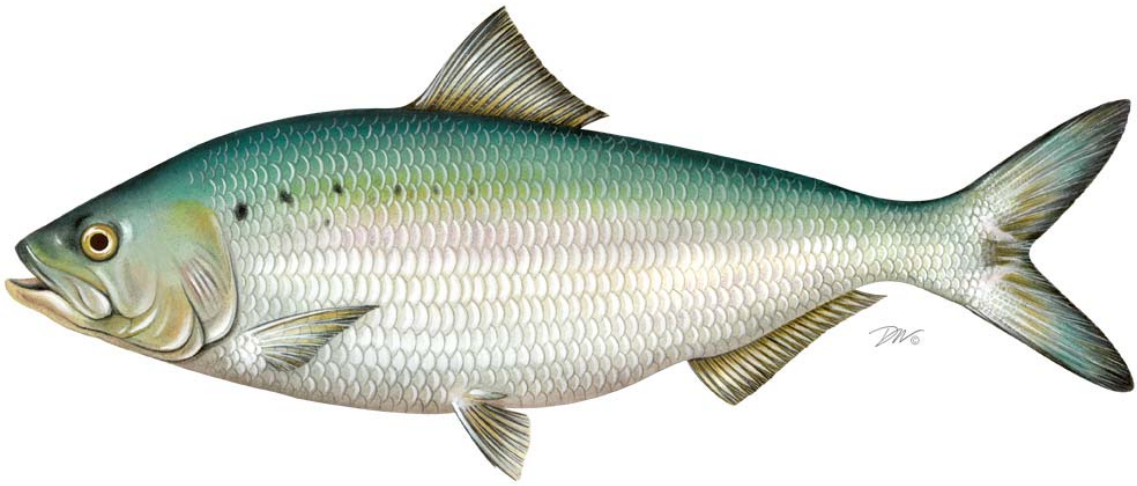
New Hampshire Fish and Game Department
Marine Fisheries Division

American Shad Habitat Plan for New Hampshire Coastal Rivers



Submitted to the Atlantic States Marine Fisheries Commission as a requirement of Amendment 3 to the Interstate Management Plan for Shad and River Herring

Approved February 6, 2014

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September 2013

This habitat plan is submitted by the New Hampshire Fish and Game Department as a requirement of Amendment 3 to the Interstate Fishery Management Plan for Shad and River Herring. Historically populations of American shad have been present in the coastal waters of New Hampshire including the Merrimack River, Connecticut River, and major tributaries of Great Bay Estuary. However, over the past 30 years of monitoring by the Department the number of returning American shad adults has been highly variable and in significant decline over the past 10 years. This plan outlines the current and historic habitat for American shad within the state. The greatest threat identified to the successful restoration of the species is the presence of dams along the rivers. Dams fragment the habitat and may further reduce the numbers entering fresh water due to the absence of a fish passage structure or poor passage efficacy for American shad of the existing structure.

1) Habitat Assessment

a) Spawning Habitat

Exeter River:

i) Amount of historical in-river and estuarine spawning habitat:

The headwaters of the Exeter River are in Chester, NH and the river flows approximately 75.7 rkm into Great Bay in Newfields, NH. The current surface area of the Exeter River from headwaters to river mouth is approximately 246.6 hectares. The tidal portion of the surface area accounts for half of the total area (123.6 hectares). These surface areas were calculated from current water levels and include impoundments created by existing dams which would reduce total surface area upon their removal.

ii) Amount of currently accessible in-river and estuarine spawning habitat (i.e., habitat accessible to adult fish during the upstream spawning migration).

Anadromous fish, including American shad, currently have access to approximately 32.2 rkm, which includes 10.3 rkm of tidal waters until reaching the Great Dam Fish Ladder in Exeter, NH. The freshwater access for American shad spawning area is the remaining 21.8 rkm and is bounded upriver by the Crawley Falls Dam in Brentwood, NH. Currently access is available to 60.3 hectares of the freshwater portion of the Exeter River, or approximately 49% of the total surface area of the river.

