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Anadromous Fish Investigations, Year 2005

NH Fish and Game

PROGRESS REPORT

State: **New Hampshire** **Grant**: **F-61-R**

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John I. Nelson, Chief of Marine Fisheries

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

Project 1: **ANADROMOUS FISH INVESTIGATIONS**

Job 1: **Anadromous Alosid Restoration and Evaluation**

Objective: To restore the anadromous alosids, river herring (*Alosa pseudoharengus* and *Alosa aestivalis*) and American shad (*Alosa sapidissima*), to an abundance and distribution that allows them to utilize historical freshwater spawning habitat in the coastal areas of New Hampshire.

Period Covered: January 1, 2005 - December 31, 2005

Abstract:

Seven department fish ladders on six coastal rivers were operated during the spring of 2005 to facilitate the passage of river herring, American shad, and other diadromous fish over dams.

Estimated numbers of river herring monitored in 2005 were lower than in 2004 in all six rivers. This may be attributed to high flows in all monitored rivers during the river herring run. Record low returns at the Exeter and Taylor river ladders are of concern. Possible causes of low return numbers in the Exeter are low dissolved oxygen levels in the river, impediments to downstream migration, excessive harvest by the in-river fishery, or a combination of the three. Alewives constituted 100% of the returns in the Lamprey and Exeter rivers and dominated returns in the Cocheco and Winnicut rivers. River herring returns in the Oyster and Taylor rivers were

exclusively blueback herring.

Confirmed returns of shad to the fishways were 12 in the Lamprey, three in the Exeter, and eight in the Cocheco rivers. The number of returns to the Exeter River decreased from 22 in 2004 to three in 2005. It is speculated that the reduction in returns could be due to water quality problems in the impoundment above the dam or incidental mortality in the in-river fishery for river herring. Biological samples indicated that ages ranged from III to VII and the ratio of males to females was three to one.

In a concerted effort between New Hampshire Fish and Game and the U.S. Fish and Wildlife Service (USFWS), approximately 3,200 river herring were transferred into impoundments or lakes in the Great Bay Estuary drainage to enhance spawning stocks. No American shad were stocked this year as low numbers at the Merrimack River fish lift prevented collection of gravid adults.

In addition, other collaborative efforts to restore anadromous fish to NH coastal rivers include dam removal or fish passage projects on three rivers within the Great Bay system. The first dam located at the head-of-tide on the Bellamy River was removed in 2004 to provide access to additional spawning and rearing habitat for species such as river herring and rainbow smelt. A feasibility study has recently been completed on fish passage options for the Winnicut River dam with dam removal and installation of a technical fishway at the next upstream barrier being chosen as the preferred option. Finally, a nature-like fishway has been selected as the preferred option for fish passage at Wiswall Dam on the Lamprey River and an Environmental Assessment for this project has been developed and approved.

Introduction:

New Hampshire's coastal rivers once supported abundant runs of anadromous fish including river herring (alewife and blueback herring) and American shad (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 coastal rivers. Restoration of diadromous fish populations began with construction of fishways in the late 1960’s and early 1970’s by the New Hampshire Fish and Game Department (NHFGD) 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 have been made to the Winnicut and Exeter River fish ladders to improve their effectiveness at passing alosids. In an additional modification, a holding trap was constructed at the top of the Exeter River fish ladder to facilitate monitoring of spawning populations by allowing accumulation of spawning fish for enumeration and collection of biological data.

River herring serve as a significant bait source for commercial and recreational fisheries, while American shad are an important recreational fish. Unlike the Atlantic salmon 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 runoffs for spawning.

The river herring runs have been monitored at NHFGD 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 sample lengths, sex ratios, and age data, are available from previous studies under Federal Aid Projects F-36-R and F-50-R. In addition, 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, Bigelow and Schroeder 1953), construction of fishways, 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 shad per year. With the purchase of circular transport tanks in the 1980's came the opportunity to transport live, gravid adults to spawn in the coastal river systems. From 1980 to 1988, between 600 and 1300 gravid adult shad were transported annually and distributed into the Exeter, Lamprey, and Cocheco rivers. In 1989, the decision was made to concentrate restoration efforts to 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. This river continues to be the focus of the American shad restoration program, however, residual American shad spawning runs still remain in the Lamprey and Cocheco rivers.

<u>Procedures</u>:

Seven fish ladders on six, coastal, New Hampshire rivers (Cocheco, Exeter, Lamprey, Oyster, Winnicut, and Taylor rivers) were operated from early April to mid-July, to allow for the passage of river herring, American shad, and other diadromous fish to historical spawning and nursery areas. All fish passing through the fishways were either enumerated by hand passing 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.

The Pickpocket fishway, which is the second fish ladder on the Exeter River, was operated without monitoring to provide upstream and downstream fish passage from spring through fall. The Lamprey River ladder was operated as a swim through operation with a counting tube until the majority of the river herring run had passed. The ladder was then set as a trap to allow for enumeration and biological sampling of American shad that arrive later in the spawning season.

Biological samples consisting of length measurements, sex determination, and scale samples, used for age determination, were collected from river herring and shad at all fishways each year. The biological sampling target for river herring was apportioned between the beginning, middle, and end of the spawning runs of each river. Each sample attempted to gather approximately 150 length measurements (total length in millimeters) and sex determinations. Scale samples were taken from approximately 50 fish per sample when available. All American shad encountered were sampled unless the fish showed signs of stress due to elevated water temperatures.

All alosid 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. Scale samples were also used for species determination for river herring (i.e. alewife or blueback herring) using methods described by MacLellan et al. (1981). Two or more readers independently aged all scales.

NHFGD and the U.S. Fish and Wildlife Service (USFWS) continued a cooperative trap and transport program to enhance river herring runs in New Hampshire rivers. During the spawning run, river herring were collected from coastal fishways and transported to impoundments or lakes in coastal watersheds. Any out-of-basin transfers are limited to 10% of the spawning run from rivers that river herring are transferred from if conditions allow.

Additional anadromous fish restoration activities included NHFGD working with dam owners, state and federal agencies and non-governmental organizations (NGO's) 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 hearings.

