Strategic Plan & Status Review

Anadromous Fish Restoration Program

Merrimack River

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&
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INTRODUCTION

This document represents the scheduled revision of the Atlantic Salmon Strategic Plan (1990). It provides historical perspective, basin descriptive information, a restoration program summary, a detailed description of progress made to date relative to the target fish species, and the Strategic Plan for continued restoration of these fish species into the 21st century. The cooperating fisheries agencies have expanded the restoration program planning effort in several important ways. First, this Status Review and Strategic Plan addresses the river herrings (alewife and blueback herring), and the American shad, in addition to the Atlantic salmon. Second, this plan proposes a holistic approach to anadromous fish restoration. This "watershed approach" recognizes the dynamic physical, biological, political and economical connectedness of the Merrimack River basin from its headwaters in the White Mountains to its confluence with the Gulf of Maine.

It is hoped that this document will challenge the public and other watershed resource stakeholders to assist the program cooperators in identifying the acceptable measurement of success of the anadromous fish restoration effort. Measuring success will require a candid portrayal of expectations and agreement on whether the program results are ecologically, scientifically, economically, and politically acceptable.

This document will be updated in the year 2005. If changes in program direction or significant new information occur prior to 2005, updates may be required at an earlier date. The Strategic Plan (Section III) still embodies the goal of restoring the Atlantic salmon to a self-sustaining level estimated at 1,900 multi-sea-winter females reaching the spawning grounds. Restoration of American shad and the river herrings is also directed at developing and maintaining self-sustaining populations to their historical habitat. Full restoration levels for the American shad and river herrings are unknown at this time because of insufficient life-history and habitat data. Within the planning period of this document it is unlikely that any of the target species will reach levels of self-sustainment. Cyclical fluctuations in marine survivals, ineffective upstream and downstream fish passage, and a host of additional factors make it impossible to predict accurately what population levels can be achieved through this restoration program. In light of this, the cooperating agencies have developed three interim objectives that are considered achievable within the next decade.

I. An adult Atlantic salmon population that will exceed the sea run broodstock holding capacity of the Nashua National Fish Hatchery (300) and provide some level of reproduction in the wild.

II. An annual average of 35,000 adult American shad passing the Essex fish-lift in Lawrence.

III. An annual average of 300,000 adult river herring passing the Essex fish-lift in Lawrence.

The completion of this document does not signal an end to the planning process. Several of the actions identified within the Strategic Plan address the need to develop additional management plans. Specifically, American shad and the river herrings are without management plans that would guide their restoration directions. Additionally, the development of an Operational Plan, that will include detailed activities to implement the various strategies and actions identified in the Strategic Plan, will be required. The Operational Plan itself, will be revised annually or as the need arises.

THE MERRIMACK RIVER BASIN

BASIN FORMATION AND COLONIZATION BY FISH

As written by Oatis (1977), "The Merrimack River basin (Figure 1) took on its basic form approximately 550 million years ago when the heavy mantle of metamorphic and igneous rocks buckled, folded and collapsed in on the core of a cooling earth thus giving rise to high mountain ranges."

"Flowing southeasterly the river drains a 5,010 square mile area from sources high in the Franconia Range of the White Mountains. It flows through Profile Lake where, under the watchful eye of the Old Man of the Mountain, it drops rapidly between a gradual series of lesser mountains and hills through progressively broader valleys for a distance 136 miles, whereupon it turns perpendicular to its axis and meanders north-easterly for 45 miles among rolling hills to a point where it returns to the sea at Plum Island Sound.

The precipitous northern slopes drained by the Pemigewasset River system, being formed of hard granite, continue to reflect an appearance that only the forces of wind, water and ice can fashion, while the southern slopes of the Winnipesaukee drainage are made of softer granites which are less resistant to the forces of nature and man.

