GULF OF MAINE HABITAT RESTORATION STRATEGY

--DRAFT--

Restoring Estuarine, Coastal, and Marine Habitat in the Gulf of Maine Region

Gulf of Maine Council

on the Marine Environment

Gulf of Maine Habitat Restoration Strategy

Prepared by the Gulf of Maine Council, Habitat Committee
Restoration Subcommittee

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Council on the
Marine Environment

About the Cover

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Executive Summary

This document was developed with the recognition that restoring habitats is necessary to support aquatic resources in the Gulf based on biological and socioeconomic needs in the region. Therefore, this document will meet the following objectives:

- State the purpose and scope of restoration in the Gulf.
- Identify habitat types, impacts and restorative actions.
- Develop recommendations for enhancing habitat restoration in the region.

Habitat restoration has been undertaken in all of the Council's jurisdictions; these efforts have been in response to individual state and provincial goals. While these restoration projects have at times addressed habitats and shared resources within the GOM, this has happened as a fortuitous byproduct of individual efforts rather than as part of a Gulf-wide vision. While the Gulf of Maine Habitat Restoration Strategy will not act as a prescriptive list of restoration projects, it will identify resources of regional significance and promote the restoration of habitats required to support the continued viability of these resources.

The strategy focuses on four general categories of habitats found within the Gulf. The first category is riverine habitat that consists of inland river habitat for diadromous fishes. The second habitat type is intertidal areas in which the tidal cycle floods and ebbs leaving submerged or dry habitat. The third category is subtidal areas, which includes areas that are permanently submerged as well as offshore marine waters. The final category consists of beaches, sand dunes, and islands throughout the Gulf.

Such a regional strategy for restoration will provide benefits to many in the region. In particular, the strategy will increase community interest, provide a common blueprint for the Gulf, improve efficacy of resource utilization, enhance local projects, generate increased funding, increase the capacity of restoration practitioners, and focus limited resources to priority needs. There are many other issues of concern related to coastal, estuarine and marine habitats in the region such as stormwater management, toxins reduction, conservation and protection, riparian buffer improvement, stewardship, land use regulation, and other upland issues that this strategy does not address. The Gulf of Maine Council is leading efforts related to these topics, which can be viewed at www.gulfofmaine.org.

In addition to the environmental benefits, the socioeconomic advantages associated with habitat restoration are significant. Restored habitats provide communities with opportunities for sustainable commercial fishing, recreation and natural resource based tourism.

The following summary of recommendations is suggested for continued success with habitat restoration efforts in the Gulf:

- Restore the four coastal/marine habitat types identified in the Gulf of Maine using a regional strategy to prioritize projects.

- Improve habitat restoration site identification in the region in order to focus regional efforts and understand trends in the Gulf for long-range planning.

- Increase habitat restoration development and management capacity in all political jurisdictions in the region to foster efficient and effective responses to identified projects.

- Enhance outreach efforts to federal, state, local governments and the private sector in order to create a common understanding of the social, economic and environmental benefits of habitat restoration.

- Complete and maintain database of restoration projects in the region to evaluate progress over time and ensure accordance the National Estuary Restoration Inventory.

- Refine existing salt marsh monitoring protocols and develop monitoring protocol for other habitat types identified in this strategy so that biological impacts are documents for both pre- and post-restoration.

Introduction--Purpose and Scope

Habitat Restoration Purpose Statement

The primary reason for developing a regional restoration strategy within the Gulf of Maine is to focus on riverine, estuarine, coastal and marine habitats and the species functioning within such habitats. These habitats require a holistic approach to restoration due to the interconnectedness of the natural systems. The three states and two provinces comprising the Gulf are presently developing, funding and implementing habitat restoration projects to varying degrees. While these restoration projects have undoubtedly improved habitat within the region, it is inherently difficult to develop restoration projects that address Gulf-wide issues when each independent jurisdiction within the region has differing goals and objectives, funding resources and restoration capacity. Nonetheless, a regional framework that focuses on overarching restoration objectives, based on regional habitats that function as an integral natural system, will allow the states and provinces bordering the Gulf to meet jurisdictional objectives as well as regional restoration objectives.

This regional planning approach to habitat restoration with the Gulf offers the opportunity to meet common goals and objectives for restoration despite the inherent difficulty of planning for a natural resource that spans five jurisdictions and two countries. With land use planning laws and management practices differing due to varying social, political and economic situations, each jurisdiction should ideally be able to use the framework in this strategy to improve habitat in a manner that is most effective for their particular circumstances.

The primary focus of restoration efforts in the Gulf is to ensure that existing degraded habitat for migratory and marine species is improved and protected once restored. There are several migratory species of fish, birds and mammals that use the Gulf of Maine as part of their annual migration routes. These species depend upon the habitat of the Gulf for various aspects of their life cycles, including species that return to the same habitat locations year after year. Migratory and marine species within the Gulf of Maine represent fish, birds and mammals that function within an interconnected natural environment with no link to the political boundaries that demarcate the coastal areas within the Gulf. There are several other habitat types found in the Gulf of Maine watershed where degraded conditions require restoration activity that would significantly improve the health of the Gulf of Maine watershed. However, details of the restoration needs in these additional habitat categories, such as grasslands and forests, are not included in this document.

Notwithstanding the difficulty of defining habitat precisely or consistently, this strategy focuses on several habitat types that are the focus of the Council's restoration efforts in the near future. Working from the inland area of the watershed to the sea, those types include (1) rivers; (2) intertidal habitats such as salt marshes, rocky shores, and mud flats, and beaches and dunes below the high water line; (3) subtidal habitats and deep water

marine areas; and (4), beach, dune, and island habitat in upland buffer areas above the high water line.

Coastal and marine habitat restoration is important on a regional scale due to the biological and physical interconnectedness of the Gulf's natural systems. Numerous species of fishes, birds and mammals depend on the Gulf for at least part of their lifecycle, and in some instances spend their entire lives in the region. Additionally, the socioeconomic benefits of Gulf-wide habitat restoration are significant in terms of creating enhanced employment opportunities and an improved quality of life for people in the region. Sustainable commercial and recreational fisheries, for instance, provide local jobs and support local businesses, which improves the quality of life for everyone in the Gulf.

Definition of Habitat Restoration

Restoration means returning an identified habitat to a successful, self-sustaining ecosystem with both clean water and healthy habitat that support fish and wildlife and human uses of the resource. The goal is to help rebuild a healthy, functioning system that works like it did before it was degraded. Restoration projects can promote local community interest for improving coastal habitats. Effects of these projects are felt at many levels including within the social and economic fabric of communities via sustainable commercial fisheries, ecotourism, and recreational opportunities.

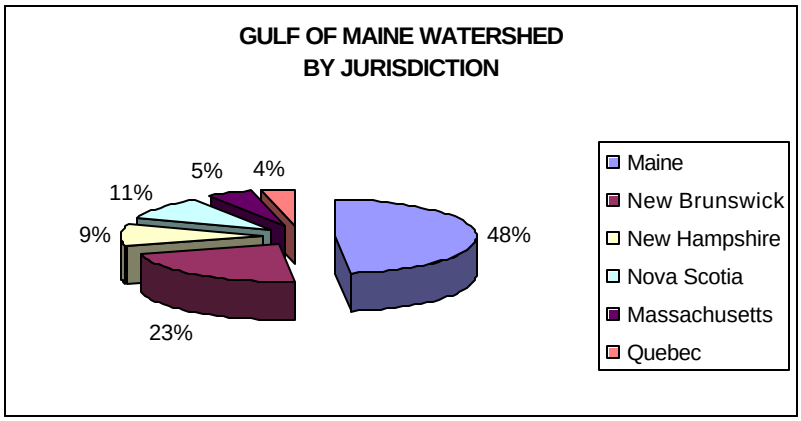
About the Gulf of Maine

The Gulf of Maine is a semi-enclosed sea bounded to the south and east by tall underwater land forms called "banks" that rise up to form a barrier to the North Atlantic. The coastlines of Massachusetts, New Hampshire, Maine, New Brunswick, and Nova Scotia make up its western and northern boundaries. The color, shaded-relief map shows some of the diverse landscapes of the Gulf of Maine. The darker blues represent the deeper regions and the lighter blues indicate shallower depths. As on land, life in the Gulf of Maine occurs in a variety of landscapes that were shaped by glaciers 10,000 to 20,000 years ago. Under the waters and waves of the Gulf of Maine, valleys plunge to depths of 1,500 feet (500 meters) and mountains thrust up from the depths 800 feet (266 meters) almost to the surface of the sea. But instead of winds and clouds, ocean currents control temperatures and bring nutrients and food to the plants and animals that occupy these rich landscapes.

The Gulf of Maine Watershed

[2] This definition is based on the definition of restoration from Restore America's Estuaries but was modified to include other habitats in the Gulf of Maine.

The Gulf of Maine Watershed encompasses much of Nova Scotia, New Brunswick, Maine, New Hampshire and Massachusetts, and a small portion of Quebec. The total land area of this watershed is 69,115 square miles, or 179,008 square kilometers. Only one of the six jurisdictions, Quebec, does not have Gulf of Maine shoreline; and only one of the six, Maine, is located entirely in the Watershed.



Source: Gulf of Maine Council Action Plan 2001-2006.

