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Diadromous Fish Investigations, 2016: Anadromous Alosid Restoration and Evaluation

NH Fish & Game

PROGRESS REPORT

State: **NEW HAMPSHIRE** **Grant**: **F-61-R-21/F16AF00163**

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Grant Title: **NEW HAMPSHIRE'S MARINE FISHERIES INVESTIGATIONS**

Project I: **DIADROMOUS FISH INVESTIGATIONS**

Job 1: **ANADROMOUS ALOSID RESTORATION AND EVALUATION**

Objective: To restore anadromous alosids to a level of abundance that will enable them to fully utilize historical spawning habitat in the coastal rivers of New Hampshire.

Period Covered: January 4, 2016 – March 31, 2017

ABSTRACT

Eight fishways on six New Hampshire (NH) coastal rivers were operated during the spring of 2016 to facilitate the passage of river herring (Alewife *Alosa pseudoharengus* and Blueback Herring *Alosa aestivalis)*, American Shad *Alosa sapidissima*, and other diadromous fish over dams.

Estimated numbers of river herring using all coastal river fish ladders in 2016 increased by approximately 40.5% from 2015. Alewives dominated returns to the Cocheco, Exeter, and Lamprey rivers while the Oyster River had a slightly higher percentage of Blueback Herring returning. The Oyster River continues to have low return numbers and exhibits signs that habitat problems are inhibiting restoration efforts. The Winnicut River fishway is ineffective at passing river herring and an investigation to determine a solution is ongoing. In the absence of restoration efforts, no American Shad returned to NH fishways in 2016.

In an effort to enhance local spawning stocks, thousands of river

herring were transferred from the Cocheco and Lamprey rivers to the Merrimack River drainage to assist in anadromous fish restoration efforts. In 2016, 2,250 river herring were stocked in impoundments or lakes within the Great Bay Estuary drainage. The NH Fish and Game Department has continued to work with state and federal agencies and non-governmental organizations on various cooperative diadromous fish passage projects on coastal NH rivers.

INTRODUCTION

New Hampshire's coastal rivers once supported abundant runs of anadromous fish including river herring (Alewife *Alosa pseudoharengus* and Blueback Herring *Alosa aestivalis*) and American Shad *Alosa sapidissima* (Jackson 1944). These and other diadromous species had been denied access to historical, freshwater spawning habitat since the construction of dams during the nineteenth century textile boom in most New Hampshire (NH) coastal rivers. Restoration of diadromous fish populations began with construction of fishways from the late 1950's through the early 1970's by the New Hampshire Fish and Game Department (NHFG) in the Cocheco, Exeter, Oyster, Lamprey, Taylor, and Winnicut rivers. These fishways re-opened acres of freshwater spawning and nursery habitat for river herring, American Shad, and other diadromous fish.

Since that time, modifications were made in 1999 to the Exeter River fish ladder to improve its effectiveness at passing alosids. Then after many years of study the Town of Exeter removed Great Dam and the associated Exeter fish ladder during the summer of 2016.

The Winnicut River Dam and Canada step-weir fishway were removed in 2009. A pool-and-weir fishway was constructed in late 2011 approximately 100 m upstream of the former dam site so fish can pass through a constricted channel under a bridge created after the impoundment was lowered.

The Town of Durham, NH, completed construction of a Denil fishway in January 2012 on the Lamprey River at Wiswall Dam. Wiswall Dam is the next barrier upstream from the NHFG owned fishway at the head-of-tide dam in Newmarket, NH. The Town of Durham maintains and operates the fishway with technical assistance and monitoring provided by NHFG.

River herring serve as a significant bait source for commercial and recreational fisheries, while American Shad are an important recreational fish. Unlike Atlantic Salmon *Salmo salar* and American Shad, whose populations were eliminated by barriers, river herring only declined in numbers by utilizing the small area of freshwater at the base of dams during spring runoff for spawning.

The river herring runs have been monitored at NHFG fish ladders since initiation of restoration programs in the early 1970's. Estimates or actual

counts of fish passed above the fishways, as well as biological data such as lengths, sex ratios, and age data, are available from previous studies under Federal Aid Projects F-36-R and F-50-R. Additionally, river herring have been trapped and transported to various upriver locations for stock enhancement purposes since 1984.

