CONNECTICUT RIVER ANADROMOUS SEA LAMPREY MANAGEMENT PLAN

Connecticut River Atlantic Salmon Commission
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INTRODUCTION

In 1967, the "Policy Committee for Fishery Management of the Connecticut River Basin" was formed in response to the passage of the 1965 Anadromous Fish Conservation Act (Public Law 89-304) by the U.S. Congress. This committee was replaced by the more formal "Connecticut River Atlantic Salmon Commission" (CRASC), created by an act of Congress (P.L. 98-138) in 1983 (Gephard and McMenemy 2004) and continues to coordinate restoration and management activities of anadromous fish species, including Sea Lamprey (*Petromyzon marinus*).

Table 1. Mainstem and tributary sites where fish passage facilities or dam removals have facilitated passage of Sea Lamprey.

Dam Site	Stream	Type of Fish Passage	Date	River Miles Reopened
Holyoke*	mainstem	Fish Lift	1955	35
Turners Falls*	mainstem	Modified Ice Harbor & Vertical Slot	1980	20
Vernon*	mainstem	Modified Ice Harbor & Vertical Slot	1981	32
Bellows Falls*	Mainstem	Vertical Slot	1984	43
Wilder**	Mainstem	Ice Harbor	1987	50
Moulson Pond*	Eightmile	Steeppass	1998	6
Ed Bills	E. Br. Eightmile	Removal	2015	9
Leesville	Salmon	Denil	1980	11
Norton Mill	Jeremy, Salmon	Removal	2016	17
Stan Chem*	Mattabesset	Denil	2013	6
Springborn	Scantic	Removal	2017	2.5
Rainbow*	Farmington	Vertical Slot	1976	4.3
Spoonville	Farmington	Removal	2013	20
West Springfield*	Westfield	Denil	1996	14
Manhan*	Manhan	Denil	2013	11
Fall River	Fall	Removal	2014	10
Bartlett Rod Shop	Amethyst, Fort	Removal	2012	0.5
Fiske	Ashuelot	Fish Lift	2012	1.5

* Denotes fishway with monitoring capability.

** Ladder has historically been operated only to pass Atlantic Salmon

Historically, Sea Lamprey spawned and reared throughout a large portion of the Connecticut River basin, migrating at least as far as Bellows Falls and likely farther (Scarola 1973). However, construction of dams during the 18th, 19th and 20th centuries restricted access to the majority of lamprey spawning habitat.

Although there have been no direct restoration efforts for Sea Lamprey in the Connecticut River basin, the species has benefited from the upstream fish passage efforts for Atlantic Salmon (*Salmo salar*) and American Shad (*Alosa sapidissima*) through improved access to spawning and rearing habitat (Table 1). However, the efficiency of these fishways in passing lampreys has not been studied and therefore is unknown.

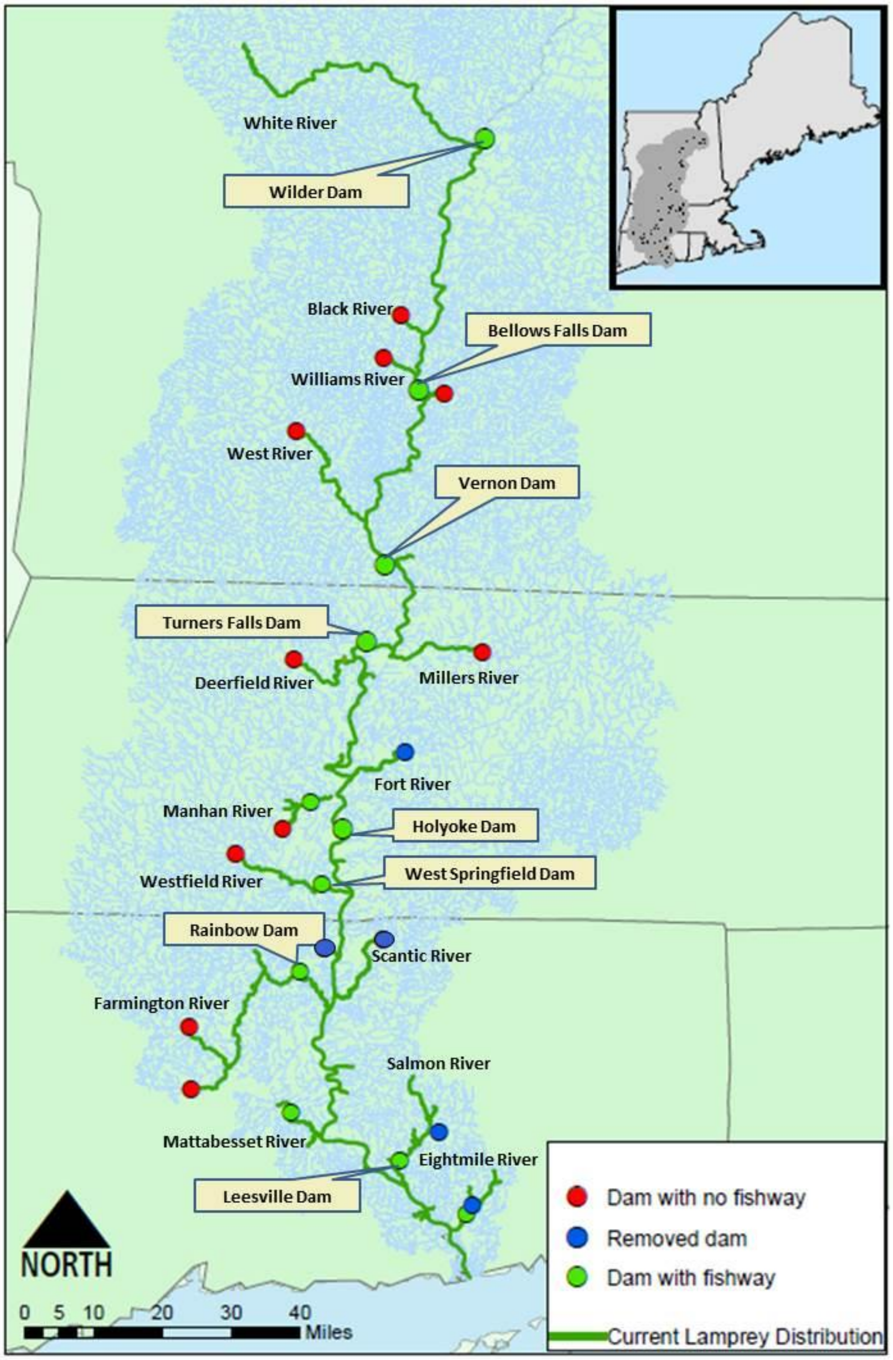


Figure 1. Current known distribution of Sea Lamprey within the Connecticut River basin.

The current known distribution of Sea Lamprey within the mainstem and major tributaries is shown in Figure 1. In addition, lamprey nests and/or juvenile lamprey have been observed in a number of first and second order tributaries (both those that enter directly into the mainstem and those that enter in lower sections of larger tributaries). Appendix A provides a detailed description of the status and distribution of Sea Lamprey within the basin.

While historical levels of spawning run abundance are unknown, access to habitat began increasing in in 1976 when the rudimentary first fishway on the Connecticut River was expanded at Holyoke Dam. In the Connecticut River, fishway passage counts (Figure 2) are an important metric to help determine adult abundance and trends over time, although many factors can influence fish passage rates and counts within and among years. Annual Sea Lamprey counts at the Holyoke fish lift on the Connecticut River for the period 1976 through 2016 have ranged from 14,089 to 97,277, with an annual mean of 34,413 (https://www.fws.gov/r5crc/pdf/Select_Fish_Passage_Summary_Count_Data_2016.pdf). Currently, the Connecticut River Sea Lamprey population appears stable (Appendix A). Additional long-term population monitoring information includes nest surveys conducted by the Connecticut Department of Energy and Environmental Protection (CTDEEP, Appendix B), independent researchers, and the U.S. Fish and Wildlife Service Connecticut River Coordinator's office.

Sea Lamprey is considered a nuisance species due to parasitism on sportfish in areas where it has become landlocked (e.g., the Great Lakes; Appendix C). However, along the East Coast, the Sea Lamprey plays an important role in the riverine ecosystem, fulfilling key ecological functions in watersheds where it can move between freshwater and marine environments (Appendix D). Lampreys are also a food source in the estuarine and marine environment for a number of fish, marine mammals, and bird species.

Given the increased understanding of this native species' role, it has been designated as a "Species of Greatest Conservation Need" by all four basin states (as stated in the comprehensive State Wildlife Action Plans[1]). This designation recognizes the need to develop and implement conservation strategies and actions to improve Sea Lamprey's status in the Connecticut River basin.

This Plan reflects knowledge gained through empirical investigations and long-term monitoring that has occurred over nearly two decades within the watershed. It is believed to be the first management plan for Sea Lamprey in North America that is focused on restoration and recovery rather than on control of nuisance populations.