The Gulf of Maine Council

The Gulf of Maine Council on the Marine Environment is collaboration between public and private entities around the Gulf of Maine that was developed to enhance, improve and protect the estuarine, coastal and marine resources of the Gulf. In 1989, the Governors of Maine, Massachusetts, and New Hampshire as well as the Premiers of New Brunswick and Nova Scotia passed a resolution indicating that each jurisdiction within the Gulf of Maine is committed to the mission of the Gulf of Maine Council. The Council's mission is as follows:

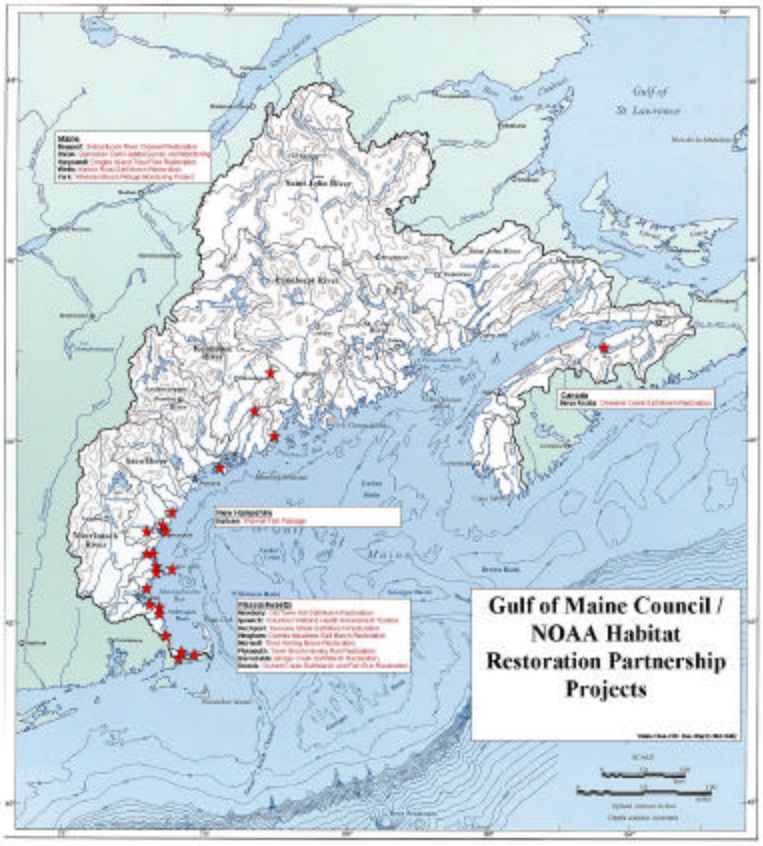
> "To maintain and enhance environmental quality in the Gulf of Maine and to allow for sustainable resource use by existing and future generations."

GOMC Habitat Restoration Committee

This strategy is focused primarily on the objectives of the Habitat Restoration Subcommittee. The Subcommittee functions under the assumption that its activities should be consistent with the Council's habitat restoration objective from the Action Plan as stated above. Members include experienced habitat restoration practitioners from throughout the Gulf. The intent of the Restoration Subcommittee is to develop a regional habitat restoration strategy for the Gulf of Maine and assist with the implementation by providing technical and financial resources.

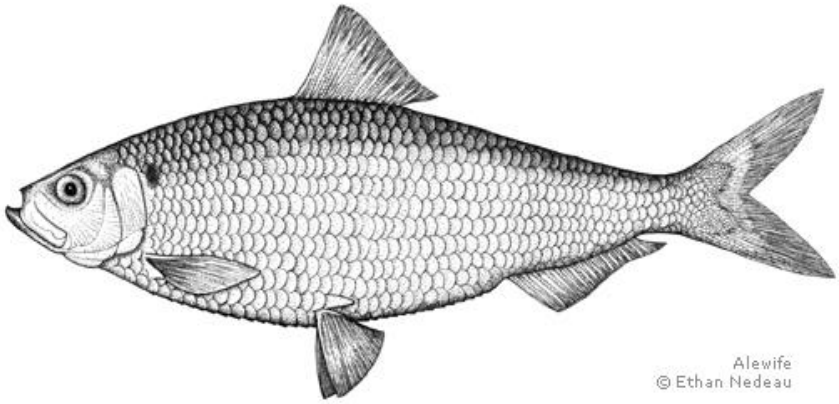
The Gulf of Maine Council's Habitat Restoration Committee addresses several components of habitat restoration necessary for sustainability in the Gulf. The Committee consists of the two co-chairs of the Habitat Monitoring, Restoration, and Protection Subcommittees as well as the Gulf of Maine Mapping Initiative, for a total of eight members on the Habitat Committee.

The GOMC/NOAA Habitat Restoration Partnership was established in 2001 to solicit restoration projects in the Gulf that could be funded using a competitive process. Grant proposals are reviewed annually by a review team that includes representatives from Massachusetts, New Hampshire, Maine and the NOAA Restoration Center. The Partnership has funded 22 projects for a total of $512,335, with roughly $2.4 million of project funding from other sources. This partnership has proven to be an effective method of restoring regionally significant habitat in the Gulf.



Gulf of Maine Highlight: Alewife

Alewives are an example of a migratory diadromous fish species that depend on several habitat types found in the Gulf to complete their lifecycle. Alewives return from the ocean each spring to their natal rivers and inland ponds and lakes to spawn. The adults then return to the ocean until returning to spawn again the following spring. The juvenile alewives begin their migration from the freshwater environment downstream to the sea in early summer. In each of the habitat types that they occupy, alewives play an important role in the Gulf of Maine food web and in maintaining the health of the ecosystem. In the inland freshwater environment alewives provide forage for bass, salmonids, eels, ospreys, eagles, kingfishers, loons, and aquatic furbearing mammals. They are a host to native freshwater mussels, which they carry up- and down rivers in their gills. Spawning alewives heading upriver give cover to out-migrating salmon smolts in the spring. In the marine environment, alewives are eaten by a variety of commercially and recreationally important fish, such as bluefish, striped bass, cod, pollock and silver hake. The Alewife is a particularly important commercial species in the Gulf of Maine since it is used as lobster bait. This example demonstrates the regional benefits of restoring habitat in the Gulf.



Gulf of Maine Habitat Restoration Web Portal

The Gulf of Maine Council and NOAA are developing a regional habitat restoration web portal. This effort will bring together information about restoration projects from the US and Canadian jurisdictions of the Gulf of Maine region. The web portal will include the Gulf of Maine Habitat Restoration Strategy, a restoration database, project vignettes and general information on identifying, planning for, and funding habitat restoration projects within the Gulf of Maine.

The database section of the web portal will be a geographic module of the National Estuary Restoration Inventory and will be accessible through the GOM web portal as well as through the NERI itself. This will allow the GOM Council to leverage NOAA's technical capacity in the development of the restoration inventory and will provide NOAA with essential restoration data for three New England states and two Canadian provinces.

I. Habitat Descriptions, Impacts and Restorative Actions

RIVERINE

Photos to be included.

Replace with photo of Smelt Hill Dam before and after photo.

Riverine Habitat in the Gulf

Dozens of rivers and hundreds of streams and creeks empty directly into the Gulf of Maine, while thousands more rivers, streams, and creeks feed indirectly into the Gulf. These freshwater arteries are connected to innumerable lakes, ponds, springs and a variety of freshwater wetlands. Such freshwater bodies collectively support the wealth of aquatic species in the watershed, as well as all species that depend, at least in part, on aquatic life for their existence.

The conservation and restoratioin of riverine habitat is of special concern to the Council due to its importance for sustaining the Gulf's anadromous and catadromous fish species, among the most charismatic and valued of the region's biodiversity. Only 87 of 24,700 species of fish in the world are anadromous by nature, beginning life in freshwater, maturing and spending their adult lives at sea, and then returning to freshwater to spawn (Atlantic Salmon Federation, 2002). The Gulf supports 11 of these species, including a signature species of eastern North America, the Atlantic salmon (*Salmo salar*), as well as rainbow smelt (*Osmerus mordax*), alewife (*Alosa pseudoharengus*), and striped bass (*Morone saxatilis*). The catadromous American eel (*Anguilla rostrata*), which begins life in salt water, matures and spends its adult life in freshwater, and returns to salt water to spawn, is found in almost all waterbodies within the watershed.

Anadromous Fish in the Gulf of Maine

- white perch
- striped bass
- sea lamprey
- American shad
- Atlantic sturgeon
- shortnose sturgeon
- alewife
- blueback herring
- rainbow smelt
- tomcod
- Atlantic salmon

The riverine habitats these and other fish need to survive include rock bottom, unconsolidated bottom (mud, sand, cobble, gravel), areas of floating or submerged plants, and areas of emergent wetland, where plants are rooted in water but are only partially submerged. Other key habitats requiring conservation include cold, fast flowing streams (required by such fish as sea run brook trout, *Salvelinus fontinalis*); medium flowing streams preferred by such fish as blueback herring; and slower flowing or even standing water, preferred by alewife, for example (Bright, 1995). Important for the survival of many fish is retention of shoreline vegetation habitat. Healthy riparian habitats, with adequate buffers between sources of runoff and the river, are essential to maintain water quality conditions required by many riverine fisheries, such as cool water temperatures preferred by Atlantic salmon and brook trout.

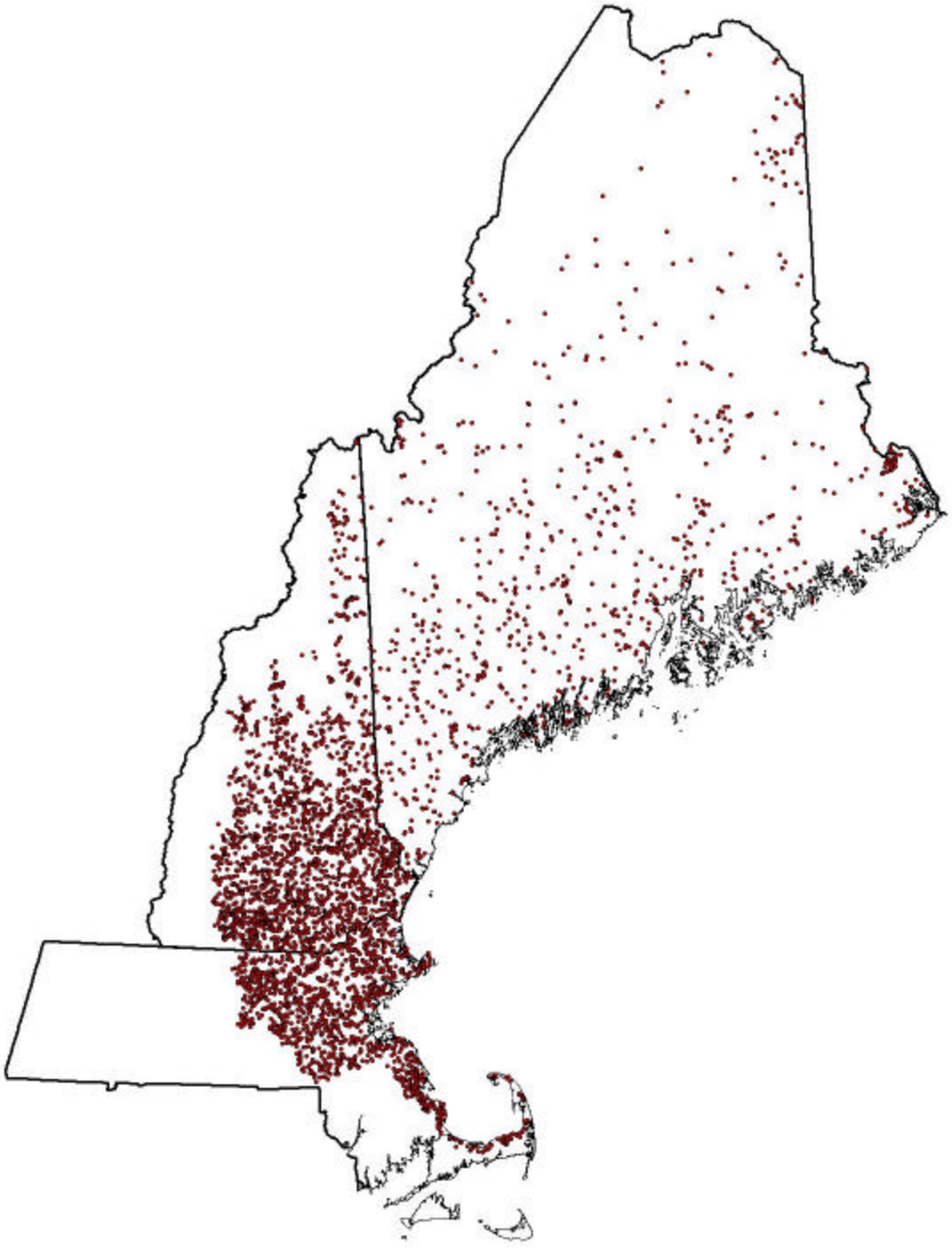
Impacts to Riverine Habitat and Restoration Opportunities

