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The Plight and Outlook for Migratory Fish in the Gulf of Maine

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Rivers throughout the Gulf of Maine once contributed billions of juvenile fish into the marine ecosystem where they served as a critical forage base for cod and other groundfish. In the Central Gulf of Maine—Bay of Fundy watershed alone, over sixty rivers formed nine drainage basins and thirteen estuaries. For the past 12,000 years, the immense runs of migratory fish from these Gulf rivers provided important cultural, economic and ecological services throughout the Gulf watershed. However, in just a few short centuries, the heavy hand of humans has decimated native migratory populations and has broken the connections between rivers and the ocean. The resilience of these native species has allowed them to survive in low numbers throughout the Gulf, but fundamental shifts in fisheries management are needed to prevent their ultimate demise.

Though much attention has been given to depleted groundfish stocks in the Gulf, there is a growing interest in restoring the historic, native assemblage of migratory fish to the rivers spanning the Gulf. Ecosystem management that has worked well on land is being adapted to the Gulf as scientists now recognize the strong linkages between the freshwater and marine environments. In the past several years, historic researchers such as Ted Ames and Deb Trefts have documented the disappearance of migratory forage stocks such as the river herrings and the subsequent disappearance of inshore cod stocks in both the 1800s and 1900s. The emergence of this practical knowledge and the awareness of the restoration potential of the rivers flowing into the Gulf is now generating Gulf-wide interest in implementing strategies that collectively contribute to the restoration of migratory fish and groundfish stocks.

More than twelve species of migratory fish once returned each year to the major rivers in the Gulf of Maine. While the decline of Atlantic salmon has garnered much recent attention, it is, of course, only part of a larger decline in once-abundant migratory fish populations that historically defined rivers in the Gulf of Maine. Native populations of Atlantic and endangered shortnose sturgeon, American shad, alewives, blueback herring, and sea lamprey have also been nearly or completely extirpated from many of our larger rivers. The populations of other native sea-run species, such as American eel, rainbow smelt, striped bass, and tomcod, which have fared somewhat better, are severely limited in production potential compared to historical conditions.

Historic Decline

Accounts of explorers' dating back to the 1500s describe a diversity and abundance of anadromous fishes throughout the Gulf of Maine, especially river herrings, shad, salmon, striped bass and sturgeons. Many Native American place-names along the coast refer to areas where river herrings and shad were especially plentiful. Others signify places where eels, sturgeons, and tomcod were abundant. Indians fished for Atlantic shad along the Penobscot and Sebec rivers as early as 6,000 to 8,000 years ago. They caught sturgeon beginning at least 3,000 years ago at the junction of the Pushaw and Dead streams at Alton and along the Penobscot at Old Town, as well as at numerous locations along Penobscot Bay. In colonial America, salmon, shad, and river herrings ranged far inland and all had important economic value along with the coastal cod fishery (Trefts 2006).

From 1600 to 1900, New England's seemingly inexhaustible supply of migratory fishes steadily declined from west to east. The size of Maine's rivers and their distance from major urban centers shielded the enormous runs of fish they naturally sustained until widespread damming and clogging of rivers and overfishing led to the demise of most commercial salmon, shad and river herring fisheries by 1870. The loss of prey upon which cod stocks had foraged inshore each summer seems to have caused their disappearance from the Gulf of Maine's estuarine and coastal waters from west to east after impassable dams were constructed in the main stem of large rivers running to the Gulf (Trefts 2006).

Today, historic populations of migratory fish in the Gulf of Maine are at a fraction of their historic levels. Atlantic sturgeon numbers have plummeted, while shortnose sturgeon populations are down 98 percent and listed as endangered under the Endangered Species Act (Smith 1997). Due largely to dams, Atlantic salmon have lost more than 90 percent of their historic spawning habitat in the Gulf of Maine. Sea-run brook trout, which are still common in all the Canadian maritime provinces, are now found in only a few small Gulf streams that have been untouched by dams and industrial use. Eel landings declined from 1.8 million pounds in 1985 to 649,000 pounds in 2002 (Atlantic States Marine Fisheries Commission 2000). In 2004, the Atlantic States Marine Fisheries Council petitioned the federal government to conduct a status review of American eel populations due to their precipitous decline. Eels are a relatively long lived species that may live in freshwater up to 30 years and grow to five feet in length before heading out into the Gulf of Maine on their way to the Sargasso Sea. Due to their size, turbines exact a heavy mortality on the downstream migration of sexually mature eels. In a 1998 study, the U.S. Fish and Wildlife Service determined that eels may have been eliminated from 81 percent of their historic habitat from Connecticut to Maine (Atlantic States Marine Fisheries Commission 2000). The once abundant river herrings have continued to decline remarkably as well. Alewife landings in Maine declined from 3.4 million pounds in 1970 to less than 1 million today (Maine Department of Marine Resources 2005).