[1] http://www.ct.gov/deep/lib/deep/wildlife/pdf_files/nongame/ctwap/CTSGCN.pdf (DRAFT); http://www.mass.gov/eea/agencies/dfg/dfw/wildlife-habitat-conservation/massachusetts-species-of-greatest-conservation-need.pdf; http://www.wildlife.state.nh.us/wildlife/documents/wap/sgcn-habitats-handout.pdf; http://www.vtfishandwildlife.com/UserFiles/Servers/Server_73079/File/About%20Us/Budget%20and%20Planning/WAP_2015draft/5.%20SGCN%20Lists%20&%20Taxa%20Summaries%20DRAFT%209-28-2015.pdf

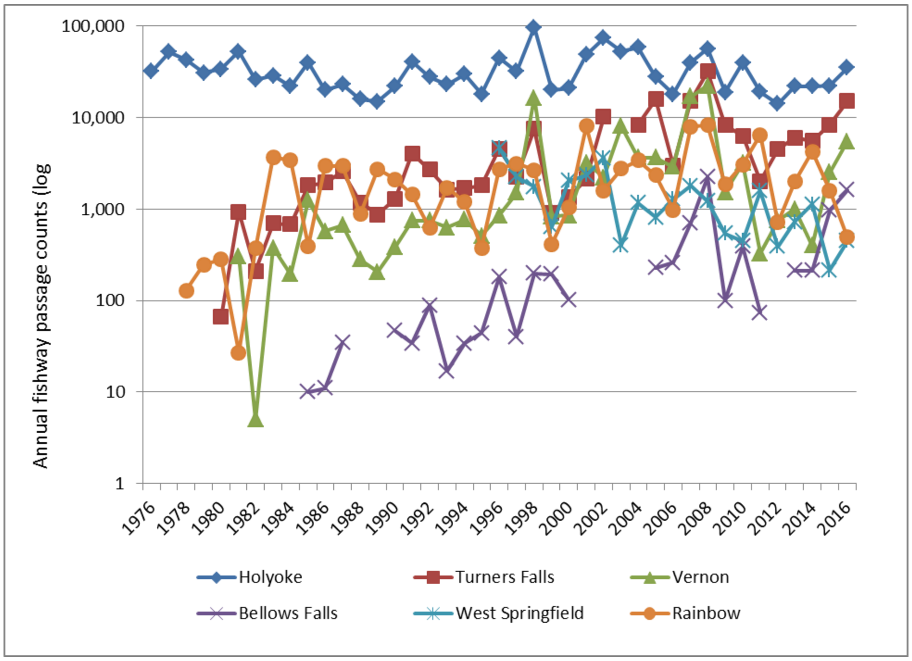


Figure 2. Numbers of Sea Lamprey passed at mainstem and tributary dams within the Connecticut River from 1976 to 2016.

GENERAL LIFE HISTORY

The Sea Lamprey (*Petromyzon marinus*) is a primitive non-bony fish species with a long eel-like body (Applegate 1950; Beamish 1980). It is the largest of the 41 lamprey species worldwide. Sea Lampreys lack scales, bones, jaws, ribs, shoulder and pelvic girdles and paired fins, unlike the more common and diverse group of bony fishes such as Atlantic Salmon (*Salmo salar*) and American Shad (*Alosa sapidissima*). They also lack paired nostrils and vertical gills, instead having a single nostril in front of and between the eyes and seven pairs of gill openings resembling small portholes.

Sea Lampreys are unique because they have a third pineal eye, located on the top of their head, which functions to regulate circadian rhythms. Adults have a circular sucking mouth, which surrounds a funnel-like oral disk lined with concentric rows of horny teeth that is enclosed by an oral hood. This arrangement, along with a protractible toothed tongue, allows adults to drill a small hole in the side of a host fish and feed upon their body fluids. Sea Lampreys cling to their hosts by suction, scrape a hole in the skin with their rasping tongue, and suck their blood, body fluids, and flesh (assisted by the secretion of lamphedrin to prevent blood clotting and begin digesting muscle tissue before ingestion; Beamish et al. 1979). Although host fish often die, some survive, albeit scarred from the experience (Scott and Crossman 1973; Beamish and Potter 1975). The parasitic feeding on prey fish begins only after juveniles migrate from freshwater and enter saltwater (S. McCormick, USGS personal communication). Timing for cessation of feeding and reduction of digestive organs and expansion of gonads to occupy the entire body cavity is not precisely known, but observations by Applegate (1950) suggest it likely begins before or about the time adults enter fresh water.

Sea Lampreys spawn in the spring. Spawning adults construct a nest that consists of a shallow depression created by removing gravel and cobble in or at the head of rocky riffle habitat and piling them just downstream of the nest depression. Eggs are fertilized in the bottom of the depression and drift into the rocks piled at the downstream end of the nest. After 4 to 5 days the eggs hatch and the eyeless larvae drift downstream, living a benthic life buried in the soft stream bottom. Larvae feed on microorganisms and particulate organic material for 4 years prior to metamorphosing into juveniles and migrating to the sea. Present data on migration timing of non-parasitic juveniles (known also as transformers or macrophthalmia) in freshwater are in line with Applegate's (1950) data, which found migration peaks in fall, winter, and spring (Kynard unpublished data).

Parasitic juveniles and later adults remain at sea for one or more years before being attracted to enter freshwater in response to pheromones from larvae rearing in the watershed. There is no homing to natal rivers by Sea Lampreys. Specific research related to Connecticut River Sea Lamprey life history and habitat requirements can be found in Appendix E.

GOAL

To restore and maintain runs of Sea Lamprey within the Connecticut River basin for human and ecological benefits.

OBJECTIVES

1. POPULATION

   Restore and/or enhance Sea Lamprey runs within the watershed

2. MONITORING

   Conduct and/or support monitoring programs to assess population status and trends

3. RESEARCH

   Periodically determine and support short- and long-term research needs to achieve or evaluate the Plan Goal and Objectives

4. PUBLIC OUTREACH AND EDUCATION

   Establish outreach and education about the CRASC Plan and the benefits and ecological values of Sea Lamprey in the Connecticut River basin.

STRATEGIES

1. POPULATION
   - 1.1. Identify spawning and rearing habitat – historical or suitable
     - 1.1.1. Consult with state biologists to identify historical distribution and identify which of those areas are suitable for restoration
     - 1.1.2. Identify impediments to restoration (e.g., barriers, amount and quality of habitat, etc.)
     - 1.1.3. Generate list/map of targeted restoration areas and use to prioritize, based on potential to provide suitable habitat for Sea Lamprey as well as the benefit to other species
   - 1.2. Determine current distribution of Sea Lamprey throughout the watershed
     - 1.2.1. With partners, comprehensively survey tributaries to identify habitat being utilized for spawning and/or rearing by lampreys
   - 1.3. Protect identified spawning and rearing habitat
     - 1.3.1. Use existing regulations and promote improved regulations where appropriate to protect habitat quality (riparian and instream) and quantity (flows)
     - 1.3.2. Disseminate information to land protection organizations/agencies
   - 1.4. Restore access/habitat connectivity
     - 1.4.1. Provide lamprey passage at barriers to migration within targeted habitat
     - 1.4.2. Operate fishways as appropriate for Sea Lamprey (i.e., season, time of day, upstream and downstream)

1.5. Assess feasibility of transplanting adult or larval lamprey into suitable, but currently unoccupied, historical habitat
   1.5.1. Identify opportunities for transplantation
   1.5.2. Coordinate and undertake transplantation activities where deemed compatible with other fishery management activities and after securing any necessary State permits.
   1.5.3. Evaluate success of transplantation and share information
   1.5.4. Coordinate activities with researchers
1.6. Regulate harvest
   1.6.1. Seek to have each State implement regulations that promote conservation and restoration of Sea Lamprey
   1.6.2. Support consistency among State harvest regulations
1.7. Climate change adaptation strategy
   1.7.1. Assess degree to which Sea Lamprey may be at risk due to anticipated climate change impacts within the watershed (e.g., rising river temperature, increased frequency of drought, etc.)
   1.7.2. Consider climate change vulnerability when developing prioritization methodology (refer to Section 1.1.3)

Supporting Narrative

Sea Lampreys in the Connecticut River are part of a larger, panmictic Northwest Atlantic population. As a result, abundance in the basin is a joint function of basin-specific factors and range-wide conditions, including dynamics in the coastal marine environment.

Although there is no information on the historical abundance of Sea Lamprey within the Connecticut River basin, both the adult run size and juvenile production likely are much lower now than they were historically due to the loss of suitable spawning and rearing habitats caused by the construction of dams over the past three centuries.

