Appendix A: Fish

Shortnose Sturgeon

Acipenser brevirostrum

Federal Listing	E
State Listing	E
Global Rank	G3
State Rank	SH
Regional Status	V. High

Photo by Robert Michelson

Justification (Reason for Concern in NH)

Shortnose sturgeon are federally listed as endangered and presumed extirpated in New Hampshire. Until a recent detection of a tagged fish by an acoustic telemetry receiver in Great Bay, shortnose sturgeon had not been observed in New Hampshire waters since 1971 (M. Kieffer, U.S. Geolological Survey (USGS) Biologist, personal communication). Population declines due to the development of barriers (such as dams) in coastal rivers, alteration of spawning habitat, and commercial harvest have been well documented.

Distribution

Shortnose sturgeon are found in large coastal rivers and estuaries from New Brunswick south to Florida. Early records suggest that sturgeon were once able to move as far upstream on the Merrimack River as Amoskeag Falls (Noon 2003). They were also once thought to be common in the Piscataqua River.

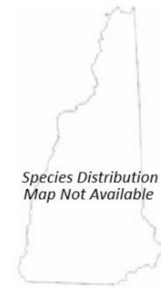
Access to the upper portion of the Merrimack River is blocked by the Essex Dam in Lawrence. A fish elevator at the Essex Dam on the Merrimack River in Massachusetts has never recorded sturgeon use, although spawning activity has been documented a few miles downstream. There is a well-documented population of shortnose sturgeon in the Connecticut River, but the upstream limit of the population is south of the New Hampshire border, in Turners Falls Massachusetts.

Habitat

Shortnose sturgeons occupy freshwater rivers, estuaries, and nearshore coastal habitat. Spawning occurs in freshwater over substrates consisting of boulder, cobble, and gravel with water depths of 10 m or less (Kynard 1997). Water temperatures during spawning range from 9.0 to 18.0°C. Spawning runs were observed during late April in the Merrimack River, Massachusetts (Kieffer and Kynard 1996). Adults forage on sandy and muddy substrates often near the upper reaches of tidal influence. They use fleshy barbels on their pointed snouts to detect benthic invertebrates with their sucker-like mouths, which they use to vacuum up their prey (Scott and Crossman 1973). Shortnose sturgeon remain in preferred river reaches for overwintering. In northern populations they do not feed during the winter months.

NH Wildlife Action Plan Habitats

- Estuarine
- Marine
- Large Warmwater Rivers



Distribution Map

Current Species and Habitat Condition in New Hampshire

There are no known spawning populations in New Hampshire waters.

Population Management Status

N/A

Regulatory Protection (for explanations, see Appendix I)

- Federal Endangered Species Act
- Possession prohibited

Quality of Habitat

Recent tagging studies using acoustic telemetry have revealed that some shortnose sturgeon are more migratory than previously believed (Fernandes et al. 2010; Wippelhauser et al. 2015). Individuals tagged in the Kennebec and Penobscot Rivers have been found to move between the two river systems. Shortnose sturgeon tagged in the Merrimack River have been detected in the Kennebec River (Wippelhauser et al. 2015). A tagged individual was recently detected by an acoustic telemetry receiver deployed for an unrelated project in Great Bay. It is possible that shortnose sturgeon move between multiple foraging areas among the rivers and estuaries that flow into the Gulf of Maine.

A status assessment of shortnose sturgeon in the Merrimack River suggests that the population may have expanded since surveys were last conducted in the late 1980's (Kynard and Kieffer 2009). Recent studies have also identified documented shortnose sturgeon in the Androscoggin, Kennebec, and Penobscot Rivers (Fernandes et al. 2010). Shortnose sturgeon native to the Kennebec River have been captured in the Merrimack River, but later detected in the Kennebec River during the spawning season (Kynard and Kieffer 2009). It appears that shortnose sturgeon may move extensively between coastal river systems to forage, but return to their natal rivers to reproduce. Understanding the importance of movement between river systems and identifying critical foraging and spawning habitat will help further the recovery of this species. The NHFG should support acoustic tagging studies of shortnose sturgeon in the Gulf of Maine rivers to assess the extent of movement into New Hampshire waters.

Habitat Protection Status

Habitat Management Status

N/A

Threats to this Species or Habitat in NH

Threat rankings were calculated by groups of taxonomic or habitat experts using a multistep process (details in Chapter 4). Each threat was ranked for these factors: Spatial Extent, Severity, Immediacy, Certainty, and Reversibility (ability to address the threat). These combined scores produced one overall threat score. Only threats that received a "medium" or "high" score have accompanying text in this profile. Threats that have a low spatial extent, are unlikely to occur in the next ten years, or there is uncertainty in the data will be ranked lower due to these factors.

Disturbance from dams that block species from spawning areas or other important habitat (Threat Rank: Medium)

Dams block access to freshwater spawning habitat.

There are no known spawning populations of shortnose sturgeon in New Hampshire. The extent of habitat used by sturgeon before dams is not known, but records of sturgeon exist as far upstream as Amoskeag Falls in Manchester (Noon 2003).

List of Lower Ranking Threats:

Mortality from commercial over-harvest due to fishing bycatch

Disturbance from dredging

Actions to benefit this Species or Habitat in NH

Support research in the Gulf of Maine

Objective:
Use acoustic telemetry studies to identify important shortnose sturgeon habitat throughout the Gulf of Maine.

General Strategy:
The network of acoustic telemetry receivers continues to expand in the North Atlantic. Recent research in the Merrimack River suggests that many shortnose sturgeon move into into different rivers and estuaries to forage before returning to their natal river to spawn. The extent of habitat use and movement among shortnose sturgeon populations in the Gulf of Maine is not well understood. Supporting sturgeon movement studies may help determine the relative importance of New Hampshire coastal waters and estuaries as sturgeon habitat.

Political Location:

Watershed Location:

References, Data Sources and Authors

Data Sources

Published literature was used to define global range and characteristics of habitat used in freshwater. Historical distribution of the species was also obtained from published literature. Fisheries professionals provided information on current populations.
Published literature and personal communications with fisheries biologists.

Data Quality

Data are limited to 3 confirmed observations. The most recent observation was an incidental recording of a shortnose sturgeon by a stationary acoustic telemetry receiver in Great Bay (M. Kieffer, USGS, personal communication). Historical distribution information should be treated cautiously because there was often no distinction made between Atlantic sturgeon and shortnose sturgeon.

Acoustic telemetry studies in the Gulf of Maine are providing a growing source of information on shortnose sturgeon populations in the northeast (Fernandes et al. 2010; Kynard and Kieffer 2009; Wippelhauser et al. 2015). The extent and quality of data will improve as more receivers are deployed and more extensive studies are conducted.
There are only 3 confirmed records of shortnose sturgeon in the Great Bay estuary.

2015 Authors:

Matthew Carpenter, NHFG, Benjamin Nugent, NHFG

2005 Authors:

Literature

Fernandes, S.J., G.B. Zydlewski, J.D. Zydlewski, G.S. Wippelhauser, and M.T. Kinnison. 2010. Seasonal distribution and movements of shortnose sturgeon and Atlantic sturgeon in the Penobscot River estuary, Maine. Transactions of the American Fisheries Society 139: 1436-1449.

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Wippelhauser, G. S. , G. B. Zydlewski, M. Kieffer, J. Sulikowski, and M. T. Kinnisone. 2015. Shortnose Sturgeon in the Gulf of Maine: Use of Spawning Habitat in the Kennebec System and Response to Dam Removal. Transactions of the American Fisheries Society. Volume 144, Issue 4, 2015

Atlantic Sturgeon

Acipenser oxyrinchus

Photo by Robert Michelson

Federal Listing	
State Listing	T
Global Rank	
State Rank	S1
Regional Status	V. High

Justification (Reason for Concern in NH)

Atlantic sturgeon were once abundant in the estuaries and larger rivers of the northeast. Early maps sometimes referred to the Merrimack River as the "Sturgeon River". Over-harvest, habitat degradation, and migration barriers contributed to the population declines that were first noticed at the beginning of the twentieth century (Smith 1995). They were harvested as a food source, but their most notable commercial product was their eggs, which were shipped to Europe as caviar to replace the dwindling supply of caviar from the over harvested sturgeon populations in the Black Sea. The Atlantic sturgeon is listed as a federally endangered species throughout its range in the coastal U.S., except for the Gulf of Maine population, where it is listed as threatened (Apostle et al. 2013).

Distribution

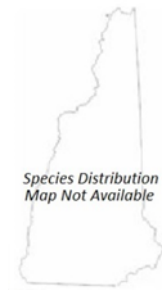
Atlantic sturgeon spawn in Atlantic coastal rivers from Newfoundland to Louisiana. While at sea, Atlantic sturgeon aggregate on foraging grounds along the coastal plain including areas in the Bay of Fundy, Long Island Sound, and off the coast of Virginia (Scott and Crossman 1973). They are a wide ranging fish species and may occasionally forage in the Great Bay Estuary. Since 1981, there have been 2 reports of Atlantic sturgeon in the Great Bay estuary (Doug Grout, NHFG, personal communication). It is not known how far Atlantic sturgeon upstream Atlantic sturgeon swam up the Merrimack River before the construction of dams in the 1800's, but historical records indicate that sturgeon were caught in the river up to Amoskeag Falls in Manchester (although no distinction was made between shortnose and Atlantic sturgeon) (Noon 2003).

Habitat

The Atlantic Sturgeon is anadromous, living in marine waters and entering fresh and brackish waters during spawning migrations. Spawning runs are from February to July depending on the location of the river (Scott and Crossman 1973). In Maine, spawning occurs in July. Migration activity during spawning periods has been observed at depths of 10 to 42 feet and temperatures of 13.3° to 18.4°C (Scott and Crossman 1973, Everhart 1976, Kieffer and Kynard 1993). The return migration of spent adults to marine waters appears to be somewhat random, and the highest concentrations of adults return between September and November (Scott and Crossman 1973). Spawning substrates consist of hard clay, small rubble, and gravel (Everhart 1976). Eggs are adhesive when dispensed, attaching to vegetation and stones. Juveniles will spend up to 4 years in riverine or tidal habitats, where they forage in areas of soft sediment usually at the upstream edge of tidal influence (Scott and Crossman 1973). Atlantic sturgeon are found at relatively shallow depths in the ocean, usually between 5 and 150 meters.

NH Wildlife Action Plan Habitats

- Large Warmwater Rivers
- Estuarine
- Marine



Distribution Map

Current Species and Habitat Condition in New Hampshire

The seasonal abundance and distribution of Atlantic Sturgeon in New Hampshire waters is poorly understood.

Population Management Status

There are no ongoing population management efforts specific to Atlantic sturgeon in New Hampshire.

Regulatory Protection (for explanations, see Appendix I)

- Federal Endangered Species Act
- Possession prohibited

Quality of Habitat

There is no information on the relative quality or importance of habitat for Atlantic sturgeon in NH waters.

Habitat Protection Status

Habitat Management Status

There are no ongoing habitat management efforts specific to Atlantic sturgeon in New Hampshire.

Threats to this Species or Habitat in NH

Threat rankings were calculated by groups of taxonomic or habitat experts using a multistep process (details in Chapter 4). Each threat was ranked for these factors: Spatial Extent, Severity, Immediacy, Certainty, and Reversibility (ability to address the threat). These combined scores produced one overall threat score. Only threats that received a "medium" or "high" score have accompanying text in this profile. Threats that have a low spatial extent, are unlikely to occur in the next ten years, or there is uncertainty in the data will be ranked lower due to these factors.

There are no threats ranked high or medium for this species.

List of Lower Ranking Threats:

Disturbance from dams that block species from spawning areas or other important habitat

Mortality from commercial over-harvest due to fishing bycatch

Disturbance from dredging

Actions to benefit this Species or Habitat in NH

Support research in the Gulf of Maine

Objective:
Use acoustic telemetry studies to identify important Atlantic sturgeon habitat throughout the Gulf of Maine.

General Strategy:
The network of acoustic telemetry receivers continues to expand in the North Atlantic. Recent research in the Merrimack River suggests that many shortnose sturgeon move into different rivers and estuaries to forage before returning to their natal river to spawn. The extent of habitat use and movement among Atlantic sturgeon populations in the Gulf of Maine is not well understood. Supporting sturgeon movement studies may help determine the relative importance of New Hampshire coastal waters and estuaries as sturgeon habitat.

Political Location:

Watershed Location:

References, Data Sources and Authors

Data Sources
Published literature was used to define habitat characteristics and historical distribution. Fisheries professionals provided additional information on recent sightings. Published literature and personal communications with fisheries biologists.

Data Quality
Atlantic sturgeon cannot reach historic spawning areas in the Connecticut and Merrimack watersheds (Micah Kieffer, United States Geological Survey (USGS), personal communication), and only 2 recent (1981 and 1991) observations of the species have occurred in the coastal waters of New Hampshire. A monitoring project for shortnose sturgeon (*Acipenser brevirostrum*) from 1987 to 1988 lacked any incidental catches of Atlantic Sturgeon (NHFG unpublished data).
There are only two records of Atlantic sturgeon in NH waters.

2015 Authors:
Matthew Carpenter, NHFG, Benjamin Nugent, NHFG

2005 Authors:

Literature

Apostle, R., Dadswell, M. J., Engler-Palma, C., Litvak, M. K., McLean, M. F., Stokesbury, M. J., & VanderZwaag, D. L. (2013). Sustaining Atlantic Sturgeon: Stitching a Stronger Scientific and Governance Net. Journal of International Wildlife Law & Policy, 16(2-3), 170-197

Everhart W. 1976. Fishes of Maine. Maine Department of Inland Fisheries and Wildlife. 96p.

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Noon, J. 2003. Fishing in New Hampshire: A History. Moose Country Press. Warner, NH

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Blueback Herring

Alosa aestivalis

Federal Listing	
State Listing	SC
Global Rank	
State Rank	S4
Regional Status	High

Photo by NHFG

Justification (Reason for Concern in NH)

Blueback herring numbers have declined throughout their range. Commercial landings of river herring, a collective term for alewives and blueback herring, have declined by 93% since 1985 (ASMFC 2009). These declines have been observed in local rivers, such as the Oyster River in Durham and the Taylor River in Hampton (Mike Dionne, NHFG Biologist, personal communication). The river herring population in the Merrimack River watershed has been severely depleted. Historic spawning runs, which likely numbered in the millions, have been reduced to the low thousands each year. Blueback herring are rarely observed using the fish lift at the Essex Dam on the Merrimack River, although they have been captured below the dam (Doug Smithwood, USFWS Biologist, personal communication). Blueback herring have not reached New Hampshire waters in the Connecticut River since the population declined in the early 1990's (CRASC 2004).

Distribution

Blueback herring migrate from the ocean into Atlantic coastal rivers from Nova Scotia to Florida. In New Hampshire, blueback herring historically spawned in the rivers and streams that drain into Great Bay, coastal drainages, the Merrimack River, and the Connecticut River (Scarola 1987).

Habitat

Blueback herring inhabit coastal waters for most of their lives, but they migrate into freshwater rivers and streams to spawn (Bigelow and Schroeder 1953). Unlike alewives, which spawn in the calm water of lakes, ponds, and backwaters of rivers, blueback herring prefer to spawn in flowing water.

The blueback herring has a more southern distribution than the alewife and prefers to spawn in slightly warmer water. In New Hampshire, the spawning run of blueback herring usually begins in late May and peaks in June. Eggs are deposited in areas of moderate current in rivers and streams. Juvenile blueback herring grow rapidly in freshwater until late summer and fall, when they migrate downstream to the ocean.

NH Wildlife Action Plan Habitats

- Warmwater Rivers and Streams
- Estuarine
- Marine
- Warmwater Lakes and Ponds

Distribution Map

Current Species and Habitat Condition in New Hampshire

Coastal populations have undergone significant declines in blueback herring numbers counted at fishways. Twenty years ago, the Oyster and Taylor Rivers supported productive blueback herring runs. Currently, only a few thousand blueback herring are counted at the Oyster River each spring and the Taylor River blueback herring run has been reduced to less than 100 fish. Few, if any, blueback herring have been observed passing upstream of the Essex Dam on the Merrimack River. Blueback herring in the Connecticut River have not likely reached New Hampshire waters since the early 1990's.

River herring have been observed in large schools below dams in some rivers, such as the Lamprey River and the Merrimack River. Large numbers of blueback herring have been sampled in the Connecticut River below the Holyoke Dam in Massachusetts, but few river herring are counted at the Holyoke fishway. It is not clear why blueback herring seem to be more reluctant than alewives to enter some fishways. Some biologists have suggested that predators, such as striped bass, which lay in wait at fishway entrances, may prevent blueback herring from using certain fishways (Personal communication Ted Castros-Santos USGS). Blueback herring numbers may have to reach a threshold before they can overwhelm predators that accumulate below fishways (Personal Communication Steve Gephard Connecticut DEP). Alewives, which migrate earlier, would encounter fewer striped bass during their migration period. An alternative explanation is that generations of blueback herring have been spawning below the first barrier on a river because there has been no recent imprinting on habitat upstream. A third possibility is that the fishways themselves are acting as barriers due to flow fields or attraction flows that are not conducive to blueback herring passage. More study is needed on the factors that influence blueback herring upstream migration.

Blueback herring populations may also be influenced by influenced by changes in ocean temperatures and currents, which in turn may affect the zooplankton communities that provide forage for river herring and other planktivores. Bycatch in commercial fishing boats targeting Atlantic herring, mackerel, or other species, may be an important cause of mortality at sea (ASMFC 2009). A better understanding of the marine phase of the blueback herring life cycle will provide some context for setting freshwater population restoration goals.

The following is a summary of known blueback herring population status by watershed:

Salmon Falls River:
The Salmon Falls River supports a mixed run of both alewives and blueback herring. The run is monitored at a fish ladder maintained by staff with the hydroelectric company that owns the South

Berwick Dam, at the head of tide. The fish ladder is in Maine, but it is monitored once every 3 to 5 years by staff from the Marine Division of the NHFG. Counts typically range between 10,000 and 15,000 river herring per year. Length, weight, and age data are not available.

Cocheco River:
In the last three years, river herring returns have been slightly below the long term average of about 30,000 fish per year. The Cocheco River contains a mixed run of both alewives and blueback herring. The relative abundance of each species varies by year.

Bellamy River:
River herring have been observed in the river since the removal of a timber crib dam at the head of tide in 2004. There are currently no population estimates available.

Oyster River:
The Oyster River herring run is primarily composed of blueback herring, but an increasing number of alewives have been observed at the fish ladder in recent years. Blueback herring counts in the Oyster River exceeded 100,000 fish per year in the early 1990's. Currently the population appears to be maintaining low, but stable numbers at fewer than 10,000 fish per year. High summer water temperature and low dissolved oxygen levels in the impoundment upstream of the Mill Pond Dam may be impacting juvenile survival.

Lamprey River:
Large schools of blueback herring have been observed just downstream from the fish ladder at the Macallen Dam on the Lamprey River. These observations have been confirmed using cast nets. It is not clear why blueback herring are not entering the ladder. Recent pit tagging studies at the site suggest that the fish ladder may favor larger fish. Blueback herring, which tend to be smaller than alewives, may not be large or strong enough to ascend the ladder. Adjustments in baffle height or overall fishway design may be necessary to improve passage for blueback herring.

Exeter River:
Large schools of blueback herring have been observed downstream of the String Bridge in Exeter. Stream channel modifications that have occurred below the Great Works Dam over the past 10 ten to 15 years may have created unsuitable passage conditions for blueback herring in the ledges upstream of the bridge. The proposed removal of the Great Works Dam may improve passage by restoring flow to the eastern channel beneath the bridge.

Winnicut River:
River herring numbers ranged between 5,000 and 10,000 before the Winnicut River Dam and fishway were removed in 2009. Unfortunately, a fish ladder installed beneath the Rt. 33 bridge to help ensure passage was poorly designed and has created a velocity barrier for migrating fish. Efforts are currently under way to modify the structure to restore fish passage into the Winnicut River.

Taylor River:
The river herring run in the Taylor River has been essentially extirpated as a result of poor water quality in the impoundment upstream and issues with the fish ladder. Due to leaks in the dam, which has fallen into disrepair, it is difficult to maintain water in the fish ladder without draining the impoundment. Fish passage will not likely improve until either the dam is removed or repaired. Historically, the Taylor River herring run was primarily composed of blueback herring. Annual counts varied, but the river typically supported a run of 30,000 to 50,000 fish each spring.

Other coastal rivers and tributaries:
There are anecdotal reports of herring runs in some of the smaller rivers and streams that flow into Great Bay or coastal NH. There are no data to confirm these reports or provide population estimates.

Population Management Status

The NHFG is working to restore river herring to coastal rivers and the Merrimack River watershed. Fish ladders are monitored by the NHFG on the major tributaries of Great Bay, including the Cocheco, Oyster, Lamprey, and Exeter Rivers. However, much of the former spawning habitat of river herring remains inaccessible in New Hampshire. River herring have been stocked upstream of impassable dams in New Hampshire to try to restore extirpated runs and enhance existing, but depleted runs. This strategy has been deployed in the Lamprey, Cocheco, and Merrimack River watersheds.

The NHFG is working with partners like the U. S. Fish and Wildlife Service and the Massachusetts Fish and Wildlife Division to restore river herring numbers in the Merrimack River. Strategies include stocking adult river herring from other rivers including the Kennebec, Androscoggin, Lamprey, and Cocheco Rivers, into suitable habitat within the Merrimack River watershed. The largest of these stocking sites is Lake Winnisquam, which has the potential to produce herring returns in the hundreds of thousands by the year 2017.

Regulatory Protection (for explanations, see Appendix I)

- Anadromous Fish Conservation Act
- Harvest permit - season/take regulations

Quality of Habitat

The Oyster, Taylor, Lamprey, Cocheco, Exeter, Winnicut, and Bellamy Rivers are capable of supporting sizeable river herring runs. The challenge is to provide access and monitor/manage the fishways. The Merrimack River has excellent habitat in its mainstem and tributaries as far north as Franklin. Fish passage is currently available at the first three dams on the mainstem of the Merrimack River (the Essex Dam in Lawrence, MA, the Pawtucket Dam in Lowell, MA, and the Amoskeag Dam in Manchester, NH) and at the first two dams on the Nashua River. The upper Connecticut River (from the Turners Falls Dam in Massachusetts up to the Bellows Falls in New Hampshire) is capable of supporting an estimated blueback herring population of up to 5,000,000 fish (CRASC 2004).

The following is a summary of blueback herring spawning habitat availability by watershed:

Connecticut River Watershed:
The Connecticut River has tremendous potential for restoration. The blueback herring run in the upper Connecticut River has been essentially extirpated. There are at least 87 river km of potential blueback herring spawning habitat in the Connecticut River upstream of the Turners Falls Dam (CRASC 2015).

Merrimack River Watershed:
The ultimate success of river herring restoration programs in the New Hampshire portion of the Merrimack River watershed will depend on improvements in fish passage, which will allow river herring to reach as much suitable spawning habitat as possible. Currently, very few blueback herring have been documented passing upstream of the Essex Dam in Lawrence despite anecdotal observations of blueback herring below the dam. If blueback herring were able to pass upstream of the two dams in Massachusetts, they would have access to over 50 river km of potential spawning

habitat in New Hampshire. This does not include potential habitat in the tributaries. There is tremendous potential for blueback herring restoration in the Merrimack River watershed, but this potential cannot be reached until fisheries managers can identify the cause (or causes) of poor blueback herring passage at the Essex Dam.

Lamprey River:
There are a potential 75 km of potential river herring spawning habitat in the Lamprey River watershed. Blueback herring appear to spawn primarily in the short section (less than 1 km) of brackish water just below the Macallen Dam in Newmarket. Modifications to the fish ladder may help improve fish passage for blueback herring, but more research is needed to identify the reasons for poor passage at this site.

Winnicut River:
The Winnicut River Dam removal and fish ladder construction has the potential to improve access for spawning river herring, but it needs some modifications. Fish passage engineers with the USFWS have identified a velocity barrier caused by the design of the fish ladder that was installed to ensure fish passage underneath the bridge, which is located just upstream from the dam removal site. Minor adjustments to this fish ladder should restore access to approximately 6 km of potential spawning habitat.

Exeter River:
The Great Works Dam at the head of tide in Exeter has been proposed for removal. This would greatly improve river herring passage into the river. Blueback herring have not been observed in the fish ladder at the Great Works Dam in over a decade, although there have been schools observed spawning downstream. The Exeter River has approximately 19 km of potential river herring spawning habitat. There is a fish ladder at the Pickpocket Dam, which is approximately 10 river km from the head of tide. Not much is known about the efficiency of this ladder due to the small number of fish that have historically reached the Pickpocket Dam.

Cocheco River:
The first two dams on the Cocheco River contain active hydropower facilities. A relatively long fish ladder at the Central Ave Dam provides fish passage over the dam and the ledges on which the dam was constructed. This fishway provides access to approximately 5 km of potential river herring spawning habitat. The next upstream dam, the Watson Dam, is the upstream limit for fish passage in the Cocheco River. There is some question about the ability of river herring to ascend the steep ledges, known as Factory Falls, downstream of the Watson Dam. If it can be proven that river herring reach the Watson Dam, then upstream fish passage would be negotiated through the Federal Energy Regulatory Commission (FERC) hydropower licensing process. Downstream fish passage for juvenile river herring is required at the Central Ave Dam, but there is little information on juvenile herring survival during the downstream migration period.

Oyster River:
The Oyster River has historically been considered a primarily blueback herring run, but an increasing number of alewives have been noted in the fish ladder at the head of tide. The faster flowing river reach upstream of the Mill Pond Dam impoundment is suitable spawning habitat for blueback herring, but low dissolved oxygen levels in the impoundment in the summer may inhibit juvenile survival. The total length of accessible river habitat is relatively short, at less than 4 km.

Bellamy River:
The removal of a small timber crib dam at the head of tide provided access to a small amount freshwater river habitat (less than 1 km) in 2004. Anecdotal reports suggest that there is a river herring run in the river, but the abundance of the run and the relative composition of alewives vs.

blueback herring is unknown. Proposed dam removals on the next two upstream dams (upper and lower Sawyers Mill Dams) would provide access to over 6 km of potential spawning habitat.

Salmon Falls River:
There is approximately 1.5 river km of potential spawning habitat upstream of the fish ladder at the South Berwick Dam. Fish passage is not provided at the next upstream dam, which is owned by the town of Rollinsford.

Coastal tributaries:
The extent of suitable spawning habitat in the small rivers and streams that drain into the Great Bay and the seacoast is unknown. Without fishways, these streams are difficult to monitor. Some streams, such as Fresh Creek in Rollinsford, may have great restoration potential. Replacing an elevated stream crossing at the head of tide, on Fresh Creek, would both restore salt marsh habitat and provide access for diadromous fish species, possibly including searun brook trout, to over 5 km of freshwater habitat.

Habitat Protection Status

Habitat Management Status

Dam removals and fish passage construction increase the availability of spawning habitat for river herring. The ultimate success of river herring restoration programs will depend on improvements in fish passage, which will allow river herring to reach as much suitable spawning habitat as possible. The long term goal of a self-sustaining river herring population in New Hampshire will depend largely on the efficiency of existing fishways and on the construction of new fishways at dams throughout the state.

Fishways must be monitored to ensure efficient passage. Seemingly minor adjustments in flow through a fish passage facility can make a big difference in its performance. Attraction flow and flow fields/velocity through the fishway can fluctuate significantly with changes in water level at a dam. Dams must also be monitored for downstream passage in the fall when juvenile river herring are migrating to the ocean. Dam removals are the preferred solution in most cases, because river herring are able to move freely upstream and downstream, while fishways have a relatively narrow range of flows where passage is optimal. There are currently at least 14 fishways in NH that require some level of maintenance and monitoring for diadromous fish species. The coastal fishways are monitored by NHFG staff. The Merrimack River dams are monitored by a combination of hydroelectric company staff and biologists from USFWS and NHFG. The Connecticut River Dams are monitored using video counting software deployed by Vermont Fish and Wildlife.

Threats to this Species or Habitat in NH

Threat rankings were calculated by groups of taxonomic or habitat experts using a multistep process (details in Chapter 4). Each threat was ranked for these factors: Spatial Extent, Severity, Immediacy, Certainty, and Reversibility (ability to address the threat). These combined scores produced one overall threat score. Only threats that received a "medium" or "high" score have accompanying text in this profile. Threats that have a low spatial extent, are unlikely to occur in the next ten years, or there is uncertainty in the data will be ranked lower due to these factors.

Disturbance from dams that block species from spawning areas or other important habitat (Threat Rank: High)

Dams block fish species from accessing important habitat (Burdick and Hightower 2006).

Dams have been implicated in the declines of diadromous species throughout the northeast (Limburg and Waldman 2009). They have also contributed to declines in freshwater fish and mussel species (Watters 1995).

Disturbance from predation and predator avoidance at fishways (striped bass) (Threat Rank: Medium)

Although fishways provide access to habitat upstream of dams, they create an unnatural bottleneck in fish movement. Predator species take advantage of this bottleneck by laying in ambush at the entrance to the fishway. High densities of predators at the entrance to the fishway may act as a deterrent to upstream movement for some species.

Congregations of both blueback herring and striped bass have been noted downstream of dams on the Connecticut, Merrimack, and coastal rivers where few, if any, blueback herring make it through the fishway. It is not clear whether poor blueback herring passage at these sites is due to predator avoidance, design issues with the fishways, or other factors. More research is needed on the factors that limit blueback herring passage.

List of Lower Ranking Threats:

Disturbance from dams causing delayed migration

Mortality from hydropower turbines

Species impacts from changes in timing of migration and flooding that decrease spawning success

Actions to benefit this Species or Habitat in NH

Marine research

Objective:
Investigate the factors that influence river herring abundance and survival at sea.

General Strategy:
A number of factors, including bycatch in commercial fisheries, changes in the marine food webs, and striped bass predation, have been blamed for the dramatic declines in river herring populations, but more information is needed on the relative importance of the factors limiting river herring survival at sea. A better understanding of potential marine productivity would be useful in setting restoration goals for spawning rivers.

Political Location: **Watershed Location:**

Reduce bycatch

Objective:
Reduce the number of river herring caught unintentionally in the commercial Atlantic herring and mackerel fishery.

General Strategy:

The Massachusetts Department of Marine Resources (DMR) and the National Marine Fisheries Service (NMFS) coordinate Fisheries Observer and Port Sampling bycatch monitoring programs. There is also a volunteer bycatch avoidance program operated in real time by Mass DMR based on bycatch reports from vessels at sea. Seasonal area closures and catch quotas have also been used to reduce impacts related to the commercial fishery. State and federal agencies should support efforts to improve bycatch data collection and avoidance. NHFG should investigate the necessity and feasibility of increased port sampling for river herring bycatch at New Hampshire landing areas.

Political Location: **Watershed Location:**

Fish transfers

Primary Threat Addressed: Disturbance from dams that block species from spawning areas or other important habitat

Specific Threat (IUCN Threat Levels): Natural system modifications / Dams & water management/use / Dams (size unknown)

Objective:

Transfer diadromous fish species into suitable freshwater habitat that is currently inaccessible due to dams or other manmade barriers.

General Strategy:

In some cases it may be appropriate to move diadromous fish into habitat that is currently inaccessible. Improving access to quality spawning habitat may increase the spawning population within a river system. In many cases, a certain number of returning fish will trigger fish passage at a dam where a fish passage prescription has been negotiated through the FERC licensing process. In other cases, congregations of diadromous species downstream from a dam demonstrate a clear need for fish passage at the site. Sources of fish transfers should come from within basin whenever possible, but in river reaches where diadromous fish species have been extirpated, fish may need to be transferred from neighboring watersheds. The risk of introducing diseases or invasive organisms should be considered when transferring fish from out of basin. Some level of testing may be required.

Political Location: **Watershed Location:**

Improve fish passage at dams

Primary Threat Addressed: Disturbance from dams that block species from spawning areas or other important habitat

Specific Threat (IUCN Threat Levels): Natural system modifications / Dams & water management/use / Dams (size unknown)

Objective:

Construct, maintain, and monitor fishways at dams that currently limit access to suitable freshwater habitat for diadromous fish.

General Strategy:

At sites where dam removal is not an option, fish passage construction can improve connectivity between freshwater and marine habitats. Fish passage construction may be negotiated during the FERC licensing process. Fish passage engineers with the USFWS are available to assist with designing the appropriate fishway for a particular site, depending on the needs of the species and the size of the dam (among other factors). At some sites outside of FERC jurisdiction, funding may have to come from other sources. Once installed, there should be a plan for fish passage operation, maintenance, and monitoring. Identifying the party responsible for each aspect of fishway operation is critical for maintaining effective passage over the long term. Periodic performance evaluations should also be completed at each fishway to ensure that fish are moving efficiently through the project without excessive delays.

Political Location: **Watershed Location:**

Dam removal

Primary Threat Addressed: Disturbance from dams that block species from spawning areas or other important habitat

Specific Threat (IUCN Threat Levels): Natural system modifications / Dams & water management/use / Dams (size unknown)

Objective:
Remove barriers to migration.

General Strategy:
When the opportunity presents itself, dam removals provide the best long term solution to reconnecting diadromous fish with their historical freshwater spawning habitat. Dam removal projects are challenging and they often stall without a dedicated project manager. Hiring and training staff to identify and facilitate dam removal projects will increase the number of projects that can be completed each year. Creating priority lists of dam removal projects for each species would also help focus resources on the projects with the most benefit as well as help generate funding.

Political Location: **Watershed Location:**

Map spawning habitat

Objective:
Map the spawning habitat used by anadromous fish in the Connecticut, Merrimack, and Coastal watersheds.

General Strategy:
While spawning adults are counted each spring in many New Hampshire Rivers, the exact location of actual spawning areas has yet to be mapped. The extent of suitable spawning habitat for alewives, blueback herring, sea lamprey, and American shad is not well known. This research would likely involve the use of radio telemetry and visual surveys during the spawning season.

Political Location: **Watershed Location:**

Population assessment

Objective:
Assess the current and potential productivity of diadromous fish species in New Hampshire waters.

General Strategy:
Setting restoration goals for diadromous fish species is difficult without realistic targets for population recovery. Developing population models based on fecundity, extent and quality of habitat, and sources of mortality would help estimate the potential abundance of diadromous fish species under different management scenarios. This information would be useful to fisheries managers as they set stocking targets or prioritize restoration work. Understanding the potential abundance of diadromous fish populations would more clearly define successful restoration and put current population levels in perspective.

Political Location: **Watershed Location:**

Fish passage efficiency studies

Objective:
Investigate the factors that influence the use of fishways by blueback herring.

General Strategy:
Blueback herring have been observed accumulating in large numbers below a number of dams with fishways that are used by other diadromous fish species. Some have speculated that striped bass and other predatory species at the entrance of the fishways may be preventing passage. More research is needed to answer the question of why blueback herring appear less likely to use upstream fish passage facilities.

Political Location: **Watershed Location:**

Monitor fish passage

Objective:
Monitor upstream and downstream passage at dams.

General Strategy:
Monitor diadromous fish passage at dams with trained staff, video equipment or periodic sampling. Assess the efficiency of upstream and downstream passage facilities. Make recommendations for improving existing or proposed fish passage structures.

Political Location: **Watershed Location:**

References, Data Sources and Authors

Data Sources

Literature reviews and historical records of fish passage at dams in New Hampshire and Massachusetts were used to identify distribution and habitat requirements. River herring management plans, fishway counts, and stocking records.

Data Quality

River herring returns are monitored at fishways on the Connecticut, Merrimack, and coastal rivers.The best data comes from coastal rivers where biologists periodically sample during the migration period to determine the relative abundance of alewives vs. blueback herring. Blueback herring and alewives are usually grouped as river herring in fishway counts. The two species are difficult to tell apart and hybridization does occur. Subsamples are taken on some coastal rivers, the lower Connecticut River, and more recently, the Merrimack River. Typical data collected includes species, age, sex, length, and weight. Fish count estimates vary widely in accuracy by site. They should be considered rough estimates useful in evaluating long term trends.

2015 Authors:

Matthew Carpenter, NHFG, Benjamin Nugent, NHFG

2005 Authors:

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Alewife

Alosa pseudoharengus

Photo by NHFG

Federal Listing	
State Listing	SC
Global Rank	G5
State Rank	S5
Regional Status	High

Justification (Reason for Concern in NH)

Alewife numbers have declined significantly throughout their range. Commercial landings of river herring, a collective term for alewives and blueback herring, have declined by 93% since 1985 (ASMFC 2009). Dams severely limit accessible anadromous fish spawning habitat, and alewives must use fish ladders for access to most spawning habitat in New Hampshire during spring spawning runs. River herring are a key component of freshwater, estuarine, and marine food webs (Bigelow and Schroeder 1953). They are an important source of prey for many predators, and they contribute nutrients to freshwater ecosystems (Macavoy et al. 2000).

Distribution

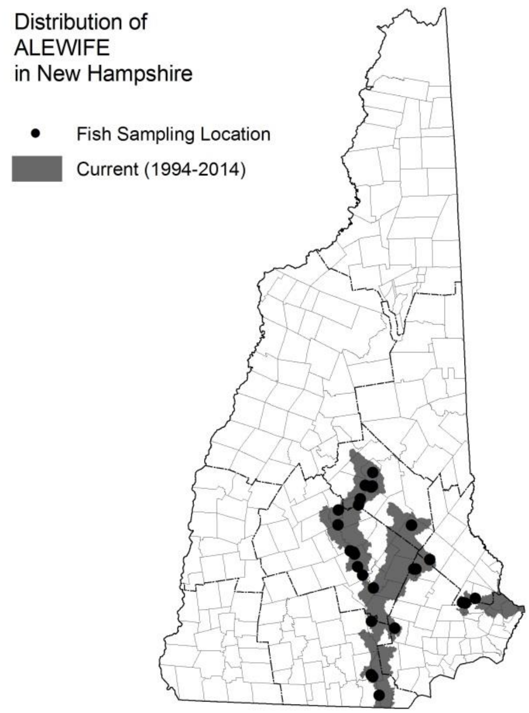
The alewife is found in Atlantic coastal rivers from Newfoundland to North Carolina. It has been introduced into a number of inland waterbodies (Scott and Crossman 1973). In New Hampshire, alewives migrate into the Merrimack River and the seacoast drainages (Scarola 1987).

Habitat

Adult alewives migrate from the ocean into freshwater spawning habitats with slow moving water, including riverine oxbows, lakes, ponds, and mid-river sites (Scott and Crossman 1973). Juveniles remain in freshwater until late summer and early fall when they migrate downstream into estuaries and eventually to the ocean. There is little information available on alewife movement and habitat use in the ocean.

NH Wildlife Action Plan Habitats

- Large Warmwater Rivers
- Warmwater Lakes and Ponds
- Warmwater Rivers and Streams



Distribution Map

Current Species and Habitat Condition in New Hampshire

Coastal Watersheds:
Alewife populations in the coastal watersheds are generally stable or increasing in recent years at fish ladders where river herring and other diadromous species have been monitored since 1979. However, alewife numbers in all rivers are still well below their potential. Populations have not yet responded to recent increases in available habitat due to dam removals or fish passage improvements.