Lamprey River:

i) *Amount of historical in-river and estuarine spawning habitat:*

The headwaters of the Lamprey River are in Northwood, NH and the river flows approximately 80.2 rkm into Great Bay in Newmarket, NH. The current surface area of the Lamprey River from headwaters to river mouth is approximately 255.7 hectares. The tidal portion of the surface area accounts for 15% of the total area (38.1 hectares). These surface areas were calculated from current water levels and include impoundments created by existing dams which would reduce total surface area upon their removal.

ii) Amount of currently accessible in-river and estuarine spawning habitat (i.e., habitat accessible to adult fish during the upstream spawning migration).

Anadromous fish, including American shad, currently have access to approximately 21.4 rkm, which includes 3.0 rkm of tidal waters until reaching the Macallen Dam Fish Ladder in Newmarket, NH. The freshwater access for American shad spawning area is the remaining 18.4 rkm and is bounded upriver by the Wadleigh Falls Dam site (breached) in Lee, NH. Currently access is available to 68 hectares of the freshwater portion of the Lamprey River, or approximately 31% of the total surface area of the river.

b) Rearing Habitat

i) Amount of historical in-river and estuarine young-of-year rearing habitat (e.g., river kilometers, water surface area (hectares)).

In addition to the in-river spawning habitat for each of the rivers, American shad have access to 2,494.4 hectares of possible rearing habitat in Great Bay Estuary. Below the estuary, the Piscataqua River flows an additional 21.14 rkm to the Atlantic Ocean with a surface area of approximately 2,106.3 hectares including Little Harbor.

ii) Amount of currently utilized in-river and estuarine young-of-year rearing habitat (i.e., habitat available to larval stage and young-of-year fish through natural spawning or artificial stocking of hatchery reared juvenile fish).

The amount of rearing habitat that is currently used is unknown, but the amount of available rearing habitat is equal to the accessible spawning habitat (*see sections "a)", part "i" above*) within each river plus the estuarine habitat identified (*see sections "b)", part "I" above*).

2) **Threats *Assessment*** *– Inventory and assess the critical threats to habitat quality, quantity, access, and utilization (see - Appendix C for a detailed habitat description). For those threats deemed by the state or jurisdiction to be of critical importance to restoration or management of an American shad stock, the state or jurisdiction should develop a threats assessment for*

inclusion in the Habitat Plan. Examples of potential threats to habitat quality, quantity, and access for American shad stocks include:

a) Barriers to migration inventory and assessment

i) Inventory of dams, as feasible, that impact migration and utilization of historic stock (river) specific habitat. Attribute data for each dam should be captured in an electronic database (e.g., spreadsheet) and include: name of dam, purpose of the dam, owner, height, width, length, impoundment size, water storage capacity, location (i.e., river name, state, town, distance from river mouth, geo-reference coordinates), fish passage facilities and measures implemented (i.e., fish passage type, capacity, effectiveness, and operational measure such as directed spill to facilitate downstream passage), and information source (e.g., state dam inventory).

I. Exeter River:

Description:

The Exeter River drains an area of 326 square km in southern NH. The river flows east and north from the Town of Chester to the Town of Exeter. It empties into Great Bay northeast of Exeter. The head-of-tide occurs at the Town of Exeter and the saltwater portion of the river is called the Squamscott River.

There are two man-made barriers to American shad migration on the main stem Exeter River. The Great Dam in Exeter occurs at river kilometer (rkm) 13.5 and the Pickpocket Dam at rkm 26.9 (each at 4.6 meters high). The next barrier above Pickpocket Dam is a natural waterfall at rkm 38.1. The New Hampshire Fish & Game Department (NHFGD) constructed Denil fishways at both dams from 1969-1971 for anadromous fish. Fish ladder improvements occurred in 1994 and 1999, including the addition of a fish trap at the upriver end of the Great Dam fishway. There are no downstream fish passage facilities on either dam so emigrating adult and juvenile shad must pass over the spillway when river flows allow.

