

PROGRESS REPORT

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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 1, 2019 - December 31, 2019

ABSTRACT

Seven fishways on six New Hampshire (NH) coastal rivers were operated during the spring of 2019 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 2019 decreased by approximately 49% from 2018. Alewives dominated returns to the Cocheco, Exeter, and Lamprey rivers while the Oyster and Winnicut rivers had a higher percentage of Blueback Herring returning. The Cocheco River had its lowest return since 1985. The Oyster River continues to have low return numbers and exhibits signs that degraded impoundment habitat 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 2019.

In an effort to enhance anadromous fish restoration efforts, 760 river

herring were transferred from the Lamprey River fish ladder to Pawtuckaway Lake, an upper tributary impoundment, and 3,000 to the Merrimack River 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 rivers in NH.

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, fishway modifications, improvements, and dam removals have occurred in NH coastal rivers. Fishway modifications have been conducted to improve efficiency to upstream passage for several reasons, such as improving on older fishway designs and changing dam uses (hydroelectric development, municipal water withdrawals, etc.). In addition, upstream and downstream passage systems have been improved or added (Wiswall and Cocheco dams). Dam removals affecting diadromous species in NH coastal rivers started in earnest around 2004 with head-of-tide dams (Bellamy, Winnicut, and Exeter rivers), further upstream dams (Lamprey River), and others are underway (Bellamy River). Additionally, new fishways have been constructed (Winnicut, Salmon Falls, and Lamprey rivers) to allow fish passage through upstream obstructions.

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

Seven 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 or 1601 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 NHRFG'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 at a channel constriction under a bridge 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.

After removal of the Great Dam in Exeter during the summer of 2016, the next upstream dam and associated fishway (Pickpocket Dam) is the monitoring site for returning diadromous fish. In addition to the daily accounting of fish passage, qualitative monitoring of river herring still occurs at the former Great Dam site several times per week during the migration.

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. Annually, NHFG installs an electronic fish counter to estimate the number of river herring passing at Wiswall.

In a cooperative effort with the Maine Department of Marine Resources and Green Mountain Power, an electronic fish counter was installed and monitored by NHFG at the Salmon Falls River fish passage in South Berwick, ME. This border river is typically monitored every three to five years to assess the spawning run and fish passage operation. Currently the South Berwick hydroelectric project is undergoing relicensing, so we have monitored the fishway each year since 2017 to have accurate fish counts throughout the relicensing process.

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 monitored rivers 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 cm 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 NH 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 coastal rivers in 2019 ranged from zero fish at the Winnicut River fishway to 34,684 fish in the Lamprey River (Table 1.1-1). The total coastal river herring return was 41,363 fish in 2019. The earliest date fish were observed at a fish ladder was April 22 in the Cocheco River (Table 1.1-2). The spawning runs in the remaining rivers began between April 23 and May 8. Water temperatures during the peak of the spawning runs ranged between 13°C and 16°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 Exeter River. Females had a larger mean length than males in all sampled locations. Alewives accounted for 100% of the run to the Exeter River and 94.8% in the Lamprey River. Blueback Herring were the majority in the Oyster and Winnicut Rivers representing 56.0% and 63.4% of the return respectively.

Tables 1.1-4 and 1.1-5 present results of age analysis of 403 river herring scale samples collected in 2019. Table 1.1-4 depicts the age structure of returning river herring within each river over time and Table 1.1-5 shows the length-at-age data obtained from the BIN sample method for 2019. Age-5 fish comprised the largest percentage returning to the Exeter Oyster, and Winnicut rivers. Age-6 fish dominated the Lamprey and Cocheco River returns (Table 1.1-4). In 2019, there were very few returning age-3

fish. Mean lengths-at-age were generally larger in the Cocheco, Exeter, and Lamprey rivers than in the Oyster and Winnicut rivers (Table 1.1-5).

In 2019, approximately 3,760 river herring were transferred via stocking trucks from the head-of-tide fishway on the Lamprey River to enhance local spawning runs (Table 1.1-6). There was one out-of-basin transfer in 2019 from the Lamprey River; 3,000 to Potanipo Lake within the Merrimack River watershed. In-river transfer of river herring in 2019 included 760 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 2019, no American Shad returned to NH coastal rivers (Table 1.1-8).

Various cooperative anadromous fish passage projects occurred in 2019. NHFG staff has been working with other state, federal and local partners on dam removal projects in Rochester, NH, on the Cocheco River (Gonic dams) and Sawyer Mill dams, Dover, NH, on the Bellamy River.