Results:

River Herring

Estimated numbers of spawning adult river herring passing through the six monitored fishways in 2005 ranged from 66 at the Exeter River fish ladder to 40,026 at the Lamprey River ladder (Table 1-1). Cumulatively, river herring numbers were down 59% from 176,383 in 2004 to 72,346 in 2005. The earliest runs occurred in the Cocheco and Lamprey rivers with both beginning on April 21 (Table 1-2). River herring runs in the Exeter, Oyster, Taylor, and Winnicut rivers started in mid-May. Water temperatures during the peak of the spawning runs ranged from 12.0° C in the Cocheco River to 20° C in the Winnicut River.

A summary of biological data collected from samples of river herring migrating through all the fishways is presented in Table 1-3. Males dominated biological samples in all rivers. Females had a larger mean length than males in all sampled locations. Alewives comprised 100% of fish sampled in the Lamprey and Exeter river's spawning runs, and the largest percentage of the runs in the Cocheco and Winnicut rivers. Blueback herring made up 100% of sampled fish in the Oyster and Taylor rivers.

Tables 1-4 and 1-5 presents results of age analysis of the 612 river herring scales sampled from all fishways in 2005. Age III and IV fish dominated the Winnicut River run making up 65.7% of aged fish. The majority of fish in the Taylor River were age IV, comprising 92.8% of the sample. Age IV and V fish dominated the river herring sampled in the Exeter and Oyster rivers (89.6% and 66.8%, respectively). Older fish (VII+) were represented in all rivers but the Oyster and Taylor rivers.

Approximately 3,200 river herring were transferred via stocking trucks from two coastal fishways to enhance local spawning runs; 2,200 from the Lamprey River and 1,000 from the Cocheco River (Table 1-6). In-river transfers of fish to the Lamprey River drainage included 950 river herring to Pawtuckaway Lake and 1,050 above the Wiswall Dam, the second obstruction in the river. Cocheco in-river transfers included 400 fish to Bow Lake and 600 above the Watson Dam. Two hundred river herring taken from the Lamprey River and stocked in the Exeter River above the Pickpocket fishway were the only out-of-river transfers. Table 1-7 shows a complete list of river herring enhancement stockings since 1984.

American Shad

In 2005, no supplemental American shad stocking occurred in the Exeter River due to low returns to the Lawrence fish lift on the Merrimack River (Table 1-8).

Confirmed shad returns in 2005 to coastal fishways were three in the Exeter River, 12 in the Lamprey River, and eight in the Cocheco River (Table 1-9). Shad returns to the Cocheco fish ladder occurred between May 31 and June 26, at the Exeter ladder from May 30 to June 4, and at the Lamprey ladder from May 25 to June 29 (Table 1-10). The Lamprey ladder was operated as a swim through equipped with an electronic counting device until June 8. During that period, some shad may have passed through the ladder without being observed.

Of the 19 shad from which biological samples were taken in the three rivers, the sex ratio was approximately 3:1 with 11 males and eight females. Males dominated the shad returns to the Cocheco and Lamprey rivers while females dominated the returns to the Exeter River (Table 1-10). Sampled shad ranged from age V to VII with the majority being age VI (53%). Average length for females was greater than males in all rivers (Table 1-10). Table 1-11 shows the complete age distribution for American shad encountered in each river.

Additional Cooperative Anadromous Fish Passage Projects:

In 2005, NHFGD staff participated with New Hampshire’s Rivers Restoration Task Force (RRTF). The RRTF is comprised of state, federal and NGO’s in a collaborative effort of exploring opportunities to selectively remove dams for a variety of reasons, including the restoration of rivers, fish movement and eliminating public safety hazards.

One project undertaken by this group in 2004 was the complete removal of the partially breached, head-of-tide dam on the Bellamy River (Bellamy River V Dam; Figure 1-1). As a follow up to the removal, Normandeau Associates donated time and resources to assess post-dam fish habitat. NHFG personnel assisted in directing the survey. The project’s report continues to be in draft form at the end of 2005.

Two other projects which will enhance anadromous fish passage in coastal rivers are still in the planning phase. A feasibility study was completed for a dam owned by NHFGD on the Winnicut River in Greenland, NH to provide alternative options for river restoration at that site. The options analyzed included no action, install an Alaska Steeppass fishway, or remove the dam and install a technical fish pass system at the next barrier. In 2005, a decision was made to remove the dam and install a fish passage system at the Rt. 33 bridge obstruction. State agencies, the River Restoration Task Force, and the consultant have initiated the second phase that includes fishway design, dam removal planning, plus riverbed and shoreline restoration.

The NHFGD has also been working this year with the Army Corp of Engineers and several other federal, state and local agencies and organizations to evaluate options for fish passage of anadromous fish at Wiswall Dam on the Lamprey River in Durham. Three major options were evaluated: dam removal, a denil fish ladder, and a nature-like fishway. In 2004, the nature-like fishway was chosen as the preferred option for this location. In 2005, a draft Environmental Assessment (EA) was prepared and presented at a public informational hearing in Durham. The EA was subsequently approved with a finding of no significant impact.

Discussion:

River Herring

In 2005, the numbers of spawning adult river herring utilizing New Hampshire coastal fishways decreased to lows not recorded since 1977 (Table 1-1). High flows during the spawning run are considered a significant factor in lower return numbers in 2005. Figure 1-2 gives an example of the high water discharge rate in the Exeter River and can be compared to the nine-year mean daily discharge from April through June. All six rivers experienced these flows during the spawning migration of river herring and shad. High flows prevent river herring and American shad from either finding the entrances of fishways or traversing the current to a fishway. Those rivers that had an early pulse of alewives prior to the high flow conditions (~April 21, 2006) were able to pass more river herring than other rivers with later spring runs, such as the Oyster River.

The Lamprey River's spawning stock of alewives decreased for the first time since 1997 (Table 1-1). However, the total number of returning river herring was the largest of the six rivers monitored. This river traditionally has the earliest run of river herring and this likely allowed the majority of fish to pass before the extended period of high flows set in at the end of May. Additionally, annual in-river transfers of spawning fish to Pawtuckaway Lake since 1994 (Table 1-7) have allowed river herring to make use of inaccessible spawning and nursery habitat within the Lamprey River drainage system and influenced the continual increases in returns observed in recent years.