Recommended Action:

The fishway at the Great Dam in Exeter has a low efficiency of anadromous fish passage. Each spring thousands of river herring, and potentially many American shad, are observed spawning just several hundred meters below the fishway. Over the last ten years an average of 218 river herring and approximately four American shad are passed through the fishway annually. Fish passage efficiency could improve by manipulation of the river channel below the fishway, fishway modification, or complete removal of the Great Dam.

Due to low shad passage numbers at the Great Dam fishway, it is unknown how effective the Pickpocket Dam fishway is at shad passage. With higher shad returns to the Pickpocket Dam fishway efficiency could be determined.

Regulatory Agencies/Contacts:
Dam Owners:
Great Dam and Pickpocket Dam:
The Town of Exeter, NH
Public Works Department
Mr. Keith Noyes
10 Front Street, Exeter, NH 03833

The Dam Bureau of the New Hampshire Department of Environmental Services (NHDES) oversees the maintenance, construction, and operation of all dams in the state.

NH Department of Environmental Services, Dam Bureau
Ms. Grace Levergood
29 Hazen Dr, Concord, NH 03301

The NHFGD owns and operates the fishways at both dams and facilitates implementation, monitoring, and oversight of fish passage.

Current Action:
The fishway at the Great Dam is monitored daily from early April to late June each year to allow for the passage of river herring, American shad, and other diadromous fish to historical spawning and nursery areas. All shad passing through the fishway are captured in the trap at the top, enumerated, and passed upstream by hand. Biological samples consisting of length measurement, sex determination, and scale samples used for age determination are attempted to be collected from each shad that returns. The fishway at Pickpocket Dam is also operated from early April through late June. This fishway is operated as a swim through with no trap at the top. Since fish are enumerated and sampled downstream at Great Dam the Pickpocket Dam fishway is monitored weekly to be sure it is operating correctly.

Currently the NHFGD is working with the Town of Exeter on a feasibility study looking at ways to increase the flood capacity of the Great Dam during large rain events. Options in this study include modification of the spillway and total removal of the dam.

Goals/Target:
It is the goal of NHFGD to remove or provide passage around/over as many barriers to the migration of anadromous fish in the Exeter River as possible to provide access to historical spawning habitat. This requires the continued maintenance and operation of existing fish ladders and efforts to identify barriers further upstream where passage may be provided through modification or restoration. Efforts should be made to increase usage of the Great Dam fishway through river/fishway modifications or complete dam removal which would allow any returning American shad access to habitat upstream and potentially reach the Pickpocket Dam fishway.

Timeline:
Final draft of the Great Dam feasibility study should be released before end of 2013. Town vote on the preferred alternative will be spring of 2014. No timeline has been established for improving the usage of the fishway, but NHFGD will continue monitoring the fishways and identified barriers to fish passage and will work to increase the amount of spawning habitat available to anadromous fish in the Exeter River.

Progress:
Both fishways at Great Dam and Pickpocket Dam have been monitored since the early 1970's. Average annual return of American shad to the Great Dam fishway from 2004-2013 is 3.6 shad/yr.

NHFGD continues to work with the Town of Exeter on development of the Great Dam feasibility study. When a decision is reached on the preferred alternative in 2014, NHFGD will oversee fish passage implementation.

In addition, NHFGD continues to work to identify barriers to anadromous fish passage within the Exeter River and work towards a resolution.

II. Lamprey River

Description:
The Lamprey River flows approximately 80 km through southern New Hampshire to the Town of Newmarket where it becomes tidal and enters the Great Bay estuary just north of the mouth of the Squamscott River. There are three potential man-made barriers to American shad migration on the main stem of the river. The Macallen Dam, located at rkm 3.8 in Newmarket, is the lowermost head-of-tide dam on the Lamprey River, and has a standard denil fishway constructed by NHFGD between 1969 and 1970. There is no downstream passage facility at the Macallen Dam and emigrating juveniles and adults must pass over the spillway. The Wiswall Dam is located 4.8 rkm above the Macallen Dam at rkm 8.6. A standard denil fishway and downstream notch for emigration of juveniles and adults were constructed in 2012. A third potential manmade barrier, Wadleigh Falls Dam (breached), occurs 12.4 rkm above Wiswall Dam at rkm 21.4 and the ability/inability of passage by anadromous fish at the site is currently undetermined.