Methods to restore river herring runs in other areas have been through stocking of Alewives (Rounsefell and Stringer 1945), construction of fishways (Collette and Klein-MacPhee 2002), or removal of defunct dams (Havey 1961). Some dam owners are required to provide fish passage and decisions must be made whether it is more appropriate to design and construct a fishway or to remove the dam. These options are often decided collaboratively with state and federal agencies.

American Shad restoration began in 1972 with egg stocking that continued under Federal Project F-36-R from 1973-1978. This technique produced returns of fewer than a dozen American Shad per year. The purchase of circular transport tanks in the 1980's provided the opportunity to transport live, gravid adults to spawn in the coastal river systems. From 1980 to 1988, between 600 and 1,300 gravid adult American Shad were transported annually and distributed into the Exeter, Lamprey, and Cocheco rivers. In 1989, the decision was made to concentrate restoration efforts on one river at a time. The Exeter River was the river chosen for the American Shad restoration program due to the presence of two fish ladders that provided access to the greatest amount of habitat. Currently there is no American Shad restoration effort; however residual American Shad spawning runs still remain.

PROCEDURES

Eight fishways on six NH coastal rivers (Cocheco, Exeter, Lamprey, Oyster, Taylor, and Winnicut rivers) were operated from early April to early July, to allow for the passage of river herring, American Shad, and other diadromous fish to historical spawning and nursery areas. At all fishways except the Taylor, all fish passing through were enumerated by hand passing, daily time counts, or counts estimated by use of Smith-Root Model 1100/1101 electronic fish counters. Numbers recorded by the electronic fish counters were adjusted by results of daily calibration consisting of a minimum of ten, one-minute counts. During daily visits, fish ladders and electronic counting devices were examined to assure proper functioning. In 2015, the Atlantic States Marine Fisheries Commission's Shad and River Herring Management Board approved NHFG's request to discontinue the river herring monitoring requirement of the Taylor River due to returns diminishing to near zero. The Taylor River fishway is now operated as a swim through and not monitored

daily.

The head-of-tide dam on the Winnicut River was removed in the fall of 2009 and a pool-and-weir fish passage was constructed in the fall of 2011. Daily time counts began in 2012 and were conducted at the uppermost section of the fish passage for ten one minute intervals, to estimate the number of river herring able to navigate the pool-and-weir fishway.

The Pickpocket fishway, which is the second fish ladder on the Exeter River, had passage numbers estimated using a Smith-Root 1101 fish counter. The fishway was monitored daily during the spring migration to perform fish counter calibration counts and verify proper flow.

The fishway at Wiswall Dam on the Lamprey River is operated and maintained by the Town of Durham, NH, with technical assistance and monitoring provided as needed by NHFG. A Smith-Root Model 1101 electronic fish counter was installed to estimate the number of river herring passing at Wiswall. During periodic visits NHFG conducted time counts at ten one-minute intervals to calibrate the electronic fish counter.

Attempts are made to collect biological samples consisting of length measurements, sex determination, and scale samples used for age determination from river herring and American Shad at the five head-of-tide fishways each year. Separate biological samples from river herring were targeted for collection at the beginning, middle, and end of the spawning runs of each river. Each run sample consisted of up to 150 random total length measurements (mm), species identifications, and sex determinations. In addition to collecting lengths, five scale samples were attempted to be taken from each centimeter increment, or "BIN", from each sex and species from each river (e.g., five scale samples for male Blueback Herring in the Oyster River between 25.0 and 25.9 cm, etc). All American Shad encountered were sampled unless the fish showed signs of stress due to elevated water temperatures.

Scale samples were cleaned, mounted between glass slides, and aged using an overhead scale projector via methods described by Marcy (1969) for river herring and Cating (1953) for American Shad. In addition, river herring scale images were independently aged by a second reader using a QImaging microscopy camera and Image-Pro software. Scale samples were also used to confirm the species determination for river herring, either Alewife or Blueback Herring, using methods described by MacLellan et al. (1981).

NHFG and the U.S. Fish and Wildlife Service continued a cooperative trap and transport program to enhance river herring runs in NH rivers. During the spawning run, river herring were collected from coastal fishways and transported to impoundments or lakes in both coastal and Merrimack River watersheds. Out-of-basin transfers of river herring are limited to 10% of the previous year's spawning run from the source river.

