FINAL REPORT

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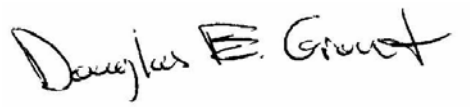
Prepared By: Cheri Patterson, Mike Dionne, Kevin Sullivan, Rebecca Heuss, Renee Zobel, Jessica Fischer, Kim Trull, Robert Eckert, and Chris Warner.

Approved By: 

Douglas Grout, Chief of Marine Fisheries

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Grant Title: NEW HAMPSHIRE'S MARINE FISHERIES INVESTIGATIONS

Project I: ANADROMOUS 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, 2004 - December 31, 2008

Abstract:

Seven department fish ladders on six coastal rivers were operated each spring from 2004-2008 to facilitate the passage of river herring and other anadromous fish over dams. The Cocheco, Exeter, Oyster, and Taylor rivers showed an overall decrease in numbers of river herring within this project period compared to the previous five years. The Lamprey and Winnicut rivers had an increase of 6% and 90%, respectively during the project period. The Exeter and Taylor rivers saw the largest decrease in returns to ladders with numbers dropping by approximately 97%. The most prominent contributing factor to decreased river herring returns could have been flood conditions in 2005, 2006, and 2007.

Analysis of scale samples indicated good recruitment from the 1999 year class with strong age V returns sampled in all rivers in 2004. There was also

good recruitment from the 2000 year class indicated by increased returns in the Winnicut River and a high percent of age IV fish in 2004 and age V fish in 2005 in the Lamprey, Exeter, and Cocheco rivers. Scale analysis indicated the runs of river herring in the Lamprey, Cocheco, Winnicut and Exeter rivers continued to be dominated by alewives, with the exception of a blueback herring dominated run in the Winnicut River in 2006. The Oyster and Taylor rivers spawning runs were mostly comprised of blueback herring from all sampled years between 2004 and 2008, with the exception of the Taylor in 2007.

Approximately 14,000 river herring were transferred into impoundments or lakes in the Great Bay Estuary drainages between 2004 and 2008 to enhance existing spawning populations.

American shad returns during the 2004 to 2008 project period decreased significantly from the last project period. Exeter River returns decreased from 22 fish in 2004 to none in 2007 and 2008. Lamprey River returns ranged from 4 to 33 and Cocheco returns from zero to 12.

During 2004 and 2008, 1448 spawning adult American shad were transported from the Merrimack River in Massachusetts to the Exeter River in an effort to provide additional spawning stock to bolster the native run to this river. Due to flood water conditions, trap and transport operations were not conducted in 2005, 2006, and 2007.

Throughout the project period Department staff was involved in working with the Town of Durham on fish passage at Wiswall Dam. Work also progressed at the Winnicut River with dam removal and run-of-river technical fish passage slated for late in 2009 through 2010. Staff also assisted New Hampshire Department of Transportation on a feasibility study on the Taylor River dam. Maintenance on fishways included a dredge adjacent to the fishway on the Cocheco River as well as leak repair at the Cocheco, Oyster, and Exeter fishways.

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 from the late 1950’s through the 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 rivers fish ladders to improve their effectiveness at passing alosids. In addition, 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 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. 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 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 remains in the Lamprey and Cocheco rivers.

Procedures:

Seven fish ladders on six, coastal, New Hampshire Rivers (Cocheco, Exeter, Lamprey, Oyster, Winnicut, and Taylor 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. All fish passing through the fishways were either enumerated while passing fish with hand held nets or by counts estimated by use of Smith-Root Model 1100/1101 electronic fish counters. Numbers recorded by the electronic fish counters were adjusted from 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 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 reconfigured 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, are attempted to be collected from river herring and shad at all fishways each year. Separate biological samples for river herring were targeted for collection at the beginning, middle, and end of the spawning runs of each river. Target levels for each biological sample consists of 150 length measurements (total length in millimeters) and sex determinations as well as scale samples from 50 fish. 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) attempted to continue 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:

Numbers of spawning adult river herring utilizing New Hampshire coastal fishways varied widely between 2004 and 2008. Returns ranged from a high of 176,383 in 2004 to a low of 34,809 in 2006. Overall, river herring returns decreased by approximately 46% from the last five year project period, declining from 883,067 fish to 477,021 (Table 1-1). The most prominent factor contributing to the decline was severe flood conditions in 2005, 2006, and 2007 affecting fish passage where only 72,346, 34,809, and 96,261 river herring, respectively, passed through fish ladders. Four of the six rivers decreased in total returning river herring over the prior five year project period. Only the Lamprey and Winnicut rivers showed increased return rates.