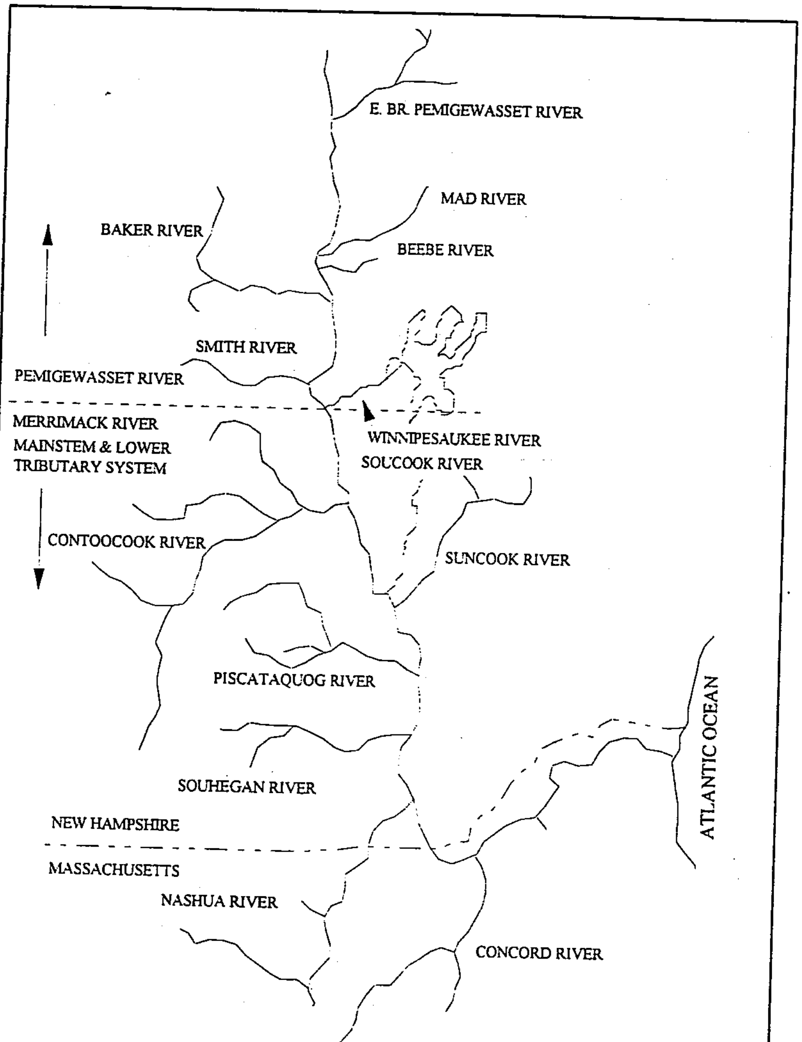

FIGURE 1. PRINCIPAL MERRIMACK RIVER TRIBUTARIES.

It is at the junction of these two unique rivers where the steep, swift, cold Pemigewasset meets the gentle, warmer Winnipesaukee, that the Merrimack is born. The unique contribution of both of these river systems has made the Merrimack what it is with respect to the colonization of all life forms including fish and man.

Most of the fish that we are familiar with today are believed to have originated in freshwater approximately 400 million years ago. Since then the land and sea have undergone many significant changes. As a result many ancient forms of fish have died out while others have given rise to the modern forms.

Some of these modern fish descendants continue to live their entire life cycle in freshwater, while many have completely reverted to the sea. Completing the spectrum are the anadromous and catadromous species that are of necessity linked to both worlds. The former, represented by salmon, shad, alewife, smelt and sturgeon, require freshwater to spawn, while the young must migrate to the sea in order to grow to maturity. Catadromous species, represented by the eel, spawn in the ocean and mature in freshwater.

The Merrimack River basin was completely covered by a continental ice sheet twenty to fifty thousand years ago. As the ice cap retreated, fish began to colonize this new habitat. These early pioneers doubtless belonged to such coldwater species as salmons, chars, sculpins and burbots which were followed by those other anadromous species (like alewives, striped bass and shad) that require warm water for spawning and development. As old river beds were captured, and moraine and kettle ponds formed, some of these fishes became landlocked, giving rise to recognizable races or subspecies such as landlocked salmon and Sunapee trout.

As the waters warmed another group of strictly freshwater species invaded the river basin either from a now defunct water course that connected with the Great Lakes and Mississippi Drainages and/or from the middle Atlantic region via a less salty ocean (the result of ice melt). These species represented by the common and longnose suckers, dace, pickerel, pumpkinseed, perch, bullheads and certain shiners."

The Merrimack River was first surveyed by Goodman Woodward in 1638, and is the fourth largest in New England (Browne 1906). The Merrimack River has nine major tributaries (Table 1). The largest, the Pemigewasset River, has five major tributaries within its own system.

CLIMATE

A variable temperate climate characterized by moderately warm summers, cold winters, and ample rainfall, prevails in the watershed. Severe weather conditions occur in the upper basin. The basin lies in the path of prevailing westerlies and the cyclonic disturbances that cross the country from the west or southeast toward the east or northeast. The lower sections of the watershed are occasionally exposed to coastal storms traveling up the Atlantic Coast.

The basin receives an annual average precipitation of 43 inches; northern and southern areas averaging 46 and 41 inches, respectively. Annual snowfall varies from approximately 98 inches in the headwaters to half that in the southern portion of the basin.

Table 1. Major Tributaries of the Merrimack River Basin.

Tributary Name	Distance from Tributary's Confluence with Main Stem to Ocean	Drainage Area in Square Miles	Percent of Total Basin
Concord River	40	405	8
Nashua River	55	538	11
Souhegan River	63	171	3
Piscataquog River	71	202	4
Suncook River	83	157	3
Soucook River	86	77	2
Contoocook River	101	776	15
Winnipesaukee River	115	488	10
Pemigewasset River Smith River Baker River Beebe River Mad River East Branch	115	1021	20

RIVER FLOW

The Merrimack River has an average annual flow of approximately 8,000 cubic feet per second (CFS) at the mouth of the river, with extreme fluctuations occurring among the seasons and within a given month. The nine tributaries identified within Table 1 account for nearly 50% of the average annual flow. The fluctuations in river discharge are due to the flashy nature of the headwaters where steep gradients and relatively young flood plain forests are subject to rain-on-snow events annually and hurricanes occasionally. This can have significant impacts on spawning and rearing habitat for Atlantic salmon. Recorded extremes for maximum and minimum discharges (Lowell, MA) are 173,000 CFS on March 20, 1936 and 199 CFS on September 23, 1923, respectively (Kuzmeskus, et al 1982). Historically, low flows occur during the months of August, September, and October whereas high flows typically occur from March through May.