The Cocheco River spawning run also experienced an early pulse of river herring, producing the second highest returns to any monitored coastal river in 2005. Returns, however, may also have been affected by the high flow conditions, and thus 2005 experienced the lowest return since 1987. Between 2000 and 2003 the returns to this river system increased to a peak of 71,199 river herring. Since 2003, the Cocheco River run decreased 33% to 47,934 in 2004 and another 66% in 2005 (Table 1-1).

Trap and transport operations from the Cocheco fish ladder continued in 2005 with approximately 400 river herring transported to Bow Lake and 600 to above the Watson Dam, both impoundments within the watershed (Tables 1-6 and 1-7). The Bow Lake transfers appear to have driven the sharp increases in the spawning run observed since the 1990s, most notably during 1992, 1995, 2002 and 2003 (Table 1-1).

Smaller river systems than the Lamprey and Cocheco rivers also experienced lower returns. The Exeter River returns were the lowest number observed since the installation of the fish trap in 1991(Table 1-1). The returns in the Oyster River were the lowest numbers observed since 1985. The Taylor River run has continued its precipitous decline to record low levels for the fifth year in a row.

While modifications to the Exeter River ladder in 2000 had an initial positive impact on river herring usage of the fish ladder, the numbers have continued to drop since 2001 (Table 1-1). This indicates that the problem is most likely not with the ladder but with the spawning run, recruitment, and possibly flow regime.

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 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, (Rich Langan, unpublished data) 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 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 (Smith et al, 2005). 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 (Figure 1-3). The decreased spawning returns of river herring to the Exeter River may be due to poor survival of juvenile out-migrating 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.

Another potential reason for this river's precipitous drop in returns could be in-river harvest of river herring by coastal netters. The most significant harvest pressure of river herring in this river occurs at a constriction point below the String Bridge located immediately down river of the dam. This could be resulting in excess harvest of river herring before they are able to utilize the ladder to access spawning habitat.

The largest reported harvest of river herring in NH each year occurs in the Exeter/Squamscott River averaging approximately 29,000 fish annually between 1999-2003 (see Project I Job 6). Harvest during 2005 in this river dropped to roughly 1,704 river herring. This decline may in part be due to regulations instituted in 2005, in response to the declining spawning runs to this river, that restricted the harvest of river herring by coastal netters (See Project 1 Job 6).

In 2005, the Oyster River saw a significant decline in river herring numbers (Table 1-1). As with the other rivers, high flows during the latter portion of the run may account for much of this decline (Figure 1-2). Blueback herring, which arrive from the ocean markedly later than alewives, constitute 100% of the run in this river. 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). Additional monitoring is needed to determine whether or not water quality issues are affecting the river herring run in this river.

River herring using the Taylor River fish ladder have continued to decrease dramatically from 44,010 fish in 2000 to 223 in 2005 (Table 1-1). Large accumulations of fish historically observed below the dam were not observed in 2005. The low returns and the difficulty in obtaining biological samples at this fishway have posed problems in obtaining sufficient samples to accurately assess the population in this river system. The 14 samples that were gathered from a nearby culvert were comprised primarily of males that were predominantly age IV individuals. Low sample numbers make analysis of recruitment and age structure unsound.

The Taylor River dam site is currently being evaluated for either repair or removal by state and federal agencies. A feasibility study will be conducted in 2006 that will not only assess options for the dam, but will also monitor water quality within the impoundment above the dam to determine if it may be causing a detrimental effect on both immigrating and emigrating diadromous fish.

This year marks the eighth year of successful passage of river herring through the Winnicut River step-weir fish ladder since modifications were made in 1997. Further changes to the water flow dynamics of the fishway were implemented in 2002 by altering the position of chutes located within each pool of the ladder. These changes served to effectively reduce the eddying effect of water within each pool, which may have prevented fish from utilizing the ladder in previous years. Due to high flows in 2005 the entrance to the fishway may have been difficult to find accounting for the lowest returns since 2001 (Table 1-1). The age distribution, however, is typical of a river under restoration with age III and IV fish accounting for 65.7% of returns indicating a growing population (Table 1-4). The initiation of enhancement stocking of spawning river herring in the Winnicut River in 1998 (through 2000), plus good recruitment, may also have produced a positive effect indicated by the relatively high percentage of age VII+ fish in 2005(Table 1-4).

American Shad

In 2005, total number of returning American shad decreased from 67 in 2004 to 23 (Table 1-10). Returns in all three rivers decreased after having increases in the Cocheco and Lamprey rivers for the past two years. High flows before and during the runs in monitored rivers may account for this occurrence. The return numbers in the Lamprey River exceed those of the Exeter River again this year, while those in the Cocheco River were greater than the Exeter for the first time since 1992.

While all rivers declined, none did so to the extent of the Exeter River, which dropped from 22 fish in 2004 to three fish in 2005 (Table 1-9). Furthermore, numbers of returns in the Exeter River have been decreasing each year since 2000 when a peak of 163 shad returned. This is a confounding occurrence given that restoration efforts using trap and transport operations have focused exclusively on the Exeter River since 1989. Despite American shad’s strong philopatry, there have been studies indicating straying occurs to spawn within other nearby river system (Waters, et al., 1999). Considering the close proximity of the confluence of the Lamprey and Squamscott/Exeter River into Great Bay, straying of these two shad populations may be occurring between the two river systems.

Apart from the possibility of straying, there are several other potential explanations for continued reduction in shad returning to the Exeter River ladder in 2005. The first of these explanations is the ongoing impact from lack of supplemental stocking between 1995 and 1997, due to constraints on shad transfers from the Connecticut River (Table 1-8). This impact is reflected in the absence of ages VIII and IX^{+} that correspond to years supplemental stocking did not occur (Table 1-12). Age class VII and younger correspond to years that the trap and transfer of adult shad resumed in the Exeter River after a three year hiatus (Table 1-12). Closer examination of Table 1-12 reveals that the decline in return numbers over the last year occurred across all year classes, suggesting that other factors are affecting returns other than the three year cessation of shad transfers. One potential factor is the combination of low dissolved oxygen and downstream passage problems in the Exeter River discussed in the previous river herring section.

It appears that the ocean intercept fishery in the mid-Atlantic that had been undergoing a gradual phased closure, ending in 2004, has not necessarily affected this river’s returns. Though the harvesting of American shad in state waters is prohibited by methods other than angling, there is potential for incidental mortality of this small stock of shad occurring within the river herring fishery described in the previous section.

