FINAL MINUTES OF THE AAHTC MEETING ON SUBJECT OF SHEEPSCOT POND FISHWAY

A conference call was held from 1 to 2 pm on 23 FEB 2017. Participants included John Coll and Patricia Barbash of the USFWS, David Bean of NOAA, Cem Giray and Bill Keleher of Kennebec River Biosciences, Michele Walsh the State of Maine Veterinarian, Debbie Bouchard with the University of Maine Cooperative Extension and Aquaculture Research Institute, Mike Brown and Marcy Nelson of Maine DMR, and David Russell and Todd Langevin of Maine IF&W.

On the question of increased disease risk associated with opening passage to alewives and river herring: The consensus of the group is that the open water source (lack of filtration and UV) at the hatchery is already a major risk. Because migratory species are currently coming into contact with the open water source at the hatchery, opening of the fish way for the entire year rather than just for 10 months of the year would not represent a significant increase in risk for introducing a disease of regulatory concern. Ich was mentioned as an example of "nuisance" disease organisms that are encountered by having open, untreated water supplies and having associated increased operations costs via needed treatments. Trish and John asked IFW about Ich at the facility and suggested that UV would not only tackle the bait issue but also remove any potential Ich problems.

The consensus from the group was that the hatchery should add filtration and ultra violet light treatment. David Bean of NOAA mentioned "section 6" funding from NOAA or USFWS. If a disease were to be introduced into the hatchery, the biomass of the hatchery could amplify the disease agent and thus put wild stocks, including endangered Atlantic salmon, at risk. The best way to mitigate the risk is to prevent disease from getting into the hatchery. It was mentioned that funding for UV infrastructure could likely be a good match for some of the grant programs available. Follow up information after the meeting; the NOAA grant has closed for 2016 and the USFWS section 6 funding was primarily focused on habitat improvement projects for 2017. NOAA Restoration Center funding may be available for a redesign of the intake with better screening to prevent juvenile alewives from entering the facility through the intake. It was encouraged by NOAA to seek Federal Funding Opportunities and should be investigated further to assist with facility upgrades.

On the subject of testing wild populations: Several members of the group expressed concern that limited testing of wild populations could potentially give a false sense of security. Debbie mentioned that testing wouldn't hurt and suggested that confidence only comes with time and more data points. Michele warned about the potential harm in getting a negative and then having a false sense of security. She said to consider the long view with population monitoring. Bill Keleher felt a negative doesn't always mean negative. There are lots of variables. Debbie Bouchard said that a testing regime to quantify risks could be designed. The group seemed to be split on whether or not information from disease testing of wild populations would be of use.

On subject of disease risks such as VEN and other minor disease agents: Risk was not viewed as being increased due to the current "open" state of the water source. Any questions of VEN and pathogens become irrelevant with appropriately sized UV. There was little discussion of VEN specifically, because it fell into the realm of what was already discussed and the suggestion that UV treatment be prioritized. Bill Keleher mentioned that disease screening may be best focused to keep screening to the worse of the worse (OIE reportable and major pathogens of regulatory concern). He cautioned about not "setting the needle" for action too low.

On topic of closing the pond to use of bait and keeping the fishway closed year round: Several members said that they would not be comfortable stating that risk for the hatchery would be reduced with such operation. Others felt the historical lack of pathogen detections at the hatchery were not due to the present closure schedule of the fishway. Some of this discussion came after Todd Langevin suggested that the multi-decade record at the Palermo SDH of no diseases of regulatory concern being detected in screening may be the result of the current seasonal fishway closure practices. Patricia Barbash mentioned that the pooling of alewives below a closed fishway could be viewed as a factor for increasing risk. Such pooling results in stress and if a disease agent is present, the stress could result in a disease outbreak. Animal activity and migration of eels, which can bypass a closed fishway, could easily introduce diseases present below the fishway passage into the pond. They felt there was not enough historical data on the wild populations and made general statements that large populations have potential to increase pathogen risk “dose makes the poison”. Davis Russell mentioned that Trish brought up a good point about pooling of fish below the fishway in that if migratory fish numbers up to the fishway are to be enhanced from downstream removal of barriers, the risk for Sheepscot Pond and the hatchery could increase regardless of fishway operation practices.

Alewife numbers and risk: Mike Brown mentioned that annual alewife numbers could build to tens of thousands after a decade. It was acknowledged by someone in the group that large fish populations moving through a system could have more pronounced pathogen transfer. All AAHTC members present agreed that the water source needs to be treated and that the risk is already high, regardless of the fishway. Only IFW and DMR did not express an opinion. Debbie B. stated that large populations can increase risk, but doesn’t see where IF&W has been protected by closing it off. Michele W. stated that higher numbers can equal higher risk, but don’t know the true risk without data. The lack of a problem at the hatchery is not likely because of the fishway closure. Trish Barbash there is always going to be a risk, but no more than fish that are passing through. The fishway is not the only risk. Open water source is the problem. Cem G said fish are already intermingling. Bill K - untreated water is the big risk regardless of opening because you already have migratory species coming in contact – open water source is the problem.

Conclusion: The recommendation of the AAHTC was that the opening of the Sheepscot Pond fishway did not constitute a significant added risk over current practices and that installation of UV treatment at the Palermo State Fish Hatchery should be prioritized to protect the hatchery water supply.

Maine's Sebasticook River

A Rare and Critical Resource for Bald Eagles in the Northeast

MAINE DEPT. OF INLAND FISHERIES AND WILDLIFE

bri

Overview

Due to the combined effects of pesticide use, direct killing, and habitat loss, Bald Eagles (*Haliaeetus leucocephalus*) were nearly extirpated by the mid-20th century. As a consequence of concerted efforts to prevent the loss of this iconic species, the natural history of this eagle is closely intertwined with some of the most important landmark environmental policies in U.S. history, such as banning of the pesticide DDT and the Endangered Species Act.

While traditional conservation efforts focused on increasing reproduction at nest sites, the current management focus is now shifting toward protecting eagle aggregation areas, typically centered on seasonally abundant fisheries.

In 2014, with support from the American Eagle Foundation and local landowners, researchers from Biodiversity Research Institute (BRI) and the Maine Department of Inland Fisheries and Wildlife (MDIFW) conducted ground-based and aerial surveys of Bald Eagles utilizing fishing and perching areas along the Sebasticook River.

The Recovery of Maine's Bald Eagle Population

Fifty years ago, our nation's symbol was in serious decline. Nationwide, populations, once estimated at 300,000-500,000 in the 1700s, had dropped to fewer than 500 individuals by 1963. The widespread use of the pesticide DDT was largely responsible for the significant drop in productivity among breeding pairs.

Conserving nesting habitat has been a vital tool in both the recovery and protection of Bald Eagles. Since 1972 and continuing today, the state provides technical assistance to landowners and an array of conservation organizations concerning eagles and eagle nesting habitat.

MDIFW works through voluntary conservation ownership or easement, and has successfully secured a safety net for nearly 500 eagle territories. This is a significant increase from only five nesting areas protected in 1976. The population has soared from fewer than 30 breeding pairs in the '70s to more than 633 nesting pairs currently and more than 2,500 Bald Eagles in the state.

The Role of Nonbreeding Bald Eagles in Recovery

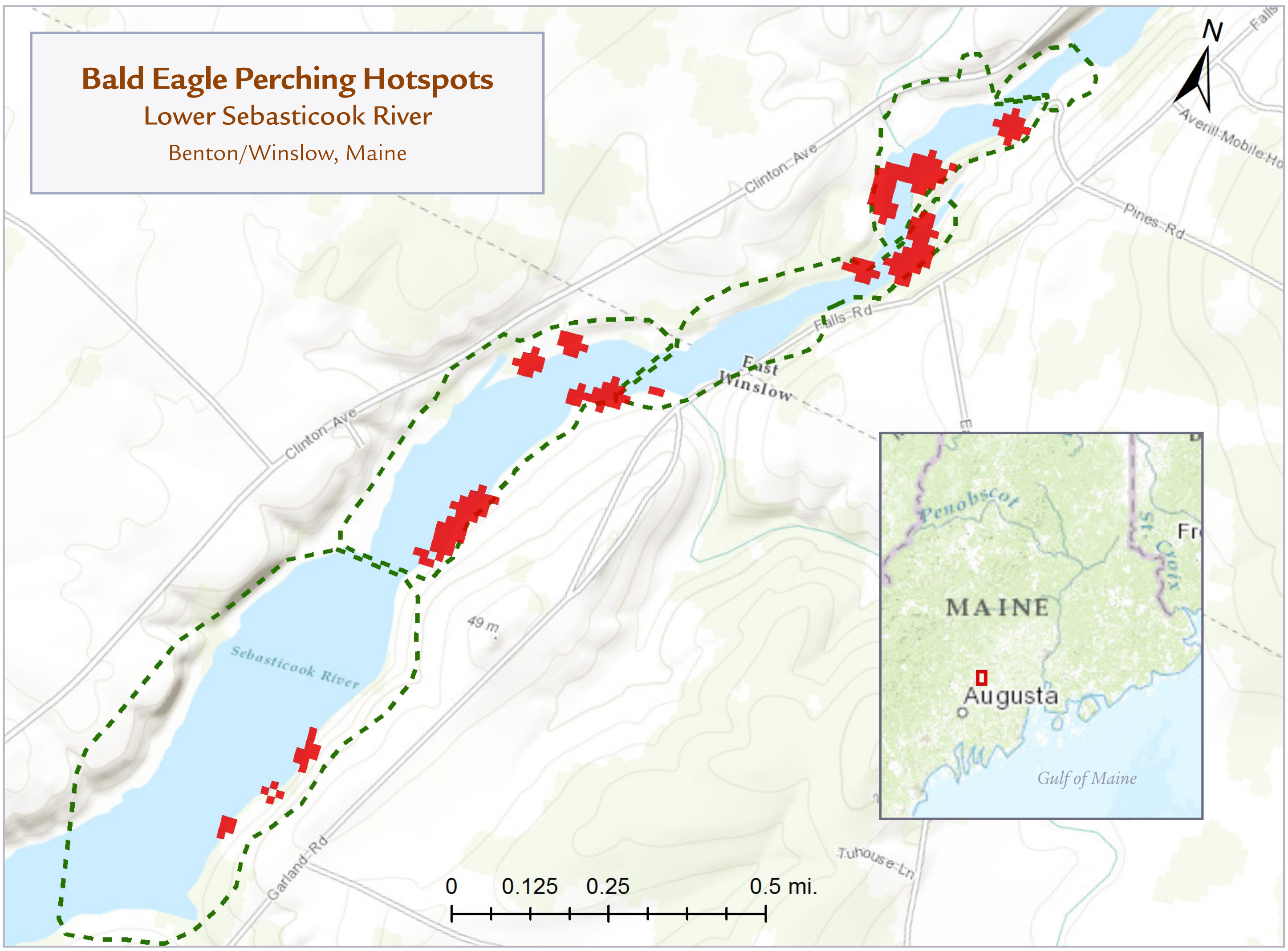
Research has shown that the survival of nonbreeding adults and subadults (younger than five years old) is key to population stability. Yet, the habits of this sector of the population are poorly understood. Conservation management efforts have traditionally focused on protecting nest sites. Since nonbreeding individuals are not associated with nest sites, they and their habitats tend to be overlooked in these efforts.