Additional anadromous fish restoration activities included NHFG working with dam owners, state and federal agencies, and non-governmental organizations to remove ageing dams and implement fish passage projects. The assistance included site reviews, consultation on the types of fishways or extent of dam decommissioning, project reviews, administrative assistance, interviewing of consultants, obtaining necessary permits, public education, and attendance at various public meetings.

RESULTS

Estimated numbers of spawning adult river herring passing through the five monitored head-of-tide fishways in 2016 ranged from zero fish at the Winnicut River fishway to 99,241 fish in the Cocheco River (Table 1.1-1). The total coastal river herring return was 199,090 fish in 2016. The earliest date fish were observed at a fish ladder was April 19 in the Cocheco River (Table 1.1-2). The spawning runs in the remaining rivers began between April 21 and May 7. Water temperatures during the peak of the spawning runs ranged between 15°C and 19°C.

A summary of biological data collected from samples of river herring migrating through all the fishways is presented in Table 1.1-3. Males dominated biological samples in all rivers except the Cocheco River where the run was 50.7% female. Females had a larger mean length than males in all sampled locations. Alewives accounted for 100% of the run to the Lamprey and 99.4% and 92.1% of the run respectively in each the Cocheco and Exeter Rivers. Blueback Herring were the majority in the Oyster River with 51.5% of the return.

Tables 1.1-4 and 1.1-5 present results of age analysis of 390 river herring scale samples collected from fishways in 2016. Table 1.1-4 depicts the age structure of returning river herring within each river over time and Table 1.1-5 shows the lengths-at-age obtained from the BIN sample method for 2016. Age-5 fish comprised the largest percentage returning to the Cocheco and Oyster rivers, whereas age-4 fish accounted for nearly half the run at 49.4% in the Exeter River and similarly Age-6 fish dominated the Lamprey River return (Table 1.1-4). Most rivers had only a small percentage of age-7+ fish returning, however, in the Lamprey River they comprised a relatively high 16.6% of the spawning population. Lengths-at-age were generally similar across all sampled rivers, although the presence of Blueback Herring in the Exeter and Oyster rivers results in a lower mean-length-at-age (Table 1.1-5).

In 2016, approximately 14,865 river herring were transferred via stocking trucks from two coastal fishways to enhance local spawning runs; 7,850 from the Lamprey River and 7,015 from the Cocheco River (Table 1.1-6).

There were several out-of-basin transfers in 2016 from both the Lamprey and Cocheco rivers. From the Lamprey River, 4,600 river herring were transferred to Winnisquam Lake, 1,000 to Pine Island Pond, 1,000 to Potanipo Lake, and 250 to the Winnicut River. The Cocheco River provided 1,000 river herring to Potanipo Lake, 3,000 river herring to the Nashua River, 1,000 to Pine Island Pond, and 1,015 river herring to Winnisquam Lake. All out-of-basin locations stocked in 2016 were within the Merrimack River watershed except the Winnicut River. In-river transfers of river herring in 2016 included 1,000 to Bow Lake and 1,000 to Pawtuckaway Lake. Table 1.1-7 shows a complete list of river herring enhancement stockings in coastal rivers since 1985.

With the lack of concerted restoration efforts only American Shad remnant runs remain in NH coastal rivers. In 2016, no American Shad returned to monitored NH coastal rivers (Table 1.1-8).

Various cooperative anadromous fish passage projects occurred in 2016. The Taylor River dam complex is being repaired until a decision by state and federal agencies can be made about removal or a permanent replacement. Temporary modifications to the fish ladder began during the summer of 2016. This work is being completed in conjunction with bridge construction just below the dam and fish ladder.

In addition, NHFG staff has been working with other state, federal and local partners on dam removal projects in Rochester on the Cocheco River (Gonic dams), Sawyer Mill dams in Dover on the Bellamy River, and the Great Dam in Exeter on the Exeter River. Removal of Great Dam and the associated fishway began on July 1, 2016 and was completed during the month of September.

DISCUSSION

Total estimated river herring returning to NH coastal rivers increased from 141,664 in 2015 to 199,090 in 2016. This was an increase of approximately 40.5% over the 2015 return (Table 1.1-1). The 2016 return is the highest seen since 1993 and exceeds the 45 year average of 156,699 fish. Return numbers have generally increased every year since the poor returns in 2005 and 2006. Favorable flow conditions, strong returns of Alewives, and modifications to the Cocheco River fishway have contributed to the increase in 2016. The diminished returns in the Oyster and Taylor rivers are keeping total return numbers slightly lower than experienced during the period 1990 through 1993 when a higher number of Blueback Herring were returning to NH coastal rivers.

