State of Rivers and Dams in Maine

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By Samuel Brakeley and Zachary Ezor

Executive Summary

The State of Rivers and Dams in Maine is the second chapter in The State of Maine’s Environment 2009, a report produced by the Environmental Policy Group in the Environmental Studies Program at Colby College in Waterville, Maine. This is the fifth State of Maine’s Environment report published since 2004.

The 31,752 miles of rivers and streams in Maine are important to Maine’s economy, ecological health, and cultural heritage. Dams have shaped both the natural flows and the societal uses of rivers in Maine for over two centuries. Although no new dams have been built since 1986, remaining dams continue to have environmental and economic impacts. In this chapter we discuss the state of rivers and dams in Maine, focusing on the history of dams, their current status, and the growing trend of dam removal. We give particular attention to diadromous – or migratory – fish and how dams and dam removals affect their traditional migration routes. We conducted an extensive literature review and performed original analysis using Geographic Information Systems. This chapter shows that Maine’s surface water quality is commendable, ranking number one in the U.S. We illustrate the growth of the number of dams in Maine over time, and investigate a boom in dam construction between 1875 and 1900. We also examine dam removal, a contentious topic, in light of the federal and state regulatory processes and the environmental benefits and drawbacks of dams. Finally, we analyze the historical habitat of 12 species of diadromous fish and find that 85% of dams that have been removed in Maine, or are slated for removal in the near future, intersect the habitats of six or more species while less than 1% of dams still standing intersect the habitats of six or more species. We conclude that while Maine’s river health is in excellent condition, more can be done to allow diadromous fish populations renewed access to their historical habitat and spawning grounds. Although fish bypasses are feasible, only a small percentage of migrating fish find the necessary entrance. Dam removal is an increasing trend and should be considered as a viable option to restore diadromous fish habitat and spawning grounds. We offer several recommendations to increase river health and productivity, including the continued monitoring of river and stream health, a state-wide prioritization of dams to consider for fish bypass installation, and an increased emphasis on dam removal as a method for river restoration and public safety.

Introduction

Rivers and streams played an integral part in Maine’s history. Native Americans have always used the waterways for food, water, navigation, and cultural and spiritual sustenance. In 1607, the first settlers built a town along the Kennebec River, eventually following the rivers inland to build new settlements (Foran 2002). Lumberjacks used the rivers to float timber to downstream mills in the famous log drives, peaking in 1890 with 894 sawmills which employed 1,540 lumberjacks and sawhands (Defebaugh 1907). Later, as populations grew, rivers were employed as a source of power for emerging mills. In the early 1880s the turbine was developed, leading to an explosion in hydropower generation in the U.S. By 1940, 40% of electrical generation in the U.S. was generated by hydropower (U.S. Department of Energy 2008). Currently, hydropower accounts for about 30% of Maine power generation and 10% of U.S. power generation (Wisconsin Valley Improvement Company; State of Maine Public Utilities Commission 2009). Although rivers and streams are important, they have also been used as refuse dumping grounds for as long as humans have populated their shores. In 1899, the Rivers and Harbors Act was passed in recognition that this practice not only impeded navigation but also posed significant threats to river ecosystems. Since rivers appear to remove all debris, they are often degraded over time, and Maine is still facing the repercussions of some of these past poor practices.

Dams have been constructed since the first settlers arrived in Maine, creating reservoirs for navigational aid, flood control, drinking water, recreational use and later, hydropower generation. By 1986, a total of 782 dams had been built (GIS Data Catalog - Maine Office of GIS 1987). They have significant helped to harness the river’s power and wealth, as well as increase safety along rivers from seasonal floods. However, dams also interrupt the natural flow of a river, and can cause ecological harm through sedimentation, erosion, and pollution. They can also inhibit fish migrations. Fish bypass systems have been constructed alongside some dams for as long as dams have been built, but they are never 100% effective, and for some species such as the Atlantic sturgeon, they are useless since sturgeon have never been shown to successfully use a bypass (American Rivers 2002). Since the mid 1980s, dam administrators, government agencies, and environmental groups have begun to advocate for dam removal (Becker 2009). In 1986, the Milton Leatherboard Lower Dam became the first dam in Maine to be removed through a joint effort with the New Hampshire Department of Environmental Services, and since then 16 additional dams have been removed, with more proposed or under study (Murch 2009). Dam removal remains a controversial process, however, and other factors should also be considered when attempting to improve river health.

Focus of this Chapter

In this chapter we provide an overview of the state of river and stream health in Maine, and compare Maine to other states. We describe the historical trends of dam construction in Maine, examine why these trends occurred, and discuss recent dam removal cases. We examine the effect that dams have on river ecosystems, specifically diadromous fish (fish that spend part of their lives in freshwater and part in salt water) and their habitats. We assess the effectiveness of fish bypass systems in Maine. Finally, we describe three scenarios of what the future of river health, dams, dam removal, and fish bypass systems might look like, examining the possibility and potential repercussions of each trend on Maine’s environment. We conclude by summarizing our key findings and offering some suggestions for moving forward on dam policy and ensuring that Maine continues its record of excellent river health.

Methods

We assembled background historical information by surveying and reviewing existing literature and commentary on rivers and dams in the U.S. Federal reports, issued by the Army Corps of Engineers (Corps), the Federal Energy Regulatory Commission (FERC), and the Environmental Protection Agency (EPA) were used to obtain national data on both rivers and dams. The Maine Department of Environmental Protection (DEP), the National Oceanic and Atmospheric Administration (NOAA), the U.S. Fish and Wildlife Service (USFWS), and the nonprofit groups Natural Resource Council of Maine (NRCM) and Maine Rivers provided explanations of federal and state laws, and of the regulatory process for constructing, altering, and removing dams in Maine. This information was supplemented by email correspondence with representatives from the Atlantic Salmon Federation (ASF), Florida Power and Light Company (FPL), and the Maine Department of Marine Resources (DMR).
We obtained spatial data from the Maine Office of GIS for impounds and historic and current diadromous fish habitats (GIS Data Catalog - Maine Office of GIS 1987). The impounds data contained construction dates, primary usage, locations, and sizes for all dams in Maine. The fish habitat data spatially depicted habitat for 12 species of migratory fish.

We used the Geographic Information System (GIS) software program ArcGIS 9.3 (ESRI 2009) to visually represent and to analyze spatial data. We grouped dams by age and displayed the growth of dams in Maine over time. We developed a simple method to determine which impoundments intersected migratory fish habitat. We placed a 50 meter spatial buffer on each river that had one of the twelve fish species inhabiting it. We selected all the dams that intersected each buffer. Dams that intersected a species’ habitat received a value of (1) while dams that did not intersect habitat retained a (0) value. By totaling these values we were able to rank dams based on the number of species’ habitats each dam intersected throughout the state.

Several attributes of the data affected our analysis. Because the impounds data were represented as simple centroids, the locations of some impoundments were slightly skewed. Our source at the Maine Office of GIS claims a high degree of certainty for these data, but does not rule out possible inconsistencies (Houston 2009).

Laws and Institutions

Maine’s rivers are protected by several federal and state laws. These laws govern activities along the rivers, set standards for water quality and ecosystem health, and regulate sources of pollution. The following sections detail some of these important laws and institutions. Special attention is given to the laws and agencies responsible for overseeing the construction and removal of dams.

Federal Laws

The Rivers and Harbors Act is generally considered to be the first federal environmental law, but it dealt primarily with navigation. The Environmental Protection Agency (EPA) was created in 1970, which has greatly aided the U.S. in comprehensive environmental protection and better management practices. Several laws addressed water protection in the 1950s and 1960s but it was not until 1972 that the U.S. passed comprehensive legislation dealing with water quality: the Clean Water Act. Table 2.1 below provides a short summary of federal laws affecting rivers and dams.