Salmon Falls River: The Salmon Falls River supports a mixed run of both alewives and blueback herring. The run is monitored at a fish ladder maintained by staff with the hydroelectric company that owns the South Berwick Dam, at the head of tide. The fish ladder is in Maine, but it is monitored once every 3 to 5 years by staff from the Marine Division of the NHFG. Counts typically range between 10,000 and 15,000 river herring per year. Length, weight, and age data are not available.

Cocheco River: In the last three years, river herring returns have been slightly below the long term average of about 30,000 fish per year. Both alewives and blueback herring occur in the Cocheco River. The relative abundance of each species is highly variable, but alewives generally outnumber blueback herring, which return later in the spring.

Bellamy River: River herring have been observed in the river since the removal of a timber crib dam at the head of tide in 2004. There are currently no population estimates available.

Appendix A: Fish

Oyster River: The Oyster River herring run is primarily composed of blueback herring, but an increasing number of alewives have been observed at the fish ladder in recent years.

Lamprey River: The Lamprey River contains the most abundant alewife population in coastal New Hampshire. Alewife counts at the fish ladder over the last three years (2012 – 2014) have ranged between 79,000 and 86,000 fish per year. This is more than double the long term average. Recent improvements in fish passage, including a fish ladder constructed at the next upstream dam and a dam removal in Epping, should greatly expand the quality and quantity of spawning habitat available to alewives in the Lamprey River. However, there are some concerns that the fish ladder has reached its capacity, and may limit the total number of alewives that can enter the river.

Exeter River: The river herring count at the Exeter River has only exceeded 1,000 fish once since 2001. The fish ladder does not appear to be effectively passing the large number of river herring that are frequently observed downstream, near the head of tide. Plans to remove the Great Works Dam have the potential to greatly improve access to spawning habitat up river. Monitoring the number of river herring that return to the Exeter River will require new sampling methods without a fish ladder.

Winnicut River: River herring numbers ranged between 5,000 and 10,000 fish per year before the Winnicut Dam and fishway were removed in 2009. Unfortunately, a fish ladder installed beneath the Route 33 bridge to help ensure passage was poorly designed and has created a velocity barrier for migrating fish. Efforts are currently under way to modify the structure to restore fish passage into the Winnicut River.

Taylor River: The river herring run in the Taylor River was primarily composed of blueback herring. The run has been essentially extirpated, with less than 100 fish counted at the ladder in recent years. Contributing factors include poor water quality in the impoundment upstream and issues with the fish ladder. Due to leaks in the dam, which has fallen into disrepair, it is difficult to maintain water in the fish ladder without draining the impoundment. Fish passage will not likely improve until the dam is either removed or repaired.

Other coastal rivers and tributaries: There are anecdotal reports of herring runs in some of the smaller rivers and streams that flow into Great Bay or coastal NH. There are no data to confirm these reports or provide population estimates.

Merrimack River Watershed

Efforts to restore river herring (alewives and blueback herring) to the Merrimack River watershed began as early as 1830, with the construction of a fish ladder at the Amoskeag Dam in Manchester. Fish ladders were then built at the dams constructed in Lowell and Lawrence, MA sometime after 1847. Early records from the New Hampshire Fish and Game Commission in 1879 and 1882 show a strong alewife run at the fish ladder on the Essex Dam in Lawrence, MA . Precolonial alewife runs in the Merrimack River likely numbered in the millions. Fish passage was not consistently provided at the dams above Amoskeag, including the Hooksett Dam and the Garvins Falls Dam, which essentially extirpated the river herring population in the upper Merrimack River (Noon 2003).

Modern attempts to restore river herring, along with other diadromous species, began with new fishway construction at the first three dams on the lower Merrimack River mainstem. Trap and transport efforts to restore river herring to the Merrimack River began in the 1990's as a partnership between the United States Fish and Wildlife Service (USFWS), the New Hampshire Fish and Game Department (NHFG), and Massachusetts Division of Fisheries and Wildlife (MDFW). These agencies, in addition to the United States Forest Service (USFS) and National

Marine Fisheries Service (NMFS), are represented on the Merrimack River Policy Committee, an interstate cooperative which makes decisions related to diadromous fish resources in the Merrimack River.

Prior to 1990, alewives were stocked in Lake Winnisquam to provide forage for salmonids and export excess nutrients from effluent flowing into the lake in the early 1980's. An unintentional consequence of the stocking was a large increase in the Merrimack River alewife run after juvenile herring emigrated to the sea and attempted to return as adults. Five years after the first alewives were stocked in Lake Winnisquam, nearly 400,000 river herring returned to the Merrimack River.

Unfortunately, Fisheries managers were not prepared to deal with this number of fish and river herring were unable to access the majority of their historic spawning habitat. The temporary increase in river herring numbers masked the underlying problem of poor connectivity between marine and freshwater habitats. The last stocking of Lake Winnisquam occurred in 1990, and not long afterward the run declined. The average number of river herring counted at the Essex Dam in Lawrence after 1995 was less than 7,000 fish, compared to an average of over 100,000 returning alewives in the years prior to 1995.

After 1990, alewife trap and transport efforts shifted to smaller waterbodies in the Merrimack River watershed, including a number of stocking sites in the Contoocook, Suncook, and Nashua River drainages. These stocking efforts were limited in scale by a lack of fish available for transfer. Additional factors that may have limited alewife restoration include overharvest or bycatch issues in ocean fisheries, or predation from striped bass, which peaked in abundance in the 1990's during a period of significant decline in river herring returns (Grout 2006; Schultz et al. 2009).

Population Management Status

The New Hampshire Fish and Game Department is working to restore river herring to coastal rivers and the Merrimack River watershed. Fish ladders are monitored at the first dams on the major tributaries of Great Bay, including the Cocheco, Oyster, Lamprey, and Exeter Rivers. However, much of the former spawning habitat of river herring remains inaccessible in New Hampshire. Dam removals are the best long term strategies for restoring river herring runs. Fish passage construction at dams is the next best option where removal is not possible. Fishways can be effective, but they must be constantly monitored and passage rates can vary significantly by species and flow rate. In some rivers, primarily the Lamprey and Cocheco Rivers, NHFG biologists have transferred alewives from fishways near the mouth of the river to inaccessible spawning habitat upstream to help increase the population size.

The New Hampshire Fish and Game Department is working with partners like the U. S. Fish and Wildlife Service and the Massachusetts Fish and Wildlife Division to restore river herring numbers in the Merrimack River. In 2012, NHFG and USFWS resumed alewife transfers to a number of stocking sites, including Lake Winnisquam, throughout the Merrimack River watershed as part of a three phase river herring restoration plan for the Merrimack River (MRTC 2014). The plan was modelled after the successful river herring restoration efforts by the Maine Department of Marine Resources in the Kennebec River watershed, which now supports a river herring run of over 2,000,000 fish annually (MDMR 2009).

Regulatory Protection (for explanations, see Appendix I)

- Anadromous Fish Conservation Act
- Harvest permit - season/take regulations

Quality of Habitat

Coastal Watersheds

The amount of spawning habitat available to alewives in the coastal watersheds has increased since 2005. The greatest restoration benefit came from fish passage improvements in the Lamprey River. Despite this increase in habitat available to river herring in the coastal drainages, the majority of spawning habitat is still blocked by dams. Estimates of accessible spawning habitat, here measured in river km, are intended to provide a rough idea of current versus potential habitat availability. Actual spawning runs may be limited by unforeseen barriers such as small waterfalls or the ruins of old dams. Mapping the actual extent of restored spawning runs and documenting important spawning areas within rivers will be important to refining restoration goals. The following is a summary of accessible habitat status by river:

Lamprey River: Fish ladder construction at the Wiswall Dam improved access and the removal of the Bunker Pond Dam opened up a potential 75 km of the Lamprey River watershed to migrating alewives. A recent telemetry study by biologists with the Marine Division of NHFG has shown that alewife upstream movement is currently blocked by the ruins of a dam, known as Wadleigh Falls. It is hoped that some minor modifications of the stream channel will improve fish passage at the site.

Winnicut River: The Winnicut River Dam removal and fish ladder construction has the potential to improve access for spawning river herring, but it needs some modifications. Fish passage engineers with the USFWS have identified a velocity barrier caused by the design of the fish ladder that was installed to ensure fish passage underneath the bridge, which is located just upstream from the dam removal site. Minor adjustments to this fish ladder should restore access to approximately 6 km of potential spawning habitat.

Exeter River: The Great Works Dam at the head of tide in Exeter has been proposed for removal. This would greatly improve alewife passage into the river. Fish passage is currently limited to less than 1,000 fish per year by a poorly functioning fish ladder. The Exeter River has approximately 19 km of potential alewife spawning habitat. There is a fish ladder at the Pickpocket Dam, which is approximately 10 river km from the head of tide. Not much is known about the efficiency of this ladder due to the small number of fish that have historically reached the Pickpocket Dam.

Cocheco River: The first two dams on the Cocheco River contain active hydropower facilities. A relatively long fish ladder at the Central Ave Dam provides fish passage over the dam and the ledges on which the dam was constructed. This fishway provides access to approximately 5 km of potential river herring spawning habitat. The next upstream dam, the Watson Dam, is the upstream limit for fish passage in the Cocheco River. There is some question about the ability of river herring to ascend the steep ledges, known as Factory Falls, downstream of the Watson Dam. If it can be proven that river herring reach the Watson Dam, then upstream fish passage would be negotiated through the FERC hydropower licensing process. Downstream fish passage for juvenile river herring is required at the Central Ave Dam, but there is little information on juvenile herring survival during the downstream migration period.

Oyster River: The Oyster River has historically been considered a primarily blueback herring run, but an increasing number of alewives have been noted in the fish ladder at the head of tide. The impoundment upstream of the dam is suitable spawning habitat for alewives, but low dissolved oxygen levels in the summer may inhibit juvenile survival. The total length of accessible river habitat is relatively short, at less than 4 km.

Bellamy River: The removal of a small timber crib dam at the head of tide provided access to a small amount of freshwater river habitat (less than 1 km). Anecdotal reports suggest that there is a river herring run in the river, but the abundance of the run and the relative composition of alewives vs. blueback herring is unknown. Proposed dam removals on the next two upstream dams (upper and lower Sawyers Mill Dams) would provide access to over 6 km of potential alewife spawning habitat.

Salmon Falls River: There are approximately 1.5 river km of potential spawning habitat upstream of the fish ladder at the South Berwick Dam. Fish passage is not provided at the next upstream dam, which is owned by the town of Rollinsford.

Coastal tributaries:
The extent of suitable spawning habitat in the small rivers and streams that drain into the Great Bay and the seacoast is unknown. Without fishways, these streams are difficult to monitor. Some streams, such as Fresh Creek in Rollinsford, may have great restoration potential. Replacing an elevated stream crossing at the head of tide, on Fresh Creek, would both restore salt marsh habitat and provide access for diadromous species, possibly including searun brook trout, to over 5 km of freshwater habitat.

Merrimack River Watershed
The ultimate success of river herring restoration in the New Hampshire portion of the Merrimack River watershed will depend on improvements in fish passage that will allow river herring to reach as much suitable spawning habitat as possible. Fish passage is currently available at the first three dams on the mainstem of the Merrimack River and at the first two dams on the Nashua River. The long term goal of a self-sustaining river herring population in the Merrimack River will depend largely on the efficiency of these existing fishways and on the construction of new fishways at dams throughout the upper Merrimack River watershed, including tributaries like the Suncook River, the Soucook River, and the Contoocook River. At least 6,877 acres of potential alewife spawning habitat in lakes and ponds has been identified where fish passage construction may be feasible in the Merrimack River watershed (NHFG unpublished data).

Habitat Protection Status

N/A

Habitat Management Status

Fishways must be monitored to ensure efficient passage. Seemingly minor adjustments in flow through a fish passage facility can make a big difference in its performance. Attraction flow and water velocity through the fishway can fluctuate significantly with changes in water level at a dam.

Dams must also be monitored for downstream passage in the fall when juvenile river herring are migrating to the ocean. Dam removals are the preferred solution in most cases, because river herring are able to move freely upstream and downstream, while fishways have a relatively narrow range of flows where passage is optimal. There are currently 10 fishways in NH that require some level of maintenance and monitoring for river herring. The coastal fishways are monitored by NHFG staff. The Merrimack River dams are monitored by a combination of hydroelectric company staff and biologists from the USFWS and NHFG.

Threats to this Species or Habitat in NH

Threat rankings were calculated by groups of taxonomic or habitat experts using a multistep process (details in Chapter 4). Each threat was ranked for these factors: Spatial Extent, Severity, Immediacy, Certainty, and Reversibility (ability to address the threat). These combined scores produced one overall threat score. Only threats that received a "medium" or "high" score have accompanying text in this profile. Threats that have a low spatial extent, are unlikely to occur in the next ten years, or there is uncertainty in the data will be ranked lower due to these factors.

Disturbance from dams that block species from spawning areas or other important habitat (Threat Rank: High)

Dams block access to freshwater spawning habitat.

Dams have greatly reduced the amount of freshwater habitat available to alewives and other diadromous species (Limburg and Waldman 2009).

Mortality resulting from over-harvest related to commercial fishing bycatch (Threat Rank: Medium)

River herring are unintentionally harvested in the commercial midwater trawl fishery for Atlantic herring and mackerel. River herring bycatch makes up a small proportion of total harvest, but it has the potential to severely deplete river herring spawning runs, especially in smaller river systems or populations under restoration.

Massachusetts Department of Marine Fisheries and the National Marine Fisheries Service monitor bycatch using fisheries observers and port sampling (Cieri 2008).

Mortality from hydropower turbines (Threat Rank: Medium)

River herring are killed as they pass through hydropower turbines.

River herring mortalities are observed each year downstream of the dams on the Winnipesauke River and the Merrimack River.

List of Lower Ranking Threats:

Mortality and disturbance (predator avoidance) from predation at fishways (striped bass)

Disturbance from dams causing delayed migration

Species impacts from changes in timing of migration and flooding that decrease spawning success

Actions to benefit this Species or Habitat in NH

Population assessment

Objective:
Assess the current and potential productivity of diadromous fish species in New Hampshire waters.

General Strategy:
Setting restoration goals for diadromous fish species is difficult without realistic targets for population recovery. Developing population models based on fecundity, extent and quality of habitat, and sources of mortality would help estimate the potential abundance of diadromous fish species under different

management scenarios. This information would be useful to fisheries managers as they set stocking targets or prioritize restoration work. Understanding the potential abundance of diadromous fish populations would more clearly define successful restoration and put current population levels in perspective.

Political Location: **Watershed Location:**

Reduce bycatch

Primary Threat Addressed: Mortality resulting from over-harvest related to commercial fishing bycatch

Specific Threat (IUCN Threat Levels): Biological resource use / Fishing & harvesting aquatic resources / Unintentional effects (species being assessed is not the target)

Objective:
Reduce the number of river herring caught unintentionally in the commercial Atlantic herring and mackeral fishery.

General Strategy:
The Massachusetts Department of Marine Resources (DMR) and the National Marine Fisheries Service (NMFS) coordinate Fisheries Observer and Port Sampling bycatch monitoring programs. There is also a volunteer bycatch avoidance program operated in real time by Mass DMR based on bycatch reports from vessels at sea. Seasonal area closures and catch quotas have also been used to reduce impacts related to the commercial fishery. State and federal agencies should support efforts to improve bycatch data collection and avoidance. NHFG should investigate the necessity and feasibility of increased port sampling for river herring bycatch at New Hampshire landing areas.

Political Location: **Watershed Location:**

Improve fish passage at dams.

Primary Threat Addressed: Disturbance from dams that block species from spawning areas or other important habitat

Specific Threat (IUCN Threat Levels): Natural system modifications / Dams & water management/use / Dams (size unknown)

Objective:
Construct, maintain, and monitor fishways at dams that currently limit access to suitable freshwater habitat for diadromous fish.

General Strategy:
At sites where dam removal is not an option, fish passage construction can improve connectivity between freshwater and marine habitats. Fish passage construction may be negotiated during the Federal Energy Regulatory Commission (FERC) dam relicensing process. Fish passage engineers with the USFWS are available to assist with designing the appropriate fishway for a particular site, depending on the needs of the species and the size of the dam (among other factors). At some sites outside of FERC jurisdiction, funding may have to come from other sources. Once installed, there should be a plan for fish passage operation, maintenance, and monitoring. Identifying the party

responsible for each aspect of fishway operation is critical for maintaining effective passage over the long term. Periodic performance evaluations should also be completed at each fishway to ensure that fish are moving efficiently through the project without excessive delays.

Political Location: **Watershed Location:**

Map spawning habitat

Objective:
Map the spawning habitat used by anadromous fish in the Merrimack River and Coastal watersheds.

General Strategy:
While spawning adults are counted each spring in many New Hampshire Rivers, the exact location of actual spawning areas has yet to be mapped. The extent of suitable spawning habitat for alewives, blueback herring, and American shad is not well known. This research would likely involve the use of radio telemetry and visual surveys during the spawning season.

Political Location: **Watershed Location:**

Marine research

Objective:
Investigate the factors that influence river herring abundance and survival at sea.

General Strategy:
A number of factors, including bycatch in commercial fisheries, changes in the marine food webs, and striped bass predation, have been blamed for the dramatic declines in river herring populations, but more information is needed on the relative importance of the factors limiting river herring survival at sea. A better understanding of potential marine productivity would be useful in setting restoration goals for spawning rivers.

Political Location: **Watershed Location:**

Monitor fish passage

Objective:
Monitor upstream and downstream passage at dams.

General Strategy:
Monitor river herring passage at dams with trained staff, video equipment or periodic sampling. Assess the efficiency of upstream and downstream passage facilities. Make recommendations for improving existing or proposed fish passage structures.

Political Location: **Watershed Location:**

Dam removal

Primary Threat Addressed: Disturbance from dams that block species from spawning areas or other important habitat

Specific Threat (IUCN Threat Levels): Natural system modifications / Dams & water management/use / Dams (size unknown)

Objective:
Remove barriers to migration.

General Strategy:
When the opportunity presents itself, dam removals provide the best long term solution to reconnecting diadromous fish with their historical freshwater spawning habitat. Dam removal projects are challenging and they often stall without a dedicated project manager. Hiring and training staff to identify and facilitate dam removal projects will increase the number of projects that can be completed each year. Creating priority lists of dam removal projects for each species would also help focus resources on the projects with the most benefit as well as help generate funding.

Political Location: **Watershed Location:**

Fish transfers

Primary Threat Addressed: Disturbance from dams that block species from spawning areas or other important habitat

Specific Threat (IUCN Threat Levels): Natural system modifications / Dams & water management/use / Dams (size unknown)

Objective:
Transfer diadromous fish species into suitable freshwater habitat that is currently inaccessible due to dams or other manmade barriers.

General Strategy:
In some cases it may be appropriate to move diadromous fish into habitat that is currently inaccessible. Improving access to quality spawning habitat may increase the spawning population within a river system. In many cases, a certain number of returning fish will trigger fish passage at a dam where a fish passage prescription has been negotiated through the FERC dam relicensing process. In other cases, congregations of diadromous species downstream from a dam may demonstrate a clear need for fish passage at the site. Sources of fish transfers should come from within basin whenever possible, but in river reaches where diadromous fish species have been extirpated, fish may need to be transferred from neighboring watersheds. The risk of introducing diseases or invasive organisms should be considered when transfering fish from out of basin. Some level of testing may be required.

Political Location: **Watershed Location:**

References, Data Sources and Authors

Data Sources

Literature reviews and historical records of fish passage at dams in New Hampshire and Massachusetts were used to identify distribution and habitat requirements. River herring management plans, fishway counts, and stocking records.

Data Quality

River herring numbers are monitored annually at fishways on the Connecticut, Merrimack, and coastal rivers. The current distribution of river herring in New Hampshire is well documented. Accounts of historical distribution vary, but early records suggest that many lakes and ponds in the Merrimack River and coastal watersheds supported abundant alewife runs (Noon 2003)
Adult river herring annual return counts are estimates, but reliable for monitoring population trends. The quality of the data varies by site. Limited length, age, sex, and weight data are available for coastal rivers. Increased subsampling of the river herring population will be conducted by the Massachusetts Department of Marine Fisheries for the Merrimack River. Passage efficiency and upstream movement studies (pit tag and telemetry) have been conducted on the Lamprey River. Other than the Lamprey River, passage efficiency has not been recently studied on most fishways.

Downstream passage mortality has been monitored and route selection studies have been conducted for some dams in the Merrimack River watershed, but sample sizes were low. There is little known about juvenile production potential in different waterbodies, factors that influence survival at sea, and population structure and upstream/downstream passage efficiency in the Merrimack River.

2015 Authors:

Matthew Carpenter, NHFG, Benjamin Nugent, NHFG

2005 Authors:

Literature

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American Shad

Alosa sapidissima

Photo by NHFG

Federal Listing	
State Listing	SC
Global Rank	
State Rank	S3
Regional Status	V. High

Justification (Reason for Concern in NH)

American shad still run up the rivers of the east coast, but abundance levels are significantly reduced when compared to early colonial times. While over fishing likely impacted abundance levels, dam construction blocked access to spawning areas and decimated the abundant runs of shad and other migratory fish (Limburg and Waldman 2009). Prior to a dam constructed on the Connecticut River at Turners Falls in 1798, American shad reached Bellows Falls and the Ashuelot River in great numbers. The Essex dam, in Lawrence, Massachusetts, built on the Merrimack River in 1847, extirpated the Atlantic salmon population and crippled the American shad run. American shad are among the fish managed by the Atlantic States Marine Fisheries Commission (ASMFC). The Fisheries Management Plan for Shad and River Herring states that by 1993, commercial landings of American shad were estimated at 1.5 million pounds, down from 50 million pounds landed in the early 1900's (ASMFC 2010). A coastwide American shad stock assessment, conducted in 2007, found that shad populations are currently at an all-time low and do not appear to be recovering (ASMFC 2007).

Distribution

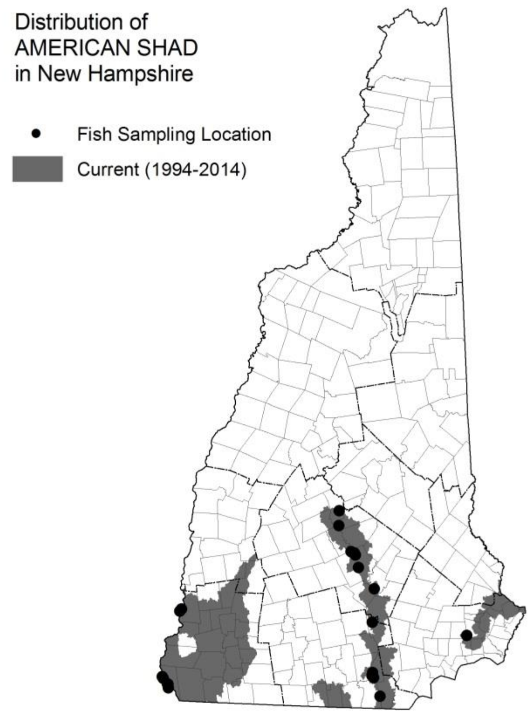
American shad spawn in rivers from Florida to Newfoundland, though they are most abundant from Connecticut to North Carolina. In New Hampshire, the largest historic populations spawned in the Connecticut and Merrimack Rivers. The distribution of historical shad spawning areas in New Hampshire coastal rivers is not well documented.

Habitat

American shad are anadromous fish that spawn in moderate to large freshwater rivers along the Atlantic coast. Spawning occurs between 12-200C and flows of 10-132 cm2/sec. The nonadhesive eggs drift in the current until they hatch. Dissolved oxygen levels below 5 mg/l are detrimental to shad at all life stages. In the ocean, shad prefer temperatures between 7-130C and migrate to deeper water during winter. During summer and fall, adult shad congregate in the Gulf of Maine and the Bay of Fundy (Bigelow and Schroeder 1953). Juvenile shad will remain in freshwater habitats until they descend to saltwater in the fall.

NH Wildlife Action Plan Habitats

- Large Warmwater Rivers
- Marine
- Estuarine



Distribution Map

Current Species and Habitat Condition in New Hampshire

Connecticut River:
The Connecticut River shad population has increased in recent years, but it is still below restoration targets. The Fisheries Management Plan for American Shad in the Connecticut River sets a restoration target of between 1.5 and 2 million shad returning to the mouth of the Connecticut River each year (CRASC 1992). It also establishes a fish passage efficiency target of 40 - 60% passage at each upstream fishway (5 year running average). These targets allow for a wide range of variability in annual return numbers. At the lower end of the range (1,500,000 at the river mouth and 40% passage at each upstream fishway) the target translates into a minimum passage number of 600,000 shad at the Holyoke Dam, 240,000 shad at the Turners Falls Dam, and 96,000 shad at the Vernon Dam. The shad count at the Holyoke Dam has only exceeded 600,000 once, with 720,000 shad recorded in 1992.

The Turners Falls Dam and the Vernon Dam have a large influence on the number of shad that are able to reach their historic range in New Hampshire. Passage efficiency has been historically poor at these dams, although there have been some recent improvements. Since 2004, the number of shad counted at the Turners Falls Dam has averaged only 5% of the number of shad counted at Holyoke, with a high of 11% in 2014. At Vernon, passage efficiency averaged 8% until 2012, when some repairs at the fishway increased passage efficiency to 40%. Passage efficiency at the Vernon Dam over the last three years has been within restoration target levels (40%, 51%, and 69% respectively). With the Vernon Dam Fishway functioning relatively well, the poor passage efficiency at the Turners Falls Dam is the main limiting factor on the number of shad that reach the upper Connecticut River.

Appendix A: Fish

Merrimack River:

The Merrimack River shad population averages 23,529 adult returns per year, based on counts at the Essex Dam fishway in Lawrence, MA between 1983 and 2014. The greatest number of shad counted at the Essex Dam fishway was 76,717 in 2001. Historically, the Merrimack River shad population likely numbered over a million returns per year. The shad population remains well below its potential in the Merrimack River. Restoration targets for shad passage set in the Shad Restoration Plan for the Merrimack River (MRTC 2010) call for shad counts of over 740,000 fish at the Essex Dam and 650,000 fish at the next upstream dam in Lowell (The Pawtucket Dam). These are ambitious restoration targets, but they are based on the large amount of suitable shad spawning habitat in the upper Merrimack River watershed. Shad numbers to the upper Merrimack River in New Hampshire are currently limited by poor fish passage efficiency at the Pawtucket Dam in Lowell. Shad counts at in Lowell average about 10% of counts at the Essex Dam (Sprankle 2005). Despite above average shad returns in recent years, the total number of fish counted at Lowell has not exceeded 10,000 in over 10 years. Shad are rarely observed at the Amoskeag Dam fishway in Manchester.

Coastal Rivers:

Shad are occasionally observed in coastal river fish ladders, but spawning populations have been virtually extirpated from the watersheds that drain into Great Bay. Anecdotal observations of shad have also been reported in the Salmon Falls River, but the fishway on this river is in Maine and is not monitored regularly by NHFG staff.

Population Management Status

Connecticut River

Up to 750 shad are trucked each spring to the Ashuelot River (a tributary of the Connecticut River in New Hampshire) to help restore the shad migration in the upper Connecticut River.

Merrimack River

Each spring the NHFG trucks shad from the Essex Dam fishway to inaccessible spawning habitat in the upper Merrimack River watershed. The Merrimack River Shad Restoration Plan calls for a target of 5,000 shad to be transferred annually. Currently, shad transfers typically range between 1,000 and 2,000 fish per year.

Adult shad are captured at the Essex Dam fishway and transported to the Nashua National Fish Hatchery, where they spawn in circular tanks. The resulting shad fry are then stocked to support shad restoration efforts in the Merrimack and other rivers. Typical shad fry numbers stocked into the Merrimack River have ranged between 1 million and 6 million per year since the project was initiated in 2009. All fry are immersed in an oxytetracycline bath to mark otoliths prior to release (Brooks et al. 1994). Sampling of returning adult shad at the Essex Dam has documented shad with marked otoliths, but a larger sample size will be needed to determine the overall contribution of hatchery shad to the restoration effort.

Coastal Watersheds:

Attempts to establish a shad population in the Exeter River by stocking adult shad from the Merrimack and Connecticut River populations were discontinued in 2008 due to poor return rates. Passage issues in the fish ladder at the Great Works Dam, in Exeter, and low dissolved oxygen levels in the impoundment upstream are two factors that may have limited the recovery (Mike Dionne, NHFG Biologist, personal communication).

Regulatory Protection (for explanations, see Appendix I)

- Anadromous Fish ConservaTIon Act
- Harvest permit - season/take regulations

Quality of Habitat

Connecticut River:
The Connecticut River is known for its highly productive American shad habitat from the river mouth to Bellows Falls in New Hampshire. Shad numbers are currently limited more by fish passage issues and factors influencing survival at sea than by habitat quality in the Connecticut River (Sprankle, Connecticut River Program Coordinator, personal communication). Shad currently have access to the majority of their historic spawning habitat in the upper Connecticut River, but fish passage efficiency could be improved at each dam. Fluctuating water levels and increased summer water temperatures at dams may negatively influence juvenile survival.

Merrimack River:
According to the Merrimack River American Shad Management Plan, there are approximately 6,512 acres of potential spawning habitat in the upper Merrimack River, 2,205 acres of which are currently accessible (MRTC 2010). These are rough estimates. The relative importance of spawning areas within each section of river is unknown, but the estimates provide a general idea of the amount of habitat that would be available to shad in the absence of dams. Much of the mainstem of the Merrimack is considered excellent shad habitat in terms of depth, substrate, and flow rate. American shad technically have access from the mouth of the Merrimack River to the Hooksett Dam in New Hampshire and a small portion of the Nashua River. The actual numbers of shad reaching the upper Merrimack river is limited by poor fish passage efficiency at the Pawtucket Dam in Lowell (Sprankle 2005).

Coastal Rivers
Suitable spawning habitat for shad has been identified in the Exeter River and the Lamprey River (NHFG 2014). Fish ladder construction at the Wiswall Dam has provided access to 18.4 river km (68 hectares) of the Lamprey River for anadromous fish. The relative accessibility of the Lamprey River may offer the best chance for shad restoration on the New Hampshire seacoast. The proposed removal of the Great Works Dam may also make shad restoration feasible in the Exeter River.

Habitat Protection Status

Habitat Management Status

Shad habitat management activities focus primarily on managing river flow upstream and downstream of dams to maximize the efficiency of fishways. Fishways require constant maintenance and monitoring to be effective. They must be adjusted or redesigned to ensure successful fish passage over the widest range of flow conditions possible. The fishways in the most need of improvement are at the Turners Falls Dam on the Connecticut River and the Pawtucket Dam on the Merrimack River. Dam removals have the greatest potential for restoring American shad populations, but dam removals are unlikely on the larger rivers in New Hampshire and Massachusetts. The potential removal of the Great Works Dam creates an opportunity for natural shad recolonization of the freshwater portion of the Exeter River.

Threats to this Species or Habitat in NH

Threat rankings were calculated by groups of taxonomic or habitat experts using a multistep process (details in Chapter 4). Each threat was ranked for these factors: Spatial Extent, Severity, Immediacy, Certainty, and Reversibility (ability to address the threat). These combined scores produced one overall threat score. Only threats that received a "medium" or "high" score have accompanying text in this profile. Threats that have a low spatial extent, are unlikely to occur in the next ten years, or there is uncertainty in the data will be ranked lower due to these factors.

Disturbance from dams that block species from spawning areas or other important habitat (Threat Rank: High)

Dams block access to freshwater spawning habitat.

Dams have greatly reduced the amount of freshwater habitat available to American shad and other diadromous species (Limburg and Waldman 2009).

Mortality from hydropower turbines (Threat Rank: Medium)

Fish are killed during downstream migration when they pass through hydropower turbines.

Dead or injured fish are observed downstream of hydropower turbines each year at dams throughout the state. The level of mortality varies significantly by site.

Disturbance from dams causing delayed migration (Threat Rank: Medium)

Delays in migration occur at dams as fish try to successfully navigate fish passage facilities. These delays may become energetically costly to the point where they impact spawning behavior.

Studies of shad on the Connecticut River have documented potential impacts from significant delays of American shad at multiple dams during the spring migration period (Castro-Santos and Letcher 2010).

Mortality from predation (striped bass) (Threat Rank: Medium)

Mortality from abundant predator populations has been documented as a factor that is potentially limiting the recovery of some diadromous fish populations.

A tenfold increase in the striped bass population coincided with a decline in many diadromous fish populations in the late 1990's (Grout 2006). Very large striped bass will consume adult shad, but large fish account for a small proportion of the striped bass population (Davis et al. 2009). Most predation of American shad likely occurs at the juvenile life stage, with some predation of adult shad by larger marine predators.

List of Lower Ranking Threats:

Mortality from commercial over-harvest due to fishing bycatch

Species impacts from changes in timing of migration and flooding that decrease spawning success

Actions to benefit this Species or Habitat in NH

Monitor fish passage

Objective:
Monitor upstream and downstream passage at dams.

General Strategy:
Monitor diadromous fish passage at dams with trained staff, video equipment or periodic sampling. Assess the efficiency of upstream and downstream passage facilities. Make recommendations for improving existing or proposed fish passage structures.

Political Location:

Watershed Location:

Monitor shad stocking

Objective:
Monitor the contribution of restoration strategies including hatchery supplementation and adult shad transfers.

General Strategy:
Hatchery raised shad fry stocked in the Merrimack River have otoliths marked with tetracycline. Lethal sampling of adult returns or juvenile shad is used to determine the percentage of hatchery origin shad in the population. The offspring of adult shad stocked into habitat up river can be sampled using electrofishing boats or seines. The level of sampling effort required to achieve statistically significant results is currently beyond the capacity of the NHFG and the USFWS.

Political Location:

Watershed Location:

Map spawning habitat

Objective:
Identify and map the spawning habitat used by anadromous fish in the Connecticut, Merrimack, and Coastal watersheds.

General Strategy:
While spawning adults are counted each spring in many New Hampshire Rivers, the locations of important spawning areas have yet to be quantitatively identified and mapped. The extent of suitable spawning habitat for alewives, blueback herring, sea lamprey, and American shad is not well known. This research would likely involve the use of radio telemetry and visual surveys during the spawning season.

Political Location:

Watershed Location:

Fish passage efficiency studies

Objective:
Evaluate the effectiveness of both upstream and downstream fishways.

General Strategy:
Studies should be conducted to evaluate the upstream and downstream passage efficiency at dams using pit tags and radio telemetry equipment. Information on size selection, mortality, migration delays, and passage success should be collected at each site.

Political Location: **Watershed Location:**

Fish transfers

Primary Threat Addressed: Disturbance from dams that block species from spawning areas or other important habitat

Specific Threat (IUCN Threat Levels): Natural system modifications / Dams & water management/use / Dams (size unknown)

Objective:
Transfer diadromous fish species into suitable freshwater habitat that is currently inaccessible due to dams or other manmade barriers.

General Strategy:
In some cases it may be appropriate to move diadromous fish into habitat that is currently inaccessible. Improving access to quality spawning habitat may increase the spawning population within a river system. In many cases, a certain number of returning fish will trigger fish passage at a dam where a fish passage prescription has been negotiated through the FERC licensing process. In other cases, congregations of diadromous species downstream from a dam demonstrate a clear need for fish passage at the site. Sources of fish passage should come from within basin whenever possible, but in river reaches where diadromous fish species have been extirpated, fish may need to be transferred from neighboring watersheds. The risk of introducing diseases or invasive organisms should be considered when transferring fish from out of basin. Some level of testing may be required.

Political Location: **Watershed Location:**

Dam removal

Primary Threat Addressed: Disturbance from dams that block species from spawning areas or other important habitat

Specific Threat (IUCN Threat Levels): Natural system modifications / Dams & water management/use / Dams (size unknown)

Objective:
Remove barriers to migration.

General Strategy:
When the opportunity presents itself, dam removals provide the best long term solution to reconnecting diadromous fish with their historical freshwater spawning habitat. Dam removal projects are challenging and they often stall without a dedicated project manager. Hiring and training staff to identify and facilitate dam removal projects will increase the number of projects that can be completed each year. Creating priority lists of dam removal projects for each species would also help focus resources on the projects with the most benefit as well as help generate funding.

Political Location: **Watershed Location:**

Population assessment

Objective:
Assess the current and potential productivity of diadromous fish species in New Hampshire waters.

General Strategy:
Setting restoration goals for diadromous fish species is difficult without realistic targets for population recovery. Developing population models based on fecundity, extent and quality of habitat, and sources of mortality would help estimate the potential abundance of diadromous fish species under different management scenarios. This information would be useful to fisheries managers as they set stocking targets or prioritize restoration work. Understanding the potential abundance of diadromous fish populations would more clearly define successful restoration and put current population levels in perspective.

Political Location: **Watershed Location:**

Improve fish passage at dams

Primary Threat Addressed: Disturbance from dams that block species from spawning areas or other important habitat

Specific Threat (IUCN Threat Levels): Natural system modifications / Dams & water management/use / Dams (size unknown)

Objective:
Construct, maintain, and monitor fishways at dams that currently limit access to suitable freshwater habitat for diadromous fish.

General Strategy:
At sites where dam removal is not an option, fish passage construction can improve connectivity between freshwater and marine habitats. Fish passage construction may be negotiated during the FERC licensing process. Fish passage engineers with the USFWS are available to assist with designing the appropriate fishway for a particular site, depending on the needs of the species and the size of the dam (among other factors). At some sites outside of FERC jurisdiction, funding may have to come from other sources. Once installed, there should be a plan for fish passage operation, maintenance, and monitoring. Identifying the party responsible for each aspect of fishway operation is critical for maintaining effective passage over the long term. Periodic performance evaluations should also be completed at each fishway to ensure that fish are moving efficiently through the project without excessive delays.

Political Location: **Watershed Location:**

References, Data Sources and Authors

Data Sources

American shad returns have been recorded at the fishways in the Merrimack and Connecticut Rivers since the early 1980's. Fishway count data is maintained by state and federal fish and wildlife agencies.

Data Quality

American shad return numbers are relatively accurate at staffed or video recorded counting facilities. Counts at the fish lift in Lowell are estimated. The annual abundance of juvenile shad in the New Hampshire sections of the Connecticut and Merrimack River is unknown.
Counts of American shad vary in quality by site, but in most cases they provide relatively accurate estimates of the spawning population in a river. These estimates are useful for evaluating long term trends. There is very little understanding of factors that influence juvenile shad productivity or survival at sea. Subsamples of American shad in the Connecticut and Merrimack Rivers provide population data including length, weight, age, sex, and percentage of repeat spawners. These samples are taken and analyzed by staff with the Massachusetts Division of Marine Fisheries (MDMF).