WATER QUALITY

As recently as the 1960s, the Merrimack was among the ten most polluted rivers in the United States. The Clean Water Act was instrumental in bringing about a "sea of change" in the river's health. Today, largely as a result of the construction of municipal and industrial wastewater treatment plants, the Merrimack is a much cleaner river. Three-hundred thousand watershed residents within Massachusetts and New Hampshire now drink Merrimack River water. A major improvement observed has been a dramatic decrease in biological oxygen demand (BOD) and phosphorous levels - both attributable to improved treatment of municipal and industrial wastewater. That said, pollution problems persist.

Wastewater treatment plants address the majority of point source pollution issues. However, a number of cities situated along the mainstem of the Merrimack continue to contribute untreated wastewater directly to the river through dated combined sewer overflows during periods of excessive precipitation. Runoff from roadways that border the river are another source of contaminants. During the winter months this type of runoff can significantly lower the pH for short periods.

One particular concern raised by a number of environmental scientists is the bioaccumulation of mercury in fish. Both NH and MA have issued public health advisories in an effort to limit the public's consumption of certain fish species from certain sections of the river. Trash and medical waste incinerators, as well as powerplants, are thought to be sources of airborne mercury. In the past mercury has also been used as a wood preservative and fertilizer, pointing to runoff as another potential method of its introduction to the river.

Perhaps the largest challenge facing the Merrimack is nonpoint source pollution. Its control will require the education and cooperation of the watershed's 1.6 million residents.

DAMS

The mainstem of the Merrimack River has five hydroelectric dams (Figure 2). The mainstem of the Pemigewasset River has two hydroelectric dams and an open flood control structure. The remaining tributary system contains more than 100 dams; some utilized for power production and some providing only water control. Because of the hydroelectric dams associated with the basin, the river, as a whole, is not free-flowing. The mainstem of the river from Lawrence, MA to Concord, NH as well as the lower portions of some tributaries, the Concord, Nashua, Piscataquog, Suncook, and Contoocook Rivers, are primarily ponded and slow moving in nature. The upper portions of those tributaries, the Souhegan, Soucook, and Pemigewasset Rivers, and the Merrimack River's mainstem from Concord, NH upstream are the areas possessing some gradient and swifter flowing water.

FISH

During the last 150 years at least 15 or 20 non-indigenous species such as largemouth and smallmouth bass, northern and walleye, carp, rainbow and brown trout, various catfish species and goldfish have successfully established themselves through human introduction. The impact of these introductions on the native species is unknown. More recently the Gizzard shad has reappeared without any intervention by man (Hildebrand 1928, O'Leary and Smith 1987). Today the Merrimack River basin is home to approximately 50 species of fish, nine of which are anadromous (Stolte 1982). The slower moving, ponded reaches within the basin contain the majority of the warmwater species while those areas having steeper gradients contain the majority of the coldwater species.

BASIN RESOURCES

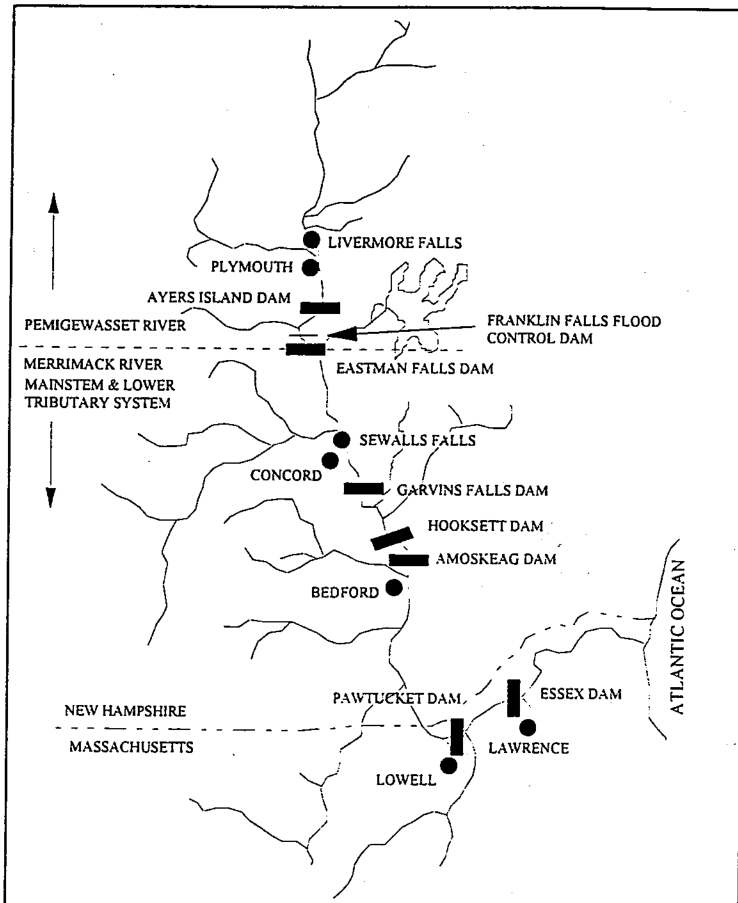

FIGURE 2. PRINCIPAL MERRIMACK RIVER DAMS AND IMPORTANT LANDMARKS.