Nonbreeders often form aggregations in areas of high food abundance, which are important in maintaining their survival. Efforts to protect areas containing seasonally abundant resources therefore contribute to the long-term stability of Maine's thriving, but still sensitive, eagle population.

While highly territorial at nest sites, Bald Eagles commonly group together in higher numbers, called aggregations, where food is abundant (as shown at right). In central Maine, dozens of eagles frequent the Sebasticook River corridor to feed upon millions of river herring migrating between the ocean and their upriver spawning areas.

Roughly three-quarters of the eagles using the Sebasticook during the summer fish runs are subadults aged 1 - 4 years, a period when eagles are vulnerable to mortality. Nonbreeding eagles and the habitats that boost their survival are often overlooked in conservation efforts despite their critical role in maintaining the stability of populations.

Bald Eagles use their keen eyesight to catch fish out of swiftly moving waters. To minimize energy expenditure, they employ a “sit and wait” foraging strategy, perching adjacent to water, awaiting the easiest prey. Bald Eagles are also known to frequently steal fish from Ospreys and other eagles. As a result, eagles in areas with abundant food are seemingly often in conflict with each other as they all strive to procure a meal.



Important Bald Eagle foraging areas identified by analyzing significant clusters, or “hotspots” (indicated by red areas), of perching locations documented during 2014 survey efforts. The map shows five of the surveyed areas (indicated by dashed green line), those farthest upstream and closest to the Benton Falls Dam. In total, 10 sites along the lower Sebasticook River were surveyed.

The Sebasticook River – A Restoration Success Story

Plight of the Alewife

Accounts dating back to the 1500s describe an abundance of alewives throughout the Gulf of Maine. Alewives (*Alosa pseudoharengus*) and blueback herring (*Alosa aestivalis*), also known collectively as river herring, are native to the eastern seaboard—from South Carolina to New Brunswick, Canada—and are mostly known for their commercial value as lobster bait. These anadromous species spend the majority of their lives at sea, returning to their natal freshwater streams and lakes each spring to spawn in large annual migrations known as *runs*.

Widespread dam construction blocking migration, water pollution, and long-term overfishing led to drastic declines in river herring populations.

The Road to Recovery

Recovery of the Kennebec River Basin's dwindling river herring population began following the 1999 removal of Edwards Dam near Augusta. The collaborative restoration efforts of the State of Maine, federal agencies, conservation organizations, and several upstream dam owners have led to removal of the Fort Halifax Dam (2008) and installation of a fish lift at the Benton Falls Dam (2006), enabling migrating fish to reach expanded spawning habitat for the first time in 100 years.

The Sebasticook River—A Resource for Eagles and Other Wildlife

The Sebasticook River in central Maine is an ecologically valuable river running 50 miles from its headwaters near Dexter to the Kennebec River in Winslow. The Sebasticook is the Kennebec's largest tributary, with a watershed covering about 606,000 acres, and it supports the largest annual run of river herring in New England.

More than 2.75 million river herring were able to swim up the river in 2011—an increase from just 47,000 in 2006. Even the much larger Connecticut and Merrimack Rivers do not see river herring runs of this magnitude.

Bald Eagles gather along the Sebasticook River in groups while feeding on this seasonably reliable food resource. Such an unusual abundance of food provides benefits to both nonbreeding and subadult eagles, in addition to local breeding pairs. River otter, cormorant, osprey, and kingfisher also benefit from the renewed river herring run.

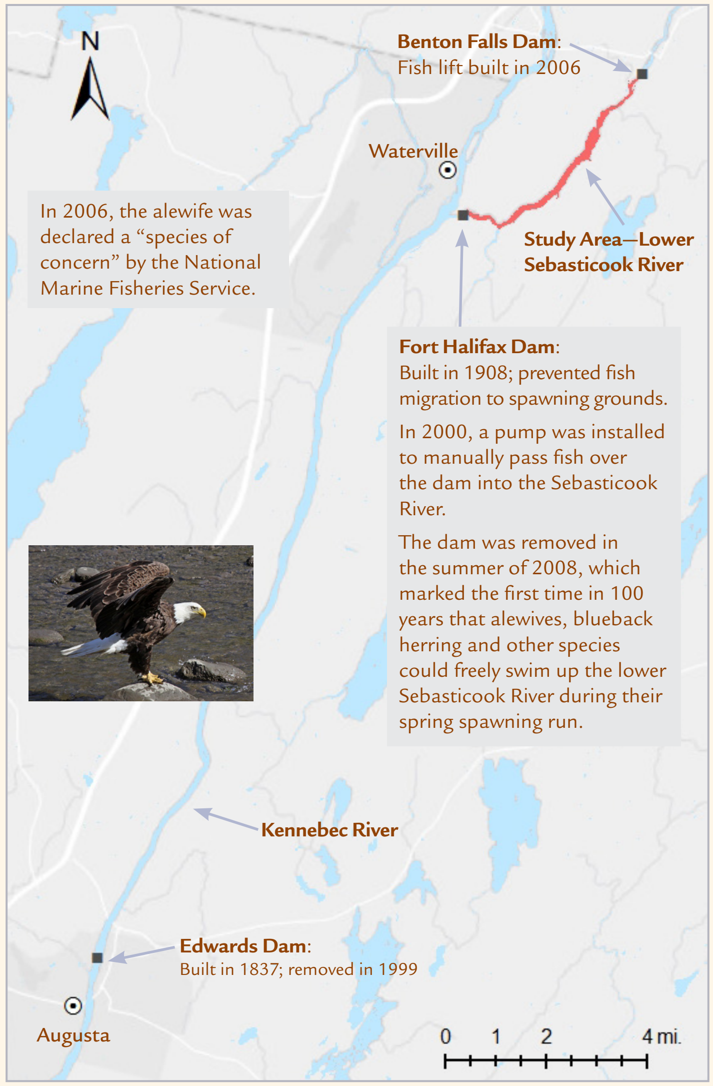


Photo above: River herring pour out of the fish elevator at the Benton Falls Dam. A fish elevator, or *lift*, carries fish over a barrier (the dam). Fish swim into a collection area at the base of the dam. When enough fish accumulate there, they are moved into an "elevator" compartment that carries them into a flume that empties into the river, above the dam. At left: An Osprey catches a river herring along the Sebasticook River.

Surveys of Bald Eagle Use along the Sebasticook River

From mid-May to early July, aggregations of Bald Eagles frequent the reach of the lower Sebasticook River spanning between the Kennebec River, five miles upstream to the Benton Falls Dam.

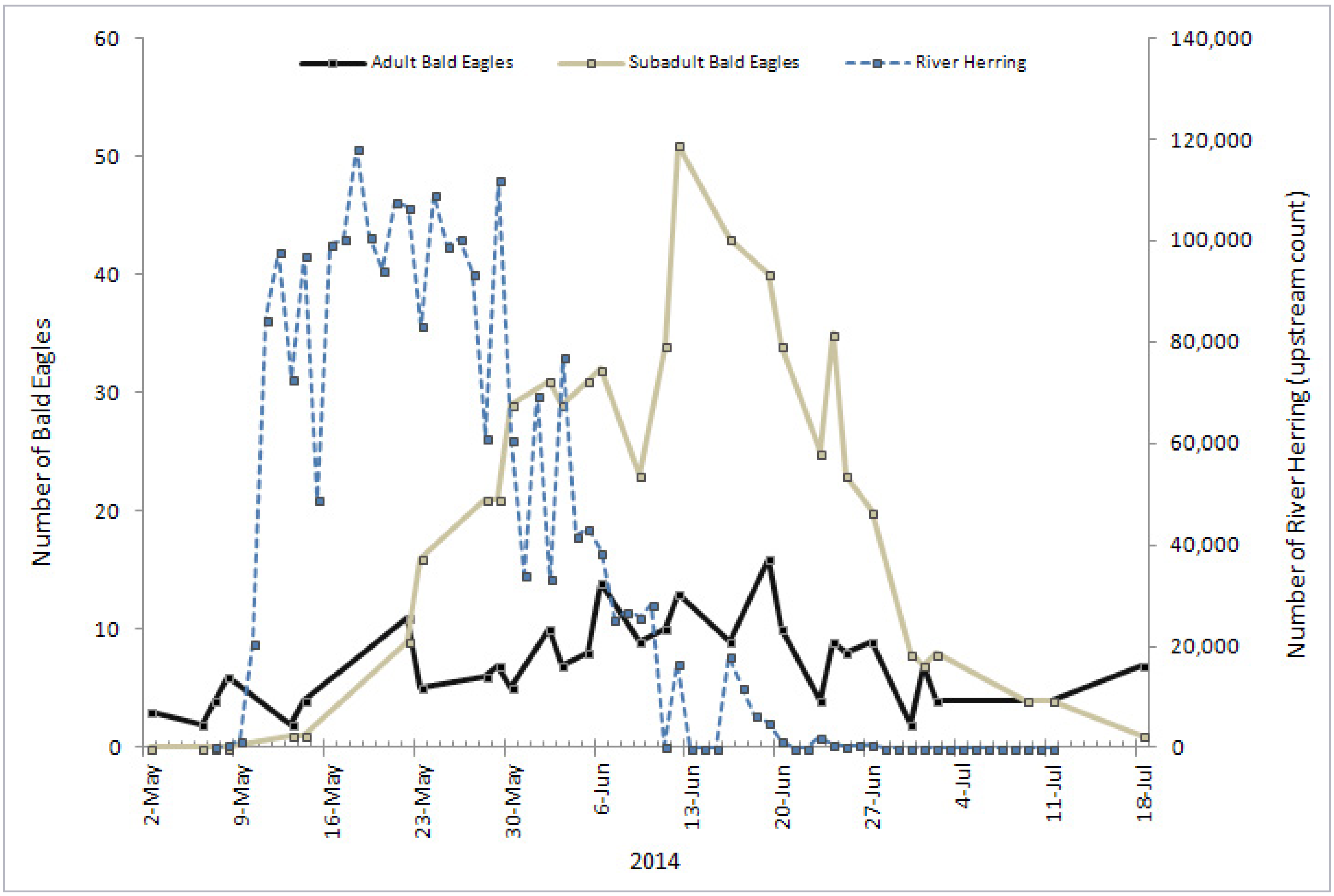
While the relationships between fisheries and wildlife populations are well recognized, no prior research efforts have focused on quantifying the use of the Sebasticook River by Bald Eagles. The information gained in this project will improve the ability of wildlife and conservation managers to make informed decisions about fish-eating birds, river herring, and the critical habitats that support them.