In 2016, the Cocheco River experienced a return of 99,241 river herring representing the highest return in 41 years of operation (Table 1.1-1). The Cocheco River spawning run was the earliest observed of all monitored rivers

with a start date of April 19th (Table 1.1-2). The 2016 spawning run consisted of 99.4% Alewives (Table 1.1-3). Like the Lamprey River, where Alewives dominate; favorable flow conditions, good water quality, and enhancement stocking in the upper reaches of the Cocheco River watershed could be factors that led to a high return in 2016. In addition, modifications made to the fishway trap during the summer 2015 allowed for the use of a Smith-Root Model 1101 electronic fish counter for the first time since the fishway was constructed. This eliminated the laborious task formerly performed by NHFG staff of netting and passing the entire anadromous run by hand. The free passage of fish through the counting tube also allowed for constant movement of fish through the entire length of the fishway. In the past, movement through the fishway would cease once the trap was full until NHFG personnel arrived to empty it out. This possibly denied many fish access to the fishway.

Age-5 fish dominated the percent returns to the Cocheco River accounting for 45.7% of the spawning run (Table 1.1-4). Age6 and age-4 fish followed with 34.9% and 11.7%, respectively. This is the third straight year that approximately 50% of the return has consisted of age-5 fish indicating strong recruitment of the 2009, 2010, and 2011 year-classes. Conditions for in-river survival and viable emigration passage of juvenile river herring were likely good.

Historically, there has been a goal to stock approximately 500 gravid river herring each to Bow Lake at the upper reaches of the Cocheco River system and to the impounded area above the second dam (Watson Dam). The practice of placing pre-spawned river herring in inaccessible reaches of river systems due to barriers allows use of available spawning habitat to returning river herring, helps supplement constricted habitat that may lead to lower returns, and augments declining runs in other watersheds. In 2016, no river herring were stocked immediately above Watson Dam; however, 1,000 river herring were stocked above in Bow Lake.

In a continuing focused restoration effort between state and federal agencies 6,015 gravid river herring from the Cocheco River were stocked within the Merrimack River drainage to restore depleted river herring runs (Table 1.1-6).

The return of 6,622 river herring to the Exeter fish ladder is the third highest return since 1975 and is the highest return since 2001 (Table 1.1-1). The run began on April 21st making it the second monitored anadromous fish run to begin in 2016. The river's spawning return in 2016 was comprised of 92.1% Alewives (Table 1.1-3). With the exception of 2015 when Blueback Herring dominated, the run at the Exeter River had been dominated by Alewives.

A likely contributor to the third and fourth highest returns, respectively, in 2016 and 2015 in the Exeter River was a change initiated in 2014 with operation of the lower weir associated with attraction to the fish ladder. Modifications made to the weir in 2000, intended to improve attraction to the fishway, actually resulted in a long-term negative impact on fish passage up two channels bisected by a bridge abutment below the weir. The modifications reduced flow to river-left, allowed debris and vegetation to accumulate, blocked fish passage, and only allowed passage upstream via river-right, which has a small ledge that creates its own flow-dependent passage issues. The operational change in 2014 introduced additional flow down river-left which reduced the accumulated debris and vegetation. After being absent for several years, NHFG biologists observed large numbers of river herring ascending the river-left channel in the years 2014-2016.

After many years of investigating the possibility of removing Great Dam and the associated fishway in Exeter, removal began on July 1st just after the spring migration had ended for the season. The dam removal and river restoration project was finished by mid-September 2016. In addition to town funds, the Town of Exeter was awarded federal and state grants for the project.

New Hampshire Fish and Game is required to continue Atlantic States Marine Fisheries Commission's fishery management monitoring for the Exeter River, despite removal of the dam. In anticipation of the removal, electronic counts have been conducted for two years at the Pickpocket Dam fishway located at the next barrier upstream from Great Dam. Counts in 2015 and 2016 were 1,330 and 2,316 river herring, respectively, accounting for approximately 29% of the fish passed at Great Dam. Modifications to the Pickpocket fishway are planned to allow for continuation of the biological sampling. Future fish counts made at Pickpocket fishway will be adjusted for comparison with counts from the fishway in Exeter since 1975. Qualitative visual monitoring at the former Great Dam location will be conducted in upcoming years to be assured river herring and other diadromous species are able to pass the site. Passage barriers identified during these observations will be addressed, where possible, to increase fish passage.