Basin usage varies from densely populated metropolitan areas in the lower reaches to mountainous rural communities in the headwaters. Much of the headwaters lie within the White Mountain National Forest, which is the most heavily used outdoor recreation attraction in New England, receiving visits on a level comparable or greater than the nation's largest national parks including Yellowstone and Yosemite (New Hampshire Office of Travel and Tourism 1995 - unpublished).

The high recreational use of the White Mountains, including recreational angling, hiking, camping, and skiing, etc., also have associated impacts such as water withdrawal for snow-making, shoreline habitat degradation, and development to support the recreational industry. In addition, the National Forest provides timber for New Hampshire's wood products industry. Quantifiable economic benefits to New Hampshire and Massachusetts from the multiple uses of the watershed are substantial. There is also immeasurable intrinsic value in the scenic beauty and the desire of the public to see fish and wildlife thriving in their own habitats. These multiple uses must be carefully managed to protect the quality of prime salmon spawning and rearing habitat.

In contrast to the rural nature of the upper valley, the lower reaches of the Merrimack can be characterized as the urban industrial hub of the basin. The "Industrial Revolution", sparked by the efficient utilization of water power to run textile milling machinery, was responsible for the growth and development of major manufacturing centers such as Lowell and Lawrence. The contributions of these mills to our national heritage has been duly recognized by the creation of the Lowell National Historical Park. Communities at the river's mouth historically based their economies on shipbuilding, fishing and commerce.

Today, boating and sport fishing are the dominant recreational uses of the lower river, while the role that water power played in the development and industrialization of the lower basin continues to provide energy through hydroelectricity generation. Commercial fishing and associated support facilities also continue to support the economy of the river mouth communities.

SECTION III

STRATEGIC PLAN FOR THE RESTORATION OF ANADROMOUS FISH TO THE MERRIMACK RIVER

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Strategy 1: Implement a watershed approach to anadromous fish restoration.

1.A. Cooperate with local, state and federal agencies to maintain and restore aquatic habitat critical to anadromous fish restoration including water quality, water quantity, riparian condition, substrate quality, and adequate fish passage throughout the watershed, including the following:

1.A.1. Work with state, local and federal agencies to assure protection and enhancement of existing aquatic habitat in the basin.

- Identify, map and make available to agencies that regulate activities affecting aquatic habitat (discharge permits, road and bridge construction, bank stabilization activities, development proposals, water withdrawals), the location and importance of spawning and rearing habitat in the basin for the target species.

- Water Quality: work with Merrimack River Initiative and discharge permitting agencies (NH Department of Environmental Services, MA Department of Environmental Protection, US Environmental Protection Agency) to assure high water quality in the Basin.

- Water Quantity: work within appropriate regulatory processes (Federal Energy Regulatory Commission hydro licensing, 404 permits, , state 401 permits, Forest Service Special Use Permits, Water Management Act and Inter-basin Transfer Act for MA), and basin planning initiatives (NH and MA Rivers Protection Programs) to assure adequate instream flows for spawning and rearing habitat of target species.

- Substrates: work within appropriate regulatory processes to maintain low levels of percent fines in prime Atlantic salmon spawning and rearing habitat.

- Identify and prioritize riparian and aquatic habitat areas impacted by past or ongoing human disturbance, and explore opportunities for restoration.

1.A.2. Fish Passage: assure safe and effective upstream and downstream fish passage for all target species by monitoring the efficiency of fish passage facilities and implementing new measures or modifying existing projects as needed.

- Continue to work with Consolidated Hydro, Inc. and Public Service of New Hampshire to ensure that upstream passage at the Lawrence, Lowell and Amoskeag hydroelectric projects operate effectively to pass target species.

- Continue to work with Public Service of New Hampshire to ensure that smolt downstream passage at the Public Service of New Hampshire hydroelectric projects is pursued in accordance with the existing fish passage plan.

- Continue to work with Consolidated Hydro, Inc. to ensure that downstream passage issues at the Lawrence and Lowell hydroelectric projects are resolved effectively and in a timely manner.

- Continue to pursue the resolution of the downstream fish passage issues at those projects not included within existing fish passage agreements.

- Identify and evaluate potential downstream fish passage problems at specific sites where potential passage problems exist.

1.B. Identify and implement initiatives to restore stocks of target species.

1.B.1. Produce Atlantic salmon fry and smolts to meet program needs (currently projected at 4,000,000 fry and 200,000 smolts).

- Continue to evaluate the current fry stocking target.

- Maintain adult sea run salmon holding capability at the Nashua National Fish Hatchery.

- Maintain domestic broodstock production at the Nashua National Fish Hatchery to meet program needs.

- Maintain and utilize existing egg incubation capability at the North Attleboro National Fish Hatchery to meet program needs.

- Maintain and utilize existing capability at the Warren State Fish Hatchery to incubate eggs for the program.

- Maintain annual production of 50,000 yearling smolts at Green Lake National Fish Hatchery.

- Identify and implement measures to increase smolt production to meet the target of 200,000.

- Determine the desirability and feasibility for maintaining kelts or domestic broodstock at the North Attleboro National Fish Hatchery to assist in providing for a stable supply of eggs.

1.B.2. Develop a comprehensive adult salmon management plan for sea run salmon and domestic broodstock.