Recommended Action(s):
Determine success of American shad passage through the recently constructed standard denil fish ladder at the Wiswall Dam and assess the ability of passage over the breached Wadleigh Falls Dam If passage of anadromous fish, including American shad, is not possible then efforts should be made to work with landowners and partner agencies to allow fish to pass the barrier.

Due to low returns of American shad to the Lamprey River in recent years, it is unknown if American shad currently reach the Wiswall dam and use the standard denil fish ladder to continue upriver to the third potential barrier, Wadleigh Falls.

Regulatory Agencies/Contacts:

Dam Owners:

Macallen Dam:
The Town of Newmarket, NH
Newmarket Community Development Center
Mr. Leon Filion or Mr.Rick Malasky
186 Main Street, Newmarket, NH 03857

Wiswall Dam:
The Town of Durham, NH
Public Works Department
Mr. Michael Lynch or Mr. David Cedarholm
100 Stone Quarry Drive, Durham, NH 03824

Wadleigh Falls Dam (breached):
Mr. Dodge
RR1, Rte 152, Lee, NH 03824

The Dam Bureau of the New Hampshire Department of Environmental Services (NHDES) oversees the maintenance, construction, and operation of all dams in the state.

NH Department of Environmental Services, Dam Bureau
Ms. Grace Levergood
29 Hazen Dr, Concord, NH 03301

The NHFGD owns and operates the fishway at Macallen Dam and the Town of Durham, NH owns the fishway at Wiswall Dam and NHFGD facilitates implementation, monitoring, and oversight of fish passage.

Current Action:

The fishways at the Macallen and Wiswall Dams are monitored from early April to late June each year to allow for the passage of river herring, American shad, and other diadromous fish to historical spawning and nursery areas. All shad passing through the Macallen fishway are captured in the trap at the top, enumerated, and passed upstream by hand. Biological samples consisting of length measurement, sex determination, and scale samples used for age determination are attempted to be collected from each shad that returns. The fishway at Wiswall Dam is operated as a swim through with no trap at the top.

Currently the Town of Newmarket is conducting a feasibility study looking at ways to increase the flood capacity of Macallen Dam during large rain events. Options in this study include modification of the spillway and total removal of the dam.

Goals/Target:
It is the goal of NHFGD to remove or provide passage around/over as many barriers to the migration of anadromous fish in the Lamprey River as possible to provide access to historical spawning habitat. This requires the continued maintenance and operation of existing fish ladders and efforts to identify barriers further upstream such as Wadleigh Falls Dam (breached) where passage may be provided through modification or restoration.

Timeline:
No timeline has been established, but NHFGD will continue monitoring the fishways and identified barriers to fish passage and will work to increase the amount of spawning habitat available to anadromous fish in the Lamprey River.

Progress:
The fishway at Macallen Dam has been monitored since the early 1970's. Average annual return of American shad to the Macallen Dam fishway from 2004-2013 is less than one shad/yr. The Wiswall Dam fishway has been monitored since construction completed in 2012 through volunteer counting efforts and NHFGD electronic fish counters to estimate passage numbers and maintain ladder conditions conducive to fish passage during the spring.

NHFGD conducted a radio tagging study with river herring in 2013 to determine the passage success of anadromous fish over the Wadleigh Falls Dam location (breached). The study is ongoing and data have not been reviewed at the time of this report.

ii) *Inventory of other human–induced physical structures (e.g., stream crossing/culverts), as feasible, that impact migration and utilization of historic habitat (data on each structural impediment should include: type, source, and location)*-**DATA CURRENTLY NOT AVAILABLE**

iii) *Inventory of altered water quality (e.g., low oxygen zones) and quantity (e.g., regulated minimum flows that impact migration corridors and/or migration cues), as feasible, impediments that impact migration and utilization of historic habitat (data on each water quality and quantity impediment should include: type, source, location, and extent).*

In New Hampshire the NH Department of Environmental Services (NHDES) protects the state's inland surface water through its active lakes and rivers monitoring programs and its biological and chemical analyses of rivers and water bodies. During the year, NHDES conducts thousands of water analyses on state waters, including those involving drinking water and industrial and municipal wastewater effluents. The Water Division also oversees lake and river volunteer monitoring programs, a

public beach and swimming pool inspection program, and an acid rain monitoring program.