Table 2.1 Federal laws, years, and descriptions pertaining to rivers and dams

<table>
<thead>
<tr>
<th>Law</th>
<th>Year</th>
<th>Description</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rivers and Harbors Act</td>
<td>1882</td>
<td>Requires a permit for altering navigable waters, and forbids the discharge of refuse matter into navigable waters. Overseen by the Army Corps of Engineers.</td>
<td>USC Title 33 § 403</td>
</tr>
<tr>
<td>Federal Water Power Act</td>
<td>1920</td>
<td>Created the Federal Water Power Act (1920) to authorize construction of public works, or for the improvement of harbors or navigation.</td>
<td>USC Title 16 § 791-826c</td>
</tr>
<tr>
<td>National Historic Preservation Act</td>
<td>1966</td>
<td>Created a national inventory of all districts, sites, buildings, structures, and objects worthy of preservation, and requires a review process of any project that will affect listed sites. Overseen by the Advisory Council on Historic Preservation Officers (SHPOs).</td>
<td>USC Title 16 § 470</td>
</tr>
<tr>
<td>National Environmental Policy Act</td>
<td>1970</td>
<td>Requires all agencies to consider environmental impacts of potential projects by preparing an Environmental Impact Statement (EIS) for all projects. Overseen by the Council on Environmental Quality, a division of the Executive Office of the President (CEQ).</td>
<td>USC Title 42 § 4321</td>
</tr>
<tr>
<td>Clean Water Act</td>
<td>1948</td>
<td>Amended the Federal Water Pollution Control Act of 1948 and created national water quality standards and a National Pollutant Discharge Elimination System (NPDES) permitting scheme for polluters to regulate the amount of pollution emitted. Overseen by the EPA.</td>
<td>USC Title 33 § 1251-1376</td>
</tr>
<tr>
<td>Endangered Species Act</td>
<td>1973</td>
<td>Lists nationally endangered species and provides for protection and recovery of species. Encourages the formulation of state endangered species programs.</td>
<td>USC Title 16 § 1531-1544</td>
</tr>
<tr>
<td>Magnuson-Stevens Act</td>
<td>1996</td>
<td>Requires establishment of regional fishery management plans to prevent overfishing and exploitation of resource. Overseen by the National Oceanic and Atmosphere Administration (NOAA).</td>
<td>USC Title 16 § 1801-1882</td>
</tr>
<tr>
<td>American Recovery and Reinvestment Act</td>
<td>2009</td>
<td>Provides federal funding for renewable energy projects</td>
<td>USC Title 26 § 1101-1112</td>
</tr>
</tbody>
</table>

Rivers and Harbors Act (1899)

The Rivers and Harbors Act was originally intended to prevent the dumping of garbage and refuse into New York harbor. The law also includes provisions prohibiting the construction of any bridge, dam, dike, or causeway over or in navigable waterways without the Army Corps of Engineers’ (Corps) approval. The building of wharfs, piers, jetties, or other structures into navigable waterways is also prohibited without approval from the Corps, and any excavation, dredging, or fill required for projects in navigable waters requires approval as well (U.S. Fish and Wildlife Service 2009c).

Federal Water Power Act (1920)
The Federal Water Power Act and its later amendments created the Federal Power Commission (FPC), now known as the Federal Energy Regulatory Commission (FERC), to oversee the licensing and re-licensing of hydropower projects. FERC is authorized to issue licenses to construct, maintain, and operate any dams, water conduits, reservoirs and transmission lines that are in, on, or affecting navigable waters. In deciding whether to issue or renew a license, FERC is required to give ‘equal consideration’ to power and development; energy conservation; protection, mitigation of, damage to, and enhancement of fish and wildlife; protection of recreational opportunities, and preservation of other aspects of environmental quality (U.S. Fish and Wildlife Service 2009d). Licenses may not exceed fifty years, and FERC must consider recommendations from various bodies and agencies, including any affected Indian tribes (USC Title 33 § 518. 2002). FERC is required to mandate the construction, maintenance, and operation of fish passage facilities such as fish ladders or elevators if necessary to the continued preservation of the fisheries (U.S. Fish and Wildlife Service 2009d). In 1994 FERC concluded that it has the authority to refuse to relicense a dam, as well as the authority to order the removal of a dam if necessary for the continued maintenance of fisheries, recreation, wildlife, and other factors. This authority has been used once, and resulted in the removal of the Edwards Dam in Maine (see Case Study 2.2 below) (Natural Resources Council of Maine 2009).

National Historic Preservation Act (1966)

The National Historic Preservation Act created the National Register of Historic Places, a list of historically significant sites, buildings, districts, structures, and objects to the United States. The Advisory Council on Historic Preservation and the National Park Service oversee the program while states appoint State Historic Preservation Officers (SHPOs) to create a statewide preservation program, standards for applying to the register historic sites, and plans to ensure the continued integrity of historic places. Any dam or waterway construction that may impact an historic place requires the proper permitting from the SHPOs for it to begin. Additionally, dams themselves may become historic places and therefore any plans for maintenance, upkeep, or removal also need to consult the SHPO before undertaking any projects (Advisory Council on Historic Preservation 2002).

National Environmental Policy Act (1970)

NEPA requires the preparation of an environmental impact statement (EIS) for any federal project which may impact the environment. It must include the environmental impact of the proposed action; any adverse environmental effects which cannot be avoided should the proposal be implemented; alternatives to the proposed action; the relationship between local short-term uses of man’s environment and the maintenance and enhancement of long-term productivity; and any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented (USC Title 42 1969).

All relevant agencies must be consulted when preparing the EIS and it must be made public with a suitable time period for comment. The EIS has become the most influential part of NEPA, and its effects have been wide-ranging on a number of proposed projects (USC Title 42 1969).

Clean Water Act (1972)

The Clean Water Act (CWA) issued broad objectives to restore and maintain the nation’s navigable waters, requiring water quality standards to be set as well as point and non-point sources of pollution to be addressed. It also created the National Pollutant Discharge Elimination System (NPDES) which authorized the EPA to issue discharge permits to polluters, and to limit pollution on an industry-wide basis. The CWA was the first federal law that comprehensively addressed water quality. The newly created Environmental Protection Agency (1970) was mandated with its enforcement (U.S. Fish and Wildlife Service 2009a).

CWA also specifically addressed dams. FERC is required to consider the biological and environmental effects of a hydroelectric project before issuing a license to a proposed hydroelectric dam. If certain considerations are not met, then FERC cannot issue a license. Additionally, the EPA is required to monitor the water quality effects attributable to the stillwater (the reservoir created behind the dam as a result of construction) (EPA 2009).

Finally, CWA states that Native American tribes are to be treated as states and therefore have a right to be included in all discussions pertaining to water rights and pollution on rivers and streams on Native American lands. This is important to Maine since there are several tribes throughout the state. See Case Study 2.1 for a description of the Penobscot River Restoration Project, which included the Penobscot Indian Tribe in the agreement (USC Title 33 § 518. 2002).

Endangered Species Act (1973)

The Endangered Species Act (ESA) authorizes the determination and listing of species as endangered and threatened; prohibits unauthorized taking, possession, sale, or transport of endangered species; provides authority to acquire land for the conservation of listed species, using land and water conservation funds; authorizes establishment of cooperative agreements and grants-in-aid to states that establish and maintain active and adequate programs for endangered and threatened wildlife and plants (U.S. Fish and Wildlife Service 2009b).

States are required to create and implement recovery plans for endangered species within their borders. All federal agencies must ensure that proposed projects do not endanger either endangered species or their critical habitats. Recovery plans must be created and implemented to ensure the long-term maintenance and recovery of endangered populations. Environmental groups have used the ESA to halt many federal projects, such as dam construction, to protect fragile land and water habitat for endangered species (NOAA 2009b; U.S. Fish and Wildlife Service 2009b).

Magnuson-Stevens Act (1976)

The Magnuson-Stevens Act creates an exclusive economic zone (EEZ), stretching 200 miles off the U.S. coast, which gives the U.S. authority over all actions that occur within the EEZ. The U.S. imposes regulations on permitting, importation, and fishery management. NOAA is given federal authority to oversee fishery management, and the act creates eight regional fishery management councils that are mandated to establish fishery management plans (FMPs) for each region. Since diadromous fish migrate up rivers periodically, the Magnuson-Stevens Act also affects any section of river that includes diadromous fish habitat. Any proposed project on these river sections needs to be done within the bounds of the FMP, and permitting may be required if the diadromous fish are adversely affected (NOAA 1996).


The American Recovery and Reinvestment Act of 2009 provides various tax incentives and stimulus funds for many aspects of the U.S. economy and infrastructure. In regards to river health and dams, energy companies can take advantage of these funds to upgrade existing infrastructure and power generation equipment. This can allow improved efficiency of dams’ power generation capabilities (USC Title 26 § 1101-1112 2009).
State Laws

Maine state law acts to protect rivers and streams so that they meet or exceed federal standards for water quality and species protection. Since the 1950s various incarnations of a Water Classification Program have categorized Maine rivers based on goals for water quality. The Maine Natural Resources Protection Act regulates all construction activity near rivers, streams and brooks, and the Maine Endangered Species Act allows the government to protect the habitat of threatened and endangered species—even if they don’t appear on the national registrar. The Maine Waterway Development and Conservation Act governs the building, altering, or removal of hydropower dams by requiring state permits for these activities. Finally, two important laws, the Maine Natural Resources Protection Act and the Non-Point Source Pollution Program, regulate non-traditional sources of pollution and disturbance that may affect river health.