No adult shad were stocked in 2005 due to concern over low returns to the fish lift in the Merrimack River (Table 1-9). This lack of supplemental stocking should be evident in return numbers in future years.

Although the smallest decrease was seen in returning shad in the Cocheco River, dropping from 12 to eight fish, these numbers are still low, reflecting the termination of stocking adult shad in 1988 (Table 1-8). It appears that wild returns from previous stockings may be insufficient to sustain a spawning population in this river.

<u>Additional Cooperative Anadromous Fish Passage Projects:</u>

The three fish passage projects NHFGD has been working on with other state, federal and NGO’s are dam removal projects in the Taylor and Winnicut Rivers and fish passage at Wiswall Dam in the Lamprey River.

The collaborative effort is exploring fish passage options at Wiswall Dam, which is the second dam above head-of-tide on the Lamprey River.

Representatives from several federal, state and local agencies and organizations formed the Wiswall Fish Passage Working Group in 2001 to assess various fish passage options for this dam. The three major options evaluated were dam removal, construction of a Denil fish ladder or construction of a nature-like fishway. In 2004, the Working Group selected the latter option as the preferred alternative and a draft Environmental Assessment was prepared and approved with a finding of no significant impact for the nature-like fishway. The dam owner, Town of Durham, will develop final design specifications during 2006 in preparation for seeking final approval for the project.

The NHFGD had received a Dam Inspection Report from New Hampshire Department of Environmental Services (DES) Dam Bureau regarding safety concerns of the Winnicut River head-of-tide dam. This dam was rebuilt in the 1950’s for waterfowl habitat and a Canadian step-weir ladder was installed for anadromous fish passage. Since this fishway is an inefficient design for the predominant anadromous species using this river, river herring, the NHFGD initiated a feasibility study in collaboration with DES-Office of State Planning and the National Oceanic and Atmospheric Administration to show the various options available for efficient fish passage. The feasibility study was completed in 2004 and outlined the options of repairing the dam, redesigning a more efficient fish passage or dam removal. The NHFGD has decided in 2005 to remove this dam and build a fish passage system at the next barrier. The remaining in-river obstacle is rock-fill placed in the river created during the construction of the Route 33 Bridge about 100 feet above the current dam. State and federal agencies have reconvened a workgroup to oversee consultants in designing a fish passage system, obtain permits, and produce a decommission design for dam removal and habitat restoration. This will enhance overall river restoration potential for both river herring and rainbow smelt.

In summary, the total number of river herring using all coastal river fish ladders in 2005 decreased by 59% from 2004 levels. High flows during the major portion of the river herring run is the most probable factor behind these low returns. The Taylor and Exeter rivers continue to exhibit signs that restoration problems are occurring, and the Oyster River is beginning to show indications of similar concern. These problems are probably resulting from downstream migration impediments during prolonged low water conditions, poor water quality within the impoundments during emigration, over harvesting from in-river fisheries, or a combination of the three.

These same conditions may also be affecting declining returns of

American shad to the Exeter River despite active restoration efforts. Other potential factors that may be contributing to the decline could be the cessation of adult stocking from 1995 to 1997, incidental mortality in the in-river fishery for river herring, and straying into the adjacent Lamprey River.

In the continuing efforts to increase and improve anadromous fish spawning and rearing habitat, NHFG has been involved with state and federal agencies and NGO’s in initiating dam removal of fish passage options at dams in three coastal New Hampshire rivers: the Winnicut, Taylor, and Lamprey rivers.

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Table 1-1. Numbers of river herring returning to fishways on coastal New Hampshire rivers from 1972 - 2005.

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	525	172,557
2001	46,590	6,703	66,989	39,330	7,065	1,118	167,795
2002	62,472	3,341	58,179	58,605	5,829	7,041	195,467
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	223	2,703	72,346

* - Due to damage to the fish trap, fishway became a swim through operation.
+ - Fishway unable to pass fish until modifications in 1997.
++ - Fish netted below and hand passed over Winnicut River dam.

Table 1-2. Summary data for river herring spawning runs for coastal New Hampshire rivers, 2005.

RIVER	RIVER HERRING RUN		TEMPERATURE (ºC)			RETURN (#'s)	COUNT METHOD*
	START	END	MIN.	MAX.	PEAK+		
COCHECO	4-21-05	6-26-05	7.0	22.0	12.0	16,446	H
EXETER	5-12-05	6-10-05	8.0	24.0	15.0	66	H
OYSTER	5-12-05	6-29-05	8.0	25.0	15.0	12,882	E, H
LAMPREY	4-21-05	6-8-05	7.0	26.0	14.0	40,026	E, H
TAYLOR	5-19-05	6-17-05	10.0	29.0	15.0	223	E, H
WINNICUT	5-12-05	6-29-05	6.0	27.0	20.0	2,703	E, H

+ - Temperature at peak of spawning run
* - H = hand count; E = electronic counter

Table 1-3. Mean length (total length in centimeters), percent sex composition and percent species composition of river herring spawning runs from samples obtained at coastal New Hampshire fish ladders, 2005.

RIVER	MEAN LENGTH (cm)		% MALE	% FEMALE	N	% ALEWIVE	% BLUEBACK
	MALE	FEMALE					
COCHECO	28.49	29.37	50.4	49.6	347	96.0	4.0
EXETER	27.77	28.92	66.2	33.8	77	100.0	0.0
OYSTER	25.69	27.31	60.5	39.5	343	0.0	100.0
LAMPREY	28.98	29.81	57.2	42.8	402	100.0	0.0
TAYLOR	25.55	26.30	71.4	28.6	14	0.0	100.0
WINNICUT	24.69	26.62	78.4	21.6	343	65.8	34.2

Table 1-4. **Age composition of river herring spawning in New Hampshire coastal rivers derived from scale samples taken at the beginning, middle and end of the run, 2000-2005.**