Two factors effecting recruitment and out-migration of adults may be poor water quality and impediments to downstream migration. Floodgate closure issues with the Exeter River dam, water withdrawals from the river by the Town of Exeter, or a combination of both have resulted in prolonged periods of limited or no flow over the Great Dam at various times of the year. The lack of flow over the dam restricts downstream migration of both adult and juvenile American shad and river herring subjecting them to periods of poor water quality. Water quality data collected by the Cooperative Institute for Coastal and Estuarine Environmental Technology (CICEET), from 1995, has indicated low levels of dissolved oxygen between two and five mg/L in impoundment reaches of the Exeter River. More recent water quality data collected in 2004 by NHFG in cooperation with the University of New Hampshire during a study of the effects of passage impediments and environmental conditions on out-migrating juvenile American shad have also indicated levels of dissolved oxygen below 5 mg/L. These low levels of dissolved oxygen were recorded even with the Exeter River's 2004 average daily flows being above the eight-year median daily flow between July and September. The decreased spawning returns of American shad and river herring to the Exeter River may be due to poor survival of juvenile out-migrating American shad and river herring as well as adults during periods of low water quality from June through October. Currently, state agencies and the Town of Exeter are working to improve the water quality of impounded reaches of the Exeter River and to allow better passage of emigrating anadromous fish.

Although NHFG has not performed water quality monitoring in other coastal rivers it is likely these conditions are not unique to the Exeter River. Other rivers, especially the Oyster and Taylor Rivers, often experience very low summer flows that result in minimal to no flow out of impoundments. These conditions do not allow adult or juvenile anadromous species to escape periods of low dissolved oxygen caused by low flows.

iv) *Assess barriers to migration in the watershed and characterize potential impact on American shad migration and utilization of historic habitat.*

(See part "I" above)

b) *Water withdrawals inventory and assessment* – **DATA CURRENTLY NOT AVAILABLE**

c) *Toxic and thermal discharge inventory and assessment*- **DATA CURRRENTLY NOT AVAILABLE**

d) *Channelization and dredging inventory and assessment*- **DATA CURRRENTLY NOT AVAILABLE**