2015 Authors:

Matthew Carpenter, NHFG, Benjamin Nugent, NHFG

2005 Authors:

Literature

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American Eel

Anguilla rostrata


Photo by NHFG

Federal Listing	
State Listing	SC
Global Rank	
State Rank	S3
Regional Status	V. High

Justification (Reason for Concern in NH)

American eel numbers have reached a historic low, according to the Atlantic States Marine Fisheries Commission (ASMFC) 2012 benchmark stock assessment (ASMFC 2012). Yellow eel abundance has dropped dramatically in the St. Lawrence River over the past 20 years (Castonguay et al. 1994). Causes of eel declines may include commercial harvest, dams, unfavorable environmental conditions in marine and freshwater environments, pollution, and climate change (Friedland et al. 2007; Haro et al. 2000). The relatively long life span of the Americal eel, combined with an extensive migration and a single breeding event, makes the American eel population vulnerable to collapse (ASMFC 2000).

Distribution

The American eel ranges from Greenland and Labrador south to northern South America and west to the Mississippi Valley. Although American eels are relatively common in the coastal rivers of New Hampshire, it is understood that they inhabit just a fraction of their historical range in the state. There is a significant drop in eel abundance upstream of the first major dams on the Merrimack and Connecticut Rivers (Sprankle 2002). Historical records indicate that eels were found as far upstream as the Connecticut Lakes within the Connecticut River watershed (Scarola 1987). The historical range of American eels within the Merrimack River watershed indicates presence as far upstream as Merrymeeting, Winnipesaukee, and Winnisquam lakes (Bailey 1938). No historical information is available on the presence of eels in the New Hampshire section of the Androscoggin River. American eels were noted in Ossipee Lake within the Saco River watershed in historical records.

Recent survey data indicates that American eels have been documented as far north as Claremont, Holderness, and Wakefield in the Connecticut River, Merrimack River, and Coastal watersheds, respectively. No current information is available to describe the distribution of American eels within the New Hampshire sections of the Androscoggin River and Saco River watersheds.

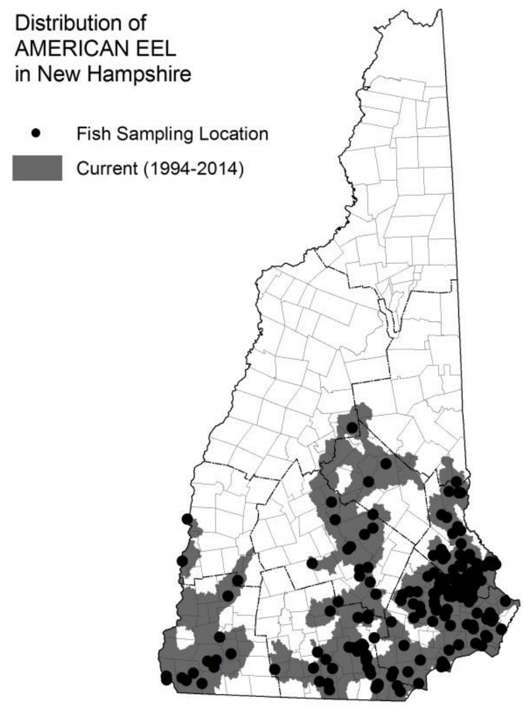
Habitat

American eels use marine, estuarine, and freshwater habitat (Atlantic States Marine Fisheries Committee (ASMFC) 2000). American eels breed collectively in the Sargasso Sea, a large area of the western Atlantic Ocean. After hatching, larval eels (leptocephali) drift in ocean currents to the shores of eastern North America, northeastern South America, Europe, and North Africa where they transform into glass eels and then pigmented elvers. Elvers migrate into estuaries and freshwater where they grow into the yellow eel phase.

American eels may be found in almost any freshwater habitat that can be accessed from the ocean, although they reach their largest sizes and abundance in lakes, ponds, and larger rivers. Sexual differentation occurs at lengths of about 8 to 10 inches depending on factors such as population density and salinity. Males, which tend to be smaller than females, usually remain in estuaries, while females often migrate miles upstream and can reach lengths of over 4 feet. After three to 25+ years, yellow eels metamorphose into silver eels, which migrate back to the Sargasso Sea to spawn and die (ASMFC 2000).

NH Wildlife Action Plan Habitats

- Warmwater Rivers and Streams
- Warmwater Lakes and Ponds
- Coldwater Rivers and Streams
- Lakes and Ponds with Coldwater Habitat
- Large Warmwater Rivers



Distribution Map

Current Species and Habitat Condition in New Hampshire

Records of historic American eel abundance levels are not available in New Hampshire, but, before the construction of dams, eels were likely an important component of the fish community in nearly all aquatic habitat types throughout the state (Hitt et al. 2012). The current distribution and abundance of American eels in New Hampshire is just a small fraction of their potential.

Merrimack River

Although juvenile eels have the ability to ascend almost any wetted surface, including vertical dam faces, and find passage through small cracks or leaks in most structures, the overall upstream movement of American eels in most river systems is greatly reduced and size selective. A number of studies have documented reduced eel densities upstream of dams (Haro et al. 2000). Sprankle (2002) noted a significant difference in eel catch per unit effort between sampling sites upstream and downstream of the first dam on the Merrimack River in Lawrence, MA. Catch rates from the upper Merrimack River, in New Hampshire, were the lowest of all sites surveyed in the study.

Connecticut River
Records of American eel are scarce in the upper Connecticut River, although they were documented as far north as the Connecticut Lakes Region in the 1930's. More recent surveys have documented American eels in the Ashuelot River watershed and the Connecticut River mainstem as far north as Charlestown. American eels may be more widespread in the Connecticut River than current records indicate, but low population densities make them difficult to capture.

Coastal Watersheds
Although American eels are generally more abundant in New Hampshire coastal watersheds than in the upper Merrimack and Connecticut River watersheds, there is little information on which to evaluate their population status in each river system. However, some information can be gleaned from fish surveys conducted in the region. American eels were commonly encountered during electrofishing surveys conducted to map American brook lamprey habitat throughout the Oyster River watershed. American eels were abundant in surveys of the Winnicut River prior to the removal of the Winnicut River Dam at the head of tide. Their abundance is expected to increase now that the barrier has been removed.

In a backpack electrofishing survey of the Lamprey River watershed, American eels were present at 23 0f 105 sites (22%) and accounted for 98 (2.3%) of the 4,226 fish counted at all sites combined (NHFG 2012). American eels can be difficult to capture in electrofishing surveys, so the actual abundance of American eels is likely higher than what was recorded in this survey. However, eel abundance in the upper Lamprey River and its tributaries is far below what one would expect in an unfragmented river system. Over 67% of the eels counted were captured at one survey site, just downstream from the Wiswall Dam in Lee. American eels are often found at higher densities downstream of dams or other obstructions to upstream migration. Fish passage construction at the Wiswall Dam, completed in 2012, and the removal of the Bunker Pond Dam in 2011 should increase the distribution and abundance of American eels in the Lamprey River watershed. These recent improvements in upstream eel passage present an opportunity to monitor trends in the American eel population now that habitat throughout the watershed has become more accessible.

Silver eel mortality:
Dams are clearly limiting the upstream movement of American eels, but there is less documentation of silver eel mortality during downstream migration. The American eel population is dependent on silver eel escapement to spawning areas in the Sargasso Sea. Increased access to freshwater and higher densities of yellow eels will be meaningless if the majority of silver eels are killed on their way out to sea (Sweka et al. 2014).

Population Management Status

There are no ongoing population management efforts for American eel in New Hampshire. Stocking juvenile American eels into quality habitat where eels have been extirpated or exist at very low population densities is a strategy that has been used in other watersheds, including the Upper St. Lawrence River (Pratt and Threader 2011). The larger lakes of New Hampshire, including Lake Winnipesaukee, may be suitable habitat for a stocking program. The ultimate goal of a stocking program would be to produce a larger sample size of silver eels for downstream passage studies and to increase the number of silver eels that migrate to the ocean to spawn. There are many risks associated with a stocking program for American eels, including the potential to spread parasites and disease, including the swim bladder parasite (*Anguillicoloides crassus*). Any benefit of a stocking program may be offset by poor survival of silver eels as they migrate downstream through multiple hydropower projects. The long life span of American eels creates additional challenges as it will be decades before any stocking program can be evaluated. A shorter term strategy could involve stocking older, yellow phase eels into habitats where they may be later captured as silver eels. This type of stocking effort may increase the number of silver eels available for downstream passage studies. A better understanding of downstream passage mortality rates at each dam will help guide decisions on when and where to install upstream eel passage.

Regulatory Protection (for explanations, see Appendix I)

- Federal Endangered Species Act - under consideration
- NH NHB Database - current
- NH NHB Database - historic
- Harvest permit - season/take regulations

Quality of Habitat

Coastal watersheds:
Coastal river habitat is relatively accessible, with much higher densities of American eels compared to that of the Merrimack or Connecticut River drainages. The relatively small dams in these watersheds present less of a barrier than the large dams found on the mainstems of larger rivers. American eel densities should increase as fish passage improvements are made for diadromous fish in the rivers along the New Hampshire Seacoast. Declining habitat and water quality is an increasing issue for all aquatic species in the developing seacoast region.

Merrimack River:
The Merrimack River watershed contains a huge network of suitable eel habitat. While eels are present in the lower Merrimack River and its tributaries, their population density is much lower than what would be expected in a free flowing river system (Sprankle 2002). There are many opportunities to improve upstream eel passage at dams, but this strategy should be pursued cautiously at hydropower facilities. Increases in eel density upstream of hydropower facilities may be offset by high mortality rates of silver eels as they migrate downstream through the project (Sweka et al. 2014). Night time shut downs, downstream bypass measures, and guidance structures may be used to improve downstream passage for silver eels. Studies of route selection and hydropower turbine mortality rates for silver eels through each hydropower facility should be a component to any plan to improve upstream eel passage at a hydroelectric dam. Upstream eel passage improvements at dams without active hydropower plants can be a relatively cost effective restoration approach without the uncertainty of turbine mortality during downstream migration.

The Winnipesauke River watershed is an example of high quality American eel habitat with a high density of hydropower dams. Lake Winnipesauke and Lake Winnisquam are large lakes with low densities of American eels, but they are known to produce large silver eels. Eel mortalities have been observed at three of the 6 hydropower dams in the watershed. The dam owners are currently working on improvements to downstream eel passage at each facility. A silver eel trap, maintained from September to November at the Lakeport Dam in Laconia, provides a source of American eels for downstream migration studies.

Connecticut River:
Eel densities naturally decrease with distance from the ocean, but eel densities in the upper Connecticut River are far below their potential despite the huge expanse of suitable habitat. There are records from the Ashuelot River watershed and the mainstem, but eel distribution and density in most tributary watersheds is not well documented. Improvements in upstream and downstream passage throughout the Connecticut River watershed have tremendous potential to increase the contribution of the Connecticut River to the spawning population of American eels each year.

Habitat Protection Status

Habitat Management Status

Although American eels use a variety of routes to pass upstream of dams, including existing fishways designed for other species, there are few examples of dams where upstream passage has been provided specifically for eels. Permanent eelways have been installed on the Merrimack River at the Essex Dam in Lawrence and the Amoskeag Dam in Manchester. Potential locations for upstream eelways are currently being evaluated at the Hooksett Dam and the Garvins Falls Dam in Bow. Elver traps are operated by the NHFG Marine Division on the Lamprey River and the Oyster River, both of which drain into Great Bay. Upstream eel passage is relatively inexpensive to install and there is great room for improvements in eel passage at dams throughout the state.

Providing downstream passage for silver eels is more difficult than improving upstream passage. The number of silver eels killed in hydropower turbines on New Hampshire's rivers is largely unknown. Dead eels have been documented below the dams on the Winnipesauke River and the mainstem of the Merrimack River. Night time shutdowns during fall rain events are being used as an interim measure to reduce silver eel mortality while dam owners on the Winnipesauke River develop plans to provide downstream passage for eels.

An ongoing telemetry study on silver eel survival and movement in the mainstem of the Merrimack River suggests that fewer eels are killed as they pass through the larger dams. The study has been limited by the lack of silver eels available for tagging. USFWS and NHFG staff are working to increase the sample size of silver eels for this long term study by expanding trapping efforts for silver eels throughout the Merrimack River watershed. A proposal to import test eels from other watersheds is currently being evaluated.

A large number of silver eels will be imported and tested for disease before their release in a proposed telemetry study on the upper Connecticut River. This silver eel telemetry study is one of many fish passage studies being conducted as part of the relicensing process for dams owned by the Transcanada Corporation (FERC 2013). The scale of this study has the potential to answer questions about silver eel survival as they pass through larger mainstem dams. There are concerns that importing silver eels from out of basin sources for use in telemetry studies may expose the local eel populations to foreign diseases and parasites, including the swim bladder nematode (*Anguillicoloides crassus*). However, low population densities and limited resources make obtaining suitable numbers of silver eels from within the Connecticut River watershed nearly impossible in the time required for this study. There is also the risk that eels from other river systems will not behave in a manner that is representative of local populations. These are some of the challenges that must be resolved as more studies are conducted to evaluate downstream passage for silver eels. Silver eel mortality is most likely lowest in New Hampshire coastal rivers, where there are fewer active hydropower dams.

Threats to this Species or Habitat in NH

Threat rankings were calculated by groups of taxonomic or habitat experts using a multistep process (details in Chapter 4). Each threat was ranked for these factors: Spatial Extent, Severity, Immediacy, Certainty, and Reversibility (ability to address the threat). These combined scores produced one overall threat score. Only threats that received a "medium" or "high" score have accompanying text in this profile. Threats that have a low spatial extent, are unlikely to occur in the next ten years, or there is uncertainty in the data will be ranked lower due to these factors.

Mortality from hydropower turbines (Threat Rank: High)

The long body length of American eels makes them particularly vulnerable to mortality from certain types of hydropower turbines during downstream migration.

Eviscerated pieces of American eels are observed each year downstream from a number of dams on the Winnipesauke River. Turbine mortality rates may be high enough in some river systems to negate the restoration benefits of upstream eel passage (Sweka et al. 2014).

Disturbance from dams that block species from spawning areas or other important habitat (Threat Rank: Medium)

Dams restrict access to freshwater habitat for American eels.

American eel densities decline significantly upstream of dams, especially on larger rivers with large mainstem dams (Hitt et al 2012; Sprankle et al. 2002).

Disturbance from disease and parasites (swim bladder nematode) (Threat Rank: Medium)

Apparently introduced from Japanese eel populations, the swim bladder parasite *Anguillicoloides crassus* has spread rapidly through American eel populations in the northeast. The exact means of transfer between individual eels is not well understood. Silver eels with infested swim bladders may have difficulty reaching their spawning grounds.

Swim bladder parasite infection rates have been examined at various locations throughout the northeast (Denny et al. 2013; Zimmerman 2008)

List of Lower Ranking Threats:

Disturbance from long-term exposure to contaminants and associated bioaccumulation

Disturbance from dams causing delayed migration

Mortality from commercial harvest and unregulated take

Species impacts from changes in ocean temperature and currents that affect larval survival

Actions to benefit this Species or Habitat in NH

Test for disease/parasites

Objective:
Test eels for the swim bladder nematode parasite.

General Strategy:
American eels should not be transferred between waterbodies for restoration until the extent of infection by the swim bladder nematode (*Anguillicola crassus*) has been assessed in donor populations. Testing may be conducted the USFWS Fish Health Center in Lamar, PA.

Political Location:

Watershed Location:

Population monitoring

Objective:
Monitor population trends of diadromous fish species.

General Strategy:
NHFG and USFWS biologists are currently working to establish protocols for eel survey index sites to track population trends at various locations in NH. At the same time, surveys along the periphery of known populations will help establish the current range of the species.

Political Location: **Watershed Location:**

Dam removal

Primary Threat Addressed: Disturbance from dams that block species from spawning areas or other important habitat

Specific Threat (IUCN Threat Levels): Natural system modifications / Dams & water management/use / Dams (size unknown)

Objective:
Remove barriers to migration.

General Strategy:
When the opportunity presents itself, dam removals provide the best long term solution to reconnecting diadromous fish with their historical freshwater spawning habitat. Dam removal projects are challenging and they often stall without a dedicated project manager. Hiring and training staff to identify and facilitate dam removal projects will increase the number of projects that can be completed each year. Creating priority lists of dam removal projects for each species would also help focus resources on the projects with the most benefit as well as help generate funding.

Political Location: **Watershed Location:**

Research survey methods

Objective:
Develop or improve survey methods for diadromous fish species.

General Strategy:
Potential methods for eel survey studies include backpack electrofishing, boat electrofishing, eel traps, angler surveys, and fyke nets. More research is needed to identify the most effective methods for eel surveys in a variety of habitat types and population densities.

Political Location: **Watershed Location:**

Improve fish passage at dams

Primary Threat Addressed: Disturbance from dams that block species from spawning areas or other important habitat

Specific Threat (IUCN Threat Levels): Natural system modifications / Dams & water management/use / Dams (size unknown)

Objective:
Construct, maintain, and monitor fishways at dams that currently limit access to suitable freshwater habitat for diadromous fish.

General Strategy:
At sites where dam removal is not an option, fish passage construction can improve connectivity between freshwater and marine habitats. Fish passage construction may be negotiated during the FERC licensing process. Fish passage engineers with the USFWS are available to assist with designing the appropriate fishway for a particular site, depending on the needs of the species and the size of the dam (among other factors). At some sites outside of FERC jurisdiction, funding may have to come from other sources. Once installed, there should be a plan for fish passage operation, maintenance, and monitoring. Identifying the party responsible for each aspect of fishway operation is critical for maintaining effective passage over the long term. Periodic performance evaluations should also be completed at each fishway to ensure that fish are moving efficiently through the project without excessive delays.

Political Location: **Watershed Location:**

Fish passage efficiency studies

Objective:
Evaluate the effectiveness of both upstream and downstream fishways.

General Strategy:
Studies should be conducted to evaluate the upstream and downstream passage efficiency at dams using pit tags and radio telemetry equipment. Information on size selection, mortality, migration delays, and passage success should be collected at each site.

Political Location: **Watershed Location:**

Fish transfers

Primary Threat Addressed: Disturbance from dams that block species from spawning areas or other important habitat

Specific Threat (IUCN Threat Levels): Natural system modifications / Dams & water management/use / Dams (size unknown)

Objective:
Transfer diadromous fish species into suitable freshwater habitat that is currently inaccessible due to dams or other manmade barriers.

General Strategy:

In some cases it may be appropriate to move diadromous fish into habitat that is currently inaccessible. Improving access to quality habitat may increase the population within a river system. In many cases, a certain number of returning fish will trigger fish passage at a dam where a fish passage prescription has been negotiated through the FERC licensing process. In other cases, congregations of diadromous species downstream from a dam demonstrate a clear need for fish passage at the site. Sources of fish transfers should come from within basin whenever possible, but in river reaches where diadromous fish species have been extirpated or significantly reduced, fish may need to be transferred from neighboring watersheds. The risk of introducing diseases or invasive organisms should be considered when transferring fish from out of basin. Some level of testing may be required. When transferring American eel, for example, there is a risk of spreading the parasitic swim bladder nematode (Denny et al. 2013). Another factor to consider when transferring American eels is the probability of mortality during downstream migration. Excessive mortality of silver eels in some watersheds may offset the restoration value of transferring eels into otherwise suitable habitat.

Political Location:

Watershed Location:

References, Data Sources and Authors

Data Sources

Historical ranges were identified from NHFG biological surveys from the 1930's. The current NH distribution of American eels was gathered from NHFG fish survey records. In most cases, American eels were recorded as incidental catch during surveys for other species, but more recently, NHFG has been conducting targeted surveys for American eel. Annual American eel counts are available at some dams. Observations of American eel are recorded in a statewide fish database.

Data Quality

There has been no comprehensive survey of American eels in New Hampshire waters. The distribution and abundance of American eels in all major watersheds of New Hampshire is poorly understood. Very limited baseline information is available on which to compare current eel distribution and abundance.

Although fishway counts provide a relative index of American eel migration into New Hampshire waters each year, these counts are often rough estimates and it is likely that only a small fraction of eels find their way into these fishways (some may find different ways to move upstream of barriers). Additionally, fishway counts are not available for all rivers. Efforts should be made to refine these inventories to help better quantify trends in year class strength.

Counts at dams are estimates, but provide a relative comparison of annual eel numbers. Distribution data is patchy and based mostly on incidental catches or observations during fish surveys for a variety of projects. NHFG biologists are currently working with USFWS staff to expand survey efforts for monitoring American eel population trends in New Hampshire.

Potential American eel index survey locations were identified in the Merrimack River watershed in 2013 and 2014. Sites were selected downstream from dams where eels are likely to congregate as they try to move upstream. It is expected that surveys will be established in these areas on an annual or semiannual basis. Metrics such as catch per unit of effort (CPUE), body condition, and rate of recapture will help determine population trends. Pit tags will be used to identify recaptured individuals and to collect information on eel movement within the watershed. In addition to collecting baseline population data, eel surveys at established index sites will be used to monitor the response of the resident eel population to improvements in upstream eel passage or changes in dam operations.

Biologists with the Marine Division of the NHFG deploy two elver traps to monitor trends in annual American eel recruitment. The elver trap at the first dam on the Lamprey River has been monitored for 14 years. The elver trap at the Mill Pond Dam on the Oyster River was established more recently, in 2013. Annual counts are highly variable (NHFG 2014). Although there is no apparent trend in the data, this long term data set may become valuable for detecting trends in the future.

Eel passage ramps or traps are also maintained at the Essex Dam in Lawrence, the Amoskeag Dam in Manchester, and the Garvins Falls Dam in Bow. These traps are operated by the hydropower companies, which own the dams. Although the data may not be indicative of the total number of eels passing upstream of the dams, it is valuable for monitoring long term population trends in the Merrimack River watershed.

There is very little data on silver eel migration cues, timing, numbers, or mortality at dams. Radio telemetry studies at Garvins Falls have begun to shed some light on downstream passage at the Merrimack River mainstem dams (USFWS unpublished data). Mortality is routinely observed at the dams on the Winnipesaukee River. A silver eel trap operated from September through November at the Lakeport Dam in Laconia provides a source of silver eels for study, but sample sizes remain low. Silver eels will be collected from out of basin sources for use in downstream passage studies for the five Connecticut River Dams that are currently undergoing relicensing. There is little information on the extent of silver eel mortality in coastal rivers.

2015 Authors:
Matthew Carpenter, NHFG, Benjamin Nugent, NHFG

2005 Authors:

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Northern Redbelly Dace

Chrosomus eos

Photo by NHFG

Federal Listing	
State Listing	SC
Global Rank	
State Rank	S3
Regional Status	

Justification (Reason for Concern in NH)

Northern redbelly dace are vulnerable to habitat alterations that reduce summer base flows and riparian cover. Populations upstream of dams are also vulnerable to artificial water level fluctuations, especially during spawning. The extent of their distribution in New Hampshire is not well understood. Although aquatic habitats in northern New Hampshire are under less pressure from development than those of southern New Hampshire, there may be certain regions that are important for the persistence of the species, which has somewhat limited dispersal abilities. The biggest threat to northern redbelly dace populations may be the introduction of large predatory fish species, including bass, pike, and sunfish. The brightly colored breeding males, in particular, are not well adapted to avoiding larger fish predators. As a result of the widespread introductions of littoral predators, native minnow communities have become rare in lakes and ponds throughout the northeast outside of northern Maine (Whittier et al. 1997).

Distribution

The northern redbelly dace has a northern distribution in North America, inhabiting most of Canada, with isolated populations in the Missouri and upper Mississippi River watersheds, northern New York, Pennsylvania, Massachusetts, Vermont, New Hampshire, and Maine (Scott and Crossman 1973). In New Hampshire, northern redbelly dace populations occur north of the White Mountains, in the Androscoggin and upper Connecticut River watersheds, with isolated populations as far south as the Sugar and Cold River watersheds.

Habitat

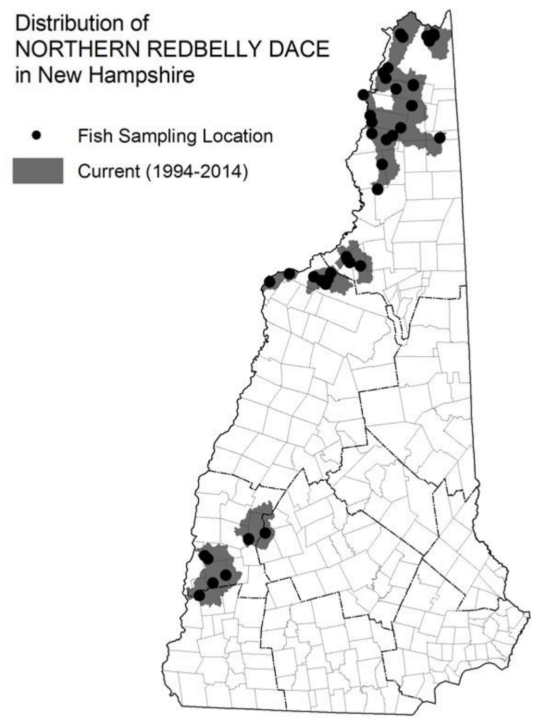
The northern redbelly dace inhabits acidic lakes, ponds, and backwater streams in areas with minimal water velocity. Spawning occurs in algae masses within these habitats (Scarola 1987). Spawning times range from May to August and are dependent on latitude and local environment (Scott and Crossman 1973).

In New Hampshire, northern redbelly dace are usually found in lower gradient, cool headwater streams and small ponds with sluggish flow and ample cover from over hanging shrubs or aquatic vegetation. They tend to thrive in areas with a history of beaver activity. Individuals may be found in rivers or steams with higher gradients and flow, but they are assumed to have either washed out of or dispersed from areas of more suitable habitat upstream.

Adapted to thick ice cover and low oxygen levels, northern redbelly dace are well suited to living in northern climates, although they are slightly more tolerant of warm water conditions than finescale dace. Northern redbelly dace feed primarily on filamentous algae and other plant matter, but zooplankton and fish larvae are also consumed (Scott and Crossman 1973). Where finescale dace overlap with northern redbelly dace, hybridization may occur. The offspring tend to be all female and diploid, meaning that they contain a full set of chromosomes from each parent. The hybrids are able to reproduce clonally and they share characteristics from both species, including a more omnivorous diet. Northern redbelly dace usually spawn about two weeks later than finescale dace in warmer water temperatures (190C/670F for redbelly dace and 160C/600F for finescale dace). Hybridization occurs in areas where rapid temperature increases in spring may cause more overlap between the spawning seasons of the two species (Scott and Crossman 1973).

NH Wildlife Action Plan Habitats

- Coldwater Rivers and Streams
- Lakes and Ponds with Coldwater Habitat



Distribution Map

Current Species and Habitat Condition in New Hampshire

Survey records for northern redbelly dace are inadequate for assessing population health. Northern redbelly dace were recorded at 7 locations in 1939, although they were considered more abundant in northern New Hampshire than indicated by the survey record (Bailey and Oliver 1939). These sites were revisited in 2008 and redbelly dace were found at 5 of the seven sites with previous records. Since 1998, northern redbelly dace have been recorded at 54 sites, including the first documented presence of the species in the Cold River watershed. Although the survey record is limited, it does not suggest a decline in range.

Population Management Status

There are no population management projects targeting northern redbelly dace.

Regulatory Protection (for explanations, see Appendix I)

Quality of Habitat

Redbelly dace habitat is relatively intact in northern New Hampshire. The average impervious surface coverage in watersheds with redbelly dace records is 1.3%, which is below the threshold of 4% where aquatic habitats typically show signs of degradation (Wang et al. 2001; Stranko et al. 2008; Cuffney et al. 2010). Although some of the 54 watersheds upstream of sites with redbelly dace records have impervious surface coverages as high as 7.1%, more than half of the watersheds have less than 1% impervious cover. Habitat degradation due to development is less of an issue for northern redbelly dace than it is for species that are restricted to southern New Hampshire. Populations in the Cold River and Sugar River watersheds may be more at risk than populations in northern portions of New Hampshire, where there are large tracts of protected land.

Although redbelly dace habitat in rivers and streams is largely intact, populations in ponded habitat, with water levels maintained by a dam, are vulnerable to rapid water level fluctuation, especially during dam repair. Lakes and ponds within the range of redbelly dace are also subject to shoreline development. With increased access comes a greater chance for introduced fish species, such as largemouth bass, which have contributed to the decline in minnow diversity throughout the northeast (Whittier et al. 1997).

Habitat Protection Status

Habitat Management Status

There are no habitat management projects targeting northern redbelly dace.

Threats to this Species or Habitat in NH

Threat rankings were calculated by groups of taxonomic or habitat experts using a multistep process (details in Chapter 4). Each threat was ranked for these factors: Spatial Extent, Severity, Immediacy, Certainty, and Reversibility (ability to address the threat). These combined scores produced one overall threat score. Only threats that received a "medium" or "high" score have accompanying text in this profile. Threats that have a low spatial extent, are unlikely to occur in the next ten years, or there is uncertainty in the data will be ranked lower due to these factors.

Mortality from subsidized or introduced predators (Black Bass; pickerel; sunfish) (Threat Rank: High)

Fish species including largemouth bass, smallmouth bass, black crappie, and northern pike are often illegally introduced into waterbodies by anglers to create new fishing opportunities. These introductions can significantly alter the species composition of a lake or pond.

Introductions of predator fish species have been implicated in an overall loss of minnow species diversity throughout the northeast (Whittier et al. 1997)

List of Lower Ranking Threats:

Habitat degradation from water level management

Habitat loss and degradation due to shoreline development

Actions to benefit this Species or Habitat in NH

Distribution surveys

Objective:
Map the distribution of fish species of conservation concern.

General Strategy:
Continue to conduct surveys to monitor the distributions of fish species of concern in New Hampshire.

Political Location: **Watershed Location:**

Life history research

Objective:
Study the life histories of fish species of conservation concern in New Hampshire.

General Strategy:
There is a lack of basic information on the reproductive behavior, foraging habits, habitat requirements, seasonal movement patterns and other aspects of the life history of many lesser known fish species of concern in New Hampshire. A better understanding of these species would aid in the assessment of potential threats and the development of appropriate management actions.
Also of interest is their ecological role in aquatic communities and their potential use as indicators for water quality or intact habitat.

Political Location: **Watershed Location:**

Water level management

Primary Threat Addressed: Habitat degradation from water level management

Specific Threat (IUCN Threat Levels): Natural system modifications

Objective:
Reduce the aquatic habitat impacts associated with artificial water level fluctuation at dams.

General Strategy:
Work with dam managers to achieve water level fluctuations that mimic natural flow regimes. Practices such as rapid changes in water level, excessive winter drawdown, and significantly reducing downstream flow to refill a waterbody should be avoided. Engaging stakeholders, including shorefront property owners, boaters, anglers, and hydropower project owners is critical to changing long established water level management traditions. The NHDES Dam Bureau is the lead on dam mangement issues in New Hampshire. The best strategy for improving water level management practices for fish and wildlife is to work with the Dam Bureau to identify opportunities to create more

natural water level fluctuations at a certain dams and then make slow incremental changes. This allows stakeholders to adjust to the changes and make comments when conflicts arise.

Political Location: **Watershed Location:**

Prevent fish species introductions

Primary Threat Addressed: Mortality from subsidized or introduced predators (Black Bass; pickerel; sunfish)

Specific Threat (IUCN Threat Levels): Invasive & other problematic species, genes & diseases / Invasive non-native/alien species/diseases / Named species

Objective:

Prevent the introduction of predatory game fish, which alter the composition of native fish communities.

General Strategy:

Species introductions are notoriously hard to prevent. An angler determined to create a new fishing opportunity by stocking a few fish into a waterbody is hard to deter. Education on the ecological damage that can be caused by introducing nonnative species into a waterbody will help prevent some, but not all deliberate species introductions. In some cases, anglers invested in the existing fishery may make the best advocates against new species introductions. However, outreach efforts will not persuade everyone, so laws, penalties, and adequate funding for enforcement are the last line of defense against species introductions. It is important that penalties are severe enough and the presence of law enforcement is noticeable enough to act as a deterrent. New species introductions are inevitable, but the rate and overall extent of introductions may be contained.

Political Location: **Watershed Location:**

References, Data Sources and Authors

Data Sources

Published literature was used to define the global distribution and habitat requirements of northern red-belly dace. New Hampshire Fish and Game (NHFG) unpublished data, New Hampshire Department of Environmental Services (NHDES) Biomonitoring data, and biological surveys by the NHFG from 1937 to 1939 were used to define the distribution of northern redbelly dace within the state. NHFG fish survey data.

Data Quality

There are relatively few records of redbelly dace in New Hampshire (54 records out of over 2,000 sites surveyed), despite extensive electrofishing surveys conducted throughout New Hampshire by NHFG biologists over the last 10 years as part of the Eastern Brook Trout Joint Venture project. The tendency to live in beaver impounded wetland streams and small ponds, which are difficult to survey, may explain why the species is under represented in the fish survey database. Northern redbelly dace are easily confused with finescale dace. The number sites known to contain northern redbelly dace has increased from 7 in 1939 to 54 as of 2013, but the health of individual populations is unknown.

2015 Authors:
Matthew Carpenter, NHFG, Benjamin Nugent, NHFG

2005 Authors:

Literature

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Finescale Dace

Chrosomus neogaeus

Federal Listing	
State Listing	SC
Global Rank	
State Rank	S3
Regional Status	

Photo by John Lyons

Justification (Reason for Concern in NH)

Finescale dace are vulnerable to habitat alterations that reduce summer base flows and riparian cover. Populations upstream of dams are also vulnerable to artificial water level fluctuations, especially during the spawning season. The extent of their distribution in New Hampshire is not well understood. Although aquatic habitats in northern New Hampshire are under less pressure from development than those of southern New Hampshire, there may be certain regions that are important for the persistence of the species, which has somewhat limited dispersal abilities. Finescale dace populations are vulnerable to introductions of large predatory fish species, including bass, pike, and sunfish. The brightly colored breeding males, in particular, are not well adapted to avoiding predatory fish (Stasiak and Cunningham 2006). As a species adapted to cold climates, the range of the finescale dace may be reduced in the future due to the effects of climate change.

Distribution

The finescale dace has a northern distribution in North America, inhabiting most of Canada, with isolated populations in the upper Mississippi River watershed, northern New York, Vermont, New Hampshire, and Maine. In New Hampshire, finescale dace populations occur north of the White Mountains, in the Androscoggin and Connecticut River watersheds (Scarola 1987).

Habitat

Finescale dace prefer lower gradient, cool headwater streams and small ponds with sluggish flow and ample cover from over hanging shrubs or aquatic vegetation (Scott and Crossman 1974). They tend to thrive in areas with a history of beaver activity. Individuals may be found in rivers or steams with higher gradients and flow, but they are assumed to have either washed out of or dispersed from areas of more suitable habitat upstream.

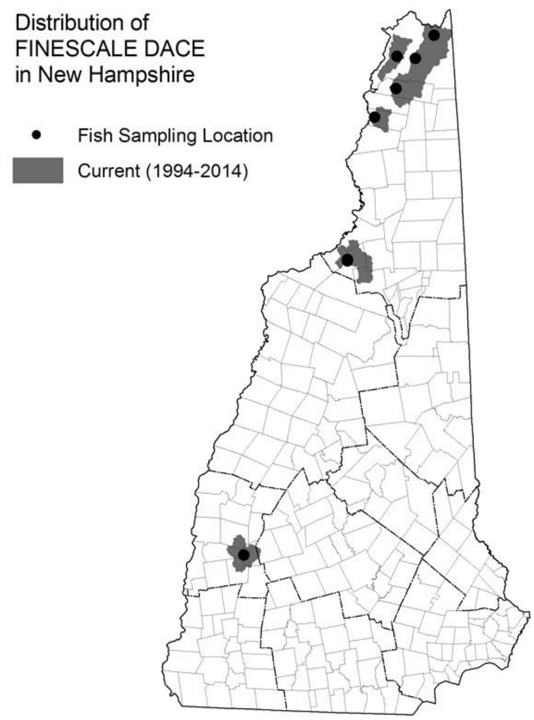
The finescale dace is a carnivorous minnow species. Its large jaws are adapted to feeding on insects, insect larvae, crustaceans, and snails. Finescale dace are non-territorial and may be observed foraging in small groups in the slower flowing sections of small streams and rivers. They are particularly well adapted to living in streams with beaver dams in various states of activity. This habitat may offer protection from large predacious fish species, with which finescale dace rarely coexist (Stasiak and Cunningham 2006).

Breeding takes place in areas of structure, such as exposed tree roots below an undercut bank, or a submerged tree branch, where the male uses its large pectoral fin to guide the female toward the substrate to deposit her eggs. Spawning takes place in small groups just after ice out. They are one of the first minnow species to spawn in early spring (Stasiak and Cunningham 2006). Adapted to thick ice cover and low oxygen levels, finescale dace are well suited to living in northern climates. Individuals may reach up to 6 years of age and 5 inches in length.

Where finescale dace overlap with northern redbelly dace, hybridization may occur. The offspring tend to be all female and diploid, meaning that they contain a full set of chromosomes from each parent. The hybrids are able to reproduce clonally and they share characteristics from both species, including a more omnivorous diet (Scott and Crossman 1974). Northern redbelly dace usually spawn about two weeks later than finescale dace in warmer water temperatures (190C/670F for redbelly dace and 160C/600F for finescale dace). Hybridization occurs in areas where rapid temperature increases in spring may cause more overlap between the spawning seasons of the two species.

NH Wildlife Action Plan Habitats

- Coldwater Rivers and Streams
- Lakes and Ponds with Coldwater Habitat
- Warmwater Lakes and Ponds



Distribution Map

Current Species and Habitat Condition in New Hampshire

There are only nine sites where finescale dace have been recorded in New Hampshire. These records must be viewed with caution due to similarities in appearance with northern redbelly dace. More information is needed to evaluate finescale dace population status and trends.

Population Management Status

There are no current population management projects specifically targeting finescale dace.

Regulatory Protection (for explanations, see Appendix I)

- Harvest permit - season/take regulations

Quality of Habitat

Finescale dace are found north of the White Mountains, where aquatic habitats are relatively intact. Populations in ponds upstream of dams are vulnerable to water level fluctuations. The dam at Scotts Bog, a shallow wetland in the town of Pittsburg where finescale dace have been documented, was recently reconstructed. Follow up surveys should be done to see how this reconstruction project may have impacted the finescale dace population upstream of the dam. Finescale dace populations in ponds, including Matthews Pond in Colebrook and Round Pond in Pittsburg, are particularly vulnerable to introduced fish species.

Habitat Protection Status

Habitat Management Status

There are no current habitat management projects specifically targeting finescale dace.

Threats to this Species or Habitat in NH

Threat rankings were calculated by groups of taxonomic or habitat experts using a multistep process (details in Chapter 4). Each threat was ranked for these factors: Spatial Extent, Severity, Immediacy, Certainty, and Reversibility (ability to address the threat). These combined scores produced one overall threat score. Only threats that received a "medium" or "high" score have accompanying text in this profile. Threats that have a low spatial extent, are unlikely to occur in the next ten years, or there is uncertainty in the data will be ranked lower due to these factors.

Mortality from subsidized or introduced predators (Black Bass; pickerel; sunfish) (Threat Rank: High)

Fish species including largemouth bass, smallmouth bass, black crappie, and northern pike are often illegally introduced into waterbodies by anglers to create new fishing opportunities. These introductions can significantly alter the species composition of a lake or pond.