The number of river herring returning to the Cocheco River fish ladder was significantly lower during the 2004-2008 time period (115,199 river herring) than in the 1999-2003 period (227,878 river herring). This was approximately half the number that returned during the previous project period. The average annual return to the Cocheco River was 23,040 fish and ranged from 47,934 fish in 2004 to 4,318 in 2006 (Table 1-1). Age V and VI individuals dominated the spawning run all years between 2004 and 2008. In 2004, age V fish represented 57.5% of the Cocheco River spawning run (Table 1-2). Alewives dominated the river herring returning to the Cocheco during the five year project period, ranging from 96% in 2005 to 56.8% in 2008 (Table 1-3). In-basin enhancement stocking of river herring to Bow Lake (an upstream impoundment in the Cocheco River) and the next impoundment above the fishway totaled 4,950 river herring, and no out-of-basin transfers occurred during the project period (Table 1-4).

The numbers of river herring utilizing the Exeter River fish ladder ranged from 16 fish in 2006 to 174 fish in 2008, representing an average annual return of 76 river herring (Table 1-1). Age V individuals dominated the spawning runs in every year during the project period except 2008 when age IV fish dominated (42.5%) the sampled run (Table 1-2). Alewives dominated the

river herring returns in the Exeter River. In three of the five years the run consisted of 100% alewives (Table 1-3).

Annual river herring totals in the Oyster River estimated from an electronic counter, ranged from 52,934 fish in 2004 to 6,035 in 2006 (Table 1-1). The Oyster River saw an average annual return of 22,010 river herring during this project period. During the 1999-2003 project period the average was 67,128 river herring per year. Age V individuals dominated the run in 2004 representing 52.6% of returns (Table 1-2). From 2005 to 2007 age IV and V fish comprised the majority of returns. In 2008, age III and IV fish had the highest percentage of returns. Blueback herring constituted 100% of the sampled population for all years except 2004 and 2008, where 2.3% and 2.7%, respectively, of the returns were alewives (Table 1-3).

The Lamprey River had the highest returns in each of the years during this project period ranging from 66,333 in 2004 to 23,471 fish in 2006 (Table 1-1). In 2006 and 2007, more river herring returned to the Lamprey River than the other five rivers monitored combined. The average yearly return has risen slightly from 41,633 fish/year during the last project period, to 44,260 fish/year this period. Age V and VI individuals dominated the spawning runs each year from 2004-2008 (Table 1-2). From the fish sampled in the Lamprey River, alewives made up 100% of the population in most years. However 1.6% of returns in 2006 and 7.3% in 2007 were blueback herring (Table 1-3). Enhancement stockings of river herring to Pawtuckaway Lake (an impoundment in the Lamprey River system) and above Wiswall Dam (first barrier upstream of fishway) during this project period totaled 8,200 river herring. Out-of-basin enhancement stockings to the Exeter River totaled 765 river herring (Table 1-4).

Estimates from an electronic counting tube indicate that Taylor River spawning runs of river herring fluctuated from 147 fish in 2006 to 1,055 fish in 2004 (Table 1-1). Due to decreasing returns of river herring and the swim-through design of the Taylor River fish ladder, it was only possible to obtain length, sex, and scale samples from a limited number of fish, with none being collected in 2006 (Table 1-2). The samples that were collected, suggest that fish ages III and IV dominated the runs in 2004 and 2008. In 2005, age IV fish dominated, and during 2007, age V fish had the highest return percentage (Table 1-2). Blueback herring accounted for almost all of the river herring sampled in each year except 2007 when 100% of fish sampled were alewives (Table 1-3).

The number of spawning river herring passing through the Winnicut River fishway during the project period ranged from 822 fish in 2006 to 8,359 fish in 2008 (Table 1-1). During this project period, three years (2004, 2007, and

2008) had the highest river herring returns observed at this ladder. Of the sampled individuals in the Winnicut River, age IV and V fish generally dominated the returns in all years except 2005 and 2008 (Table 1-2). Age III and IV individuals were the most prevalent in 2005 and age V and VI in 2008. In the Winnicut River spawning runs, alewives returned in greater numbers than blueback herring in all years except 2006 when the run was comprised of 69.5% blueback herring (Table 1-3). There was no enhancement stocking into the Winnicut River during the project period (Table 1-4).

In general, the mean length of both male and female river herring declined in each river system over the project period with a few notable exceptions (Table 1-3). The mean length of Lamprey River females increased to peaks in 2006 and 2007 before declining to its lowest level in 2008. Winnicut River females declined in mean length to its lowest level in 2006 before increasing to its highest level in 2008. In addition, the Lamprey River consistently had the greatest mean length for both males and females for all five years and the smallest mean length generally occurred in the Winnicut or Oyster rivers.

In all rivers, the majority of the returning river herring were males in most years (Table 1-3). The Winnicut River has seen an unusually large proportion of males in individuals sampled in the past five years, with the percentages of males ranging from 78% in 2005 to near 90% in 2006, much higher than the ratios seen in all other monitored rivers. The Taylor River also had high percentages of males in 2005 and 2008, but this is likely not representative of the spawning run due to small sample size.