While not exactly the same, Sea Lamprey spawning habitat is similar to Atlantic Salmon spawning habitat, which has been quantified within the basin, and can be used as a coarse means of estimating the amount of potentially suitable Sea Lamprey spawning habitat. Larval Sea Lamprey habitat (primarily low velocity silt and sand depositional beds) differs greatly from spawning habitat and it is currently unclear which habitat type is more likely to limit lamprey abundance and production.

By systematically identifying the historical range of lamprey within each State, comparing it to the current known lamprey distribution (based on data from studies, surveys, etc.), and determining how much of the presently inaccessible habitat is suitable for lamprey spawning and/or rearing, decisions can be made on where to prioritize restoration activities such as fish passage projects, dam removals, riparian restoration, land protection, and regulated flow improvements. Increasing the quantity and quality of lamprey spawning and rearing habitat should increase the number of larvae produced within the basin which, in turn, should increase the number of adults entering the river (see discussion of larval pheromones in Appendix E).

Active management actions such as transplanting pre-spawned adults into suitable habitat should be considered and undertaken, where appropriate. Because the adults are cueing in on larval pheromones, and larvae likely are drifting downstream from upstream spawning areas, natural (i.e., passive) recolonization into historical habitat could take many years. By transplanting adults into areas that have suitable spawning and rearing habitat, stream-specific runs could potentially develop more quickly than through natural recolonization. In addition, there are a number of other ecological benefits these transfers would be expected to provide, which are detailed in Appendix D.

Currently there is no consistency in how the four States regulate lamprey harvest (Appendix F). Massachusetts, New Hampshire and Vermont have no regulations in place on the harvest or possession of Sea Lamprey. In Vermont, lamprey cannot be used as bait, while in New Hampshire and Massachusetts it is not listed as a baitfish. In Connecticut, lamprey is not considered a baitfish in freshwater but is in the marine environment. CRASC supports implementing regulations that promote the conservation and restoration of Sea Lamprey, such as instituting bag limits, prohibiting use of larvae as baitfish, etc. Scientific collection permits also should undergo scrutiny to ensure that harvest for biomedical or educational purposes does not run counter to the Plan's stated objectives.

Any management decisions should be made with consideration to climate change projections. Given limited resources, restoration activities should be undertaken in areas least at risk to projected climate change impacts such as elevated stream temperature and/or susceptibility to drought. While survival rates to the last pre-larval stage were similar for embryos reared in the temperature interval 15° to 23°C, the 3-month survival rate of larvae incubated at 15°C was nearly double that of larvae incubated at 19°C (with only 1 of 240 larvae incubated at 23°C surviving; Rodríguez-Muñcoz et al. 2001).

2. MONITORING
    - 2.1. Count and document Sea Lamprey passage at fishways whenever possible
    - 2.2. Conduct nest counts on selected tributaries
    - 2.3. Develop standardized nest count protocols
    - 2.4. Calibrate nests with known fish counts when possible
    - 2.5. Use results to trigger regulatory action
    - 2.6. Utilize new technologies as they become available to monitor distribution and abundance through time (e.g. eDNA)

Supporting Narrative

Nine out of the ten dams in the watershed with upstream fish passage facilities have the capability to monitor fish runs (Table 1). Over a period of years, these data allow for evaluation of Sea Lamprey run timing, duration, and magnitude. In addition to fishway counts, annual nest surveys are conducted on a number of rivers throughout the basin (Appendix B).

Although Sea Lamprey do not home to their natal river (Waldman et al. 2008), adults migrating along the Atlantic coast are triggered to enter a stream to spawn depending on the strength of a pheromone released by larvae rearing in upstream freshwater areas that is detected in the estuary (Bjerselius et al. 2000). Similarly, adults migrating up a river are motivated to enter tributaries based on larval pheromone levels. Evidence suggests that the stronger the strength of the pheromone smell (i.e., the greater the number of larvae rearing in the river basin), the greater the number of adults that will be attracted to enter the river. Therefore, even in the absence of homing, it should be possible to measure the success of directed lamprey restoration activities through monitoring run size or nest counts (Kynard and Horgan, in press).

Monitoring data also can be used to assess the benefits of restoring access to historical spawning and rearing habitat. By implementing pre-/post-surveys, changes in the distribution and/or abundance of lamprey nests or larvae (also known as ammocoetes) can be evaluated. On the Salmon River in Connecticut, Aarrestad (1992) found that Sea Lampreys immediately colonized nearly the entire drainage basin after the Leesville fishway was constructed in 1980 and dam removal studies on Amethyst Brook, a tributary to the Fort River, showed that adult Sea Lampreys blocked by the dam quickly utilized upstream reaches and restored downstream habitat for spawning (Magilligan et al. 2016; Kynard unpublished data). Recolonization after dam removal was also found in a tributary to the Penobscot River in Maine (Hogg et al. 2013).

In all of these cases, remnant runs of Sea Lamprey existed below the first dam and the lower river had juvenile Sea Lamprey producing pheromones. It is clear that some individual male Sea Lamprey will penetrate upstream beyond the limit of the pheromone trail when given the opportunity (Wagner et al. 2009; Siefkes et al. 2005). It appears that adults will not leave the ocean and enter a river system without the presence of pheromones (Gephard, in press).

These monitoring data could be collected by fishery agency staff, researchers, or nonprofit organizations such as the Connecticut River Conservancy, after sufficient training. In fact, nonprofit participation provides the potential to create a citizen science project out of nest surveys data collection.

3. RESEARCH
    3.1. Review and approve requests for lamprey utilization (e.g., sampling)
    3.2. Share data and collaborate with researchers
    3.3. Provide technical assistance as needed
    3.4. Support funding requests (e.g., letters of support)
    3.5. Identify data gaps that would promote restoration in the Connecticut River

Supporting Narrative

Much research has been undertaken to better understand land-locked populations of Sea Lamprey, primarily to determine and develop effective control measures. Comparatively little research has been devoted to understanding basic population dynamics, habitat requirements and migratory movement characteristics of sea-run populations. Moreover, utilizing information gained from extensive research on the invasive Great Lakes Sea Lamprey to infer the biology of anadromous Sea Lamprey may not be appropriate (Clemens et al. 2010).

Fortunately, Connecticut River-specific data exist from a long-term monitoring site on the Fort River (Appendix E) in Massachusetts. In addition, ongoing studies associated with the relicensing of four Connecticut River mainstem hydropower projects will provide data on the distribution of spawning sites within the project-affected reaches, the physical characteristics of those spawning areas, and potential impacts to those spawning sites within the influence of project operations. Instream flow studies also are being completed. These studies will assess the impact of hydropower project operations on potentially suitable spawning habitat within project-affected reaches of the river (not just known spawning locations). A critical element of that study is the development/refinement of habitat suitability index curves. One of the interesting preliminary results of the spawning studies is the apparent wider range of suitable spawning substrates than previously reported (likely because studies of spawning habitat usually focused on smaller tributary drainages).

One area deserving of research is the effectiveness of existing fishways (e.g., lifts and ladders for anadromous fish) at passing Sea Lamprey. Most upstream fishways were designed to pass Atlantic Salmon or American Shad and their effectiveness at passing Sea Lamprey is unknown. CRASC should support directed studies aimed at determining fish passage design elements that facilitate improved upstream passage for Sea Lamprey In addition, juvenile Sea Lampreys are susceptible to impingement and entrainment at water intake facilities (including hydroelectric projects) along waterways. There is little information regarding the relative risk of injury or mortality these threats represent. Directed research should address this data gap.

Sea Lamprey larvae may compete with the larvae of the American Brook Lamprey (*Lampetra appendix*; Applegate 1950; Hoff 1988), although experimental studies indicate neither species is a superior competitor (Murdoch et al. 1991). Additional research is needed to understand the relationship between the two species and whether or not Sea Lamprey restoration initiatives could impact American Brook Lamprey populations.

4. OUTREACH AND EDUCATION
   - 4.1. Develop CRASC Sea Lamprey fact sheet
   - 4.2. Ensure Sea Lamprey information is provided on agency web sites
   - 4.3. Use/create opportunities to inform the public about lamprey through print, digital, and traditional media, as well as through conservation organization's outreach strategies and events
   - 4.4. Develop lamprey articles for State wildlife magazines

Supporting Narrative

Providing current information on the status of Sea Lamprey and how this Plan is relevant to the public will help create and maintain support for management actions and an appreciation for the species. Public awareness of management and research activities and needs can be achieved from CRASC outreach efforts, including identifying principal contacts in each state and by agency. The Connecticut River Fish and Wildlife Conservation Office maintains a web site (https://www.fws.gov/r5crc/) that contains information such as: CRASC and ASMFC plans, documents and web links; CRASC meeting minutes; contact information for CRASC announcements; in-season fishway fish counts updates and basin summary fishway counts; and the office's annual report that highlights a wide range of fisheries management and related activities. The CRASC will support and promote public viewing and educational opportunities at suitable fishways and provide input on messaging at various dams along the Connecticut River.