DISCUSSION

Total estimated river herring returning to NH coastal rivers decreased by approximately 49% from 81,428 in 2018 to 41,363 in 2019 (Table 1.1-1). The 2019 returns are the lowest seen since 2006 and are far below the long-term average of 150,908 fish. Prior to 2017, return numbers had generally been increasing every year since flood conditions created poor returns in 2005 and 2006. Unfavorable flow conditions and below normal water temperatures likely contributed to the decreasing return trend in 2019. Below average returns in the Oyster River, an extremely low return to the Cocheco River, and inconsistent fish passage potential at the Winnicut River also contributed to the low returns seen in 2019.

In 2019, the Cocheco River experienced a return of 1,682 river herring (Table 1.1-1). This was the lowest return seen since 1985. This is a decrease of approximately 93% from 2018 and approximately 93% below the long-term average of 27,565. The Cocheco River spawning run was the earliest observed of all monitored rivers with a start date of April 22nd (Table 1.1-2), and consisted of 65.0% Alewives (Table 1.1-3). Cool water temperatures that lingered very late into the migration season likely contributed to the extremely low return. In addition, the flashboards on the spillway crest failed during the winter in 2019. This resulted in a lower impoundment elevation during the 2019 migration; severely affecting the efficient operation of the fishway and likely negatively effecting total upstream fish passage. The flashboards were repaired on May 24th. This was past the

typical peak river herring migration period of early to mid-May.

Modifications made to the fishway trap conducted in the summer of 2015 allowed for the use of an electronic fish counter for the first time in 2016. This eliminated the laborious task, formerly performed by NHFG staff, of netting and passing the entire anadromous fish run by hand. The unimpeded passage of fish through the single counting tube also allowed for constant movement of fish through the entire length of the fishway. However, there were often times when there were more fish moving through the fishway than the single counting tube could enumerate with any good precision level. A multi-channel Smith-Root Model 1601 electronic fish counter has been used since 2017 with an eight counting tube array, which provided more passage opportunities during peak migration through the fishway. However, observation determined that this multi-channel fish counting system does not perform well with varying impoundment elevations. Therefore, a single tube electronic counter like used in 2016, is likely better suited to deal with the consistent winter flashboard failure of the adjacent hydroelectric facility that creates inconsistent impoundment levels. A Smith-Root Model 1100/1101 electronic fish counter and single counting tube will be used at the Cocheco fishway in 2020.

Age-6 fish dominated the percent returns to the Cocheco River accounting for 31.5% of the spawning run (Table 1.1-4). Age-7+ and age-5 fish followed with 28.3% and 20.0%, respectively. In 2015, the high return of river herring, good conditions for in-river juvenile survival, and viable emigration passage likely resulted in the strong year-class represented by the high percentage of age-4 fish.

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. Unfortunately, the low return numbers in 2019 made it impossible to collect fish to transfer from the Cocheco River fishway, so no in-basin stocking was conducted.

After good returns of 5,562 and 6,622 river herring in 2015 and 2016 respectively, the Great Dam and associated fishway were removed during the summer of 2016 (Table 1.1-1). 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 Great Dam. Prior to the

removal, electronic counts were 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 30% of the fish passed at Great Dam. A fish counter has been installed at the Pickpocket Dam fishway each year since 2017 to enumerate the river herring return. Total river herring passage in 2019 was 28 fish. This is similar to the return of 32 river herring in 2018. It is unknown why river herring are not reaching Pickpocket Dam in greater quantities since schools of river herring were observed by NHFGD biologist passing through the former Great Dam site on several occasions during qualitative visual monitoring.

Collection of biological samples on the Exeter River was difficult in 2019. With the removal of Great Dam and the associated fishway/trap structure, and the few fish that returned to the Pickpocket fishway/trap, age composition comparisons are difficult.

In 2019, the Oyster River had a return of 4,969 river herring (Table 1.1-1), far below the average of 39,998 fish over the time series. Despite consistent returns of around 5,000 fish per year over the last three years, there continues to be a general decline in return numbers that began around 1993. One reason for the decline could be poor water quality affecting survival of young-of-year 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 2005 showed hypoxic conditions in the impounded reaches of the Oyster River (Brian Smith, personal communication). In addition, the Oyster River impoundment is listed by NH Department of Environmental Services as a 303(d) threatened or impaired water body for dissolved oxygen.

Blueback Herring constituted 56.0% 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 degraded, 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. While a beaver dam was located, 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 had the highest return of all coastal NH Rivers in 2019 with 34,684 fish (Table 1.1-1). After a record return in 2016 this is the second time in the last three years that the return of river herring to

the Lamprey has fallen below the average. The current average return for the Lamprey River fishway over the time series is 37,020 fish.

