American Eel

Anguilla rostrata

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

Photo by NHFG

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

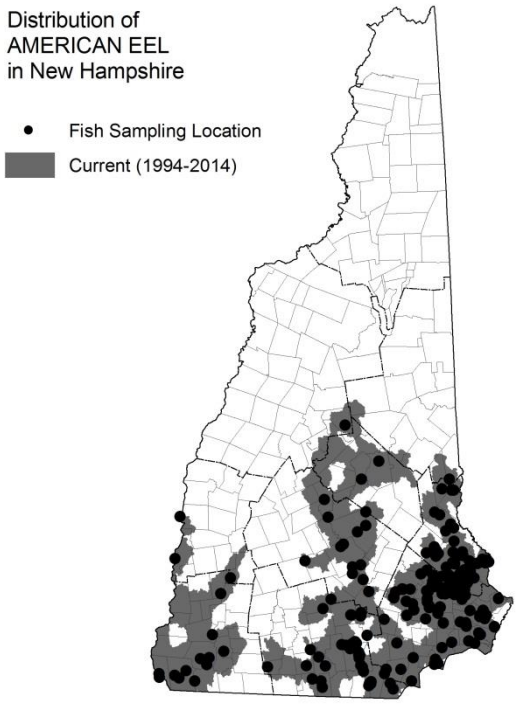
American eels use marine, estuarine, and freshwater habitat (Atlantic States Marine Fisheries Committee (ASMFC) 2000). American eels breed collectively in the Sargasso Sea, a large area of the western Atlantic Ocean. After hatching, larval eels (leptocephali) drift in ocean currents to the shores of 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:
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2005 Authors:

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