It is particularly important to disseminate accurate information on Sea Lamprey because it is managed differently depending on whether the population in question is anadromous or land-locked. Due to the Sea Lamprey's nuisance status in areas where is has become land-locked (Appendix C), many people view the species negatively. Increasing awareness of the distinction between anadromous and land-locked lamprey populations will facilitate public support for restoration and enhancement activities for the species in the Connecticut River watershed.

Participation by watershed-based nonprofit organizations is an important component of this objective, as they have a well-established presence, a large network of volunteers, and the ability to disseminate information to the public on social media and through the many events they conduct.

Appendix A

STATUS & DISTRIBUTION

Historical Distribution

Sea Lamprey populations most likely were established in all watercourses with access to the ocean prior to the building of dams. They once ascended the Merrimack River to the Pemigewasset River as far as Plymouth, New Hampshire. On the Connecticut River, it is believed Sea Lamprey historically ranged at least as far upstream as Bellows Falls, Vermont, if not farther (Scarola 1973). Sea Lampreys began using the fish ladder at Bellows Falls Dam the year it became operational (Figure 2) and they have been documented spawning as far north as the upper White River, which enters the Connecticut River immediately downstream of the Wilder Dam in Hartford, Vermont (L. Will, VT DFW, personal communication).

Current Status of Sea Lamprey in the Connecticut River

Prior to the initiation of migratory fish restoration efforts, Sea Lamprey only spawned in limited areas of suitable habitat downstream of barrier dams (Gephard and McMenemy 2004). Examples are the narrow gravelly areas below Holyoke Dam and Enfield Dam on the mainstem river and the lower few miles of the Salmon, Farmington, and Westfield rivers. Small runs entered brooks downstream of these dams, mostly in Connecticut, such as Roaring (Lyme), Pine (Haddam), and Roaring (Glastonbury). In 1967, only 46 Sea Lampreys were counted passing the Holyoke Dam (http://www.fws.gov/r5crc/Fish/hist.html). However, with construction of fishways and removal of dams, Sea Lampreys were able to colonize newly reconnected river reaches and habitats that allowed the run size to increase.

From 1976 through 2016, between approximately 14,000 and 100,000 Sea Lampreys have been counted using the Holyoke fish lift (http://www.fws.gov/r5crc/Fish/hist.html; Figure 2). Sea Lampreys have been counted at fishways on tributaries in the basin and many enter tributaries uncounted. The Connecticut River may host the largest annual run of Sea Lamprey on the east coast of North America (Steir and Kynard 1986a). Sea Lampreys do not imprint and home to natal streams like other anadromous fish species. Adults are attracted to spawning streams by the detection of olfactory pheromones. The mechanism that regulates the size of the adult run is not well understood but it is believed to be commensurate with the relative abundance of Sea Lamprey larvae (and therefore, pheromones) presence in the Connecticut River compared to other rivers. The number of Sea Lampreys counted is just an index of relative abundance of the entire run. Not only are many spawning streams not monitored, but the percentage of spawning fish that reach any fishway varies from year-to-year based upon the run timing and the nature of the streamflow.

Sea Lampreys are able to ascend all of the fishways that have been built in the Connecticut River drainage, although the efficiency of passage probably varies from site to site. Currently, adults have been documented as far upstream in the basin as the White River. The geographical distribution of the species is summarized in Figure 1 (although runs into small tributaries are not shown). In general, the status of Sea Lamprey in the Connecticut River basin can be summarized as large and stable with potential for future growth.

Potential Connecticut River Sea Lamprey Abundance

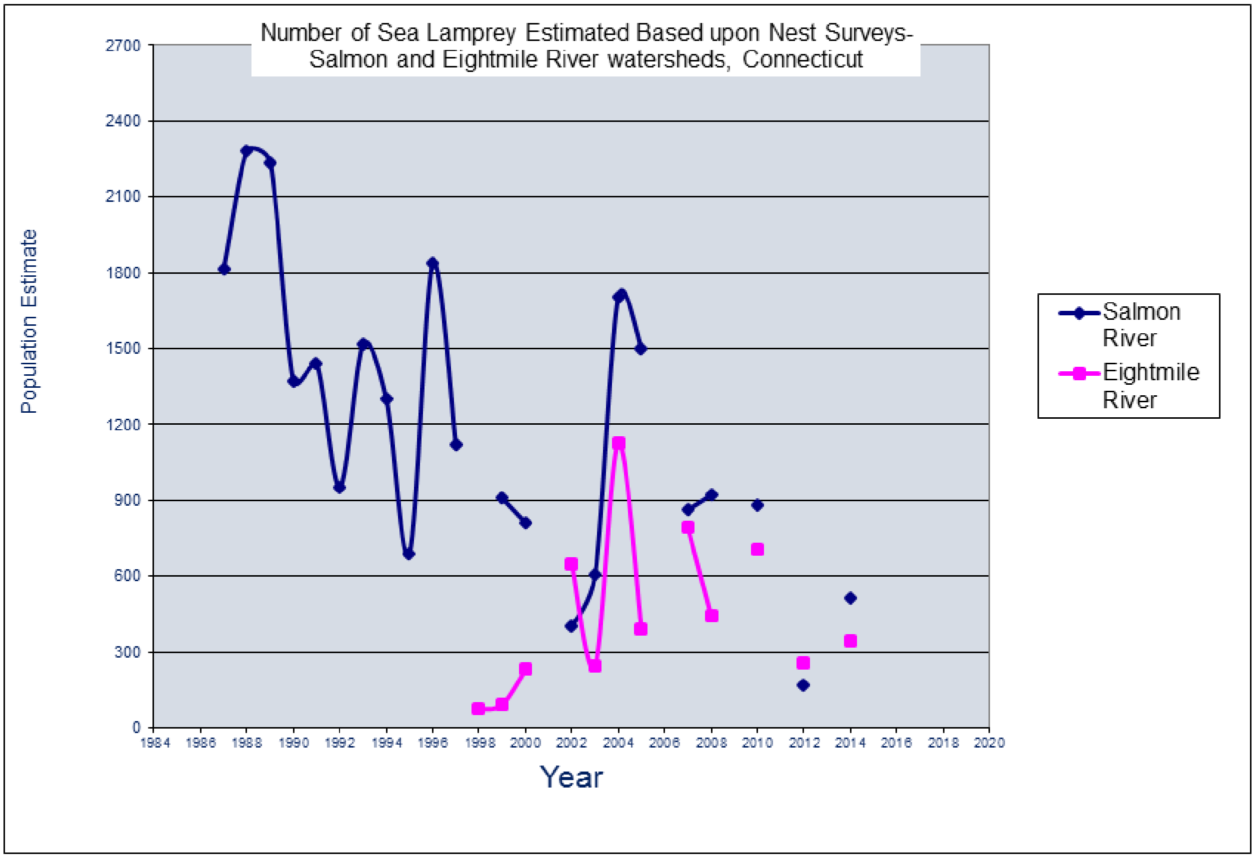
Several factors make it difficult to set quantitative targets for Sea Lamprey abundance in the Connecticut River basin. First and foremost, in contrast to other anadromous fishes in the basin which form distinct stocks, Sea Lampreys in the Connecticut are part of a larger, panmictic Northwest Atlantic population. As a result, abundance in the basin is a joint function of basin-specific factors and range-wide conditions (including dynamics in the coastal marine environment). In addition, unlike other basins (such as the Columbia in the Pacific Northwest US) which have set abundance targets, there is no historical baseline abundance estimates on which to estimate potential future abundance.

Given these limitations, several principles inform the approach of this management plan. First, it is clear that the basin contains a substantial amount of suitable spawning and rearing habitat. As a coarse comparison, it has been estimated that there are currently over 240,000 square meters of potential Atlantic Salmon spawning habitat in the Connecticut basin. While not all of this is likely to be suitable for Sea Lamprey, the similarity in substrate size requirements between the two species underscores the large amount of potential lamprey spawning habitat available. There is less information about the availability of suitable larval habitat (generally low velocity silt and sand beds). The dissimilarity between the rearing habitats of the two species prevents the use of Atlantic Salmon habitat surveys to be helpful when estimating the amount of available Sea Lamprey rearing habitat. Furthermore, it is unknown which habitat type (spawning or rearing) may be more influential in limiting the population size of Sea Lamprey. Perhaps even more important than overall habitat availability is the fact that much of this potentially suitable habitat is not accessible due to dams. These dams may also negatively affect downstream habitat by sequestering potential spawning substrate.

Dam removal studies on Amethyst Brook, a tributary to the Fort River, showed that adult Sea Lampreys blocked by the dam quickly utilized upstream reaches and restored downstream habitat for spawning (Magilligan et al. 2016; Kynard unpublished data). Recolonization after dam removal was also found in a tributary to the Penobscot River in Maine (Hogg et al. 2013). Therefore, management plan strategies related to basin-wide abundance include (1) developing a better understanding of the link between habitat, occupancy and abundance and (2) supporting actions (such as dam removal and outplanting adults) that increase the quality and availability of spawning and rearing habitat.