Dams and Fish Passage Barriers

Dams and undersized or improperly placed road culverts can greatly restrict or prohibit upstream and downstream fish passage for both resident freshwater and migratory diadromous fish species. Diadromous fish -- those that migrate from salt to fresh water, or fresh to salt water -- are especially at risk because barriers to their movement greatly impact spawning behaviors and success. Reconstructing problematic culverts can be a relatively low-cost and effective means of restoring fisheries access to some rivers. The preferred method is to install an adequately sized culvert with natural bottom habitat where feasible, and to ensure that the hydraulics of the new structure will not serve as a barrier to fish movement.

When a dam is the barrier of concern, in most cases the preferred alternative from the ecological perspective is to remove the dam in a carefully planned fashion. Dam removal reconnects artificially fragmented river systems, often resulting in restoration of important spawning, nursery and feeding habitats for both migratory and resident fish species, as well as improving water quality conditions and the natural flow regime. Removing a dam is a legitimate option that deserves to be considered on its merits, and should be incorporated into any analysis of alternatives that has the goal of improving dam safety, reducing costs of dam maintenance and operation, and reducing environmental impacts. Including adequate information about the dam removal option will enable well-informed decisions on the future of dams – and therefore the future of rivers and migratory fishes -- throughout the Gulf of Maine Watershed. Of course, dam removal may not be the best option due to a variety of social and economic factors, such as water supply needs, hydropower production, recreational activity and cultural desires. In these cases installation of both up- and downstream fish passage is the preferred alternative to reducing the dam's impacts on fisheries.

The US side of the Gulf of Maine has 2,506 dams in New Hampshire, 780 in Maine and X in Massachusetts. Methods for dam inventories in each jurisdiction vary according to parameters used for categorizing dams. For instance, in New Hampshire all dams are counted regardless of height, size of impoundment area and type of use. In Maine, dam owners voluntarily registered dams between 1983-93. Dam registration in Maine required a minimum height of the structure as well as a minimum water capacity behind the dam (i.e, surface acres and volume of water). There are undoubtedly many more dams in Maine since some owners may not of registered their dams, as well as many abandoned log driving mills that are not included in the inventory. Although each jurisdiction records dams using different parameters, the best available number of dams identified above is useful for planning purposes.



Dams in the US portion of the Gulf of Maine Watershed.

Dam removal not only results in environmental benefits but also potential economic and social savings. Long-term costs of maintaining dams that might have limited financial return due to obsolete or damaged equipment in the case of power producing facilities, or

dams that no longer have any financial return, may outweigh the benefits. Another consideration is the liability associated with dams that have deteriorated and may be breached by high flows, causing flooding and repair expenses. Social and economic benefits can result from restoring river habitat such as the development of recreational opportunities such as river canoe, kayak and whitewater rafting. Angling for migratory sea run fish species, such as American shad, striped bass, as well as festivals surrounding annual springtime alewife runs provide tourist attractions in many areas of the Gulf.

Installing a fishway on a dam can greatly improve fisheries movement in a river system. However, it should be stated that fishways do not provide the overall benefit of dam removal because a fishway does not restore riverine function or habitat, only fisheries access. They also typically only improve access for specific species (i.e., those that the fishway are designed to pass) but not others. There are several types of fishways that have been proven to be highly effective, particularly for migratory species like American shad and river herring (e.g., Denil-type, Alaskan steep pass). There is an increasing interest in new and innovative fishways that are designed to mimic nature, either in the form of a riffle (i.e., rock ramp fishway) or a tributary to the main river (i.e., bypass channel). These "nature-like fishways" have been shown to pass a broader diversity of fish species, and even reptiles and amphibians. Regardless of the type of fishway decided upon for a particular site, the design and placement must take into consideration a variety of factors that are critical to its success, such as adequate hydraulics within the fishway and proper attraction flow so that the fish of interest are able to find and navigate the length of the structure. Identifying an entity to take long-term maintenance and operational responsibility for the fishway is also critical to the success of the project.

Techniques for Removing Dams and Improving Fish Passage

Rock Ramps-These structures, built with cobble and boulders to replace an existing dam, retain water levels behind the structure but also provide a more natural flow of water to allow migrating fish to pass.

Sennebec River--Union, Maine

Rock Sills
[Photo of rock sills in Nova Scotia]

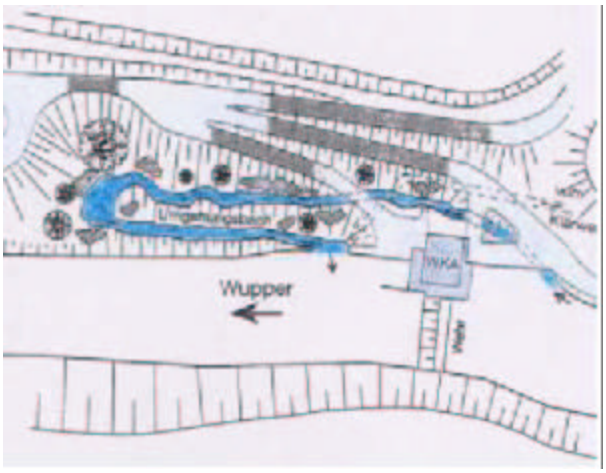
Rock sills are built out from the riverbank on both sides of the river in an alternating pattern. The purpose of the sills is to create a riffle and pool environment that creates habitat for fish by concentrating water flow and providing opportunities for resting and spawning within the river.

Fish Ladders and Nature-like By-pass Options

Fish ladders are engineered to allow fish passage over a dam. While these can successfully pass some species, they are not feasible for all fish species that require migration for spawning.

By-pass channels are constructed around dams in order to create a channel that has riffles and pools as well as stream channel bottom and riparian habitat that mimics the natural system as closely as possible. These types of fish passage structures can be designed to pass many species of fish. However, they can require large areas of land since they often have to overcome substantial elevation differences above and below the dam.

Fish ladder Sebasticcok River, Newport, Maine.



Plan for a by-pass channel around a dam, Buchenhofen, Germany.

Degraded Stream Morphology and Riparian Buffers

Many rivers in the Gulf of Maine have been impacted by commercial activities in the past. Sections of rivers have been straightened by removing the natural sinuosity of rivers in a misguided effort to divert water for purposes of flushing impounded waters or attempts to reduce the incidence of floods. Also, using rivers for log drives to harvest timber had a drastic impact on the natural stream morphology. Restoration efforts to re-align river channels to their original courses has proven to be an effective technique for creating improved fish habitat on the bottoms and edges of sinuous rivers for spawning

and reducing flood impacts to communities by reconnecting the natural absorption capacity of the floodplain to the river.

Riparian buffers help control water temperatures for cold water fish, provide cover for riverine species, and reduce erosion by holding soil within its root systems. Natural vegetation along river corridors such as shrubs and trees has been removed and altered as a result of human activities, which reduces the effectiveness of these natural buffers in the Gulf. Efforts to stabilize river banks with native shrubs and trees have proven to be a valuable restoration technique for riverine habitats.

Policy Recommendations for Riverine Habitat Restoration:

The Council's objective is to restore, enhance and provide access for fish and wildlife to riverine habitats. In many areas of the Gulf, the functions and values of riverine systems have been reduced or eliminated. Emphasis is placed on diadromous fish since access to much of these species' historic spawning habitat has been lost.

INTERTIDAL

Photo of restored intertidal habitat to be included.

Intertidal Habitat in the Gulf

Around the intertidal zone of the Gulf's coastline are found three major types of habitat – salt marsh, rocky intertidal, and mudflat – each distinct from the other in appearance and character. Substrate and levels of wave and tidal energy help determine which habitat type is found where, while the extent of habitat is determined by slope and tidal range (Gordon, 1994).

Intertidal habitats support several species that are commercially important to local traditions and economies in the region. For instance, the total value of the softshell clam harvest in Maine was valued at $17 and $15 million, respectively for 2001 and 2002 (Maine Dept. of Marine Resources, 2004). Irish moss (*Chondrus crispus*) is another species that is commercially important throughout the Gulf. This moss is used as a thickener, stabilizer, and gelling agent in foods, pharmaceuticals, toothpaste, cosmetics, and paints, which is derived from carrageenan extracted from the moss (White, S. and M. Keleshian. 1994).

Salt Marshes

Salt Marshes are found throughtout the Gulf of Maine as either large estuarine complexes or more fragmented *fringing* marshes, environments within which only a select number of species can exist due to wildly fluctuating temperature, wetness, and salinity. Straddling land and sea, the salt marsh is wetted daily with salt water, and thus only those plants that can tolerate such water take root in the marsh. Prominent among those plants are cordgrass (*Spartina alterniflora*), salt meadow cordgrass (*S. patens*), spike grass (*Distichlis spicata*), and black grass (*Juncas gerardii*).

In a salt marsh, seawater flows in and ebbs away twice a day-pulled by the moon and sun. On the rising tide, cold, nutrient-rich salt water invigorates marsh life. Grasses take in nutrients, clams filter food from the water, fish enter in search of sustenance, waterbirds feed, and other organisms relish the rich marsh soup. As tides fall, the estuary drains to the sea, carrying nutrient-laden waters from the marsh back into coastal food webs. It's a pattern that places salt marshes among the most productive ecosystems on earth.