Table 2.2 State laws, years, and descriptions pertaining to rivers and dams

<table>
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<th>Law</th>
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<th>Description</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Classification Program</td>
<td>1950</td>
<td>Classifies Maine’s surface waters, establishes water quality goals, and directs the state to meet these goals.</td>
<td>MRS Title 38 § 464-470</td>
</tr>
<tr>
<td>Land Use Regulation Law</td>
<td>1971</td>
<td>Creates the Land Use Regulatory Commission (LURC) and identifies its mission. LURC is tasked with permitting dams in the unorganized territory.</td>
<td>MRS Title 12 § 683-685</td>
</tr>
<tr>
<td>Maine Endangered Species Act</td>
<td>1975</td>
<td>Authorizes the Department of Inland Fisheries and Wildlife (IF&amp;W) to identify species that should be listed as either threatened or endangered. IF&amp;W also establishes protection guidelines for the species and their “essential habitat.”</td>
<td>MRS Title 12 § 7751-7759</td>
</tr>
<tr>
<td>Maine Waterway Development and Conservation Act</td>
<td>1983</td>
<td>Mandates that a permit be issued for the construction, reconstruction, alteration or removal of hydropower projects.</td>
<td>MRS Title 38 § 630-640</td>
</tr>
<tr>
<td>Maine Rivers Policy</td>
<td>1983</td>
<td>Declares general policy guidelines for managing Maine’s rivers.</td>
<td>MRS Title 12 § 401-406</td>
</tr>
<tr>
<td>Maine Natural Resources Protection Act</td>
<td>1987</td>
<td>Requires that a permit be obtained for dredging or construction projects near rivers, streams and brooks.</td>
<td>MRS Title 38 § 480-A to Z</td>
</tr>
<tr>
<td>Non-Point Source Pollution Program</td>
<td>1991</td>
<td>Enacted to combat Non-Point Source Pollution (NPS). Implements the Maine Department of Environmental Protection’s “best management practice” guidelines for such sources.</td>
<td>MRS Title 38 § 410-H</td>
</tr>
</tbody>
</table>

Water Classification Program (1950)

Maine values its surface waters. Water classification programs were established in the 1950’s in concordance with the long-term goal of achieving the best possible water quality standards. The current water classification system establishes water quality goals for the State and is used to advise agencies and policy makers on protecting and managing surface waters. The classification standards designate uses, related characteristics of those uses, and the criteria necessary to protect those uses. Once classified, a water body is protected by the anti-degradation provisions of the water quality statute (MDEP 2005c).

Water Quality Classifications

Maine currently has eight classifications for surface waters: four classes for freshwater rivers, three classes for marine and estuarine waters, and one class for lakes and ponds. The classes, which range from AA to D, may be understood as a hierarchy of risk (MDEP 2005c). Water-based ecosystems with higher class ratings are considered to be less susceptible to disturbance - man-made or natural - and recover rapidly when disrupted. Conversely, ecosystems with lower classifications are considered to be more vulnerable, with a high risk of degradation. All of these classifications meet the CWA’s fishable-swimmable criterion, which mandates that all rivers be suitable for human recreation unless the EPA determines that these standards are impossible to meet (MDEP 2005c). The designated uses vary only slightly from class to class.

Table 2.3 Standards for classification of rivers in Maine

<table>
<thead>
<tr>
<th>Class</th>
<th>Criteria</th>
<th>% Maine Rivers and Streams (2006)</th>
</tr>
</thead>
</table>
| AA | • Applied to “outstanding natural resources,” which should be preserved for their unique ecological, social, scenic, or recreational importance.  
• No direct discharge of pollutants allowed if reasonable alternatives exist without approval from the MDEP.  
• Aquatic life, dissolved oxygen and bacteria content are as naturally occurs. | 7% |
| A | • Direct discharges are only allowed if the discharged effluent is of equal or better quality than the existing water quality of the receiving rivers.  
• Aquatic life and bacteria content are as naturally occurs. The dissolved oxygen content may not be less than 7 parts per million or 75% of saturation, and must be higher during fish spawning. | 46% |
| B | • Habitat must be clarified as unimpaired.  
• The dissolved oxygen content may not be less than 7 parts per million or 75% of saturation, and must be higher during fish spawning.  
• Discharges may not cause adverse impact to aquatic life. | 46% |
Reclassification

From time to time MDEP is required to conduct water quality studies to determine if any changes need to be made to the water classification system. The Board of Environmental Protection is also obliged to hold hearings on the classifications and propose changes. At the very least, this process must occur every three years. Most rivers recommended for reclassification are viewed as having a pressing social or ecological need which can often be achieved with current technology in a reasonable amount of time.

Land Use Regulation Law and LURC (1971)

The Maine Land Use Regulation Commission (LURC) was created in 1971 to oversee the planning and zoning of Maine’s townships, plantations and unorganized areas, which have no form of local government. The Commission’s jurisdiction includes more than 10.4 million acres and the largest contiguous undeveloped area in the Northeast (Land Use Regulation Commission 2009). MDEP and LURC adopted joint regulations for the processing of applications for hydropower projects, pursuant to the Maine Waterway Development and Conservation Act. LURC is the water quality certifier and permit issuer for all activities located within its jurisdiction (MDEP 2005b).

Maine Endangered Species Act (1975)

The federal ESA of 1973 was designed to protect imperiled, threatened, and endangered species and their habitats. Section 6 of the act provides funding to state wildlife agencies for consultation and assistance (NOAA 2009b). Many states, including Maine, have created their own lists of endangered and threatened species to protect species which may be endangered within one state but not elsewhere.

Today, more than 60 species found in Maine are listed as either threatened or endangered under either ESA or MESA (Maine Department of Inland Fisheries and Wildlife 2007). In June 2009, the NOAA Fisheries Service and the U.S. Fish and Wildlife Service extended protection to Atlantic salmon in the Penobscot, Kennebec, and Androscoggin Rivers (NOAA 2009b). The act has important implications for rivers, since all activities which require a state or local permit that fall within the habitat of a listed species become subject to review by IF&W.


At the state level, hydropower projects are regulated under the 1983 Maine Waterway Development and Conservation Act (MWDCA). The act requires that a permit be issued for the construction, reconstruction, or structural alteration - including maintenance and repair - of a new or existing hydropower project. The MWDCA includes a comprehensive state permitting process for projects in organized municipalities - which are administered by the Department of Environmental Protection - as well as in the organized territories - which are administered by the Land Use Regulatory Commission (LURC) (MDEP and Maine Department of Conservation 2009).

The MWDCA ensures that the state only approves an application when it finds that the project has met standards in the following areas:

- Financial Capability: The applicant has the financial and technical wherewithal to support the project through completion.
- Safety: The applicant has made provisions to ensure public safety.
- Public benefits: The applicant has demonstrated that the project includes the creation of potential employment opportunities.
- Traffic Movement: The applicant has made provisions for all traffic generated by the project.
- Environmental Mitigation: The applicant has considered the environmental impact of the project, and made reasonable effort to mitigate any environmental damage caused by the project.
- Environmental and Energy Considerations: The applicant has demonstrated how the project will significantly affect fish, wildlife, soils, coastal waters, shoreline, historic resources, public usage, flood control, and/or non-renewable fuel usage.
- Water Quality: The applicant has realized if the project will alter water temperatures, exceed 30 acres in surface area, or have any upstream direct discharges (other than cooling water).

A 2003 amendment to the MWDCA requires applicants to hold public information meetings prior to filling the application.

Maine Rivers Policy (1983)

This general policy guides the state’s management of rivers. The first clause sets the legislature’s tone of valuation: “[sic] the State’s nearly 32,000 miles of rivers and streams comprise one of its most important natural resources, historically vital to the state's commerce and industry and to the quality of life enjoyed by Maine people.” The Maine Rivers Policy sets forth the goal of stimulating a balanced approach towards rivers, which includes (MRS Title 12 Chapter 200 1983):

- Restoration of waterways
- Revitalization of waterfronts
- Maintenance of scenic beauty
- Interests of riparian owners
- Hydroelectric power
- Hydropower (traditional water power)
Natural Resources Protection Act (1987)

In accordance with the general values adopted in the Maine Rivers Policy, the Natural Resources Protection Act (NRPA) aims to identify the significant role natural resources have in creating and maintaining state character and identity. The act requires that individuals engaging in construction-like activities within 75 feet of a protected resource must first acquire a permit. Applicants must demonstrate that the proposed “activity” does not interfere with existing uses of the resource or cause environmental disturbances. Importantly, the act also prohibits any part of the “activity” from crossing a river segment that the legislature has identified as “outstanding” unless there is no other alternative that has a less adverse impact on the river (MDEP 2005b).

Non-point Source Pollution Program (1991)

In an effort to limit pollution from all sources, Maine implemented the Non-Point Source Pollution Program (NPSPP) in 1991. Recognizing that the majority of the pollution entering water bodies in Maine comes from sources that are not direct dischargers, the legislature has tasked state agencies with the development of “best management practice guidelines.” These guidelines detail the recommended techniques or procedures that may be the most effective practicable means of preventing or reducing pollution from non-point sources, which include, but are not limited to, agriculture, forestry, transportation and development (Maine Rivers 2009c).