Appendix B

SEA LAMPREY NEST SURVEY DATA



Graph showing the estimated number of Sea Lamprey based upon nest surveys conducted on the Salmon and Eightmile River watersheds, Connecticut from 1984 through 2014.

Appendix C

GREAT LAKES EXPERIENCE

Sea Lamprey runs in New England are not very visible and many residents are not aware of their presence. Much of what the general public knows about Sea Lamprey is of the species' invasion of the Great Lakes, the severe impact Sea Lamprey had on native species in the Great Lakes, and the long-term effort to control that Sea Lamprey population. Scientists are still debating whether the Sea Lamprey was native to Lake Ontario (Waldman et al. 2004) and Lake Champlain (Waldman et al. 2006) and even when and how the species spread into the Upper Great Lakes (Eshenroder 2009). However, it is clear that the species did not get past Niagara Falls and into the upper Great Lakes, historically. With the construction of the Erie and Welland canals in the mid-1800s to support commercial shipping, Sea Lampreys were provided waterborne access to Lake Erie and beyond. The invading species became well established and the population skyrocketed by the mid-1900s. It is beyond the scope of this plan to relate in detail what occurred in the Great Lakes, but it is well accepted that the parasitism of Sea Lamprey played a role in the decimation of important native fish species in the upper Great Lakes (Scott and Crossman 1973).

Given this environmental calamity, members of the public are often perplexed that CRASC and East Coast States wish to restore Sea Lamprey runs to local rivers. The answer relates to the differences between native, anadromous, Atlantic Coast Sea Lamprey and non-native, lake-run, Great Lakes Sea Lamprey. The life history of the Sea Lamprey has been described in detail in this plan but the main point worth repeating is that Atlantic Coast anadromous Sea lamprey do not parasitize fish while in freshwater. All fish parasitism occurs in the Atlantic Ocean. It is believed that feeding occurs a considerable distance offshore because it is rarely observed (Halliday 1991). Conversely, the Great Lakes Sea Lamprey parasitize fish while in freshwater. They are unable to reach the Atlantic Ocean when they leave the rivers and the Great Lakes act as their 'ocean,' where they initiate feeding. The impact of this lake feeding is much greater than ocean feeding because the feeding habitat and the host species are more geographically concentrated. Furthermore, the host species in the Great Lakes did not co-evolve with Sea Lamprey, as did the host species in the Atlantic Ocean. They therefore lack the appropriate avoidance behavior and resistance physiology. Perhaps the sheer size of some targeted Atlantic Ocean host species allows them to survive lamprey parasitism as in a normal parasitic-host relationship (Kircheis 2004; Becker 1983).

Not only does the native, anadromous Sea Lamprey not have harmful impacts to East Coast rivers such as the Connecticut River, they have beneficial impacts (Saunders et al. 2002). They are preyed upon as important food at every life stage by other aquatic and terrestrial species and their nest building helps clear sand and silt from habitat used by other spawning fish species (Kircheis 2004). Other species of fish spawn over Sea Lamprey nests (Kircheis 2004). The benefits of Sea Lamprey have also been described elsewhere in the plan. It has been suggested that efforts to restore any single native East Coast anadromous fish species would be helped by concurrently restoring all native anadromous fish species (Saunders et al. 2002) and that is the strategy adopted by CRASC.

Appendix D

ECOLOGICAL ROLES AND BENEFITS TO SOCIETY

Ecology

Sea Lampreys are a Keystone Fish Species in the watershed. They import marine derived nutrients and minerals into tributaries that have low productivity (Nislow and Kynard 2009). Carcass decomposition provides nutrients and minerals to the aquatic and riparian ecosystem and it is likely that Sea Lamprey eggs and larvae provide more direct positive effects to the fish community by serving as prey for their entire life cycle in freshwater. Other ecological contributions of Sea Lamprey are related to nest construction and diversification of the streambed (Appendix E).

Use as Environmental Indicator

Sea Lamprey larvae reflect the mercury level of their surrounding substrate in the mainstem Connecticut River (Turners Fall canal) and in three tributaries (Fort, Millers, and Sawmill rivers; Drevnick et al. 2006). Thus, larvae could be used to monitor mercury levels. Levels of mercury decrease during ontogenetic development from larva to adult and mercury levels show no relationship to sex, total length (TL), or weight (Drevnick et al. 2006).

Historical and Potential Future Use as Food

Sea lampreys could represent a relatively untapped food resource. A principal food in Colonial New England, and historically known as a great delicacy in Europe, there is potential for recreational and commercial harvest if appropriate markets could be developed for lamprey flesh or fishmeal. An artisanal fishery occurred in the Farmington River in the Poquonnock section of Windsor, Connecticut during at least the first half of the 20th Century. Fishers would wade out into the rapids with a spear and a burlap bag, collect adult lampreys, and bring them to shore and sell them to people, some of whom took the trolley up from Hartford. This fishery faded after World War II. The last known fisher was still around in the 1980s but was no longer fishing (S. Gephard, CTDEEP, Old Lyme, CT, personal communication). From a food quality and marketability standpoint, a North American commercial fishery for lampreys might be practical if harvests were conducted in winter or early spring. Capture would need to take place in shallow ocean waters or estuaries, despite the greater effort required as compared to harvesting during peak upriver migration and spawning.

Current Benefits

There are a number of benefits to having Sea Lamprey in the Connecticut River watershed:

1) Adults are a source of food for a number of animals; eggs are food for small native fishes; larvae are prey for native fish for 4+ years in tributaries and the mainstem; and emigrating 5-year old transformers are likely eaten by mainstem and estuarine predators (Kynard and Horgan unpublished data; Kircheis 2004).
2) Adults bring marine-derived nutrients and minerals into the Connecticut River Basin, and in particular, to the aquatic and riparian life systems in productivity poor tributaries (Nislow and Kynard 2009).
3) Spawning activities restore and diversify streambed structure. This benefits other species, as the loosened and cleaned substrates are desired for building sites, or, as refuge or spawning-

foraging sites for many small fish. Atlantic Salmon and Brook Trout are known to spawn in old Sea Lamprey nests (Kircheis 2004).

4) Adult nesting activity improves water flow for aquatic invertebrates and salmonid fry and parr by loosening substrate (Kircheis 2004).

5) Lampreys are a good medical research specimen due to their unique biology. They are a valuable subject for research on neurological and spinal cord regeneration, locomotion, eyes, kidneys, blood and hormones. Some schools use ammocoetes for dissection projects (Kircheis 2004).

6) Abundant runs of Sea Lamprey provide research opportunities for international efforts to control nuisance Sea Lamprey in the Great Lakes. Adult lampreys and juveniles have been collected by the USFWS to support this research (Gephard and McMenemy 2004).

7) In some countries in Europe, lamprey is a highly prized food and could be consumed in the U.S. as they had been in the past. European importers have contacted commercial Maine fish harvesters about sources of Sea Lamprey (Kircheis 2004).

8) Sea Lamprey could be used as bait by recreational anglers. This is currently being done in Quebec.

9) Sea Lamprey spawn-timing is a good early responder to climate change (Holmes 1990; Kynard and Horgan 2011) and could be useful for monitoring changes in the basin.

To summarize, Sea Lamprey in the Connecticut River Basin and its tributaries increases watershed biodiversity and results in many benefits to the aquatic and riparian ecosystem. Any restoration efforts for anadromous fish will directly affect Sea Lamprey and therefore benefit the basin as a whole.

Appendix E

LIFE HISTORY AND HABITAT REQUIREMENTS WITH EMPHASIS ON THE CONNECTICUT RIVER

Adult

Marine life: Sea Lamprey is found in the Western North Atlantic from Labrador to Florida and in the Mediterranean Sea (review by Beamish 1980; Maitland 2003). Movement patterns during the marine parasitic phase of adult life are poorly studied, but juveniles and adults are known to occur along the coast in deep and shallow water and seem associated with foraging on schooling prey fish (Beamish 1980). From captures off the Canadian coast, Halliday (1991) concluded that adults likely have a 2.5 year parasitic period at sea and forage on a wide variety of fish and marine mammals. However, duration of the marine phase of life likely varies with latitude: 3 to 4 years was estimated for juveniles leaving New Brunswick rivers (Beamish and Potter 1975), 1.5 to 2.5 yrs for those leaving Maine rivers (Halliday 1991), and an estimated 1.3 to 1.5 years for juveniles leaving the Connecticut River (Kynard and Horgan, unpublished data). None of these estimates has been verified by tagging or other means.