Introductions of predator fish species have been implicated in an overall loss of minnow species diversity throughout the northeast (Whittier et al. 1997)

List of Lower Ranking Threats:

Habitat degradation from water level management

Habitat loss and degradation due to shoreline development

Actions to benefit this Species or Habitat in NH

Prevent fish species introductions

Primary Threat Addressed: Mortality from subsidized or introduced predators (Black Bass; pickerel; sunfish)

Specific Threat (IUCN Threat Levels): Invasive & other problematic species, genes & diseases / Invasive non-native/alien species/diseases / Named species

Objective:

Prevent the introduction of predatory game fish, which alter the composition of native fish communities.

General Strategy:

Species introductions are notoriously hard to prevent. An angler determined to create a new fishing opportunity by stocking a few fish into a waterbody is hard to deter. Education on the ecological damage that can be caused by introducing nonnative species into a waterbody will help prevent some, but not all deliberate species introductions. In some cases, anglers invested in the existing fishery may make the best advocates against new species introductions. However, outreach efforts will not persuade everyone, so laws, penalties, and adequate funding for enforcement are the last line of defense against species introductions. It is important that penalties are severe enough and the presence of law enforcement is noticeable enough to act as a deterrent. New species introductions are inevitable, but the rate and overall extent of introductions may be contained.

Political Location: **Watershed Location:**

Distribution surveys

Objective:

Map the distribution of fish species of conservation concern.

General Strategy:

Continue to conduct surveys to monitor the distributions of fish species of concern in New Hampshire.

Political Location: **Watershed Location:**

Water level management

Primary Threat Addressed: Habitat degradation from water level management

Specific Threat (IUCN Threat Levels): Natural system modifications

Objective:

Reduce the aquatic habitat impacts associated with artificial water level fluctuation at dams.

General Strategy:

Work with dam managers to achieve water level fluctuations that mimic natural flow regimes. Practices such as rapid changes in water level, excessive winter drawdown, and reducing downstream flow to refill a waterbody should be avoided. Engaging stakeholders, including shorefront property owners, boaters, anglers, and hydropower project owners is critical to changing long established water level management traditions. The NHDES Dam Bureau is the lead on dam mangement issues in New Hampshire. The best strategy for improving water level management practices for fish and wildlife is to work with the Dam Bureau to identify opportunities to create more natural water level fluctuations at a certain dams and then make slow incremental changes. This allows stakeholders to adjust to the changes and make comments when conflicts arise.

Political Location: **Watershed Location:**

Life history research

Objective:

Study the life histories of fish species of conservation concern in New Hampshire.

General Strategy:

There is a lack of basic information on the reproductive behavior, foraging habits, habitat requirements, seasonal movement patterns and other aspects of the life history of many lesser known fish species of concern in New Hampshire. A better understanding of these species would aid in the assessment of potential threats and the development of appropriate management actions.
Also of interest is their ecological role in aquatic communities and their potential use as indicators for water quality or intact habitat.

Political Location:

Watershed Location:

References, Data Sources and Authors

Data Sources

Published literature was used to define the species global distribution and habitat descriptions. NHFG unpublished data and historical biological surveys provided locations of finescale dace in New Hampshire. The NHFG maintains a database of fish survey records.

Data Quality

Surveys targeting sites with historic records of finescale dace were conducted in 2011. Finescale dace have also been captured during electrofishing surveys for brook trout. There are still large gaps in the distribution data for finescale dace.
There is little information available on the status of finescale dace populations in New Hampshire. There are only 9 confirmed records and identification is questionable due to similarities in appearance with redbelly dace. Finescale dace are likely more widespread than survey records indicate. Their preferred habitat of beaver ponds and wetland streams in northern New Hampshire is not well represented in the NHFG fish survey database.

2015 Authors:

Matthew Carpenter, NHFG, Benjamin Nugent, NHFG

2005 Authors:

Literature

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Scott, W., and E. Crossman. 1973. Freshwater Fishes of Canada. Fisheries Research Board of Canada.

Stasiak, R. and G.R. Cunningham. 2006. Finescale Dace (*Phoxinus neogaeus*): a technical conservation assessment. [Online]. USDA Forest Service, Rocky Mountain Region. Available: http://www.fs.fed.us/r2/projects/scp/assessments/finescaledace.pdf [Accessed June, 2015].

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Lake Whitefish

Coregonus clupeaformis

Federal Listing	
State Listing	SC
Global Rank	
State Rank	S3
Regional Status	High

Photo by Submitted by angler

Justification (Reason for Concern in NH)

The lake whitefish is considered vulnerable in New Hampshire, and is believed to be limited to 6 water bodies in the state. Information about these populations is limited, though historical creel surveys and reports indicate populations with good health and high abundance (Towne 1959, Noon 1999). Current information pertaining to lake whitefish almost solely comes from occasional captures by anglers. Further studies on the population's health and status are warranted.

Distribution

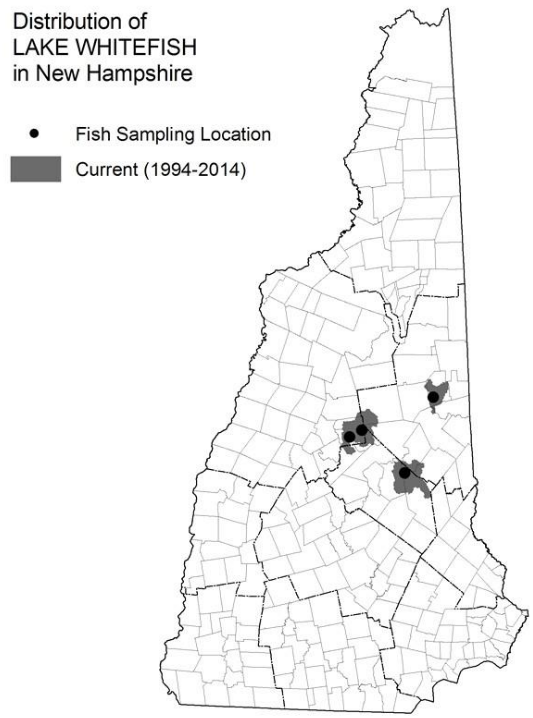
Lake whitefish are distributed throughout Canada and the northern United States. Populations in New Hampshire are at the southern extent of the species' global range (Scarola 1987). Scarola (1987) maintains lake whitefish were native to 2 New Hampshire lakes (Umbagog and Winnipesaukee lakes), whereas Gordon (1937) believes lake whitefish were introduced in the Androscoggin watershed (e.g., Umbagog Lake). Two lake whitefish, possible stocked, were found in Umbagog Lake in 1905, and none have been found since (Basley 2001). It is currently believed that populations exist in Winnipesaukee, Big Squam, Wentworth (Scarola 1987), Winnisquam, Silver (Madison) (D. Miller, New Hampshire Fish and Game (NHFG), personal communication), First Connecticut, and Francis Lakes (M. Garabedian, NHFG, personal communication, Bailey and Oliver 1939). The species has also been reported in several other water bodies within the state through stocking programs (Newfound Lake, Island Pond (Hampstead), Ossipee Lake, Sunapee Lake, Little Squam Lake, and Second Connecticut Lake) (NHFG, unpublished data). The status of these stocked populations is unknown.

Habitat

Lake whitefish are a pelagic, cool water species requiring either large rivers or deep, cold, clear lakes (Scarola 1987, Scott and Crossman 1973). Lake whitefish seek the cooler waters of the hypolimnion during summer months and are occasionally found along shoals in spring (Scott and Crossman 1973). Spawning habitats consists of shallow water reefs or tributary streams with hard or rocky substrates (Scarola 1987, Scott and Crossman 1973). Spawning occurs at temperatures ranging from 40° to 50°F (Scarola 1987) at depths typically less than 25 feet (Scott and Crossman 1973). Newly hatched larvae congregate along steep shorelines and move to deeper water by early summer (Scott and Crossman 1973).

NH Wildlife Action Plan Habitats

- Lakes and Ponds with Coldwater Habitat



Distribution Map

Current Species and Habitat Condition in New Hampshire

Abundant populations of lake whitefish were historically seen in some of New Hampshire's waterbodies. Scarola (1987) noted that anglers once eagerly targeted the lake whitefish. A creel census in 1952 and 1953 indicated lake whitefish were highly targeted by ice fishermen in the Squam Lakes, with estimated annual harvest yields of 500 pounds (Towne 1959). Lake whitefish have been observed in tributaries of both First Connecticut Lake and Lake Francis, and were noted for size ("three pounds or more") and fight (M. Garabedian, NHFG, personal communication). There have been reports of recent angler catches from Silver Lake (Madison) and Squam Lake (Don Miller, NHFG, personal communication). According to Scarola (1987), populations have significantly declined due to "overexploitation and abuse". The current status, abundance, and distribution of lake whitefish populations in New Hampshire remains poorly understood.

Population Management Status

At this time, it is unlikely that the 2 fish daily harvest limit affects existing populations. A recent survey of resident and nonresident anglers indicated that the lake whitefish is very rarely, if at all, caught (Duda and Young 1996). Accounts of accidental captures of lake whitefish are rare. No other direct management effort exists at this time.

Regulatory Protection (for explanations, see Appendix I)

- Harvest permit - season/take regulations

Quality of Habitat

Deep, coldwater habitat is abundant and healthy forage populations exist in the waterbodies where lake whitefish are known to occur. Important spawning habitat has not been identified.

Habitat Protection Status

Habitat Management Status

There are no habitat management efforts targeted for lake whitefish.

Threats to this Species or Habitat in NH

Threat rankings were calculated by groups of taxonomic or habitat experts using a multistep process (details in Chapter 4). Each threat was ranked for these factors: Spatial Extent, Severity, Immediacy, Certainty, and Reversibility (ability to address the threat). These combined scores produced one overall threat score. Only threats that received a "medium" or "high" score have accompanying text in this profile. Threats that have a low spatial extent, are unlikely to occur in the next ten years, or there is uncertainty in the data will be ranked lower due to these factors.

Disturbance from water level management (Threat Rank: Medium)

Lake whitefish spawn on reefs with gravel and boulder substrate. The depth of these reefs may make them vulnerable to exposure if lake levels drop after the spawning season in late fall and early winter.

Lake trout eggs are known to be vulnerable to water level drawdowns (Thill 2014). Observations of lake trout and round whitefish spawning on a shallow reef in Newfound Lake have raised concerns about the impacts of water level management practices, which involve drawing down the lake throughout the winter. The location and depth of lake whitefish spawning areas must be identified before an assessment can be made on the potential impacts of water level fluctuation on lake whitefish egg survival.

List of Lower Ranking Threats:

Species impacts from competition (introduced species)

Disturbance from reduced area of coldwater habitat

Actions to benefit this Species or Habitat in NH

Water level management

Primary Threat Addressed: Disturbance from water level management

Specific Threat (IUCN Threat Levels): Natural system modifications

Objective:
Reduce the aquatic habitat impacts associated with artificial water level fluctuation at dams.

General Strategy:
Work with dam managers to achieve water level fluctuations that mimic natural flow regimes. Practices such as rapid changes in water level, excessive winter drawdown, and shutting off downstream flow to refill a waterbody should be avoided. For coldwater species that spawn on shallow reefs, including lake trout, round whitefish, lake whitefish, and burbot, it is important that water levels do not drop significantly after the spawning season, such that the eggs would be exposed. Engaging stakeholders, including shorefront property owners, boaters, anglers, and hydropower project owners is critical to changing long established water level management traditions. The NH Dam Bureau is the lead on dam management issues in New Hampshire. The best strategy for improving water level management practices for fish and wildlife is to work with the Dam Bureau to identify opportunities to create more natural water level fluctuations at a certain dams and then make slow incremental changes. This allows stakeholders to adjust to the changes and make comments when conflicts arise.

Political Location: **Watershed Location:**

Reduce nutrient loading

Primary Threat Addressed: Disturbance from reduced area of coldwater habitat

Specific Threat (IUCN Threat Levels): Climate change & severe weather

Objective:
Reduce the impacts of eutrophication by removing excess sources of nutrients.

General Strategy:
The primary sources of excess nutrients are lawn fertilizers in residential and commercial developments, agricultural fertilizers, and poorly functioning septic systems. Reducing nutrient loads can be achieved on two fronts. One is through outreach, which includes creating awareness about the effects of fertilizers on water quality and offering alternatives to fertilization practices that lead to the greatest amount of nutrient loading in nearby waterbodies. Best management practices can be developed for property owners with a focus on reducing runoff, minimizing or eliminating fertilizer use, and landscaping in a way that reduces the need for fertilization. In the case of septic failure, shoreline property owners with older septic systems can be targeted with incentives for upgrading. The second front is legislative. Laws that set limits on fertilizer use and require upgrades to septic systems will have long term benefits on water quality throughout the developed watersheds of southern New Hampshire. Requirements for new septic systems have greatly improved in recent years. The challenge is identifying and upgrading older systems that were constructed before septic systems were required to meet modern standards.

Political Location: **Watershed Location:**

Map spawning habitat

Objective:
Map the distribution of coldwater fish spawning habitat in deep water lakes.

General Strategy:
Although some important spawning reefs have been well documented, the extent of spawning habitat for coldwater fish species remains undocumented in most lakes where they occur. Acoustic

or radio telemetry, gill or fyke net surveys, underwater cameras, and visual observations are potential methods for identifying important spawning areas. Depth recordings at spawning areas well help inform water level management policy.

Political Location: **Watershed Location:**

Population assessment

Objective:
Assess the status of lake whitefish populations in New Hampshire.

General Strategy:
Explore methods for assessing the populations of lake whitefish in lakes where they are known to occur. Confirm and update the current distribution of the species in New Hampshire.

Political Location: **Watershed Location:**

References, Data Sources and Authors

Data Sources
Peer-reviewed literature was used to define the species' distribution and habitat. NHFG unpublished data, published literature, and personal communications with a NHFG conservation officer and fisheries biologist were used to define statewide distribution.
There are very few recent records of lake whitefish, other than incidental catches during surveys for lake trout and salmon as well as anecdotal reports from anglers.

Data Quality
Recent data for the species are scarce, with the majority of information available dating to the 1930s. Population distribution data are based on historical sampling data and recent angler reports to biologists and conservation officers. Data should be treated cautiously, for the round whitefish (*Prosopium cylindraceum*) may have been misidentified as the lake whitefish (Normandeau 1963).

NHFG biologists have attempted to survey for lake whitefish using gill nets and fyke nets on potential spawning reefs and summering grounds on Squam Lake and Lake Winnipesaukee. The surveys have so far been unsuccessful. These methods require a significant time commitment, which is beyond the current capacity of NHFG staff. Other methods, such as angling, should be tested.
There is a lack of information on which to evaluate the population status of lake whitefish. NHFG biologists have conducted gill net and fyke net surveys targeting the species, but they have so far been unsuccessful.

2015 Authors:
Benjamin Nugent, NHFG, Matthew Carpenter, NHFG

2005 Authors:

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Banded Sunfish

Enneacanthus obesus

Photo by NHFG

Federal Listing	
State Listing	SC
Global Rank	
State Rank	S3
Regional Status	V. High

Justification (Reason for Concern in NH)

Surveys conducted since the first Wildlife Action Plan was completed in 2005 suggest that the banded sunfish is more widely distributed in southern New Hampshire than previously thought. However, much of the habitat where banded sunfish are found has been degraded by shoreland development, eutrophication, and runoff from impervious surfaces. Habitat degradation, especially upstream of dams, may increase the vulnerability of banded sunfish to predation by both introduced (largemouth bass) and native (chain pickerel) predators. The long term viability of banded sunfish populations in New Hampshire is still unclear.

Distribution

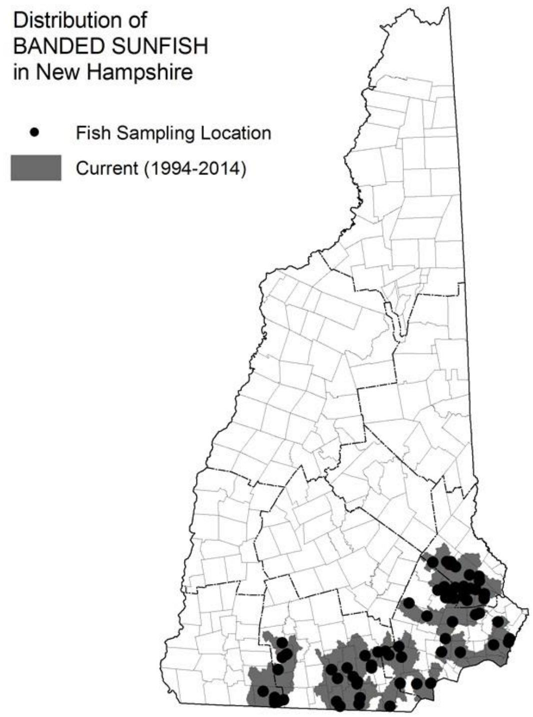
Banded sunfish inhabit the Atlantic coastal plain from southern New Hampshire to Florida (Scarola 1987). In New Hampshire they are found in lowland areas of the Merrimack River and in coastal watersheds (Scarola 1987). A population has also been documented in the upper Millers River watershed, which drains into the Connecticut River (Bailey and Oliver 1939). This is the only known population of banded sunfish within the Connecticut River Watershed in New Hampshire.

Habitat

Banded sunfish prefer vegetated areas of ponds, lakes, and the backwaters of lowland streams (Scarola 1987). Banded sunfish are highly tolerant of acidic water and can withstand pH levels as low as 4.0 (Gonzales and Dunson 1989). Tolerance for acidic water may be an adaptation that provides banded sunfish with access to habitats unavailable to other fish species (Graham and Hastings 1984, Gonzales and Dunson 1991) and may provide the banded sunfish with refuge from both native and introduced species of predaceous fish (Graham 1993). In New Hampshire, banded sunfish are found in a variety of habitats from lakes and ponds to low gradient headwater streams with beaver activity.

NH Wildlife Action Plan Habitats

- Warmwater Lakes and Ponds
- Warmwater Rivers and Streams



Distribution Map

Current Species and Habitat Condition in New Hampshire

Fish surveys for banded sunfish were intended to confirm presence, not to assess the health of individual populations. Banded sunfish are often captured unexpectedly during fish surveys for other target species in southeastern NH. They appear to be more common than previously expected, especially in the Millers River watershed and in the headwaters of the coastal drainages. Banded sunfish are more easily captured in low gradient streams with a history of beaver activity. They appear to be less common in lakes and ponds with high densities of shoreline development, where introduced predators, degraded water quality, and aquatic vegetation removal may impact banded sunfish populations. The relative abundance of banded sunfish populations in New Hampshire presents an opportunity to protect the species at the northern edge of its range, where its habitat is still relatively intact.

Population Management Status

There are no current population management activities for banded sunfish.

Regulatory Protection (for explanations, see Appendix I)

- Harvest permit - season/take regulations

Quality of Habitat

Low gradient, warmwater streams in the watersheds of southern New Hampshire, such as the Isinglass River, Bellamy River, Lamprey River, and Millers River support healthy populations of banded sunfish. These streams often flow through wetlands with a history of beaver activity. There tends to be fewer predators and better water quality in the low gradient, warmwater stream habitat that makes up much of the headwaters of the rivers in southeastern NH. In the watersheds upstream of sites known to contain banded sunfish, an average of 13% of the landscape is classified as developed, but the level of development is highly variable, ranging from a high of 54% to a low of less than 1%. GIS landcover data can be used to identify the least impacted watersheds where banded sunfish are likely to occur. Protecting headwater stream habitat in the drainages of coastal, southern Merrimack, and upper Millers Rivers, will benefit a number of other aquatic species of concern in addition to banded sunfish.

Banded sunfish populations in some shallow eutrophic ponds are subjected to degraded water quality. Low dissolved oxygen levels and increased turbidity due to shoreline development and polluted runoff from the surrounding watershed can impact fish species like banded sunfish, which prefer to forage in healthy stands of submerged aquatic vegetation. These ponds, often created by dams, tend to have abundant populations of introduced predators, such as bass and bluegill, which may limit banded sunfish productivity. Examples include Flints Pond (Hollis), Canobie Lake (Salem), Powwow Pond (Kingston), and Mill Pond (Durham). Reducing nutrient loading, managing stormwater runoff, and protecting shoreline habitat will improve habitat for banded sunfish and other aquatic species in shallow warmwater ponds.

Habitat Protection Status

Habitat Management Status

There are no habitat management projects directed at banded sunfish.

Threats to this Species or Habitat in NH

Threat rankings were calculated by groups of taxonomic or habitat experts using a multistep process (details in Chapter 4). Each threat was ranked for these factors: Spatial Extent, Severity, Immediacy, Certainty, and Reversibility (ability to address the threat). These combined scores produced one overall threat score. Only threats that received a "medium" or "high" score have accompanying text in this profile. Threats that have a low spatial extent, are unlikely to occur in the next ten years, or there is uncertainty in the data will be ranked lower due to these factors.

Disturbance from eutrophication (Threat Rank: High)

Nutrients from agricultural sources, sedimentation, lawn fertilizers, and poorly functioning septic systems contribute to increased algal growth in lakes and ponds. This excess productivity causes reductions in water quality and eventually lower dissolved oxygen levels as microorganisms consume the dead algal cells, using up oxygen in the process.

Many lakes and ponds in New England show signs of degraded water quality due to cultural eutrophication (USEPA 2010). Increasing development pressure in southern New Hampshire has led to eutrophication issues with many of the water bodies that support aquatic species of concern, including banded sunfish, bridle shiner, redfin pickerel, swamp darter, and eastern pondmussel.

Species disturbance from shoreline development (Threat Rank: Medium)

Development along the shoreline of lakes, ponds, and larger rivers degrades critical habitat for aquatic species.

Aquatic plant removal, clearing of trees and branches that fall into the water, shoreline armoring, dock construction, tree and shrub thinning, and lawn maintenance are common practices associated with shoreline development. The cumulative effects of shoreline development combine to reduce habitat quality throughout a waterbody (Brian and Scarnecchia 1992; Hicks and Frost 2010). Vegetation removal, in particular, degrades habitat for species like banded sunfish, bridle shiner, and swamp darter, which depend on submerged aquatic plant species for spawning and refuge from predators.

Habitat conversion and degradation caused by water level management (Threat Rank: Medium)

Unnatural water level fluctuations alter upstream lake and pond habitat. Lake drawdowns, usually during winter, reduce shoreline plant communities and expose aquatic organisms to desiccation. Poor recruitment may be an issue for species that spawn on shallow reefs or along the shoreline, depending on the timing and extent of the drawdown. River and stream habitat below lakes and ponds may also be impacted as flows are shutdown in an attempt to refill lakes or increased rapidly to lower the water level.

Aquatic habitat in the littoral zone becomes degraded during excessive water level drawdown, including declines in aquatic macrophytes, invertebrate density, and species diversity. These impacts are linked to overall lake function, including potential influences on nutrient cycling (Zohary and Ostrovsky 2011). Changes in fish communities that result from artificial flow manipulation involve a shift to habitat generalist fish species. These changes have been have been well documented in studies related to instream flow (Kanno and Vokoun 2010).

Mortality from subsidized or introduced predators (Threat Rank: Medium)

Fish species including largemouth bass, smallmouth bass, black crappie, and northern pike are often illegally introduced into waterbodies by anglers to create new fishing opportunities. These introductions can significantly alter the species composition of a lake or pond.

Introductions of predator fish species have been implicated in an overall loss of minnow species diversity throughout the northeast (Whittier et al. 1997)

Species disturbance from impervious surface run-off (Threat Rank: Medium)

Stormwater runoff from impervious surfaces changes the hydrology of local rivers and streams. Flashier flows cause an increase in erosion and sediment deposition along stream banks and in the stream channel. More surface flow during rain events reduces the amount of precipitation that infiltrates into the ground, which results in lower base flows during dry periods. Oil based pollutants, sediment, and road salt are washed from roads and parking lots into surrounding waterbodies which can lead to chronic declines in water quality. Runoff from pavement warmed by the sun can also lead to increased water temperatures in local streams when stormwater flows directly into surface waters.

The impacts of impervious land cover on aquatic habitats have been well documented (Wang et al. 2001; Cuffney et al. 2010; Stranko et al. 2008).

List of Lower Ranking Threats:

None

Actions to benefit this Species or Habitat in NH

Reduce nutrient loading

Primary Threat Addressed: Disturbance from eutrophication

Specific Threat (IUCN Threat Levels): Pollution

Objective:
Reduce the impacts of eutrophication by removing excess sources of nutrients.

General Strategy:
The primary sources of excess nutrients are lawn fertilizers in residential and commercial developments, agricultural fertilizers, and poorly functioning septic systems. Reducing nutrient loads can be achieved on two fronts. One is through outreach, which includes creating awareness about the effects of fertilizers on water quality and offering alternatives to fertilization practices that lead to the greatest amount of nutrient loading in nearby waterbodies. Best management practices can be developed for property owners with a focus on reducing runoff, minimizing or eliminating fertilizer use, and landscaping in a way that reduces the need for fertilization. In the case of septic failure, shoreline property owners with older septic systems can be targeted with incentives for upgrading. The second front is legislative. Laws that set limits on fertilizer use and require upgrades to septic systems will have long term benefits on water quality throughout the developed watersheds of southern New Hampshire. Requirements for new septic systems have greatly improved in recent years. The challenge is identifying and upgrading older systems that were constructed before septic systems were required to meet modern standards.

Political Location: **Watershed Location:**

Water level management

Primary Threat Addressed: Habitat conversion and degradation caused by water level management

Specific Threat (IUCN Threat Levels): Natural system modifications

Objective:
Reduce the aquatic habitat impacts associated with artificial water level fluctuation at dams.

General Strategy:
Work with dam managers to achieve water level fluctuations that mimic natural flow regimes. Practices such as rapid changes in water level, excessive winter drawdown, and shutting off downstream flow to refill a waterbody should be avoided. Engaging stakeholders, including shorefront property owners, boaters, anglers, and hydropower project owners is critical to changing long established water level management traditions. The NHDES Dam Bureau is the lead on dam mangement issues in New Hampshire. The best strategy for improving water level management practices for fish and wildlife is to work with the Dam Bureau to identify opportunities to create more natural water level fluctuations at a certain dams and then make slow incremental changes. This allows stakeholders to adjust to the changes and make comments when conflicts arise.

Political Location: **Watershed Location:**

Land Protection

Primary Threat Addressed: Species disturbance from impervious surface run-off

Specific Threat (IUCN Threat Levels): Pollution / Domestic & urban waste water / Run-off

Objective:
Preserve the natural ecological functions of an area by protecting land from development.

General Strategy:
Land protection is a strategy that can be used to ensure a level of habitat quality that is necessary to support certain species and habitats of conservation concern. For aquatic species, land protection prevents many of the impacts caused by sprawling development. Groundwater recharge, intact riparian zones, and unrestricted migration corridors are some of the benefits. Species with limited ranges and mobility may be protected almost entirely through land conservation. For wider ranging species, land protection will be part of a greater restoration strategy. Land conservation projects that include lake and pond shorelines and low gradient streams in southern New Hampshire will benefit banded sunfish. Land protection projects in New Hampshire usually require the coordination of a variety of funding sources, with involvement from town conservation commissions, local land trusts and watershed associations, government agencies, and state or national NGO's. Since 2005, the NH Wildlife Action Plan has helped direct land protection efforts toward conserving habitat for species and habitats of concern. The effectiveness of land conservation could be improved by identifying and addressing barriers to land conservation in New Hampshire and increasing outreach to help prioritize projects that benefit species and habitats of concern.

Political Location: **Watershed Location:**

Shoreline Buffer Protection

Primary Threat Addressed: Species disturbance from shoreline development

Specific Threat (IUCN Threat Levels): Residential & commercial development

Objective:
Protect important habitat features along the shorelines of lakes, ponds, and larger rivers.

General Strategy:
The NH Shoreland Water Quality Protection Act provides a minimum level of protection for shoreline habitat along New Hampshire's lakes, ponds, and rivers (third order and larger). While the Shoreland Water Quality Protection Act focuses on protecting natural vegetation along the shoreline, it falls short of protecting other important habitat features such as submerged aquatic vegetation and trees that fall into the water. Landowners often remove plants and trees from the water to improve access for swimming and boating. These trees and submerged aquatic plants offer important structure for spawning, foraging, and evading predators. Increasing the percentage of natural or undeveloped shoreline will improve the overall habitat quality in a lake or pond. Conservation easements, changes in zoning, legislative acts, or landowner outreach programs may be used to restore natural shoreline features to New Hampshire lakes and ponds, many of which have little remaining undeveloped shoreline.

Political Location: **Watershed Location:**

Stormwater Management

Primary Threat Addressed: Species disturbance from impervious surface run-off

Specific Threat (IUCN Threat Levels): Pollution / Domestic & urban waste water / Run-off

Objective:
To reduce the impacts of runoff from impervious surfaces by using Low Impact Development Technology.

General Strategy:
Stormwater runoff from impervious surfaces has been shown to damage aquatic habitats (Wang et al. 2001; Cuffney et al. 2010). Much of this damage can be prevented by stormwater management practices that filter runoff through the ground before it enters surface water. This practice not only removes much of the sediment and toxins that are typically washed into streams, but it also reduces the rapid fluctuation in temperature, as well as the excess erosion and sediment deposition that have become a chronic issue for rivers and streams in developed areas. The University of New Hampshire Stormwater Center is an excellent resource for Low Impact Development (LID) practices for stormwater management.

Political Location: **Watershed Location:**

Life history research

Objective:
Study the life histories of fish species of conservation concern in New Hampshire.

General Strategy:
There is a lack of basic information on the reproductive behavior, foraging habits, habitat requirements, seasonal movement patterns and other aspects of the life history of many lesser known fish species of concern in New Hampshire. A better understanding of these species would aid in the assessment of potential threats and the development of appropriate management actions. Also of interest is their ecological role in aquatic communities and their potential use as indicators for water quality or intact habitat.

Political Location: **Watershed Location:**

Distribution surveys

Objective:
Map the distribution of fish species of conservation concern.

General Strategy:
Continue to conduct surveys to monitor the distributions of fish species of concern in New Hampshire.

Political Location: **Watershed Location:**

References, Data Sources and Authors

Data Sources
Published literature provided information on distribution and habitat requirements. The NHFG fish survey database, NHDES Biomonitoring data, and watershed biological surveys conducted by NHFG from 1937 to 1939 were used in identifying current and historic records of the species within New

Hampshire.

The NHFG fish survey database includes records from a variety of projects both within and outside the department. Data sources include the NHDES Biomonitoring Program, Eastern Brook Trout Joint Venture wild brook trout brook monitoring surveys, Sportfish Restoration project data, and status assessments for the Wildlife Action Plan.

Typical survey methods include backpack electrofishing, boat electrofishing, seine surveys, gill netting, and fyke netting. Surveys targeting sites with historical records of banded sunfish were generally conducted with a bag seine. Banded sunfish are most often captured incidentally during backpack electrofishing surveys in shallow, low gradient warmwater stream habitat.

Data Quality

There have been 82 records of banded sunfish collected since 1984. This is a significant increase over the 14 sites where banded sunfish were recorded in a statewide biological inventory conducted in the late 1930s by the NHFG (Gordon 1937, Bailey 1938, Bailey and Oliver 1939). The 81 records of banded sunfish span 31 watersheds in southern New Hampshire at the United States Geological Survey (USGS) Hydrologic Unit Code 12 digit scale (HUC 12) (Seaber et al. 1987). The broad scale distribution of banded sunfish in New Hampshire has been established, but the distribution of the species within each watershed where it occurs is less well understood. Banded sunfish appear to be relatively common in the Oyster River watershed, where the species was recorded at 13 sites during fish surveys conducted in 2007 and 2008 as part of an American brook lamprey habitat mapping project.

While there is increasing knowledge of the distribution of banded sunfish in New Hampshire, there is little information on the health and long term viability of individual banded sunfish populations.

2015 Authors:

Matthew Carpenter, NHFG, Benjamin Nugent, NHFG

2005 Authors:

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Redfin Pickerel

Esox americanus

Photo by NHFG

Federal Listing	
State Listing	SC
Global Rank	
State Rank	S3
Regional Status	

Justification (Reason for Concern in NH)

Redfin pickerel are restricted to southeastern New Hampshire, where rapid urbanization makes the species susceptible to poor water quality, fragmentation, and other habitat related threats (Richter et al. 1997).

Distribution

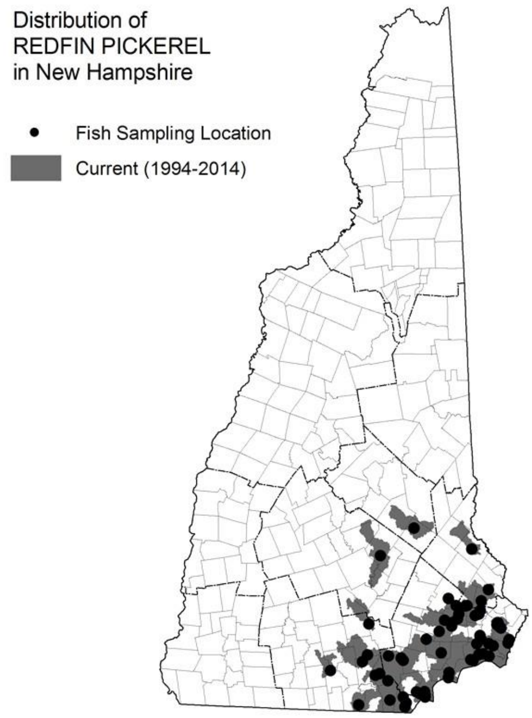
Redfin pickerel are native to the Atlantic coastal plain and reach the northern extent of their range in New Hampshire (Scarola 1987). There are a few isolated populations in Maine, where the species is listed as State Endangered. In New Hampshire, the species is restricted to lower elevation rivers and streams along the coastal plain in the lower Merrimack and southern coastal drainages.

Habitat

Redfin pickerel inhabit slow-moving, acidic, tea-colored streams with dense vegetation. The species is commonly found within brush piles or beneath overhanging vegetation (Ming 1968; Scarola 1987). Redfin pickerel also have been observed in brackish waters and swampy areas with low dissolved oxygen levels (Steiner 2004). In New Hampshire it is frequently found in lower gradient streams flowing through abandoned beaver ponds. Redfin pickerel appear to be well adapted to living in small headwater streams that may have intermittent flow in some years. Spawning occurs in shallow flood margins of stream habitats with thick vegetation. Redfin pickerel spawn mainly in the early spring, but there is some indication of spawning in the fall (Scott and Crossman 1973, Scarola 1987). Wintering habitat is often associated with leaf litter (Ming 1968).

NH Wildlife Action Plan Habitats

- Warmwater Rivers and Streams
- Warmwater Lakes and Ponds



Distribution Map

Current Species and Habitat Condition in New Hampshire

There are a total of 71 sites where redfin pickerel have been captured in New Hampshire. Other than a few outliers to the north and west, the majority of these records are clustered in the lower elevation watersheds of the southern Merrimack and coastal river drainages. The greatest number captured at one site was 20 individuals in 100m during an electrofishing survey of the Piscassic River in the town of Freemont. Redfin pickerel are locally abundant in some streams, especially low gradient, tannic streams with patches of aquatic vegetation and a history of beaver activity. Examples of this habitat can be found in the Powwow River, Winkley Brook, the Winnicut River, Beaver Brook, the Piscassic River, and parts of the Oyster River watershed.

Population Management Status

There are no population management projects targeting redfin pickerel.

Regulatory Protection (for explanations, see Appendix I)

- NH NHB Database - current

Quality of Habitat

Redfin pickerel appear to be somewhat tolerant of degraded habitat. They are often found in streams that have been fragmented by stream crossings within watersheds with relatively high impervious surface coverages. The average impervious surface coverage in watersheds upstream of sites where redfin pickerel have been recorded is 16% (max = 55%; min = 1%; SD = 13). Forty three of the 71 sites had impervious surface coverages over 10%, which is well above the threshold of 4% where impacts to aquatic habitats are typically obserevd (Wang et al. 2001; Cuffney et al. 2010). Common signs of impairment include stream bank erosion and sediment deposition from stormwater runoff and undersized stream crossings, low flow conditions due to upstream water level management or loss of groundwater recharge, and poor water quality. It is not clear how these impacts affect redfin pickerel populations or at what point they may lead to population declines.

Examples of relatively intact habitat for redfin pickerel can be found in tributaries to the Lamprey River, including the North River and Piscassic River, the Exeter River, Great Brook, Winnicut River, and the Powwow River. Examples of the most impacted habitat can be found in the southern tributaries of the Merrimack River, including the watersheds of Beaver Brook and Policy Brook.

Habitat Protection Status

Habitat Management Status

There are currently no habitat management projects targeting redfin pickerel.

Threats to this Species or Habitat in NH

Threat rankings were calculated by groups of taxonomic or habitat experts using a multistep process (details in Chapter 4). Each threat was ranked for these factors: Spatial Extent, Severity, Immediacy, Certainty, and Reversibility (ability to address the threat). These combined scores produced one overall threat score. Only threats that received a "medium" or "high" score have accompanying text in this profile. Threats that have a low spatial extent, are unlikely to occur in the next ten years, or there is uncertainty in the data will be ranked lower due to these factors.

Habitat degradation due to stream crossings (Threat Rank: Medium)

Poorly sized stream crossings alter the natural sediment transport characteristics of a river or stream, which leads to erosion and excess sediment deposition in the stream channel. The cumulative effect of under sized stream crossings can lead to increased sedimentation and turbidity throughout a watershed during storm events. Road fill from washed out stream crossings during flood events accumulates in the stream channel and buries the natural stream bed substrate.

Stream crossing surveys throughout New Hampshire have documented signs of stream habitat degradation at the majority of survey sites. Damage from washed out roads and failed stream crossings was apparent in most southern and coastal New Hampshire watersheds after the flood on Mother's Day 2006 (Stack et al 2010).

Habitat conversion and degradation from water level management (Threat Rank: Medium)

List of Lower Ranking Threats:

Disturbance from impervious surface run-off

Disturbance from dams that cause fragmentation

Disturbance from stream crossings or dams that fragment habitat

Actions to benefit this Species or Habitat in NH

Riparian Buffer Protection

Primary Threat Addressed: Disturbance from impervious surface run-off

Specific Threat (IUCN Threat Levels): Pollution / Domestic & urban waste water / Run-off

Objective:
Preserve the water and habitat quality of rivers, streams and the shorelines of lakes and ponds by preventing development in the riparian zone.

General Strategy:
Riparian buffer protection can be achieved through town ordinances, state law (i.e. the Shoreland Water Quality Protection Act), deed restriction, conservation easement, or voluntary land use practices (such as forestry best management practices). In general, the wider the buffer protected, the more ecological benefit. A buffer of at least 10 m will provide a minimum level of water quality and habitat benefits. A protected buffer of 100 m or greater provides maximum water quality and habitat benefits while also acting as a migration corridor for larger species of wildlife. Buffer protection is lacking on headwater streams despite the cumulative effect that intact riparian zones in headwater streams have on downstream water quality.