Healthy salt marshes are good for fish and wildlife. Finfish such as striped bass, bluefish, flounder, and bait fish use salt marshes for food, shelter, spawning and nursery areas. Shellfish such as clams and mussels settle into tidal flats and are sustained by the twice-daily influx of salt water. Geese, herons, shorebirds, and sparrows rely on salt marshes for breeding habitat and migratory rest stops. They also thrive on the abundant food found in mudflats, creeks, salt marsh pannes (pools), and on the marsh surface. The salt marsh hosts many other animals that find their needs met between the high and low water marks.

The last episode of glaciation wiped out the salt marshes that used to exist in the Gulf. Ice scouring, which can retard the growth of a salt marsh for decades, remains a natural threat to these habitats (Berrill and Berrill, 1981). Where new salt marsh begins to take hold, when *Spartina* grasses first colonize a mud flat in the Gulf, some 500 to 600 years must pass before the marsh reaches maturity (Berrill and Berrill, 1981). Today, about 61 square miles (158 km^2) of salt marsh is found around the Gulf, representing a very small fraction of the total Gulf coastline.

Where salt marsh does occur, its contribution to the local ecology can be very significant. Vegetation grows densely in the marsh and results in a significant export of primary production to the marine environment, thereby enriching nearshore waters. The vegetation also serves as an important food source for a variety of organisms, as well as protective cover for numerous aquatic and terrestrial species. The significant biodiversity of salt marshes is evident from the following species: the ribbed mussel (*Modiolus demissus*), one of the few burrowers more characteristic of salt marshes than other habitats; the plant hopper (*Prokelesia marginata*), an insect which drains liquid from *Spartina* grasses; smaller fish such as mummichog (*Fundulus heteroclitus*), nine-spined stickleback (*Pungitius pungitius*), and pipefish (*Syngnathus fuscus*); and birds such as sharptailed sparrow (*Ammospiza caudacuta*), seaside sparrow (*Ammospiza maritima*), long-billed marsh wren (*Cistothorus palustris*), and American bittern (*Botaurus lentiginosus*), all of which nest in salt marsh (Berrill and Berrill, 1981).

The marshes of the Gulf are also vital nursery grounds for immature fish and invertebrates, with many of the commercially important species of fish and shellfish harvested in the Gulf dependent on salt, brackish and *tidal-fresh* marshes for some part of their life cycles (Conkling, 1995; Rickleffs, 1993). Of particular note, the food webs of the marshes and mudflats in the upper Bay of Fundy are believed to support the entire population of shad (*Alosa sapidissima*) on the eastern seaboard of the U.S. and Canada in the summer (Conkling, 1995).

What is a *tidal-fresh* Marsh?

Rocky Intertidal

Shores strewn with rocks, boulders and bedrock are found all around the Gulf but are most common along the coast of Maine and the lower Bay of Fundy. Where water movement is strong enough to wash away sediments and leave a rocky substrate, dense mats of rockweeds are found, individual plants of which are held down to rocks by special structures called holdfasts. Four of these large brownish-green algae species most commonly straddle rocky shores and adjacent subtidal habitats: knotted wrack (*Ascophyllum nodosum*), spiral wrack (*Fucus spirilis*), bladder wrack (*Fucus vesiculosus*), and *Fucus distichus*. Bladder wrack is prevalent in areas more exposed to wind and waves, while knotted wrack tends to dominate in more sheltered places (Conkling, 1995).

The rockweeds are keystone species around which many other species in an outside of the intertidal zone are strongly dependent. At high tide the fronds of individual plants float to the sea surface, forming a plant canopy not unlike that of a forest and providing cover from predators for young fish. At low tide, the fronds collapse in heaps over the rocks, providing a wet and cooler environment for innumerable stranded marine invertebrates that otherwise would desiccate under the warm summer sun.

Principal among those invertebrates are the amphipod crustacean, *Gammarus oceanicus*, perhaps the commonest of all organisms living in the rockweed understory, and three periwinkle species that are by far the dominant herbivores of the entire intertidal region: smooth periwinkle (*Littorina obtusata*), rough periwinkle (*Littorina saxatilis*), and common periwinkle (*Littorina littorea*), a non-native species likely introduced into the Gulf of Maine in the mid-1800s. Other common invertebrates of rocky shores, often living outside areas of rockweed coverage, include the acorn barnacle (*Balanus balanoides*), a species capable of withstanding wide-ranging temperature fluctuations.,, and the blue mussel (*Mytilus edulis*), an animal that can colonize a new area on a rocky shore faster than any other (Berrill and Berrill, 1981).

In addition to their importance for many invertebrates, rockweeds provide habitat crucial for many fish and bird species. More than 30 species of fish utilize rockweeds for feeding and for shelter from predators. Herring (*Clupea harengus*) also lay their sticky eggs around rockweed plants (and other materials). More than 15 species of birds utilize floating rockweed during some part of their life cycle, for example black duck (*Anas rubripes*) and common eider (*Somateria mollissima*) which forage extensively for periwinkles and amphipods found in rockweed gardens (Platt, 1998; Conkling, 1995).

The fronds of rockweed plants may be up to two decades old but eventually break off to float free on the sea, often in huge mats, or be tossed up on shore. In both cases, rockweeds continue their contribution to ecological functioning within the Gulf: In some estuaries and bays, this rockweed detritus can contribute from thirty to forty percent of available nutrients (Platt, 1998).

Mudflats

Where an intertidal area is protected from waves or currents, where the slope of the seafloor is low, and where there is or has been sufficient sediment available to accumulate, mudflats may be found. Mudflats are found everywhere in the Gulf, such flats are particularly prevalent in Cape Cod Bay and in the upper reaches of the Bay of Fundy, location of more than 180,000 acres (74,000 ha) of mudflats including some of the world's largest (Harvey *et al.*, 1988).

Fluctuating salinity, extremes of summer heat and winter cold, and the raking of severe storms inherently restrict the diversity of organisms that can survive in the mudflat environment. However, what mudflats may lack in species diversity is compensated by

exceptional species abundance. At the surface layer, to a depth of ½ inch (1 cm), live billions of microorganisms such as diatoms, dinoflagellates, and blue-green algae (Berrill and Berrill, 1981). Abundant algae support invertebrates in staggering abundance, such as the tiny mud shrimp, *Corophium volutator*, which can occur in densities of more than 5,000 per square foot (60,000 per sq m) (Platt, 1998), and very slender burrowing worms called nematodes, 2,000 individuals of which can occupy a square inch (6.25 cm^2) (Berrill and Berrill, 1981}. These microorganisms are forage food for fish such as American shad, as well as a number of shorebirds and wading birds, most notably the semipalmated sandpiper (*Calidris pusilla*). Up to one million individuals – most of the global population – of this species migrate annually through the upper Bay of Fundy each year, gorging on *Corophium volutator* at the rate of several thousand amphipods per day per bird (Hamilton and Diamond, 2000), and doubling their weight in two weeks (Gordon, 1994).

Mudflats provide resources not only for fish and birds, but humans, too. Among the valued species resident in the flats are the blood worm (*Glycera dibranchiata*), a large worm prized as fish bait, and the soft-shelled clam (*Mya arenaria*), long the target of commercial and recreational clam diggers. Intertidal habitat for soft-shell clams is important for economic, environmental and cultural reasons in the Gulf of Maine. The clam industry is important to residents of the Gulf as a source of income, and it represents a considerable dollar value. There is also a unique cultural aspect to shellfish harvesting that is evidenced by recent efforts throughout the region to open clam flats not only to commercial harvesters, but also recreational harvesters as well.

Impacts to Intertidal Habitat and Restoration Opportunities

The intertidal habitat impacts identified below are currently the focus of restoration efforts in the Gulf. However, there are many other recognized impacts to intertidal areas that are beyond the scope of this document.

Hydrology

[hydrology language from S. Lary] The natural hydrology of tidal wetlands is impacted by tidal restrictions, dikes, and fill deposited on the wetland.

Tidal restrictions occur where man-made structures block or partially restrict natural tidal flow to wetlands. Tidal restrictions are common throughout the Gulf of Maine caused by roads, causeways, dikes and filled areas. Inventories of tidal restrictions are either completed or underway in all jurisdictions surrounding the Gulf.

Tidally influenced systems that once supported salt tolerant species of vegetation become freshwater dominated environments when much or all of the tidal influence is restricted by structures. Tidal flow restrictions also prevent fish from accessing the surface of marshes, change the physical and chemical properties of tidal wetlands, and causes erosive *scour pools* on either side of the restriction resulting from increased water velocity.

Tidal restrictions can be reduced or eliminated by enlarging existing culverts or installing bridges where increased tidal flow to the restricted wetland is appropriate. Each restriction project must measure the degree of restricted flow and determine the anticipated saltwater elevations in light of increased flows. In highly developed areas of the Gulf, it may be necessary to regulate tidal flow in order to protect infrastructure that might be impacted if flow were unregulated.

Self regulating tidegates (SRT) are devices that allow the tidal flow through culverts to be regulated. SRT's are used in situations where there is risk of tidal flooding from unrestricted ocean water flow due to structures located in low-lying areas. The SRT is set to remain open and allow the free exchange of tides through the culvert provided that the tides are not abnormally high due to storm surges or lunar tidal events. If the tide reaches the maximum setting of the SRT, the gate(s) will close and stop the inland flow of ocean water until the water level recedes to the preset height. Self regulating gates are an alternative in highly developed areas of the Gulf.

Self Regulating Tide Gates (SRT)

See Appendix D for tidal restriction information by jurisdiction within the Gulf.

Diked, Filled and Ditched Coastal Wetlands

Many salt marshes in the Gulf of Maine have been filled with sediment, dyked to hold back the ocean, and ditched in attempt to drain the marsh. Often times marshes show evidence of sediment fill from nearby dredging for navigation purposes, which usually meant that the marsh was used as the spoils area for sand or mud from the estuary bottom. Dumping sediments on top of the marsh surface kills the native salt marsh vegetation and raises the elevation of the marsh to an unnatural height. Since salt marsh vegetation is dependent upon regular influxes of saltwater as well as the peat accumulation constituting the marsh itself, sediment placed on top of the marsh is detrimental to the natural functions of the ecosystem. Using nearby salt marshes as a spoils site for dredged material was a common practice through out the Gulf of Maine into the 1970's.