e) Land use inventory and assessment- **DATA CURRRENTLY NOT AVAILABLE**

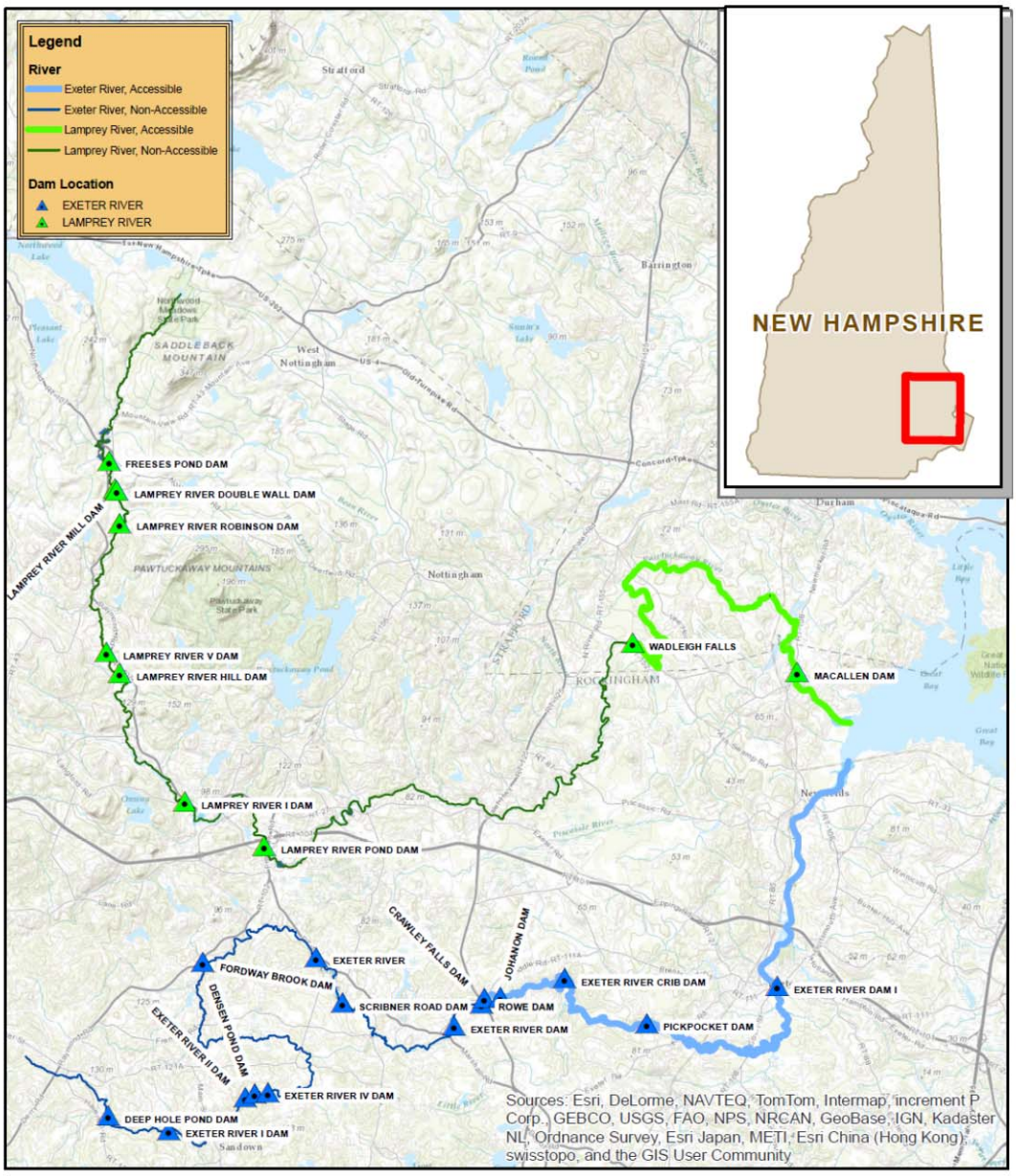
f) *Atmospheric deposition assessment*- **DATA CURRRENTLY NOT AVAILABLE**
g) *Climate change assessment*- **DATA CURRRENTLY NOT AVAILABLE**
h) *Competition and predation by invasive and managed species assessment*- **DATA CURRRENTLY NOT AVAILABLE**