Stakeholders

Rivers provide a diverse wealth of recreational, industrial, cultural, aesthetic, and economic value to the state of Maine. River ecosystems provide important services and support a diverse variety of biological life. Unsurprisingly, the stakeholders with vested interests in rivers are also diverse and numerous.

Government Agencies

Municipal, state, and federal government agencies are included in river health monitoring and dam maintenance and removal. Agencies such as the Fish and Wildlife Service (USFWS), the Army Corps of Engineers (Corps), and the Federal Energy Regulatory Commission (FERC) monitor and issue permits at the federal level, while the Department of Inland Fisheries and Wildlife (IF&W) and the Maine Department of Environmental Protection (MDEP) monitor river health and fish habitat and population levels at the state level. Municipal governments are less concerned with river health but frequently become involved in dam removal conversations. Each level of government and agencies within have their own mission statement and mandate. These stated priorities can overlap and sometimes conflict, causing increased complications in any proposed removals or data gathering projects.

FERC regulates interstate energy transmission and licenses hydropower projects. They have the power to grant the license to build a dam, or to refuse to issue a license to a proposed project. Once the dam is built, and the license expires, FERC has the power to renew the license or, as of the 1994 internal ruling by FERC, to refuse to renew a license and subsequently mandate removal. In any licensing situation, FERC must not only consider power needs but also the needs of surrounding communities, the environment, river health and habitat, recreational value, and the input of other specialized agencies including the USFWS, the EPA, and the MDEP (Federal Energy Regulatory Commission 2009b).

USFWS is mandated to work with other groups and agencies to conserve, protect, and enhance fish, wildlife, and plants and their habitats for the continuing benefit of the American people. USFWS and MDEP are jointly committed to the continued monitoring of Maine’s environment and the protection of its natural habitats and resources. If any proposed federal project might have a harmful affect on the environment, they can mandate clean-up, block the project, or mandate dam removal (U.S. Fish and Wildlife Service 1999).

The Corps ensures the proper construction and maintenance of any facilities in or along navigable interstate waterways. If any construction occurs then the Corps must issue permits. These permits not only ensure safety but also, working with DEP and USFWS, ensure that no adverse harm will occur to the natural environment, particularly to endangered species (U.S. Army Corps of Engineers 2009).

IF&W works with MDEP to ensure proper compliance with ESA and MESA in order to guarantee that all proposed projects comply with the above listed acts. IF&W develops recovery plans for endangered species, and any proposed dam can be denied or a current dam can be forced to be removed should it significantly harm an endangered species or its habitat (Maine Rivers 2009a).

Other agencies include any municipal governments that may become involved, or district organizations such as LURC which oversees planning and zoning in Maine’s unorganized territory.

Communities

Homeowners’ associations are only sometimes involved with river health, although some environmentally-minded organizations can embark on grassroots movements to clean up a river. Frequently, however, homeowners’ associations become involved with dam removal proposals. Preserving the status quo of river levels and environment, the loss of jobs, and worry over changes in water levels and river flow are frequently reasons cited by these associations as a protest against dam removal. Homeowner’s associations have had limited influence in past dam removal occurrences but they remain an interested stakeholder (Goode 2009).

Native American tribes may have reservations along dammed rivers and by law under the Federal Water Power Act their concerns must be addressed by FERC when considering any dam construction or removal. As a semi-autonomous body, Native American tribes have a special body of rights when it comes to changing the character and nature of a river. Native Americans have distinct cultural and historical ties to the rivers which have been used for hundreds of years as fishing grounds, navigational routes, and as sources of food, water, and spiritual health. Their rights to the river must be considered in any proposed project that affects the health of a river (USC Title 33 § 518. 2002).

In Maine, the Penobscot River Restoration Trust (Case Study 2.1) included the Penobscot Indians who lived upstream of the two dams that were being proposed for removal. The Penobscot Indians had lost the ability to use their traditional fishing rights on the water since dams further downriver of their lands prohibited diadromous fish to travel far enough upstream for them to be accessed. With the proposed dam removals, the opportunity for fishing will be renewed, and their traditional fishing rights restored. They have a representative on the board of trustees that is overseeing these removals, and since they were included as a stakeholder, additional clout was brought to ensure the removal of these two dams (Penobscot River Restoration Trust 2005-2009).
Recreational and Environmental Non-Profits

Local, state, and federal non-profit organizations are crucial supporters and defenders of Maine’s waterways. Driven by a desire to preserve the cultural, ecological, recreational and economic assets that rivers provide, non-profit groups endeavor to promote their causes through grassroots campaigning, litigation, fundraising, watchdogging, and negotiation. Several of these groups are described below. While there are dozens of groups holding a stake in Maine’s rivers, the following groups may be seen as typical of the types of groups involved due to their enduring record of involvement.

Environmental Protection and Restoration Groups

The Natural Resources Council of Maine (NRCM) is a non-profit membership organization that works to protect, restore and conserve Maine’s environment. NRCM focuses specifically on enhancing the quality of Maine’s rivers, eradicating toxic chemicals from the environment, and decreasing atmospheric pollution. The organization boasts over 12,000 supporters and was a crucial advocate for the removal of the Edwards Dam. A sister organization, Maine Rivers, was borne out of NRCM's desire to take a more unified approach on river issues. Comprised of representatives from a broad coalition of environmental and recreational interests, Maine Rivers advocates the return of native fish to rivers and supports efforts to monitor and reclassify rivers (Natural Resources Council of Maine 2009).

Recreational Fishing Groups

The Maine Council of the Atlantic Salmon Federation (MC-ASF) is an umbrella organization that aims to protect Atlantic salmon and other native diadromous fish. Since dams create recognizable barriers to diadromous fish spawning, MC-ASF advocates for the removal of dams or, when necessary, the installation of fish passage systems. MC-ASF was also key in securing federal protection and funding for endangered Atlantic salmon in eight Maine watersheds (The Maine Council of the Atlantic Salmon Federation 2004-2009).

Case Study 2.1 The Penobscot River Restoration Project

In 1999 Pennsylvania Power and Light Corporation (PPL) purchased three dams on the Penobscot River in Maine, setting in motion a unique river restoration project. PPL, the Penobscot Indian Nation, conservation groups, and the state and federal governments cooperated to produce a distinctive agreement. The three dams were purchased by the Penobscot River Restoration Trust. Two of these dams are to be removed and a third depowered and a state-of-the-art bypass built around it. PPL will also construct fish passage at four additional dams. In return, PPL will be able to increase power generation at six other dams (Penobscot River Restoration Trust 2005-2009).

Instead of fighting before a court over dam removal, the interested stakeholders collaborated to form an agreement mutually beneficial to the parties involved. Fish will be able to once again migrate up the Penobscot River, and the Penobscot Indian Nation will be able to fish from the banks of the river. While not all stakeholders were included (riverside communities were not involved in the agreement) it has set a precedent for dam removal in the future. By working with the state and federal governments, FERC, FWS, and NOAA, the members of the agreement were able to avoid many of the pitfalls that previous dam removal proponents have met with and instead formed a result that was agreeable to all. By including all stakeholders’ interests they did not need to resort to legal action. By demonstrating a new procedure for dam removal, the Penobscot River Restoration Project has broadened the opportunities for dam removal (Natural Resources Council of Maine 2009b).

In August, 2009 the Penobscot River Restoration Trust exercised the option to purchase the three dams. Demolition of the two dams slated for removal is scheduled to occur in 2010 or 2011 (The Nature Conservancy 2009a; Natural Resources Council of Maine 2009b).

Industry

Industrial activity along rivers has become an indelible part of Maine’s culture, affecting both rivers and people from the time the first paper mills began operation in the 1850s. Rivers have served as transportation for lumber, discharge receptacles for dyes and chemicals, sources of hydroelectric power, fishing grounds, and tourist attractions. While many of these industries have receded from Maine, notable industrial stakeholders are still active:

The Maine Pulp & Paper Association represents the pulp and paper industry in Maine, which is still a major industrial force along Maine’s rivers, even though the number of working mills has declined (Maine Pulp and Paper Association 2009). Pulp and paper companies in Maine are subject to discharge regulations under both federal and state law. In 2004, twelve mills were still operating within the state (Maine Forest Service and Maine Technology Institute 2005).

Hydropower accounts for about 30% of all electricity produced in Maine (State of Maine Public Utilities Commission 2009). Maine’s 179 hydro-electric dams are owned and operated by numerous companies, some residing in-state, some licensing from out of state (Maine Department of Marine Resources 2008).

Finally tourism is important. In 2006, tourists to the state spent nearly $1 billion on lodging, $3 billion on food, and $1 billion on recreation (Maine Office of Tourism 2008). The Kennebec and Moose River valleys have become significant hubs for recreation and tourism, offering kayaking, rafting, canoeing, fishing, and hunting along the rivers. A unique diversity of fish draws visiting anglers, and historic river towns have become attractive tourist destinations.