Findings from the Field

To identify when Bald Eagles were most reliant on the river herring run and which areas along the river stretch were most heavily used, BRI and MDIFW field biologists surveyed from May to July in 2014. Researchers focused on ten locations along the five-mile corridor of the Sebasticook River from the Benton Falls Dam downstream to the former Fort Halifax Dam. Surveys were conducted before, during, and after the river herring run to document eagle abundance and identify perching locations.

For a three-week period in June, along this five-mile stretch of riparian corridor, we consistently observed 40-50 eagles. On a single day in mid-June, 64 eagles were observed, the largest aggregation documented in New England.

Bald Eagle aggregations along the Sebasticook River span well beyond the period of the fish run; anecdotal counts by ground and aerial observers regularly note these aggregations during late summer and winter months. There are few examples of comparable aggregations in the northeastern United States. The daily counts of eagles using the Sebasticook River may translate to use by hundreds of eagles over the course of the entire year.



Daily riverwide estimates of adult and subadult Bald Eagles counted along a five-mile stretch of the Sebasticook River, Maine, compared with numbers of river herring (alewives and blueback herring) counted at the Benton Falls fish lift. The apparent time lag between upstream fish passage and the number of eagles documented does not account for, and is likely explained by, post-spawning downstream migrating fish (fish are only counted as they swim upstream). Downstream fish presumably continue to attract eagles long after the upstream fish migration subsides. Fish passage data courtesy of Maine Department of Marine Resources.

Supporting Maine's Eagles

Increasing awareness of conservation efforts along the lower Sebasticook River may be one of the most important investments in maintaining a lasting recovery for New England's Bald Eagle population.

Making a Difference: What You Can Do

- *Get Involved.* Many Maine organizations are dedicated to land and wildlife conservation. Participation and membership are critical to their missions.
- *Conserve Habitat.* Shoreline trees stabilize riverbanks, but they are also used by eagles to perch while foraging. Riverfront property owners can protect eagles, fish populations, and other wildlife by obeying municipal shoreland zoning ordinances, which helps conserve water quality and minimize erosion.
- *Make a Donation.* Private donations play a critical role in conservation. You can support Bald Eagle conservation and research in Maine by contributing to BRI's Bald Eagle Research Fund and by supporting the Maine Department of Inland Fisheries and Wildlife. Support MDIFW conservation efforts through the Chickadee Tax Check-off, the Loon Conservation Plate, Maine Birder Bands, and special lottery ticket sales (Maine Outdoor Heritage Fund).
- *Be Responsible.* Keep a respectful distance from nesting trees and foraging eagles. Properly discard used fishing line and hooks that can entangle wildlife. Consider using non-lead lead fishing weights and ammunition (see www.huntingwithnonlead.org). Vehicle collisions with eagles are common; be aware of eagles feeding on roadkill and flying near waterways.

For more information about Bald Eagles, habitat conservation and restoration, and eagle research in Maine, contact biologists at:

- Maine Department of Inland Fisheries & Wildlife: www.maine.gov/ifw/wildlife
- Biodiversity Research Institute Raptor Program: www.briloon.org/raptors
- U.S. Fish and Wildlife Service Maine Field Office: www.fws.gov/mainefieldoffice

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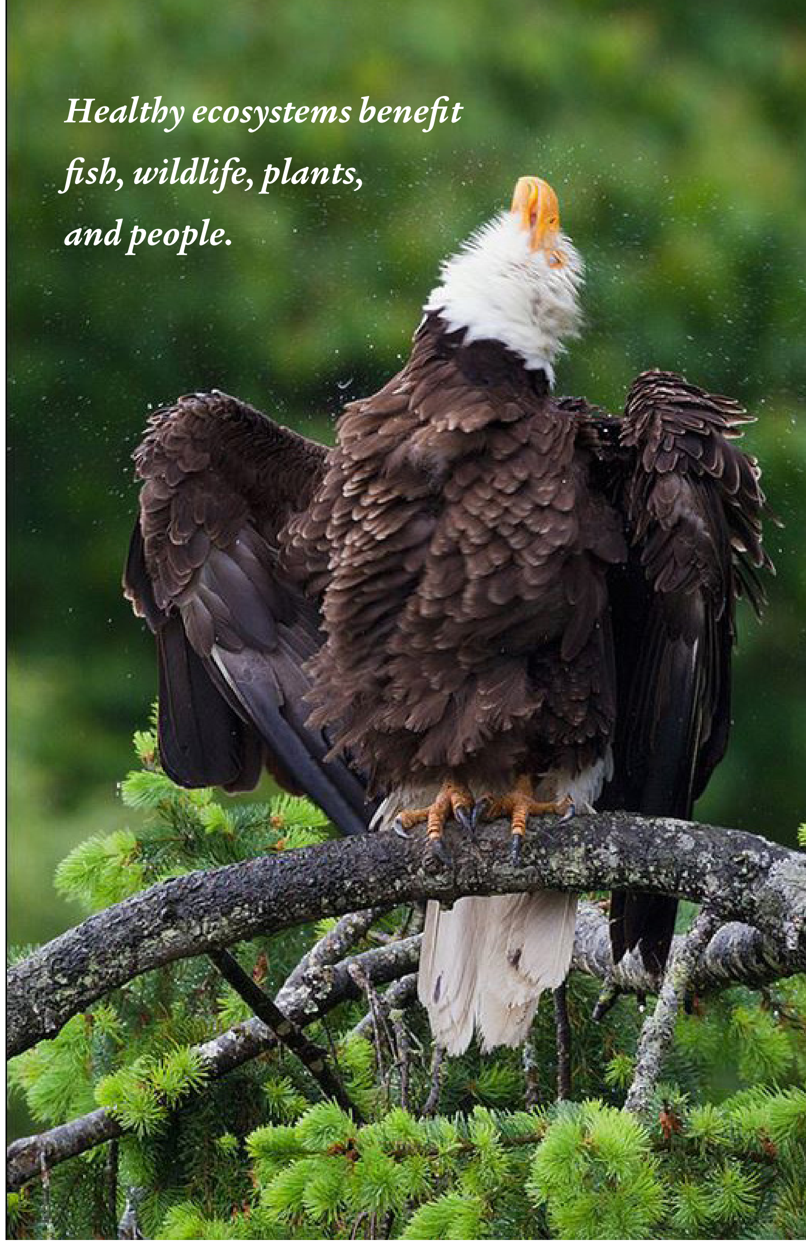

Suggested Citation for this Report:

DeSorbo, C. R., D. Riordan, and E. Call. 2015. Maine's Sebasticook River: A Rare and Critical Resource for Bald Eagles in the Northeast. Biodiversity Research Institute, Portland, Maine, and Maine Department of Inland Fisheries & Wildlife, Bangor, Maine. 6 pp.

Acknowledgments

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Maps and Graph: Dustin Riordan

Editing and Production: Deborah McKew and Leah Hoenen

This study and production of this brochure was supported in part by a grant from the American Eagle Foundation (www.eagles.org)

SEA LAMPREY

Petromyzon marinus Linnaeus 1758

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January 2004

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Executive Summary

This paper describes the anadromous (sea-run) sea lamprey, *Petromyzon marinus*, including its biology and role in freshwater ecosystems, with particular emphasis on the Sheepscot River drainage in central Maine. The paper concludes that healthy river and lake ecosystems in Maine must contain viable populations of native species assemblages and that managing rivers to exclude certain organisms, specifically sea lamprey, is not warranted. Sea lamprey provide demonstrable biological benefits with no appreciable negative impact to Maine rivers and their protection and restoration should be encouraged.

The sea lamprey is an anadromous (sea-run) fish native to coastal North Atlantic watersheds. Adult sea lamprey spend 1-1/2 to 2 years in the ocean, where they grow to maturity, after which they return to rivers and streams for spawning. Incubation takes 10 to 13 days and once the eggs hatch, larval sea lamprey stay in the nest for 4 or 5 more days during which time they develop gills, pigmentation and buccal hood. They then drift downstream where they burrow into the muddy bottoms of streams, rivers and lakes. These ammocoetes stay in the substrate for 4 to 8 years filter feeding upon planktonic drift. Eventually, they emerge from their burrows and metamorphose into transformers, the migration life stage which is similar to the final adult form.

Anadromous sea lamprey benefit freshwater habitat in several ways:

1. Sea lamprey bring valuable nutrients into freshwater systems and provide a valuable source of food for a variety of birds, fish, and mammals, including people. Fisheries biologists have observed aquatic species foraging on lamprey eggs, striped bass and other species eating emigrating transformers, and caddisfly larvae consuming lamprey carcasses.

2. Out-migrating sea lamprey transformers export valuable nutrients back to the sea.

3. Sea lamprey spawning activities restore and enhance streambed structure that benefits many other species. Some minnow species use sea lamprey nests for their own spawning activities and salmonids find the loosened and cleaned substrate desirable as redd building sites and as refugia for some life stages of their offspring. Improved water flows through loosened substrate are also beneficial for biologically important aquatic insects and other invertebrates.

4. The sea lamprey is also an irreplaceable study specimen for medical research because of its several unique biological functions.

Because there is little scientific information about sea lamprey in Maine there is confusion and misunderstanding about the role of sea lamprey in Gulf of Maine coastal tributaries. Two of these issues include the possibility of Maine's native sea lamprey population becoming landlocked in Maine lakes, and sea lamprey interactions with other native fishes. These issues are explored in-depth in this report.

It is important to recognize that the situation in the upper Great Lakes, where populations of native lake trout have been impacted by non-native landlocked sea lamprey, is quite different from what has happened, or what can happen, in Maine. Maine native sea lamprey are anadromous and a natural component of our aquatic ecosystems. The landlocked sea lamprey is not native to the upper Great Lakes, although it is believed to have originated in Lake Ontario and accessed the rest of the Great Lakes through man-made canals that allowed ship passage, as well as fish access. The sea lamprey observed in Maine's freshwater systems is not a predator or a parasite while in fresh water. Mature adults do not feed while on their spawning migration, ammocoetes feed upon planktonic drift, and transformers, although they may temporarily attach to fish in freshwater, do not linger long before migrating to sea. Transformers typically migrate in autumn downstream to sea where they grow to adulthood. Circumstances that delay this downstream passage, such as uncommonly low water flows or obstructions such as dams, may cause transformers to remain in freshwater until the following spring, when higher flows permit them to move downstream. Transformers are the only stage in the life cycle of anadromous sea lamprey that may attach to, and possibly feed upon other fish in freshwater. However, freshwater feeding by transformers is relatively rare and almost always non-lethal. Therefore, freshwater feeding by juvenile sea lamprey has minimal or no negative impact on populations of native or sport fisheries.