- Develop a management plan for the disposition of adult sea run salmon.
- Develop a management plan for the disposition of domestic broodstock.

1.B.3. Assess the American shad and river herring populations in the Merrimack River and develop plans for their restoration.

- Evaluate the shad and herring populations in the river.
- Identify, quantify and map shad and herring spawning and rearing habitat throughout the basin.
- Determine the need for and evaluate the effectiveness of intra-basin as well as inter-basin transfers of adult shad and river herring and continue and/or modify program as appropriate.
- Evaluate and pursue opportunities for providing fish passage to facilitate restoration of river herring into currently blocked habitat.
- Identify and quantify exploitation of adult shad and river herring within the Merrimack River Basin.
- Evaluate the feasibility of implementing fish cultural operations for American shad.

1.B.4. Evaluate the population effects of predation on target species.

1.B.5. Work towards the development of Merrimack River specific stocks of target species.

1.C. Monitor and evaluate the measurable components of the restoration program to guide modifications as needed.

1.C.1. Develop and implement an evaluation and monitoring plan to (1) continue basin wide estimates of fall parr abundance (tributary specific preferred), (2) obtain an annual basin wide smolt production index (tributary specific preferred), (3) determine timing of smolt migration within the Merrimack River watershed and (4) identify and quantify the sources of smolt mortality that occurs in the river and estuary.

1.C.2. Develop and implement a program for monitoring the quality of salmon spawning and rearing habitat.

1.C.3. Continue to provide for evaluation of the domestic broodstock releases (sport fishery, natural reproduction, fish movement, etc.) to maximize their benefit to the Merrimack River program.

1.C.4. Refine instream habitat evaluation to best use hatchery Atlantic salmon products (eggs, unfed fry, fry, parr, and smolts).

1.C.5. Monitor existing upstream and downstream fish passage facilities and modifications for efficiency in passing American shad, river herring, and Atlantic salmon.

1.C.6. Continue to support monitoring efforts proposed by the North Atlantic Salmon Conservation Organization, the Atlantic States Marine Fisheries Commission, other cooperators, agencies and organizations to evaluate oceanic habitat conditions, marine fisheries and their impact on the target species.

1.C.7. Develop and implement a program for monitoring the recreational fishery downstream from the Lawrence hydroelectric project.

Strategy 2. Continue to develop new and enhance existing partnerships with watershed stakeholders which maximize resources available for achieving program objectives.

2.A. Collaborate with other anadromous fish restoration programs and Merrimack River basin resource programs in order to exchange information and minimize duplication of efforts.

2.A.1. Seek ways to monitor and adjust management objectives that are based on state-of-the-art technologies and methodologies through collaboration with the research community.

2.B. Continue to encourage communication and information exchange with those agencies, regulatory bodies, and organizations having related jurisdictional interests and responsibilities.

2.B.1. Continue to support the reduction in the ocean fishery for Atlantic salmon and any monitoring that is proposed by North Atlantic Salmon Conservation Organization.

2.B.2. Provide technical input and assistance to other watershed resource planning efforts within the basin to assure objectives are compatible with and support anadromous fish restoration efforts.

2.C. Coordinate fish stocking with state agencies such that species known to be predaceous on juvenile salmon are not stocked in key restoration areas.

2.D. Develop new and maintain and enhance existing partnerships with other water resource users such as Public Service of New Hampshire, Essex Hydro, Consolidated Hydro, Inc. etc.

2.D.1. Establish an advisory group to the Policy Committee consisting of other water resource users.

Strategy 3. Continue to develop and implement educational and outreach activities to promote anadromous fish restoration.

3.A. Continue to implement the interim Domestic Broodstock Sport Fishery as a byproduct of the overall program to restore salmon to the river.

3.A.1. Continue to utilize domestic broodstock for the Domestic Broodstock Sport Fishery such that the harvest objective of 1,000 fish (includes fish caught and released) can be achieved.

- Expand the sport fishery as appropriate to enhance recreational opportunities and economic benefits for the program as well as economic opportunities for local towns.

- Continue to promote angler ethics through the broodstock fishery program.

3.A.2. Expand the role of the Sport Fishery Advisory Board to serve not only as a liaison between anglers and the Policy Committee but to assist the Committee with public involvement and advocacy for the restoration program.

3.B. Expand a coordinated Adopt-a-Salmon Family program as an educational effort to reach people throughout the watershed.

3.C. Continue working with the Amoskeag Fishways Partnership in order to promote the anadromous fish restoration program and aquatic ecosystem management in the watershed.

3.D. Integrate existing outreach activities with other programs in the watershed, including but not limited to the Atlantic Salmon Federation, Trout Unlimited, Natural Resource Conservation Service and local conservation commissions, Merrimack River Initiative, and Gulf of Maine Project.

3.E. Work with the appropriate organizations in developing the outreach contact center in Lawrence, MA.

3.F. Develop an anadromous fish program hot-line for the Merrimack River.

3.G. Develop an active outreach program for the dissemination of information to the media.

3.H. Provide educational and outreach materials to program volunteers.