State of the Topic

In this section we present an overview of the current status of rivers and streams, dams, fish bypasses, and dam removal in Maine. We focus on the state of the issues, the current trends, and describe ongoing actions related to dam removal and river restoration in Maine.

Rivers and Streams

In 1998, EPA prepared a National Water Quality Inventory as required by CWA. Each state was required to evaluate the health of all bodies of water, from wetlands to lakes to rivers and streams, based on criteria such as aquatic life support, fish consumption, swimming use, and drinking water. States were not required to evaluate every mile of river, and indeed, Maine was among only three states to assess all its 31,752 miles.
Ninety-nine percent of Maine’s rivers are considered to fully support aquatic life uses (Table 2.1), the highest percent of rivers that fully support aquatic life in any state. In comparison, 58% of rivers and streams nationwide fully support aquatic life. Ninety-nine percent of Maine’s rivers also fully support fish consumption and 99% fully support primary contact (swimming), compared to nationwide averages of 87% and 69%, respectively. This is a significant improvement over the years before CWA when many of Maine’s rivers were among the nation’s most severely polluted rivers, from paper and textile mill, sewage, and city discharges (EPA 1998).

In addition to the standards set in 1972 by CWA, the Maine Bureau of Land & Water Quality (BLWQ) has had a river and stream classification system for over 50 years. The purpose of the system is to create water quality goals for the state of Maine by evaluating the risk level of a particular river or stream. By establishing this management system for the protection of Maine’s waters, the BLWQ can designate permitted uses, establish the necessary guidelines to protect those uses, and limit certain activities such as pollution or wastewater releases (MDEP Bureau of Land & Water Quality 2006).

The classification system has four classes for rivers (Table 2.3). These classifications can be updated as necessary based upon the necessity for additional protection or increased ecosystem health. For example, when the Edwards Dam was removed on the Kennebec River, the stretch of river where it was located improved from a Class C rating to a Class B rating within 2 years, representing improved river health and changed uses (Goode 2009). Downgrades in classification are rare and not encouraged but can be made if necessary (MDEP Bureau of Land & Water Quality 2006).

Only seven percent of Maine’s rivers are classified as AA, and these rivers are generally protected within a park or preserve such as Baxter State park or Acadia National Park (Figure 2.2). Since no direct discharge is permitted in these rivers, this classification is used carefully. Class A is allotted to much of Maine’s North Woods, where discharges are limited and population is sparse. Fish spawning areas, for those fish that can reach the upper reaches of the rivers, are protected here, as is all aquatic life. Class B is generally allotted to areas with increasing numbers of people, where some discharges are permitted. Finally, Class C, only 1% of Maine’s rivers, permits some discharges that may affect aquatic life. However, the biological community must remain viable, and all classes must maintain the minimum fishable-swimmable standards of the CWA (MDEP 2005c).

In sum, most of Maine’s rivers and streams are currently in an excellent state of health, especially when compared to the rest of the U.S. The risk classification system used by BLWQ is an effective way to continue to monitor ecosystem health as well as regulate pollution discharges.

**Dams**

There are 782 dams in Maine, which have been built for a number of purposes including water storage, flood control, navigation, and hydropower. This figure is paltry, however, compared to the number of dams in many other states. Figure 2.3 shows the number of dams per state normalized by the miles of rivers in each state. We used data from the National Inventory of Dams (NID) because this was the only available data for number of dams for every state. NID lists only dams above a certain height or dams at a certain public safety risk and this may skew the data somewhat since many of Maine’s dams are small. However, it does show that Maine generally has fewer dams than most states.
The rate of dam building in Maine grew slowly from 1800 until 1880 (Figure 2.4). Early dams were predominantly built for water storage, and many of Maine’s towns and cities are still located on small stillwaters created by these dams (GIS Data Catalog - Maine Office of GIS 1987). They provide areas for recreation and fishing, as well as provide flood control and fresh water. Other early dams were built by logging and paper companies to facilitate log drives. Log jams were frequent, especially at steeper drops in the river, and dams offered a safer solution by covering trouble spots in water, as well as providing a storing place for the logs in the stillwater behind the dams.

In 1880 the water turbine was developed in Michigan, initially powering street lighting (U.S. Department of Energy 2008). Breakthroughs followed quickly and many of the dams built in 1900 and the following years were hydropower dams, powering many of the growing Maine towns (Figure 2.4). Most hydropower dams in Maine are what are known as “run of the river” dams which, unlike many of the large dams in the west, create only a small reservoir that diverts the river through turbines to generate electricity (the Flagstaff Dam is an exception).

The most recent dams built in Maine have been constructed to control flooding, but no dams of significant size have been built in the last 30 years. We suggest that factors curbing dam construction include: a stricter permitting process, increased knowledge of potential environmental risks, and a decreasing number of suitable locations.
Dams have been built throughout Maine (Figure 2.5). They are focused generally in the southern part of the state, but have been built throughout. The large increase around 1900 is due primarily to the development of the turbine, and demonstrates a time of growth in dams in Maine.

One of the most striking differences between dams in Maine and those in the rest of the U.S. is the average age of dams. Maine’s dams are significantly older than an average U.S. dam (see Figure 2.6), and no dam has been built since 1980. Nationwide dams are, on average, about 51 years old (American Society for Civil Engineers 2009). Additionally, 85% of dams will near the end of their operational lives by 2020 (Doyle, Stanley et al. 2003). Maine’s dams are, on average, older than U.S. dams at 94 years of age (GIS Data Catalog - Maine Office of GIS 1987). Therefore, it logically follows that greater than 85% of Maine’s dams will near the end of their operational lives by 2020. This poses significant safety concerns for Maine. As dams age, they fall into disrepair. Maine does not have a comprehensive management plan to deal with aging dams.

Maine currently has only one State Dam Inspector (SDI), with the Maine Emergency Management Agency (MEMA). MEMA inspects all Maine dams in a rotating fashion. Currently more than 15% of inspected dams are considered high-hazard-potential or significant-hazard-potential dams. Seventeen of the high-hazard-potential dams currently need over $12 million in repairs, demonstrating just how significant an effect aging has had on Maine’s dams (American Society for Civil Engineers 2008).

Another facet of the dam aging problem in Maine affects only hydropower dams. The Federal Energy Regulatory Commission (FERC) regulates all hydropower dams in the U.S. FERC issues licenses for hydropower dams for 30-50 years. Since many of Maine’s dams are aging, many of FERC’s permits are coming up for re-licensing soon (Figure 2.7).
century fish ladders were developed to combat this problem by creating a ramp. Downstream migrations require the construction of a fish ladder or elevator (Goode 2009). Additionally, some dam owners are voluntarily building fish bypasses to facilitate consideration of migratory species when conducting their cost-benefit analysis of a dam. As part of the relicensing scheme, FERC can are neither efficient nor cost effective and are used infrequently (Northwest Power and Conservation Council 2009).

Other means of moving fish around dams include the incidental use of navigational locks, as well as trucking or flying fish around an obstruction. These increased maintenance and operating costs over the traditional fish ladder (Larinier 2000). Increasingly environmental groups and the government are fish elevators represent another viable form of fish passage. Fish elevators also use flow to attract fish into a holding pool. The fish are then forced into a tank filled with water and lifted over the dam, to be deposited above in the stillwater. Fish elevators are more efficient for species such as shad, but require Fish bypass systems

Dams create an impassable barrier to migrating species. Diadromous (migrating) fish are some of the most significantly affected species, since they cannot pass dams to continue to their spawning grounds. In the late 18th century fish ladders were developed to combat this problem by creating a ramp constructed of a variety of materials such as rock, concrete, or wood to allow fish to swim around or over a dam. They are a series of steps with pools of water that enable fish to jump from level to level, slowly rising until they reach the top of the impoundment. Unfortunately, fish ladders need to be precisely engineered since too little flow down the ladder will result in the fish not being attracted to it, while too much flow will tire out the fish and not permit them to swim upstream.

Fish ladders vary greatly in their effectiveness. Different species of fish prefer different levels of water flow and different jumping heights between pools, so comprehensive studies are difficult to perform (Jungwirth, Schmutz et al. 1998). One study on the Deerfield River in Massachusetts found fish bypasses around dams to be between 15% and 81% effective for migrating smolt depending on the modifications made to the dams, demonstrating the extreme variability in fish bypass effectiveness (Ragonese 2004). It can simply be noted that all species demonstrate at least some loss of successful migration numbers. Notable exceptions to this rule are sturgeon, striped bass, and rainbow smelt, which have never been proven to successfully use a fish ladder (Goode 2006).