Key points made in this paper are listed below:

1. Although adult sea lamprey prey on other fish in the ocean they do not attach to other fish or feed in freshwater and die soon after spawning.

2. Larval sea lamprey spend 4 to 8 years burrowed in stream, river, and lake substrate where they feed entirely on planktonic drift.

3. Newly transformed lamprey typically spend only a few months in fresh water before heading to sea. They may briefly attach to, and possibly feed upon other freshwater fish species, in a manner that is almost always non-lethal.

4. Transformers are more likely to attach to, or feed on, other fish in freshwater if downstream passage is delayed by low flows or impediments to passage such as dams. To minimize the potential for attachment or feeding by transformers, river managers should ensure effective downstream passage so that transformers are most likely to migrate downstream without over-wintering delays.

5. Native Maine anadromous sea lamprey cannot survive in freshwater as adults.

6. Sea lamprey are a native species that has co-evolved and co-existed with other native species without demonstrable detriment.

It is the consensus of Maine fisheries biologists that there are no cases of sea lamprey negatively affecting populations of freshwater fish in Maine.

Introduction

The objective of this paper is to summarize existing knowledge of the sea lamprey, *Petromyzon marinus,* so that well-informed river management decisions can be made in Maine's rivers. The paper provides a description of sea lamprey and summaries of its biological and behavioral characteristics and interactions with other species. Material is also presented on its distribution, commercial value and on suggested areas for future research. The paper provides management recommendations for the Sheepscot River watershed where a number of fish passage enhancement projects are in progress. The paper concludes that healthy river and lake ecosystems in Maine must contain viable populations of native species assemblages and that managing rivers to exclude specific organisms, especially sea lamprey, is not warranted. A more complete understanding of the role that sea lamprey play in freshwater environments will lead toward greater acceptance of this native component of Maine's aquatic ecosystems.

Description

Linnaeus first described the sea lamprey, now known to science as *Petromyzon marinus*, in 1758. There are 41 species of lamprey in the Order Petromyzontiformes divided among 4 subfamilies and 6 genera. Lampreys are considered taxonomically to be among the most primitive of living vertebrates, and they have co-evolved and co-existed with other native fish for millenia.

<u>Adult</u>: The adult sea lamprey has an elongated body (720 mm -880 mm, with a maximum reported size of 990 mm). They are similar in appearance to the American eel, *Anguilla rostrata*, but differ in several significant ways. The sea lamprey has no ribs, no paired fins, no jaws, and has seven pairs of gill pouches instead of the usual gill structure of the bony fishes (Flescher and Martini 2002). Lampreys are considered vertebrates because they have cartilaginous skeletal structures in the form of vertebral arches that protect the spinal cord.

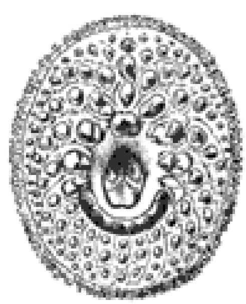


Figure 1. **Buccal Funnel**

One of the most distinguishing external characteristics of the adult sea lamprey is its mouth that contains 11 or 12 rows of teeth, arranged in concentric circles enclosed by an oral hood (Figure 1). The teeth-hood arrangement, called a buccal funnel (Scott and Scott 1988), is superbly designed to allow the adult lamprey in the ocean to attach to the side of fish and to hold on while rasping a hole in the side of its prey and feeding on its body fluids and tissues. Adult sea lamprey are variably colored but predominately bluish-brown and mottled with blackish patches on their dorsal surface and white on the ventral surface. They become more colorful with yellow and blue patterns during spawning (Leim and Scott 1966).

Ammocoetes: Larval lamprey, called ammocoetes, are dark colored on the dorsal surface and light colored on the ventral surface. They are blind and have no teeth and filter feed on planktonic drift.

Macrophthalmia: Newly metamorphosed lamprey, often referred to as transformers or macrophthalmia (because of their large eyes) (Applegate 1950), may have white bellies and silvery sides with a dark dorsal surface. They look similar to adult lamprey but are only 100 – 200 mm long, depending upon growing conditions (Bigelow and Schroeder 1953; Davis 1967; Halliday 1991; Beamish and Medland 1988; Scott and Scott 1988).

Biology

The sea lamprey is anadromous and adults spend 18 months to two years feeding at sea prior to returning to spawn in freshwater streams. When adult lamprey return to freshwater, their digestive system breaks down, the enamel caps fall of their teeth, they stop feeding, and they go blind. Adult sea lamprey may migrate hundreds of kilometers upstream to find suitable spawning habitat. They use their specialized mouths to hold onto wet rocks or other structures to assist them in overcoming obstacles. Adult sea lamprey do not feed in freshwater (Flescher and Martini 2002).

Spawning season varies longitudinally within the range of the lamprey, but in Maine, spawning occurs from late May through early summer. Spawning peaks when water temperatures are about 17 to 19 ^{0}C (Applegate 1950; Beamish 1980). Sea lamprey construct elongated nests of gravel and small rocks in riffles that are 25 to 50 cm deep. Males and females work together on nest construction and more than one female may share in this activity. Lampreys often carry stones to the nest with their mouths and use body motions to create a silt free nest that may be as much as 25 cm deep and up to a meter long (Leim and Scott 1966; Scott and Scott 1988). Nests may remain visible for several years after construction. Each female will produce an average of 230,000 (maximum 305,000) adhesive, non-buoyant eggs (Scott and Scott 1988; Leim and Scott 1966; Applegate 1950; Beamish 1980) and both males and females die after spawning.

Eggs hatch after 10 to 13 days (Piavis 1972) and the small larvae move downstream into still water areas of streams and lakes (Wagner and Stauffer 1962) where they burrow into muddy substrate. Larvae remain in the substrate for four to eight years (Scott and Scott 1988; Applegate 1950) filter feeding on algae and planktonic drift. Larval lamprey have no teeth or eyes but are equipped with a specialized oral hood to facilitate this life style (Flescher and Martini 2002).

Typically in July, larval sea lampreys begin a metamorphosis that lasts for four to six months. During metamorphosis, larval lamprey lose the oral hood and develop teeth, eyes, and kidneys. Four to six months later, the newly transformed lamprey ("transformers") emerge from the substrate and begin their migration to sea. Newly transformed lamprey average between 100 and 200 mm long.

At this point, it is helpful to distinguish between two sea lamprey behaviors – feeding and attachment. Feeding is generally what adult sea lamprey do in the ocean when they rasp a hole in the side of their prey and burrow their buccal funnel under the scales of their prey to feed on fluids and tissue. If you were to pull a feeding lamprey off its prey, you would find a large raw hole under the spot where the lamprey's buccal disk was located. As parasitic feeders, feeding activity is based on the sea lamprey gaining its food from a host, ideally without killing it. However, delayed mortality can occur due to the physical stress from feedings or severe wounds that weaken the host fish. Feeding behavior that causes ocean prey to die is referred to as predation. However, ocean prey frequently survive lamprey feeding and sea lamprey feeding behavior is most correctly referred to as parasitism. Attachment is the non-feeding act of holding on to another fish or object and refers to what transformers are most likely to do, and what adults sometimes also do. Attachment means that the lamprey attaches by means of its buccal funnel to another fish, but does not penetrate the skin to feed. If you were to pull an attached lamprey off another fish, you would likely simply see a superficial wound where scales had been dislodged.

The transformer stage is the only stage in the life cycle of anadromous sea lamprey when they may attach to and perhaps feed on other fish in freshwater. The period of transformer residence in freshwater typically only lasts a few months (most transformers travel from inland locations to the ocean between September and December). Davis (1967) reported that newly transformed sea lamprey migrated out of Love Lake, Maine, from October through May with the vast majority of the out-migration occurring during November and December. Feeding by transformers is generally non-lethal because the period of attachment by an individual transformer is short, and transformers are small. Therefore, freshwater feeding by transformers generally has little lasting impact on the fish that serve as hosts.

Steve Gephard, a fisheries biologist who has studied sea lamprey and other anadromous fish in Connecticut for 30 years, observes that sea lamprey, and transformers in particular, are not strong swimmers. Therefore, their emigration is highly dependent on water flows. Typically, most transformers emigrate in fall as rain fills the streams. However, if drought conditions prevail in fall, or if transformer migration is delayed by downstream impediments such as dams, some may overwinter in freshwater – because once water temperatures drop below a certain threshold, migration stops (Gephard, personal communication). Migration will resume in spring during high spring flows and during this spring migration transformers may attach to other out-migrating fish such as alewives (Flagg, Sutter, personal communication) or Atlantic salmon smolts (Gephard, personal communication). Once spring flows increase, the small transformers are rapidly flushed downstream, offering little time for outmigrating transformers to attach to potential host fish.

Gephard observed a very large run of migrating spring transformers and American salmon smolt in spring 2002, after a prolonged drought. During this migration only 3.9% of the smolts had lamprey attachment marks, and most marks did not break the skin but merely displaced scales – indicating no active feeding. Transformers over-wintering in Sheepscot Lake, however, have been observed attached to, and feeding upon resident lake trout and landlocked Atlantic salmon. While this caused unsightly wounds on the host fishes there is no evidence that fish were killed by this sea lamprey feeding activity and, in fact, several fish had well healed scars from previous feeding attachments (Boucher, Brautigam, McNeish, Woodward, personal communication).

Documented values of native sea lamprey in freshwater systems

Sea lamprey are historic and vital components of ecosystems where they occur. Nutrients brought into coastal streams from the sea by spawning adults are beneficial to aquatic insects, crawfish, and other decomposers. In turn, juvenile lamprey export nutrients from the lakes and rivers back to the ocean. Nest building activities reduce compactness of the substrate by shifting small rocks around and allowing the current to sweep away the silts and fines that are commonly found in stream bottoms. This "cleaning" provides for improved movement of oxygen rich water through the lamprey nest and this, in turn makes the nest area attractive to other species. Lamprey nests may be used for spawning sites by common shiners (Gephardt, personal communication). Other resident stream fish, such as fallfish, are also likely to find the sites attractive. Lamprey nests are attractive locations for spawning salmonids, such as Atlantic salmon and brook trout that arrive in fall and utilize lamprey nests to construct their own spawning redds. The loosened substrate also provides improved microhabitat for many forms of aquatic insects and smaller sizes of salmonid fry and parr. Many Maine streams are severely impacted with silts and fines due to past management practices, and the natural loosening of stream beds provided by sea lamprey can be very helpful in recovering native fish populations, especially Atlantic salmon.