Diked marshes consist of elevated berms that were designed to hold back saltwater in order to reduce the amount of water on the marsh and use the remaining land as agricultural land. This occurs throughout the Gulf, but is particularly extensive in the upper Bay of Fundy in New Brunswick and Nova Scotia. Many of the largest salt marshes in the Gulf are in Canada in the Bay of Fundy region and large areas have been dyked for agricultural use. Many of these areas remain dyked, and in Canada the

agricultural agencies at the Provincial level are obligated to repair the dykes to maintain farmland.

Marsh ditching was a common practice throughout the Gulf in an effort to drain marshes for agricultural uses, as well as an attempt at mosquito management. Ditches are often found in a grid pattern when viewing aerial photographs of marshes. While mosquitoes are undoubtedly a component of the saltmarsh ecosystem, healthy marshes with pools (areas that retain water between flood tides) and pannes (areas of water on the marsh surface that can dry out between flood tides) allow fish that feed on mosquitoes to thrive in the areas that contain mosquito larvae, thus mosquito populations are reduced naturally due to fish feeding on the larvae. Ditch plugging is done in some instance in an attempt to return the natural hydrological regime to the altered salt marsh.

Removal of dredge sediments from salt marsh that have been filled in the past is another opportunity to restore impacted marsh. Spoil material, in many cases sand or mud from nearby dredge projects, is removed from the marsh. Grading the surface elevation of the marsh is critical to restoring the native vegetation since different species of plants rely on varying salt regimes depending upon the amount of saltwater inundation.

In some instance diked marshes have failed due to lack of maintenance of the structures holding the saltwater back and created serendipitous habitat restoration by allowing saltwater back onto the marsh. There is considerable opportunity for removal of dykes from salt marshes that are no longer used for agriculture.

Invasive Species

Native salt marshes are typically made up of smooth cordgrass (*Spartina alterniflora*), salt meadow hay (*Spartina patens)*, and other vegetation that is particular to the cycle of salt inundation resulting from tidal influence. However, a number of invasive species are present in many marsh in the Gulf, which indicates anthropogenic disturbance to tidal ecosystems. The invasive species *Phragmites australis,* or common reed, is an indicator of disturbance to salt marshes.

Increased occurrence of common reed in a marsh can create a more monoculture environment that eventually will reduce the diversity of the salt marsh plant community by crowding out other species. Lower species diversity is generally associated with less diversity of fish, birds and other species that typically use the marsh as habitat. Common reed can become so dense that it makes it difficult for salt marsh vertebrates to utilize the habitat. In addition, common reed can be a fire hazard since the dry stems of the plant can fuel large fires, especially if the marsh is located in a densely populated area more common in the southern portion of the Gulf of Maine.

Common reed can be managed at acceptable levels by eliminating tidal restrictions and allowing adequate saltwater to enter and exit the marsh system on a regular basis. Cutting common reed, and in some case spraying with an herbicide, can slow the growth of the invasive and allow native salt marsh vegetation to return.

Altered Water Quality and Benthic Conditions

Shellfish habitat is often denigrated by poor water quality as a result of non-point or point source runoff. Often fecal coliform counts are too high to allow consumption of shellfish unless depuration is employed, which allows the pollutants to filter out of the shellfish in specially designed tanks. Another common problem in the Gulf is that the flow of saltwater to a previously productive clam flat is reduced or eliminated due to an undersized or misplaced culvert or a causeway / roadway that reduces or completely eliminates tidal flushing. Without regular flushing, including nutrient import and export, tidal flats that have limited tidal flow can often have lowered productivity.

Policy Recommendations for Intertidal Habitat Restoration:

The Council's objective is to restore a natural tidal regime, and thus the functions and values of tidal wetlands, to intertidal habitats through the removal of dikes, fill, water control structures, and inadequately sized culverts.

SUBTIDAL HABITAT

Eelgrass photo from Great Bay, New Hampshire.

Subtidal Habitat in the Gulf

Beneath the 36,000 square mile (90,700 km^2) surface of the Gulf of Maine (Stevenson and Braasch, 1994), seaward of its intertidal zones, lie a diversity of habitats supporting numerous species that live in the water column or along the seafloor, from brightly lit nearshore shallows to the dark reaches of the 21 deep basins of the Gulf.

Estuaries

Of special importance to the productivity of the Gulf are the estuaries, places where freshwater from land meets the saltwater of the sea. Such places are comparatively rare worldwide, making up less than one percent of Earth's coastline. However, the Gulf is comparatively rich in them: About 30 significant estuaries, 17 on the U.S. side of the Gulf, 13 on the Canadian side, cover at least 3,000 miles (5,000 km) of Gulf coastline, making the Gulf as a whole (and the Bay of Fundy especially) somewhat estuarine in character. The Merrimack, Kennebec and Saint John rivers contribute significantly to the estuarine make up of the Gulf. Major bays include Massachusetts Bay, Ipswich Bay, Great Bay, Casco Bay, Muscongus Bay, Penobscot Bay, Blue Hill Bay, Frenchman Bay, Cobscook Bay, the St. Croix Estuary and Passamaquoddy Bay, Shepody Bay, Cumberland Bay, Minas Basin, and Chignecto Bay (Platt, 1998; Bright, 1995).

Estuaries are the downstream receptacles for high concentrations of nutrients washed from land, particularly in late winter and early spring following melting of the winter snowpack. Nutrient loading from land combines with upwelling of deep, nutrient-rich saltwater and further nutrient export from salt marshes and rockweeds to stimulate the growth of immense blooms of phytoplankton throughout the spring and summer. In these ways, estuaries become nurseries for the planktonic larvae of many invertebrates, as well as for small fish. Indeed, because estuaries within the Gulf generally support the three main types of primary producers (macrophytic plants such as seaweeds, sea grasses and marsh grasses; benthic microphytic algae, and phytoplankton), they are exceptionally productive, as ecosystems similar in that regard to the productivity of tropical rainforests and coral reefs (Platt, 1998).

Not surprisingly the Gulf's estuaries are critically important to many species. They are particularly attractive as fish and shellfish nurseries, as well as feeding habitat and nesting sites for migratory fish and birds (Platt, 1998). As examples, the spawning ground for cod (*Gadus mohua*) at the mouth of the Sheepscot River estuary is a highly productive spawning ground for offshore fish in Maine estuaries (Maine Coastal Program, 1991), while Penobscot Bay supports the highest densities of the American lobster (*Homarus americanus*) yet recorded in North Atlantic waters (Platt, 1998).

Indeed, it is estimated that many of the commercially important marine species in the Gulf spend part or all of their life cycles in Gulf estuaries. Furthermore, migratory birds along the North Atlantic Flyway find vital feeding and resting grounds in the estuaries, which also support a diversity of waterbirds including loons and ducks that seek ice-free estuarine habitat in winter after inland lakes freeze over (Bright, 1995). For such reasons, the Gulf's estuaries have trans-national and even hemispheric ecological importance (Platt, 1998).

Eelgrass and Kelp Beds

Within and outside of estuaries, in nearshore subtidal environments, are habitats characterized by several other keystone plant species. One of these is eelgrass (*Zostera marina*), a long and slender-leaved plant that needs prolonged submergence by salt water to survive, and is rarely uncovered by low tides. Eelgrass affords multiple functions. For example, eelgrass provides sediment filtering and trapping, water quality maintainance, nursery habitat for lobster and bay scallop (*Aequipecten irradians*) (Short and Burdick, 1994), and is important feeding habitat for migrating populations of waterfowl, particularly American brant (*Branta bernicla*) {Maine Coastal Program, 1991; Berrill and Berrill, 1981}.

The other key plants are several species of kelps such as hollow-stemmed kelp (*Laminaria longicruris*), edible kelp (*Alaria escuelenta*), and sea colander (*Agarum cribosum*). The broad, thick-leaved kelps form dense beds or "forests" 6.5-10 feet (2-3 m) tall or greater, and may grow to depths of 65-100 feet (20-30 m) and to 5 miles (8 km) from shore. Within the perennial kelp garden, numerous other smaller annual macroalgaes may compete for light and space (Berrill and Berrill, 1981). At the same time, the kelps are grazed heavily by the green sea urchin (*Strongylocentrotus droebachiensis*), which in turn is hunted by the American lobster, a species that prefers kelp beds for shelter during the period when individual lobsters are shedding their old shells (Conkling, 1995).

Deep Bottom Habitats

Moving further offshore, where light penetration weakens and the presence of marine plants is diminished or absent, bottom habitats across the seamounts, marine trenches, and flats of the Gulf seafloor are characterized primarily by the substrate, whether sand, mud, gravel, cobble, boulder, or combinations thereof. Each substrate may support certain fauna more than others. For example, many species and an abundance of individuals per species may inhabit gravel beds, the particles of which are quite large and loosely packed, leaving interstitial spaces large enough to be inhabited by various creatures (Watling *et al.*, 1988). As another example, burrowing mud anemones appear to characterize sand or claylike substrate with a minor amount of overlay gravel, while white hake (*Urophycis tenuis*), jonah crab (*Cancer borealis*) and several other species appear to characterize sand or claylike substrate overlain by siltstone outcrops and talus

up to boulder size. Within these macrohabitats occur features, such as depressions, shells, burrows, and sand wave crests that constitute microhabitat for other species that strongly associate with such features. For example, the long-finned squid (*Ilex illecebrosus*) and the scup (*Stenotomus versicolor*) utilize the depressions produced by species such as red hake (*Urophycis chuss*) and American lobster (Langton *et al.*, 1994).

Water Column

The water column of the sea is itself habitat for innumerable organisms, from the drifting microscopic plankton to enormous pelagic (open water) fishes such as swordfish (*Xiphias gladius*) and bluefin tuna (*Thunnus thynnus*), the largest bony fishes found along the northeast Atlantic coast (Berrill and Berrill, 1981). Also present, although rarely seen, are four endangered species of sea turtles, such as the leatherback (*Dermochelys coriacea*), which feed on jellyfish.

Typical Water Column Zones
[Insert graphic of the Gulf of Maine water column]

The water column is also home to more than 30 species of marine mammals known to occur, at least occasionally, within the Gulf. These include an estimated 30,000 harbor seals (*Phoca vitulina*), the most widely distributed of the world's 33 species of seal, and gray seals (*Halichoerus grypus*) that reach their extreme southern limit along the Massachusetts coast. The marine mammals also include five species of the plankton-straining great whales, numbering perhaps 3,500 individuals in total (from a pre-colonial exploitation number of perhaps 25,000). Prominent among these, from a conservation viewpoint, is the highly endangered right whale (*Eubalaena glacialis*), a slow-swimming, moderately large (35-50 feet, or 10-16 m) whale that migrates in summer to its only known nursery area, the Grand Manan basin of the Bay of Fundy (Conkling, 1995).