Examination Appendix A we note that these species’ habitats extend not much further than the high tide mark. Downstream migrations can be just as deadly to a fish population. While fish can’t move up the outflow from the turbines since the flow is so powerful, they can be sucked into the turbines when moving downstream. The American eel is particularly affected by this problem and has seen up to 100% mortality of some populations. Additionally, some other species such as the American shad rarely use ladders, and so a newer technology, the fish elevator, must be used for an increased success rate (Goode 2006).

Fish elevators represent another viable form of fish passage. Fish elevators also use flow to attract fish into a holding pool. The fish are then forced into a tank filled with water and lifted over the dam, to be deposited above in the stillwater. Fish elevators are more efficient for species such as shad, but require increased maintenance and operating costs over the traditional fish ladder (Larinier 2000). Increasingly environmental groups and the government are promoting the use of elevators since they have been shown to increase successful fish migration.

Other means of moving fish around dams include the incidental use of navigational locks, as well as trucking or flying fish around an obstruction. These are neither efficient nor cost effective and are used infrequently (Northwest Power and Conservation Council 2009).

Recently, more care has been taken by governing agencies to ensure that dams have less impact upon migratory fish populations. FERC now must consider the ecological value of migratory species when conducting their cost-benefit analysis of a dam. As part of the relicensing scheme, FERC can require the construction of a fish ladder or elevator (Goode 2009). Additionally, some dam owners are voluntarily building fish bypasses to facilitate migration. Environmental groups are increasingly recognizing that fish elevators, while also not 100% effective, are a reasonable alternative to dam removal, since removal is a longer, more arduous and complicated process (see “Dam removal” section below).
Maine has reviewed their statewide fish passage efforts and prioritized all fish bypass systems on all watersheds based upon the effects on fish migrations. The report, entitled *DMR Review of Statewide Fish Bypass Efforts,* recommended that the Maine Department of Marine Resources (DMR) and the Maine Department of Environmental Protection (DEP) work together to implement the priority fish bypass projects (MDMR 2007). The evaluation was conducted on a state-wide basis for only hydropower dams, and it was found that 45% of hydropower dams are within the historic range of alewives, American shad, and blueback herrings, 53% within the range of Atlantic salmon and 65% within the range of the American eel (MDMR 2007). The DMR evaluated hydropower dams since these are most often on the main stem of rivers and therefore directly affecting fish migration. The Saco, Presumpscot, Kennebec, Damarciscotta and Penobscot Rivers all received a high restoration priority and in the coming years DMR will be emphasizing river restoration and fish bypass construction efforts in conjunction with the FERC relicensing process to improve river quality and fish migration throughout the state (MDMR 2007).

**Dam removal**

While river health is excellent in Maine, Diadromous fish populations are shrinking. Fish bypass systems are only partially effective, so dam removal has appeared as a viable alternative to help restore these fish populations, as well as increase public safety. Hundreds of miles of habitat have been cut off from fish populations (see Appendix A), and dam removal is intended to restore historic habitat, revitalizing lagging species. Dam removal is a growing trend in Maine, with 17 removed dams and 12 more under consideration for removal, but involves a long and complicated process. Dams can be removed in several ways:

First, a dam owner can decide to remove a dam privately. A number of permits are still needed (described below), but since the removal is voluntary, the process is less complex.

Second, the federal government can mandate removal. The Federal Energy Regulatory Commission (FERC) oversees all hydro-power dams not owned by the federal government (see above in “Government Agencies”). These dams have licenses lasting from 30-50 years, and must be renewed by the owner when they expire. If the power company decides to renew its license, then there are three options FERC has that lead to removal: relicensing, mandating repairs, and surrendering licenses:

- Option 1: FERC can refuse to relicense a project. FERC can decide that it is not in the public’s interest to relicense an agreement, balancing both power and non-power needs (e.g. fishing, wildlife, recreation) in a cost-benefit analysis. FERC can decide that the dam is not worthwhile (see Case Study 2.2) (Bowman 2002). FERC can also make re-licensing agreements with large companies who own several dams: FERC will re-license some dams on the condition that one or several others are removed. This occurred in Wisconsin and allowed eight dams to be re-licensed on the condition that three others owned by the same company were removed. Finally, as part of the re-licensing, FERC can require fish ladders or elevators to be installed. Should the dam owner determine these improvements to not be worth the cost, then this can result in removal.

- Option 2: FERC can mandate repairs or improvements (such as a fish bypass) to be made to a dam as part of the safety inspections that occur about every five years. If FERC mandates repairs, and the owner finds them to be too costly, then the removal process may begin.

- Option 3: FERC can accept the surrender of a dam’s operating license. If a dam owner wants to stop using the dam to produce power, then he/she must seek approval from FERC to surrender the license. As part of this depowering agreement, FERC can order the dam to be removed, though as of yet this has not been done, and FERC has simply issued the license surrender or nonpower license without mandating removal (Bowman 2002).

Third, dams can also be removed by the state. The Maine Emergency Management Agency (MEMA) monitors dams in Maine for public safety, ensuring that routine maintenance and upkeep are performed. In an emergency situation, MEMA is permitted to breach or remove a dam if public safety is threatened. Additionally, during the inspection of a high hazard or significant hazard dam (which must be inspected once every 2 and 4 years, respectively) the inspector creates a condition report. Based upon his/her recommendations, the recommendations of the commissioner, and of the dam owner, dam removal can be ordered. This has not occurred in Maine to date (Fletcher 2009).

Fourth, third parties can influence or force dam owners into removal. They can either work cooperatively with dam owners (Case Study 2.1) or attempt to force dam owners to remove dams through litigation, using ESA or MESA (see “Laws and Institutions” section above). There are three different ways ESA can be used, although to date, ESA has not been used solely to mandate removal:

- Option 1: Section 7 of ESA prohibits federal action that jeopardizes the continued existence of an endangered species or its habitat. If an activity jeopardizes the species or its habitat, then USFWS or NMFS must be consulted, and they are authorized to recommend removal as a ‘reasonable and prudent alternative’. An example where environmentalists attempted to stop dam construction is the Tellico Dam in Tennessee. The dam was near completion when the snail darter, an endangered species, was discovered in the river. Construction was ordered to halt, and a long
battle ensued. The Supreme Court eventually ruled that, under Section 7 of ESA, construction must stop. Congress later exempted the Tellico Dam from ESA, but it still stands as a landmark ruling for the protection of endangered species (Wheeler and McDonald 1986). There are, however, several problems with using Section 7 to enforce a dam removal. 1) Section 7 only applies to the federal government. 2) It applies only to a proposed action. It is difficult to prove that the continued use of an existing dam is ‘proposed action’. 3) It is difficult to prove that existing dams jeopardize a species and that dam removal will remove that jeopardy. 4) It is difficult to prove that future river habitat above the dam where stillwater exists as a result of the dam will be critical habitat for the species in question (Bowman 2002).

• Option 2: Section 9 of ESA prohibits the taking of an endangered species. If it can be proven that a dam is killing an endangered species (turbines, pollution, etc.) then USFWS or NMFS can declare an impermissible taking. Often the result is simply fines, but it could result in eventual removal. If a dam is completely blocking a river, it is difficult to prove a taking since there are no migratory fish nearby to be taken. This clause can also have a reverse effect on removal since removal operations may result in the taking of a species. Finally, USFWS or NMFS can issue an ‘incidental’ take permit if the take will be small and not likely to adversely affect the species as a whole (Bowman 2002).

• Option 3: USFWS and NMFS are required to design and implement recovery plans to remove endangered species from the endangered species list. As part of a recovery plan dam removal could be required (Bowman 2002).

Federal permits
There are many federal permits required for dam removal, and it can take many years before ground is actually broken on a dam removal project. Numerous agencies must be consulted, and at any step, the removal can be blocked. To illustrate the complicated nature of the process, we list below the federal permits (the laws that address these permits are described above in the “Laws and Institutions section”):

• A Clean Water Act (CWA) section 404 permit from the Corps will be issued if there will be no significant degradation to the water, no net loss of wetlands, no adverse impacts, and no practicable alternatives. It must also be in the public interest. The biggest problem is loss of wetlands since dam removal will often result in a free-flowing river again with few wetlands along the shore. The Corps issued a regulatory guidance letter in 2001 to ignore this provision if the project takes place in a non-wetland habitat. A NPDES permit will be required for any pollutant emissions pursuant to the construction, excavation, and removal activities (Commonwealth of Massachusetts Riverways Program 2009).

• The Corps also issues a Rivers and Harbors Act (Section 10) permit which states that no adverse affects will occur to interstate navigation. Additionally, if there will be any fill, temporary or permanent, used to construct temporary dams while removing the main one, permits are needed from the Corps (MDEP Bureau of Land & Water Quality 2009).

• If FERC is involved, then the owner needs to apply for a surrender of his FERC license or the issuance of a nonpower license (see above).

• NEPA may require the preparation of an environmental impact statement, to look at the myriad of environmental impacts dam removal has.

• ESA must be consulted to determine if any endangered species will be adversely affected (see above).