While at sea, juveniles and adults prey on a large list of fish, most of which have smaller, less protective scales that make them a suitable prey. Some host species include Alewife, Blueback Herring, American Eel, American Shad, sturgeons, Atlantic Cod, Atlantic Herring, Atlantic Mackerel, Atlantic Menhaden, Basking Shark, Bluefin Tuna, Bluefish, Haddock, Hake, Swordfish, Weakfish, Pollock, Sei Whale and even other Sea Lamprey (Scott and Crossman 1973; Beamish and Potter 1975; Beamish 1980; Halliday 1991; Kircheis 2004).

Riverine Spawning Migration: Recent genetic evidence found that anadromous Sea Lamprey adults lack natal stream homing (Waldman et al. 2008), a result found previously in land-locked Sea Lamprey populations (Bergstedt and Seelye 1995). Thus, there is no Connecticut River population and instead, the species uses a strategy of entering a river to spawn based on “a most suitable river strategy”. Adults that are migrating along the Atlantic coast are triggered to enter a stream to spawn depending on the strength of the bile acid-based pheromone released by larvae rearing upstream that is detected in the estuary (Bjerselius et al. 2000). All evidence suggests that the stronger the strength of the pheromone smell (the greater number of larvae rearing in the river basin), the greater the number of adults that will be attracted to enter the river. The same goes for adults entering tributaries within a river basin. Thus, the large number of adults that enter the Connecticut River is the result of the strong pheromone odor from the large number of larvae rearing throughout the basin. The fish passage program in the Connecticut River basin has greatly expanded the spawning-rearing reaches for Sea Lamprey, and thus, is directly responsible for the large number of adults that enter the Connecticut River.

Upstream migration in New England rivers likely begins in late-March or early- April (Bigelow and Schroeder 1953). At Holyoke Dam, located at river km 140, the first migrants typically reach the dam in April at river temperatures of 10.5°C to 15.5°C, migration peaks in May at 19°C to 25°C, and some late-migrants pass the dam in late June (Steir and Kynard 1986a). Body size of adults at Holyoke Dam in 1981 and 1982 ranged from 60 cm to 85 cm TL for both sexes; males were a mean TL = 71.3 cm in 1981 and 71.4 cm in 1982 (Steir and Kynard 1986b). Female TL was 71.5 cm in 1981 and 71.1 in 1982. In 1982, mean weight of males was 794 g and mean weight of females was 806 g. Lengths of males and females did not differ significantly within years or between 1981 and 1982.

Auto-correlation analysis of the adult counts at Holyoke from 1976 to 2008 found a strong trend ($p<0.04$) for a 6-year cycle of abundance (Kynard and Horgan 2011). No explanation for these cycles is known.

Larger, more fecund individuals tend to begin their upstream migrations early, although greater numbers of individuals migrate up the Connecticut River in mid- to late-season (Yergeau 1983). Radio telemetry of 45 adult migrants tagged at Holyoke Dam in the 1980s found the following movement patterns: 1) early- and mid-migrant adults moved at a similar speed (daily mean including rest periods = 1.01 km/h or 0.4 body lengths/s; 2) rate of movement was greatest at night, but adults continued to move slowly during the day; 3) nocturnal movement was strongest in early-migrants; 4) peak migrants had a higher rate of movement than early-migrants because they moved more in the day (mornings only); and 5) 9% of the tagged adults swam upstream to the fish ladder at Cabot Station (Turners Falls Dam), 42% were last located at the mouth of tributaries with known spawning, and spawning of tagged adults was documented in the Fort River (Steir and Kynard 1986b).

Sea Lamprey can ascend nearly vertical barriers 1.5 meters (m) to 2 m in height with only a shallow film of water by alternating attachment to the structure by sucking with their mouth and quick short bursts of upstream swimming. Thousands of downstream migrant juveniles were observed in the water filter system at Cabot Station (Turners Falls Dam) in December 1979 (Kynard, unpublished data), before fish passage was installed at the dam in 1980. These data suggest that some adults ascended into the Turners Falls impoundment by some unknown means, spawned upstream, and produced the juvenile migrants observed by B. Kynard.

Spawning: In a 25 year study of Sea Lamprey spawning in the Fort River upstream of Holyoke Dam (Kynard and Horgan 2011, in press, unpublished data), nest building typically began 5 weeks after the first adult passed Holyoke or 10 days after 50 percent of the adults passed Holyoke. During the study period, spawning began in June (mean, 7 June; range, 1-22 June) and ended in June except for 1 year (mean, 23 June; range, 13 June-1 July). Nest building lasted a mean of 14.5 days (range, 6-24 days). Maximum mean daily water temperatures during spawning follows: begin = 18.0°C (range, 14°C-23°C) and end = 20.5°C (range, 17.5°C-23.8°C). Also, duration of nest building was significantly longer in years when nest building started early. Initial nest building occurred during a river discharge period each year when flows were decreasing with less variation in discharge among years (a more predictable flow regime). Climate change may be affecting timing of nest building with a trend ($P< 0.10$) over the past 25 years for the gradual increase in the temperature when the first nest is built.

Mating is typically monogamous (one pair), but polygamous mating (one male-multiple females) is not uncommon, particularly late in the spawning season when males are rare. The mating sequence begins with a solitary male using their oral disc mouth to adhere to rocks and move them to form a small circular nest site (typically, a 38 cm-46 cm diameter depression surrounded by the relocated rocks). This is typically done in 24 to 48 hours with the male typically remaining alone in the nest a day or longer until a female selects him. After a female selects a male, the pair will take several days to greatly expand the nest, digging it deeper and larger. Adults alternate spawning with moving gravel and small to medium size cobble rocks by attaching to them one at a time and swimming violently, dragging the rocks downstream to form a nest depression with a large elevated rock mound just downstream of the nest (Kynard and Horgan, unpublished data). Over a 3 year period in the Fort River, of 265 nests observed, 60.4% occurred in riffles, 32.1% in heads of riffles, 7.4% in runs and none in pools; upper reaches of the river had a significantly lower percent of nests in riffles compared to lower reaches (Kynard, unpublished data). Based on nest characteristics observed in the Fort and Connecticut rivers, Kynard and Horgan (unpublished data) developed habitat frequency curves for substrate type, velocity, and water depth (Figure 3).

Females typically produce about 200,000 eggs (range: 124,000 to 305,000; Beamish and Potter 1975), which are usually spawned over 2 days. During the spawning act, the male wraps himself around the female, the male vibrates strongly to trigger simultaneous release of gametes, and eggs are fertilized as they are released. The 1-mm diameter eggs drift into the stone pile at the downstream edge of the nest where settled eggs remain for several days before hatching (Robins and Ray 1986; Scott and Crossman 1973; Kynard and Horgan, unpublished data). Eggs that do not settle in the rocks drift downstream past the nest and likely die (Kynard, unpublished data). Post-spawned females depart the nest quickly, while post-spawned males remain on the nest for a day or so, then leave and die.

Larva (ammocoetes)

Sea Lamprey larvae (ammocoetes) occur throughout the year in the watershed downstream of spawning reaches in deposition habitat (eddies, pools, inside of stream curves with soft deposits). Eggs in the Fort River usually hatch in 4 days at around 20°C and the larvae remain in the downstream rocks at the nest for a few more days while gills, pigmentation, and buccal hood develop on this eye-less life stage. Eggs spawned in colder headwater tributaries require additional days to hatch. The small larvae drift downstream until settling in deposition areas, particularly in pools with a bottom of sand-clay mix, mud, silt, and organic debris. In this soft bottom, larvae burrow into the bottom forming a solid U-shaped tube of sand particles glued together by mucus secreted by the skin. Fish protrude their filter feeding oral hood from one end of the tube, remain in the tube until they outgrow it, move downstream to another soft bottom site, burrow into the bottom, and form another housing tube around themselves. Artificial stream experiments with Connecticut River larvae found the peak of daily downstream movement occurred with increasing river discharge (Horgan, unpublished data). Further, artificial stream tests with Connecticut River larvae suggested turbidity was the factor triggering larval movement (Kynard et al., unpublished data).

Length frequency analyses of Connecticut River larvae collected over 10 years (1997-2006) during the summer drawdown of the Turners Falls Hydropower Project canal found 6 year classes of larvae in July (year classes 0 through V; Figure 4). Similar canal collections made during drawdowns in the fall (at Turners Falls) or the spring (at Holyoke) documented fewer year classes, either due to the 0-age class being too small to sample or the V-age class having transformed and emigrated already (Kynard et al., unpublished data). It seems likely that time in freshwater is a latitudinal cline with larvae remaining longer in colder northerly rivers before transforming into seaward migrating juveniles.