Because of their value to freshwater ecosystems, some states have begun programs to restore sea lamprey to areas from which they have been eliminated due to dams and pollution. The Connecticut Department of Environmental Protection and the New Haven (CT) Land Trust have joined with various other local, state and federal agencies to install fish passage on the West River in New Haven, Connecticut, specifically to restore populations of migratory fishes, including sea lamprey (CT Dept. of Environmental Protection, 2001). Fishways have also been built at dams on the Naugatuck, Salmon, Farmington, and Eightmile Rivers to pass sea lamprey into historical habitat as part of a larger effort to restore all native anadromous species (Gephard, personal communication). Fish passage enhancement plans for the Connecticut River system will provide sea lamprey (along with several other fish species the projects are designed to benefit) access to upstream areas in Connecticut, Massachusetts, Vermont, and New Hampshire. The sea lamprey is designated as a "State Species of Special Concern" in Connecticut and New Hampshire (CT River Atlantic Salmon Commission, 1998).

Predator-Prey Interactions With Other Species

Ocean Environment

Adult lamprey are obligatory parasites of other fish during their several months maturing at sea. Parasitism is defined as what sea lamprey do when they rasp a hole in the side of a fish to gain access to the host's body fluids and tissues. Parasitism, by definition, usually does not involve killing the host (Bond, 1979), but sometimes parasitism can lead to the death of the host from secondary infection at the feeding wound or from weakening of the host fish from large or multiple feedings. When parasitism does lead to the death of the host animal it may be classified as predation.

Lampreys usually attach themselves to the lateral or ventral surfaces of their prey but will attach to any part of a host fish if they cannot access the preferred spots. While attached, the sea lamprey uses its uniquely designed mouth and teeth to rasp a feeding hole into the tissue of the host fish and sucks out blood and other body fluids. Sometimes flesh or ova may be found in the stomachs of sea lamprey, but these items are probably ingested incidentally while lamprey feeds on the preferred fluids. Sea lamprey drop off the host fish after feeding and the host usually survives with only a scar to show for it. However, in some cases, sea lamprey feeding may negatively impact the growth and condition of the host. The host fish provides blood to the sea lamprey, and the open wound may provide an entry site for secondary infection. Host fish may sometimes die as a result of lamprey feeding – especially if the prey is small or if multiple lamprey attack the same fish for extended periods. However, because of the nature of fish, it is very difficult to document mortality, so sufficient documentation to accurately quantify the nature and severity of ocean parasitism is not available.

Sea lamprey transformers in Connecticut have been sometimes observed attached to freshwater fish. This usually occurs in spring after a dry fall and it is assumed that some transformers do not successfully emigrate in the fall but instead overwinter in the river. Examination has revealed that most hosts are emigrating Atlantic salmon smolts (headed to sea) and the skin is rarely broken and no feeding has occurred. Only one case of attachment on a non-migratory species has been reported during the past 20 years and that was a black crappie found in a brackish estuary in Guilford, CT (Gephard, personal communication).

The sea lamprey can parasitize or attach to a long list of marine fish species. While sea lamprey do not appear to discriminate among victims, they seem to prefer fish that have smaller, less protective scales and thus, are easier to feed upon. Marine fish reported to have been preyed upon by sea lamprey include: alewives, blueback herring, American eel, American shad, sturgeons, Atlantic cod, Atlantic herring, Atlantic mackerel, Atlantic menhaden, Atlantic salmon, basking shark, bluefin tuna, bluefish, haddock, hake, swordfish, weakfish, pollock, sei whale (Flescher and Martini 2002; Halliday 1991; Scott and Crossman 1973). Sea lamprey have been also been reported to parasitize their own kind (Davis 1967) and to attach to ships' hulls and floating debris in the sea.

It is important to recognize that while lamprey parasitize other fish they, in turn, serve as prey for many other. Marine fish that have been documented to prey upon sea lamprey include Atlantic cod, swordfish, striped bass and other sea lamprey.

Freshwater Environment

Adult sea lamprey returning to fresh water to spawn do not feed once they enter freshwater. Larval sea lamprey spend four to eight years burrowed in the mud and are planktonic filter feeders and do not feed on fish. Newly transformed lamprey may briefly attach to, and possibly feed upon other freshwater fish species in a manner that is almost always non-lethal.

Davis (1967) made observations on sea lamprey in Love Lake in Washington County, Maine, where he concluded that, while recently transformed lamprey did sometimes attach to landlocked salmon, and other species, the attacks were short-lived and did not have an impact on the population of salmon in Love Lake. Bob Foye, retired IFW fishery biologist, recalls observing brook trout with lamprey scars in Pleasant River Lake, Washington County, but did not consider the lamprey to be problematic in that lake either.

Sea lamprey have been documented to have attached to/or fed upon other freshwater fishes, including; black crappie, bullhead, burbot, carp, channel catfish, chubs (Coregonus spp.), Eastern brook trout, lake trout, longnose sucker, northern pike, rainbow trout, redhorse, walleye, whitefish, white perch, white sucker, yellow perch. Freshwater fish that prey upon sea lamprey include brown trout, northern pike and walleye. While in freshwater, sea lamprey adults are particularly vulnerable during spawning migration, while building redds, and while out-migrating as young adults. Bitterns, hawks, herons, kingfishers, gulls, osprey, and owls, as well as fox, mink, muskrat, otter, raccoon, weasel, and water snakes have all been documented to prey on sea lamprey. It is also likely that bald eagle prey upon adult sea lamprey, although this has not been documented (Todd, personal communication). Scott and Crossman (1973) report that two genera of minnows have been documented feeding upon lamprey eggs during spawning. They also speculate that other fish species may also prey upon lamprey eggs. Common shiner, fallfish, and American eel have been observed in Connecticut actively feeding on lamprey eggs (Gephard, personal communication).

Distribution and Status

<u>Worldwide distribution</u>

The sea lamprey is found on both sides of the Atlantic Ocean. It ranges from northern Norway along the western European coast to the Mediterranean Sea, including the Baltic and the offshore islands of the Faroes and the British Isles. The North American range is discontinuous in that there are sea lamprey on the southwest coast of Greenland and then a gap in distribution until the coast of Labrador (Dempson and Porter 1993). They then may be found in coastal drainages all along the Atlantic coast to northern Florida and the Gulf of Mexico (Vladyov and Kott 1980) (Figure 2).

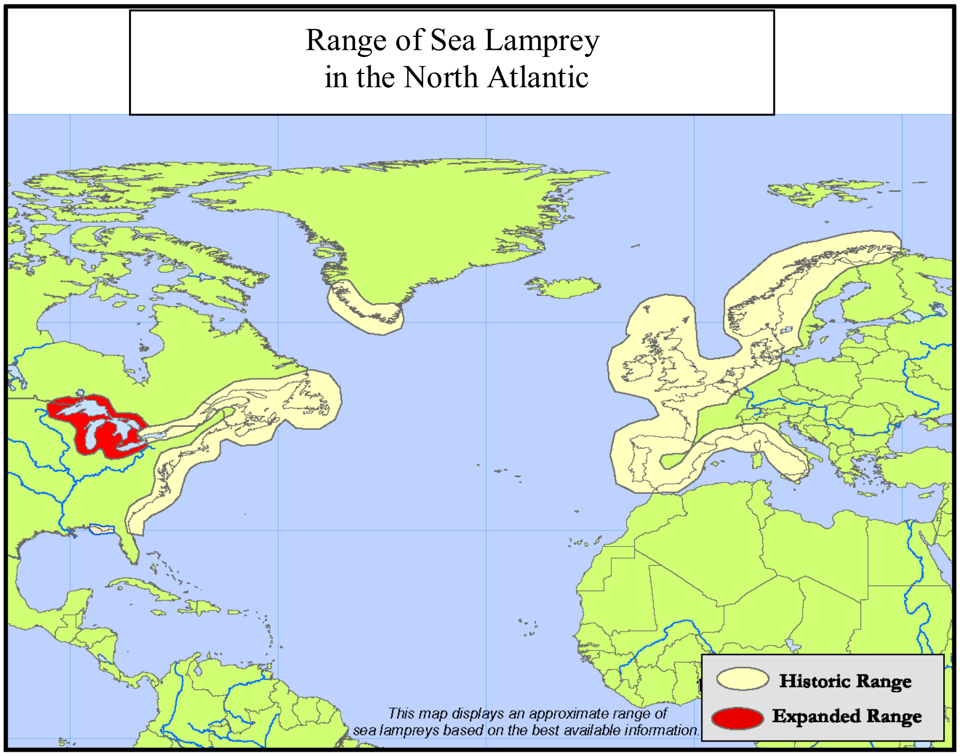


Figure 2. **Range of sea lamprey in the North Atlantic including the expanded range into the Great Lakes.**

<u>Maine Distribution</u>

Sea lampreys are a native species found in Maine watersheds all the way from the New Hampshire to the New Brunswick borders. The Maine Department of Inland Fisheries and Wildlife (IFW) species distribution map (Figure 3) includes only those few (13) lakes where they officially have been documented. Documentation does not exist for this species in many Maine rivers nor in many lakes through which it must migrate to access other areas from where it has been reported. This lack of documentation should not be construed to mean that they do not exist in waters other than those for which they are listed. Personal communications with biologists from IFW and the Atlantic Salmon Commission confirm that the species is widespread all along the Maine coast but that reports of lampreys or lamprey scars on fishes in lakes is very uncommon.

There is little documentation of sea lamprey in Maine for several reasons:

1. Reports from the general public directed to natural resource agencies regarding sea lamprey typically relate to wounding of fish caught by anglers. Because sea lamprey wounds are very uncommon, there are very few of these reports.
2. Sea lamprey living in Maine's coastal watersheds are of little direct commercial value to people in Maine. Therefore, little funding has been available to study lamprey.

3. Lamprey are not easily observed. Sea lamprey adult and transformers are transient in lakes and are not easily caught in gill nets or trap nets. Ammocoetes are well concealed in burrows in the bottoms of rivers, lakes and streams.