• Per the Magnuson-Stevens Act, FERC, the Corps, and NMFS need to consult the regional fishery management council to make sure the removal does not adversely affect the fishery if there is a fishery management plan in place for the region.

• The National Historic Preservation Act must be consulted to determine if the dam will affect any historic properties such as nearby sites or the dam itself. Proper paperwork needs to be filled out, but even if the dam is on the National Register of Historic Places, it can still be removed with proper documentation.

• Finally, for the Corps or FERC to issue the above licenses and permits, they may need to consult with the state to ensure water quality and coastal zone management is kept up (Bowman 2002).

State Permits
State permits are also required, and although they are not as numerous as the federal permits, they still complicate an already convoluted process.

• A permit is required under MWDCA to remove hydropower or storage dams.

• In organized towns and cities a NRPA permit is needed, ensuring that public safety is guaranteed, navigation are maintained the environment is protected by maintaining water quality standards and wetlands, soils, fish and wildlife are considered, historical sites are protected, and public access maintained.

• In the unorganized territory, a development permit is needed from LURC, ensuring the continued maintenance of the environment, existing uses, and natural and historic resources (MDEP Bureau of Land & Water Quality).

Municipal Permits
Municipal permits are often not required. However, in some districts must meet shore land zoning ordinances or development standards (MDEP Bureau of Land & Water Quality).

Overall, the Maine removal process comparable to the initial process required for dam construction. Permits are needed from a number of sources ensuring that environmental, social, cultural, public safety, navigational, and recreational uses are maintained during and after removal. Dam removal is a lengthy and expensive process, but one that is becoming increasingly used over the past several decades.

Analysis of Migratory Fish Habitats and Dams
Dams pose an obvious impediment to traditional fish spawning routes. In this study we aimed to quantify the impact of dams on fish spawning in a useful, but easily understood way. Using GIS data on the historic and current habitats of twelve diadromous fish species we mapped the points where dams and impoundments intersected these habitats. Included in this analysis were dams which have been or will be removed. Our analysis led to two interesting observations: we determined 1) the number of dams intersecting the habitat of a single species, and 2) the number of habitats that each individual dam intersects.
### Table 2.4 Number of intersections between dams and habitats, and percent of total dams intersecting habitat by species (Data Sources: GIS Data Catalog - Maine Office of GIS 1987; Maine Office of GIS 2007).

<table>
<thead>
<tr>
<th>Species</th>
<th>Intersections</th>
<th>Percent of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>American Eel</td>
<td>454</td>
<td>58%</td>
</tr>
<tr>
<td>Alewife</td>
<td>272</td>
<td>35%</td>
</tr>
<tr>
<td>Sea Lamprey</td>
<td>246</td>
<td>31%</td>
</tr>
<tr>
<td>Atlantic Salmon</td>
<td>242</td>
<td>31%</td>
</tr>
<tr>
<td>Rainbow Smelt</td>
<td>97</td>
<td>12%</td>
</tr>
<tr>
<td>Blueback Herring</td>
<td>93</td>
<td>12%</td>
</tr>
<tr>
<td>American Shad</td>
<td>91</td>
<td>12%</td>
</tr>
<tr>
<td>Sea-Run Brook Trout</td>
<td>70</td>
<td>9%</td>
</tr>
<tr>
<td>Striped Bass</td>
<td>22</td>
<td>3%</td>
</tr>
<tr>
<td>Short-nosed Sturgeon</td>
<td>20</td>
<td>3%</td>
</tr>
<tr>
<td>Atlantic Sturgeon</td>
<td>20</td>
<td>3%</td>
</tr>
<tr>
<td>Atlantic Tomcod</td>
<td>19</td>
<td>2%</td>
</tr>
</tbody>
</table>

We found that the American Eel (*Anguilla rostrata*), whose historical habitat is quite extensive throughout Maine, had the highest number of dam-habitat intersections, with 454 dams (58% of total dams) impeding access to historical habitat. On the low end, the Atlantic Tomcod’s (*Microgadus tomcod*) habitat is intersected by only 19 dams (2% of total dams). We make no assumptions about the harm a species is subjected to by these intersections with dams; we simply observed that dams can limit access to traditional habitat and spawning grounds, and that some species face more of these obstacles than others.

In the second half of our analysis, we focused on the effects of individual dams on multiple habitats. In river ecosystems, the emergence or disappearance of a single keystone species may have an outsized effect on the health of an ecosystem. That being said, all species present in an ecosystem are important, and we should adopt policies that consider many species, rather than emphasizing a single fish (For more information on ecosystem-based approaches to policy-making, please refer to the first chapter of this report, which focuses on coastal and marine policy.)

![Figure 2.8 Dam-habitat intersections by species](image)

Figure 2.8 Dam-habitat intersections by species (Data Source: GIS Data Catalog - Maine Office of GIS 1987; Maine Office of GIS 2007).

Of the 782 dams we analyzed, 608 (78%) only intersected the habitats of three or fewer species. Eighty-eight dams (11%) were “high intersection” dams, meaning they intersected the habitats of six or more species. Eleven dams (1%) were “very high intersection” dams, meaning they intersected the habitats of more than ten species. Using a list of 23 removed and soon-to-be-removed dams, we determined that two very high intersection dams, the Smelt Hill and Bangor dams, have already been removed, and one very high intersection dam, Veazie Dam, is slated for removal around 2010 or 2011 (Penobscot River Restoration Trust 2005-2009). Seven other removed dams were high intersection dams, and five dams with planned removal are high intersection dams.

### Implications

Of all dams either already removed or soon-to-be-removed in Maine, 65% are either high or very high intersection dams. The remaining dams - those which intersect five species’ habitats or fewer - comprise only 35% of the group. Out of all dams which still stand (and will stand in the near future), less than 1% can be considered high intersection dams.

What does this say about dam removal in Maine? Dams might be removed for a number of reasons: to achieve conservation goals, for public safety, or to revitalize dormant communities (Bowman 2002). The striking percentage of high intersection dams removed in Maine suggests that migratory fish passage and habitat availability might have been one of the dominant factors influencing dam removal. While other factors - structure age, power generation capacity, federal licensing renewal dates, etc. - influenced the decisions to remove these dams, migratory fish habitat was likely an important consideration.
Scenarios

In the following section we speculate on three possible scenarios for the future of dams in Maine. Scenarios are based on our research on the current state of rivers and dams and other influential factors.

“Cry Me a River”: Continue Dam Construction

In an effort to meet growing energy demand with electrical generation from renewable sources, economic and legal incentives would be put in place at the state and federal levels for the construction of new dams. In Maine, where most high-capacity generation sites are already dammed up, small hydropower projects would begin to sprout up on previously free-flowing rivers and tributaries. Concerns about migratory fish habitat would still be voiced, but the state would consider efforts against broader, global climatic change and the potential for economic and developmental rejuvenation in declining mill towns to be more urgent.

This new surge in dam building might resemble the explosion of dams between 1875 and 1900 in Maine: with federal and state incentives to invest in clean-energy projects, dam construction could become a desirable and highly feasible option. Unlike the previous explosion, however, these new dams would generate hydropower exclusively for consumer use. A shift in Maine’s electricity portfolio would occur, as hydropower moves onto equal footing with natural gas and other fossil fuels.

“Lazy River”: Maintain the Status Quo

A slow process of dam removal would continue. Due to excessively cumbersome permitting and relicensing processes, advocates of dam removal would struggle to meet the necessary criterion and become bogged down in the process. FERC would continue to assert, at an accelerating rate, its ability to deny relicensing based on cost-benefit analysis that includes, among other things, the effects of dams on migratory fish. Owners of hydroelectric facilities would continue to run those dams that remain profitable, but begin to consider selling off older, structurally deficient dams that may cost more in upkeep than they are worth.

Maine’s river health would continue to improve, but diadromous fish populations would continue to flounder. Some success stories, like the return of alewives to the Kennebec, would occur occasionally. The general picture, however, would be one of noticeable, but slow progress.

“You Can’t Argue With a River”: Accelerate Dam Removal, Increase Hydropower Capacity

Following the collaborative example of the Penobscot River Restoration Trust, power companies and dam removal advocates would seek out opportunities to remove high risk and habitat interfering dams while maintaining total hydroelectric generation capacity. Federal subsidies would encourage the implementation of new technology at generation facilities, which, just as the turbine did in the late 19th century, would allow for a significant increase in hydropower capacity. Adding additional turbine generators, installing new more efficient and greater flow capacity turbines, and raising dam heights can significantly increase generation capacity at existing cites (though these processes are difficult, and very expensive) (Clark 2009). These increases could occur at preexisting sites, allowing Maine to meet renewable energy goals without building any new dams.