Despite the slightly below average return this year, the Lamprey River generally has the highest return of all coastal rivers each year. Several factors have likely contributed; enhancement stocking into Pawtuckaway Lake, an upper watershed impoundment, good water quality resulting from the upper reaches of the Lamprey system being more rural and less inhabited than other monitored coastal 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 since 2012 by the Town of Durham with technical guidance and monitoring provided by the NHFG. In 2019, the NHFG estimated 33,271 river herring migrated through the Wiswall Dam fishway, represents a passage of 95.9% of the total river herring that passed through the head-of-tide fish ladder of the Lamprey River system.

In a continued focused restoration effort between state and federal agencies, 3,000 fish from the Lamprey River were stocked in Potanipo Lake within the Merrimack River watershed (Table 1.1-6) and 760 river herring were transported and stocked in-basin at Pawtuckaway Lake.

Due to a severely diminished spawning run and lack of a sampling trap at the Taylor River, the NHFG has previously 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 2019, 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 2019 for river herring passage. There is no trap to enumerate returns so daily time counts are performed. Each year since 2012, river herring have been observed in small quantities below the fishway, but were never observed within the upper pools of the fishway until 2018. Although no fish were enumerated passing the fishway in 2019, fish were once again observed ascending to the upper pools. It has been determined that a velocity barrier to river herring may exist within the fishway during the majority of spring flows. A solution to the problem is currently being explored. In 2019, flow conditions within the river and

fishway were favorable for herring to ascend the structure during the late part of the spring migration. During this time period a small number of fish were captured via cast net and sampled. The sample was dominated by age-5 and age-6 fish (Table 1.1-4) and consisted mostly of Blueback Herring (Table 1.1-3).

In 2019, no American Shad returned to coastal fishways (Table 1.1-8). There are currently no adult American Shad restoration efforts occurring on the NH coast, so it is likely the few fish occasionally encountered are strays from other rivers. While most American Shad return to their natal rivers to spawn there is a small percentage that stray to nearby non-natal river systems (Mansueti and Kolb 1953; Williams and Daborn 1984; Melvin et al. 1985).

In summary, the estimated total number of river herring that passed through monitored NH coastal fish ladders in 2019 decreased 49% from 2018 estimates. This is the lowest return since 2006. Unfavorable flow conditions and below normal water temperatures likely contributed to the decreasing return trend in 2019. Below average returns in the Oyster River, an extremely low return to the Cocheco River, and a lack of full access to freshwater habitat in the Winnicut River also contributes to the low returns seen in 2019. The Oyster River continues to exhibit signs that the spawning population is in a general decline since 1993. 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 and Winnicut rivers were comprised mostly of Blueback Herring. To assist in regional anadromous fish restorations efforts, 3,000 river herring from the Lamprey River were stocked into the Merrimack River drainage. There were no American Shad that returned to coastal rivers in 2019. 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, 1972–2019.

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
2017	28,926	***	4,492	35,920	*	0	69,338
2018	24,743	32	5,716	50,884	*	53 ⁺⁺⁺	81,428
2019	1,682	28	4,969	34,684	*	0	41,363

* Swim through operation.

** Due to fish counter malfunction there was up to two weeks where passing fish were not enumerated.

*** Sea lamprey inundation caused fish counter to false count.

+ 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, 2019.

River	River herring run		Temperature (°C)			Return (#'s)	Count method*
	Start	End	Min	Max	During peak of run		
Cocheco River	4/22/19	6/19/19	6	18	15	1,682	H,E
Exeter River	5/8/19	5/24/19	11	17	13	28	H
Oyster River	4/23/19	6/14/19	7	17	15	4,969	H
Lamprey River	4/23/19	6/14/19	8	20	16	34,684	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, 2019.

River	Mean length (cm)		%		%	
	Male	Female	Male	Female	Alewife	Blueback
Cocheco River	28.4	29.5	51.1	48.9	65.0	35.0
Exeter River	28.5	29.6	46.4	53.6	100.0	0.0
Oyster River	26.9	28.1	55.1	44.9	44.0	56.0
Lamprey River	28.3	29.7	60.9	39.1	94.8	5.2
Winnicut River	26.5	27.9	63.4	36.6	36.6	63.4

Table 1.1-4. Weighted age composition of river herring spawning in coastal rivers of New Hampshire derived from scale samples, 2013–2019.

