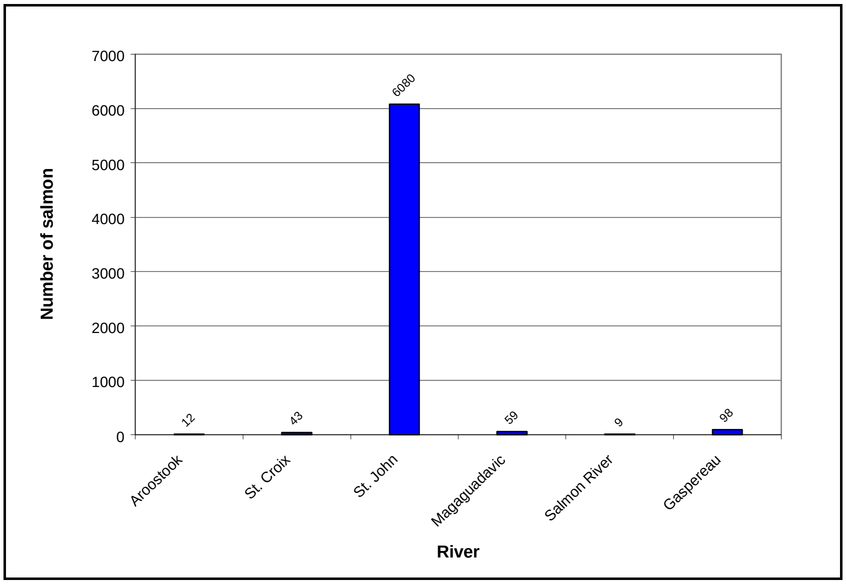
Numbers are determined by trap counts and rod catches and therefore are considered minimum numbers. Total for each year is the sum of salmon returns documented on those rivers listed in Figure 11-8 and includes the Penobscot River. Data acquired from the 1998 U.S. Atlantic Salmon Assessment Committee report to NASCO.

Figure 11-8 Total Salmon Returns in 1997 for Rivers in Massachusetts, New Hampshire, and Maine



Numbers are determined by trap counts and rod catches and therefore are considered minimum numbers. Of the total 1,504 salmon documented, 238 were considered of " wild" origin and 1,266 were considered hatchery fish. Numbers were unknown for the Kennebec, Sheepscot, Ducktrap, Machias, and East Machias Rivers. Data acquired from the 1998 U.S. Atlantic Salmon Assessment Committee report to NASCO.

Figure 11-9 Total Salmon Returns in 1997 for Rivers in New Brunswick and Nova Scotia



Numbers for Magaguadavic and St. Croix are actual counts. The numbers for the other rivers are estimates. All salmon returning to the Magaguadavic are considered wild. For the St. John, 2,301 and 3,398 salmon were determined to be of wild and hatchery origin, respectively. On the St. Croix, 15 and 28 salmon were determined to be of wild and hatchery origin, respectively. In the Aroostoock, six and six salmon were determined to be of wild and hatchery origin, respectively. Origin of salmon on other rivers is unknown. Data acquired from Fisheries and Oceans Canada - Diadromous Fish Division. Data for the Aroostook River acquired from the 1998 U.S. Atlantic Salmon Assessment Committee report to NASCO.

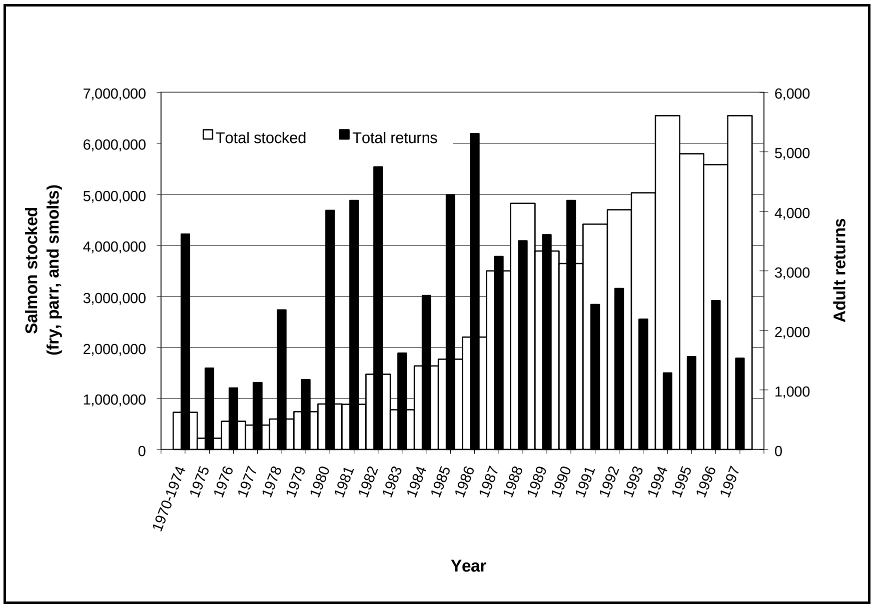
Discussions with fish biologists in the Gulf of Maine suggest that there are no “restored” rivers. Fish numbers should not be the sole measure of restoration effectivness, and therefore, the numbers and figures provided here may not adequately reflect our progress. In addition, causes of degradation of rivers and fish populations may extend throughout the watershed. Restoration projects that are conducted in only a few spots together with mass stocking of fish may not be effectively restoring the system (Rutherford, pers comm., 1998).