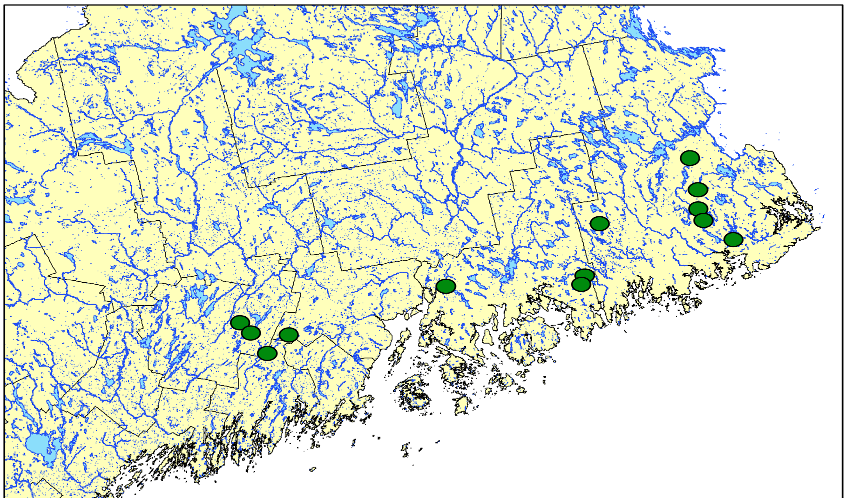


***Figure 3*. Green dots indicate sea lamprey documentation in Maine lakes. (Maine Department of Inland Fisheries and Wildlife, Fisheries Division data). Lakes included in Figure 3 are (from right to left): Gardner Lake, Love Lake, Round Lake, and Second Lake (East Machias River drainage); Pocamoonshine Lake (Machias River drainage); Pleasant River Lake (Pleasant River drainage); Tunk Lake and Spring River Lake (Tunk Stream drainage); Alamoosook Lake (Orland River drainage); Sheepscot Lake and Long Pond (Sheepscot River drainage); and Webber Pond and Threemile Pond (Kennebec River drainage).**

Sea Lamprey in the Great Lakes

Many people are aware of the accidental introduction of sea lamprey into the upper Great Lakes (Erie, Huron, Michigan and Superior). A land-locked form of lamprey, native to Lake Ontario, gained access to the upper Great Lakes after construction of the Welland Ship Canal that was built in 1829 to pass ocean-going ships around Niagara Falls. Niagara Falls had previously been a complete obstruction to upstream fish passage for all species into the upper Great Lakes. Lake Erie, the next upstream lake, first reported sea lamprey in 1921 and the first lamprey spawning was reported in tributaries to Lake Erie in 1932. The sea lamprey has never become abundant in Lake Erie but invaded the rest of the upper Great Lakes rapidly and was firmly established throughout the lakes by the end of the 1940's (Smith 1971; Smith 1985).

There are a number of differences between sea lamprey found in the upper Great Lakes and native sea lamprey found in Maine's freshwater habitats. Land-locked lamprey were not a native component in the upper Great Lakes system. The introduction of non-native species always holds potential to disrupt natural systems, and the introduction of sea lamprey into the upper Great Lakes is a case-in-point. But even in the upper Great Lakes, the introduction of non-native sea lamprey was only one of many problems affecting the aquatic communities. Excessive commercial harvests, water pollution, and degraded habitat were already taking their toll on Great Lakes ecosystems prior to the introduction of sea lamprey (Smith 1985). The land-locked lamprey that extended its range into the upper Great Lakes has been blamed, along with excessive commercial fishing, for the demise of resident and introduced sport fisheries. However, recent analysis of the chemical contaminate history of Lake Ontario shows that factors other than commercial fishing or sea lamprey predation were also responsible for the extinction of lake trout in that lake. Cook, et al. (2003) determined that contaminate levels of 2,3,7,8-tetrachlorodibenzo-p-dioxin and structurally related chemicals were high enough to cause 100% mortality of lake trout eggs and fry for the period ranging from the mid-1940' through the mid 1980's, a period of more than 40 years. Adult lake trout declined and disappeared from Lake Ontario in the mid- 1960's. While this study was conducted only on Lake Ontario, which has also had a very long history of occupation by landlocked sea lamprey, the same factors could well have played a deciding role in lake trout declines in the rest of the upper Great Lakes. The sea lamprey that invaded the upper Great Lakes were a freshwater land-locked form native to Lake Ontario, distinctly different from the anadromous sea lamprey that inhabit Maine. The land-locked Lake Ontario form had apparently undergone genetic/behavioral modifications of an evolutionary scale that allowed it to survive year-round in Ontario's fresh water. Land-locked sea lamprey, that grow to adulthood in the Great Lakes, prey on other fish in freshwater while Maine's anadromous adult sea lamprey do not.

It is very difficult to create freshwater populations of anadromous lamprey (Beamish and Northcote 1989). Their studies with the anadromous lamprey, *Lampetra tridentate*, showed that the species did not become landlocked after construction of a dam denied the species access to the ocean. Nor were they able to hold young anadromous lamprey in freshwater captivity longer than 10 months. Most died after five months, even when given access to appropriately sized host species. The lamprey attached to the host fish, and fed upon them but did not remain attached for long and did not kill any of the host fish in the test aquaria. The authors concluded that a genetic change in anadromous lamprey is required in order to create freshwater populations. Beamish et al. (1978) showed that the osmoregulatory abilities of landlocked sea lamprey transformers was significantly less than those of anadromous sea lamprey transformers, supporting the theory that genetic changes have occurred that has allowed the Great Lakes fish to adapt to a completely freshwater life history. Therefore, isolation due to dams or other obstructions is not enough to cause anadromous populations to become adapted to a wholly freshwater existence. Biologists in Connecticut, after passing sea lampreys upstream on the Farmington River for 27 years and at several other locations for many years, have never encountered any evidence that sea lampreys have become landlocked, even though some systems have extensive impoundments. (Gephard, personal communication).

In summary, it is important to recognize that sea lamprey activities in the upper Great Lakes, where the fish is a genetically land-locked form and not native to those ecosystems, have little bearing on the ecology of sea lamprey in Maine's freshwater systems. There are no reported cases where sea lamprey presence within its native range has caused population declines among other freshwater fish species. Therefore in Maine, where sea lamprey are anadromous and have always been a native component of our lakes and rivers, comparisons with the upper Great Lakes are inappropriate.

Commercial Value of Sea Lamprey

The sea lamprey is highly prized as food in parts of Europe, but today they are seldom consumed in North America. The author has observed smoked lamprey offered for sale in a fish market in Stockholm, Sweden, alongside smoked eel, fresh yellow perch, brown trout, Arctic charr and Atlantic salmon. European migrants to North American brought many of their culinary habits with them and during colonial times, many sea lamprey were harvested for food from the Merrimack and Connecticut Rivers. There was even a short-lived experimental canning operation for sea lamprey in Maritime Canada (Scott and Scott 1988). The sea lamprey was also very highly regarded as food during the Middle Ages (Dempson and Porter 1993). Leim and Scott (1966) state that the sea lamprey has no commercial or human use in Canada, but Scott and Scott (1988) mentioned that larval lamprey are sometimes used as bait by recreational anglers in Quebec. Although the sea lamprey currently has almost no value in Maine as a food or export item, lamprey directly benefit other recreational and commercial species by providing nutrients, forage and enhancing spawning habitat.

During the 1970's and 1980's, Carolina Biological Supply Company harvested as many as 8,000 sea lamprey from the Sheepscot River at Head Tide (Flagg, Maine Department of Marine Resources, unpublished data). The sea lamprey has many unique features that make it a valuable subject for biological and medical research on neurological and spinal cord regeneration, locomotion, eyes, kidneys, blood research, and hormones. There is also a small market for ammocoetes for school dissection purposes. Although significant numbers of sea lamprey may still be found in the Sheepscot River the company now prefers to purchase their supply from commercial fishermen (Sutter, personal communication) instead of harvesting themselves. European importers have contacted commercial Maine fish harvesters about sources for sea lamprey, but local harvesters have not shown much interest in trying to meet their demands.

There are currently three companies permitted to harvest lamprey in Maine. Two of these concentrate their efforts on obtaining and processing adult lamprey and the third harvests ammocoetes. All three companies provide specimens for the aforementioned biological and scientific research needs. However, the two companies that concentrate on obtaining adult lamprey are unable to harvest the volume of fish they need from Maine waters and must obtain them elsewhere. One company imports sea lamprey from a fisherman in Nova Scotia and the other from suppliers in the Great Lakes.

Sheepscot River Issues and Management Recommendations

Sheepscot River Watershed

The Sheepscot River, located in mid-Coast Maine, is approximately 58 miles long and drains a watershed of over 320 square miles. It contains all, or part of, 20 towns in Lincoln, Sagadahoc, Waldo and Kennebec counties. The Sheepscot River has two main tributaries, the West Branch and the Dyer River. There is very little industrial development in the watershed. The primary commercial activity is dairy farming, in addition to which there is limited forestry. The river is a valuable recreational resource, notable for its canoeing and recreational fisheries and is home to many residents as well as a vacation spot for many seasonal visitors.

The entire river is listed as "highest priority" on the Maine Department of Environmental Protection (DEP) Non-Point Source (NPS) Priority Watershed list. The two major tributaries of the watershed, the West Branch and Dyer River, are on the State 303 (d) list. Several sub watersheds are also on the NPS priority list, including, Adams Pond, Branch Pond, Clary Lake and Dyer Long Pond. Much of the fresh water section of the river has a designated water quality classification of Class AA or B. The estuary is classified as SB (Halstead, personal communication). Classification indicates what the DEP has determined for a water quality goal and not the current water quality.

Current Impediments

Sea lamprey are generally the most proficient of Maine's anadromous species at overcoming obstructions because they can grasp any obstruction that remains wet with their sucker-like mouth while they inch their way past. There are three potential impediments to sea lamprey passage in the Sheepscot River including Head Tide, Coopers Mills, and Sheepscot Lake Dam (Figure 4). Descriptions of each impediment are provided below.

Head Tide: When the dam at Head Tide, located furthest downstream, (Appendix 1) was fully intact, upstream migration by sea lamprey was delayed. This dam was a major obstruction to fish passage for sea-run fish, including river herring, American eel, rainbow smelt, sea lamprey, Atlantic salmon and other anadromous species until 1943, when it was partially breached. However, it remained a significant obstacle to migration by most species of fish, in spite of additional breaches occurring in 1953 and 1955. Meister and Foye (1963) noted that, as of 1963, most anadromous fish could make their was past Head Tide Dam with some delays, depending upon water flow. Sea lamprey nests and ammocoetes are commonly found upstream of Head Tide Dam and even above Cooper's Mills Dam, 9 miles upstream.

Coopers Mill: Sea lamprey spawning migrations were also partially obstructed by dams at Coopers Mills, approximately 9 miles upstream from Head Tide (Appendix 1). The current situation at Coopers Mills dam (severe water leakage through and under the dam, inadequate flow for fishway operation) impedes upstream movement of most fishes, but it is clear that it is not a significant deterrent to the spawning lamprey migration. Today, at least some lamprey move upstream of Coopers Mill, because lamprey nests and ammocoetes are commonly found between Cooper's Mills and Sheepscot Lake, an additional 9 miles further upstream.