River	Year	Age (%)					N
		Age-3	Age-4	Age-5	Age-6	Age-7+	
Cocheco River	2013	2.7	57.8	17.2	10.2	12.1	91
	2014	0.0	14.8	50.8	18.6	15.7	108
	2015	4.5	30.3	42.0	21.3	1.9	80
	2016	0.6	13.5	41.8	36.6	7.3	78
	2017	0.1	2.5	24.5	57.2	15.7	70
	2018	0.0	11.5	12.6	14.2	61.7	90
	2019	1.0	19.2	20.0	31.5	28.3	123
Exeter River	2013	6.4	53.2	33.0	4.9	2.4	70
	2014	1.1	43.8	42.6	11.6	1.0	103
	2015	1.9	74.0	19.7	4.3	0.1	104
	2016	0.0	31.1	52.1	16.6	0.2	103
	2017	9.1	56.8	18.2	15.9	0.0	44
	2018	0.0	31.6	58.3	6.9	3.1	26
	2019	0.0	16.7	35.4	30.6	17.4	23
Oyster River	2013	11.7	74.6	12.4	1.3	0.0	125
	2014	4.4	34.0	55.8	5.3	0.5	114
	2015	1.8	52.3	29.1	15.0	1.4	112
	2016	3.2	25.5	35.1	31.1	5.1	136
	2017	4.0	72.3	18.5	4.4	0.7	108
	2018	3.8	44.4	35.6	14.6	1.6	121
	2019	2.4	24.4	41.1	23.4	8.4	109
Lamprey River	2013	0.9	32.7	20.1	31.0	15.2	81
	2014	1.1	27.7	32.5	25.8	12.9	101
	2015	0.7	26.9	33.0	21.9	17.6	83
	2016	0.0	0.1	36.2	47.8	15.9	73
	2017	0.0	10.3	14.6	51.7	23.4	76
	2018	0.0	49.2	26.8	8.1	16.0	86
	2019	0.0	16.7	33.9	37.6	11.8	77
Winnicut River	2013	No samples taken					
	2014	No samples taken					
	2015	No samples taken					
	2016	No samples taken					
	2017	No samples taken					
	2018	8.3	40.0	33.3	15.0	3.3	60
	2019	0.0	23.9	38.0	35.2	2.8	71

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, 2019.

		Age					N
		3	4	5	6	7+	
Cocheco River	Mean	24.9	25.8	27.0	28.3	31.2	122
	Min	24.1	23.5	24.2	26.0	29.3	
	Max	25.3	27.9	29.3	32.0	33.7	
Exeter River	Mean	-	28.1	28.7	29.5	30.2	23
	Min	-	27.4	27.8	27.7	29.1	
	Max	-	28.6	29.8	30.7	30.9	
Oyster River	Mean	25.2	26.3	27.9	28.4	29.0	108
	Min	23.3	24.2	25.3	24.6	25.9	
	Max	26.4	30.1	30.7	31.6	30.9	
Lamprey River	Mean	-	27.0	27.8	29.0	31.8	77
	Min	-	25.0	25.3	26.7	30.4	
	Max	-	28.6	30.5	31.6	33.1	
Winnicut River	Mean	-	26.6	27.1	27.4	27.3	71
	Min	-	24.3	23.8	24.5	27.3	
	Max	-	29.0	29.3	29.5	27.3	

Table 1.1-6. Summary of river herring transfers from the Cocheco and Lamprey rivers, 2019.

Date	# Transferred	Source of river herring	Stocking location	Drainage system
5/11/2019	3,000	Lamprey River	Potanipo Lake	Merrimack River
5/29/2019	760	Lamprey River	Pawtuckaway Lake	Lamprey River

Table 1.1-7. Numbers of adult gravid river herring stocked in New Hampshire coastal rivers, 1985–2019.

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	
2017		250		1,000 ^a	
2018		250		1,000 ^a	
2019				760 ^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, 1983–2019.

Year	Exeter River	Lamprey River	Cochecho River	Oyster River
1983	0	0	3	0
1984	0	0	0	0
1985	0	2	1	0
1986	0	39	1	0
1987	0	0	0	0
1988	*	*	4	0
1989	*	*	8	0
1990	*	*	3	0
1991	12	2	6	0
1992	22	5	24	0
1993	21	200 ^a	17	0
1994	*	13 ^a	9	0
1995	18	14 ^a	8	0
1996	58	2 ^a	5	0
1997	30	4 ^a	11	0
1998	33	3 ^a	6	0
1999	129	3 ^a	2	0
2000	163	7 ^a	14	0
2001	42	6 ^a	6	0
2002	41	4 ^a	4	0
2003	33	26 ^a	6	0
2004	22	33 ^a	12	0
2005	3	12 ^a	8	0
2006	2	6 ^a	0	0
2007	0	4 ^a	7	0
2008	0	4 ^a	7	0
2009	7	4 ^a	11	0
2010	0	5 ^a	2	0
2011	2	1	6	0
2012	0	0	4	0
2013	0	0	1	0
2014	0	0	1	0
2015	0	0	1	0
2016	0	0	0	0
2017	0	0	0	1
2018	0	0	0	0
2019	0	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.