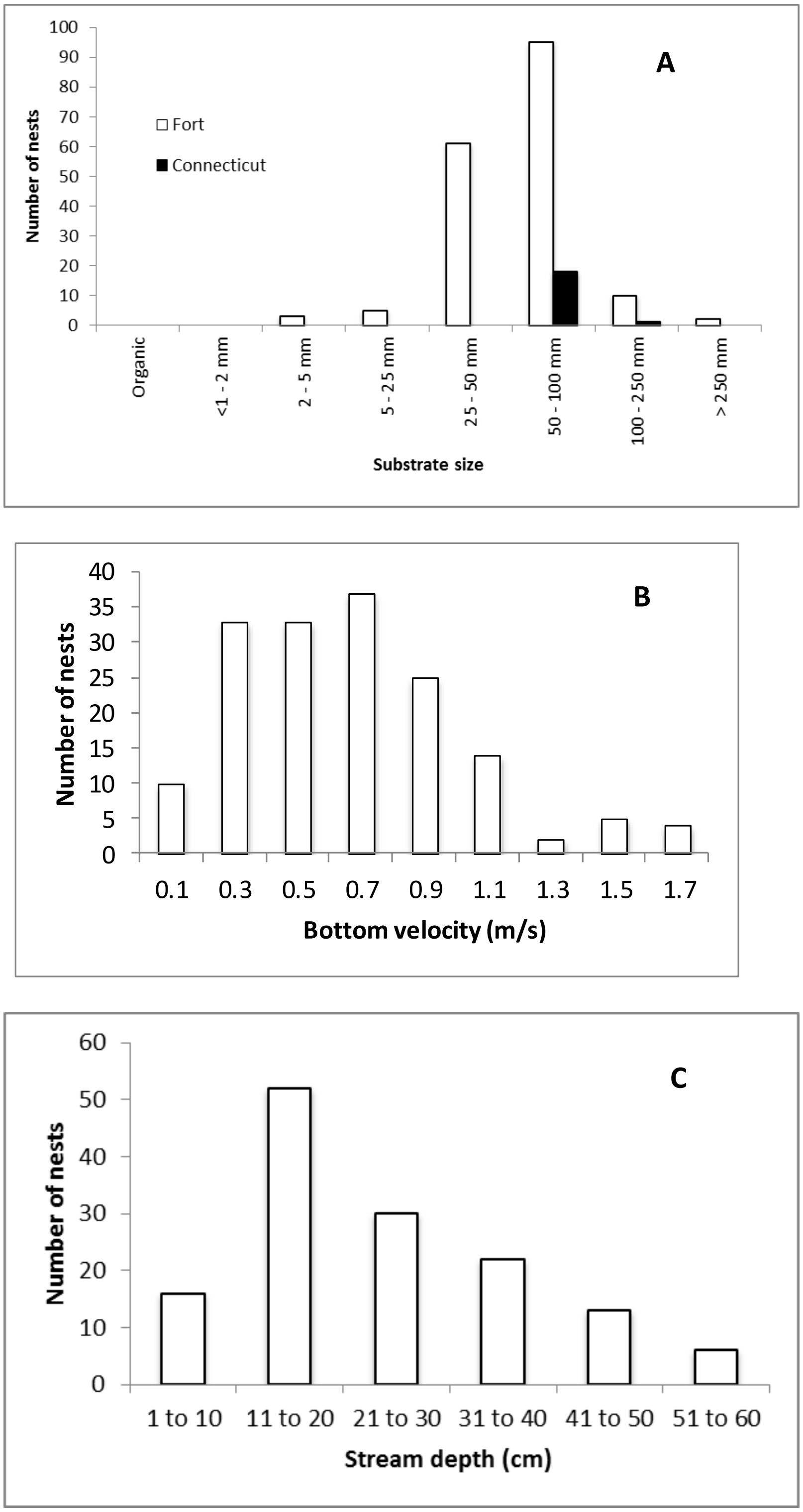


Figure 3. Spawning microhabitat at nests in the Fort (n=169) and Connecticut rivers (n=19). Panels B and C contain data from the Fort River only.

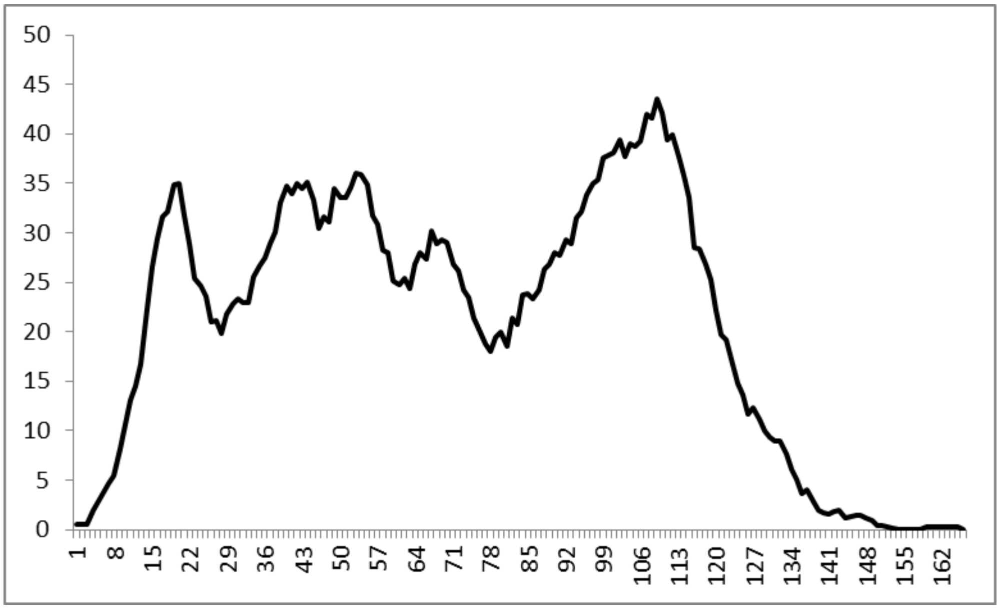


Figure 4. Pooled length frequency distribution of larvae collected over 10 years (1997-2006) from the Turners Falls Canal during the July drawdown. Size of larvae on X-axis and number of individuals on the Y-axis. Six year classes of larvae are present in the mainstem river in July. Data are smoothed using a moving average of 7; N = 3,447 (Kynard et al. unpublished data).

Sampling conducted over 2 years in September along the entire length of the Fort River downstream of Sea Lamprey spawning reaches found zero transforming larvae or juveniles and few large (age III-IV year) juveniles (Kynard et al., unpublished data). This suggests larvae grow for a few years in small tributaries like the Fort River and then migrate downstream to the mainstem Connecticut River for their final year or so in freshwater.

Growth is slow for larvae, with a mean growth of 27 mm/yr estimated by Kynard and Horgan (unpublished data) for larvae collected in the Turners Falls canal in 2011. During July to mid-October of their 5th year, most larvae begin a metamorphosis in body morphology, physiology, and behavior as they change from a buried fish feeding on microorganisms and detritus into a mobile parasitic fish (Applegate 1950; Beamish and Potter 1975; Potter 1980; Aarrestad 1992). However, Potter (1980) presents evidence that some larvae in New Brunswick spend an extra year of "rest" and no growth prior to migration and a similar situation may exist in the Connecticut River. During metamorphosis, the oral hood develops into an oral disc with teeth and Sea Lamprey develop kidneys and large eyes. At this stage Sea Lamprey are considered juveniles, otherwise known as "transformers" or macrophthalmia (meaning "large eyes").

There is a 99% mortality rate between the egg life stage and the juvenile life stage (Applegate 1950) thus year class strength is established during the egg and larval life stages. Natural mortality factors for Sea Lamprey identified by Scott and Crossman 1973 were drying of stream areas containing larvae and predation on pre-spawning adults. Predation on eggs and larvae is likely another important cause of natural mortality because these life stages are small enough for a wide variety of predators to consume. Density of larvae may also be an important natural factor influencing mortality, as it has been shown to affect growth (Murdoch et al. 1991) and the two parameters are often intrinsically linked.

Juvenile (Transformer or Macrophthalmia)

In September to October, pre-migratory-eyed juveniles sampled in the Turners Falls and Holyoke canals were a mean of 139-145 mm TL (Figure 5; Kynard et al., unpublished data). If these juveniles have a similar migration schedule as Sea Lamprey in New Brunswick (Potter 1980) and the Great Lakes (Applegate 1950), they will migrate in October-November, although juvenile migrants have also been collected from Holyoke Dam in December (1979). Those transformers had a mean TL of 140.6 mm (SD = 3.5 mm; Kynard et al., unpublished data). Like landlocked juveniles (Applegate 1950), a spring migration is also likely.

Many larvae are as long as or longer than recently transformed juveniles, suggesting that larvae may lose body length during transformation from larvae to migrant juveniles as observed by Applegate (1950). Behavioral observations on Connecticut River migrant juveniles in an artificial stream found that migration only occurred at night, with juveniles seeking cover in the day by attaching to (or underneath) diverse bottom objects. Interestingly, juveniles selected habitat with the fastest available water current during the day (Kynard et al., unpublished data).