Impacts to Subtidal Habitat and Opportunities for Restoration

Submerged Aquatic Vegetation Loss

An important submerged aquatic vegetation (SAV) found in the Gulf of Maine are eelgrass beds that act as juvenile rearing areas for finfish and shellfish as well as food source for fish invertebrates and waterfowl. Eelgrass habitat ranges from North Carolina to the Canadian Maritimes and requires adequate light conditions and relatively low turbidity in the water column. It is estimated that 50 percent of the eelgrass in the North Atlantic has disappeared over the last 100 years or so (Short, UNH). The reasons for the decline in eelgrass range from nutrient overloading that deprives the species of light to impacts from boat propellers, anchors and dredging activities that dislodge the aquatic plants relatively easily. Other destructive impacts to eelgrass can be caused by wasting disease, a slime mold that cases die-off, and from drag fisheries that bottom fish within such habitats of the Gulf.

Some areas in New Hampshire and Maine have undergone eelgrass restoration in the past, and there are many areas throughout the Gulf that once had more extensive eelgrass beds and are candidates for restoration. Methods of restoration include transplanting native plants from other parts of the Gulf and seeding areas that once supported eelgrass habitat.

Nonpoint Source and Dredging

Subtidal habitat in the Gulf is impacted by nonpoint source runoff from development in the region. Runoff for areas that lack adequate buffers to filter nutrients and pollutants before entering coastal areas can lower water quality and negatively impact subtidal habitat such as SAV's, the water column itself, and deep bottom areas. Navigational dredging affects the water quality by increasing turbidity, and possibly suspending pollutants and redistributing them to additional locations.

There is currently limited restoration activity occurring for subtidal habitats in the Gulf of Maine. Nonetheless, this is an emerging habitat restoration area that has a great need for additional identification of projects, funding and monitoring of subtidal areas throughout the Gulf.

Policy Recommendations for Intertidal Habitat Restoration:

The Council's objective for subtidal areas of the Gulf is to pursue an increase of eelgrass as it is critically important for juvenile fish and encourage shellfish restoration to improve subtidal water quality, thus supporting social and economic needs in the region.

BEACH, DUNE AND ISLAND HABITAT

[photo to be included]

Island Habitat in the Gulf

More than 5,000 islands are found within the Gulf of Maine, most of which (4,617) are in the island-rich state of Maine. Their importance for habitat is in two major respects. Firstly, as hills or mountains rising from the seafloor to top out above sea level, they cause upwelling of deeper, nutrient-rich water, thereby helping bring an abundance of nutrients towards the sea surface, enriching the nearby waters. Currents driven by tidal action also swirl around islands and surge through passages, "creating a funnel effect that increases the volume of feed available to filter feeders, as well as those species that prey on the filter feeders" (Conkling, 1995). In this way, then, the physical presence of islands augments the productivity and biodiversity of the Gulf.

Secondly, islands, particularly those uninhabited or least developed by humans, often offer habitat required or preferred by various bird species. These include, notably, some seabirds but also certain neotropical migrants and raptors such as Bald Eagle (*Haliaeetus leucocephalus*) and Osprey (*Pandion haliaetus*), which also make use of adjacent coastal and upland habitats.

The seabirds – gulls, terns, cormorants, petrels, guillemots, puffins, and others – have habitat requirements, particularly for nesting, not met by all islands or, for that matter, even most islands. Only about ten percent of the islands of the Gulf provide suitable seabird habitat, suitability including a general absence of tree growth, a complete absence of large mammals, and quick access to offshore food sources. Within the Gulf, Machias Seal Island off Grand Manan, a number of islands in Maine (e.g. Libby, Brothers, Schoodic, Great Duck, Matinicus Seal, Metinic), and sandy islands off Cape Cod (e.g. Manomet, Monomoy) are among the best islands that meet these exacting conditions (Conkling, 1995). On the best islands, seabird colonies numbering thousands or even tens of thousands of breeding birds blanket the rocks, cliffs, and scant grasses.

Among the most sensitive of all the seabirds in the Gulf are the four species of terns that nest there, including the rarest of all North American terns, the endangered Roseate Tern (*Sterna dougallii*). While the terns do not breed exclusively on islands as do other seabirds, and will breed and nest on sandy beaches and sand dunes on the mainland (Berrill and Berrill, 1981), disturbance to those mainland sites increases the importance of suitable island sites, the number of which is less than 30 in the Gulf. To a degree matched by few other species within the Gulf, the fish-eating, nesting-sensitive terns help indicate the overall health of the Gulf ecosystem (Conkling, 1995).

There is currently a seabird restoration grouping throughout the Gulf of Maine, consisting of local, state and federal partners, which focuses on re-establishing populations of terns

(Artic, *Sterna paradisaea*, Common, *Sterna hirundo* and Roseate), puffins, razorbills and others birds to islands within the Gulf. Such efforts involve discouraging gull populations from overtaking island habitat and providing decoys to attract desirable birds to the selected locations.

Impacts to Island Habitat and Opportunities for Restoration

More than 4,500 islands found within the Gulf of Maine provide several key habitat values to plant, fish and wildlife species. These underwater mountains cause upwellings of deep, nutrient-rich waters, thereby bringing an abundant supply of nutrients to the surface and increasing the feed available to filter feeders, as well as the numerous marine species that prey on filter feeders. In this way, the physical presence of islands stimulates the biological productivity of the Gulf.

In addition, islands that are free of predators and free of human disturbance provide habitat preferred or required by nesting and migratory birds. Nesting coastal island birds in Maine include 13 species of seabirds, eight species of wading birds, many neotropical migrants and birds of prey such as osprey and bald eagle. As habitat disturbance on the mainland increases, it is also likely that islands are playing an increasingly important role as feeding and roosting areas for migratory shorebirds.

By the end of the 19th century, after several hundred years of habitat disruption and overharvesting for food and feathers, Maine's seabird populations were decimated. John James Audubon, the famed ornithologist, commented that he was hard-pressed to see a gull flying along the Maine coast. In 1907, only one pair of nesting eiders was found in Maine. The outlook for seabirds was bleak, but in the early 20th century, migratory bird protection laws went into effect. In addition, people began to emigrate from islands to the mainland, taking pressure off the seabird nesting colonies. Consequently, some seabirds have bounded back from the brink of extermination. Today, common eider, double-crested cormorant, herring gull and black-backed gull occur in relative abundance on numerous coastal islands. Unfortunately, the human activity such as garbage dumps provide herring gulls and black-backed gulls with a dependable but unnatural food supply, and gull numbers have likely risen eight times in the last 60 years. Gulls, being large and aggressive, tend to usurp the best nesting habit, and today, gull populations are higher than ever, threatening the future for other seabirds requiring habitat on coastal islands.

Populations of other species (roseate, common and arctic tern) began to rebound – just like the eiders and gulls. But since the 1930s, as the gull populations rose, the terns have been squeezed out. By the 1970s, terns had abandoned nearly all Maine islands – except a few islands where lighthouse keepers discouraged gulls from roosting. However, when automated lights replaced the lighthouse keepers, the remaining terns faced devastation by marauding gulls. Roseate terns are a federally endangered species. Today, populations of all three species of island-nesting terns have begun to improve due to active habitat protection and restoration management programs.

Populations of other species (Atlantic puffins, razorbill auk, black guillemots, leach's storm-petrels, laughing gulls) appear to be stable, but like all of the nesting island birds, they merit careful attention because nesting populations are limited to only a small number of islands.

Only about 10% of coastal islands in the Gulf of Maine provide appropriate conditions for nesting seabirds, wading birds or birds of prey. In Maine, for example, a database maintained by the U.S. Fish and Wildlife Service identifies that only 630 of the 3,500 islands have nesting populations. Of those 630 islands, approximately 330 have been recognized as "nationally significant," based

on indices of species diversity and/or the percentage of the statewide population of each species. The small percentage of suitable islands for the entire population of nesting seabirds indicates the importance of permanently protecting these islands and appropriately managing them. Currently only half of the 330 islands in Maine are under some form of conservation ownership, and only a small portion of those that are "protected" are actively managed by federal, state and non-government organizations to minimize threats and maximize nesting potential. In Maine, 45 islands are currently owned and managed as part of the U.S. Fish and Wildlife Service's Petit Manan National Wildlife Refuge. More than 300 islands and ledges are owned by the Maine Department of Inland Fisheries and Wildlife as part of its Coast of Maine Wildlife Management Area. The remaining islands are owned or held in easement by a variety of national, state and local conservation agencies or groups.

Nesting island suitability depends on several factors:

- Availability of abundant food supply nearby. (Maintaining healthy marine fisheries is vitally important for maintaining healthy seabird populations).
- Lack of predators (house pets, raccoons, mink, fox, black-backed gulls)
- Lack of human disturbance during the nesting season (Human disturbance can frighten birds, make them abandon nests, or leave eggs and chicks vulnerable to predation. During the nesting season, people should stay off nesting islands and direct their activities to many suitable non-nesting islands).
- Appropriate vegetation. (Nesting seabirds, wading birds and eagles have different nesting requirements. Cormorants, for example, nest in tall trees or rocky ledges. Gulls nest on ledges or grass. Terns typically require short grass. Eiders need shrubby thickets. Puffins nest in burrows amongst large rocks. Leach's storm petrels nest in burrows dug in the soil in grassy and forested areas. Glossy ibis and some of the herons prefer nesting in the tops of small tress).

The Gulf of Maine Seabird Working Group, an informal coalition of local, state and federal partners from the United States and Canada, meets twice a year to share information on seabird activity in the Gulf of Maine. The Working Group has focused on re-establishing healthy populations of terns, puffins and razorbills to islands within the Gulf of Maine. The Seabird Working Group, with technical support from the U.S. Fish and Wildlife Service Gulf of Maine Coastal Program, maintains a database of nesting island activity Gulf-wide. The Working Group supports habitat protection and restoration projects to restore and maintain nesting populations throughout the Gulf. In Maine alone, since the mid-1990's, nearly $6 million in federal funds and $2 million in non-federal funds have been spent to acquire 44 nationally significant nesting islands and protect their habitat values for nesting birds. In addition, restoration activities continue on 12 islands.