Political Location:

Watershed Location:

Stream crossing restoration

Primary Threat Addressed: Disturbance from stream crossings or dams that fragment habitat

Specific Threat (IUCN Threat Levels): Transportation & service corridors

Objective:
Increase connectivity and reduce habitat degradation caused by stream crossings.

General Strategy:
There are two phases to stream crossing restoration. The first phase is assessment. Stream crossing surveys are currently being conducted in several watersheds throughout the state. It is important that these surveys follow the standardized methods and protocols outlined by the New Hampshire Geological Survey (NHGS). NHGS maintains a statewide database of stream crossing survey data. Once the data is collected, stream crossing restoration projects can be prioritized to achieve the greatest benefits to aquatic organism passage, along with reductions in flood damage and habitat degradation. Prioritization may take place within small watersheds or across a large region. The second phase is implementation. Once a stream crossing is identified as a good candidate for restoration there are many obstacles to a completed project, including permitting and cost. Streamlining the permitting process for crossing restoration, increasing available funding sources, and developing innovative stream crossing design and construction techniques that significantly reduce cost would greatly increase the number of stream crossing restoration projects in New Hampshire.

Political Location:

Watershed Location:

Protect instream flow

Primary Threat Addressed: Habitat conversion and degradation from water level management

Specific Threat (IUCN Threat Levels): Natural system modifications

Objective:
Manage water withdrawal and protect groundwater recharge to ensure adequate flow for supporting aquatic species in rivers and streams.

General Strategy:
Surface water and groundwater withdrawals for drinking water, irrigation, and other uses can reduce river flows, especially during critical periods of low flow during the summer months. Water level management at dams also affects the streamflow in a watershed. The NHDES Instream Flow Program works to balance water use while maintaining flow for aquatic life. Two pilot studies, one in the Souhegan River and one in the Lamprey River, have been conducted and Water Management Plans have been approved. The lessons learned from these studies and management plans should be expanded into other watersheds throughout New Hampshire. The practices implemented in the Water management Plans for the Souhegan and Lamprey Rivers should be monitored to ensure that they are achieving the desired level of protection for instream flow. Dam managers should seek to manage water levels so that raising or lowering the water level in a lake or pond does not excessively decrease or increase the stream flow downstream of the dam. Headwater streams are especially vulnerable to water withdrawal and should not be overlooked during the permitting process.

Political Location: **Watershed Location:**

Life history research

Objective:
Study the life histories of fish species of conservation concern in New Hampshire.

General Strategy:
There is a lack of basic information on the reproductive behavior, foraging habits, habitat requirements, seasonal movement patterns and other aspects of the life history of many lesser known fish species of concern in New Hampshire. A better understanding of these species would aid in the assessment of potential threats and the development of appropriate management actions.
Also of interest is their ecological role in aquatic communities and their potential use as indicators for water quality or intact habitat.

Political Location: **Watershed Location:**

Distribution surveys

Objective:
Map the distribution of fish species of conservation concern.

General Strategy:
Continue to conduct surveys to monitor the distributions of fish species of concern in New Hampshire.

Political Location: **Watershed Location:**

Stormwater Management

Primary Threat Addressed: Disturbance from impervious surface run-off

Specific Threat (IUCN Threat Levels): Pollution / Domestic & urban waste water / Run-off

Objective:
To reduce the impacts of runoff from impervious surfaces by using Low Impact Development Technology.

General Strategy:
Stormwater runoff from impervious surfaces has been shown to damage aquatic habitats (Wang et al. 2001; Cuffney et al. 2010). Much of this damage can be prevented by stormwater management practices that filter runoff through the ground before it enters surface water. This practice not only removes much of the sediment and toxins that are typically washed into streams, but it also reduces the rapid fluctuation in temperature, as well as the excess erosion and sediment deposition that have become a chronic issue for rivers and streams in developed areas. The University of New Hampshire Stormwater Center is an excellent resource for Low Impact Development (LID) practices for stormwater management.

Political Location: **Watershed Location:**

References, Data Sources and Authors

Data Sources
Published literature provided information on distribution and habitat requirements. The NHFG fish survey database, NHDES Biomonitoring data, and watershed biological surveys conducted by NHFG from 1937 to 1939 were used in identifying current and historic records of the species within New Hampshire. The NHFG fish survey database contains over 2,000 records collected over the past 35 years.

Data Quality
A number of new redfin pickerel records have been added to the NHFG Fish Survey database as a result of surveys by the NHFG to assess the status of redfin pickerel and other species of concern. Due to variations in survey methodologies, survey records are, in most cases, not representative of the actual population size at each site. They provide a general overview of redfin pickerel distribution in NH. Before status assessments for fish species of concern were initiated in 2005, there were a total of 29 sites where RFP were recorded. Since 2005, an additional 42 records of redfin pickerel have been added to the database. Interestingly, redfin pickerel were only recorded at 5 sites in 1938 (Bailey 1938). The increase in the number of records has alleviated concerns for a decline in redfin pickerel distribution in New Hampshire, but the health and status of individual populations is not well understood.

2015 Authors:
Matthew Carpenter, NHFG, Benjamin Nugent, NHFG

2005 Authors:

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Swamp Darter

Etheostoma fusiforme

Federal Listing	
State Listing	SC
Global Rank	
State Rank	S3
Regional Status	High

Photo by NHFG

Justification (Reason for Concern in NH)

Swamp darter populations appear to be restricted to watersheds in the southeastern corner of the state. New Hampshire is near the northern extent of the swamp darters' global range. The short life span of the swamp darter (1 to 2 years), combined with aquatic habitat degradation caused by increasing development in southeastern New Hampshire, make the species vulnerable to extirpation from state waters (Schmidt 1983). Swamp darters are difficult to capture, and as a result they may be more widely distributed than records indicate. They are listed as imperiled, critically imperiled, or vulnerable in the majority of states throughout their range. The swamp darter is a state threatened species in Maine and is presumed extirpated from the state of Pennsylvania.

Distribution

Swamp darters have a patchy distribution along the Atlantic coastal plain from southern Maine to the gulf coast and the Lower Mississippi drainages (Scarola 1987). In New Hampshire, swamp darters are restricted to the coastal and lower Merrimack River watersheds.

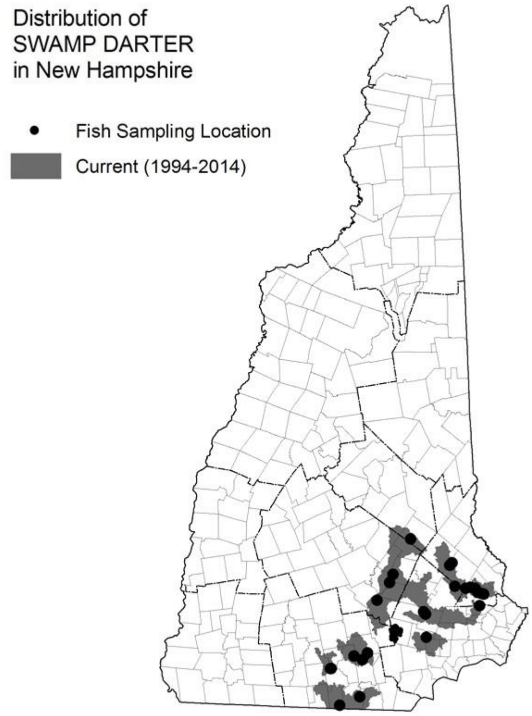
Habitat

The swamp darter inhabits lakes and ponds in shallow areas of soft muddy substrate, dense vegetation, and accumulated detritus. Stream habitats include both swift and slow moving water with patches of thick vegetation (Schmidt and Whitworth 1979, Scarola 1987). Research in Connecticut streams and ponds found swamp darters to be more abundant in ponds than in streams, and stream populations were usually found near known pond populations. Spawning activity was not observed in streams, indicating that stream populations may depend on recruitment from ponds (Schmidt and Whitworth 1979). Swamp darters are dependent on vegetation for spawning (Toth et al. 1998).

In New Hampshire, swamp darters have been observed in a wide variety of habitat types, including small vegetated ponds, impounded rivers, low gradient streams with little instream vegetation, and large rivers with sandy substrate.

NH Wildlife Action Plan Habitats

- Warmwater Rivers and Streams
- Warmwater Lakes and Ponds



Distribution Map

Current Species and Habitat Condition in New Hampshire

There are 26 records of swamp darter from 13 watersheds at the United States Geological Survey (USGS) Hydrologic Unit Code 12 digit scale (HUC 12) in southeastern New Hampshire (Seaber et al. 1987). Records most likely reflect survey effort rather than actual distribution. In most cases, a small number of individuals were captured and little can be said about the relative abundance of swamp darters where they are known to occur. The greatest number of records from one watershed is 6, in the Oyster River. This is likely due to an extensive survey effort to map habitat for the state endangered American brook lamprey, but it does suggest that swamp darters are widespread and relatively common in the Oyster River watershed. Other watersheds with multiple records of swamp darters include Baboosic Brook, the Suncook River, the Lamprey River, and the Isinglass River.

Population Management Status

There are no population management efforts focused on swamp darters.

Regulatory Protection (for explanations, see Appendix I)

- NH NHB Database - current

Quality of Habitat

Swamp darters have been captured in watersheds of a variety of sizes ranging from 3 square km to

622 square km. They have been documented in both riverine and ponded habitats. The overall quality of these habitats has been degraded by the impacts of urbanization throughout much of southeastern New Hampshire, where swamp darters are found. However, there is little information on the tolerance level of swamp darters to different types of environmental stress.

The percent impervious surface coverage in watersheds upstream of the 26 sites where swamp darter have been recorded averages 5% (min=1.8; max=20.2; SD = 3.7). The effects of impervious cover vary by watershed size and the sensitivity of different stream types, but measurable effects on aquatic habitats can occur at low levels of impervious cover (Schueler et al. 2009). Most streams show signs of degradation at between 5 and 10% impervious cover, but when impervious cover exceeds 10%, impacts to aquatic habitats can be severe (Cuffney et al. 2010; Stranko et al. 2008; Wang et al. 2001).

Records of swamp darter are too scarce to be used for targeting conservation actions. Swamp darters will benefit from overall land protection and aquatic habitat restoration work in southeastern New Hampshire. However, there are some areas that should be prioritized. The Oyster River appears to support a healthy population of swamp darters, along with other species of concern, including the state endangered American brook lamprey. The Isinglass River watershed also contains a variety of native fish species. The aquatic habitat throughout the Isinglass River watershed is relatively intact and should be the focus of land protection efforts, especially along the riparian zone. The Lamprey River is under development pressure and has shown signs of degradation, with a significant loss of freshwater mussel abundance and diversity (Nedeau 2011). Efforts to reduce the impacts of stormwater runoff and undersized stream crossings in the headwaters of the Lamprey River will improve aquatic habitat quality throughout the watershed (NHFG 2012).

Habitat Protection Status

Habitat Management Status

Swamp darters will benefit from habitat management projects focused on riparian buffer protection, barrier removal, stormwater management upgrades, and water level management practices that imitate natural flow regimes. There are no current habitat management projects that specifically target swamp darters in New Hampshire.

Threats to this Species or Habitat in NH

Threat rankings were calculated by groups of taxonomic or habitat experts using a multistep process (details in Chapter 4). Each threat was ranked for these factors: Spatial Extent, Severity, Immediacy, Certainty, and Reversibility (ability to address the threat). These combined scores produced one overall threat score. Only threats that received a “medium” or “high” score have accompanying text in this profile. Threats that have a low spatial extent, are unlikely to occur in the next ten years, or there is uncertainty in the data will be ranked lower due to these factors.

Species disturbance from shoreline development (Threat Rank: Medium)

Development along the shoreline of lakes, ponds, and larger rivers degrades critical habitat for aquatic species.

Aquatic plant removal, clearing of trees and branches that fall into the water, shoreline armoring, dock construction, tree and shrub thinning, and lawn maintenance are common practices associated with shoreline development. The cumulative effects of shoreline development combine to reduce habitat quality throughout a waterbody (Bryan and Scarnecchia 1992; Hicks and Frost 2010). Vegetation removal, in particular, degrades habitat for species like banded sunfish, bridle shiner, and swamp darter, which depend on submerged aquatic plant species for spawning and refuge from predators.

Disturbance from impervious surface run-off (Threat Rank: Medium)

Stormwater runoff from impervious surfaces changes the hydrology of local rivers and streams. Flashier flows cause an increase in erosion and sediment deposition along stream banks and in the stream channel. More surface flow leads to a decrease in groundwater infiltration, which results in lower base flows during dry periods. Oil based pollutants, sediment, and road salt are washed from roads and parking lots into surrounding waterbodies which can lead to chronic declines in water quality. Runoff from pavement warmed by the sun can also lead to increased temperatures in local streams when stormwater flows directly into surface waters.

The impact of impervious land cover on aquatic habitats has been well documented (Wang et al. 2001; Cuffney et al. 2010; Stranko et al. 2008).

Disturbance from eutrophication (Threat Rank: Medium)

Nutrients from agricultural sources, sedimentation, lawn fertilizers, and poorly functioning septic systems contribute to increased algal growth in lakes and ponds. This excess productivity causes reductions in water quality and eventually lower dissolved oxygen levels as microorganisms consume the dead algal cells, using up oxygen in the process.

Many lakes and ponds in New England show signs of degraded water quality due to cultural eutrophication (USEPA 2010). Increasing development pressure in southern New Hampshire has led to eutrophication issues in many of the water bodies that support aquatic species of concern, including banded sunfish, bridle shiner, redfin pickerel, swamp darter, and eastern pondmussel.

List of Lower Ranking Threats:

None

Actions to benefit this Species or Habitat in NH

Distribution surveys

Objective:
Map the distribution of fish species of conservation concern.

General Strategy:
Continue to conduct surveys to monitor the distributions of fish species of concern in New Hampshire.

Political Location:

Watershed Location:

Reduce nutrient loading

Primary Threat Addressed: Disturbance from eutrophication

Specific Threat (IUCN Threat Levels): Pollution

Objective:
Reduce the impacts of eutrophication by removing excess sources of nutrients.

General Strategy:
The primary sources of excess nutrients are lawn fertilizers in residential and commercial developments, agricultural fertilizers, and poorly functioning septic systems. Reducing nutrient loads can be achieved on two fronts. One is through outreach, which includes creating awareness about the effects of fertilizers on water quality and offering alternatives to fertilization practices that lead to the greatest amount of nutrient loading in nearby waterbodies. Best management practices can be developed for property owners with a focus on reducing runoff, minimizing or eliminating fertilizer use, and landscaping in a way that reduces the need for fertilization. In the case of septic failure, shoreline property owners with older septic systems can be targeted with incentives for upgrading. The second front is legislative. Laws that set limits on fertilizer use and require upgrades to septic systems will have long term benefits on water quality throughout the developed watersheds of southern New Hampshire. Requirements for new septic systems have greatly improved in recent years. The challenge is identifying and upgrading older systems that were constructed before septic systems were required to meet modern standards.

Political Location:

Watershed Location:

Life history research

Objective:
Study the life histories of fish species of conservation concern in New Hampshire.

General Strategy:
There is a lack of basic information on the reproductive behavior, foraging habits, habitat requirements, seasonal movement patterns and other aspects of the life history of many lesser known fish species of concern in New Hampshire. A better understanding of these species would aid in the assessment of potential threats and the development of appropriate management actions.
Also of interest is their ecological role in aquatic communities and their potential use as indicators for water quality or intact habitat.

Political Location:

Watershed Location:

Stormwater Management

Primary Threat Addressed: Disturbance from impervious surface run-off

Specific Threat (IUCN Threat Levels): Pollution / Domestic & urban waste water / Run-off

Objective:
To reduce the impacts of runoff from impervious surfaces by using Low Impact Development

Technology.

General Strategy:

Stormwater runoff from impervious surfaces has been shown to damage aquatic habitats (Wang et al. 2001; Cuffney et al. 2010). Much of this damage can be prevented by stormwater management practices that filter runoff through the ground before it enters surface water. This practice not only removes much of the sediment and toxins that are typically washed into streams, but it also reduces the rapid fluctuation in temperature, as well as the excess erosion and sediment deposition that have become a chronic issue for rivers and streams in developed areas. The University of New Hampshire Stormwater Center is an excellent resource for Low Impact Development (LID) practices for stormwater management.

Political Location: **Watershed Location:**

Research survey methods

Objective:

Develop or improve survey methods for fish species of conservation concern.

General Strategy:

Experiment with survey methods to improve data collection on swamp darter distribution and abundance. Potential sampling methods may include kick seines, baited minnow traps, underwater cameras, electrofishing, or a combination of approaches.

Political Location: **Watershed Location:**

Shoreline Buffer Protection

Primary Threat Addressed: Species disturbance from shoreline development

Specific Threat (IUCN Threat Levels): Residential & commercial development

Objective:

Protect important habitat features along the shorelines of lakes, ponds, and larger rivers.

General Strategy:

The NH Shoreland Water Quality Protection Act provides a minimum level of protection for shoreline habitat along New Hampshire's lakes, ponds, and rivers (fourth order and larger). While the Shoreland Water Quality Protection Act focuses on protecting natural vegetation along the shoreline, it falls short of protecting other important habitat features such as submerged aquatic vegetation and trees that fall into the water. Landowners often remove plants and trees from the water to improve access for swimming and boating. These trees and submerged aquatic plants offer important structure for spawning, foraging, and evading predators. Increasing the percentage of natural or undeveloped shoreline will improve the overall habitat quality in a lake or pond. Conservation easements, changes in zoning, legislative acts, or landowner outreach programs may be used to restore natural shoreline features to New Hampshire lakes and ponds, many of which have little remaining undeveloped shoreline.

Political Location: **Watershed Location:**

References, Data Sources and Authors

Data Sources

Published literature provided information on distribution and habitat requirements. The NHFG fish survey database, NHDES Biomonitoring data, and watershed biological surveys conducted by NHFG from 1937 to 1939 were used in identifying current and historic records of the species within New Hampshire. The NHFG fish survey database contains records from over 2,000 sites dating back to 1980.

Data Quality

There are 26 sites where swamp darters have been recorded since 1984. Of these records, 14 were part of an effort to revisit sites surveyed in a statewide biological inventory conducted in the late 1930s by the NHFG (Gordon 1937, Bailey 1938, Bailey and Oliver 1939). There does not appear to be a decline in the distribution of swamp darters in New Hampshire compared to historical records (swamp darters were captured at 12 sites in the 1930's). Some of their apparent scarcity may be explained by difficulty of capture. Data on the condition of swamp darter populations is lacking. Habitat condition data continues to improve with upgrades to GIS layers such as impervious surface coverages.

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American Brook Lamprey

Lethenteron appendix

Photo by NHFG

Federal Listing	
State Listing	E
Global Rank	G4
State Rank	S1
Regional Status	V. High

Justification (Reason for Concern in NH)

The American brook lamprey has a complex life cycle that depends on 2 specific habitat types within a stream. Alteration or fragmentation of one or both of these habitats could result in local extirpations of brook lamprey populations. The presence of the American brook lamprey has only been recorded in the Oyster River watershed in New Hampshire. It is listed as a state endangered species.

Distribution

The American brook lamprey is found in rivers along the Atlantic coast from North Carolina to New Hampshire and throughout the Great Lakes drainages (Scott and Crossman 1973). In New Hampshire, American brook lamprey populations have only been confirmed in the Oyster River watershed.

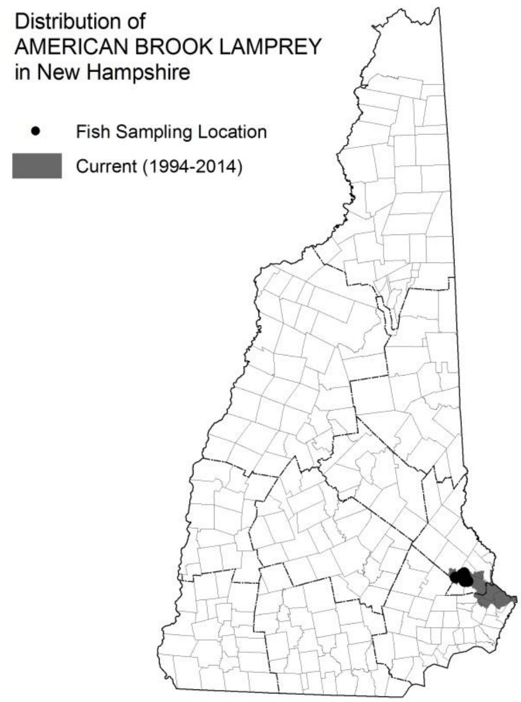
Habitat

The American brook lamprey lives in cool freshwater streams and small rivers. Adults spawn at the head of riffle areas over coarse sand and gravel substrate with stones less than 7 cm wide (Mundahl 1996). Spawning adults construct small nests by moving stones with their disc-shaped mouths (Hoff 1988). After hatching, larvae (ammocoetes) drift downstream to areas of slower flow where they burrow into the sediment and filter feed on organic detritus for about 5 years (Beamish and Lowartz 1996). Ammocoetes prefer to burrow in medium to fine grained sand mixed with organic matter (Beamish and Lowartz 1996).

American brook lampreys in the Oyster River are usually found in areas where the river channel meanders through open wetlands. Ammocoetes are often found where wood from fallen trees or abandoned beaver dams has trapped gravel and fine sediment.

NH Wildlife Action Plan Habitats

- Coldwater Rivers and Streams
- Warmwater Rivers and Streams

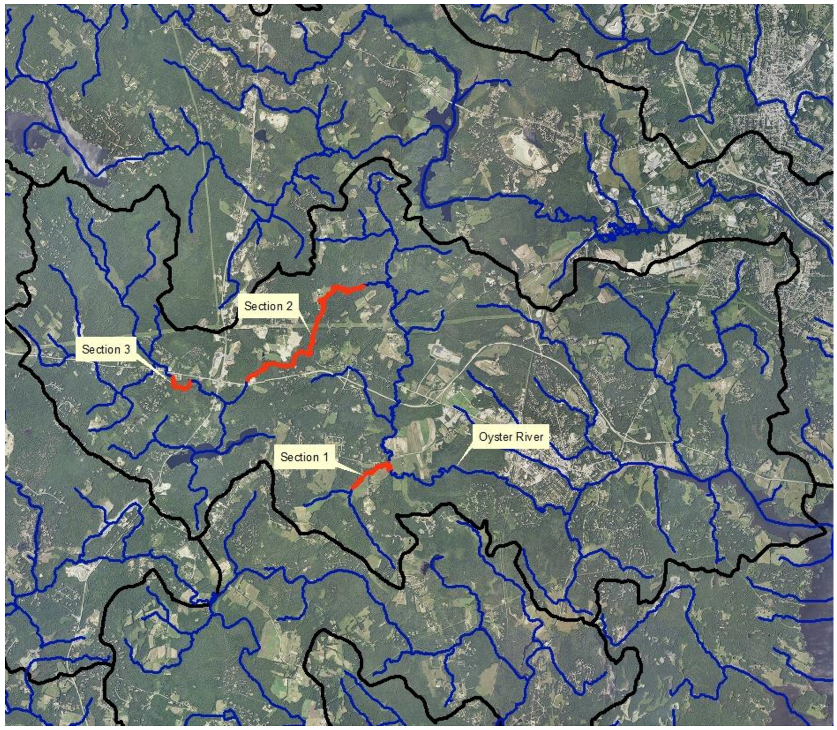


Distribution Map

Current Species and Habitat Condition in New Hampshire

There are three main populations of American brook lamprey in the Oyster River watershed. One in Chesley Brook (Section 1), one in the Oyster River from downstream of Snell Road to the bridge at Rt. 4, east of the Lee traffic circle (Section 2), and a third in the headwaters of the Oyster River downstream of Rt.4 and west of the Lee traffic circle (Section 3) (see map). Suitable, but apparently unoccupied habitat exists at a number of locations in the mainstem and headwaters of the Oyster River. Sea Lamprey have been released in the watershed by UNH for research purposes and have been discovered downstream of Chesley Brook and intermingled with American brook lamprey in Section 2. The two species coexisted historically, but any current impacts due to interspecific competition are unknown.

Section 1: Chesley Brook
The Chesley Brook population is abundant, but occupies a very small reach of stream from about 300m upstream of Packers Falls Road to the confluence with the Oyster River. Adults and ammocoetes of multiple year classes were found when the stream was last surveyed in 2007. This section of stream is a unique example of a spring fed coldwater stream, which supports both American brook lamprey and an abundant population of naturally reproducing brook trout. Water withdrawal from the Spruce Hole aquifer, which supplies groundwater to Chesley Brook, has the potential to influence water levels in Chesley Brook, which could impact this population of brook lamprey. This threat is currently being mitigated by refilling the aquifer with water pumped from the Lamprey River (NHDES 2014).



Section 2: Oyster River Mainstem
The American brook lamprey population in Section 2, the mainstem of the Oyster River, is the largest of the three populations. American brook lamprey were captured during the most recent electrofishing survey in 2014. Adults and ammocoetes of multiple year classes were identified in the survey. This reach is fragmented by two stream crossings and an old mill dam, which may impact gene flow. There is a pump station for a municipal water supply.

Section 3: Caldwell Brook
Section 3 is a short reach of sand/gravel stream meandering through a shrub swamp. When this section was originally surveyed in 2007, all of the American brook lamprey were less than 60 mm in length. According to Scott and Crossman (1973), these individuals were likely in their first year of growth, and no more than 2 years old. The reach was surveyed following a major flood in the spring of 2007. There are at least two possible explanations:
1)High water or some other factor allowed American brook lamprey from downstream to disperse into the reach and this is the first year class of an expanding population or,
2)High flows, habitat damage from the floods, or other factors caused the mortality of all but the youngest age classes in this reach.

The reach was surveyed again in 2011. Multiple year classes were found and the population appeared to have recovered. The missing year classes in 2007 illustrate the vulnerability of these small, isolated populations of brook lamprey to disturbance. It is not known whether this population is genetically isolated from populations downstream.

Population Management Status

There are no current population management projects targeting American brook lampreys.

Regulatory Protection (for explanations, see Appendix I)

- Endangered Species Conservation Act (RSA 212-A)

Quality of Habitat

Section 1: Chesley Brook
Chesley Brook is of high conservation value due to its unique fish community. Nowhere else in the state does a population of American brook lamprey coexist with a population of brook trout. The reasons for their coexistence are the habitat characteristics of Chesley Brook, which include loose gravel and fine sediment in the stream channel, along with a steady supply of groundwater from the nearby Spruce Hole aquifer. Much of the watershed is protected by conservation and deed restrictions, but the stream is still vulnerable to potential impacts from water withdrawal and

pollutants. High nitrate levels, possibly due to manure and other fertilizer use in the watershed, have been documented in the brook (ORWA 2014). Under the water withdrawal permit, municipal water withdrawals are not allowed to impact water levels in Chesley Brook (NHDES 2014). Flows are monitored annually. The aquifer is recharged by pumping water from the Lamprey River. This strategy should be effective as long as there is no gap between the period when the aquifer is in use and when it is recharged (and the infrastructure is maintained).

Section 2: Oyster River Mainstem
In Section 2, American brook lamprey are relatively abundant throughout a long stretch of stream in which the channel meanders through open grass and shrub wetlands. The remnants of beaver dams, trees, and scattered boulders trap sand, gravel, and silt, which provides both spawning substrate for adults and burrowing sediment for ammocoetes. Riparian buffers are relatively intact throughout this reach. There are two stream crossings, which appear to limit American brook lamprey movement during certain flows. NHFG biologists worked with NHDOT to construct baffles in a rusted culvert that was being lined with concrete. The baffles worked to slow flow and provide rough substrate within the culvert. Unfortunately, the structure continues to be perched at lower flow, which prevents passage by most fish species. The crossing is passable during periods when it is backwatered by beaver activity, but it likely presents a barrier to American Brook Lamprey movement for the majority of flow conditions throughout the year.

A second crossing, at Old Mill Road was also lined with concrete. This culvert is perched at low flow and water depth is very shallow in the crossing at low flow. The ruins of an old dam downstream may also be a barrier to passage, which would limit the fragmenting impacts of the Old Mill Lane crossing. However, American brook lamprey in the reach between the old dam and the crossing are likely isolated and may not be able to successfully reproduce due to unsuitable substrate.

The upstream end of Section 2 may be exposed to high road salt concentrations due to stormwater runoff in the parking lots that drain the commercial properties around the Lee Traffic circle (ORWA 2014). Increasing impervious coverage throughout the Oyster River watershed may degrade water quality and habitat conditions for American brook lamprey.

Section 3: Caldwell Brook
Caldwell brook is a small stream in the headwaters of the Oyster River. The section occupied by American brook lamprey is just over 0.5 km in length. The stream channel meanders through an alder swamp with sections of shallow gravel riffles interspersed with deeper pools lined by fine sediment. Habitat at the lower end of the reach has been degraded by a dredged pond. No American brook lampreys have been documented downstream of the pond. Upstream of the reach is a large pool below a culvert at the crossing of Rt. 4. This stream crossing may act as a barrier to upstream dispersal. Habitat upstream and downstream of Section 3 should be examined for opportunities to restore connectivity and expand the range of American brook lamprey in the Oyster River headwaters.

Habitat Protection Status

Much of the riparian zone along occupied reaches of American brook lamprey habitat has been protected by conservation easement. However, much of the Oyster River remains unprotected and some water quality metrics are showing signs of impacts from increasing densities of residential and commercial development in the watershed (ORWA 2014).

Habitat Management Status

There are no current habitat management projects targeting American brook lampreys.

Threats to this Species or Habitat in NH

Threat rankings were calculated by groups of taxonomic or habitat experts using a multistep process (details in Chapter 4). Each threat was ranked for these factors: Spatial Extent, Severity, Immediacy, Certainty, and Reversibility (ability to address the threat). These combined scores produced one overall threat score. Only threats that received a "medium" or "high" score have accompanying text in this profile. Threats that have a low spatial extent, are unlikely to occur in the next ten years, or there is uncertainty in the data will be ranked lower due to these factors.

Disturbance from stream crossings that fragmentation habitat (Threat Rank: High)

Undersized stream crossings act as barriers to the movement of aquatic species. Many stream crossings restrict movement at certain flows due to high velocities, insufficient depth within the crossing, or an outlet that is "perched above the water surface, acting as a small waterfall. These barriers prevent access to critical habitat, reduce gene flow, and result in local extirpations of isolated populations.

A number of studies have demonstrated reductions in fish species richness and abundance upstream of impassable stream crossings (Nislow et al. 2011; Jackson 2003). The American brook lamprey population in the Oyster River is fragmented by a number of stream crossings that are impassable at most flows. These stream crossings are likely limiting American brook lamprey dispersal and gene flow.

Disturbance from groundwater extraction that causes reduced base flow or water levels (Threat Rank: Medium)

Groundwater or surface water extraction may lower water levels and influence streamflow in local rivers and streams (USGS 2001).

There are a number of groundwater and surface water extractions permitted for municipal water use in the Oyster River watershed. A pump station at the Spruce Hole Aquifer has the potential to influence water levels in Chesley Brook, which supports a healthy population of American brook lamprey. Groundwater in the aquifer can be recharged with water from the Lamprey River through a recently installed pump system. Chesley brook water levels are monitored as a requirement of the groundwater withdrawal permit (NHDES 2014). However, water levels are not monitored in real time, so Chesley Brook should be assessed periodically during unusually low flow conditions to avoid unanticipated decreases in flow below critical levels. Municipal groundwater extractions also occur at a pump station along the mainstem of the Oyster River. The potential effects of groundwater withdrawal from this site on the adjacent brook lamprey population have not been studied.

Species disturbance from impervious surface run-off (Threat Rank: Medium)

Stormwater runoff from impervious surfaces changes the hydrology of local rivers and streams. Flashier flows cause an increase in erosion and sediment deposition along stream banks and in the stream channel. More surface flow leads to a decrease in groundwater infiltration, which results in lower base flows during dry periods. Oil based pollutants, sediment, and road salt are washed from roads and parking lots into surrounding waterbodies which can lead to chronic declines in water quality. Runoff from pavement warmed by the sun can also lead to increased water temperatures in local streams when stormwater flows directly into surface waters.

The impact of impervious land cover on aquatic habitats has been well documented (Wang et al. 2001; Cuffney et al. 2010; Stranko et al. 2008).

List of Lower Ranking Threats:

Disturbance from excess nutrients (fertilizer or failed septic)

Disturbance from various pesticide uses (invasive plant control or agriculture)

Actions to benefit this Species or Habitat in NH

Stormwater Management

Primary Threat Addressed: Species disturbance from impervious surface run-off

Specific Threat (IUCN Threat Levels): Pollution / Domestic & urban waste water / Run-off

Objective:
To reduce the impacts of runoff from impervious surfaces by using Low Impact Development Technology.

General Strategy:
Stormwater runoff from impervious surfaces has been shown to damage aquatic habitats (Wang et al. 2001; Cuffney et al. 2010). Much of this damage can be prevented by stormwater management practices that filter runoff through the ground before it enters surface water. This practice not only removes much of the sediment and toxins that are typically washed into streams, but it also reduces the rapid fluctuation in temperature, as well as the excess erosion and sediment deposition that have become a chronic issue for rivers and streams in developed areas. The University of New Hampshire Stormwater Center is an excellent resource for Low Impact Development (LID) practices for stormwater management.

Political Location: **Watershed Location:**

Population monitoring

Objective:
Monitor the status of American brook lamprey in the Oyster River watershed.

General Strategy:
Electrofishing surveys should be periodically conducted to detect changes in the distribution of the American brook lamprey in the Oyster River watershed. American brook lamprey populations should be monitored to ensure that multiple age classes exist, including both ammocoetes and mature adults, in each section of occupied habitat. Identify specific threats that may be impacting the population and make management recommendations. Monitor the population response to restoration projects, such as stream crossing replacements.

Political Location: **Watershed Location:**

Protect instream flow

Primary Threat Addressed: Disturbance from groundwater extraction that causes reduced base flow or water levels

Specific Threat (IUCN Threat Levels): Natural system modifications / Dams & water management/use / Abstraction of ground water (domestic use)

Objective:
Manage water withdrawal and protect groundwater recharge to ensure adequate flow for supporting aquatic species in rivers and streams.

General Strategy:
Surface water and groundwater withdrawals for drinking water, irrigation, and other uses can reduce river flows, especially during critical periods of low flow during the summer months. Water level management at dams also affects the streamflow in a watershed. The NHDES Instream Flow Program works to balance water use while maintaining flow for aquatic life. Two pilot studies, one in the Souhegan River and one in the Lamprey River, have been conducted and Water Management Plans have been approved. The lessons learned from these studies and management plans should be expanded into other watersheds throughout New Hampshire. The practices implemented in the Water Management Plans for the Souhegan and Lamprey Rivers should be monitored to ensure that they are achieving the desired level of protection for instream flow. Dam managers should seek to manage water levels so that raising or lowering the water level in a lake or pond does not excessively decrease or increase the stream flow downstream of the dam. Headwater streams are especially vulnerable to water withdrawal and should not be overlooked during the permitting process. Chesley Brook, which supports a population of American brook Lamprey, is potentially vulnerable and should continue to be monitored for any impacts in water levels related to water withdrawals from the Spruce Hole Aquifer, which supplies drinking water to the town of Durham.

Political Location:

Watershed Location:

Riparian Buffer Protection

Primary Threat Addressed: Species disturbance from impervious surface run-off

Specific Threat (IUCN Threat Levels): Pollution / Domestic & urban waste water / Run-off

Objective:
Preserve the water and habitat quality of rivers, streams and the shorelines of lakes and ponds by preventing development in the riparian zone.

General Strategy:
Riparian buffer protection can be achieved through town ordinances, state law (i.e. the Shoreland Water Quality Protection Act), deed restriction, conservation easement, or voluntary land use practices (such as forestry best management practices). In general, the wider the buffer protected, the more ecological benefit. A buffer of at least 10 m will provide a minimum level of water quality and habitat benefits. A protected buffer of 100m or greater provides maximum water quality and habitat benefits while also acting as a migration corridor for larger species of wildlife. Buffer protection is lacking on headwater streams despite the cumulative effect that intact riparian zones in headwater streams have on downstream water quality.

Political Location: **Watershed Location:**

Land Protection

Primary Threat Addressed: Species disturbance from impervious surface run-off

Specific Threat (IUCN Threat Levels): Pollution / Domestic & urban waste water / Run-off

Objective:
Preserve the natural ecological functions of an area by protecting land from development.

General Strategy:
Land protection is a strategy that can be used to ensure a level of habitat quality that is necessary to support certain species and habitats of conservation concern. For aquatic species, land protection prevents many of the impacts caused by sprawling development. Groundwater recharge, intact riparian zones, and unrestricted migration corridors are some of the benefits. Species, such as the American brook lamprey, with limited ranges and mobility, may be protected almost entirely through land conservation. For wider ranging species, land protection will be part of a greater restoration strategy. Land protection projects in New Hampshire usually require the coordination of a variety of funding sources, with involvement from town conservation commissions, local land trusts and watershed associations, government agencies, and state or national NGO's. Since 2005, the NH Wildlife Action Plan has helped direct land protection efforts toward conserving habitat for species and habitats of concern. The effectiveness of land conservation could be improved by identifying and addressing barriers to land conservation in New Hampshire and increasing outreach to help prioritize projects that benefit species and habitats of concern.

Political Location: **Watershed Location:**

Stream crossing restoration

Primary Threat Addressed: Disturbance from stream crossings that fragmentation habitat

Specific Threat (IUCN Threat Levels): Transportation & service corridors

Objective:
Increase connectivity and reduce habitat degradation caused by stream crossings.

General Strategy:
There are two phases to stream crossing restoration. The first phase is assessment. Stream crossing surveys are currently being conducted in several watersheds throughout the state. It is important that these surveys follow the standardized methods and protocols outlined by the New Hampshire Geological Survey (NHGS). NHGS maintains a statewide database of stream crossing survey data. Once the data is collected, stream crossing restoration projects can be prioritized to achieve the greatest benefits to aquatic organism passage, along with reductions in flood damage and habitat degradation. Prioritization may take place within small watersheds or across a large region. The second phase is implementation. Once a stream crossing is identified as a good candidate for restoration there are many obstacles to a completed project, including permitting and cost. Streamlining the permitting process for crossing restoration, increasing available funding sources, and developing innovative stream crossing design and construction techniques that significantly reduce cost would greatly increase the number of stream crossing restoration projects in New Hampshire.

Stream crossing surveys have already been completed in the Oyster River watershed (Stack et al. 2010). There are at least six potential stream crossing replacement projects that would directly benefit habitat connectivity for American brook lamprey. One of these crossings has been designed and is awaiting funding. Fish passage at another crossing was augmented with concrete baffles installed by NHDOT during a culvert repair. Coordinating with NHDOT and identifying additional funding sources for the relatively costly culvert replacement projects in the Oyster River watershed will be necessary to maximize habitat connectivity for American brook lamprey in the long term.

Political Location: **Watershed Location:**

Life history research

Objective:
Study the life histories of fish species of conservation concern in New Hampshire.