RIVER	YEAR	N	Age (%)				
			III	IV	V	VI	VII+
COCHECO	2000	131	46.6	27.5	20.6	5.3	0.0
	2001	142	14.1	43.0	30.3	6.3	6.3
	2002	146	11.6	37.0	30.8	16.4	4.1
	2003	136	4.4	65.4	21.3	5.1	3.7
	2004	120	0.8	12.5	57.5	22.5	6.6
	2005	125	1.6	23.2	37.6	36.8	0.8
EXETER	2000	97	54.6	38.1	5.2	2.1	0.0
	2001	141	5.7	31.9	33.3	22.0	7.1
	2002	54	3.7	27.8	50.0	18.5	0.0
	2003	55	3.6	54.5	25.5	10.9	5.5
	2004	57	0.0	10.5	54.3	31.5	3.5
	2005	64	3.1	39.0	40.6	12.5	4.6
OYSTER	2000	145	42.8	39.3	17.2	0.7	0.0
	2001	146	14.4	33.6	28.1	17.1	6.8
	2002	142	8.5	38.0	26.1	19.7	7.7
	2003	148	21.6	41.2	29.1	4.7	3.4
	2004	131	15.2	12.9	52.6	16.0	3.0
	2005	127	17.3	31.4	35.4	15.7	0
LAMPREY	2000	195	25.6	34.9	22.6	13.3	3.6
	2001	145	7.6	33.8	35.9	17.9	4.8
	2002	139	2.2	20.1	28.1	30.2	19.4
	2003	143	5.6	37.1	28.7	11.9	16.8
	2004	162	4.3	16.0	38.8	27.7	12.9
	2005	130	0	20.0	43.0	33.8	3.0
TAYLOR	2000	97	33.0	47.4	14.4	5.2	0.0
	2001	NO SAMPLES TAKEN					
	2002	30	3.3	3.3	20.0	53.3	20.0
	2003	NO SAMPLES TAKEN					
	2004	68	32.3	27.9	22.0	10.2	7.3
	2005	14	7.1	92.8	0	0	0
WINNICUT	2000	178	33.3	39.5	16.9	9.0	1.1
	2001	146	28.8	43.8	17.1	9.6	0.7
	2002	147	19.7	41.5	21.1	13.6	4.1
	2003	147	24.5	59.9	14.3	1.4	0.0
	2004	137	2.1	43.0	48.1	5.1	1.4
	2005	152	31.5	34.2	25.0	8.5	6.0

Table 1-5. **River herring age distribution, by length, from scale samples taken at the Cocheco, Exeter, Lamprey, Oyster, Taylor, and Winnicut River fish ladders during the spring spawning run, 2005.**

Area: Cocheco River

Sex: Both

	Age III	IV	V	VI	VII+	Total
Length Group (centimeters)						
21.						
22.						
23.						
24.						
25.	1	3	1			5
26.	1	6	6			13
27.		14	9	4		27
28.		5	13	6		24
29.		1	15	8		24
30.			2	18		20
31.			1	9	1	11
32.				1		1
33.						
34.						
35.						
36.						
37.						
Total	2	29	47	46	1	125
% Dist.	1.6	23.2	37.6	36.8	0.8	
Mean	25.8	27.2	28.3	30.0	31.5	
Minimum	25.1	25.6	25.6	27.7	31.5	
Maximum	26.5	29.1	31.7	32.7	31.5	

Table 1-5 continued.

Area: Exeter/Squamscott River Sex: Both

	Age					
	III	IV	V	VI	VII+	Total
Length Group (centimeters)						
21.						
22.						
23.	2					2
24.						
25.		3	1			4
26.		6	1			7
27.		14	7			21
28.		1	8	2		11
29.		1	8	4		13
30.			1		1	2
31.				1		1
32.					1	1
33.				1	1	2
34.						
35.						
36.						
37.						
Total	2	25	26	8	3	64
% Dist.	3.1	39.0	40.6	12.5	4.6	
Mean	23.6	27.1	28.3	30.0	32.2	
Minimum	23.4	25.1	25.9	28.5	30.6	
Maximum	23.8	29.1	30.1	33.7	33.5	

Table 1-5 continued.

Area: Oyster River Sex: Both

	Age					
	III	IV	V	VI	VII+	Total
Length Group (centimeters)						
21.						
22.	4	1				5
23.	6	3				9
24.	8	8	1			17
25.	3	11	5			19
26.	1	13	10	3		27
27.		3	16	7		26
28.		1	13	5		19
29.				5		5
30.						
31.						
32.						
33.						
34.						
35.						
36.						
37.						
Total	22	40	45	20		127
% Dist.	17.3	31.4	35.4	15.7		
Mean	24.1	25.5	27.1	27.9		
Minimum	22.2	22.4	24.1	26.5		
Maximum	26.1	28.2	28.8	29.1		

Table 1-5 continued.

Area: Lamprey River   Sex: Both

Length Group (centimeters)	Age III	IV	V	VI	VII+	Total
21.						
22.						
23.						
24.						
25.		3	1			4
26.		7				7
27.		9	4			13
28.		7	22	7		36
29.			20	11		31
30.			9	16		25
31.				7	1	8
32.				2	2	4
33.				1	1	2
34.						
35.						
36.						
37.						
Total		26	56	44	4	130
% Dist.		20.0	43.0	33.8	3.0	
Mean		27.2	29.0	30.1	32.3	
Minimum		25.6	25.2	28.0	31.1	
Maximum		28.8	30.9	33.6	33.4	

Table 1-5 continued.

Area: Taylor River Sex: Both

	Age III	IV	V	VI	VII+	Total
Length Group (centimeters)						
21.						
22.						
23.						
24.		1				1
25.	1	7				8
26.		3				3
27.		2				2
28.						
29.						
30.						
31.						
32.						
33.						
34.						
35.						
36.						
37.						
Total	1	13				14
% Dist.	7.1	92.8				
Mean	25.3	25.8				
Minimum	25.3	24.8				
Maximum	25.3	27.2				

Table 1-5 Continued.