Fish populations in rivers would return to historic levels. Among these species is the Atlantic Salmon, which could become a success story if it is removed from state and federal endangered species lists. The tourism industry in Maine would be given an added jolt as anglers flocked to the rivers. Maine residents would be relieved of impending safety hazards as old, structurally deficient dams are removed.

Conclusion

Thanks to the efforts of Mainers over the last 30 years, rivers in Maine are healthy and continue to surpass federal water standards. Maine has the highest percentage of rivers that fully support aquatic life in the nation, and all rivers in the state meet the Clean Water Act’s (CWA) fishable-swimmable criteria (EPA 1998; MDEP 2005c).

Dams have played an integral role in Maine’s cultural and economic history. Today, 30% of power generated in Maine comes from hydroelectric facilities. Many dams are aging, and have fallen into disrepair. Dams also significantly inhibit diadromous fish migrations. No new dams have been built in Maine since the 1980s, and the current trend is towards removal: 17 dams have been removed since 1986 (Fletcher 2009). Many dams in Maine are licensed by the Federal Energy Regulatory Commission (FERC) and will be up for re-permitting in the next 20 years. In 1994 FERC asserted its authority with the Edwards Dam removal to refuse relicensing based on cost-benefit analyses that include economic, social, cultural, and environmental factors. We should, therefore, be conscious that federally mandated dam removal is a possibility for the future.

Restoring diadromous fish to their historical habitats has been a significant factor in dam removals to date. Based on our analysis, 65% of dams that have been removed or are under consideration for removal can be considered “very high intersection” dams with diadromous fish habitat, while less than 1% of remaining dams fall into the same category. This is extremely pertinent considering the declining populations of diadromous fish. Shortnose sturgeon are at 2% of their historical population and are a listed endangered species, and alewife populations are down 70%. Atlantic salmon and American eels have access to only 10% and 19% of their historic habitats, respectively (Goode 2006).

In the following section we detail our recommendations for the continued management and improvement of the health of Maine’s rivers and streams. The recommendations are divided into three groups: river and stream health, fish bypasses, and dam removal.

River and Stream Health

Maine is a leader in river and stream health, and the rest of the U.S. should look to Maine as a model in river conservation. Not only do 99% of the rivers in Maine fully support aquatic life but 99% of them support swimming uses, 99% support fish consumption uses, and 100% support drinking water use (EPA 1998). Since CWA was passed in 1972 vast leaps have been made in river protection in Maine, and the Maine Department of Environmental Protection (DEP) and Maine Department of Marine Resources (DMR) have done an excellent job in river and stream management.
There is some cause for concern. The leading three sources of pollution in Maine’s rivers are industrial point sources, agriculture, and hydromodification (EPA 1998). While the amount of pollution from these sources pales in comparison to many other states’ problems, it remains an area for worry. As Maine’s population grows these pollution sources can only become a larger issue. The DEP has completed a Strategic Plan to focus environmental protection efforts, and we recommend that DEP and DMR continue to coordinate their efforts in the protection of Maine’s rivers and streams, focusing some of their resources on point discharges. Treating or removing existing point discharges will require additional funds (Murch 2009), and we recommend that DEP and DMR devote the necessary money to continue to address these site-specific issues. By monitoring these sources of pollution and continuing in their efforts to mitigate the negative effects they have on Maine’s rivers and streams, Maine can continue to be the leader in river conservation.

Fish Bypasses

Fish bypasses are becoming increasingly efficient at moving fish upstream and downstream around impassable dams and destructive turbines. Fish passages, especially elevators, are a viable way for the government, dam owners, and environmentalists to work together to mitigate some of the negative effects dams have on diadromous fish. DMR has done an extensive overview of fish passage efforts throughout the state of Maine, creating a report to address hydropower dam fish passage (MDMR 2007). Hydropower dams not only block fish passage but also kill fish when they try to swim through the turbines. Additionally, through the FERC relicensing process described above, one of the conditions of relicensing can be the mandated installation of a fish passage, making hydropower dams significantly easier to construct fish passages on. According to the report, 116 dams are within the historic range of at least one species of diadromous fish. By analyzing the current state of fish passage in each of Maine’s watersheds, DMR was able to prioritize which watersheds had high restoration priorities. This is an excellent start.

We recommend DMR take this report a step further. By examining not only hydropower dams but all dams in Maine within diadromous fish habitat, DMR can create a comprehensive effort at fish passage. There are several limitations to comprehensive fish passage in Maine. Fish passage efforts should be part of a broader effort at fish restoration efforts, and we do not recommend one without the other. In some cases, fish passage should not be installed since dams can provide a barrier to the upstream migration of invasive species (Murch 2009). Finally, non-hydropower dams require more effort to find the owner and to enforce fish passage. However, given these restraints, fish passage is still extremely important to the overall restoration of diadromous fish populations and river ecosystems. We have done a preliminary analysis above, using all the data currently available on all impoundments as well as the most current data on the statewide distribution of the twelve species of diadromous fish in Maine in 2007, although they consider it still to be a “work in progress” (USFWS Gulf of Maine Coastal Program 2007). With the announcement that the Gulf of Maine Coastal program had finished mapping the GIS data for the diadromous fish, USFWS included a sub-heading, “What’s next?” Their answer: overlay the map of current dams in Maine with the newly mapped diadromous fish data to prioritize future restoration and fish bypass efforts (USFWS 2007). We have done this and we recommend that DMR consider a similar analysis as ours when examining how best to prioritize all fish bypass and restoration efforts in the future.

Dam Removal

DEP and DMR should emphasize dam removal as a possible river restoration method. River health is excellent throughout the state of Maine, as documented above. However, it can be improved with the removal of dams. Not only will diadromous fish be able to once more return to their historical habitats, boosting spawning grounds and enhancing Maine’s depressed fisheries, but overall river health will improve.

First of all, additional research should be done. Less than 5% of all dam removal projects in the U.S. have simultaneous river health and habitat studies (Collins et al 2007). The body of scientific research dealing with dam removal has not been fully explored, and additional studies should be conducted on future dam removal projects. There is no consensus on whether or not dam removal is implicitly good for a river in all cases, and there are some cases where removal is not warranted (such as the threat of invasive species spreading further upstream) (Goode 2009). Continued research should be done to monitor the effect of dam removal and to fully establish all the costs and benefits of the removal process.

Efforts should be made to develop collaborative agreements to address all concerns in dam removal. Comprehensive agreements between power companies, environmental groups and governmental agencies can result in not only environmentally beneficial dam removals but also socially beneficial agreements if power generation is permitted to increase at other dams. By upgrading turbines, generators, or increasing impound height additionally power generation can be achieved without building new dams. While this typically costs millions of dollars, there are currently production tax credits and stimulus funds available from the American Recovery and Reinvestment Act of 2009 for certain improvements (Clark 2009). Environmental groups and government agencies should work together with power companies to take advantage of these funds and credits where possible to increase power generation at dams that minimally impact fish populations while removing dams that adversely affect fish migrations.

Many dams in Maine are aging, posing safety concerns for the nearby populace. The Maine Emergency Management Agency (MEMA) has a comprehensive database of potentially hazardous dams, and these dams should be considered for removal. The current dam removal process is the same as the process for dam construction which can involve numerous permits and many years of processing and appeals (Clark 2009; Murch 2009). We recommend that state legislature streamline the dam removal process for extreme cases of public safety. Several states including Wisconsin, Pennsylvania, Ohio, and Connecticut have already created policies to expedite the permitting process involved in dam removal and Maine should follow their lead (Doyle, Stanley et al. 2003).

Finally, Maine should dedicate an office to oversee dam issues and dam removal, as Pennsylvania and New Hampshire have done (Gable 2009; Goode 2009). As documented in this report, dam removal is a complex issue fraught with many complications. A dedicated office can comprehensively oversee all dams within the state, working with DEP and DMR to identify dams that significantly harm river health, MEMA to identify safety hazard dams, and the Maine state government and power companies to identify dams that have outlived their usefulness and no longer are needed. By bringing together all this information under one office, Maine can comprehensively examine dam removal as it moves forward into the future.

Appendix A: Current and Historical Diadromous Fish Habitats

Current and Historical Alewife Habitat:
Current and Historical American Eel Habitat:

Current and Historical American Shad Habitat:

Current and Historical Atlantic Salmon Habitat:
Current and Historical Atlantic Sturgeon Habitat:

Current and Historical Atlantic Tomcod Habitat:
Current and Historical Blueback Herring Habitat:

Current and Historical Brook Trout Habitat:

Current and Historical Rainbow Smelt Habitat:
Current and Historical Sea Lamprey Habitat:

Current and Historical Shortnose Sturgeon Habitat:

Current and Historical Striped Bass Habitat:

Source: (U.S. Fish & Wildlife Service 2007)
Works Cited:


Maine Department of Marine Resources (2008). DMR Review of Statewide Fish Passage Efforts.


USC Title 33 § 518. 2002 Federal Water Pollution Control Act.