SECTION IV

HISTORICAL PERSPECTIVE

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PRE-COLONIAL

In pre-colonial times, anadromous fish, most notably the Atlantic salmon (salmon), the American shad (shad), and the river herrings populated the Merrimack River basin. The salmon resource may have numbered as many as 30,000 fish (Stolte 1981). The sizes of the shad and the river herring resources can only be speculated, but were probably much larger than the salmon resource.

Records indicate that salmon frequented the Pemigewasset River system, the Contoocook River, the Soucook River, the Suncook River, the Piscataquog River, the Souhegan River, and the Nashua River (Farmer and Moore 1822, Whiton 1845, Little 1888, Livermore and Putnam 1888, and Musgrove 1904). The Pemigewasset River system encompassed the principal salmon spawning and juvenile production areas of the basin. Whether or not the mainstem of the Merrimack River supported Atlantic salmon production is unknown but spawning and juvenile production areas exist within the mainstem.

The Merrimack's mainstem and some of its tributaries supported shad and river herring. These three fish species did not likely enter the Pemigewasset River system, instead turning east and entering the Winnipesaukee River (Musgrove 1904, and Hanaford 1932).

The Native Americans, who resided in or traveled through the basin, gave the Merrimack River a number of names, each denoting some particular feature of various sections of the river (Browne 1906). The name, Merrimack (merruasquamack), which outlived all other names, means the "swift water place" and is suspected to have originally applied to that portion of the river between Garvins Falls in Bow, NH and Pawtucket Falls in Lowell, MA. The Native Americans depended upon the fish and wildlife resources of the area. These early fishermen pursued the Merrimack's anadromous fish at such places as Pawtucket Falls, and the falls at Amoskeag, Hooksett, and Penacook (Goodkin 1674). There were, in fact, 14 sets of falls on the mainstems of the Merrimack and Pemigewasset rivers where fishing could have occurred: Whipples Falls, Pawtucket Falls, Wicasuck Falls, Taylors Falls, Cromwell's Falls, Goffs Falls, Amoskeag Falls, Hooksett Falls, Garvins Falls, Sewalls Falls, Webster Falls, Bristol Falls, Bridgewater Falls, and Livermore Falls (Meader 1872).

THE 1600s THROUGH THE 1850s

Anadromous Fish Abundance

Following colonization of the river basin by the English in the 1600s and until the late 1700s, the anadromous fish resources continued to prosper. In 1866, it was written that in the 1700s vast numbers of salmon reached the Pemigewasset River annually and that each family living near the stream salted away about 100 salmon yearly (Mullan 1960). Mullan writes further that areas where the salmon would lie and rest in the river were all numbered, and the fishermen were reported to have certain customs and rights in these spots. It was reported by Mullan, that in the lower waters of the river, one fisherman, Charles Ramsay of Amesbury, MA, using a 90-yard seine, customarily harvested 60 to 100 salmon a day during the peak of the salmon run.

The diary of Matthew Patten of Bedford, NH provides additional insight into the abundance of anadromous fish in the Merrimack River (Patten 1903). Three excerpts from the diary follow:

> "... took 3 depositions for Aarchibald Starke and a pint and a jill of rum and a mug of cyder at Tho Halls and got 44 lbs of salmon for my part" --- May 31, 1758. "I fished at Amoskeag and I got about 550 shad home and a small salmon home and I changed 120 for two bushell of salt, 20 I sold, 27 I gave away and 11 I had stole" --- May 28, through 31, 1766. "We got 7 salmon and I got 2 that weighed 17 pounds. I am 3 lb behind and Tho MacLaughlin is one pound behind James Patterson" --- August 1, 1768.

It is interesting to note with respect to the fishery at the Amoskeag Falls, "... one man had equal rights with another; the rule which secured the rights of each being tacitly understood and generally respected, any infringement being settled on the spot by what was termed Scotch Argument" (Meader 1872).

In an 1877 address to the Fish and Game League of New Hampshire, a Doctor Spalding illustrated further the abundance of salmon in the river (NH Fish and Game Commission 1877).

> "Lieut. Josiah Brown, who lived at Plymouth between 1764 and 1818, was accustomed to go up to Little's, now Livermore Falls, on horseback, at night, and return in the morning with a couple of meal-bags filled with salmon, which he had taken with the spear. Mr. Edward Taylor, who lived at Campton, some miles above Plymouth, stated that salmon were formerly so plenty at Taylor's eddy, near an island that if they would lie still he could walk across the river on their backs, without once touching the bed of the stream. Daniel Webster told Hon. George W. Nesmith, that in his boyhood salmon were so abundant that fishermen used to bring large quantities to his father and sell them at three cents per pound, not for cash, but in exchange for corn. It is related to widow Hemphill, who lived near the mouth of the Suncook, at Garvins Falls that on one occasion she assisted in spreading the net, and at one haul took eighteen salmon. Col. Wm. Kent told my informant that in 1817 a party from Concord, escourted President Monroe in a boat-ride down

> the river, and in passing through the locks in Bow a large salmon was caught and taken on board alive and kicking, and presented to the president, who expressed great pleasure..."

Throughout Matthew Patten's diary there are references to the shad; references indicating that these fish were not only heavily harvested, but also eagerly sought. Although shad were harvested throughout the mainstem of the Merrimack River, they were also harvested in the Winnipesaukee River. One particular story in the New Hampshire Gazette (May 23, 1760) tells of a spectacular catch of shad (Meader 1872). The article stated that approximately 2,500 shad were captured in a single net in one haul.