Dams

In the past three decades, meaningful steps have been taken to make rivers in the Gulf of Maine more capable of supporting fish populations. Due to the Clean Water Act, poor water quality is not the limiting factor to fish populations it once was. No longer do we see industrial or municipal pollution creating anoxic barriers to fish migration that was the norm in the Gulf's larger rivers only four decades ago. Today, both commercial and recreational fisheries are better managed and habitat-altering log drives are now just a part of folklore. Amendments to the Federal Power Act have required regulators to consider a broader range of public uses of our rivers beyond just energy production when dams are re-licensed. This has often resulted in better fish passage, increased minimum flows and in rare cases, orders for a dam to be removed. Despite these improvements, virtually all native migratory fish populations in the Gulf of Maine have continued to decline. A reliance on unproven engineering schemes to mitigate the impacts of dams continues to block the meaningful (self-sustaining) restoration of migratory fish. In particular, the cumulative impacts of dams continues to exact a severe toll on migratory fish as regulators have largely chosen to look at each dam independently, rather than taking into consideration the whole configuration of dams on a river. Since major rivers in the Gulf of Maine average five or more main stem dams, the cumulative impact issue is the major reason for the failure of most migratory fish restoration efforts.

The impacts of dams differ with each species. For species such as sturgeon, striped bass and rainbow smelt, there is no proven technology to pass these fish over dams. For skittish species such as American shad, fish elevators are required since they are reluctant to use fish ladders. Even with a fish lift, it is rare to find a self sustaining shad run above two or more dams. For Atlantic salmon, it is virtually impossible to find a self-sustaining run of salmon above three or more dams in North America or Europe. As mentioned earlier, the downstream impacts may be as detrimental or, in the case of the American eel, worse to fish populations.

A good example of the cumulative impacts of dams can be seen on the Penobscot River, the largest river in the Gulf of Maine. With the possible exception of the American eel, the river is not capable of supporting any self-sustaining population of migratory fish above the first dam. In this particular river, a guantlet of three dams close to the ocean continue to retard the meaningful restoration of Atlantic salmon, despite decades of efforts and millions of dollars.

Cultural, Economic, and Ecological Benefits of Diadromous Fish

Cultural

Certainly for Indian tribes such as the Penobscot Indian Nation, migratory fish were important part of their history and still play important ceremonial and religious roles. For decades, they have been unable to exercise their treaty reserved fishing rights as migratory fish are not able to reach their reservation. The resident fish offer the tribe little as an alternative. Fish consumption advisories are present throughout much of the Penobscot River watershed due to the presence of dioxins, furans, PCB's and mercury in fish species tested, including smallmouth bass, white suckers and American eel. The restoration of shad, blueback herring and alewives to the Penobscot River would provide a clean source of food for the tribe and render meaningful the Penobscot Nation's federally recognized subsistence fishery rights.

Sport angling for the Atlantic salmon and other species has longstanding traditions that have helped tie riverfront communities together. In Maine alone, more than a dozen salmon clubs buzzed with excitement each spring in anticipation of the salmon's return from Greenland. As recently as fifteen years ago, the first salmon caught on the Penobscot was presented to the President. Today, many of the salmon clubs and their rich history have gone away. On the Penobscot, three clubs hang on with the old timers now playing cribbage instead of fishing on the river.

Economic

The commercial and recreational value of migratory fish should provide momentum for a Gulf-wide restoration effort. On the East coast, the recreational fishery for striped bass is $6.6 billion and supports 63,000 jobs (Southwick Assoc 2005). Just outside of the Gulf of Maine, Canada's recreational Atlantic salmon fishery pumps tens of millions of dollars into local economies while playing an important cultural role as well. On the Miramichi River alone, recreational salmon fishing is a $25 million industry that has proven to be far more sustainable than many other boom and bust resource industries along the coast. In a few southern rivers in the Gulf of Maine such as the Merrimack, recreational shad fisheries are becoming popular due to restoration efforts. Further south on the Connnecticut and Hudson Rivers, popular shad festivals welcome the return of what John McPhee has titled, The Founding Fish, for shad's important economic role in centuries past. Obviously, a restored coastal cod fishery would be a tremendous economic and cultural boon to communities surrounding the Gulf of Maine.