Beach and Dune Habitat in the Gulf

Beaches, pounded by an average of 8,000 waves a day (Berrill and Berrill, 1981), are high-energy, climatically extreme environments within which only certain organisms can survive. They range from shores of fine-grained silt or sand to shores of boulders as wide or much wider than a catcher's mitt. Classic sandy beaches within the Gulf, of any significant extent, are mostly found from Cape Cod to southern Maine.

The principal factor in the size of beach particles is beach slope: the greater that slope, the larger the size of the sand grains or rock fragments that cover it. The size of beach

particles, in turn, influences the life that can exist in the beach environment. For example, fine-grained sand beaches play host to bacteria, diatoms, and blue-green algae, as well as meiofauna less than 1-2 mm in diameter, such as nematodes. Coarser-grained sands offer habitat for not only many members of the meiofauna (1 mm in size) but also the larger copepods – small, primarily marine crustaceans (Berrill and Berrill, 1981).

Behind the rear of some sand beaches are sand dunes. These are hillocks of wind-blown sand originally brought to the rear of beaches by ocean waves, and stabilized primarily by the salt-tolerant American beachgrass (*Ammophila brevigulata*). This is a remarkable sand-trapping plant that itself must be covered by an average of almost 3 inches (7 cm) of sand per year to survive, and which responds to sand coverage by rooting further within the dune, thus stabilizing the dune even more (Berrill and Berrill, 1981).

Sand dunes have their own particular ecological zonation, within which various species like Sea Rocket (*Cakile edentula)*, Black Cherry (*Prunus serotina*), and Pitch Pine (*Pinus rigida*) are adapted to varying levels of moisture and the presence of salt (Berrill and Berrill, 1981). A prominent endangered species that depends heavily on sand dune habitat areas devoid of vegetation for survival is the Piping Plover (*Charadrius melodus*).

Major dune systems in the Gulf are found in the Provincelands area of Cape Cod (including the older dunes of Mt. Ararat which rise to over 100 feet {33 m} in height), at the Parker River National Wildlife Refuge on Plum Island in northern Massachusetts, and at Ogunquit Beach, Scarborough Beach State Park, Popham Beach, and Reid State Park in Maine.

Impacts to Beach and Dune Habitat and Opportunities for Restoration

Impacts to beach and dune habitat are limited access for birds and other wildlife that utilize this habitat for feeding or nesting, loss of habitat due to coastal development, and human disturbance of feeding and nesting sites.

Threats to beaches and dune systems include seawalls, jetties, roads, trampling of beach grass by people, ATVs, driving on beaches, house development on coastal dunes. Road building, conversion of beach grass habitat to lawn, seawalls, houses all prevent the natural functioning/development of these systems. They need overwash to sustain them - but rarely get it. Public use, trash and the attraction of predators (gulls, crows, feral cats, dogs) are threats. Artificial barriers in dune systems (snow fencing, dune stabilization projects using christmas trees area also threats - anything which prevents the formation and maintenance of the critical foredune section is detrimental to nesting plovers. In addition, the removal of wrack is a threat to the beach ecosystem.

GOM beaches are key pieces for the management / restoration of beaches to benefit piping plovers and least terns.

RECOMMENDATIONS FOR ENHANCING HABITAT RESTORATION IN THE GULF OF MAINE

Regionally Significant Potential Restoration Projects

The following potential restoration projects in the region have been identified by the GOMC Restoration Subcommittee as having regional significance within the Gulf of Maine. These sites are by no means a complete listing of degraded habitat in the Gulf in need of restoration. However, this listing of sites identifies at least one regionally significant project within each of the Gulf's five jurisdictions.

Riverine

- Penobscot River, Maine—The Penobscot River historically supported a considerable Atlantic salmon population. However, dams have impacted diadromous fish runs on the river and greatly reduced usable habitat. There is currently an agreement among interests to reduce the number of dams on the Penobscot and improve fish passage where needed to improve habitat for native fishes. This location represents an opportunity to restore a significant salmon population to the Gulf of Maine.

- St. Croix River, Maine and New Brunswick—The St. Croix presently has dams that impede diadromous fish runs as well as low water quality, resulting in highly degraded habitat. Also, riverine habitat has been severely altered due to past and present industrial uses of the river. This location represents an opportunity to restore a sizable river and estuary along the international boarder between the US and Canada.

- Ipswich River, Massachusetts—This highly impacted river is currently undergoing assessment for fisheries restoration. The Ipswich River is currently listed as one of the most endangered rivers in the US due to flow alteration, low

Ipswich River Fisheries Restoration

[Description and photo of the project to be included]

[3] The text, map and photos are from the Petitcodiac Riverkeeper website: www.petitcodiac.org.

dissolved oxygen and other factors.

Intertidal

- West Branch Pleasant River, Addison, Maine—The tide gate in Addison on the West Branch of the Pleasant River, in place since 1940, has restricted saltwater from reaching a nearly 2000 acre salt marsh behind the gate.

- Herring River, Wellfleet, Massachusetts--The Herring River and associated salt marshes in Wellfleet (MA) represent the largest riverine estuarine system within the Cape Cod National Seashore. The local conservation commission is supporting a marsh restoration plan that will address a tidal restriction from a dyke and tide gate, taking flooding and infrastructure into consideration.

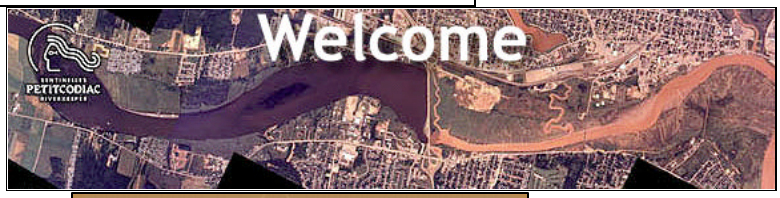
- Cheverie Creek, Cheverie, Nova Scotia—This is a highly restricted salt marsh due to an undersized road culvert. The marsh is the gateway to 30 acres of salt marsh habitat for Gulf of Maine species. This project represents a pilot for GOMC / NOAA Partnership funding for restoration efforts in Canada.

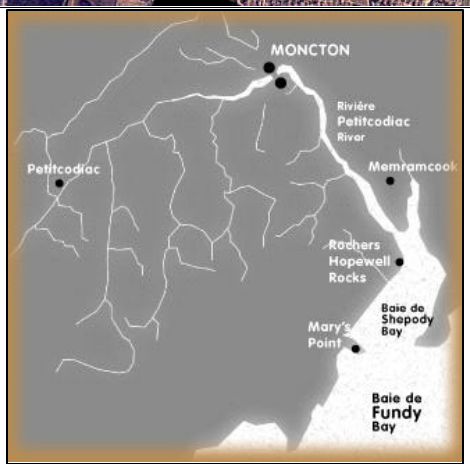
- Petitcodiac River, Moncton, New Brunswick—This river system has been highly impacted from a causeway that has eliminated the influence of the tidal waters carrying mud upstream of the structure. The upstream stretch of river is impounded behind the causeway and has altered this section of river to a pond environment, disconnecting the once tidal river from the ocean. Considerable amounts of sediment have deposited below the causeway causing an unnatural accumulation. The Avon River Causeway in Windsor, Nova Scotia is a similar situation in which the river has been disconnected from the ocean, altering habitat that once benefited the Gulf.

[Gulf of Maine map with locations of each regionally significant project identified to be inserted here]

The Petitcodiac River Causeway

The Petitcodiac River, which flows into Shepody Bay, drains a 3,000 km2 watershed area situated at the far reaches of the Inner Bay of Fundy. It is the source of life of the most important ecosystem in south-eastern New Brunswick. The aboriginal Micmacs named the river Pet-Kout- Koy-ek, meaning 'the river that bends like a bow', An important historic transportation route, the Petitcodiac River and the Shepody Bay Estuary are important tidal systems influenced by the phenomenal Bay of Fundy tides (from 9 m to 14 m), uncovering kilometers of mudflats at low tide and nourishing some of the world's greatest estuaries. Shepody Bay is home to a unique hemispheric shorebird refuge and the feeding grounds of the entire East Coast American shad fish population. [1]





Map and aerial of the Petitcodiac River causeway in Moncton, NB.

Subtidal

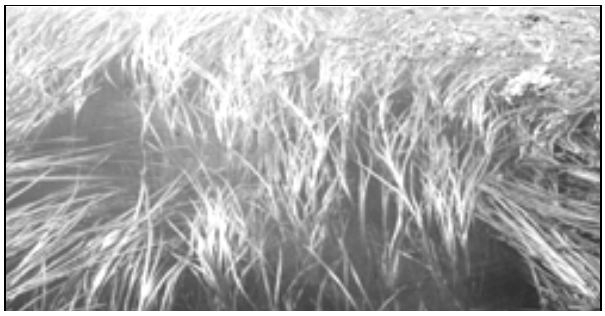
- Great Bay and Little Bay, New Hampshire—This area has undergone eelgrass assessments to determine the extent and health of the resource, as well as a reseeding program to restore eelgrass to once productive habitat. Additional restoration efforts are needed to restore and protect eelgrass resources in Great and Little Bays.

Eelgrass Restoration in Great Bay / Little Bay, New Hampshire

The Great Bay Estuary begins at the mouth of the Piscataqua River. Tides carry salt water into the estuary twice daily from the Atlantic Ocean. Here it mingles with the fresh water influence from the various rivers that empty into Great Bay. New Hampshire has the shorte coastline of any state, but those 18 miles increase to 150 miles of tidal shoreline when the Great Bay Estuary is included. It is one of the largest estuaries on the Atlantic Coast and at 10 miles inland is one of the most recessed.

There are five very different water dominated habitats that make up the Great Bay. In order of abundance they are: eelgrass meadows, mudflats, salt marsh, channel bottom, and rocky intertidal. These habitats are home to 162 bird, fish and plant species (23 of which are threatened or endangered), countless invertebrate species and even the occasional harbor seal.

Eelgrass is one of a very few underwater marine flowering plants. It has many functions in the estuarine system. The eelgrass communi provides habitat for several organisms, especially the young of fish and invertebrates. Eelgrass roots help stabilize the bottom sediments Eelgrass plants help maintain water quality and clarity by filtering the water allowing sediments to settle and then using the excess nutrients for growth.



[4] The eelgrass photo is from the Gulf of Maine Times (http://www.gulfofmaine.org/times/summer98/5a.html) and the text is from the Great Bay National Estuarine Research Reserve (http://www.greatbay.org/heritage/).