American Shad:

During the 2004 to 2008 project period, 1,448 American shad were stocked. No shad were stocked between 2005 and 2007 (Tables 1-5 and 1-6). The numbers represent the known number of fish obtained minus the observed transport mortality (Table 1-7).

The highest confirmed shad returns for all rivers combined during the project period was 67 fish in 2004 (Table 1-8). The Lamprey River had a high of 33 shad returning in 2004 and only 4 shad in both 2007 and 2008. (Note: The Lamprey River fishway was operated as a swim through until late May each year so some shad may have passed through the ladder without being observed). Returns to the Exeter River fishway were very low for the project period ranging from 22 in 2004 to no shad in 2007 and 2008. The Cocheco River continues to have low shad returns with a high of 12 fish in 2004 and a low of no shad in 2006.

Biological samples were taken from 102 American shad during the project

period. Of the fish sampled the sex ratio was generally 2 males:1 female. In all rivers sampled, the average length of females was longer then males. Ages of returning shad ranged from IV to VIII with the majority in the age class V and VI (Table 1-10). A complete set of annual tables showing American shad age distribution in the Cocheco, Lamprey, and Exeter river are presented in Appendix 1-1 for the project period.

Analysis:

River Herring:

The New Hampshire annual migrations of river herring declined by approximately 406,000 fish from the previous five year period (Table 1-1). The decline is primarily a result of flood events in 2005, 2006, and 2007 during the river herring migratory period of April through June (Figure 1-1), the most dramatic event occurred in 2006.

Despite flooding conditions in 2006 and 2007, the Lamprey River spawning run increased by approximately 13,000 fish during this project period (Table 2-1). This increase could be partly attributed to the highest river herring return seen at the Lamprey fishway since its construction in 2004 with 66,333 fish. During 2006, when other rivers were being heavily impacted by the flooding, the Lamprey fishway still managed to pass 23,471 fish, over twice as many as the other five fishways combined. Generally, river herring accessing the fish ladder arrive earlier in the Lamprey than other rivers. This may also account for more fish successfully passing through the fishway before the May flood event occurred.

The average annual return of spawning river herring in the Lamprey River from 2004 to 2008 was 44,260, up from 41,633 between 1999 and 2003 and 14,192 fish between 1994 and 1998. The continued increase in returns since 1996 appear to be partly related to the enhancement stocking into Pawtuckaway Lake, an upper impoundment of the Lamprey River system, that allows river herring to utilize inaccessible spawning and nursery habitat within the Lamprey River drainage system. The number of individuals transported to enhance spawning in the upper reaches of the Lamprey River during this project period totaled 8,200 fish (Table 1-4). 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.

In each year with the exception of 2007 age V fish dominated returns to the Lamprey River (Table 1-2). This shows good recruitment during the years

1999-2003. The run of river herring through the Lamprey River fishway still primarily consists of alewives, with less than 8% blueback herring accessing freshwater periodically.

The total number of migrating river herring using the Cocheco River fishway declined by approximately 113,000 fish from the previous five year period (Table 1-1). The decline could be related to low numbers of river herring returning in 2005, 2006, and 2007 primarily due to epic flood events during river herring migratory period. The timing of the flooding in May 2006 affected returning river herring due to its occurrence during the peak period of the spawning run in New Hampshire rivers.

The Cocheco River had the second highest returns of river herring of the six coastal rivers monitored. Age V and VI fish dominated returns during this project period suggesting that there was good year class recruitment from the previous project period (Table 1-2). The Cocheco River continues to have a low occurrence of age III fish during this project period with an exception in 2008 indicating a good recruitment year in 2005. Further indication of a strong 2005 year class is reflected in all river systems except the Winnicut River. River herring age distribution tables for all rivers and project period are presented in Appendix 1-2.

Modifications to the Winnicut River fishway in 1998 and additional minor modifications of water flow dynamics throughout the years have produced successful passage of river herring with nearly twice as many fish passing in the 2004-2008 period (27,471) as previously (Table 1-1). The 2004 to 2008 period had the three highest (2008, 2004, and 2007 respectively) annual spawning returns, since the fishway was constructed. The Winnicut and the Lamprey were the only two rivers monitored to increase in river herring returns from the previous project period in 1999 to 2003. Even with the flood waters that occurred from 2005-2007.

Strong evidence exist that enhancement stocking of spawning river herring in the Winnicut River from 1998 through 2000 continue to support the increase in returning fish. This can be seen by age IV, V, and VI fish comprising 96% of the sampled individuals in 2004 (Table 1-2). Since there has been no additional enhancement stocking since 2000, it appears the increased number of fish passing through the Winnicut River fishway has produced successful recruitment and continued growth in the spawning run.

Plans to remove the Winnicut dam and build a technical fish pass under the Route 33 Bridge are progressing and is planned for late 2009 through 2010. The run-of-river technical fish pass will be a permanent structure requiring only periodic maintenance for Fish & Game Department staff.