Juveniles can temporarily attach to fish in fresh water, but do not feed until they enter the estuary. Thus, feeding in freshwater is rare and almost always non-lethal, due to the short periods of attachment and the small size of the transformers. However, delayed mortality can occur due to physical stress from feeding especially with multiple lampreys, or in the case of severe wounds that can weaken the host. Some transformers attach to a fish in a non-feeding act, where they do not penetrate the skin and only cause a superficial wound that may dislodge some scales. This activity might be because they are not strong swimmers and are hitching a ride down the river. They have been observed to stay longer in freshwater systems if downstream passage is delayed by uncommonly low water flows or by obstructions, such as dams, causing them to stay until the following spring (Kircheis 2004).

The presence of transformers has been monitored in the Farmington River at the Rainbow Dam Downstream Bypass. No transformers are generally observed in the spring following a normal or high flow fall. However, when there are low flows or a drought during the fall, many transformers are observed during the following spring (S. Gephard, CTDEEP/Fisheries Division, Old Lyme, CT, personal communication). During these times, transformers were observed attached to actively migrating Atlantic Salmon smolts. In one year, 3.9% of Atlantic salmon smolts had juvenile Sea Lamprey attachment marks, most of which did not even break the skin (CTDEEP/ Fisheries Division, Old Lyme, CT, unpublished data).

Sea Lamprey serves as an important prey item throughout their complex life history, acting as prey to a variety of fishes and mammals. Animals known to prey on Sea Lampreys include bitterns, hawks, herons, kingfishers, gulls, osprey, owls, fox, mink, muskrat, otter, raccoon, weasel, and water snakes. Fish that feed on larval and juvenile Sea Lamprey include Brown Trout, Northern Pike, Striped Bass and Walleye (Applegate 1950; Beamish 1980) and in Connecticut River, Common Shiner, Fallfish, and American Eel have been spotted feeding on Sea Lamprey eggs. During observations of Sea Lamprey nests in the Fort River, it was common to see small native fishes foraging on eggs and early-larvae of Sea Lamprey and using lamprey nests for spawning (B. Kynard, personal observation). Additionally, stonefly larvae frequently feed on Sea Lamprey carcasses in Connecticut River tributaries (Kircheis 2004; S. Gephard, personal communication).

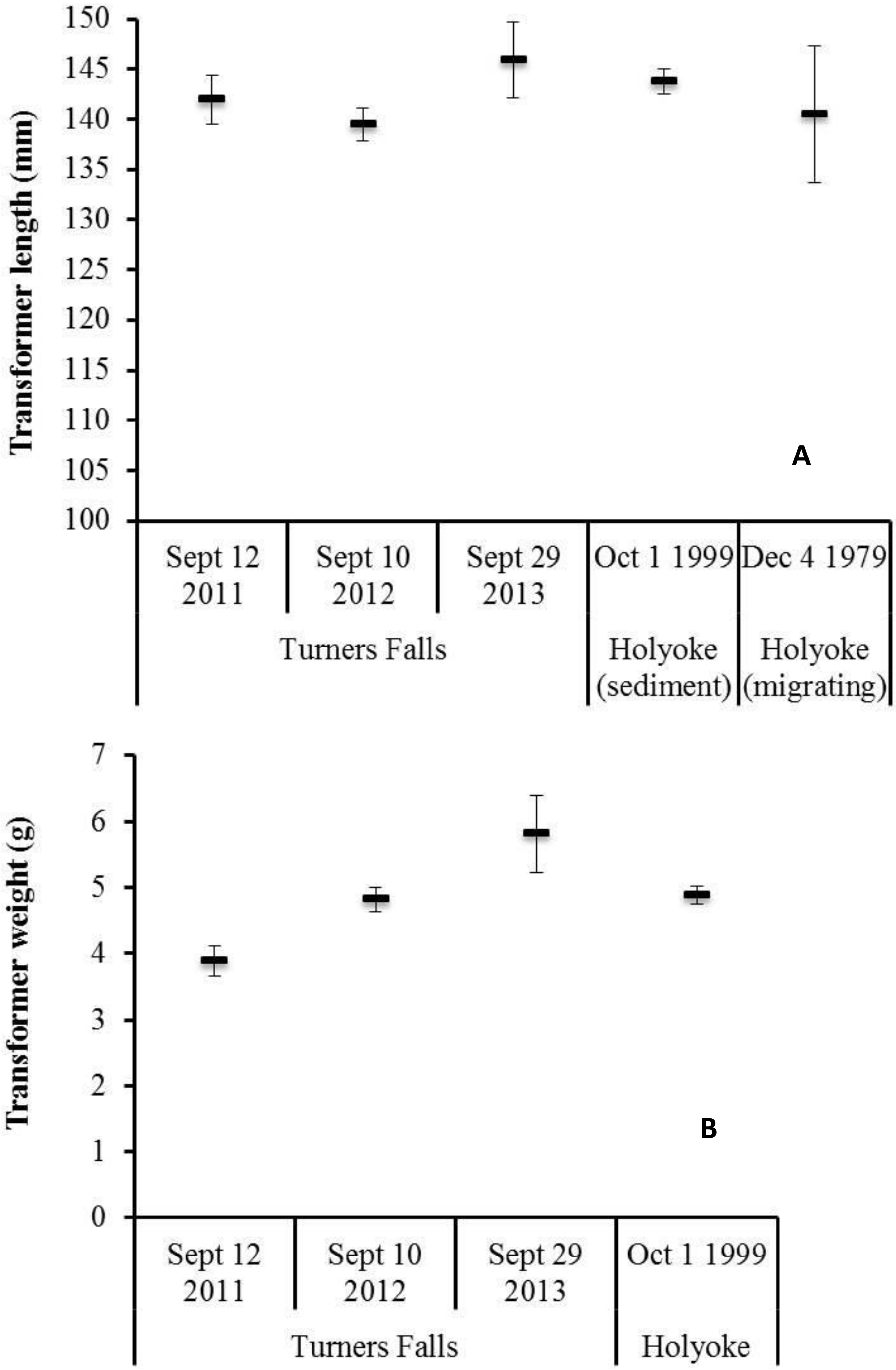


Figure 5. Length (A) and weight (B) of juvenile Sea Lamprey captured at two locations on the Connecticut River. Bars are 95% confidence intervals. Results show little difference in length but a substantial difference in weight.

Anthropogenic factors in the Connecticut River can cause mortality to juveniles. For example, Sea Lampreys are susceptible to impingement and entrainment at water intake facilities on tributaries as well as the mainstem.

Competitive Interactions

Sea Lamprey larvae may compete with the larvae of the American Brook Lamprey (*Lampetra appendix*; Applegate 1950; Hoff 1988), although experimental studies indicate neither species is a superior competitor (Murdoch et al. 1991). Additional research is needed to understand the relationship between the two species and whether or not Sea Lamprey restoration initiatives could impact American Brook Lamprey populations.

Appendix F

CURRENT REGULATIONS

Current regulations regarding capture, possession, and use of Sea Lamprey in the Connecticut River in each of the basin states is summarized below. None of the states report any commercial harvest. Lamprey larvae and recently transformed adults serve as baitfish in both freshwater and saltwater recreational fishing.

Connecticut: In freshwater, harvest by angling, ice fishing, bobbing, bow and arrow, and spearing are allowed year round in all areas with no length or bag limits. The Sea Lamprey is not listed as a bait species in freshwater, but is considered a marine baitfish. In the latter situation, harvest for personal use is allowed with capture by cast nets, minnow traps, scoop or scap nets (≤91 cm diam.), seines (≤9 m long), up to two eel pots, hook and line, and by hand.

Massachusetts: There are no regulations in place on the harvest or possession of Sea Lamprey in either freshwater (falling under the category of “all other species” with no limits on take) or saltwater systems, and the species is not listed as a baitfish.

Vermont: In Vermont tributaries to the Connecticut River Sea Lamprey cannot be used as bait; they are not on the approved bait species list. There are no other regulations specific for Sea Lamprey. However, the only legal means to harvest Sea Lamprey in Vermont is by Angling. Per 10 V.S.A. § 4001 angling is fishing by any of the following methods: (A) By means of hook and line in hand or attached to a rod, in accordance with regulations of the Board; (B) By casting or trolling artificial flies, lures, or baited hooks, in accordance with regulations of the Board. Therefore, harvest of Sea Lamprey in Vermont is unlikely.

The Connecticut River itself, including tributaries and setbacks to the first highway bridge on both sides of the river, is under New Hampshire regulations.

New Hampshire: There are no regulations in place on the harvest or possession of Sea Lamprey in the New Hampshire portion of the Connecticut River, including tributaries. The species is not listed as a baitfish. For saltwater systems, although specifically defined as a fish in the regulations, harvest and possession of Sea Lamprey is not regulated.

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