Ecological

Migratory fish are a conveyor belt of nutrients from the ocean to the river and from the river to the ocean. Increasingly, there has been a growing consensus among researchers and scientists who believe that one of the reasons groundfish continue to struggle in the Gulf of Maine is because their forage base is depleted. Historically, the forage base of coastal cod stocks and other groundfish has been largely comprised of Atlantic herring, which spend their entire life in the ocean, and the river herrings (alewife, blueback and shad). Rainbow smelt, tomcod, and eels have also been a component of the forage base. The loss of billions and billions of juvenile forage fish from the Gulf of Maine can only have a negative impact on species like cod that depend on them. In fact, recent papers by Ames (2004) and Trefts (2006), covering different time periods, have documented declines in migratory fish and the subsequent declines in nearshore groundfish populations. Whether it is river herrings role as forage fish for coastal groundfish populations, or rainbow smelts role as food for salmon kelts, or alewives role in feeding the young of eagles and ospreys, the possibility of restoring the broken connections that tie together the terrestrial, river, estuary and marine ecosystems should drive the impetus needed for a Gulf-wide diadromous fish restoration effort.

Historically, diadromous fish were a source of nutrients for the generally nutrient poor rivers in the Gulf of Maine. These fish were a significant source of carbon, nitrogen, and phosphorous to the river. This transfer of clean nutrients into the river served many important roles, not only for the other fish in the river, but also for a diverse benthic community of invertebrates and for life along the river corridor. Recent studies have shown that river herring predators derive a substantial portion of their carbon biomass during the spawning run (Garmin 1998). In a Pacific Northwest study, 22 species of mammals and birds were observed to eat salmon carcasses on seven Pacific Northwest streams (Cederholm 1989).

The influence of salmon on rivers in the Pacific Northwest is well documented. The five species of Pacific Northwest salmon are thought to have historically caused a "nutrient shadow" throughout the ecosystem. Clem Fay, the late fisheries biologist for the Penobscot Indian Nation, believed that the twelve fish species that comprised the native assemblage of migratory fish in the Gulf of Maine may have once played a similar role in casting a 'nutrient shadow' far inland.

Past Management Failures

The over exploitation of migratory fish stocks and the damming of rivers often wiped out abundant migratory fisheries in individual rivers in just a few short decades. Subsequent restoration efforts have largely failed for many reasons. The first is the failure to address the root of the problem. Public agencies now have 130 years of field experience in the Gulf of Maine to understand that fish ladders, lifts, and hatcheries can not overcome the impacts of multiple dams on a river. Yet tens of millions of public dollars continue to be spent perpetuating the myths of these technologies. While these technologies can play a limited role, such as a hatchery being used to keep a species from going extinct, they should not be considered lasting solutions. Second, both public and private groups have put too great a focus on individual species and not enough attention on restoring the full native assemblage of migratory fish in a river. This single species focus has ignored many of the ecological relationships fish have between species and other parts of their ecosystem. For example, Atlantic salmon spawn in the fall then overwinter before heading back to sea in the spring. In a healthy Gulf of Maine river, their downstream migration coincides with the upstream spawning migration of rainbow smelt. These smelt are a critical nutrient source for the salmon that have not eaten for 6-10 months and are headed back to a long migration at sea. To continue this theme, just a month later, the downstream migration of young salmon smolts coincides with the arrival of alewives in the river. The alewives serve as a critical prey buffer to the smolts from cormorants and other predators. The failure of fishery managers and policy makers to focus on these relationships has undermined their success. Ultimately, to save a species such as Atlantic salmon, we need to ensure the health of the other species with which it is co-dependent.

Potential Solutions

The National Academy of Sciences report, Atlantic salmon in Maine (2004), recommended a focus on large rivers and emphasized the urgent need for a ". . . program of dam removal, with a priority on those dams whose removal would make the greatest amount of spawning and rearing habitat available." This is not only good advice for salmon, but for all the native migratory species in the Gulf whose populations are today just a fraction of historic levels. Obviously, large rivers have the most habitat and over time are more resilient to environmental stochastic perturbations. In Maine, the Downeast coastal rivers historically supported populations of 300 to 800 adult salmon, whereas the Penobscot supported up to 100,000 adults. When a natural or man-made decline occurs, these larger rivers retain the critical mass needed to recover far quicker than the smaller rivers that take longer to emerge from the numbers bottleneck like the Downeast salmon rivers are in today.

At the same time, the medium and smaller rivers cannot be ignored. These rivers are important for the genetic diversity they provide within the range of each species and for spreading the risk of population extirpation. These smaller rivers may have fewer threats to address and, in the short term, may be where the best restoration opportunities lie. Small scale, successful restoration projects will only build momentum and public support for larger efforts.

As implied in the National Academy of Sciences report, a primary focus on habitat and a focus on addressing the root of the problem is needed. The removal of the Edwards Dam on Maine's Kennebec River is a good example of addressing the root of the problem. Situated at the head of tide, the removal of the dam opened up 17 miles of free-flowing habitat. Six years later, sturgeon, herring and shad have all recolonized the open habitat. The Maine Department of Marine Resources estimates that the shad population has gone from under 1,000 to more than 8,000 fish today (Wippelhauser pers comm.).