General Strategy:
There is a lack of basic information on the reproductive behavior, foraging habits, habitat requirements, seasonal movement patterns and other aspects of the life history of many lesser known fish species of concern in New Hampshire. A better understanding of these species would aid in the assessment of potential threats and the development of appropriate management actions.
Also of interest is their ecological role in aquatic communities and their potential use as indicators for water quality or intact habitat.

Political Location: **Watershed Location:**

References, Data Sources and Authors

Data Sources
Biologists with the Fish Conservation Program of the NHFG conducted an American brook lamprey habitat mapping survey in the Oyster River watershed in 2007 and 2008. American brook lamprey records are maintained in the NHFG Fish survey database and submitted to the NH Natural Heritage Bureau.

Data Quality
The majority of occupied American brook lamprey habitat has been mapped in the Oyster River watershed. Records from the Baboosic Brook watershed, in the Merrimack River drainage, were likely misidentified sea lamprey. No additional American Brook Lamprey populations have been documented outside of the Oyster River watershed. In 2007 and 2008, NHFG biologists conducted surveys to map the occupied American brook lamprey habitat in the mainstem and tributaries of the freshwater portion of the Oyster River. This survey effort will serve as a baseline for monitoring changes in the distribution and relative abundance of American brook lamprey populations. Periodic surveys have been conducted to monitor the American brook lamprey populations in the Oyster River watershed since 2007. Healthy age class structure and recruitment is inferred by length data and the presence of both mature adults and juveniles.

2015 Authors:
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2005 Authors:

Literature

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Burbot

Lota lota

Photo by NHFG

Federal Listing	
State Listing	
Global Rank	
State Rank	S5
Regional Status	High

Justification (Reason for Concern in NH)

Burbot are one of a few self-sustaining native coldwater fish species targeted by anglers in New Hampshire. However, due to the small size of individuals encountered in lotic environments, the majority of harvest occurs in large lakes (John Viar, New Hampshire Fish and Game (NHFG), personal communication). The species was tied with brook trout (fourth) during a survey of angler preference during the ice-fishing season (Duda and Young 1996). Lake populations of burbot are restricted to a small number of water bodies. Anthropogenic eutrophication can reduce dissolved oxygen at depth, where burbot seek thermal refuge during summer. Therefore, the species may be an indicator for the condition of oligotrophic lakes (Kelso et al. 1996). Lotic populations also appear to be limited to particular coldwater rivers or streams. The degradation of these habitats may lead to declines in burbot, as well as other coldwater fish species. The burbot is a cold water species that is potentially vulnerable to climate change. It is rarely found where water temperatures exceed 70F, with 74F as its upper limit of temperature tolerance (Scott and Crossman 1973). As the climate warms in the northeast, rivers and streams at the southern end of the species' range may no longer have suitable temperatures for supporting burbot populations. There may also be a reduction in the total area of deep, cold water habitat in lakes and ponds that support cold water fish species (Thill 2014). The effect of habitat degradation and angler harvest on abundance levels of both lentic and lotic populations of the species are not well understood in New Hampshire. In other locations burbot populations have been negatively impacted by lake level management, dam creation, eutrophication, competition with invasive species, and angler harvest (Stapanian et al. 2010).

Distribution

Burbot are found throughout the world in northern latitudes. Their range in North America extends south from Canada to Connecticut on the east coast and Oregon on the west coast. In New Hampshire, burbot are found in select medium sized and large lakes which maintain cold temperatures in deep water during the warmer months. They may also be found in cold water rivers and streams in the Connecticut, upper Merrimack, Saco, and Androscoggin River drainages.

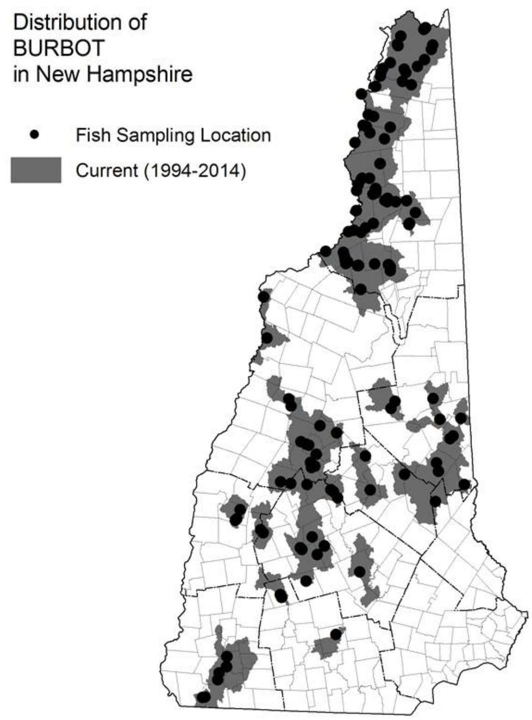
Current records indicate burbot are found in 16 lakes and ponds in New Hampshire and several rivers and streams within the Connecticut, Merrimack, Pemigewasset, and Saco watersheds.

Habitat

Burbot are found in rivers and lakes. They prefer deep, large lakes (Scarola 1987) and are commonly found in the littoral zone during winter. During the summer, burbot are thermally restricted to the profundal zone, and may make night migrations to the littoral zone (Hoffman and Fischer 2002). In rivers, burbot prefer areas with woody debris, vegetation, pools, rocky riffles, and cool temperatures. Nighttime spawning occurs in February at shallow depths over sand or gravel substrates (Scott and Crossman 1973; Roy 2001).

NH Wildlife Action Plan Habitats

- Lakes and Ponds with Coldwater Habitat
- Coldwater Rivers and Streams



Distribution Map

Current Species and Habitat Condition in New Hampshire

Burbot are found primarily within cooler water rivers and cold water lakes and ponds. No targeted effort has focused on determining the abundance levels of any burbot population in New Hampshire. Detecting changes in abundance levels will be difficult because historical information beyond species presence is not available.

Population Management Status

There are no current management efforts specific to burbot in New Hampshire. There are no length or harvest limits for burbot in lakes and ponds or rivers and streams. There is no closed season for the species in lakes and ponds, but burbot cannot be harvested between September 16 and December 31 in rivers and streams. This seasonal closure is not specific to burbot. It was designed to protect spawning brook trout from harassment by anglers. The effect of harvest rates on burbot populations in New Hampshire is unclear.

Regulatory Protection (for explanations, see Appendix I)

- Harvest permit - season/take regulations

Quality of Habitat

Burbot are found primarily within cooler water rivers and cold water lakes and ponds. Large lakes with extensive deep coldwater habitat have the best chance of maintaining healthy burbot populations. Smaller lakes with limited coldwater habitat are more vulnerable to the effects of climate change and cultural eutrophication (Thill 2014). Coldwater river and stream habitat is relatively intact in northern and western New Hampshire. However, climate change is expected to increase water temperatures in the northeast, which may threaten burbot populations in rivers and streams along the southern edge of their range (Lyons et al. 2010).

Habitat Protection Status

Habitat Management Status

There are currently no ongoing management or restoration efforts for burbot in New Hampshire. Restoring stream connectivity, riparian restoration and protection, and upland land protection are expected to benefit lotic populations. Efforts to address stormwater runoff, nonpoint source pollutants, introduced species, and climate change are expected to benefit lentic populations.

Threats to this Species or Habitat in NH

Threat rankings were calculated by groups of taxonomic or habitat experts using a multistep process (details in Chapter 4). Each threat was ranked for these factors: Spatial Extent, Severity, Immediacy, Certainty, and Reversibility (ability to address the threat). These combined scores produced one overall threat score. Only threats that received a "medium" or "high" score have accompanying text in this profile. Threats that have a low spatial extent, are unlikely to occur in the next ten years, or there is uncertainty in the data will be ranked lower due to these factors.

There are no threats ranked high or medium for this species.

List of Lower Ranking Threats:

Disturbance from water level management

Mortality from recreational harvest

Disturbance from stream crossings or dams that fragment habitat

Disturbance from reduced area of coldwater habitat

Actions to benefit this Species or Habitat in NH

Land Protection

Primary Threat Addressed: Disturbance from reduced area of coldwater habitat

Specific Threat (IUCN Threat Levels): Climate change & severe weather

Objective:
Preserve the natural ecological functions of an area by protecting land from development.

General Strategy:
Land protection is a strategy that can be used to ensure a level of habitat quality that is necessary to

support certain species and habitats of conservation concern. For aquatic species, land protection prevents many of the impacts caused by sprawling development. Groundwater recharge, intact riparian zones, and unrestricted migration corridors are some of the benefits. Species with limited ranges and mobility may be protected almost entirely through land conservation. For wider ranging species, such as burbot, land protection will be part of a greater restoration strategy. Land protection projects in New Hampshire usually require the coordination of a variety of funding sources, with involvement from town conservation commissions, local land trusts and watershed associations, government agencies, and state or national NGO's. Since 2005, the NH Wildlife Action Plan has helped direct land protection efforts toward conserving habitat for species and habitats of concern. The effectiveness of land conservation could be improved by identifying and addressing barriers to land conservation in New Hampshire and increasing outreach to help prioritize projects that benefit species and habitats of concern.

Political Location: **Watershed Location:**

Map spawning habitat

Objective:
Map the distribution of coldwater fish spawning habitat in deep water lakes.

General Strategy:
Although some important spawning reefs have been well documented, the extent of spawning habitat for coldwater fish species remains undocumented in most lakes where they occur. Acoustic or radio telemetry, gill or fyke net surveys, underwater cameras, and visual observations are potential methods for identifying important spawning areas. Depth recordings at spawning areas well help inform water level management policy.

Political Location: **Watershed Location:**

Population assessment

Objective:
Assess the status of burbot populations in New Hampshire.

General Strategy:
Explore methods for assessing the populations of burbot in lakes where they are known to occur. Confirm and update the current distribution of the species in New Hampshire.

Political Location: **Watershed Location:**

Water level management

Primary Threat Addressed: Disturbance from water level management

Specific Threat (IUCN Threat Levels): Natural system modifications

Objective:
Reduce the aquatic habitat impacts associated with artificial water level fluctuation at dams.

General Strategy:
Work with dam managers to achieve water level fluctuations that mimic natural flow regimes. Practices such as rapid changes in water level, excessive winter drawdown, and shutting off downstream flow to refill a waterbody should be avoided. For coldwater species that spawn on shallow reefs, including lake trout, round whitefish, lake whitefish, and burbot, it is important that water levels do not drop significantly after the spawning season, such that the eggs would be exposed. Engaging stakeholders, including shorefront property owners, boaters, anglers, and hydropower project owners is critical to changing long established water level management traditions. The NHDES Dam Bureau is the lead on dam management issues in New Hampshire. The best strategy for improving water level management practices for fish and wildlife is to work with the Dam Bureau to identify opportunities to create more natural water level fluctuations at a certain dams and then make slow incremental changes. This allows stakeholders to adjust to the changes and make comments when conflicts arise.

Political Location: **Watershed Location:**

Riparian Buffer Protection

Primary Threat Addressed: Disturbance from reduced area of coldwater habitat

Specific Threat (IUCN Threat Levels): Climate change & severe weather

Objective:
Preserve the water and habitat quality of rivers, streams and the shorelines of lakes and ponds by preventing development in the riparian zone.

General Strategy:
Riparian buffer protection can be achieved through town ordinances, state law (i.e. the Shoreland Water Quality Protection Act), deed restriction, conservation easement, or voluntary land use practices (such as forestry best management practices). In general, the wider the buffer protected, the more ecological benefit. A buffer of at least 10 m will provide a minimum level of water quality and habitat benefits. A protected buffer of 100m or greater provides maximum water quality and habitat benefits while also acting as a migration corridor for larger species of wildlife. Buffer protection is lacking on headwater streams despite the cumulative effect that intact riparian zones in headwater streams have on downstream water quality. Protecting riparian buffers along coldwater rivers and streams may help mitigate some of the impacts of a warming climate by shading streams and promoting groundwater recharge.

Political Location: **Watershed Location:**

References, Data Sources and Authors

Data Sources

Published literature, stream survey data, and angler reports were used to establish habitat needs and statewide distribution. Records of burbot are entered into the NHFG fish survey database. Anecdotal reports of burbot are frequently submitted by anglers.

Data Quality

There are many gaps in the distribution map of burbot, especially in river and stream habitat. They are occasionally encountered during backpack electrofishing surveys, but these surveys are limited to shallow rivers and streams. Although burbot populations are known to exist in the large coldwater lakes, distribution data in lakes and ponds may be incomplete, especially from smaller waterbodies with suitable habitat conditions near the edge of their range. Historical records suggest that burbot may have been present in certain waterbodies within the coastal watersheds, but there have been no recent reports. Information describing the status and abundance of the species is very limited for both lentic and lotic habitats.

2015 Authors:

Benjamin Nugent, NHFG, Matthew Carpenter, NHFG

2005 Authors:

Literature

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Bridle Shiner

Notropis bifrenatus

Federal Listing	
State Listing	T
Global Rank	
State Rank	S1
Regional Status	V. High

Photo by NHFG

Justification (Reason for Concern in NH)

The bridle shiner is declining over most of its range (Sabo 2000). In Pennsylvania, where the bridle shiner is listed as endangered, its range has been reduced to 1 site out of 31 historical sites (Finger 2001). Bridle shiners have been extirpated from the state of Maryland and from a number of waterbodies in Massachusetts. Despite an extensive survey effort, the New Hampshire Fish and Game Department (NHFG) documented bridle shiners at only 8 of 30 sites where they were recorded as present in 1947 (Harrington 1947).

Distribution

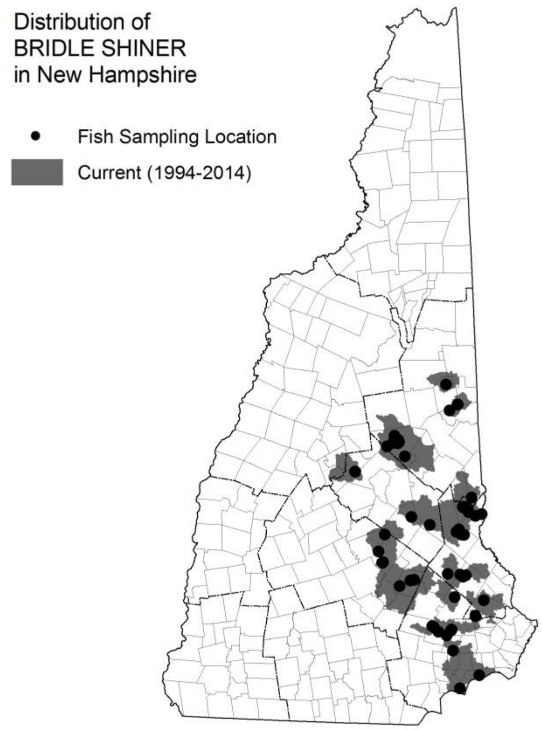
The bridle shiner was once widely distributed throughout the Atlantic coastal plain from North Carolina north to the St. Lawrence River and eastern Ontario (Scott and Crossman 1973). In New Hampshire, bridle shiner populations are scattered throughout the Merrimack River, Saco River, and coastal river watersheds.

Habitat

Bridle shiners depend on dense communities of submerged aquatic vegetation for survival (Harrington 1947). This habitat may be found along the shorelines and coves of lakes and ponds usually associated with adjacent wetlands, the backwaters of larger rivers, and in slow flowing streams.

NH Wildlife Action Plan Habitats

- Warmwater Rivers and Streams
- Warmwater Lakes and Ponds
- Lakes and Ponds with Coldwater Habitat



Distribution Map

Current Species and Habitat Condition in New Hampshire

Of the 30 sites where bridle shiners were recorded in 1947, 8 sites continue to support bridle shiner populations. Bridle shiners were not found at six of the 30 sites, but the survey effort was not sufficient to be confident that bridle shiners had been extirpated from the area. At 16 of the 30 sites, extirpation was determined to be likely based on an extensive survey of the area or obvious factors, such as habitat loss, that would explain the absence of bridle shiners at the site. Since 2005, NHFG Biologists have documented the presence of bridle shiners at a total of 57 sites, with many new records from previously undocumented locations. Populations appear to be stable at some locations, while they have declined or disappeared from other sites due to changes in habitat. The full extent of occupied bridle shiner habitat in New Hampshire has yet to be determined.

Status of known bridle shiner populations:

Jones Brook Watershed:
All areas of suitable habitat are occupied by abundant bridle shiner populations. The Jones Brook watershed contains one of the best examples of a healthy, intact bridle shiner population.

Coffin Brook Watershed:
All areas of suitable habitat are occupied by abundant bridle shiner populations. The Coffin Brook watershed supports a healthy, intact population in need of protection.

Appendix A: Fish

Trout Pond:
Arguably the most abundant population observed to date, possibly due to the absence of warmwater predator fish species in the pond. The shoreline of the pond is entirely undeveloped.

Purity Lake and associated ponds:
Bridle shiners were found in Purity Lake and Long Pond, but not in the more developed Danforth Pond. There are likely more bridle shiner populations in this watershed, which drains into Ossipee Lake.

Winnipesauke Lake:
Bridle shiners are present in vegetated coves along the northern shore of the lake, within the town of Moultonborough. These coves are usually bordered by wetlands and less developed. Some populations, including the bridle shiners documented in Fish Cove in 1938, appear to have been extirpated. Bridle shiner numbers appear to have been greatly reduced after broad scale herbicide treatment to control variable milfoil in Blackey's Cove and Moultonborough Bay.

Wentworth Lake:
Healthy populations of bridle shiners exist in larger wetland coves and tributaries. Milfoil control, shoreline development, and dredging for boats docks have likely extirpated populations in smaller coves.

Northeast Pond:
Bridle shiners are extremely abundant at the north end of the lake, where Branch Brook and the Salmon Falls River enter the lake. They are likely present at other locations in the upper Salmon Falls and Branch Brook watersheds.

Suncook River watershed:
Recorded as abundant in the 1930's, bridle shiners now appear to be rare in the Suncook River watershed. They have been documented in the river upstream of the Suncook Lakes and in a vegetated cove at the north end of Crystal Lake. There is a small population in the Little Suncook River, upstream of the Cass Pond Dam. Bridle shiner populations in the lower river may have been extirpated by the severe flooding and resulting sediment deposition that occurred in May of 2006.

Soucook River watershed:
Bridle shiners are still present at two locations in the mainstem river where they were recorded in the 1930's. No other populations have been discovered in the Soucook River watershed.

Exeter River:
Bridle shiners were relatively common in areas of suitable habitat throughout the river reach between Exeter River Dam and the Hooke Dam in the town of Fremont. Suitable habitat exists in other sections of the Exeter River, but they have yet to be surveyed.

Powwow River:
Bridle shiners were found in the Powwow River during surveys conducted in 2006, but not in Powwow Pond. They may also be present in suitable habitat in neighboring watersheds.

Lamprey River:
Bridle shiners are found in slow flowing, deeper sections of the river with aquatic vegetation, mostly in the town of Raymond. The record of a bridle shiner population below Packer's Falls in the town of Lee has not been confirmed.

Upper Cocheco River:
There are healthy populations in a series of relatively undisturbed wetlands that make up the headwaters of the Cocheco River in Farmington. Bridle shiners have not been confirmed elsewhere in the watershed.

Pemigewasset Lake:
Bridle shiners were found at the outlet of the pond, where habitat appears to be intact.

Isinglass River:
Bridle shiners have only been found at one of two sites with historical records. They continue to occupy a very small patch of suitable habitat upstream of Rt. 202. The habitat at the other site, downstream of Bow Lake, no longer appears to be suitable for bridle shiners.

Garland Pond:
The bridle shiner population appears relatively undisturbed in this pond due to the lack of shoreline development and intensive milfoil control efforts, which have impacted habitats downstream.

Lee's Pond:
Bridle shiners appear to be at very low abundance in Lee's Pond, possibly on the verge of extirpation. The pond has a long history of herbicide treatment for variable milfoil.

Upper Saco watershed:
Bridle shiners were found in Middle Pea Porridge Pond, but not Crystal Lake or Pequawket Pond. More surveys are needed in this area. Populations appear to be patchy in the upper Ossipee and Saco River watersheds, but healthy where they exist.

Bridle shiner extirpations:

Oyster River:
The bridle shiner population in Mill Pond, an impoundment on the Oyster River, was studied extensively by Harrington (1947). The population appears to have been extirpated from the pond, possibly during the construction of a fish ladder, which required draining the impoundment upstream of the dam in the 1970's.

Wheelright Pond:
Noted as present by Harrington (1947), bridle shiners appear to no longer exist in the pond. The cause of extirpation is unknown. Current habitat appears suitable for bridle shiners.

Canobie Lake, Shadow Lake, Pleasant Lake, and Winnisquam Lake:
Extirpated due to loss of habitat from shoreline development.

Merrimack River:
Extirpated from multiple sites. Habitat has been altered due to channelization and flood control. Very little aquatic vegetation left. Water clarity can be poor in the few remaining backwaters with suitable habitat.

Winnipesauke Lake:
Presumed extirpated from Fish Cove. The cove has a long history of herbicide treatments to control variable milfoil.

Heads Pond:
Bridle shiners may have been extirpated from the pond when the dam on the pond was breached, causing the water level to drop significantly. Habitat for bridle shiners appears suitable now that the pond has adjusted its new water level.

Suncook Lakes:
Presumed extirpated. The Suncook Lakes have a long history of intensive milfoil control, drawdowns, and aquatic vegetation loss from shoreline development.

Lower Suncook River (Downstream of the Suncook Lakes):
Bridle shiners were only found at one site in the lower Suncook River despite multiple records from 1938. Much of the suitable bridle shiner habitat in the lower Suncook River, south of the Rt. 4 bridge, was altered by the river avulsion and subsequent sediment deposition caused by flooding in May, 2006.

Lamprey River:
Bridle shiners were extirpated from the impoundment upstream of the Bunker Pond Dam after its removal in 2011. The river channel that formed in the accumulated sediment upstream of the dam was too shallow to support aquatic vegetation. A remnant bridle shiner population exists in a small manmade pond that drains into the river downstream from the old dam.

Warner River:
Recorded as present in 1938, but there is no sign of suitable bridle shiner habitat at the approximate site of the historical record. The population may have been extirpated due to habitat changes caused by a breached dam downstream from the site.

Jones Farm Pond:
Jones Farm pond is a small pond in Canterbury where bridle shiners were recorded in 1938. The pond may have once have been connected to the Merrimack River. It is surrounded by agricultural land and has become extremely eutrophic. There are no longer bridle shiners in the pond.

Population Management Status

There are no current population management efforts focused on bridle shiners. NHFG is considering reintroductions into suitable waterbodies. These waterbodies would meet the following criteria:
1)Bridle shiners were once recorded at the site.
2)Suitable habitat currently exists.
3)Extirpation was likely due to an isolated event (water level draw down or reclaimatio).
Potential reintroduction sites include Head's Pond (Hooksett) and Wheelright Pond (Lee).

Regulatory Protection (for explanations, see Appendix I)

● Endangered Species Conservation Act (RSA 212-A)

Quality of Habitat

Approximately 19,531 acres of bridle shiner habitat have been mapped in New Hampshire. Habitat quantity and quality vary significantly by region and waterbody. In general, the highest quality bridle shiner habitat exists in relatively undeveloped watersheds with natural flow regimes. The best example of intact bridle shiner habitat can be found from the lakes region east to the upper Saco, Ossipee, and Salmon Falls River drainages. Habitat becomes generally more impacted as you move south and east. The following is a summary of bridle shiner habitat status in New Hampshire:

Jones Brook and Coffin Brook:
The Jones Brook and Coffin Brook watersheds provide the best examples of intact bridle shiner habitat. They are relatively undeveloped watersheds with large expanses of wetland stream habitat in various stages of beaver activity. Protecting these watersheds would help prevent the significant declines in bridle shiner distribution, due to habitat degradation, that have occurred in other states.

Ossipee River, Saco, and upper Salmon Falls River watersheds:
Occupied bridle shiner habitat is patchy, but generally intact throughout this region. These watersheds have been less impacted by development than watersheds to the south. Efforts to protect shoreline habitat in this region will have long term benefits for bridle shiner populations.

Lakes Region:
Habitat quality varies considerably in this region, with examples of both intact and highly degraded sites. Bridle shiners in the more developed lakes, such as Lake Winnipesauke, usually occupy coves surrounded by wetlands, which have prevented shoreline development in the area. Efforts to control variable milfoil have reduced the extent of submerged aquatic vegetation at many locations in the lakes region. Sudden removal of aquatic plants can cause serious declines in local bridle shiner populations by compromising reproductive success and removing protective cover.

Upper Cocheco and Isinglass River watersheds:
A few isolated populations remain in the upper portions of these watersheds. The habitat is relatively intact and conservation efforts should focus on adjacent riparian buffer protection.

Lamprey River watershed:
A number of bridle shiner populations have been identified in the upper Lamprey River mainstem. Aquatic habitat in the Lamprey River has been increasingly degraded by stormwater runoff and increased sediment loads from road stream crossings. Bridle shiner populations in the Lamprey River may be vulnerable to episodes of poor water quality and high turbidity after rainfall events. Bridle shiners were notably absent from an area of apparently suitable habitat downstream of the Raymond town center. Impervious surfaces are unusually high in this area. A recent study has shown a significant decline in freshwater mussel abundance and diversity in the Lamprey River (Nedeau 2011). Freshwater mussels play an important role in maintaining healthy freshwater ecosystems (Strayer et al. 1994).

Exeter River, Powwow River, and other watersheds in southeastern New Hampshire:
The Exeter River contains relatively intact bridle shiner habitat, although populations may be vulnerable to water level fluctuations at dams. Much of the river has yet to be surveyed. The Powwow River also contains bridle shiner habitat, but the total extent of the available habitat has not been mapped. There may be other bridle populations in the small wetland streams and ponds along the southern New Hampshire coastal plain. Aquatic habitat in the southern tributaries of the Merrimack River has been highly degraded and bridle shiners have not been recently documented in the area, including waterbodies with historic records such as Canobie Lake and Shadow Lake, where bridle shiners appear to have been extirpated.

Soucook:
There are two small bridle shiner populations in the Soucook River, which will benefit from efforts to protect riparian buffers and other restoration efforts in the upper Soucook River Watershed.

Suncook River:
Bridle shiner distribution has been greatly reduced in the Suncook River watershed. Populations upstream of dams are vulnerable to water level fluctuations and vegetation removal. Much of the habitat in the lower Suncook River is no longer suitable for bridle shiners due to flood damage in 2006.

Habitat Protection Status

Habitat Management Status

There are no current habitat management projects directed at bridle shiners.

Threats to this Species or Habitat in NH

Threat rankings were calculated by groups of taxonomic or habitat experts using a multistep process (details in Chapter 4). Each threat was ranked for these factors: Spatial Extent, Severity, Immediacy, Certainty, and Reversibility (ability to address the threat). These combined scores produced one overall threat score. Only threats that received a "medium" or "high" score have accompanying text in this profile. Threats that have a low spatial extent, are unlikely to occur in the next ten years, or there is uncertainty in the data will be ranked lower due to these factors.

Habitat conversion and degradation due to shoreline development (Threat Rank: High)

Development along the shoreline of lakes, ponds, and larger rivers degrades critical habitat for aquatic species.

Aquatic plant removal, clearing of trees and branches that fall into the water, shoreline armoring, dock construction, tree and shrub thinning, and lawn maintenance are common practices associated with shoreline development. The cumulative effects of shoreline development combine to reduce habitat quality throughout a waterbody (Bryan and Scarnecchia 1992; Hicks and Frost 2010). Bridle shiners have been extirpated from a number of waterbodies where shoreline development has altered or eliminated aquatic plant communities.

Habitat conversion and degradation caused by water level management (Threat Rank: High)

Unnatural water level fluctuation can alter upstream lake and pond habitat. Lake drawdowns, usually during winter, reduce shoreline plant communities and expose aquatic organisms to desiccation. Poor recruitment may be an issue for species that spawn on shallow reefs or along the shoreline, depending on the timing and extent of the drawdown. River and stream habitat below lakes and ponds may also be impacted as flows are shutdown in an attempt to refill lakes or increased rapidly to lower the water level.

Bridle shiners are found in the slow moving sections of rivers and streams where shallow water and slow moving currents allow for the growth of submerged aquatic vegetation. These areas were favorable sites for the construction of mill dams as early colonists settled the region. Over many years, a large quantity of sediment has accumulated above these dams. When the dam eventually fails or is removed, the river or stream carves a new channel through the sediment and becomes a shallow, fast flowing stream type that no longer supports the aquatic vegetation on which bridle shiners depend.

Bridle shiners are particularly vulnerable to sudden water level drawdowns, especially during the spawning season in late spring and early summer. Their short life span of only one to two years makes it difficult for the population to recover from the loss of even a single year class. The bridle shiner population documented by Harrington (1947) in the Oyster River in Durham may have been extirpated by a water level drawdown during the construction of a fish ladder in the 1970's. More recently, a dam removal on the Lamprey River in Epping extirpated the bridle shiner population that previously occurred in the pond-like habitat created by the impoundment.

Disturbance from eutrophication (Threat Rank: High)

Nutrients from agricultural sources, sedimentation, lawn fertilizers, and poorly functioning septic systems contribute to increased algal growth in lakes and ponds. This excess productivity causes reductions in water quality and eventually lower dissolved oxygen levels as microorganisms consume the dead algal cells, using up oxygen in the process.

Many lakes and ponds in New England show signs of degraded water quality due to cultural eutrophication (USEPA 2010). Increasing development pressure in southern New Hampshire has led to eutrophication issues with many of the water bodies that support aquatic species of concern, including banded sunfish, bridle shiner, redfin pickerel, swamp darter, and eastern pondmussel. Nutrient loading has been identified as a significant impact to bridle shiners in Quebec (Boucher et al. 2011).

Mortality from subsidized or introduced predators (Threat Rank: Medium)

Fish species including largemouth bass, smallmouth bass, black crappie, and northern pike are often illegally introduced into waterbodies by anglers to create new fishing opportunities. These introductions can significantly alter the species composition of a lake or pond.

Introductions of predator fish species have been implicated in an overall loss of minnow species diversity throughout the northeast (Whittier et al. 1997). Bridle shiners coexist with introduced predators in some waterbodies with relatively intact shorelines and an abundance of aquatic vegetation. When aquatic vegetation becomes sparse, due to shoreline development, water level drawdowns, or invasive plant control, predators like largemouth bass gain an advantage as it becomes easier to locate their prey. Introduced predators may not be a significant threat in waterbodies with healthy aquatic plant communities, but they may exacerbate the decline of bridle shiners as their habitat begins to degrade.

Species disturbance from impervious surface run-off (Threat Rank: Medium)

Stormwater runoff from impervious surfaces changes the hydrology of local rivers and streams. Flashier flows cause an increase in erosion and sediment deposition along stream banks and in the stream channel. More surface flow means that less water is able to infiltrate into the ground and recharge groundwater supplies, which results in lower base flow during dry periods. Oil based pollutants, sediment, and road salt are washed from roads and parking lots into surrounding waterbodies which can lead to chronic declines in water quality. Runoff from pavement warmed by the sun can also lead to increased temperatures in local streams when stormwater flows directly into surface waters.

The impacts of impervious land cover on aquatic habitats have been well documented (Wang et al. 2001; Cuffney et al. 2010; Stranko et al. 2008). Although declines or extirpations of bridle shiners are difficult to link to water quality issues related to stormwater runoff, populations in southern New Hampshire may be at risk as impervious surface coverage continues to expand in the region. In the Lamprey River, sections of apparently suitable habitat are unoccupied by bridle shiners downstream from an area of high impervious surface coverage in the town of Raymond. As a visual forager, bridle shiners may be particularly sensitive to periods of increased turbidity caused by stormwater runoff from impervious surfaces.

List of Lower Ranking Threats:

None

Actions to benefit this Species or Habitat in NH

Threat assessment

Objective:

Assess the long term viability of bridle shiner populations in areas with declining habitat quality.

General Strategy:

Some bridle shiners in New Hampshire have shown signs of decline and may be at risk for extirpation. Significant reductions in aquatic vegetation due to herbicide treatments for variable milfoil in Lake Winnipesaukee have resulted in a decrease in the number of bridle shiners observed in the vegetated coves of Moultonborough Bay. It remains to be seen whether the bridle shiner population will recover as vegetation returns. Bridle shiners appear to be absent from sites with suitable habitat in the Lamprey River. Water quality degradation from stormwater runoff may be a factor. Rapid water level fluctuations or dam removals have greatly reduced or extirpated bridle shiners at some locations. An understanding of how threats impact bridle shiner populations and their ability to withstand changing habitat conditions is needed to better protect the species. Causes of extirpation should be documented when possible.

Political Location: **Watershed Location:**

Reduce nutrient loading

Primary Threat Addressed: Disturbance from eutrophication

Specific Threat (IUCN Threat Levels): Pollution

Objective:

Reduce the impacts of eutrophication by removing excess sources of nutrients.

General Strategy:

The primary sources of excess nutrients are lawn fertilizers in residential and commercial developments, agricultural fertilizers, and poorly functioning septic systems. Reducing nutrient loads can be achieved on two fronts. One is through outreach, which includes creating awareness about the effects of fertilizers on water quality and offering alternatives to fertilization practices that lead to the greatest amount of nutrient loading in nearby waterbodies. Best management practices can be developed for property owners with a focus on reducing runoff, minimizing or eliminating fertilizer use, and landscaping in a way that reduces the need for fertilization. In the case of septic failure, shoreline property owners with older septic systems can be targeted with incentives for upgrading. The second front is legislative. Laws that set limits on fertilizer use and require upgrades to septic systems will have long term benefits on water quality throughout the developed watersheds of southern New Hampshire. Requirements for new septic systems have greatly improved in recent years. The challenge is identifying and upgrading older systems that were constructed before septic systems were required to meet modern standards.

Political Location: **Watershed Location:**

Reintroduction

Primary Threat Addressed: Habitat conversion and degradation caused by water level management

Specific Threat (IUCN Threat Levels): Natural system modifications

Objective:
Reintroduce populations into suitable habitat within the species' former range.

General Strategy:
Bridle shiner extirpations have been documented in a number of waterbodies. In most cases, these waterbodies will no longer support bridle shiner populations due to habitat degradation. However, in some instances, extirpation was likely caused by an isolated incident such as a dam removal, a flood, or an extreme water level drawdown. In this case, habitat in the waterbody, which previously supported bridle shiners, may have recovered to a point that it would support a population of bridle shiners again. Bridle shiners could be introduced into these waterbodies from neighboring watersheds with healthy populations. This would help expand the current range of the species, which has suffered range wide declines (Sabo 2000). Two potential locations for reintroduction are Wheelright Pond in Lee and Heads Pond in Hooksett. Bridle shiners were documented in both waterbodies by Harrington (1947). Both waterbodies appear to have appropriate habitat for bridle shiners. The cause of extirpation in Heads Pond was likely a sudden water level drop due to a failed dam, which is currently in ruin. The cause of extirpation in Wheelright Pond is unknown.

Political Location: **Watershed Location:**

Distribution surveys

Objective:
Map the distribution of fish species of conservation concern.

General Strategy:
The bridle shiner distribution map is incomplete. New populations continue to be discovered each year. Areas that require more focus are the lakes, ponds, and low gradient streams of the Saco and Ossipee watersheds, the upper Salmon Falls and Cocheco River watersheds, the northern lakes region, and southeastern NH in the area of the Exeter and Powwow River watersheds.

Political Location: **Watershed Location:**

Reintroduction pilot study

Objective:
Assess the feasibility of reintroduction as a conservation strategy for bridle shiners.

General Strategy:
Bridle shiner reintroduction sites should be carefully monitored for factors that may limit successful recruitment. The long term viability of bridle shiner reintroductions at a limited number of pilot sites should be established before the strategy is expanded into additional waterbodies. An appropriate source of bridle shiners to be used for reintroductions remains to be identified. The efficacy of

culturing the species has not been evaluated.

Political Location: **Watershed Location:**

Water level management

Primary Threat Addressed: Habitat conversion and degradation caused by water level management

Specific Threat (IUCN Threat Levels): Natural system modifications

Objective:
Reduce the aquatic habitat impacts associated with artificial water level fluctuation at dams.

General Strategy:
Work with dam managers to achieve water level fluctuations that mimic natural flow regimes. Practices such as rapid changes in water level, excessive winter drawdown, and shutting off downstream flow to refill a waterbody should be avoided. Engaging stakeholders, including shorefront property owners, boaters, anglers, and hydropower project owners is critical to changing long established water level management traditions. The NHDES Dam Bureau is the lead on dam management issues in New Hampshire. The best strategy for improving water level management practices for fish and wildlife is to work with the Dam Bureau to identify opportunities to create more natural water level fluctuations at a certain dams and then make slow incremental changes. This allows stakeholders to adjust to the changes and make comments when conflicts arise.

Political Location: **Watershed Location:**

Shoreline Buffer Protection

Primary Threat Addressed: Habitat conversion and degradation due to shoreline development

Specific Threat (IUCN Threat Levels): Residential & commercial development

Objective:
Protect important habitat features along the shorelines of lakes, ponds, and larger rivers.

General Strategy:
The NH Shoreland Water Quality Protection Act provides a minimum level of protection for shoreline habitat along New Hampshire's lakes, ponds, and rivers (third order and larger). While the Shoreland Water Quality Protection Act focuses on protecting natural vegetation along the shoreline, it falls short of protecting other important habitat features such as submerged aquatic vegetation and trees that fall into the water. Landowners often remove plants and trees from the water to improve access for swimming and boating. These trees and submerged aquatic plants offer important structure for spawning, foraging, and evading predators. Increasing the percentage of natural or undeveloped shoreline will improve the overall habitat quality in a lake or pond. Conservation easements, changes in zoning, legislative acts, or landowner outreach programs may be used to restore natural shoreline features to New Hampshire lakes and ponds, many of which have little remaining undeveloped shoreline. Landowners often remove plants and trees from the water to improve access for swimming and boating. These trees and submerged aquatic plants offer important structure for spawning, foraging, and evading predators. Increasing the percentage of natural or undeveloped shoreline will improve the overall habitat quality in a lake or pond. Conservation easements, changes in zoning,

legislative acts, or landowner outreach programs may be used to restore natural shoreline features to New Hampshire lakes and ponds, many of which have little remaining undeveloped shoreline.

Political Location: **Watershed Location:**

Land Protection

Primary Threat Addressed: Habitat conversion and degradation due to shoreline development

Specific Threat (IUCN Threat Levels): Residential & commercial development

Objective:
Preserve the natural ecological functions of an area by protecting land from development.