Yearly returns of river herring through the Exeter River ladder are the

lowest of the six monitored rivers. The total number of returning fish from 2004-2008 was 379. This is a decrease of more then 13,000 fish from the last project period (Table 1-1). In addition to flood conditions, another potential factor in the low returns is the water quality of the Exeter River impoundment as nursery habitat during the summer months. During these months, normally lower summer precipitation is compounded by the fact that the Town of Exeter pumps water from the impoundment to be used as a water source for the town. In a year with less then normal summer precipitation, water can cease to flow over the dam, thereby preventing the passage of the juveniles into the estuary during normal emigration periods. This has been further corroborated with data collected by the New Hampshire Department of Environmental Services (DES) and the Cooperative Institute for Coastal and Estuarine Environmental Technology (CICEET), from 1995, (Rich Langan, unpublished data) indicating the dissolved oxygen content of the impoundment during July and August is dramatically decreased and drops below critical levels needed for the survival of juvenile river herring. The Town of Exeter and DES are currently conducting an In-Stream Flow study to investigate summer water quality issues.

Age V river herring dominated all years from 2004-2008 in the Exeter River except 2008, where 42.5% of the sampled population was age IV (Table 1-2). The Exeter River is the only river of the six monitored that has spawning habitat below the fishway above the extent of high tide. However, it is unknown how successful river herring spawning is in this area each year, and how much it contributes to the river herring population in the Exeter River.

The river herring returns to the Oyster River had historically been one of the highest yearly returns of all six rivers. During the 1999-2003 project period, more fish passed through the Oyster River fishway than any other river with more then 335,000 river herring negotiating the fishway. During the current project period the Oyster River passed the third highest number of river herring (approximately 110,000 fish) of all six rivers monitored (Table 1-1). The numbers of returning river herring have generally been declining since 1990 to a low of 6,035 in 2006. Flooding conditions in May 2006 likely contributed to the low return numbers in 2006. However, in subsequent years returns to this fish ladder have increased back up to more than 20,000 fish in 2008.

It was suggested previously that the Oyster River was following the pattern of a newly restored river, which overshot its carrying capacity in the early 1990’s, and then leveled off in recent years to what may be the current carrying capacity of the available habitat (Grout et al. 1999). However, the numbers are still decreasing and are now roughly only 10% of those seen at the peak from 1990-1992. There is evidence from water quality sampling, that

dissolved oxygen levels may be affecting survival of juvenile river herring in the impoundment.

As seen in both the Cocheco and Exeter Rivers, 1999 proved to be a year of strong recruitment in the Oyster River, with age V fish accounting for 52.6% of the spawning run in 2004 (Table 1-2). Age IV and V fish accounted for between 60% and 78%, respectively, of the spawning run for each year of the project period.

Throughout this project period, the long-term decline of spawning river herring in the Taylor River since 1986 was continued with a total of 2,618 fish passed from 2004 to 2008 (Table 1-1). The flooding in 2005, 2006, and 2007 likely contributed to the low returns in the Taylor River as it did in other rivers. In 2008, 976 river herring passed through the fishway which was comparable to levels observed just before the three years with flood waters.

As with the Oyster and Exeter rivers, poor water quality has been documented within the Taylor River impoundment, which may be affecting juvenile growth and survival. A method of downstream migration has been provided for the past three years through the use of a chute built into the center stop logs on the dam. This method was intended to provide constant flow of water from the impoundment to the estuary, however the clogging of vegetation effects its utility, despite daily removal of debris during the late summer months.

Biological samples were collected at the Taylor River fish ladder on an intermittent basis due to the lack of a trap at the top and low return numbers in recent years. The most biological data was collected in 2004 with, 68 age/length/sex samples obtained (Table 1-2). The data show a strong representation of age III and IV fish, accounting for over 60% of the sampled individuals, and consisting mostly of blueback herring (98.5%). Low biological samples obtained in 2005, 2007, and 2008 make year class strength or other correlations difficult.

Summary data from biological samples show that the rivers with spawning runs dominated by bluebacks, including the Oyster and Taylor rivers, had smaller mean lengths for both sexes compared to the Cocheco, Exeter, and Lamprey rivers which were dominated by alewives (Table 1-3). The larger mean lengths in the rivers with mostly alewives are the result of blueback herring generally being smaller in size at a given age than alewives (Collette and Klein-MacPhee 2002). The difference can be seen most prominently by comparing biological data from the Lamprey and Oyster Rivers where the mean size at age of alewives from the Lamprey are approximately 2 cm larger than the blueback herring in the Oyster River. The exception to this occurred in the Winnicut River, which had mean lengths similar to rivers dominated by blueback herring

despite having alewives account for an average 67% of fish sampled each year. A possible explanation for this is the relatively high proportion of males returning, accounting for an average 83% of sampled fish. Male river herring are typically smaller than females of the same age and the ratio of males to females within the Winnicut River system is much higher than the other five monitored rivers (Collette and Klein-MacPhee 2002).