The Penobscot project may be the most innovative, far reaching river restoration project in the country today. The project addresses both the full native complement of migratory fish in the river and the need to restore the broken ecological connections between the river and the Gulf of Maine. If successfully implemented, the project will remove the two dams closest to the ocean, bypass a third and improve fish passage at four other dams on the river. The willingness of all stakeholders to take a global view of the river and their willingness to find a balance between economic use and meaningful fisheries restoration should become a national model for river restoration.

The outright removal of dams is not always feasible for political or financial reasons. Fortunately, there are several innovative strategies with promise for restoring migratory fish. These include the use of fish lifts instead of fish ladders to allow greater numbers of species and fish to be moved upstream. The use of rock ramps and fish bypass channels can provide unencumbered passage for multiple fish species. In some cases, fisheries managers and regulators need to consider shutting down turbines during peak migration periods. A good example of this technique would allow for turbine shutdown during the well-known fall night-time emigration of pregnant eels to prevent the 100 percent mortality rate that now occurs in some Gulf rivers.

An ecosystem focus that recognizes the numerous ecological relationships between the freshwater and marine ecosystems should govern future restoration efforts of migratory fish in the Gulf of Maine. Not only will this require approaches along the scale of the Penobscot project, but it will also require a fundamental shift in fisheries management. Currently, fishery managers often allow the harvest of all fish above the minimum number of spawners needed to seed the available habitat in the river. However, research has shown the number of spawners needed may be far greater to provide the necessary ecological benefits to other species needed for their survival (Gresh 2000). Scientists today still only understand a fraction of the ecological relationships that tie the river, estuary and Gulf of Maine ecosystems together. This dictates a need for a precautionary principle that favors fisheries management for ecological benefits first rather than solely for economic benefits. The metrics of success need to change. Instead of numbers of fish stocked, managers need to consider such questions as what natural processes have been restored and what populations have become self-sustainable. For example, the parameters for successful alewife restoration could include an evaluation of the change in distribution of the alewife floater mussel (alewives transport mussel seed upriver in their gills), a decrease in predation of salmon smolts, and the presence of alewives in the stomachs of near-shore codfish. Regardless of the metric, it should be clear that the meaningful restoration of migratory fish stocks requires far more interagency collaboration at both the federal, state, and NGO level. The fact that all of the Gulf of Maine's native migratory fish still survive, albeit in very low numbers, is a testimony to their strength. Given the chance, they can re-colonize their habitat and once again play the important role of tying together our freshwater and marine ecosystems.

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References

Ames, E. P. 2004. Atlantic Cod Stock Structure in the Gulf of Maine. *Fisheries* 29(1):10-28.

Atlantic States Marine Fisheries Commission. 2000. *Interstate Fishery Management Plan for American Eel.* Report No. 36: 1-93.

Bouwes, N., Budy, Phaedra, C. J. Petrosky, Schaller, Howard, and G. P. Thiede. 2002. Evidence Linking Delayed Mortality of Snake River Salmon to Their Earlier Hydrosystem Experience. *North American Journal of Fisheries Management* 22:35-51.

Cederholm, C. J., M. D. Kunze, T. Murota, and S. Atuhiro. 1999. Pacific Salmon Carcasses: Essential Contributions of Nutrients and Energy for Aquatic and Terrestrial Ecosystems. *Fisheries Habitat* 24(10):6-13.

Gresh, T., J. Lichatowich, and P. Schoonmaker. 2000. An Estimation of Historic and Current Levels of Salmon Production in the Northeast Pacific Ecosystem: Evidence of a Nutrient Deficit in the Freshwater Systems of the Pacific Northwest. *Fisheries Habitat* 25(1): 15-20.

Maine Department of Marine Resources. 2005. *The Maine Alewife Fishery and Resource Fact sheet.*

Maine Department of Marine Resources. 2005. *The Maine Eel and Elver Fishery. Fact sheet.*

National Research Council of the National Academies. 2004. *Atlantic Salmon in Maine.* The National Academies Press: Washington DC.

Smith, T. I. J., and J. P. Clugston. 1997. Status and Management of Atlantic Sturgeon in North America. *Environ. Biol. Fishes.* 48: 335-346.

Southwick Associates. 2005. The Economics of Recreational and Commercial Striped Bass Fishing in Massachusetts. *Stripers Forever* 1-47.

Stockner, J. G. (Editor). 2003. Nutrients in Salmonid Ecosystems: Sustaining Production and Biodiversity. *American Fisheries Society Symposium,* Bethesda, MD (34): ix-13.

Trefts, D. C. 2006. Dams, Overfishing, and Environmental Crises: The Historic Link Between New England's Declining Anadromous and Groundfish Fisheries, 1500-1900. *Penobscot River Restoration Trust.*1-27.

Wippelhauser, G. 2005. Personal Communication on Kennebec River Shad.