River herring too, were utilized by the early settlers, and in the vicinity of Hudson, NH, provisions were made to permit these fish (termed alewives) free passage into ponded areas on small tributaries for the purpose of spawning (Webster 1913).

The Demise of the Anadromous Fish Resources

The colonists not only utilized the anadromous fish resources the river provided but employed the river itself, to run their sawmills and gristmills. Because this early development focused on the lower tributaries the impact was probably not population threatening since the fish could still use the primary spawning habitat. However, by the middle and late 1700s industrial development began.

Just prior to 1800, diversion dams and locks were constructed on the Merrimack River at Pawtucket Falls, Cromwell's Falls, Moore's Falls, Goffs Falls, and Hooksett Falls (Safford 1923). The locks and canals at Manchester, NH (Amoskeag Falls) were completed in 1807 (Browne 1906). By 1812, the mainstem of the river was being utilized for transportation of people and goods upstream to the wharfs in Concord.

By the middle of the 19th century, manufacturing along the river had grown tremendously. It was said that the Merrimack River turned more machinery than any other river in the world (Browne 1906). It was estimated that one-sixth of all cotton and wool carpets, one-fifth of all the woolen and cotton goods, and over one-fourth of all cotton fabrics manufactured in the United States were made in the Merrimack River valley. The Merrimack River and its fish species bore the brunt of human and industrial discharges associated directly with development of the lower basin and the accompanying population increases.

The first complete barrier to upstream movement of fish on a main artery of the river, the mainstem of the Pemigewasset, occurred when a dam was constructed in 1820 in Bristol, NH. Shortly after the construction of a partial diversion dam at Sewalls Falls in 1830, a complete dam was constructed at Amoskeag Falls. However, this dam was constructed with a fish passage facility, the first structure of its kind on the mainstem of the Merrimack River. In 1847, the Essex Dam in Lawrence, MA was constructed. This dam, located at mile 30, was not equipped with a fish passage facility and blocked access to the critical upriver areas.

Runs of anadromous fish declined during the period of rapid development within the Merrimack River valley (Stolte 1981). The decline occurred in spite of the fact that diversion dams associated with the locks and canals were not complete barriers to upstream movement of fish, and until 1847, anadromous fish had access to the first 115 miles of the river. This fact suggests that the diversion dams, locks, and canals were not the only factors in the decline of the anadromous fish resources. The industrial and human waste discharges that the Merrimack was forced to accept must have severely impacted the aquatic life of the river. Relative to the salmon, there was a genuine concern that unrestrained fishing was contributing to the decline. In 1857 the Fish and Game Commission of New Hampshire wrote the following:

> "Indeed, it is fully established, we think that if care be taken to prevent and restrain the erection of obstacles to the ascent of these fish from the salt to the freshwaters, for the deposition of their spawn, and if protective laws be rigidly enforced to render impossible the wanton destruction of the breeding flesh .... there is no limit to their reproduction or increase....."

The harvesting of salmon and shad in the Lawrence area during the period of rapid industrial development of the Merrimack River valley dramatically reaffirms the decline of the anadromous fish resources (Mullan 1960). In 1805, a good catch of salmon amounted to 20 per day, per fisherman, and by 1830, a catch of 10 salmon per day was exceptional. By the 1850s, no salmon catches were recorded. The associated economic values (in 1960's dollars) of the fishery also declined accordingly. The estimated value of the fishery in 1789 amounted to $38,000, $9,500 in 1805, $4,750 in 1835, and after 1850, the value was projected at only $1. The decline of shad, although similar to that of salmon, was not as severe. The estimated values of the commercial shad fishery in the Lawrence and Lowell areas amounted to $830,000 in 1789, $540,000 in 1805, $365,000 in 1835, and $50,000 in 1865. Although commercial landing records prior to and during the period of decline are sketchy at best, the fishery must have been quite large. In 1841, well into the period of decline for the shad resource, 365,000 shad are known to have been landed (Stolte 1981).

The New Hampshire Fish and Game Commission report issued in 1857, listed a number of causes for the decline of the anadromous fish resources; the inability of Massachusetts to regulate the commercial fisheries, the unregulated harvest of adult shad and salmon on their spawning grounds, the destruction of young fish by the millwheels, water pollution, diversion dams and the associated locks and canals, and the construction of impassable dams. The ultimate blow however, was the construction of the Essex Dam in 1847. The construction of this dam sealed the fate of the anadromous fish resources. Access for anadromous fish to all upriver areas was denied. Only the river herring and shad were able to maintain some of their numbers by utilizing habitat that remained downstream from the Essex Dam. The Atlantic salmon population was extirpated.

THE FIRST RESTORATION EFFORT

In 1864 Henry A. Bellows of Concord, NH secured from the New Hampshire State Legislature resolutions for the appointment of commissioners to investigate the restoration of migratory fish to the Merrimack and Connecticut Rivers (Stolte 1981). Mr. Bellows also requested that the other states bordering the two rivers pursue a similar investigation. The initiative proved fruitful and in 1866, the Commonwealth of Massachusetts and New Hampshire joined together to restore migratory fish to the Merrimack River. The program was sustained without interruption through 1896 (Stolte 1981).