In summary, the total number of river herring using the coastal river fish ladders declined during this project period by approximately 400,000 fish from the previous period (1999-2003). The largest decreases in the number of returning fish were seen in the Exeter and Taylor rivers where spawning runs declined by approximately 97%. The Cocheco and Oyster rivers also saw declines of 50% and 68% respectively. Despite an overall decline in returning fish to coastal New Hampshire rivers, the Lamprey River fishway passed 68% more fish than last project period while the Winnicut River run nearly doubled. The recent floods in 2005, 2006, and 2007 are likely the primary reason for the decline in river herring runs. However, poor water quality is likely a contributing factor in the Exeter, Taylor, and Oyster rivers.

In-river trap and transport operations in the Lamprey and Cocheco River continue to enhance the population of river herring along with good recruitment in both rivers from the 1999 and 2000 year classes. The stocking of spawning river herring in the Winnicut River, along with the modifications made to the ladder, have also resulted in dramatic increases in the number of returning fish to this river over the last several years.

American Shad:

The number of shad returning to the Exeter River has dropped from 22 in 2004 to 0 in 2007 and 2008. This decline occurred despite focusing restoration efforts on the Exeter River over the course of the past 20 years. A recent sharp decline in river herring returns suggests that common factors are affecting American shad and river herring. Recent floods in 2005, 2006, and 2007 as well as, poor nursery habitat due to diminished water quality are likely contributing cause.

All adult shad stocked in the Exeter River in 2004 and 2008 came from the Merrimack River. In previous years adult shad were obtained from the Connecticut River resulting in more transport stress due to the longer drive to the Exeter River stocking site. Transporting fish from the Merrimack increased the efficiency of the stocking program. Due to flood waters at the fish lift in Lawrence, MA on the Merrimack, no shad were transferred in 2005, 2006, or 2007. This will impact future shad recruitment to the Exeter River.

Low returns to the Lamprey and Cocheco rivers continue to reflect the

termination of stocking adult shad in 1988. Returns in the Lamprey River ranged from 33 fish in 2004 (highest of all rivers during project period) to four fish in both 2007 and 2008. Returns to the Cocheco River ranged from 12 in 2004 to zero in 2006. It appears that wild returns from previous stockings may be insufficient to sustain a spawning population in these rivers. However, each year during the project period there are as many or more shad returning to the Lamprey and Cocheco as there are returning fish to the Exeter where restoration is occurring. American shad returning to the Cocheco and Lamprey rivers may be strays from shad spawning runs in nearby rivers such as the Salmon Falls River and Exeter Rivers.

In conclusion, shad returns continue to decline despite restoration efforts on the Exeter River. Flood conditions in 2005, 2006, and 2007, as well as, poor water quality in nursery habitat are likely the cause. Low returns to the Lamprey and Cocheco rivers continue to reflect the termination of stocking adult shad in 1988. However, American shad from local remnant populations may continue to provide runs to New Hampshire rivers each year.

During the project period, Department staff was involved in working with the Town of Durham on fish passage at Wiswall Dam. This project is expected to be ongoing through 2010. Work has also progressed at the Winnicut River with dam removal and run-of-river technical fish passage slated for late in 2009 through 2010. Staff has also assisted New Hampshire Department of Transportation on a feasibility study on the Taylor River dam. Maintenance on fishways during the project period include a dredge adjacent to the fishway on the Cocheco River as well as leak repair at he Cocheco, Oyster, and Exeter fishways.

Recommendations:

River Herring:

The New Hampshire Fish and Game Department (NHFGD) is working with local, state, and federal officials to develop fish passage or removal at the Wiswall Dam on the Lamprey River. This will open 53 more miles of spawning and nursery habitat for river herring and other anadromous fish. In addition, NHFGD is working with local, state, and federal officials for the removal of the Winnicut River fishway and construction of a run-of-river technical fish pass under the Route 33 bridge on the Winnicut River in Greenland. This will open the entire Winnicut watershed to diadromous species for year round fish passage. Efforts such as these to either provide for fish passage or removal of dams on all of the coastal rivers in New Hampshire should be continued to establish better river connectivity between the head waters to head of tide.

Continued maintenance and modifications to the aging coastal fish ladders will be necessary to ensure efficient fish passage. Construction of a holding box within the Taylor River fishway, could also result in more consistent collection of biological samples that are generally hard to obtain in the river, allowing for better examination of age, sex, and species dynamics within they system. Continued stocking of river herring to aid in future success in the restoration efforts in various river systems is also necessary.

Downstream migration structures for juvenile river herring during summer months, similar to that currently in use at the Cocheco River fishway, need to be provided for all the fishways located on coastal rivers. This could possibly increase recruitment for all years, but especially during years with drought-like conditions, by providing continuous passage for fish, even during low flow years.