Total documented adult salmon that returned in 1997 to rivers in Massachusetts, New Hampshire, and Maine, amounted to approximately 1,504 salmon (ASAC, 1998). (See Figure 11-7.) 1,355 of these salmon were counted in the Penobscot River. (See Figure 11-8.) For rivers in New Brunswick and Nova Scotia, a total of 6,289 salmon returns were estimated. Of these, 6,080 were estimated to have returned to the Saint John River. (See Figure 11-9.) If we combine the totals, it is estimated that 7,793 salmon returned to rivers within the Gulf of Maine watershed in 1997. Of these, 7,584 returned to the Penobscot and the Saint John Rivers. According to the data, only 358 salmon are estimated to have returned to other salmon-producing rivers in the Gulf of Maine watershed. (See Figures 11-8 and 11-9.) According to the 1998 U.S. Atlantic Salmon Assessment Committee report to NASCO, totals for 1997 are down considerably from previous years. (See Figure 11-7.)

The number of salmon returning to rivers in the Gulf of Maine continues to remain low despite increased stocking efforts. (See Figure 11-10.) Perhaps with the increased stocking of river specific fry versus smolts, numbers of returning salmon will begin to increase. However, the increase in stocking efforts accompanied by a decrease in returning salmon reinforce the need go beyond hatchery and stocking programs and address the various habitats that salmon depend upon.

In addition, until problems in the open ocean are understood and resolved, efforts on the mainland to restore Atlantic salmon may continue to prove ineffective. However fruitless these efforts may seem, they are extremely important for the restoration of habitat for other species. The Atlantic salmon is an umbrella species, and as a result, efforts to restore populations will prove beneficial to the environment and other species. Discussions with fisheries biologists have suggested that other species, such as American shad, have been improving (Baum, pers. com., 1997).

Figure 11-10 Total Salmon Stocked Versus Adult Returns in Rivers in Massachusetts, New Hampshire, Maine, and New Brunswick Between 1970 and 1997 - By Year



Numbers include all fry, parr, and smolts. The total includes listed in Figure 11-8 is 66,648,808 of which 41,510,300 were fry, 9,721,525 were parr, and 15,416,983 were smolts. Data acquired from the 1998 U.S. Atlantic Salmon Assessment Committee report to NASCO.

Recommendations

It is apparent that the restoration of anadromous fish populations and habitats is a very complex subject, one that crosses many habitat and political boundaries. Due to its complex nature, special consideration should be made when designing restoration projects. The following general recommendations are based on personal observations and needs that have been identified throughout the region.

* Efforts to restore Atlantic salmon and other anadromous fish species need to expand beyond stocking and transfer programs to include projects that address water quality, fish passage, and habitat protection and restoration. Projects should be consistent with watershed based plans.

* In Massachusetts, it has been suggested by the Riverways Programs that there needs to be an ongoing volunteer based review of fishways. Information from volunteers could be submitted by forwarding completed evaluation forms to a central database. This would also assist in tracking and managing fishways.

* Mechanisms to share information, such as the Atlantic Salmon Assessment Committee's annual report to NASCO, need to be developed for other important species, such as shad and herring. In addition, such reports and databases need to be expanded to New Brunswick and Nova Scotia. Data submitted must be collected and interpreted in a consistent manner.

* A central source for information on funding opportunities and mechanism for communication needs to be established for groups active in anadromous fish restoration, especially for NGO groups in New Brunswick and Nova Scotia.

Additional Information and Contacts

For more detailed information and data refer to the Reports of the U.S. Atlantic Salmon Assessment Committee, prepared annually for the U.S. section to North Atlantic Salmon Conservation Organization (NASCO). The Annual NASCO report may be accessed on the Internet at: www.fws.gov/r5cneafp/index.html. The Atlantic Salmon Conservation Plan for Seven Maine Rivers is also posted on the Internet at www.state.me.us/governor/a-+.htm. Information on Trout Unlimited (TU) and the Embrace-A-Stream Program can be obtained on TU's homepage at www.tu.org.

Contacts listed below can provide additional information on the restoration of Atlantic salmon and other anadromous fish species. Detailed information on these and other contacts is provided in Appendix A. Please refer to the Gulf of Maine Council's website at www.gulfofmain.org for a bibliography on anadromous fish. (See Section 4.)