In 2016, the Oyster River had a return of 863 river herring (Table 1.1-1) representing the lowest return since 1979; far below the average of 43,597 fish over the previous 40 years. This continues the general decline in return numbers that began around 1993. The declining trend was likely exacerbated by high flows that occurred during 2005, 2006, and 2007. Unlike other rivers generally increasing returns that are seemingly rebounding after these high flow years, the Oyster River numbers continue to decline. One reason for the decline could be poor water quality affecting survival of

juvenile river herring in the impoundment due to low dissolved oxygen at periods of low flow which prevent downstream passage over the dam. Unpublished data acquired by the University of New Hampshire in the fall of 2005 showed hypoxic conditions in the impounded reaches of the Oyster River (Brian Smith, personal communication).

Blueback Herring constituted 51.5% of the run in the Oyster River (Table 1.1-3). In past years the river herring return was comprised of solely Blueback Herring. This might be an indication that the preferred riverine spawning habitat of the Blueback Herring might be of poor quality, disappearing, or inaccessible from the Oyster River impoundment. In March of 2016 NHFG staff performed a field investigation to determine if any previous riverine spawning habitat is now inaccessible to river herring or severely degraded. A beaver dam was located, but it was determined that the dam was low enough that during spring flows river herring likely could migrate upstream of the site.

The Lamprey River continues to have strong river herring returns with a run of 92,364 fish in 2016. This is the highest number of river herring that has ever returned to the Lamprey River fishway. With a record return in 2016 the Lamprey River has now experienced its top return years in four of the last five years (Table 1.1-1). The 2016 return was substantially greater than the average of 35,525 fish.

Despite the record return at the Lamprey River, the spawning run there wasn't the largest of the monitored rivers. The Cocheco River surpassed it for the first time since 2003. The later start date of April 24th at the Lamprey River could have contributed to the slightly smaller run total (Table 1.1-2).

However, the Lamprey River has had a general increasing trend since 1997 and several factors have likely attributed to that, such as the enhancement stocking into Pawtuckaway Lake that occurs during many years. Pawtuckaway Lake is an impoundment in the upper reaches of the Lamprey River watershed which stocked gravid river herring can utilize inaccessible spawning and nursery habitat. Another factor contributing to increased returns could be good water quality resulting from the upper reaches of the Lamprey system being more rural and less inhabited than other monitored river systems, and further protection on designated reaches through the Wild and Scenic Rivers National Program.

Additional fish passage opportunities have also been developed at upstream barriers in the Lamprey River system, including removal of a dam in Epping, NH, and construction of a Denil fish ladder in 2012 at the Wiswall Dam, which is the second passage barrier on the Lamprey River. The Wiswall Dam fish ladder has been operated during the spring migration each year since

2012 by the Town of Durham with technical guidance and monitoring provided by the NHFG. In 2016, the NHFG estimated 68,923 river herring migrated through the Wiswall Dam (second mainstem dam) fishway using a Smith-Root 1101 electronic fish counter. This represents a passage of 74.6% of the total river herring that passed through the first dam of the Lamprey River system at the head-of-tide.

Similar to the Cocheco River, gravid river herring from the Lamprey River were stocked within the Merrimack River drainage to restore depleted river herring runs. In 2016, 6,600 fish from the Lamprey River were stocked to several different water bodies within the Merrimack River system (Table 1.1-6).

Due to a severely diminished spawning run and lack of a sampling trap at the Taylor River, the NHFG decided to discontinue daily monitoring. Eutrophication of the impoundment compounded by high flow years in 2005, 2006, and 2007 are likely the main reasons for the decline of the Taylor River's river herring population. In 2016 the Taylor River fish ladder was opened to allow for diadromous fish passage, but was only monitored on a weekly basis. Daily monitoring activities will not be continued until further evidence of a river herring spawning run is observed.