American Shad:

Current trap and transport operations should be discontinued. Evidence suggests that water quality in nursery habitat is impaired and should be addressed before continuing with a trap and transport program into the Exeter River. Monitoring of returning adult American shad should continue. The use of hatchery reared American shad fry to enhance restoration efforts should be explored in the future and evaluated for river systems not experiencing poor water quality. Effort should continue to restore access to historical spawning and nursery habitat in coastal New Hampshire rivers via removal of dams or construction of fish passage structures.

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Table 1-1. Numbers of river herring returning to fishways on coastal New Hampshire rivers from 1972 - 2008.

YEAR	COCHECO RIVER	EXETER RIVER	OYSTER RIVER	LAMPREY RIVER	TAYLOR RIVER	WINNICUT RIVER
1972				2,528		+
1973				1,380		+
1974				1,627		+
1975		2,639		2,882		+
1976	9,500		11,777	3,951	450,000	+
1977	29,500		359	11,256		2,700++
1978	1,925	205	419	20,461	168,256	3,229++
1979	586	186	496	23,747	375,302	3,410++
1980	7,713	2,516	2,921	26,512	205,420	4,393++
1981	6,559	15,626	5,099	50,226	94,060	2,316++
1982	4,129	542	6,563	66,189	126,182	2,500++
1983	968	1	8,866	54,546	151,100	+
1984	477		5,179	40,213	45,600	+
1985	974		4,116	54,365	108,201	+
1986	2,612	1,125	93,024	46,623	117,000	1,000++
1987	3,557	220	57,745	45,895	63,514	+
1988	3,915		73,866	31,897	30,297	+
1989	18,455		38,925	26,149	41,395	+
1990	31,697		154,588	25,457	27,210	+
1991	25,753	313	151,975	29,871	46,392	+
1992	72,491	537	157,024	16,511	49,108	+
1993	40,372	278	73,788	25,289	84,859	+
1994	33,140	*	91,974	14,119	42,164	+
1995	79,385	592	82,895	15,904	14,757	+
1996	32,767	248	82,362	11,200	10,113	+
1997	31,182	1,302	57,920	22,236	20,420	+
1998	25,277	392	85,116	15,947	11,979	219
1999	16,679	2,821	88,063	20,067	25,197	305
2000	30,938	533	70,873	25,678	44,010	525
2001	46,590	6,703	66,989	39,330	7,065	1,118
2002	62,472	3,341	58,179	58,605	5,829	7,041
2003	71,199	71	51,536	64,486	1,397	5,427
2004	47,934	83	52,934	66,333	1,055	8,044
2005	16,446	66	12,882	40,026	223	2,703
2006	4,318	16	6,035	23,471	147	822
2007	15,815	40	17,421	55,225	217**	7,543
2008	30,686	174	20,780	36,247	976	8,359

*- Due to damage to the fish trap, fishway became a 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.

Table 1-2. 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, 2004-2008.

RIVER	YEAR	N	Age (%)				
			III	IV	V	VI	VII+
COCHECO	2004	120	0.8	12.5	57.5	22.5	6.6
	2005	125	1.6	23.2	37.6	36.8	0.8
	2006	85	0.0	15.2	24.7	29.4	30.5
	2007	160	0.0	19.4	35.0	33.8	11.9
	2008	146	4.1	18.5	39.0	30.1	8.2
EXETER	2004	57	0.0	10.5	54.3	31.5	3.5
	2005	64	3.1	39.0	40.6	12.5	4.6
	2006	16	0.0	6.2	37.5	25.0	31.2
	2007	40	7.5	22.5	37.5	27.5	5.0
	2008	146	14.4	42.5	30.1	11.0	2.1
OYSTER	2004	131	15.2	12.9	52.6	16.0	3.0
	2005	127	17.3	31.4	35.4	15.7	0.0
	2006	141	4.2	34.0	32.6	22.6	6.3
	2007	179	5.0	39.7	38.0	12.3	5.0
	2008	149	30.9	32.2	25.5	7.4	4.0
LAMPREY	2004	162	4.3	16.0	38.8	27.7	12.9
	2005	130	0.0	20.0	43.0	33.8	3.0
	2006	124	2.4	10.4	33.8	29.0	24.1
	2007	151	1.3	13.9	27.8	35.8	21.2
	2008	143	6.3	17.5	36.4	25.9	14.0
TAYLOR	2004	68	32.3	27.9	22.0	10.2	7.3
	2005	14	7.1	92.8	0.0	0.0	0.0
	2006	NO SAMPLES TAKEN					
	2007	19	0.0	5.3	52.6	31.6	10.6
	2008	7	42.9	57.1	0.0	0.0	0.0
WINNICUT	2004	137	2.1	43.0	48.1	5.1	1.4
	2005	152	31.5	34.2	25.0	8.5	6.0
	2006	105	8.5	39.0	32.3	15.2	4.7
	2007	169	3.0	33.1	35.5	18.9	9.5
	2008	150	3.3	19.3	47.3	24.7	5.4

Table 1-3. Mean length (total length in centimeters), percent sex composition and percent species composition of river herring spawning runs from samples obtained in coastal New Hampshire fish ladders 2004-2008.