For further information on the US Atlantic Salmon Assessment Committee and the NASCO report contact:

Larry Stolte
US Fish and Wildlife Service

For information on the Maine Atlantic Salmon Watersheds Collaborative contact:

Jed Wright
US Fish and Wildlife Service-Gulf of Maine Program

For information on the MA Adopt-A-Stream Program, contact:

Joan Kimball
Massachusetts Department of Fisheries, Wildlife & Environmental Law Enforcement

For information on the NS Adopt-A-Stream Program, contact:

Louis Hinks
Atlantic Salmon Federation

For general information on anadromous fish restoration contact:

Ken Reback
Massachusetts Division of Marine Fisheries

Jon Greenwood
New Hampshire Fish and Game Department

Lou Flagg
Maine Department of Marine Resources

Ed Baum
Maine Atlantic Salmon Authority

Shayne McQuaid
Department of Fisheries and Oceans - Halifax, Nova Scotia

SECTION 12 - CONCLUDING REMARKS AND RECOMMENDATIONS FOR FUTURE PROJECT DEVELOPMENT

Restoration, together with habitat and species protection, is necessary to rebuild, replace, and preserve natural resources. The opportunities for improving and increasing habitat and species restoration are numerous. However, the common limiting factor in implementing new projects and carrying on existing projects throughout the Gulf of Maine is the lack of financial resources. Until adequate resources allow for other means of restoration, such as habitat creation, more economical projects that provide the best ecological returns for the money should be pursued. It is apparent that there is no substitution for the protection of existing pristine habitats. Protection of remaining habitats should always precede habitat restoration, which in turn, should precede habitat creation.

Any impacts that are permitted must be compensated for, and their compensation must be enforced. In addition, the types of compensation must be carefully reviewed to ensure no net loss of habitat functions and values. This can be enforced through consistent monitoring and project review. The solution is to protect what remains and restore what is truly degraded. Creation should only be used once technologies and resources allow for strong ecological returns.

Numerous opportunities exist to offset the historical net loss in coastal habitats and to reverse the trend to a net gain in coastal habitats. For instance, there are hundreds of tidal marshes impacted by tidal restrictions. These are great opportunities for relatively economical and highly effective habitat restoration, and as such, should be pursued as a priority. Other projects that have shown potential, such as efforts to restore anadromous fish habitat in Canada, have lost considerable amounts of funding and in some cases have not been able to continue. This reveals the need for consistent and long-term funding that enables projects to follow through and reach their ecological goals.

Due to limited funding, allocation of money and resources must be based on economically and ecologically sound decisions. This enforces the need to prioritize potential projects based on societal, ecological, economic, and practical considerations, so that when money becomes available it can be allocated toward those projects that provide the most benefits.

It has been repeatedly stated that there is a great need for a central system or database where scientists and managers can obtain and share information on specific restoration projects, research, contacts, and funding sources. At the January 1998 National Oceanic and Atmospheric Administration Conference on Goal Setting and Success Criteria for Habitat Restoration, it was emphasized that such systems are necessary for goal setting, prioritizing, and evaluating habitat restoration projects. A central database is useful in theory, but in reality it is difficult to implement. Information is necessary to build the database and updating is required to maintain value and long-term usefullness. Ongoing collection and organization of infomation is necessary, however, it is difficult for both the collector and the submitter of information due to limited resources, time, and staff.

This report and the database do not identify all restoration efforts in the Gulf of Maine. Information gaps remain, and changes to existing information are inevitable as the number of restoration projects increase and technologies are developed and refined. Data collection and dissemination needs to be ongoing and information must be updated on a regular basis. The following next steps could be taken to further promote its implementation, usefulness, and

SECTION 13 - REFERENCES

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distribution.

* Expand the database to include spatial data for use in watershed planning and data from consistent monitoring for use in long-term evaluation of ecological success.

* Interface the database with the Internet to allow online usage, encourage updates, and increase exposure and participation. This would require housing the database on a Windows based server (since the database is in Microsoft Access). The database currently resides on a Unix based server and must be downloaded to a personal computer in order to be used.

* Establish a permanent host that has adequate resources and commitment toward managing and updating the database and making it available to users.

* Obtain memoranda of understanding between major data providers to ensure ongoing participation and submittal of updates. Major sources of information include the Massachusetts Wetlands Restoration & Banking Program, New Hampshire Coastal Program, U.S. Fish and Wildlife Service Gulf of Maine Program, Gulf of Maine Seabird Working Group, U.S. Atlantic Salmon Assessment Committee, Fisheries and Oceans Canada, and the Conservation Law Foundation.

* Develop, adopt, and distribute a standardized form (such as the one developed for this project) available in hard copy and on the Internet for submitting updates and information on new projects.