The modified pool-and-weir fishway constructed in 2012 on the Winnicut River was monitored daily in 2016 for river herring passage. There is no trap to enumerate returns so daily time counts are performed. No fish were observed passing through the Winnicut River fishway in 2016. Returns at the former fishway/dam structure had averaged approximately 7,000 fish for the years 2007 through 2009. Each year since 2012, river herring have been observed in small quantities below the fishway but never observed passing through. It has been determined that a velocity barrier to river herring may exist within the fishway and a solution is currently being explored.

In summary, the estimated total number of river herring that passed through monitored NH coastal fish ladders in 2016 increased 40.5% from 2015 estimates. Despite the increase this year and generally increasing return numbers over the past several years, they are slightly below the returns for the period between 1990 and 1993. The Oyster River continues to exhibit signs that restoration problems are occurring. The new fishway at the Winnicut River is ineffective at passing fish due to a velocity barrier and an investigation to determine a solution is undergoing. Alewives dominated returns to the Cocheco, Exeter, and Lamprey Rivers while the Oyster River was comprised of a slightly higher proportion of Blueback Herring. To assist in regional anadromous fish restorations efforts, thousands of river herring from the Cocheco and Lamprey rivers were stocked into the Merrimack River drainage. There were no American Shad returns in 2016. Finally, NHFG has

continued to work with state and federal agencies and non-governmental organizations in initiating dam removals or enhancing fish passage options at dams in coastal NH rivers in order to increase and improve diadromous fish access to viable spawning and rearing habitat.

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Table 1.1-1. Numbers of river herring returning to fishways on coastal rivers of New Hampshire, 1972–2016.

Year	Cocheco River	Exeter River	Oyster River	Lamprey River	Taylor River	Winnicut River	Annual total
1972				2,528		+	2,528
1973				1,380		+	1,380
1974				1,627		+	1,627
1975		2,639		2,882		+	5,521
1976	9,500		11,777	3,951	450,000	+	475,228
1977	29,500		359	11,256		2,700++	43,815
1978	1,925	205	419	20,461	168,256	3,229++	194,495
1979	586	186	496	23,747	375,302	3,410++	403,727
1980	7,713	2,516	2,921	26,512	205,420	4,393++	249,475
1981	6,559	15,626	5,099	50,226	94,060	2,316++	173,886
1982	4,129	542	6,563	66,189	126,182	2,500++	206,105
1983	968	1	8,866	54,546	151,100	+	215,481
1984	477		5,179	40,213	45,600	+	91,469
1985	974		4,116	54,365	108,201	+	167,656
1986	2,612	1,125	93,024	46,623	117,000	1,000++	261,384
1987	3,557	220	57,745	45,895	63,514	+	170,931
1988	3,915		73,866	31,897	30,297	+	139,975
1989	18,455		38,925	26,149	41,395	+	124,924
1990	31,697		154,588	25,457	27,210	+	238,952
1991	25,753	313	151,975	29,871	46,392	+	254,304
1992	72,491	537	157,024	16,511	49,108	+	295,671
1993	40,372	278	73,788	25,289	84,859	+	224,586
1994	33,140	*	91,974	14,119	42,164	+	181,397
1995	79,385	592	82,895	15,904	14,757	+	193,533
1996	32,767	248	82,362	11,200	10,113	+	136,690
1997	31,182	1,302	57,920	22,236	20,420	+	133,060
1998	25,277	392	85,116	15,947	11,979	219	138,930
1999	16,679	2,821	88,063	20,067	25,197	305	153,132
2000	30,938	533	70,873	25,678	44,010	528	172,560
2001	46,590	6,703	66,989	39,330	7,065	1,118	167,795
2002	62,472	3,341	58,179	58,065	5,829	7,041	194,927
2003	71,199	71	51,536	64,486	1,397	5,427	194,116
2004	47,934	83	52,934	66,333	1,055	8,044	176,383
2005	16,446	66	12,882	40,026	233	2,703	72,356
2006	4,318	16	6,035	23,471	147	822	34,809
2007	15,815	40	17,421	55,225	217**	7,543	96,261
2008	30,686	168	20,780	36,247	976	8,359	97,214
2009	36,165	513	11,661	42,425	*	4,974	95,737
2010	32,654	69	19,006	33,327	675	576+++	86,307
2011	43,090	256	4,755	50,447	59	72+++	99,338
2012	27,608	378	2,573	86,862	92	5+++	117,518
2013	18,337	588	7,149	79,408	128	0	105,610
2014	29,968	789	4,227	84,868	57	0	119,909
2015	64,456	5,562	1,803	69,843	*	0	141,664
2016	99,241	6,622	863	92,364	*	0	199,090