Table 1. Inventory of Dams on the Exeter and Lamprey Rivers

RIVER	DAM NAME	COUNTY	TOWN	TYPE	STATUS	STATUS DATE	NH DAM ID	NATIONAL DAM ID	LENGTH	HEIGHT	BUILT	REBUILT	DAM LOCATION LONG	DAM LOCATION LAT	River km
EXETER RIVER	EXETER RIVER DAM I	ROCKINGHAM	EXETER	CONCRETE	ACTIVE	2006	82.01	NH00304	140	15	1914	1968	-70.944444	42.98111	10.3
	PICKPOCKET DAM	ROCKINGHAM	BRENTWOOD	CONCRETE	ACTIVE	2004	29.07	NH00294	230	15	1920		-71.001667	42.96944	22.4
	EXETER RIVER CRIB DAM	ROCKINGHAM	BRENTWOOD	TIMBERCOMB	RUINS	1935	29.06		110	12			-71.036944	42.98417	27.6
	JOHANON DAM	ROCKINGHAM	BRENTWOOD	STONE/EARTH	RUINS	1935	29.05		60	10			-71.065	42.97806	31.5
	CRAWLEY FALLS DAM	ROCKINGHAM	BRENTWOOD	TIMBERCOMB	RUINS	1972	29.04		140	9			-71.072778	42.97778	32.2
	ROWE DAM	ROCKINGHAM	BRENTWOOD	TIMBERCOMB	RUINS	1935	29.03		80	8			-71.073889	42.97639	32.5
	EXETER RIVER DAM	ROCKINGHAM	BRENTWOOD	CONCRETE	ACTIVE	2007	29.01	NH00293	115	15	1900		-71.085833	42.96917	34.0
	SCRIBNER ROAD DAM	ROCKINGHAM	FREMONT	CONCRETE	ACTIVE	2003	89.02	NH01050	150	12	1963		-71.134167	42.97694	40.7
	EXETER RIVER	ROCKINGHAM	FREMONT	TIMBERCOMB	ACTIVE	1972	89.01	NH01876	70	7			-71.146389	42.99167	43.0
	FORDWAY BROOK DAM	ROCKINGHAM	RAYMOND	TIMBERCOMB	RUINS	0	201.1		0	1			-71.195	42.99056	49.9
	EXETER RIVER IV DAM	ROCKINGHAM	SANDOWN	STONE/EARTH	RUINS	1935	212.04		125	12			-71.166667	42.94861	62.7
	DENSEN POND DAM	ROCKINGHAM	SANDOWN	EARTH	ACTIVE	1996	212.03	NH03047	200	10	PRE 1935		-71.1725	42.94806	63.3
	EXETER RIVER II DAM	ROCKINGHAM	SANDOWN	STONE/EARTH	BREACHED	1982	212.02		100	10			-71.176667	42.94667	63.7
	EXETER RIVER I DAM	ROCKINGHAM	SANDOWN	EARTH/STONE	BREACHED	1949	212.01		0	5			-71.209722	42.93667	68.3
	DEEP HOLE POND DAM	ROCKINGHAM	CHESTER	EARTH	ACTIVE	2006	44.08	NH01003	150	15	1974		-71.2375	42.94111	71.2
LAMPREY RIVER	MACALLEN DAM	ROCKINGHAM	NEWMARKET	CONCRETE	ACTIVE	2003	177.01	NH00365	150	27	1887		-70.934722	43.08111	3.0
	WISWALL DAM	STRAFFORD	DURHAM	CONCRETE	ACTIVE	2005	71.04	NH00441	200	18	1911		-70.963333	43.10389	8.6
	WADLEIGH FALLS	STRAFFORD	LEE	CONCRETE	BREACHED	1997	135.02		300	13			-71.006667	43.09139	21.4
	LAMPREY RIVER POND DAM	ROCKINGHAM	RAYMOND		RUINS	1935	201.07		0	0			-71.167778	43.02833	48.1
	LAMPREY RIVER I DAM	ROCKINGHAM	RAYMOND		RUINS	1935	201.06		0	0			-71.2025	43.04139	54.0
	LAMPREY RIVER HILL DAM	ROCKINGHAM	DEERFIELD	STONE/EARTH	RUINS	1935	61.06		0	5			-71.230278	43.0825	61.5
	LAMPREY RIVER V DAM	ROCKINGHAM	DEERFIELD	STONE/EARTH	EXEMPT	1979	61.08	NH01656	125	2			-71.236944	43.09	62.6
	LAMPREY RIVER ROBINSON DAM	ROCKINGHAM	DEERFIELD		RUINS	0	61.05		0	0			-71.229167	43.13056	68.5
	LAMPREY RIVER DOUBLE WALL DAM	ROCKINGHAM	DEERFIELD	STONE/EARTH	RUINS	1934	61.04		0	12			-71.231111	43.14083	70.1
	LAMPREY RIVER MILL DAM	ROCKINGHAM	DEERFIELD	STONE/EARTH	RUINS	1934	61.03		0	15			-71.232222	43.14167	70.2
	FREESES POND DAM	ROCKINGHAM	DEERFIELD	CONCRETE	ACTIVE	2001	61.02	NH00472	150	12.5	1987		-71.234444	43.15028	71.4