Beaches, Dunes and Islands

- Seabird Island Nesting, Maine—Most of the seabird nesting opportunities are found on islands in Maine. There are over 4,500 islands in Maine and many are impacted by human activities. Therefore restoring habitat for colonial seabirds and ensuring future protection of such habitat is currently underway by various interests within the Gulf.

Seabird Nesting on Maine Islands

Between 1972 and 1980, the refuges in the Petit Manan National Wildlife Refuge Complex were established for the protection of migratory birds, principally colonial nesting seabirds. Acquisition of islands continues today for protection of the resource. The Service has focused on restoring terns because their populations were particularly low. The roseate tern, a federally endangered species, prefers large colonies of common or Arctic terns in which to nest. Therefore, saving this species requires assisting the other two.

To restore terns to an island, it must first be made suitable for the birds again. This requires discouragement of herring and great black-backed gulls If terns have recently abandoned an island, they may return rapidly once the gulls are gone. However, in many cases, it has been decades since terns last nested on an island. To entice them back, the Service uses sound systems playing recordings of a tern colony and tern decoys scattered in suitable nesting habitat. This method has been highly effective on several islands within the Gulf of Maine.

Tern restoration began in 1984 on Seal and Petit Manan islands, which now support large colonies of common and Arctic terns. Roseates have returned to Petit Manan. More recent restorations have occurred on Pond, Metinic, and Ship islands. The goal is to establish tern colonies on numerous refuge islands. This will ensure that a singular catastrophic event such as disease, an oil spill, or a hurricane, will not wipe out a species. Other colonial nesting seabirds have benefitted from tern restoration efforts. Atlantic puffins, black guillemots, laughing gulls, Leach's storm petrels, and common eiders have recolonized some islands. 6

[Photos to be included.]

RECOMMENDED ACTIONS FOR IMPROVED HABITAT RESTORATION

The GOMC Restoration Subcommittee has identified the following recommendations, that are consistent with the long-term goals of the Council, for continued success with habitat restoration efforts in the Gulf:

Recommendation 1: Inventory of Restoration Sites

A. Complete ongoing site inventory of potential restoration sites by identifying remaining gaps in data collection and analysis, and promoting opportunities to reduce or eliminate data gaps.
B. Regularly update Gulf-wide database of existing restoration projects in the region.

Identifying potential restoration projects and maintaining a database of previously implemented projects will allow practitioners to focus restoration efforts in the Gulf using a coordinated regional approach. Since data collection and analysis originates with many different organizations within the Gulf, protocols to standardize methods and track progress over time will result in improved regional collaboration.

Recommendation 2: Capacity Building

A. Increase capacity for habitat restoration project development and monitoring to improve capability for state/provincial government technical resources to assist with projects.
B. Increase capacity for habitat restoration project development and management to improve capability for local government and citizen organizations to implement restoration projects.
C. Evalute and modify as necessary the regulatory processes in the region that affect habitat restoration efforts.

Habitat restoration within the Gulf is growing at an ever-increasing pace. Capacities within the Gulf vary by jurisdiction due to political and regulatory considerations. Increasing project development, management and technical know-how about restoration across jurisdictions will allow an opportunity to transfer information and adapt to local or state/province situations.

Recommendation 3: Outreach and Education

A. Inform and educate Gulf-wide congressional/parliament and state/provincial legislative delegations about restoration in the Gulf.
B. Maintain and enhance relationships with foundations and the private sector in the US and Canada to include partners for technical assistance
C. Encourage and promote community involvement for restoration projects throughout all jurisdictions on the Gulf.
D. Identify steps needed and complete the Gulf of Maine Habitat Restoration Web Portal currently under development.

E. Develop GIS coverages for restoration in the Gulf.

There is a need to develop a better Gulf-wide understanding of habitat restoration in the Gulf. In addition to informing interests, current efforts to work with private sector partners could include greater technical assistance in all jurisdictions of the Gulf. The Gulf of Maine Web Portal will create a central clearinghouse for restoration projects and methods, as well as database management needs.

Recommendation 4: Research and Monitoring

A. Develop monitoring protocols for a) riverine, b) subtidal and c) islands, beaches and dunes.
B. Re-evaluate GPAC protocols previously developed for salt marshes within the Gulf by reconvening interests for a workshop to update the protocols.
C. Ensure that restoration projects within the Gulf implement applicable pre- and post-construction monitoring protocols.

Monitoring is important for measuring the benefits of restored sites in the Gulf. Protocols are currently in place for salt marsh restoration projects; however, other habitats would benefit from similar standards for data collection. Standardized protocols for research and monitoring allow for consistent evaluation of habitat restoration over time.

APPENDIX A

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Petit Manan National Wildlife Refuge--http://petitmanan.fws.gov/restoration.html

Petitcodiac Riverkeeper--www.petitcodiac.org

Gulf of Maine Times--http://www.gulfofmaine.org/times/summer98/5a.html

Great Bay National Estuarine Research Reserve--http://www.greatbay.org/heritage/

U.S. Fish and Wildlife Service – Gulf of Maine Coastal Program -- http://gulfofmaine.fws.gov/

Appendix B

Summary of GOMC/NOAA Habitat Restoration Partnership Grants

Applicant	Location	Project Title	Grant Amount
Trustees of Reservations	MA	Old Town Hill Salt Marsh Restoration Project	
Trustees of Reservations	MA	Damde Meddows Salt Marsh Restoration Project	
Town of Dennis	MA	Quivett Creek Salt Marsh and Fish Run Restoration	
Indian Ponds Assoc.	MA	Marstons Mills Herring Ladder	
Town of Plymouth		Town Brook Herring Run Restoration Project	
Mass. Dept. of Fisheries and Wildlife	MA	Third Herring Brook Restoration	
Town of Rockport	MA	Seaview Street Salt Marsh and Fishery Restoration	
Salem Sound 2000	MA	Volunteer Wetland Health Assessment Toolbox	
Town of Barnstable	MA	Bridge Creek Salt Marsh Restoration Project	
Salem Sound Coastwatch	MA	Coastal Habitat Invasive Monitoring Program	
City of Revere	MA	Oak Island Marsh Restoration and Flood Control Project	
Barnstable County Resource Development Office	MA	Sesuit Creek Herring Run Restoration	
Town of Barnstable	MA	Oyster Habitat Establishment and the Utilization of Remote Setting Techniques	
Salem Sound Coastwatch	MA	Eastern Point Salt Marsh Monitoring	
North and South Rivers Watershed Association	MA	Third Herring Brook Fish Restoration	
Mass. Dept of Marine Fisheries	MA	Woolen Mill Dam Fish Passage Improvement	
Trustees of Reservations	MA	Old Town Hill Salt Marsh Restoration Project	
Trustees of Reservations	MA	Damde Meddows Salt Marsh Restoration Project	
Town of Dennis	MA	Quivett Creek Salt Marsh and Fish Run Restoration	
Indian Ponds Assoc.	MA	Marstons Mills Herring Ladder	
Town of Plymouth	MA	Town Brook Herring Run Restoration Project	
Mass. Dept. of Fisheries and Wildlife	MA	Third Herring Brook Restoration	
York Conservation Commission	ME	Wheeler Marsh Restoration Monitoring	
River Rehab, Inc.	ME	Habitat Survey and Monitoring Effects of Dam	

Applicant	Location	Project Title	Grant Amount
		Removal to Fishery	
Town of Newport	ME	Sebasticook River Channel Restoration	
Town of Harpswell	ME	Dingley Island Tidal Flow Restoration	
Sheepscot River Watershed Council	ME	Somerville Road NPS Reduction Project	
Wells National Estuarine Research Reserve	ME	Harbor Road Marsh Restoration	
Casco Bay Estuary Project	ME	Presumpscot River Restoration Inventory	
Coastal Conservation Assoc.	ME	East Elm Street Fish Ladder / Water Flow Improvement	
Town of Bristol	ME	Pemaquid Marsh Restoration	
NH Dept. of Environmental Services	NH	Wiswall Dam Project: Study of Water Storage Mitigation Options	
Ducks Unlimited	NH	NH Marsh Monitors/Volunteer Saltmarsh Monitoring Program	
Ecology Action Centre	NS	Cheverie Creek Salt Marsh & Tidal River Restoration Project	
TOTAL			

APPENDIX C

Summary of Tidal Restriction Assessments and Activities

New Brunswick :

Assessment of Tidal Restrictions Along Hants County's Highway 215: Opportunities and Recommendations for Salt Marsh Restoration. Ecology Action Centre, September 2001, Tony M. Boron and Allison Fitzpatrick.

Massachusetts:

North Shore
The *Atlas of Tidally Restricted Marshes: North Shore of Massachusett*s was completed by MWRP in 1996 and identifies 190 potentially restricted tidal wetlands. To request a copy, contact MWRP at (617) 626-1177 or email wetlands.restoration@state.ma.us.

Buzzards Bay
Under agreement with MWRP, the Buzzards Bay Project National Estuary Program under Massachusetts Coastal Zone Management has completed the *Final Atlas of Tidally Restricted Salt Marshes: Buzzards Bay Watershed Massachusetts* which identifies and prioritizes 167 tidally restricted coastal marshes. To request a copy, contact the Buzzards Bay Program at (508) 291-3625 or visit their web site at www.buzzardsbay.org.

South Shore
Under agreement with MWRP, the Massachusetts Metropolitan Area Planning Council published the *Final Atlas of Tidal Restrictions on the South Shore of Massachusetts* in June 2001. The Atlas identifies and prioritizes 121 tidal restrictions. To request a copy, contact Bill Clark of the Metropolitan Area Planning Council at (617) 451-2770 or email bclark@mapc.org.

Cape Cod

Under agreement with MWRP, the Cape Cod Commission is currently preparing a tidal restriction atlas for the Cape Cod region. A Draft Atlas will be completed in fall 2001, followed by a Final Atlas over the winter. To request a copy, contact Stacey Justus of the Cape Cod Commission at (508) 362-3828 or email sjustus@capecodcommission.org.

Maine

The Maine Department of Transportation in conjunction with the Army Corps of Engineers created an inventory of bridges, culverts, tide gates, and railroad crossings in December 2002 to assess degraded tidal wetlands and the impact of tidal restrictions potentially caused by engineering structures.

APPENDIX D

Contacts for the Gulf of Maine Council Habitat Committee, Restoration Subcommittee

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MAINE

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NEW BRUNSWICK

Kim Hughes, New Brunswick Department of Environment

NOVA SCOTIA

Shayne McQuaid, Department of Fisheries and Ocean, Nova Scotia