RIVER	YEAR	MEAN LENGTH (cm)		%	%		%	%
		MALE	FEMALE	MALE	FEMALE	N	ALEWIFE	BBH
COCHECO	2004	28.2	28.8	42.4	57.6	450	85.8	14.2
	2005	28.5	29.4	50.4	49.6	347	96.0	4.0
	2006	28.1	29.5	60.0	40.0	300	90.6	9.4
	2007	27.2	28.5	62.8	37.2	450*	58.1	41.9
	2008	26.4	27.8	58.4	41.6	450	56.8	43.2
EXETER	2004	27.7	28.6	57.7	42.3	78	77.2	22.8
	2005	27.8	28.9	66.2	33.8	77	100.0	0.0
	2006	27.5	29.3	43.8	56.2	16	100.0	0.0
	2007	26.8	28.3	60.0	40.0	40	100.0	0.0
	2008	26.8	27.8	58.2	41.8	174	92.4	7.6
OYSTER	2004	26.3	27.5	58.0	42.0	452	2.3	97.7
	2005	25.7	27.3	60.5	39.5	343	0.0	100.0
	2006	25.1	27.3	79.1	20.9	446*	0.0	100.0
	2007	25.4	26.7	64.7	35.3	491	0.0	100.0
	2008	24.8	26.3	65.8	34.2	450	2.7	97.3
LAMPREY	2004	28.5	29.0	53.0	47.0	453	100.0	0.0
	2005	29.0	29.8	57.2	42.8	402	100.0	0.0
	2006	28.9	30.3	55.3	44.7	330	98.4	1.6
	2007	28.2	30.3	59.6	40.4	350	92.7	7.3
	2008	27.4	28.3	47.5	52.5	450	100.0	0.0
TAYLOR	2004	25.5	27.5	63.8	36.2	80	1.5	98.5
	2005	25.6	26.3	71.4	28.6	14	0.0	100.0
	2006	NO SAMPLES TAKEN						
	2007	28.7	27.9	61.1	38.9	19	100.0	0.0
	2008	23.9	+	100.0	0.0	7	0.0	100.0
WINNICUT	2004	26.0	26.9	79.0	21.0	453	67.9	32.1
	2005	24.7	26.6	78.4	21.6	343	65.8	34.2
	2006	25.1	26.4	89.5	10.5	124	30.5	69.5
	2007	25.7	27.0	88.0	12.0	404	82.2	17.8
	2008	25.9	27.4	81.4	18.6	450	89.3	10.7

*- sex not determined on two samples.
+- no females samples.

Table 1-4. Numbers of river herring stocked in coastal New Hampshire rivers from 1984 - 2008.

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[b]	
2005	1,000[a]		200	2,000[b]	
2006	1,000[a]		40	200[b]	
2007	900[a]		175	2,000[b]	
2008	1,000[a]		250	2,000[b]	

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

Table 1-5. **Numbers of spawning adult American shad stocked in coastal New Hampshire rivers, 1980-2008. 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		
1996	0		
1997	0		
1998	1,164		
1999	954		
2000	987		
2001	1,168		
2002	1,173		
2003	1,142		
2004	1,332		
2005	0		
2006	0		
2007	0		
2008	116		

Table 1-6. American shad trap and transfer dates, stocking locations, water temperatures, number of stocked shad, and mortalities for 2004-2008.

		Water Temp. (°C)					Transport mortality		
Date	Stocking Location	Merrimack R	Exeter R.	# Stocked	# Mortality	% Mortality	Female	Male	Unknown
6/2/2004	Pickpocket	16.5	15	97	3	3.00%	3		
6/3/2004	Pickpocket	16.5	15	91	9	9.00%	9		
6/4/2004	Pickpocket	17	17	100	0	0.00%			
6/4/2004	Pickpocket	17	17	100	0	0.00%			
6/4/2004	Pickpocket	17	17	97	3	3.00%	2	1	
6/5/2004	Pickpocket	17.5	16	89	11	11.00%	10	1	
6/5/2004	Pickpocket	17.5	16	92	8	8.00%	8		
6/5/2004	Pickpocket	17.5	16	90	0	0.00%			
6/7/2004	Pickpocket	17.5	17	100	0	0.00%			
6/7/2004	Pickpocket	17.5	17	88	12	12.00%	10	2	
6/8/2004	Pickpocket	18	17	98	2	2.00%	2		
6/8/2004	Pickpocket	18	17	100	0	0.00%			
6/11/2004	Pickpocket	20	20	100	0	0.00%			
6/11/2004	Pickpocket	20	20	90	3	3.23%	3		
2005	No fish stocked in 2005								
2006	No fish stocked in 2006								
2007	No fish stocked in 2007								
6/3/2008	Pickpocket	21	21	116	34	29.3	17	17	

Table 1-7. American shad mortality rates during transfers from the Merrimack and Connecticut Rivers from 1994-2008.