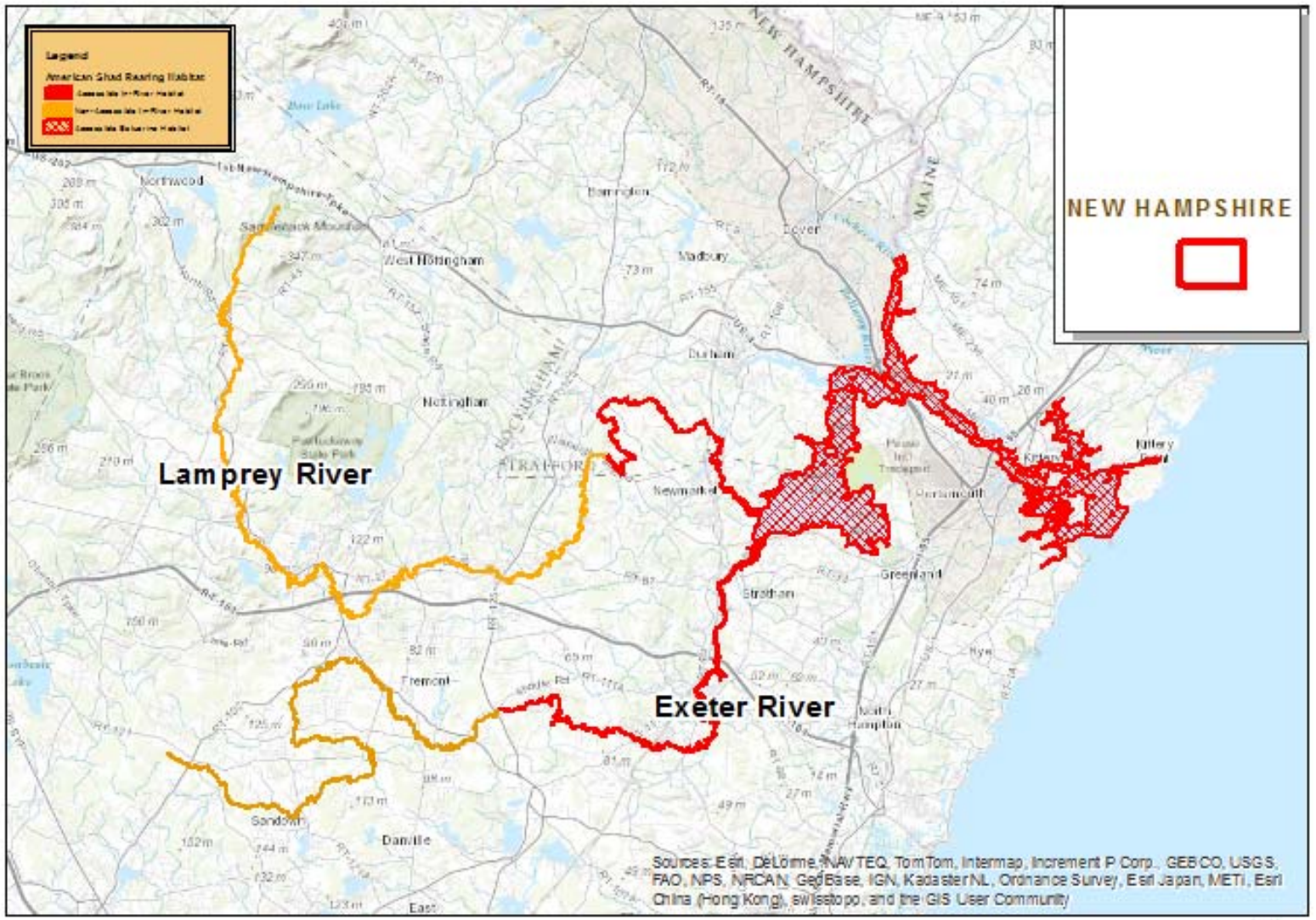
Accessible Spawning Habitat and Barrier Inventory of Exeter and Lamprey Rivers, NH

American Shad Habitat Plan



Rearing Habitat for American Shad in the Exeter and Lamprey Rivers, NH

American Shad Habitat Plan



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