Area: Winnicut River Sex: Both

	Age III	IV	V	VI	VII+	Total
Length Group (centimeters)						
21.	6					6
22.	8	2				10
23.	22	10				32
24.	11	17				28
25.	1	17	8	1		27
26.		3	14	7	1	25
27.		3	9	4		16
28.			7	1		8
29.						
30.						
31.						
32.						
33.						
34.						
35.						
36.						
37.						
Total	48	52	38	13	1	152
% Dist.	31.5	34.2	25.0	8.5	0.6	
Mean	23.3	24.7	26.8	26.8	26.3	
Minimum	21.2	22.9	25.1	25.2	26.3	
Maximum	25.2	27.6	28.6	28.2	26.3	

Table 1-6. **Summary of anadromous river herring transfers from the Cocheco and Lamprey rivers during 2005.**

DATE	# TRANSFERRED	SOURCE OF RIVER HERRING	STOCKING LOCATION	DRAINAGE SYSTEM
5/13/05	400	Cocheco River	Bow Lake	Cocheco River
5/13/05	1050	Lamprey River	Above Wiswall Dam	Lamprey River
5/17/05	810	Lamprey River	Pawtuckaway L.	Lamprey River
5/17/05	165	Cocheco River	Above Watson Dam	Cocheco River
5/19/05	200	Lamprey River	Above Pickpocket Fishway	Exeter River
5/19/05	140	Lamprey River	Pawtuckaway L.	Lamprey River
6/2/05	435	Cocheco River	Above Watson Dam	Cocheco River

Table 1-7. Numbers of adult, spawning river herring stocked in coastal New Hampshire rivers from 1984 - 2005.

YEAR	COCHECO RIVER SYSTEM	WINNICUT RIVER	EXETER RIVER	LAMPREY RIVER SYSTEM	SALMON FALLS RIVER
1984	5,000				
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]	

[a] - In-river transfer.
[b] - Combination of in-river and out-of-basin transfers.

Table 1-8. **Numbers of spawning adult American shad stocked in coastal New Hampshire rivers, 1980-2005. Numbers represent the amount transported minus the estimated transport mortality.**

YEAR	EXETER RIVER	LAMPREY RIVER	COCHECO RIVER
1980	283	286	212
1981	212	192	183
1982	185	218	120
1983	265	206	135
1984	517	453	241
1985	418	409	90
1986	680	437	205
1987	420	420	230
1988	375	372	190
1989	779		
1990	1,275		
1991	1,386		
1992	1,384		
1993	979		
1994	1,462		
1995	0[a]		
1996	0[a]		
1997	0[a]		
1998	1,164		
1999	954		
2000	987		
2001	1,168		
2002	1,173		
2003	1,142		
2004	1,332		
2005	0[b]		

[a] None stocked due to constraints placed on shad transfers at the Holyoke fish lift on the Connecticut River.

[b] None stocked due to constraints placed on shad transfers at the Lawrence fish lift on the Merrimack River.

Table 1-9. American shad returns to New Hampshire coastal fishways from 1983-2005.

YEAR	EXETER RIVER	LAMPREY RIVER	COCHECO RIVER
1983			3
1984			
1985		2	1
1986		39	1
1987			
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

* - No counts - ladder was operated as a swim through.
[a] - Minimum counts - ladder operated as swim through until late May or early June.

Table 1-10. **Number of American shad returns, beginning and ending dates of returns and summary of biological data collected from shad using the Cocheco, Exeter, and Lamprey River fish ladders, 1999 - 2005.**

				MALES		FEMALES		AGE (#'s)							
RIVER	**YEAR**	**RETURN NO'S**	**RUN DATES**	**%**	**MEAN LENGTH (cm)**	**%**	**MEAN LENGTH (cm)**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX+**	**SAMPLE SIZE**
COCHECO	2005	8	5/31 - 6/26	71%	48.6	29%	51.1			1	5	2			8
	2004	12	5/13 - 6/17	78%	49.9	22%	54.9			6	2	1			9
	2003	6	5/30 - 6/19	50%	47.5	50%	50.7		3	2		1			6
	2002	4	6/13 - 6/20	0%	NA	100%	52.8			2					2
	2001	6	6/5 - 6/21	75%	50.2	25%	54.0				2	2			4
	2000	14	5/20 - 6/30	60%	48.5	40%	53.5		1	2	5		2		10
	1999	2	5/26 - 5/30	50%	47.4	50%	45.5				2				2
EXETER	2005	3	5/30 - 6/4	33%	49.3	67%	54.2				1	2			3
	2004	22	5/25 - 7/2	52%	49.3	48%	54.1		1	8	9	3			21
	2003	33	5/22 - 6/24	82%	48.7	18%	53.5	1	5	14	11	2			33
	2002	41	5/23 - 6/17	83%	47.2	17%	54.4	1	11	9	7	8	4	2	40
	2001	42	5/2 - 6/10	39%	47.4	61%	54.9		5	2	11	14	4	2	38
	2000	163	5/6 - 6/24	48%	49.9	52%	53.7		1	11	44	62	23	10	151
	1999	129	5/8 - 6/3	79%	47.3	21%	49.7			18	60	36	11	1	126
LAMPREY	2005	12[a]	5/25 - 6/29	75%	49.6	25%	52.0			2	4	2			8
	2004	33[a]	6/7 - 7/16	35%	48.9	65%	54.1			8	11	6	2		27
	2003	26[a]	5/30 - 6/25	76%	49.1	24%	53.1		5	6	9	4	1		25
	2002	4[a]	5/21 - 6/12	100%	45.7	0%	NA		1	2	1				4
	2001	6[a]	5/29 - 6/15	60%	51.0	40%	54.6				1	4			5
	2000	7[a]	5/29 - 6/23	83%	51.2	17%	54.9				2	3	1		6
	1999	3[a]	5/23 - 6/2	67%	45.6	33%	51.2				1	2			3

[a] - Minimum counts - ladder run as swim through until late May or early June

Table 1-11. American shad age distribution of combined sexes, by length, from scale samples taken at the Cocheco, Exeter, and Lamprey river fish ladders during the spring spawning run, 2005.

Area: Cocheco River   Sex: Both

Length Group	Age IV-	V	VI	VII	VIII	IX+	Total
36.							
37.							
38.							
39.							
40.							
41.							
42.							
43.		1					1
44.							
45.							
46.							
47.							
48.			1				1
49.			1				1
50.			2				2
51.			1	2			3
52.							
53.							
54.							
55.							
56.							
57.							
58.							
59.							
60.							
61.							
62.							
Total		1	5	2			8
% Dist.		12.5	62.5	25.0			
Mean		43.7	50.0	51.3			
Minimum		43.7	48.8	51.1			
Maximum		43.7	51.3	51.6			

Table 1-11 Continued.