Year	# Stocked	# Mort.	% Mort.	River
2008	116	34	29.3	Merrimack
2007	*			
2006	*			
2005	*			
2004	1332	51	3.83%	Merrimack
2003	1142	34	2.89%	Merrimack
2002	1173	39	3.32%	Merrimack
2001	666	58	8.00%	Connecticut
2001	502	3	0.60%	Merrimack
2000	987	147	12.96%	Connecticut
1999	954	25	2.49%	Connecticut
1998	1217	53	4.40%	Connecticut
1994	1558	96	6.20%	Connecticut

* no transfers

Table 1-8. American shad returns to New Hampshire coastal fishways from 1983-2008.

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
2006	2	6[a]	0
2007	0	4[a]	7
2008	0	4[a]	7

* - No counts - ladder was operated as a swim through.
[a] - Minimum counts - ladder operated as swim through until the 3rd or 4th week of May.

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, 2004- 2008.

				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	2008	7	6/3-6/18	100%	43.5	0%					2	3			5
	2007	7	5/24-6/1	71%	47.2	29%	53.4			3	2	1	1		7
	2006	0													
	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
EXETER	2008	0													
	2007	0													
	2006	2	5/7 - 6/4	[b]	48.8	[b]				1	1				2
	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
LAMPREY	2008	4	5/29-6/10	100%	41.8	0%			1	1	1	1			4
	2007	4	5/26-6/1	100%	47.4	0%	NA		1	1	2				4
	2006	6	5/27 - 6/4	67%	49.3	33%	53.5				2		2		4
	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

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

[*] - Age groups where no stocking occurred.

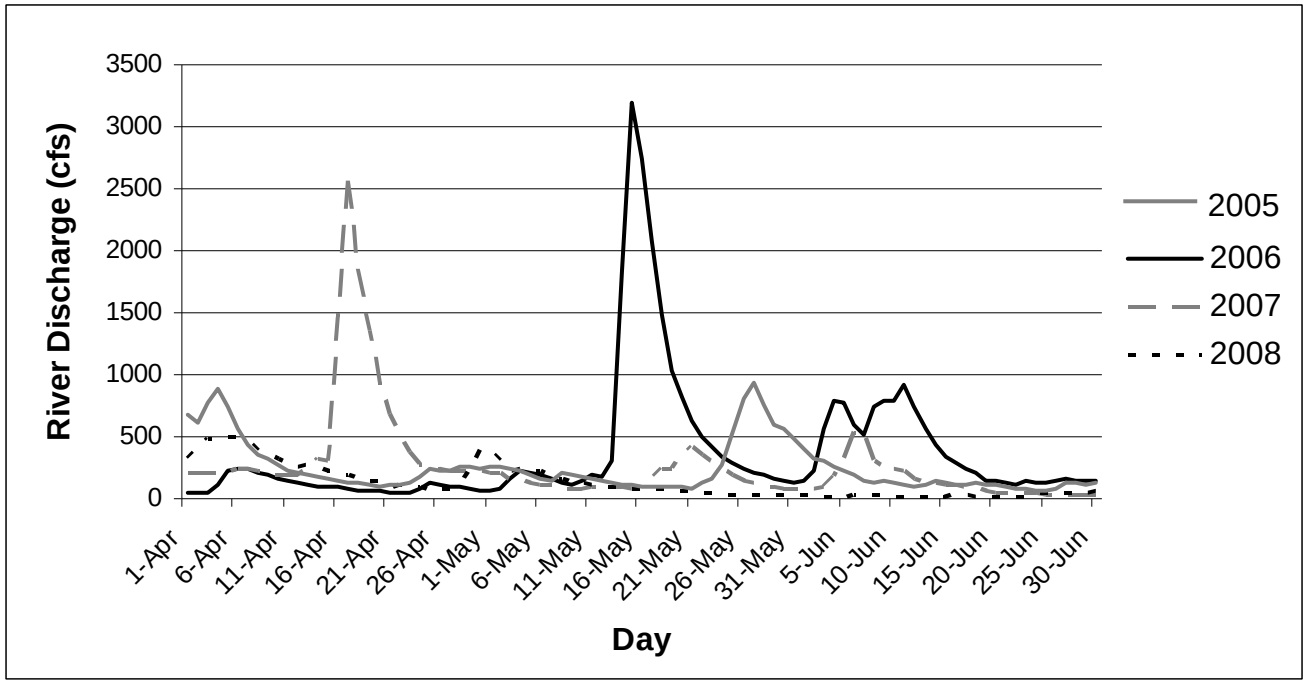

Figure 1-1 Exeter River (freshwater portion of the Squamscott River) discharge in 2005, 2006, 2007, and 2008.