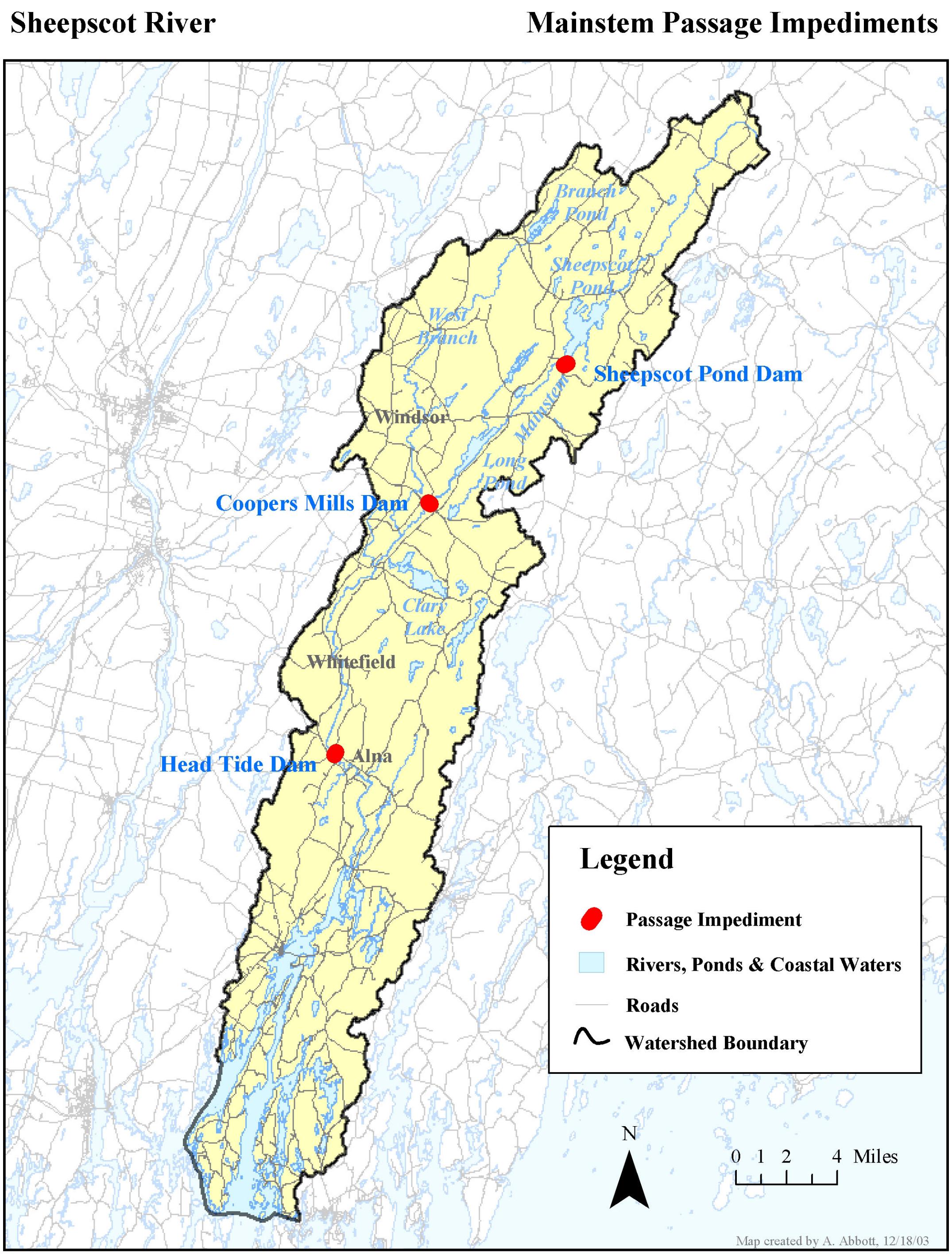


Figure 4. **Mainstem Sheepscot passage impediments.**

Sheepscot Lake: Sea lamprey spawning migrations were also partially obstructed at the outlet of Sheepscot Lake, approximately 9 miles upstream from Coopers Mills (Appendix 1). Operation of the fishway at Sheepscot Lake is the responsibility of the Maine Department of Inland Fisheries and Wildlife, Fisheries Division. The Hatchery Division is part of the Fisheries Division and has been assigned the responsibility of operating the fishway in such a manner as to exclude lamprey from Sheepscot Lake.

The current manager at the Palermo Hatchery, located immediately downstream from Sheepscot Lake, acknowledged that he has had no direction about managing the dam/fishway for lamprey exclusion and that at least since the year 2000, the fishway has been left open at all times (Roach, personal communication). Originally (since the 1960's) there was an arrangement of metal pipes and boards that was installed for sea lamprey exclusion on the spillway during late May and left in place until after the middle of July. The boards and pipes are long gone but the sleeves in the dam where the pipes were installed remain. Roach also said that there have been no dam boards installed on the face of the spillway for about the last 20 years. It is therefore clear that there is not, nor has there been for many years an effective barrier for sea lamprey to access Sheepscot Lake, and yet there have been very few incidences of lamprey attacks on resident fishes in Sheepscot Lake in recent years.

<u>Predator-prey interactions with other species</u>

Lamprey scarring on lake-resident sport fish did not become a concern with the angling public until the early 1960's (Scott and Foye, personal communication). Once access was improved at Head Tide dam in 1963, sea lamprey may have had an easier time ascending the river, although this has not been documented. Clearly, lamprey continue to gain access upstream of the Head Tide dam and Coopers Mill because between Coopers Mills and Sheepscot Lake there is ample evidence of successful sea lamprey reproduction.

Biologists from Maine Dept. of Inland Fisheries and Wildlife (Brautigam, Boucher, Foye, McNeish, Scott, Woodward and others, personal communication) have divergent opinions about the degree of impact of sea lamprey in Sheepscot Lake. However, one point where all agree is that lamprey attachments are not the cause of any failures in sport fish populations in Sheepscot Lake. W. Harry Everhart, renowned fisheries scientist and former Chief of Fisheries for IFW, concluded in his book, <u>Fishes of Maine</u> (1976) that, "there is … no evidence that any of our freshwater game fish populations have been harmed (by sea lamprey) in Maine," although individual fish, especially lake trout and landlocked salmon, have been captured with one, or more, lamprey wounds and scars on their bodies.

Data collected on landlocked Atlantic salmon and lake trout in Sheepscot Lake over the last 40 years shows that while most fish had no scars from sea lamprey attachment, some fish had as many as 18 old lamprey wounds. However, the average, among those fish that had been attached, was closer to one scar per fish (unpublished IFW file data). During years when lamprey numbers were at their peak in Sheepscot Lake (1960's – mid 1980's) 55 to 95% of the sport fish sampled in Sheepscot Lake showed signs of having been attached by lamprey. It is worth noting that the 1960's were a time of extreme and extended drought, which could have hampered the sea lamprey's ability to emigrate from the lake. Anecdotal observations by IFW and DMR suggest that since the early 1980's the number of sea lamprey entering the Sheepscot River seems to have declined. However, D. Sutter, commercial fisherman on the Sheepscot River, disagrees and suggests that during his 35 years of familiarity with the alewife and sea lamprey fisheries on the Sheepscot River there has been no significant change in the number of sea lamprey in the Sheepscot River. However, the incidence of lamprey scarring on sport fish in Sheepscot Lake has dropped to near zero in recent years perhaps due to improved flow regimes at Sheepscot Lake dam (IFW unpublished data).

There is no indication that sea lampreys have become landlocked in Sheepscot Lake, and based on documented research, it is highly unlikely that they will do so (Beamish and Northcote 1989). It is also interesting to note that Long Pond, a significant lake in the Sheepscot River drainage located downstream from Sheepscot Lake, has no history of lamprey attachments on any of its resident fishes although sea lamprey are presumed to transit through and to inhabit Long Pond.

Management and Research Recommendations

Sea lamprey are an important and valuable species native to Maine rivers. Sea lamprey spawning activities enhance riverine habitats to the benefit of many other species, including endangered Atlantic salmon, bitterns, hawks, herons, kingfishers, gulls, osprey, and owls, as well as fox, mink, muskrat, and otter. This review of available data, existing literature and regional experts has found that there are no justifiable biological reasons for denying migrating sea lamprey adults access to any portions of the river. Sea lamprey provide demonstrable biological benefits with no appreciable negative impact to Maine Rivers and their protection and restoration should be encouraged.

There are a number of potential areas for sea lamprey research in Maine that would provide additional valuable information on the species' range, behavior and impact on other species. These include the following activities.

- Survey coastal rivers and streams to better define the species' range in Maine. Much data can be obtained through an analysis of existing files collected by the three State Agencies that work on riverine species in Maine: Inland Fisheries and Wildlife, Marine Resources, and the Atlantic Salmon Commission.

- Evaluate out-migration of transformers through Maine lakes to see if there are impediments that may cause them to spend extended periods in freshwater.

- Determine if adult sea lamprey "home" to natal streams.

- Continue to critically evaluate impact of feeding transformers upon resident freshwater fish populations.

- Examine nutrient import-export functions associated with sea lamprey.

Acknowledgments

The following current or former biologists of the State of Maine Department of Inland Fisheries and Wildlife, Fisheries Division were most generous with their time and provided valuable information used to this document: David Boucher, Francis Brautigam, Scott Davis, Robert Foye, Merry Gallagher, Dennis McNeish, Mike Roach, Matthew Scott, and William Woodward.

Ken Beland and Peter Ruksznis with the Maine Atlantic Salmon Commission provided information about lamprey distribution in central and eastern Maine.

Lew Flagg and Tom Squiers, fishery scientists with State of Maine Department of Marine Resources, provided information about the history and status of the lamprey fishery in the Sheepscot River and on Maine's commercial lamprey fishery.

Information regarding the commercial use of lampreys in Maine was obtained through interviews with Lee Margolin, James Quimby, Timothy Sheehan, and David Sutter all permitted by Inland Fisheries and Wildlife or the Department of Marine Resources to harvest lamprey from Maine waters.

Information about sea lamprey in other States was obtained through communications with Steve Gephard, Supervising Fishery Biologist with Connecticut Inland Fisheries, Chet MacKenzie, Fishery Biologist with Vermont Fish and Game, and Janice Rowan, Fishery Biologist with the U.S. Fish and Wildlife Service in Massachusetts.

Melissa Halstead, Kennebec County Soil and Water Conservation District, was interviewed about water quality issues on the Sheepscot River.

Dan Kircheis, National Oceanic and Atmospheric Administration, provided assistance with artwork and mapping. The drawing of a lamprey on the cover is by E. M. Fischer located on page 46 in Bigelow and Schroeder (1948).

Jeff Reardon (Trout Unlimited), Sandra Lary (USFWS), Lois Winter (USFWS) and Jed Wright (USFWS) reviewed earlier drafts of this document and offered valuable, critical comments for improvement.

Bibliography

Anderson, J., D. Plosila, G. Barnhart, T. Jolliff. W. Schoch, P. Neth, J. Gersmehl, C. Baren. 1985. Salmonid – sea lamprey management alternatives for Lake Champlain. Fisheries Technical Committee Report. Lake Champlain Fish and Wildlife Management Committee. 59 pp.

Anonymous. 1998. Strategic plan for the restoration of Atlantic salmon to the Connecticut River. Connecticut River Atlantic Salmon Commission. http://www.fws.gov/r5src.

Anonymous. 2001. Connecticut Department of Environmental Protection News Release. http://www.dep.state.ct.us/whatshap/press/2001/ps0502.htm.