Area: Exeter/Squamscott River Sex: Both

Length Group	IV-	V	VI	VII	VIII	IX+	Total
	Age						
36.							
37.							
38.							
39.							
40.							
41.							
42.							
43.							
44.							
45.							
46.							
47.							
48.							
49.			1				1
50.							
51.							
52.							
53.				1			1
54.							
55.				1			1
56.							
57.							
58.							
59.							
60.							
61.							
62.							
Total			1	2			3
% Dist.			33.3	66.6			
Mean			49.3	54.2			
Minimum			49.3	53.1			
Maximum			49.3	55.3			

Table 1-11. Continued.

Area: Lamprey River Sex: Both

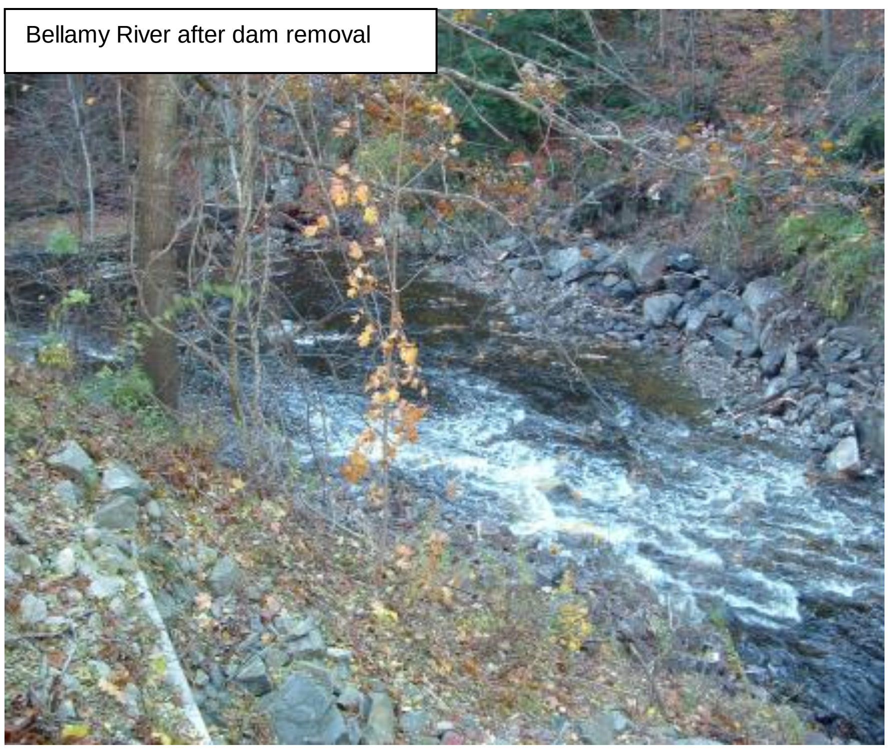
Length Group	IV-	V	VI	VII	VIII	IX+	Total
36.							
37.							
38.							
39.							
40.							
41.							
42.							
43.							
44.							
45.							
46.		1					1
47.							
48.		1	2				3
49.			1				1
50.							
51.							
52.			1				1
53.				1			1
54.							
55.				1			1
56.							
57.							
58.							
59.							
60.							
61.							
62.							
Total		2	4	2			8
% Dist.		25.0	50.0	25.0			
Mean		47.5	49.3	54.4			
Minimum		46.2	48.1	53.8			
Maximum		48.8	52.0	55.1			

Table 1-12. American shad returns by age between 1995-2005 in the Exeter River.

Year	III	IV	V	VI	VII	VIII	IX+	Biological Sample #'s	Return #'s
2005	0	0	0	1	2	0*	0*	3	3
2004	0	1	8	9	3*	0*	0*	21	22
2003	1	5	14	11*	2*	0*	0	33	33
2002	1	10	9*	7*	8*	4	2	40	41
2001	0	5*	2*	11*	14	4	2	38	42
2000	0	1*	11*	44	62	23	10	151	163
1999	0	0*	18	60	36	11	1	126	129
1998	1	16	7	4	3	1	0	32	33
1997	3	2	8	4	4	3	1	25	30
1996	0	11	12	15	7	4	1	50	58
1995	0	1	6	3	3	0	0	13	18

*age groups where no supplemental stocking occurred.

Breached Bellamy River V dam before removal



Bellamy River after dam removal

Figure 1-1: Before and after pictorial depiction of the Bellamy Dam removal project conducted in

November 2004.