* – Swim through operation
** –Due to fish counter malfunction there was up to two weeks where passing fish were not enumerated
+ – Fishway unable to pass fish until modifications in 1997
++ – Fish netted below and hand passed over Winnicut River dam
+++ – Minimum estimate based on time counts, fishway/dam removed in fall 2009

Table 1.1-2. Summary data for river herring spawning runs for coastal rivers of New Hampshire, 2016.

	River herring run		Temperature (°C)				
River	Start	End	Min	Max	During peak of run	Return (#'s)	Count method*
Cocheco River	4/19/16	6/14/16	9	21	16	99,241	H,E
Exeter River	4/21/16	6/14/16	10	21	18	6,622	H
Oyster River	5/7/16	6/16/16	10	21	19	863	H
Lamprey River	4/24/16	6/14/16	9	21	15	92,364	H,E

* – H = hand count; E = electronic counter

Table 1.1-3. Mean total length, percent sex composition, and percent species composition of river herring spawning runs at New Hampshire coastal fish ladders, 2016.

	Mean length (cm)		%	%	%	%
River	Male	Female	Male	Female	Alewife	Blueback
Cocheco River	28.1	29.2	49.3	50.7	99.4	0.6
Exeter River	26.2	28.3	70.5	29.5	92.1	7.9
Oyster River	26.4	28.6	53.8	46.2	48.5	51.5
Lamprey River	29.2	30.2	54.6	45.5	100.0	0.0

Table 1.1-4. Weighted age composition of river herring spawning in coastal rivers of New Hampshire derived from scale samples, 2010–2016.

River	Year	N	Age (%)				
			Age-3	Age-4	Age-5	Age-6	Age-7+
Cocheco River	2010	72	6.9	18.1	38.9	26.4	9.7
	2011	75	0.2	22.9	41.9	26.2	8.8
	2012	61	0.3	29.7	27.4	32.8	9.7
	2013	91	1.9	58.1	16.4	9.8	13.6
	2014	108	0.1	13.9	53.4	18.6	14.1
	2015	81	3.5	27.6	46.9	20.8	1.2
	2016	78	0.1	11.7	45.7	34.9	7.6
Exeter River	2010	38	15.8	44.7	31.6	7.9	0.0
	2011	64	20.6	38.6	30.0	10.7	0.0
	2012	59	0.8	20.8	55.0	18.0	4.3
	2013	70	5.3	54.2	33.1	4.4	2.4
	2014	103	0.5	35.5	51.7	11.1	1.1
	2015	104	0.3	64.9	30.5	4.2	0.1
	2016	103	0.0	49.4	35.6	14.9	0.1
Oyster River	2010	100	32.1	21.2	32.9	8.1	4.5
	2011	124	41.1	36.7	16.6	3.5	2.0
	2012	112	15.2	34.3	36.8	9.9	3.1
	2013	125	11.3	75.4	11.2	1.5	0.0
	2014	114	2.2	34.5	56.7	5.6	0.4
	2015	112	0.6	51.6	27.8	17.9	1.7
	2016	136	3.4	26.7	37.0	28.6	4.3
Lamprey River	2010	92	3.0	21.9	39.3	29.9	6.0
	2011	84	0.0	22.0	42.4	27.5	8.1
	2012	79	0.0	17.4	50.8	26.4	5.4
	2013	82	0.9	33.9	20.4	31.5	13.3
	2014	101	1.6	27.4	32.5	25.5	13.0
	2015	83	0.8	23.8	34.2	24.7	16.4
	2016	73	0.0	0.1	33.7	49.6	16.6

Table 1.1-5. River herring mean, minimum, and maximum length at age from scale samples taken at the Cocheco, Exeter, Oyster, and Lamprey River fish ladders during the spring spawning run, 2016.