Applegate, V.C. 1950. Natural history of the sea lamprey, *Petromyzon marinus*, in Michigan. U.S. Fish and Wildlife Service Special Science Report. No. 55. 237 pp.

Beamish, F.W. H., P.D. Strachan, and E.Thomas. 1978. Osmotic and ionic performance of the anadromous sea lamprey Petromyzon marinus. Comp. Physiolo. Biochem. 60A: 435-443.

Beamish, F.W.H. 1980. Biology of the North American anadromous sea lamprey, *Petromyzon marinus*, Can. Journal of Fisheries and Aquatic Sciences. 37:1924-1943.

Beamish, F.W.H., and T.E. Medland. 1988. Age determination for lampreys. Transactions of the American Fisheries Society. 117:63-71.

Beamish, F.W.H., and I.C. Potter. 1975. The biology of the anadromous sea lamprey (*Petromyzon marinus)* in New Brunswick. Journal of Zoology. London. 177:57-72.

Beamish, R.J. and T.G. Northcote. 1989. Extinction of a population of anadromous parasitic lamprey, *Lampetra tridentate*, upstream of an impassible dam. Canadian Journal of Fisheries and Aquatic Science. 46:420-425.

Bigelow, H.B., and W.W. Welsh. 1925. Fishes of the Gulf of Maine. Bulletin of the Bureau of fisheries. Volume XL. In two parts – part I. Document No. 965. Government Printing Office. Washington, D.C. pp 18 – 21.

Bigelow, H.B., and W.C Schroeder. 1953. Fishes of the Gulf of Maine. U.S. Fisheries Bulletin. 53:577 pp.

Bond, C.E. 1979. Biology of fishes. Philadelphia: Saunders College Publishing.

Cook, P.M., J.A. Robbins, D.D. Endicott, K.B. Lodge, P.D. Guiney, M.K. Walker, E.W. Zabel, and P.E. Peterson. 2003. Effects of aryl hydrocarbon receptor-mediated early life stage toxicity on lake trout populations in Lake Ontario during the 20th century. Environmental Science and Technology. 37(17): 3864-3877.

Craigie, E.H. ----. A laboratory outline for the dissection of the lamprey. Of the dogfish and of the skate. University of Toronto Press. pp 1 – 36.

Davis, R.M. 1967. Parasitism by newly-transformed anadromous sea lampreys on landlocked salmon and other fishes in a coastal Maine lake. Transactions of the American Fisheries Society. 96:11-17.

Dempson, J. B., and T.R. Porter. 1993. Occurrence of sea lamprey, *Petromyzon marinus,* in a Newfoundland River, with additional records from the northwest Atlantic. Canadian Journal of Fisheries and Aquatic Sciences. 50:1265-1269.

Everhart, W.H. 1976. Fishes of Maine. Maine Department of Inland Fisheries and Wildlife. Augusta, Maine. pp 10, 16 – 17.

Flescher, D., and F.H. Martini. 2002. Lampreys. Order Petromyzontiformes. IN Bigelow and Schroeder's Fishes of the Gulf of Maine. Third Edition. Collette, B.B. and G. Klein-MacPhee (eds.) Smithsonian Institution Press. Washington and London. 16-19.

Haedrich, R.L. 1977. A sea lamprey from the deep ocean. Copeia. 4:767-768.

Halliday, R.G. 1991. Marine distribution of the sea lamprey (*Petromyzon marinus*) in the northwest Atlantic. Can. Journal of Fisheries and Aquatic Sciences. 48:832-842.

Hardisty, W.M., and I.C. Potter. 1971. The biology of the lampreys, Vol 1. Academic Press, New York. 423 pp.

Hubbs, C.L., and K.F. Lagler. 1958. Fishes of the Great Lakes Region. The University of Michigan Press. Ann Arbor, Michigan. p 36.

Leim, A.H., and W.B. Scott. 1966. Fishes of the Atlantic coast of Canada. Fisheries Research Board of Canada. Ottawa. 21-22.

Lennon, R.E. 1954. Feeding mechanism of the sea lamprey and its effect on host fishes. U.S. Fish and Wildlife Service Bulletin 98, Vol. 56:247-293.

Lolek, A. 1973. Occurrence of the sea lamprey in mid-water off Europe. Copeia 1:136-137.

Margolis, L., and J.R. Arthur. 1979. Synopsis of the parasites of fishes of Canada. Bulletin of the Fisheries Research Board of Canada. 199:269pp.

Meister, A.L. and R.E. Foye. 1963. Sheepscot River drainage; Fish Management and Restoration. Atlantic Sea-Run Salmon Commission and Maine Inland Fish and Game. Augusta, Maine. 31 pp.

Neth, P.C. and T. Jolliff. 1984. Sea lamprey in New York State. The Conservationist (January-February and March-April issues). Department of Environmental Conservation. New York.

Newth, H.G. 1930. The feeding of ammocoetes. Nature 126 (3168): 94-95.

Parker, P.S., and R.E. Lennon. 1956. Biology of the sea lamprey in its parasitic phase. U.S. Fish and Wildlife Service Research Report 44:iii+32 p.

Perlmutter, A. 1951. An aquarium experiment on the American eel as a predator on larval lampreys. Copeia 2:173-174.

Piavis, G.W. 1072. Embryology. IN: M.W. Hardisty and I.C. Potter, eds. The Biology of Lampreys. Vol. 1. Academic Press, New York, pp. 361-400.

Scott, W.B., and E.J. Crossman. 1973. Freshwater Fishes of Canada. Bulletin 184. Fisheries Research Board of Canada. Ottawa, Canada. 69 – 75.

Scott, W.B., and M.G. Scott. 1988. Atlantic Fishes of Canada. Canadian Bulletin of Fisheries and Aquatic Sciences. 219:731pp.

Scott, W.B., and S.N. Tibbo. 1968. Food and feeding habits of swordfish, *Xiphias gladius*, in the western North Atlantic. Journal of the Fisheries Research Board of Canada. 25:903-919.

Smith, B.R. 1971. Sea lampreys in the Great Lakes of North America. IN: M.W. Hardisty and I.C. Potter (ed.), The Biology of Lampreys, Vol.1. Academic Press, NY.

Smith, B.R. 1980. Introduction to the Proceedings of the 1979 Sea Lamprey International Symposium (SLIS). Canadian Journal of Fisheries and Aquatic Sciences. 37:1585-1587.

Smith, B.R., and J.J. Tibbles. 1980. Sea lamprey (*Petromyzon marinus*) in lakes Huron, Michigan, and Superior: history of invasion and control 1936-78. Canadian Journal of Fisheries and Aquatic Sciences. 37: 1780-1801.

Smith, C.L. 1985. The Inland Fishes of New York State. New York State Department of Environmental Conservation. Albany, New York.

Stier, K., and B. Kynard. 1986. Movement of sea-run sea lampreys, *Petromyzon marinus*, during the spawning migration in the Connecticut River. U.S. Fisheries Bulletin. 84:749-753.

Teeter, J. 1980. Pheromone communication in sea lampreys (*Petromyzon marinus*): implications for population management. Canadian Journal of Fisheries and Aquatic Sciences. 37:2123-2132.

Vladykov, V.D., and E. Kott. 1980. First record of the sea lamprey, *Petromyzon marinus* L., in the Gulf of Mexico. Northeast Gulf Science. 4:49-50.

Wagner, W.C., and T.M. Stauffer. 1962. Sea lamprey larvae in lentic environments. Transactions of the American Fisheries Society 91:384-387.

Yousen, J.H., and I.C. potter. 1979. A description of the stages of metamorphosis of the anadromous sea lamprey, *Petromyzon marinus* L. Canadian Journal of Zoology. 57:1808-1817.

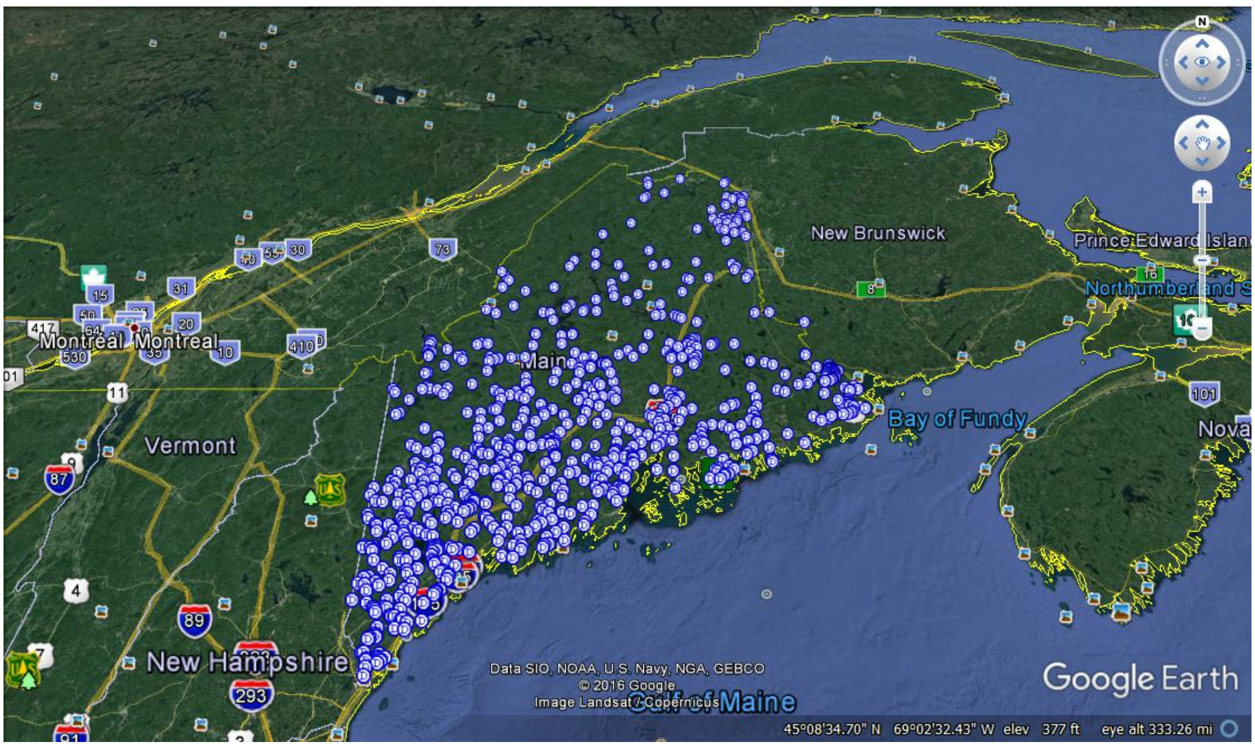
Appendix 1. Photos

Head Tide Dam; July 2003.

Coopers Mills Dam; July 2003

Sheepscot Lake Dam; July 2003

Dams in Maine



Submitted by NRCM