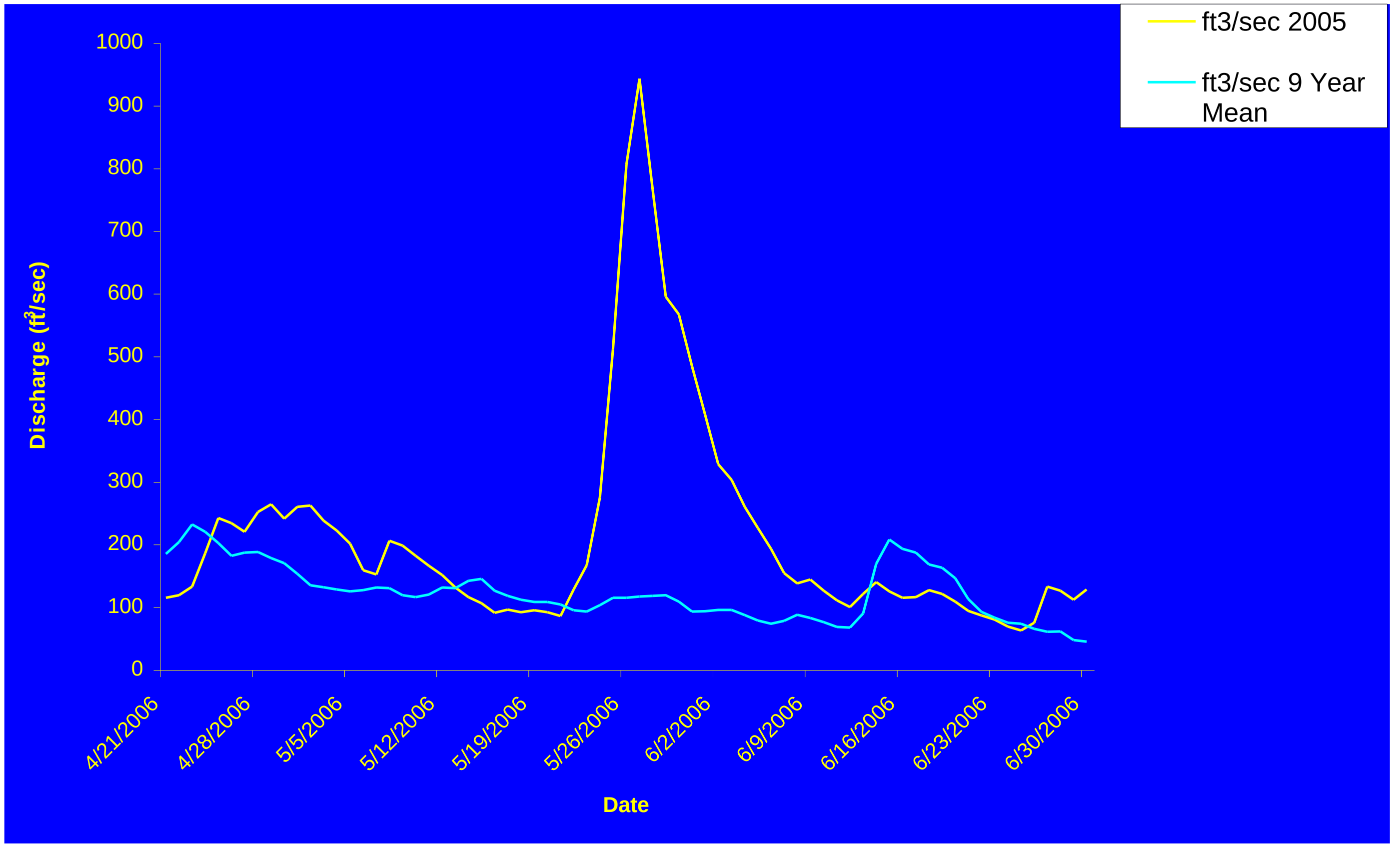


Figure 1-2. Exeter River 2005 daily water discharge and 9 year mean daily discharge from April 21 to June 30.

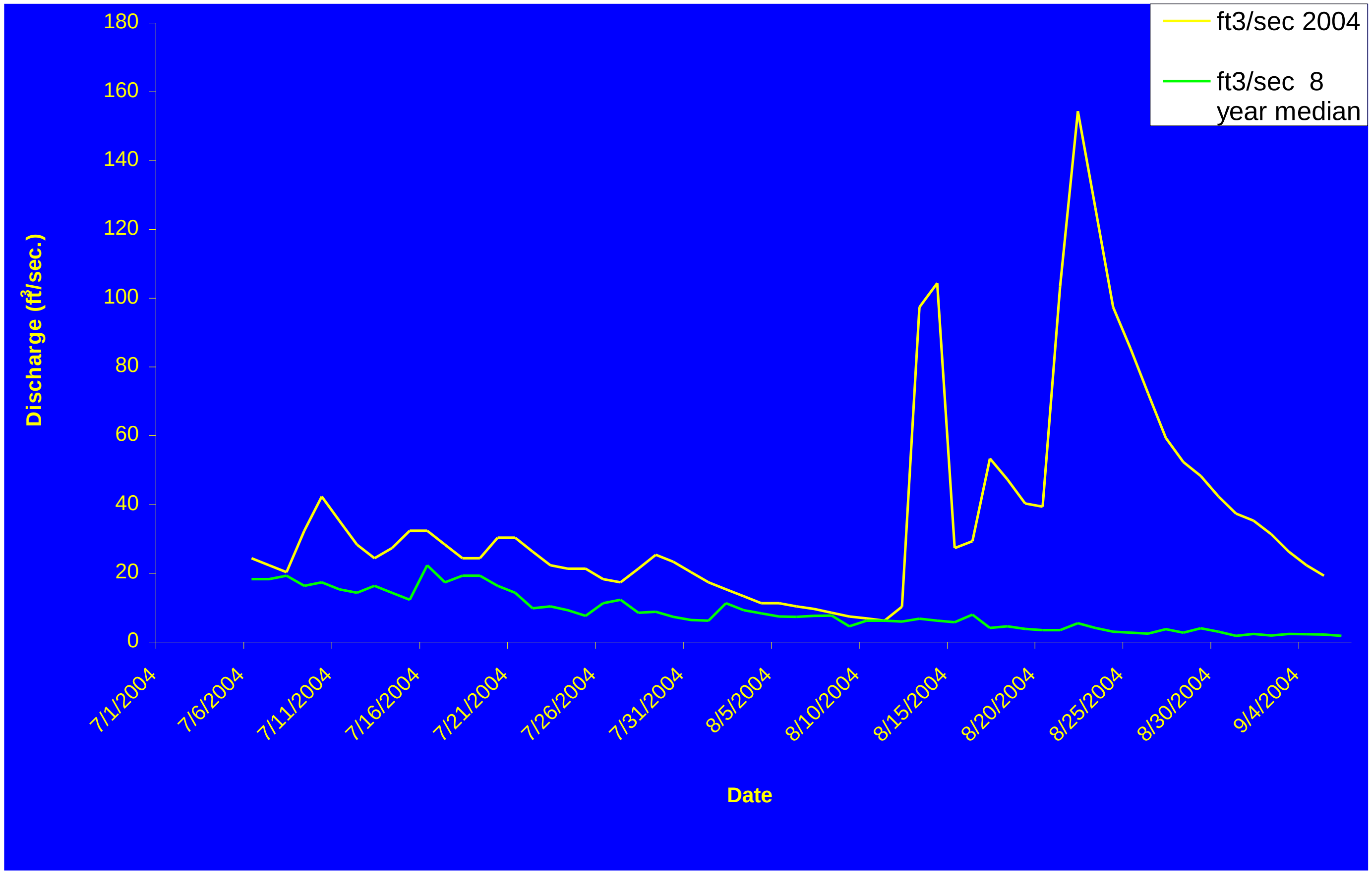


Figure 1-3. **Exeter River 2004 daily water discharge and the eight-year median daily discharge from July 1 to September 10.**