General Strategy:
Land protection is a strategy that can be used to ensure a level of habitat quality that is necessary to support certain species and habitats of conservation concern. For aquatic species, land protection prevents many of the impacts caused by sprawling development. Groundwater recharge, intact riparian zones, and unrestricted migration corridors are some of the benefits. Species with limited ranges and mobility may be protected almost entirely through land conservation. For wider ranging species, land protection will be part of a greater restoration strategy. Although land protection is not a feasible strategy for some water bodies where bridle shiners have been documented, it will be an effective tool for protecting watersheds known to contain large expanses of intact bridle shiner habitat, such as the Jones Brook and Coffin Brook watersheds. Land protection projects in New Hampshire usually require the coordination of a variety of funding sources, with involvement from town conservation commissions, local land trusts and watershed associations, government agencies, and state or national NGO's. Since 2005, the NH Wildlife Action Plan has helped direct land protection efforts toward conserving habitat for species and habitats of concern. The effectiveness of land conservation could be improved by identifying and addressing barriers to land conservation in New Hampshire and increasing outreach to help prioritize projects that benefit species and habitats of concern.

Political Location: **Watershed Location:**

Stormwater Management

Primary Threat Addressed: Species disturbance from impervious surface run-off

Specific Threat (IUCN Threat Levels): Pollution / Domestic & urban waste water / Run-off

Objective:
To reduce the impacts of runoff from impervious surfaces by using Low Impact Development Technology.

General Strategy:
Stormwater runoff from impervious surfaces has been shown to damage aquatic habitats (Wang et al. 2001; Cuffney et al. 2010). Much of this damage can be prevented by stormwater management practices that filter runoff through the ground before it enters surface waters. This practice not only removes much of the sediment and toxins that are typically washed into streams, but it also reduces the

rapid fluctuation in temperature, as well as the excess erosion and sediment deposition that have become a chronic issue for rivers and streams in developed areas. The University of New Hampshire Stormwater Center is an excellent resource for Low Impact Development (LID) practices for stormwater management.

Political Location: **Watershed Location:**

Life history research

Objective:
Study the life histories of fish species of conservation concern in New Hampshire.

General Strategy:
There is a lack of basic information on the reproductive behavior, foraging habits, habitat requirements, seasonal movement patterns and other aspects of the life history of many lesser known fish species of concern in New Hampshire. A better understanding of these species would aid in the assessment of potential threats and the development of appropriate management actions.
Also of interest is their ecological role in aquatic communities and their potential use as indicators for water quality or intact habitat.

Political Location: **Watershed Location:**

References, Data Sources and Authors

Data Sources
NHFG biologists with the Fish Conservation Program of the Inland Fisheries Division have been conducting targeted surveys for bridle shiners since 2005. Historical bridle shiner distribution is based on the work of Harrington (1947) and NHFG survey records (1937-1939).

Data Quality
All sites with historical bridle shiner records have been resurveyed. Bridle shiner habitat has been mapped at most locations with known records. New bridle shiner populations continue to be discovered by evaluating similar habitats within watersheds where the species has been documented. NHFG biologists have been conducting surveys for bridle shiners since 2006. After identifying a number of likely extirpations during an initial status assessment of sites with historical bridle shiner records, NHFG biologists focused on identifying and mapping the distribution of the remaining bridle shiner populations throughout the state. Although there are gaps in the distribution map in northwestern and southeastern regions, distribution maps for a number of watersheds, including the Lamprey River, Jones Brook, Coffin Brook, and the Soucook River, have been completed.

2015 Authors:
Matthew Carpenter, NHFG, Benjamin Nugent, NHFG

2005 Authors:

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Rainbow Smelt

Osmerus mordax

Federal Listing	
State Listing	SC
Global Rank	
State Rank	S3
Regional Status	

Photo by John Lyons

Justification (Reason for Concern in NH)

Rainbow smelt were once harvested by the barrel full in the 1800's for use as fertilizer, cattle feed, and later as a food source. Their numbers have experienced alarming declines in recent decades. Populations south of Massachusetts no longer appear viable, and in the north, a once thriving recreational winter smelt fishery is slowly fading into obscurity. Catch rates in Great Bay have declined significantly since the 1980's. A number of threats have been implicated in the decline (Enterline et al. 2012).

Distribution

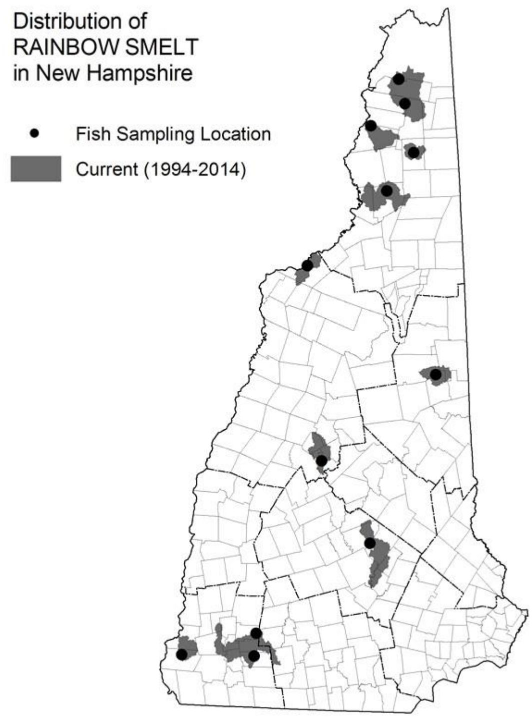
Rainbow smelt are native to Atlantic coastal drainages from Labrador south to New Jersey and Pacific coastal drainages in Canada and Alaska (Scarola 1987). Great Bay, and the rivers that flow into it, are important spawning areas and nursery habitat for coastal smelt populations. Native landlocked populations are believed to exist in Winnipesaukee, Winnisquam, and Squam lakes (Scarola 1987). Several other waterbodies throughout New Hampshire are believed to contain introduced smelt populations. As many as 105 waterbodies currently have or once held smelt populations (NHFG unpublished data).

Habitat

Marine smelt concentrate in estuaries and harbors. Coastal smelt populations move into rivers shortly after the breakup of ice to spawn at the head of tide within shallow riffles. During spawning they seek out gravel substrate with swift current (Scarola 1987). Freshwater smelt populations are mainly found in deep, cold, clear lakes. Landlocked populations will spawn in tributary rivers of lakes and ponds or along lakeshores with sand, gravel, or fallen leaves (Scarola 1987).

NH Wildlife Action Plan Habitats

- Estuarine
- Lakes and Ponds with Coldwater Habitat
- Coldwater Rivers and Streams
- Marine
- Warmwater Rivers and Streams



Distribution Map

Current Species and Habitat Condition in New Hampshire

Coastal rainbow smelt populations have declined significantly since the 1800's, with the most dramatic changes occurring at the southern edge of their range. Once caught as far south as New Jersey, rainbow smelt are now considered extirpated from coastal rivers and estuaries south of Buzzard's Bay, Massachusetts (Enterline et al. 2012). The rainbow smelt populations in the Great Bay estuary show signs of significant declines in recent years based on winter creel survey data, egg deposition surveys, and juvenile finfish seine survey index sites (Sullivan 2010; Enterline et al. 2010). Ice anglers reported the lowest catch rates in the winter of 2014/2015 since the smelt creel survey on the Great Bay estuary was initiated in 1978 (Personal communication: Rebecca Heuss, Biologist, NHFG Marine Division).

Landlocked rainbow smelt populations are stable or increasing in most waterbodies where they occur in New Hampshire. Populations have been reduced in some waterbodies, such as Lake Winnisquam, where sedimentation has degraded habitat in streams that once supported abundant smelt spawning runs (Personal communication: Don Miller, Biologist NHFG). Smaller waterbodies with limited amounts of coldwater habitat are less likely to support smelt populations over the long term.

Population Management Status

Coastal rainbow smelt harvest in New Hampshire is limited by a daily bag limit of 4 liquid quarts. At current low harvest levels, daily bag limits are unlikely to affect population size.

Landlocked smelt populations are monitored in lakes with landlocked salmon fisheries due to their importance as a forage base (NHFG 1982). Rainbow smelt populations in these waterbodies are managed indirectly by adjusting the stocking rates of predator species, including landlocked salmon and rainbow trout.

Regulatory Protection (for explanations, see Appendix I)

- Harvest permit - season/take regulations

Quality of Habitat

Rainbow smelt are known to spawn at the head of tide in rivers, including the Squamscott, Salmon Falls, Bellamy, Oyster, Lamprey, and Winnicut Rivers, that flow into the Great Bay estuary. Much of this habitat has been impaired by coastal development. High nutrient levels in these rivers contribute to periphyton growth on smelt eggs, which may affect embryonic growth and survival (Enterline et al. 2012). Head of tide dams limit the accessibility of spawning habitat, forcing smelt to spawn in tidal reaches where eggs may become exposed at low tide. Stream channel modifications due to shoreline development and bridge construction have changed flow conditions in some rivers, creating barriers which limit the upstream movement of spawning smelt at high or low flows.

Smelt habitat is largely intact in most inland waterbodies. Sedimentation has extirpated smelt spawning runs in some tributaries, including Black Brook in Lake Winnisquam. It is possible that rainbow smelt use shoreline habitat for spawning in lakes with degraded tributary spawning habitat (Personal communication: Don Miller, Biologist NHFG).

Habitat Protection Status

Habitat Management Status

Dam removals at the head of tide on the Winnicut and Bellamy Rivers have increased access to spawning habitat for smelt. However, these dam removal projects may require additional habitat restoration work to improve the quality of smelt spawning habitat at these sites. Sedimentation and past stream channel alterations may be burying gravel spawning substrate and restricting access to upstream reaches. Future dam removal projects, including the Great Works Dam in Exeter, may require additional stream restoration work to ensure that smelt can access freshwater habitat upstream. Rainbow smelt will also benefit from efforts to manage stormwater runoff and reduce nutrient loads into rivers and streams that drain into both freshwater lakes and the Great Bay estuary.

Threats to this Species or Habitat in NH

Threat rankings were calculated by groups of taxonomic or habitat experts using a multistep process (details in Chapter 4). Each threat was ranked for these factors: Spatial Extent, Severity, Immediacy, Certainty, and Reversibility (ability to address the threat). These combined scores produced one overall threat score. Only threats that received a “medium” or “high” score have accompanying text in this profile. Threats that have a low spatial extent, are unlikely to occur in the next ten years, or there is uncertainty in the data will be ranked lower due to these factors.

Species disturbance from shoreline development and associated impervious surfaces (Threat Rank: Medium)

Increased development along coastal rivers has resulted in impervious surface runoff, which may increase flows during storm events. Straightening, armoring, and other alterations of the stream banks along coastal rivers may increase flow velocities, altering natural erosion and sedimentation rates. This may prevent rainbow smelt from migrating upstream or compromise egg survival.

Alterations to coastal river and stream habitat have restricted rainbow smelt access to spawning habitat throughout the more developed coastal areas of the northeast (Enterline et al. 2012).

Mortality resulting from commercial or recreational harvest and bycatch (Threat Rank: Medium)

Rainbow smelt are harvested through the ice each winter. Angling pressure may put additional stress on a smelt population that is already in decline.

Catch rates of rainbow smelt on Great Bay have declined drastically in recent years (Personal communication: Becky Hauss, Fisheries Biologogist, NHFG, Marine Division). It is not clear to what extent, if any, historic fishing pressure contributed to the current low population levels of anadromous rainbow smelt. Angler harvest is not currently a threat to freshwater smelt populations in New Hampshire.

Disturbance from eutrophication that increases periphyton growth on spawning substrate (Threat Rank: Medium)

Excess nutrients in coastal rivers in stream may contribute to increased periphyton growth on the substrate where rainbow smelt lay their eggs. This excess periphyton may increase egg mortality (Enterline 2012).

High levels of nitrogen are a well-documented water quality issue in Great Bay (PREP 2013).

Disturbance from contaminants (heavy metals, pesticides, sediment, road salt) (Threat Rank: Medium)

Contaminants entering rivers and streams throughout coastal New Hampshire may reduce the spawning success of anadromous smelt populations.

Contaminated river water may be contributing to the population decline of rainbow smelt that is currently occurring in the Gulf of Maine (Enterline 2012).

Disturbance from sedimentation into tributary streams (Threat Rank: Medium)

Sediment from a variety of sources, including house construction, poor stormwater management, and undersized stream crossings, buries suitable spawning substrate for both anadromous and landlocked populations of rainbow smelt.

Streams that once supported abundant spawning runs of rainbow smelt, such as Black Brook, which flows into Lake Winnisquam, have become choked with sediment and no longer support rainbow smelt runs (personal communication Don Miller NHFG).

List of Lower Ranking Threats:

Mortality from increased predation (striped bass, seals, cormorants)

Habitat degradation from water level management

Disturbance from dams or stream crossings that block species from spawning areas or other important habitat

Disturbance from stream crossings or dams that fragment habitat

Species impacts from changes in marine forage base

Species impacts from unsuitable habitat conditions at the southern edge of range

Actions to benefit this Species or Habitat in NH

Stormwater Management

Primary Threat Addressed: Disturbance from sedimentation into tributary streams

Specific Threat (IUCN Threat Levels): Pollution / Domestic & urban waste water / Run-off

Objective:
To reduce the impacts of runoff from impervious surfaces by using Low Impact Development Technology.

General Strategy:
Stormwater runoff from impervious surfaces has been shown to damage aquatic habitats (Wang et al. 2001; Cuffney et al. 2010). Much of this damage can be prevented by stormwater management practices that filter runoff through the ground before it enters surface water. This practice not only removes much of the sediment and toxins that are typically washed into streams, but it also reduces the rapid fluctuation in temperature, as well as the excess erosion and sediment deposition that have become a chronic issue for rivers and streams in developed areas. The University of New Hampshire Stormwater Center is an excellent resource for Low Impact Development (LID) practices for stormwater management. Improving water quality in coastal rivers and streams may increase rainbow smelt egg survival (Enterline et al. 2012).

Political Location:

Watershed Location:

Reduce nutrient loading

Primary Threat Addressed: Disturbance from eutrophication that increases periphyton growth on spawning substrate

Specific Threat (IUCN Threat Levels): Pollution

Objective:
Reduce the impacts of eutrophication by removing excess sources of nutrients.

General Strategy:

The primary sources of excess nutrients are lawn fertilizers in residential and commercial developments, agricultural fertilizers, and poorly functioning septic systems. Reducing nutrient loads can be achieved on two fronts. One is through outreach, which includes creating awareness about the effects of fertilizers on water quality and offering alternatives to fertilization practices that lead to the greatest amount of nutrient loading in nearby waterbodies. Best management practices can be developed for property owners with a focus on reducing runoff, minimizing or eliminating fertilizer use, and landscaping in a way that reduces the need for fertilization. In the case of septic failure, shoreline property owners with older septic systems can be targeted with incentives for upgrading. The second front is legislative. Laws that set limits on fertilizer use and require upgrades to septic systems will have long term benefits on water quality throughout the developed watersheds of southern New Hampshire. Requirements for new septic systems have greatly improved in recent years. The challenge is identifying and upgrading older systems that were constructed before septic systems were required to meet modern standards. Improving water quality in coastal rivers and streams may increase rainbow smelt egg survival (Enterline et al. 2012).

Political Location:

Watershed Location:

References, Data Sources and Authors

Data Sources

NHFG survey data and the Regional Conservation Plan for Anadromous Rainbow Smelt in the U.S Gulf of Maine (Enterline et al. 2012). NHFG survey data and The Regional Conservation Plan for Anadromous Rainbow Smelt in the U.S Gulf of Maine.

Data Quality

The Regional Conservation Plan for Anadromous Rainbow Smelt in the U.S Gulf of Maine provides an excellent summary of anadromous rainbow smelt status, distribution, and population trends in each state within the species U.S range (Enterline et al. 2012). Landlocked smelt distribution is well documented in NH. Abundance levels of landlocked populations are monitored in several larger deep water lakes by NHFG biologists on an annual basis. NHFG has increased monitoring efforts in the larger coastal tributaries, but rainbow smelt spawning activity in smaller coastal streams has not been well documented. Creel survey and egg deposition survey data provide long term data sets, but results may not be comparable over time due to changes in methods. The juvenile finfish seine survey, conducted by NHFG, is a good long term indicator of juvenile smelt recruitment in New Hampshire coastal habitat.

Although there are no surveys that specifically monitor landlocked smelt habitat, tributary spawning habitat for rainbow smelt is monitored during spring dip net surveys for spawning rainbow smelt in a number of large coldwater lakes, including Lake Winnipesaukee, Squam Lake, Newfound Lake, Sunapee Lake, and the Connecticut Lakes (NHFG 2012; Personal communication: Ben Nugent, Biologist NHFG).

2015 Authors:

Benjamin Nugent, NHFG, Matthew Carpenter, NHFG

2005 Authors:

Literature

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Sea Lamprey

Petromyzon marinus

Federal Listing
State Listing
State Rank
Regional Status

SC Global Rank
S3

Photo by John Lyons

Justification (Reason for Concern in NH)

Sea lampreys are blocked from much of their spawning habitat by dams. In New Hampshire they depend on functional fishways to reach suitable spawning habitat. Although Atlantic coastal populations are not currently considered threatened, there have been significant declines in lamprey populations throughout the northern hemisphere (Renaud 1997). A complex life cycle, which is dependent on multiple habitats in freshwater and marine ecosystems, makes the sea lamprey vulnerable to the effects of urbanization in coastal watersheds (Creel 2003). Sea lamprey may also be impacted by a decline in host species due to overfishing of marine fish stocks (Nislow and Kenard 2009).

Distribution

The sea lamprey inhabits Atlantic coastal rivers throughout eastern North America and western Europe, as far south as the western Mediterranean Sea and the gulf coast of Florida (Scott and Crossman 1973). In New Hampshire, sea lampreys migrate into the Connecticut River, Merrimack River, and coastal rivers up to the first impassable barriers.

Habitat

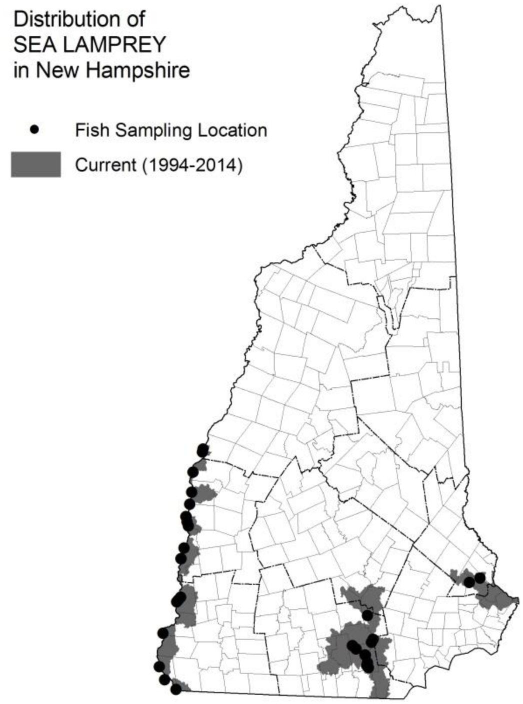
Sea lampreys spend their adult lives in the ocean as a parasite on other fish. After 20 to 30 months at sea they migrate into freshwater, following pheromones from larvae (ammocoetes) upstream (Vrieze and Sorenson 2001). Sea lampreys construct nests in gravel/cobble riffle sections of freshwater streams (Scarola 1987). Once hatched, the larvae float downstream to slow moving pools where they burrow into the substrate and filter feed on organic detritus drifting in the water column (Scarola 1987).

In freshwater, sea lampreys use river reaches with gravel substrate for spawning. Spawning habitat is similar to that used by salmon, occurring at the upstream end of riffles and the tail end of pools. Ammocoetes require fine silt and sand that is loose enough to burrow into, yet protected from washing away in higher flows. These areas often occur on the inside of river bends, along stream banks, and behind structures such as boulders or fallen trees.

Sea lamprey play an important ecological role in freshwater. Their nests improve spawning substrate for other fish species and create interstitial spaces between stones for macroinvertebrates (Kircheis 2004). Sea lamprey ammocoetes are filter feeders, which, in large numbers, may trap nutrients and improve water quality. Adult sea lampreys die after spawning and their carcasses release marine derived nutrients into freshwater rivers (Nislow and Kynard 2009).

NH Wildlife Action Plan Habitats

- Large Warmwater Rivers
- Warmwater Rivers and Streams
- Coldwater Rivers and Streams
- Estuarine
- Marine



Distribution Map

Current Species and Habitat Condition in New Hampshire

Sea lamprey numbers are well below their potential in New Hampshire rivers. Populations are generally declining or stable at low levels despite improvements in access to spawning habitat.

Coastal Watersheds
Sea lampreys typically number less than a 1,000 in coastal rivers where fish counts are recorded. The majority of sea lamprey returns are recorded each spring in the Cocheco, Exeter, and Lamprey Rivers. Sea lamprey numbers have remained low since the early 1980's, when over 25,000 sea lampreys were removed from coastal fish ladders for medical research.

Merrimack River
Sea lamprey counts at the Essex dam in Lawrence average 6,603 annual returns since 1983. Counts have declined each decade, with an average of 12,220 sea lamprey counted per year between 1985 and 1994, 6,160 between 1995 and 2004, and 2,270 in the last 10 years. No sea lamprey were recorded in 2006 due to flooding.

Connecticut River
The average number of sea lampreys counted at the Holyoke Fishway each spring since 1975 is 34,231, with a peak of 100,000 counted in 1998. Annual sea lamprey counts at the Holyoke dam are highly variable, but returns have been below average since 2010. A recent sea lamprey pit tagging study showed that most sea lamprey move rapidly upstream between dams, but only 50% of the sea lamprey that enter fish ladders successfully pass through the ladder (Ted Castros Santos, USGS, unpublished data).

Population Management Status

There are no current stocking efforts focused on sea lamprey. Migrating sea lampreys are able to detect pheremones from ammocoetes, which they use to navigate to their spawning grounds. This trait makes stocking sea lamprey upstream a potential restoration strategy for seeding new populations in rivers or stream where sea lampreys have been denied access. This approach would be most effective where a migration barrier is expected to be removed or mitigated, either by dam removal or fishway construction. However, population recovery may be limited by the availability of marine host species (Nislow and Kenard 2009).

Regulatory Protection (for explanations, see Appendix I)

● Harvest permit - season/take regulations

Quality of Habitat

The extent and quality of sea lamprey spawning and juvenile rearing habitat in New Hampshire is not well known. A large proportion of historic sea lamprey spawning habitat is currently inaccessible due to impassable dams.

Coastal watersheds:
Access to spawning habitat for sea lamprey has improved in coastal rivers over the last 10 years. A newly constructed fish ladder at the Wiswall Dam and the removal of the Bunker Pond Dam, on the Lamprey River, has greatly increased the amount of river habitat that is accessible to Sea Lamprey (12 km). The ruins of the Wadleigh Falls Dam, in Lee, has been shown to act as a barrier to river herring migration, but its effect on sea lamprey upstream movement is unknown. Potential dam removals or fishway improvements on the Exeter, Bellamy, and Winnicut Rivers may offer opportunities for sea lampreys to increase their range in New Hampshire. In the Cocheco River, sea lampreys have access to approximately 5 km of river from the fish ladder at the Cocheco Falls Dam in Dover upstream to the Watson Dam. A possible migration barrier, known as Factory Falls, which is downstream from the Watson Dam, may limit diadromous fish passage in the Cocheco River.

Merrimack River:
In the Merrimack River, sea lampreys are able to reach the Hooksett Dam, although they are rarely observed at the Amoskeag Dam Fishway, in Manchester. The Souhegan River is accessible up to the McLane Dam in Milford. Baboosic Brook, a tributary to the Souhegan River, is known to contain sea lamprey spawning habitat and ammocoetes. Sea lamprey ammocoete numbers have increased at the mouth of the Souhegan River, where excellent burrowing habitat was created by sediment deposited after the Merrimack Village Dam was removed in 2008. Juveniles have also been captured in a number of other small tributaries to the Merrimack River, but the extent of spawning habitat or the total number of individuals that spawn in the mainstem is not well known.

Connecticut River:
Sea Lamprey ammocoetes have been documented in the Connecticut River as far north as the town of Hanover, near the mouth of the White River. The location and relative importance of sea lamprey spawning areas in the mainstem and tributaries of the upper Connecticut River is not well understood. Studies related to the relicensing of the Connecticut River dams owned by TransCanada Corporation will provide more information on sea lamprey population status and spawning habitat in the upper Connecticut River.

Habitat Protection Status

Habitat Management Status

Efforts to improve the efficiency and monitoring of fishways will benefit sea lampreys, but dam removals will have the greatest long term benefit. The end of Atlantic salmon restoration efforts in the Merrimack and Connecticut Rivers was a setback for sea lamprey, which often share spawning areas with Atlantic salmon. Maintaining and improving fish passage solely for sea lamprey can be a challenge due to its image as a nuisance species not commonly targeted by anglers. Fisheries managers should emphasize the important ecological role of sea lamprey in freshwater and seek to improve access to spawning habitat whenever possible.

Threats to this Species or Habitat in NH

Threat rankings were calculated by groups of taxonomic or habitat experts using a multistep process (details in Chapter 4). Each threat was ranked for these factors: Spatial Extent, Severity, Immediacy, Certainty, and Reversibility (ability to address the threat). These combined scores produced one overall threat score. Only threats that received a "medium" or "high" score have accompanying text in this profile. Threats that have a low spatial extent, are unlikely to occur in the next ten years, or there is uncertainty in the data will be ranked lower due to these factors.

Disturbance from dams that block species from spawning areas or other important habitat (Threat Rank: High)

Dams block access to freshwater spawning habitat.

Dams have greatly reduced the amount of freshwater habitat available to sea lamprey and other diadromous species (Limburg and Waldman 2009). Before the construction of dams on the Merrimack River, sea lamprey were documented as far north as the Baker River in the town of Wentworth (Noon 2003). Currently, the Hooksett Dam is the upstream limit of sea lamprey migration in the Merrimack River. Access to the majority of sea lamprey habitat in New Hampshire coastal rivers is currently limited by dams.

Disturbance from dams that delay upstream or downstream migration (Threat Rank: Medium)

Delays in migration occur at dams as fish try to successfully navigate fish passage facilities. These delays may become energetically costly to the point where they impact spawning behavior.

A recent pit tagging study of migrating sea lampreys documented delays and poor passage efficiency at a number of dams on the Connecticut River (Ted Castro-Santos, USGS, personal communication). Sea lampreys have limited energy budgets during migration and delays at dams may force them to use poor quality spawning habitat, which could decrease recruitment.

List of Lower Ranking Threats:

Mortality from hydropower turbines

Species impacts from the overfishing of marine host species

Species impacts from changes in timing of migration and flooding that decrease spawning success

Actions to benefit this Species or Habitat in NH

Fish transfers

Primary Threat Addressed: Disturbance from dams that block species from spawning areas or other important habitat

Specific Threat (IUCN Threat Levels): Natural system modifications / Dams & water management/use / Dams (size unknown)

Objective:
Transfer diadromous fish species into suitable freshwater habitat that is currently inaccessible due to dams or other manmade barriers.

General Strategy:
In some cases it may be appropriate to move diadromous fish into habitat that is currently inaccessible. Improving access to quality spawning habitat may increase the spawning population within a river system. In many cases, a certain number of returning fish will trigger fish passage at a dam where a fish passage prescription has been negotiated through the FERC licensing process. In other cases, congregations of diadromous species downstream from a dam demonstrate a clear need for fish passage at the site. Sources of fish transfers should come from within basin whenever possible, but in river reaches where diadromous fish species have been extirpated, fish may need to be transferred from neighboring watersheds. The risk of introducing diseases or invasive organisms should be considered when transferring fish from out of basin. Some level of testing may be required.

Political Location:

Watershed Location:

Marine research

Objective:
Investigate the factors that influence sea lamprey abundance and survival at sea.

General Strategy:
Marine food webs have been altered by centuries of commercial fishing pressure. There is little information on the abundance and availability of preferred or suitable marine hosts for sea lampreys and how changes in host populations may influence sea lamprey population dynamics. It is unclear whether the availability and size of host species is currently influencing marine growth and survival of sea lampreys in the ocean. More research is needed on the factors necessary for the successful completion of the marine phase of the sea lamprey's life cycle.

Political Location:

Watershed Location:

Dam removal

Primary Threat Addressed: Disturbance from dams that block species from spawning areas or other important habitat

Specific Threat (IUCN Threat Levels): Natural system modifications / Dams & water management/use / Dams (size unknown)

Objective:
Remove barriers to migration.

General Strategy:
When the opportunity presents itself, dam removals provide the best long term solution to reconnecting diadromous fish with their historical freshwater spawning habitat. Dam removal projects are challenging and they often stall without a dedicated project manager. Hiring and training staff to identify and facilitate dam removal projects will increase the number of projects that can be completed each year. Creating priority lists of dam removal projects for each species would also help focus resources on the projects with the most benefit as well as help generate funding.

Political Location: **Watershed Location:**

Improve fish passage at dams

Primary Threat Addressed: Disturbance from dams that block species from spawning areas or other important habitat

Specific Threat (IUCN Threat Levels): Natural system modifications / Dams & water management/use / Dams (size unknown)

Objective:
Construct, maintain, and monitor fishways at dams that currently limit access to suitable freshwater habitat for diadromous fish.

General Strategy:
At sites where dam removal is not an option, fish passage construction can improve connectivity between freshwater and marine habitats. Fish passage construction may be negotiated during the FERC licensing process. Fish passage engineers with the USFWS are available to assist with designing the appropriate fishway for a particular site, depending on the needs of the species and the size of the dam (among other factors). At some sites outside of FERC jurisdiction, funding may have to come from other sources. Once installed, there should be a plan for fish passage operation, maintenance, and monitoring. Identifying the party responsible for each aspect of fishway operation is critical for maintaining effective passage over the long term. Periodic performance evaluations should also be completed at each fishway to ensure that fish are moving efficiently through the project without excessive delays.

Political Location: **Watershed Location:**

Monitor fish passage

Objective:
Monitor upstream and downstream passage at dams.

General Strategy:
Monitor diadromous fish passage at dams with trained staff, video equipment or periodic sampling.

Assess the efficiency of upstream and downstream passage facilities. Make recommendations for improving existing or proposed fish passage structures.

Political Location: **Watershed Location:**

Map spawning habitat

Objective:
Map the spawning habitat used by anadromous fish in the Connecticut, Merrimack, and Coastal watersheds.

General Strategy:
While spawning adults are counted each spring in many New Hampshire Rivers, the exact location of actual spawning areas has yet to be mapped. The extent of suitable spawning habitat for alewives, blueback herring, sea lamprey, and American shad is not well known. This research would likely involve the use of radio telemetry and visual surveys during the spawning season.

Political Location: **Watershed Location:**

References, Data Sources and Authors

Data Sources
Sea lamprey records are entered into the NHFG fish survey database.
Fish passage counts are maintained by state and federal Fish and Wildlife agencies, and in some cases, hydropower company staff. Juvenile sea lamprey distribution was obtained from survey data collected by NHFG.

Data Quality
There are counts of annual sea lamprey returns at most fishways extending back to the early 1980's. The number of sea lamprey that fail to pass through fishways is not well known.
The actual locations of sea lamprey spawning habitat and ammocoete habitat within New Hampshire watersheds are not well documented. Juveniles are occasionally captured during electrofishing surveys for other species. The presence of juvenile sea lampreys is an indication that spawning habitat exists upstream.
The quality of the data depends on the method of counting at each fishway. The best count data comes from the staffed counting rooms at the Essex Dam, on the Merrimack River, and the Holyoke Dam, on the Connecticut River, or the video counting software deployed by Vermont Fish and Wildlife on the upper Connecticut River dams. The automated counting systems used on most coastal river fish ladders do not distinguish between sea lamprey and other species, but all sea lamprey are counted and passed by hand on the Cocheco River.

2015 Authors:
Matthew Carpenter, NHFG, Benjamin Nugent, NHFG

2005 Authors:

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Round Whitefish

Prosopium cylindraceum

Federal Listing	
State Listing	SC
Global Rank	
State Rank	S1
Regional Status	V. High

Photo by NHFG

Justification (Reason for Concern in NH)

Since 1983 the round whitefish has been listed as a state endangered species in New York. Waterbodies with indigenous round whitefish populations were reduced from greater than 80 to 7. Low pH (pH<5.5) typically associated with acid deposition and introduced predators were the main causes of decline. Smallmouth bass, yellow perch, and rainbow smelt reduce round whitefish numbers directly through predation (Steinhart et al. 2007). All three of these species coexist with round whitefish in Newfound Lake (NHFG, unpublished data). There are only two confirmed populations of round whitefish in New

Distribution

The round whitefish is found throughout northeast Asia, northwestern North America, eastern Canada, the northeastern U.S., and in all of the Great Lakes except Lake Erie. It is absent from central and southwestern Canada. Round whitefish were historically reported to exist in Newfound Lake, First Connecticut Lake, and Winnipesaukee Lake, as well as the upper Connecticut River (Scarola 1987, Bailey and Oliver 1939). However, the record from Lake Winnipesauke may have been a misidentified lake whitefish. In New Hampshire the species is currently known to exist in two waterbodies: Newfound Lake and the upper Connecticut River.

The round whitefish has been documented in the Connecticut River from the Lake Francis Dam south to the bridge at North Stratford (Yoder et al 2010). Prior to the construction of the Lake Francis Dam, round whitefish were captured in 1939 in the section of river now flooded by the lake. Round whitefish were also said to have been abundant in First Connecticut Lake prior to 1939 (Bailey and Oliver 1939). There have been no recent reports of round whitefish in Lake Francis or the Connecticut Lakes.

Habitat

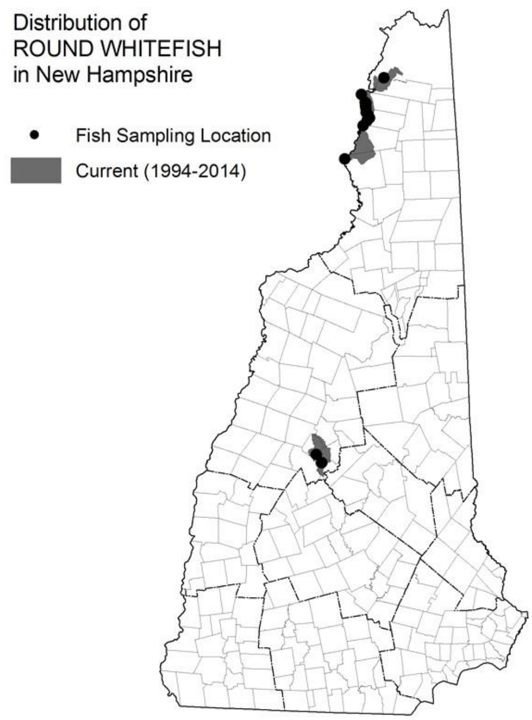
At the southern end of their range round whitefish usually inhabit medium to large sized lakes with deep, cold water habitat. They spawn in shallow water over cobble and gravel substrate. Round whitefish also inhabit medium to large sized cold water rivers. Riverine populations are more common in the northern parts of its range. Spawning begins as the water temperature falls below 40°F. Peak spawning activity occurs between late November and the second week of December in Newfound Lake (Scott and Crossman 1973, Normandeau 1963, NHFG unpublished data). Round whitefish in Newfound Lake were observed to spawn on the same reef as lake trout (*Salvelinus namaycush*) (Normandeau 1963). Information concerning habitat use of juvenile round whitefish is unavailable.

During spawning, males and females approach the reef in pairs, not in large schools as is common with other species. The eggs, deposited within rock crevices, receive no parental care and hatch between the end of March and the beginning of May (Scott and Crossman 1973). Egg predation by species such as brown bullhead, burbot, white sucker, and yellow perch appeared to be a significant cause of mortality over the winter (Normandeau 1963).

Round whitefish are bottom feeders, preying mainly on benthic invertebrates and fish eggs or newly hatched fry. Although found in deep lakes, they rarely inhabit depths greater than 120 feet. There are anecdotal reports of round whitefish movement into the tributaries of Newfound Lake in the early spring, possibly in response to the availability of prey (i.e. spawning rainbow smelt and their eggs).

NH Wildlife Action Plan Habitats

- Lakes and Ponds with Coldwater Habitat
- Coldwater Rivers and Streams



Distribution Map

Current Species and Habitat Condition in New Hampshire

In New Hampshire, the southern fringe of the overall species distribution, surveys targeting round whitefish during spawning season have produced alarmingly few round whitefish since monitoring efforts began in 2005. Normandeau (1963) focused sampling efforts along the same spawning location. The catch per unit of effort of round whitefish appears to be significantly lower in current surveys when compared to surveys conducted in the early 1960's (Normandeau 1963, NHFG unpublished data). The large size of the individuals captured since 2005 further suggests that survival rates to maturity may be low in Newfound Lake. Additionally, clipped fins to denote previous capture during spawning surveys are routinely observed in later years. It is not known if there are additional spawning areas within the lake. There is additional concern regarding the influence of lake level management on recruitment success. The current water level management strategy at Newfound Lake calls for a continued decrease in lake surface elevation throughout the fall and winter. Fertilized eggs deposited in shallow areas of the spawning reef may be frozen within the icepack or exposed to the open atmosphere. The overall status of the population in Newfound Lake is requires further study but has likely decreased in abundance since the early 1960's.

Similarly, the overall abundance of round whitefish occupying sections of the upper Connecticut River is not well understood. There is very little historical information about the species in the Connecticut River to make comparisons with current sampling data. Although the current population in the upper Connecticut River is suspected to be more secure than the Newfound Lake population, more evaluation to determine habitat requirements, core population areas, and a replicable survey technique to define population trends is required. The extent of impact from adjacent land use and dams on the round whitefish population found in the upper Connecticut River is not well understood.

Population Management Status

It is unlikely that the 2 fish daily harvest limit affects populations. A recent survey of anglers indicated that the round whitefish is very rarely, if at all, caught (Duda and Young 1996). Angling pressure is believed to have little effect on round whitefish populations within the state (Normandeau 1963). No other direct ongoing management effort exists at this time.

Regulatory Protection (for explanations, see Appendix I)

● Harvest permit - season/take regulations

Quality of Habitat

There is little information on the seasonal habitat use of round whitefish in the Connecticut River or in Newfound Lake. Electrofishing surveys on the Connecticut River suggest that round whitefish are more common in areas of gravel substrate and steady current compared to reaches with slow flow and silt bottom. In Newfound Lake, round whitefish are known to spawn on a shallow reef off of Pike's Point, at the southern end of the lake. The reef is kept clear of sediment by the wave action resulting from prevailing northwest winds. Although spawning activity has been documented on one reef in Newfound Lake, the extent of spawning activity or habitat use throughout the rest of the lake is poorly understood. Much of the shoreline of Newfound Lake consists of a mix of seasonal and year round homes. There are limited areas of wooded shorelines. The water quality of Newfound Lake continues to be very good with suitable dissolved oxygen levels in the hypolimnion during periods of stratification. An active lake association strives to maintain good water quality by addressing impacts associated with upland development, faulty septic systems, and tributary sedimentation (Boyd Peterson, Newfound Lakes Region Association, personal communication). A watershed management plan and strategies to regularly monitor water quality exists for the lake.

The adjacent land use along the areas occupied by round whitefish in the upper Connecticut River consists of a mix of agriculture and forest. A higher concentration of agriculture is present from North Stratford to the Canaan Dam in West Stewartstown. In these areas, riparian buffers are minimal along some sections. Bank armoring has been installed to protect bank erosion along bends in the river. Water temperatures remain cool throughout the summer because of a tail water release from the Lake Francis Dam. There is little adjacent residential development. The Canaan Dam is the limit of upstream movement for round whitefish that inhabit the river downstream of the dam.