		Age					
		3	4	5	6	7+	N
Cocheco River	Mean	26.8	26.2	27.8	29.8	31.4	
	Min	26.8	24.6	26.2	27.7	29.9	
	Max	26.8	28.2	30.3	31.7	33.0	78
Exeter River	Mean	-	25.4	27.5	29.1	31.5	
	Min	-	22.9	23.8	25.9	30.8	
	Max	-	29.2	30.9	32.6	32.1	103
Oyster River	Mean	21.7	25.2	27.4	29.0	31.0	
	Min	20.1	22.4	23.7	25.6	29.4	
	Max	23.4	28.3	30.4	31.2	32.7	136
Lamprey River	Mean	-	25.6	28.3	30.4	32.4	
	Min	-	25.6	26.2	27.4	30.8	
	Max	-	25.6	31.9	33.7	34.7	73

Table 1.1-6. Summary of river herring transfers from the Cocheco and Lamprey rivers, 2016.

Date	# Transferred	Source of river herring	Stocking location	Drainage system
5/5/2016	1,000	Lamprey River	Pine Island Pond	Merrimack River
5/9/2016	3,000	Cocheco River	Nashua River	Merrimack River
5/9/2016	1,000	Cocheco River	Pine Island Pond	Merrimack River
5/10/2016	3,000	Lamprey River	Winnisquam Lake	Merrimack River
5/10/2016	1,000	Lamprey River	Pawtuckaway Lake	Lamprey River
5/10/2016	1,000	Cocheco River	Potanipo Lake	Merrimack River
5/10/2016	1,000	Cocheco River	Bow Lake	Cocheco River
5/11/2016	1,600	Lamprey River	Winnisquam Lake	Merrimack River
5/11/2016	1,000	Lamprey River	Potanipo Lake	Merrimack River
5/12/2016	1,015	Cocheco River	Winnisquam Lake	Merrimack River
5/14/2016	250	Lamprey River	Winnicut River	Winnicut River

Table 1.1-7. Numbers of adult gravid river herring stocked in New Hampshire coastal rivers, 1985–2016.

Year	Cocheco River system	Winnicut River	Exeter River	Lamprey River system	Salmon Falls River
1985	500				
1986	2,000				
1987	2,125				
1988	2,000				
1989					
1990	2,000				
1991	1,700				
1992	1,300				
1993					
1994	365[a]			320[a]	220
1995	1,400[a]		125	3,230[b]	250
1996	750[a]			2,100[a]	200
1997	950[a]			2,000[a]	300
1998	1,000[a]	300		1,975[a]	240
1999	990[a]	200		2,020[a]	200
2000	1,000[a]	430		2,020[a]	320
2001	1,000[a]			2,000[a]	200
2002	1,000[a]			1,900[a]	
2003	1,100[a]			2,000[a]	
2004	1,050[a]		100	2,000[a]	
2005	1,000[a]		200	2,000[a]	
2006	1,000[a]		40	200[a]	
2007	900[a]		175	2,000[a]	
2008	1,000[a]		250	2,000[a]	
2009	500[a]		250	750[a]	
2010	1,000[a]			750[a]	
2011	2,000[a]	200	659	2,145[a]	
2012	1,000[a]			1,000[a]	
2013	480[a]				
2014					
2015	1,000[a]	250		1,500[a]	
2016	1,000[a]	250		1,000[a]	

[a] – In-river transfer

[b] – Combination of in-river and out-of-basin transfers

Table 1.1-8. American Shad returns to New Hampshire coastal fishways, 1983–2016.

Year	Exeter River	Lamprey River	Cocheco River
1983	0	0	3
1984	0	0	0
1985	0	2	1
1986	0	39	1
1987	0	0	0
1988	*	*	4
1989	*	*	8
1990	*	*	3
1991	12	2	6
1992	22	5	24
1993	21	200[a]	17
1994	*	13[a]	9
1995	18	14[a]	8
1996	58	2[a]	5
1997	30	4[a]	11
1998	33	3[a]	6
1999	129	3[a]	2
2000	163	7[a]	14
2001	42	6[a]	6
2002	41	4[a]	4
2003	33	26[a]	6
2004	22	33[a]	12
2005	3	12[a]	8
2006	2	6[a]	0
2007	0	4[a]	7
2008	0	4[a]	7
2009	7	4[a]	11
2010	0	5[a]	2
2011	2	1	6
2012	0	0	4
2013	0	0	1
2014	0	0	1
2015	0	0	1
2016	0	0	0

* – No counts – ladder was operated as a swim through

[a] – Minimum counts – ladder operated as swim through until late May or early June