Habitat Protection Status

Habitat Management Status

Water level management on Newfound Lake may affect round whitefish egg survival at the spawning reef off of Pike's Point. NHFG biologists are working with the NHDES Dam Bureau and other stakeholders to develop guidelines for water level management that protects round whitefish and lake trout eggs while balancing needs for flood control, recreational boating, shoreline property maintenance, and a downstream hydroelectric facility.

There are no current management efforts specific to the population inhabiting the upper Connecticut River.

Threats to this Species or Habitat in NH

Threat rankings were calculated by groups of taxonomic or habitat experts using a multistep process (details in Chapter 4). Each threat was ranked for these factors: Spatial Extent, Severity, Immediacy, Certainty, and Reversibility (ability to address the threat). These combined scores produced one overall threat score. Only threats that received a "medium" or "high" score have accompanying text in this profile. Threats that have a low spatial extent, are unlikely to occur in the next ten years, or there is uncertainty in the data will be ranked lower due to these factors.

Disturbance from water level management that can affect spawning success (Threat Rank: High)

Unnatural water level fluctuations alter upstream lake and pond habitat. Lake drawdowns, usually during winter, reduce shoreline plant communities and expose aquatic organisms to desiccation. Poor recruitment may be an issue for species that spawn on shallow reefs or along the shoreline, depending on the timing and extent of the drawdown. River and stream habitat below lakes and ponds may also be impacted as flows are reduced in an attempt to refill lakes or increased rapidly to lower the water level.

The water level of Newfound Lake is currently reduced every winter. This practice may have significant impacts on round whitefish spawning success. However, the actual effects of water level fluctuation on spawning success and the total extent of spawning areas in the lake are not well understood. The few round whitefish captured on the one known spawning reef in Newfound Lake are typically large individuals and, in some instances, excised fins indicate that they have been captured in multiple years. The absence of younger age classes suggests that poor recruitment may be an issue in the lake.

Artificial flow fluctuations below the Lake Francis Dam may impact the round whitefish in the Connecticut River. There has been no report of round whitefish from Lake Francis, where a population was documented in the river before it was flooded by the Lake Francis Dam in the late 1930's. Significant water level fluctuations in Lake Francis may have created unsuitable spawning conditions for a round whitefish population that was adapted to spawning in a riverine environment.

Species impacts from competion (with introduced species) (Threat Rank: Medium)

Introduced fish species may compete with native fish species at various stages of their life cycles.

Rainbow smelt, yellow perch, and smallmouth bass have been implicated in the decline or extirpation of round whitefish in a number of Adirondack lakes (Steinhart 2007).

Disturbance from sedimentation, turbidity, nutrients and contaminants (Threat Rank: Medium)

Sediment, fertilizers and pesticides from agricultural areas are known to degrade water and habitat quality in aquatic habitats (Allan 2004).

The extent that agricultural practices influence the round whitefish population in the upper Connecticut River is unknown. The population appears to be abundant with multiple age classes present (NHFG survey data). However, eroded banks, poor water clarity, embedded substrate, and rapid flow fluctuations are habitat impacts commonly observed in this section of river.

List of Lower Ranking Threats:

Disturbance from reduced area of coldwater habitat

Actions to benefit this Species or Habitat in NH

Water level management

Primary Threat Addressed: Disturbance from water level management that can affect spawning success

Specific Threat (IUCN Threat Levels): Natural system modifications

Objective:
Reduce the aquatic habitat impacts associated with artificial water level fluctuation at dams.

General Strategy:
Work with dam managers to achieve water level fluctuations that mimic natural flow regimes. Practices such as rapid changes in water level, excessive winter drawdown, and shutting off downstream flow to refill a waterbody should be avoided. For coldwater species that spawn on shallow reefs, including lake trout, round whitefish, lake whitefish, and burbot, it is important that water levels do not drop significantly after the spawning season, such that the eggs would be exposed. Engaging stakeholders, including shorefront property owners, boaters, anglers, and hydropower project owners is critical to changing long established water level management traditions. The NHDES Dam Bureau is the lead on dam management issues in New Hampshire. The best strategy for improving water level management practices for fish and wildlife is to work with the Dam Bureau to identify opportunities to create more natural water level fluctuations at a certain dams and then make slow incremental changes. This allows stakeholders to adjust to the changes and make comments when conflicts arise.

Political Location:

Watershed Location:

Population assessment

Objective:
Assess the status of round whitefish populations in New Hampshire.

General Strategy:
Explore methods for assessing the populations of round whitefish in Newfound Lake and the Connecticut River. More information on population size, age structure, and extent of spawning habitat is necessary to evaluate the status of the round whitefish in Newfound Lake, where the species may be at risk of extirpation. The round whitefish population in the Connecticut River

appears to be stable, but studies of distribution, habitat needs, and population density would help guide management decisions.

Political Location:

Watershed Location:

Reduce nutrient loading

Primary Threat Addressed: Disturbance from sedimentation, turbidity, nutrients and contaminants

Specific Threat (IUCN Threat Levels): Pollution

Objective:
Reduce the impacts of eutrophication by removing excess sources of nutrients.

General Strategy:
The primary sources of excess nutrients are lawn fertilizers in residential and commercial developments, agricultural fertilizers, and poorly functioning septic systems. Reducing nutrient loads can be achieved on two fronts. One is through outreach, which includes creating awareness about the effects of fertilizers on water quality and offering alternatives to fertilization practices that lead to the greatest amount of nutrient loading in nearby waterbodies. Best management practices can be developed for property owners with a focus on reducing runoff, minimizing or eliminating fertilizer use, and landscaping in a way that reduces the need for fertilization. In the case of septic failure, shoreline property owners with older septic systems can be targeted with incentives for upgrading. The second front is legislative. Laws that set limits on fertilizer use and require upgrades to septic systems will have long term benefits on water quality throughout the developed watersheds of southern New Hampshire. Requirements for new septic systems have greatly improved in recent years. The challenge is identifying and upgrading older systems that were constructed before septic systems were required to meet modern standards.

Political Location:

Watershed Location:

References, Data Sources and Authors

Data Sources

New Hampshire Fish and Game Department unpublished survey data, historical watershed biological surveys, and angler reports were used in defining locations of the species within the state.
Much of what is known about round whitefish in Newfound Lake is owed to the doctoral research of Donald Normandeau in 1963. NHFG biologists have been conducting gill net surveys for round whitefish during the spawning season on Newfound Lake since 2005. Electrofishing surveys have confirmed that round whitefish are relatively common in sections of the upper Connecticut River (NHFG unpublished data; Yoder et al. 2009).

Data Quality

NHFG has conducted electrofishing surveys in the upper Connecticut River and gill net/fyke net surveys on Newfound Lake. The upper and lower extent of round whitefish habitat in the Connecticut River has not been clearly defined. There have been no recent reports of round whitefish in the

Connecticut Lakes or Lake Winnipesaukee, but these are large lakes and they have not been surveyed during the round whitefish spawning season. Round whitefish catches are occasionally reported by anglers, but they are easily confused with more common species, such as fallfish.
Low catch rates and recaptured individuals in gill net surveys during the spawning season suggest that the Newfound Lake round whitefish population may be at very low abundance due to poor recruitment. There is concern that an increased survey effort may harm valuable mature adults during the spawning season. Additional sampling methods, such as acoustic telemetry, may be required to target round whitefish outside of the spawning season, so that a more complete population assessment can be conducted.

Electrofishing surveys on the upper Connecticut River have provided some baseline relative abundance data for the section of river between the Canaan Dam and the bridge in the town of Colebrook. More information is required to assess the current status of the round whitefish population in the upper Connecticut River. Current sampling efforts have focused primarily on habitats conducive to boat electrofishing.

2015 Authors:
Benjamin Nugent, NHFG, Matthew Carpenter, NHFG

2005 Authors:

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Brook Trout

Salvelinus fontinalis

Photo by NHFG

Federal Listing	
State Listing	
Global Rank	
State Rank	S5
Regional Status	V. High

Justification (Reason for Concern in NH)

Records suggest that brook trout were once far more abundant in New Hampshire than they are today (Noon 2003). Brook trout are sensitive to habitat alteration. The presence of a healthy brook trout population is generally considered a sign of a healthy stream with good water quality. Habitat degradation may exacerbate the decline of brook trout populations, especially at the southern and eastern edge of their range in New Hampshire. The species is thought to be extirpated in almost half of the watersheds in their native range in the United States (Hudy et al. 2008). In particular, historic self-sustaining, wild populations that once occupied larger river systems and lakes and ponds have been significantly reduced.

Distribution

Brook trout are found in coldwater habitat throughout New Hampshire. The species is native to eastern North America, although it has been introduced into most western states (Hudy et al. 2008). The natural range of the brook trout includes the southern Appalachians, the upper Mississippi, and Great Lakes drainages, all of the northeastern United States, and eastern Canada (Scarola 1987).

Brook trout are more common in northern New Hampshire where inherently cooler summer air temperatures maintain suitable water temperatures. In areas where habitat is not fragmented by dams and perched stream crossings, brook trout will make seasonal migrations in search of quality foraging habitat, suitable spawning areas, refuge from warmer water during the summer, and areas with less ice scour in the winter.

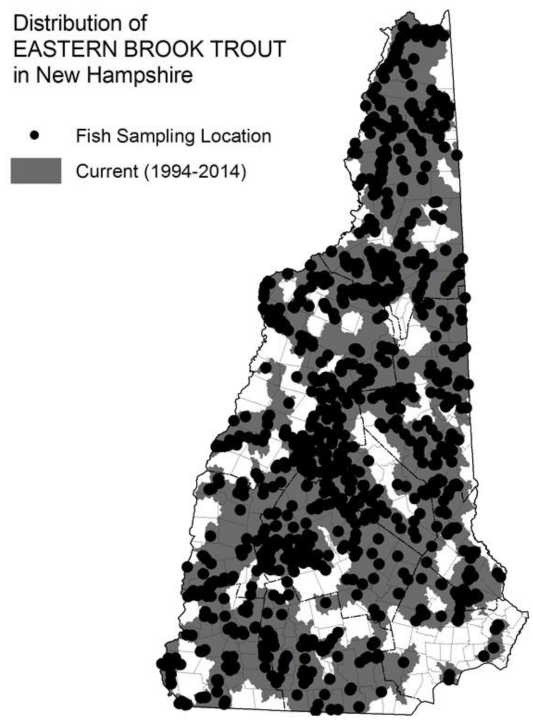
Brook trout become increasingly dependent on groundwater streams as a steady source of cool water in the summer, particularly in southern areas of New Hampshire. Here, warm water temperatures may inhibit seasonal movements throughout the watershed, restricting the population to isolated streams where groundwater maintains cool water temperatures despite the daily air temperature fluctuations typical of midsummer. The handful of wild brook trout populations currently documented in southeastern New Hampshire are entirely dependent on small groundwater fed streams.

Habitat

Brook trout can survive in almost any clean, cold, well-oxygenated aquatic habitat, though they are unable to tolerate prolonged periods of water temperature over 20C (Scarola 1987). In areas of swift flow, brook trout prefer the shelter of pools created by boulders and woody debris (Curry et al. 2002). Brook trout spawn over gravel substrate in spring-fed headwater tributaries and along lakeshores with upwelling groundwater (Scarola 1973, Quinn 1995).

NH Wildlife Action Plan Habitats

- Coldwater Rivers and Streams
- Lakes and Ponds with Coldwater Habitat



Distribution Map

Current Species and Habitat Condition in New Hampshire

Healthy brook trout populations are more commonly found in the northern and western parts of New Hampshire. Brook trout populations become restricted to isolated spring fed streams as one moves south of the lakes region and east of the Merrimack River. Although the NHFG has collected extensive data on brook trout distribution and relative abundance throughout the state, there is little information on long term population trends. Although abundance levels of brook trout are thought to have been reduced in some locations, clear evidence of brook trout extirpation from a watershed has yet to be documented in New Hampshire. Anecdotal historical records suggest that both the abundance and the average size of wild brook trout have declined.

Population Management Status

Habitat condition has the greatest influence on wild brook trout populations in New Hampshire and most conservation efforts focus on habitat protection or restoration. Population management strategies for protecting brook trout populations currently include regulations on angling pressure and changes in trout stocking practices intended to reduce impacts to wild brook trout populations. Translocations of brook trout into watersheds with restored habitat may be a potential strategy in the future. Brook trout monitoring efforts and stream restoration projects may create opportunities to expand the brook trout's range into stream reaches that had become uninhabitable due to habitat degradation.

Regulatory Protection (for explanations, see Appendix I)

- Harvest permit - season/take regulations

Quality of Habitat

New Hampshire still contains large expanses of relatively intact brook trout habitat especially in northern New Hampshire, the White Mountains, and the higher elevation areas of western New Hampshire. As one moves south and east, brook trout habitat becomes increasingly impacted by fragmentation from road/stream crossings, dams, and human development.

Habitat Protection Status

Habitat Management Status

Federal, state, and non-government agencies are collaborating on the Eastern Brook Trout Joint Venture, an initiative designed to assess the status of brook trout populations throughout the eastern United States. In New Hampshire, surveys are conducted to assess brook trout status by watershed. The results of these surveys are shared with local and regional conservation organizations and have become incorporated into a number of management plans, restoration projects, and land conservation efforts. For example, surveys conducted by NHFG in the Newfound Lake watershed raised awareness of the high quality brook trout habitat that exists in the rivers and streams which flow into the lake. Once brook trout status has been assessed in a watershed, restoration and protection projects can be targeted more effectively. Restoration projects usually focus on improving connectivity and increasing the extent and quality of the riparian zone. In some cases, wood is added to streams where a history of logging has reduced the number of pools created by trees falling into the streambed. In other cases, vegetation may be allowed to regrow along the streambank to provide shade and prevent runoff from directly entering the stream. Stream crossing replacements and dam removals increase access to tributary spawning habitat and thermal refuge during the summer. These restoration efforts are most effective when conducted at the watershed scale with a group of engaged local volunteers. Establishing full time project manager positions and providing more consistent funding sources would greatly increase the number of restoration projects that could be completed each year.

Threats to this Species or Habitat in NH

Threat rankings were calculated by groups of taxonomic or habitat experts using a multistep process (details in Chapter 4). Each threat was ranked for these factors: Spatial Extent, Severity, Immediacy, Certainty, and Reversibility (ability to address the threat). These combined scores produced one overall threat score. Only threats that received a "medium" or "high" score have accompanying text in this profile. Threats that have a low spatial extent, are unlikely to occur in the next ten years, or there is uncertainty in the data will be ranked lower due to these factors.

Disturbance from acid deposition (Threat Rank: High)

Acid rain has extirpated or reduced population densities of brook trout and other species in the northeast, especially in naturally acidic small streams and ponds at high elevations.

Episodic acidification of small streams has been shown to reduce brook trout densities and cause fish to seek refuge downstream in streams with higher pH (Baker et al.1996). Overall, episodes of acid rain are being reduced by tighter regulations on coal plants, but the buffering capacity of watersheds where calcium has been leached from the soil may not recover on its own (Huggett et al. 2007).

Disturbance from stream crossings that fragment habitat (Threat Rank: Medium)

Undersized stream crossings act as barriers to the movement of aquatic species. Many stream crossings restrict movement at certain flows due to high velocities, insufficient depth within the crossing, or an outlet that is "perched" above the water surface, acting as a small waterfall. These barriers prevent access to critical habitat, reduce gene flow, and result in local extirpations of isolated populations.

A number of studies have demonstrated reductions in fish species richness and abundance upstream of impassable stream crossings (Jackson 2003; Nislow et al. 2011; Pepino et al. 2012).

Habitat degradation due to stream crossings (Threat Rank: Medium)

Poorly sized stream crossings alter the natural sediment transport characteristics of a river or stream, which leads to amplified rates of erosion and aggradation in the stream channel. The cumulative effect of under sized stream crossings can lead to increased sedimentation and turbidity throughout a watershed during storm events. Road fill from washed out stream crossings during flood events accumulates in the stream channel and buries the natural stream bed substrate. Additionally, road drainage is often directed into streams at crossing locations. This enables more contaminants (fine sediments and polluted runoff) to enter streams.

Observations of stream crossings during brook trout surveys in New Hampshire suggest that there are very few streams that do not show some habitat damage from stream crossings (Ben Nugent, NHFG Biologist, personal communication).

Disturbance from dams that cause fragmentation (Threat Rank: Medium)

Dams restrict the movement of aquatic species. Most aquatic species make daily and seasonal movements to access spawning habitat and foraging areas. Movement is also required in response to changes in water level, temperature, or water chemistry. Dispersal and colonization of new habitat is critical for long term population viability.

The effect of dams on diadromous fish species have been well documented (Limburg and Waldman 2009). Freshwater species are also impacted by dams, but the effects have been less studied. Dams have clearly restricted the dispersal of freshwater mussel species (Watters et al. 1996). Brook trout move extensively between habitats throughout the year and are therefore vulnerable to fragmentation by dams in headwater streams (Petty et al. 2012).

Disturbance from impoundments that increase temperature and convert habitat (Threat Rank: Medium)

Surface waters impounded by dams are generally exposed to solar radiation and often exceed the temperature tolerance of brook trout. Dams on coldwater rivers and streams not only fragment brook trout habitat, but increase water temperatures both upstream, in the impoundment, and downstream, as warm surface water flows over the dam.

There are thousands of dams throughout New Hampshire. The total area of coldwater stream habitat in New Hampshire that is under the influence of dams has not been evaluated.

Disturbance from streambank and channel modification (Threat Rank: Medium)

River and streams throughout the northeast have been straightened or armored as a result of flood control efforts, historic logging activity, and streamside development. These activities have impacted the natural channel features to which brook trout have adapted, including meander bends, undercut banks, and large wood in the stream channel.

Signs of channel straightening and bank armoring can be observed throughout the White Mountains where streams were used as sluiceways to move logs to sawmills downstream. Bank armoring is a common practice used to protect infrastructure built within the flood plain of a river or stream. The effects of these physical habitat impacts are difficult to separate from other impacts, such as acid rain.

Species impacts from competion (with introduced species) (Threat Rank: Medium)

Hatchery trout (brook trout, brown trout, and rainbow trout) released into New Hampshire rivers and streams may compete with native brook trout populations.

Trout and other species are stocked throughout the state, but the effects on wild brook trout are difficult to assess in New Hampshire. Studies at Nash Stream, in northern New Hampshire, suggest that there may be less competition between wild and stocked trout than expected (John Magee, NHFG Biologist, personal communication). Stocked rainbow and brown trout have contributed to the decline of brook trout in southern states (Hudy et al. 2008). The acidic water chemistry of New Hampshire rivers and streams prevents rainbow and brown trout reproduction in most watersheds.

Disturbance from stormwater run-off from impervious surfaces (Threat Rank: Medium)

Stormwater runoff from impervious surfaces changes the hydrology of local rivers and streams. Flashier flows cause an increase in erosion and sediment deposition along stream banks and in the stream channel. More surface flow over impermeable surfaces reduces the volume of water able to infiltrate into the ground and recharge groundwater supplies, which results in lower base flows during dry periods. Oil based pollutants, sediment, and road salt are washed from roads and parking lots into surrounding waterbodies which can lead to chronic declines in water quality. NHFG water temperature monitoring data illustrates how runoff from pavement warmed by the sun can also lead to increased temperatures in local streams when stormwater flows directly into surface waters (NHFG unpublished data).

The impacts of impervious land cover on aquatic habitats have been well documented (Wang et al. 2001; Cuffney et al. 2010; Stranko et al. 2008). Impervious surfaces have increased significantly in southern New Hampshire over the past decade.

List of Lower Ranking Threats:

Disturbance from water withdrawal that causes perennial streams to become intermittent and reduces base flow

Disturbance from reduced area of coldwater habitat

Actions to benefit this Species or Habitat in NH

Dam removal

Primary Threat Addressed: Disturbance from dams that cause fragmentation

Specific Threat (IUCN Threat Levels): Natural system modifications

Objective:
Improve habitat connectivity and reduce the impacts of dams on coldwater river and stream habitat.

General Strategy:
Ideally, dam removal projects on coldwater streams should target dams that either fragment large networks of coldwater stream habitat or dams that increase water temperatures and degrade the stream habitat to conditions that no longer support brook trout downstream or within the impoundment. Identifying these dams requires a relatively extensive fish survey effort to identify healthy brook trout populations that would benefit from the habitat restoration and improved access following the dam removal. Once a dam is identified for removal, the process is the same as it is for projects targeting diadromous fish restoration. A dedicated project manager is critical for meeting permitting deadlines and managing the many issues that often arise during dam removal projects, such as the removal of contaminated sediment or documenting the historical value of the site. Despite efforts to prioritize, dam removal projects often come up opportunistically as smaller dams fall into disrepair and become expensive to maintain. Grant funding for dam removal projects is available, but limited, so resources should be directed at projects with the greatest benefit to coldwater stream habitat.

Political Location: **Watershed Location:**

Stormwater Management

Primary Threat Addressed: Disturbance from stormwater run-off from impervious surfaces

Specific Threat (IUCN Threat Levels): Pollution / Domestic & urban waste water / Run-off

Objective:
To reduce the impacts of runoff from impervious surfaces by using Low Impact Development Technology.

General Strategy:
Stormwater runoff from impervious surfaces has been shown to damage aquatic habitats (Wang et al. 2001; Cuffney et al. 2010). Much of this damage can be prevented by stormwater management practices that filter runoff through the ground before it enters surface water. This practice not only removes much of the sediment and toxins that are typically washed into streams, but it also reduces the rapid fluctuation in temperature, as well as the excess erosion and sediment deposition that have become a chronic issue for rivers and streams in developed areas. The University of New Hampshire Stormwater Center is an excellent resource for Low Impact Development (LID) practices for stormwater management.

Political Location: **Watershed Location:**

Riparian Buffer Protection

Primary Threat Addressed: Disturbance from streambank and channel modification

Specific Threat (IUCN Threat Levels): Natural system modifications

Objective:
Preserve the water and habitat quality of rivers, streams and the shorelines of lakes and ponds by preventing development in the riparian zone.

General Strategy:
Riparian buffer protection can be achieved through town ordinances, state law (i.e. the Shoreland Water Quality Protection Act), deed restriction, conservation easement, or voluntary land use practices (such as forestry best management practices). In general, the wider the buffer protected, the more ecological benefit. A buffer of at least 10m will provide a minimum level of water quality and habitat benefits. A protected buffer of 100 m or greater provides maximum water quality and habitat benefits while also acting as a migration corridor for larger species of wildlife. Buffer protection is lacking on headwater streams despite the cumulative effect that intact riparian zones in headwater streams have on downstream water quality.

Political Location: **Watershed Location:**

Improve regulations

Primary Threat Addressed: Disturbance from streambank and channel modification

Specific Threat (IUCN Threat Levels): Natural system modifications

Objective:
Improve regulatory protection for brook trout and coldwater stream habitat

General Strategy:
Work with NHDES to refine Indexes of Biotic Integrity (IBI's) for coldwater streams to help document habitat alterations and enforce violations of the Clean Water Act. Submit brook trout records to the Natural Heritage Bureau for review under the NHDES Environmental Permitting process. Promote improvements in riparian buffer protection along 1st, 2nd, and 3rd order streams at the town and state level.

Political Location: **Watershed Location:**

Eastern Brook Trout Joint Venture (EBTJV) Surveys

Objective:
Continue to monitor the distribution and status of brook trout in New Hampshire as a partner in the EBTJV

General Strategy:
Conduct backpack electrofishing surveys in suitable habitat using protocols developed under the EBTJV to monitor the status of brook trout populations in New Hampshire. Communicate survey results and recommendations to local and regional conservation organizations. Facilitate projects to with the goal of protecting healthy populations and reducing declines in vulnerable populations according to the objectives of the EBTJV. Develop representative index sites throughout New Hampshire to monitor long term trends in abundance, size, and age class structures.

Political Location: **Watershed Location:**

Stream crossing restoration

Primary Threat Addressed: Habitat degradation due to stream crossings

Specific Threat (IUCN Threat Levels): Transportation & service corridors

Objective:
Increase connectivity and reduce habitat degradation caused by stream crossings.

General Strategy:
There are two phases to stream crossing restoration. The first phase is assessment. Stream crossing surveys are currently being completed in watersheds throughout the state. It is important that these surveys follow the standardized methods and protocols outlined by the New Hampshire Geological Survey (NHGS). NHGS maintains a statewide database of stream crossing survey data. Once the data is collected, stream crossing restoration projects can be prioritized to achieve the greatest benefits to aquatic organism passage, along with reductions in flood damage and habitat degradation. Prioritization may take place within small watersheds or across a large region. The second phase is implementation. Once a stream crossing is identified as a good candidate for restoration there are many obstacles to a completed project, including permitting and cost. Streamlining the permitting process for crossing restoration, increasing available funding sources, and developing innovative stream crossing design and construction techniques that significantly reduce cost would greatly increase the number of stream crossing restoration projects in New Hampshire.

Political Location: **Watershed Location:**

Land Protection

Primary Threat Addressed: Disturbance from stormwater run-off from impervious surfaces

Specific Threat (IUCN Threat Levels): Pollution / Domestic & urban waste water / Run-off

Objective:
Preserve the natural ecological functions of an area by protecting land from development.

General Strategy:

Land protection is a strategy that can be used to ensure a level of habitat quality that is necessary to support certain species and habitats of conservation concern. For aquatic species, land protection prevents many of the impacts caused by sprawling development. Groundwater recharge, intact riparian zones, and unrestricted migration corridors are some of the benefits. Species with limited ranges and mobility may be protected almost entirely through land conservation. For wider ranging species, such as brook trout, land protection will be part of a greater restoration strategy. Land protection projects in New Hampshire usually require the coordination of a variety of funding sources, with involvement from town conservation commissions, local land trusts and watershed associations, government agencies, and state or national NGO's. Since 2005, the NH Wildlife Action Plan has helped direct land protection efforts toward conserving habitat for species and habitats of concern. The effectiveness of land conservation could be improved by identifying and addressing barriers to land conservation in New Hampshire and increasing outreach to help prioritize projects that benefit species and habitats of concern.

Political Location: **Watershed Location:**

Wood addition

Primary Threat Addressed: Disturbance from streambank and channel modification

Specific Threat (IUCN Threat Levels): Natural system modifications

Objective:

Increase the amount of wood in coldwater stream habitat to improve habitat for brook trout.

General Strategy:

The logging history of forests in the northeast has resulted in channelized streams surrounded by relatively young forests. Streams surrounded by old growth forests contain large quantities of fallen wood. Much of this wood becomes lodged in the stream channel where it alters stream flow in a manner that traps sediment and scours deeper pools. These deep pools and gravel spawning substrate make ideal brook trout habitat. Some streams with extensive logging histories are characterized by long stretches of homogenous riffle habitat with very few pools and a lack of appropriate gravel spawning substrate. Adding wood to a stream is a technique used to simulate a stream surrounded by older forest and to restore some of the stream habitat features that brook trout had adapted to before large scale logging operations altered the age composition of northeastern forests. Wood additions also reengage floodplains. This allows high flow events to be dissipated away from the stream channel, reducing scour rates.

Political Location: **Watershed Location:**

References, Data Sources and Authors

Data Sources

NHFG biologists conduct surveys to establish the distribution and status of brook trout populations in watersheds throughout the state.

Data Quality
NHFG maintains a fish database with over 4000 survey records from the early 1980's to the present. Since 2007, NHFG has partnered with local conservation groups to assess and summarize the status of wild brook trout throughout New Hampshire. Although there are still many gaps in the data, more distribution and status information is available for brook trout than for most other fish species of concern in New Hampshire.

2015 Authors:
Benjamin Nugent, NHFG, Matthew Carpenter, NHFG

2005 Authors:

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Lake Trout

Salvelinus namaycush

Federal Listing	
State Listing	
Global Rank	
State Rank	S5
Regional Status	High

Photo by NHFG

Justification (Reason for Concern in NH)

Native populations of lake trout were originally restricted to 6 water bodies in New Hampshire, though stocking success has resulted in self-sustaining populations in several other water bodies (Scarola 1987). Lake trout face several habitat and non-habitat related threats. Anthropogenic eutrophication decreases dissolved oxygen at depths where trout take refuge from summer heat (Kelso et al. 1996). Thus, the species may be an indicator for the water quality of oligotrophic lakes (Halliwell et al. 2001). A healthy population of forage fish is important for the persistence of lake trout in a given lake. The introduction of nonindigenous fish may alter the food web in a lake ecosystem, reducing the amount of prey available to lake trout (Pazzia et al. 2002). Lake trout were rated second and sixth, respectively, for species preference in an ice fishing and an open-water angler survey (Duda and Young 1996). Lake trout populations, especially low density, self-sustaining populations, have been found to be vulnerable to angling pressure (Towne 1959). As a coldwater species, lake trout are vulnerable to the impacts of climate change, especially in smaller waterbodies with a marginal supply of coldwater habitat (Thill 2014).

Distribution

Lake trout are widely distributed throughout northern North America including much of Canada (with the exception of some Hudson Bay Drainages), Alaska, the Great Lakes Region, the northwestern states, and northern New England. Populations are found in several oligotrophic waterbodies in New Hampshire.

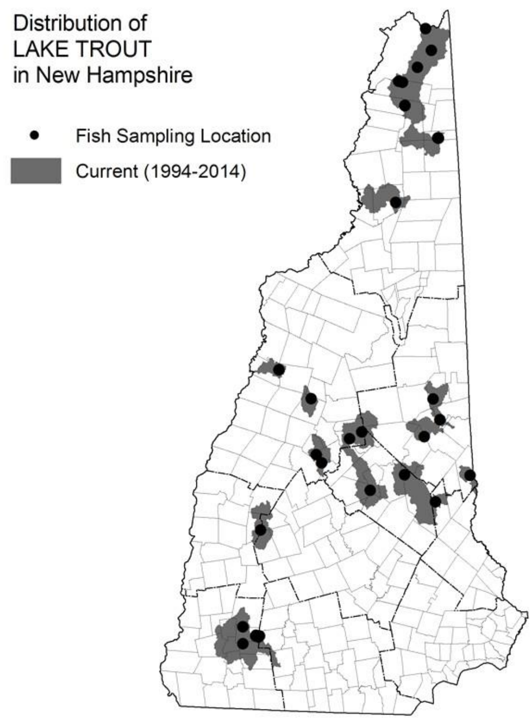
Native populations continue to exist in both central and northern New Hampshire (Squam Lake, Winnipesaukee Lake, Winnisquam Lake, Newfound Lake, First Connecticut Lake and Second Connecticut Lake). Successful stocking programs have introduced self-sustaining populations of lake trout in 17 additional water bodies, increasing their distribution to include more water bodies in the central, southwestern, and northern parts of the state. Stocking hatchery-reared lake trout was discontinued in 1981 after it was determined to have a minimal effect on angler success (Perry 1991).

Habitat

Lake trout inhabit lakes with large reservoirs of deep water, rocky shorelines, and diversely contoured bottoms. During the summer lake trout are restricted to thermal refuges below 60-65°F with preferred water temperatures around 50°F. The species will frequent surface waters in the spring, fall, and winter if temperature permits. Dissolved oxygen levels must exceed 6 parts per million (Scarola 1987, Scott and Crossman 1973, Johnson 2001). Spawning habitat consists of rocky shoals, reefs, and shorelines with substrate consisting of large rocks and rubble (Johnson 2001). Spawning depths range from 40 feet to a few inches (Scott and Crossman 1973, Johnson 2001).

NH Wildlife Action Plan Habitats

- Lakes and Ponds with Coldwater Habitat



Distribution Map

Current Species and Habitat Condition in New Hampshire

Targeted lake trout fall spawning surveys occur on an annual basis. Although it is difficult to establish abundance levels from these surveys (large waterbodies have several spawning locations), body condition and relative weight data can be used to describe trends in the health of populations. These values can be used to compare one lake population to another. All lake trout populations in New Hampshire are considered to be self-sustaining, but the body condition of lake trout in some waterbodies, such as South Pond, appears to be declining. The reasons for this decline in body condition are not clear but limited forage and reduced area in the hypolimnion are suspected causes.

Population Management Status

Angling regulations can be a tool to limit harvest and protect populations so that suitable numbers of mature spawning fish are available to sustain the population. Regulations are set and enforced by NHFG. Current regulations for lake trout include a two fish daily limit and a minimum length of 18 inches for most waterbodies.

Regulatory Protection (for explanations, see Appendix I)

- Harvest permit - season/take regulations

Quality of Habitat

Ample supplies of deep, coldwater habitat exist in New Hampshire's larger lakes, including Winnipesauke Lake, Newfound Lake, Squam Lake, Sunapee Lake, and the Connecticut Lakes. These lakes will offer protection against the effects of predicted warmer air temperatures due to climate change. Smaller waterbodies with lake trout populations, such as South Pond, Spoonwood Lake, Silver Lake, and Ossipee Lake, may be more vulnerable to the effects of climate change (Thill 2014). Declining body condition of lake trout in South Pond may be an indication of marginal habitat conditions (NHFG unpublished data). Some waterbodies, such as Newfound Lake and Lake Francis, have significant winter drawdowns, which may impact lake trout egg survival after spawning.

Habitat Protection Status

Habitat Management Status

Reducing excess nutrient loading in coldwater lakes will help protect the quality of the deep, coldwater habitat on which lake trout depend for thermal refuge in the summer. Excess nutrients can lead to an increase in algae and zooplankton, which die and drift to the bottom in large numbers, where they are consumed by microorganisms. These microorganisms consume oxygen in the process, and at high levels, can begin to deplete the limited supply of oxygen in deep water. Water quality is generally good in New Hampshire's larger lakes, but increasing development in the watersheds of some waterbodies, such as Winnisquam Lake and Lake Winnipesaukee, may increase nutrient loads over time. Reducing runoff with appropriate stormwater management techniques, limiting fertilizer use, and upgrading septic systems will help prevent excess nutrient loading. Managing shoreline development and protecting shoreline habitat in areas that have not yet been developed is also critical to maintaining water quality.

Water level management also has the potential to impact lake trout populations. Because lake trout spawn on relatively shallow, rocky reefs and shorelines in the fall, water levels during the spawning period affect the availability of spawning habitat. Once the eggs have been deposited, it is important that lake water levels do not drop significantly and leave the eggs exposed. Biologists with NHFG work with the NHDES Dam Bureau to address conflicts between water level management practices and lake trout reproduction.

Threats to this Species or Habitat in NH

Threat rankings were calculated by groups of taxonomic or habitat experts using a multistep process (details in Chapter 4). Each threat was ranked for these factors: Spatial Extent, Severity, Immediacy, Certainty, and Reversibility (ability to address the threat). These combined scores produced one overall threat score. Only threats that received a "medium" or "high" score have accompanying text in this profile. Threats that have a low spatial extent, are unlikely to occur in the next ten years, or there is uncertainty in the data will be ranked lower due to these factors.

Disturbance from water level management (Threat Rank: Medium)

Unnatural water level fluctuations alter upstream lake and pond habitat. Lake drawdowns, usually during winter, reduce shoreline plant communities and expose aquatic organisms to desiccation. Poor recruitment may be an issue for species that spawn on shallow reefs or along the shoreline, depending on the timing and extent of the drawdown.

Lake trout are observed spawning on shallow reefs each fall (NHFG survey data). Winter drawdowns on waterbodies such as Newfound Lake may expose eggs in some winters. The impact of water level drawdowns on lake trout egg survival in New Hampshire waterbodies is not well understood.

List of Lower Ranking Threats:

Mortality from recreational harvest

Disturbance from reduced area of coldwater habitat

Actions to benefit this Species or Habitat in NH

Reduce nutrient loading

Primary Threat Addressed: Disturbance from reduced area of coldwater habitat

Specific Threat (IUCN Threat Levels): Climate change & severe weather

Objective:
Reduce the impacts of eutrophication by removing excess sources of nutrients.

General Strategy:
The primary sources of excess nutrients are lawn fertilizers in residential and commercial developments, agricultural fertilizers, and poorly functioning septic systems. Reducing nutrient loads can be achieved on two fronts. One is through outreach, which includes creating awareness about the effects of fertilizers on water quality and offering alternatives to fertilization practices that lead to the greatest amount of nutrient loading in nearby waterbodies. Best management practices can be developed for property owners with a focus on reducing runoff, minimizing or eliminating fertilizer use, and landscaping in a way that reduces the need for fertilization. In the case of septic failure, shoreline property owners with older septic systems can be targeted with incentives for upgrading. The second front is legislative. Laws that set limits on fertilizer use and require upgrades to septic systems will have long term benefits on water quality in New Hampshire's lakes and ponds. Requirements for new septic systems have greatly improved in recent years. The challenge is identifying and upgrading older systems that were constructed before septic systems were required to meet modern standards.

Political Location: **Watershed Location:**

Water level management

Primary Threat Addressed: Disturbance from water level management

Specific Threat (IUCN Threat Levels): Natural system modifications

Objective:
Reduce the aquatic habitat impacts associated with artificial water level fluctuation at dams.

General Strategy:
Work with dam managers to achieve water level fluctuations that mimic natural flow regimes. Practices such as rapid changes in water level, excessive winter drawdown, and reducing downstream flow to refill a waterbody should be avoided. For coldwater species that spawn on shallow reefs, including lake trout, round whitefish, lake whitefish, and burbot, it is important that water levels do not drop significantly after the spawning season, such that the eggs would be exposed. Engaging

stakeholders, including shorefront property owners, boaters, anglers, and hydropower project owners is critical to changing long established water level management traditions. The NHDES Dam Bureau is the lead on dam management issues in New Hampshire. The best strategy for improving water level management practices for fish and wildlife is to work with the Dam Bureau to identify opportunities to create more natural water level fluctuations at a certain dams and then make slow incremental changes. This allows stakeholders to adjust to the changes and make comments when conflicts arise.

Political Location: **Watershed Location:**

Map spawning habitat

Objective:
Map the distribution of coldwater fish spawning habitat in deep water lakes.

General Strategy:
Although some important spawning reefs have been well documented, the extent of spawning habitat for coldwater fish species remains undocumented in most lakes where they occur. Acoustic or radio telemetry, gill or fyke net surveys, underwater cameras, and visual observations are potential methods for identifying important spawning areas. Depth recordings at spawning areas well help inform water level management policy.

Political Location: **Watershed Location:**

References, Data Sources and Authors

Data Sources
Peer-reviewed literature, state lake trout management plans (New Hampshire and Maine), and New Hampshire Fish and Game (NHFG) stocking records were used to define distribution and habitat. Lake trout survey data is maintained in the NHFG fish survey database.

Data Quality
The general distribution and status of lake trout in New Hampshire has been well documented in reports by NHFG. While a number of spawning locations have been documented, knowledge of the total extent of lake trout spawning habitat in coldwater lakes could be improved.
The spawning populations of lake trout are monitored with gill net surveys by the NHFG.

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Benjamin Nugent, NHFG, Matthew Carpenter, NHFG

2005 Authors:

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