One of the first orders of business for the restoration initiative was to obtain fish passage at the impassable dams. Following the construction of the Essex Dam in Lawrence in 1847, three additional complete dams were constructed on the river's mainstem at Pawtucket Falls, Hooksett Falls, and Garvins Falls. Fish passage was secured at the Essex Dam and at the dam at Pawtucket Falls. No fish passage was required at the Hooksett Falls and Garvins Falls dams, possibly because locks and canals were already in place, or because, in the case of salmon, they were not high enough to present a migratory problem. However, in the early 1880s, the Garvins Falls Dam was enlarged and a fish ladder was constructed. No further reference was made relative to the dam in Bristol on the Pemigewasset River. Either the structure had been modified or upstream fish passage was provided.

Coincident with the effort to provide fish passage for anadromous fish, strong initiatives were undertaken to stock the upper reaches of the river with Atlantic salmon and American shad. The shad restoration effort was guided by Mr. Seth Green, a noted fish culturist from New York. During 1867, a million fertilized shad eggs were transported from the Connecticut River to the Merrimack River in Concord, NH where they were hatched and the young shad released into the river (Oatis 1977). Shortly thereafter, a shad hatchery was constructed in Andover, MA and operated for over a decade. Shad eggs were obtained from the remnant shad population that existed in the lower Merrimack River, transported to the hatchery, and cared for until hatching occurred and the resulting juveniles were released back into the river. However, unchecked commercial shad fishing in the lower river which negated the efforts of the shad hatchery, led to the abandonment of the fish cultural effort. How successful the American shad restoration effort was is entirely speculative. Following the construction of the Essex Dam in Lawrence in 1847, the shad population must have declined to extremely low levels because of the small quantity of spawning and nursery habitat downstream from the dam. The shad population probably responded to the restoration activities (providing access to upriver spawning and nursery habitats via fish passage facilities), for in 1876, the New Hampshire Fish and Game Commission reported that 11,255 adult shad were commercially harvested in the Lawrence area, a level of harvest that was increasing.

Since salmon had been extirpated, the restoration effort, in addition to relying on obtaining upstream fish passage, required fish cultural activities. Eyed salmon eggs were initially obtained from Canada and the resulting fry released into the Merrimack River system. After several years, eyed eggs were obtained from adult salmon of Penobscot River origin, which became the standard operating procedure thereafter. The eyed eggs were hatched at private fish cultural facilities during the first decade. Beginning in 1877, the eggs were cared for at the newly constructed Plymouth State Fish Hatchery located near Livermore Falls. Atlantic salmon fry, although released throughout the Merrimack River basin on occasion, were primarily distributed into headwater areas of the Pemigewasset River system.

The early fry stocking efforts did not produce any adult returns of consequence and prompted the New Hampshire Fish and Game Commission to make the following statement in 1873:

> "When the enterprise was first started, we made our calculations as best we could, as to the time required to produce mature salmon in our rivers; but we were undoubtedly a little too fast, and did not make sufficient allowance in time to perfect the fishways over some of the highest dams. We also expected too many adult fish from a given number of young."

However, in 1877 salmon returned to the river sufficient to be observed at the fish ladder at the Essex Dam. From 1877 through 1898, an estimated 22,600 adult salmon passed the facility, 839 adult salmon were actually counted at the fish passage facility at the Essex Dam during 19 of those years (1877 through 1895), and from 1878 through 1891, 438 adults were captured at Livermore Falls and utilized as broodstock at the Plymouth State Fish Hatchery (Stolte 1981).

The number of adult salmon recorded at the Essex Dam fish passage facility did not represent the actual number of salmon passing upstream. Adult salmon were counted at the fish ladder by de-watering the structure. This procedure was done only twice during any particular day in the spring and in July and thereafter, only once per day. This represented an estimated two percent of the running time of the facility. During eight of the 14 years that salmon were captured at Livermore Falls, the number captured equalled or exceeded the number recorded at the fish passage facility (New Hampshire Fish and Game Commission 1883, 1884, 1885, 1886, 1887, 1889, 1891, and Massachusetts Commissioners on Inland Fisheries and Game 1892). In 11 of the 14 years, the number captured at Livermore Falls exceeded 50% of the number recorded at the fish passage facility (New Hampshire Fish and Game Commission 1878, 1879, 1880). In a number of years the adult salmon counts at the fish ladder at the Amoskeag Dam also exceeded the counts at the fish passage facility at the Essex Dam.

Additional evidence that the fish passage facility counts significantly underestimated the adult returns , is supported by the following quote from the New Hampshire Fish and Game Commission Report of 1878, which addressed the salmon returns of 1877 (actual count at the Essex Dam fish passage facility equalled 47):

> "The first of our seeing the salmon go up through Livermore Falls was in the early part of July, 1877, when our attention was called by Mr. Hodge to see if we could see any salmon

> going up the falls. The first day we saw seven at four different times during the day, stopping only about ten to twenty minutes each time; this was the first day we began to look for them; we reported the same to every one that came along. Almost every day afterward, for about six or seven weeks, there were salmon seen. The largest number in one day (seen by my brother) was twenty. I myself saw five go up in forty-five minutes. We never lost much time in watching them, as we could not afford to lose any time for we have so much work on hand. I saw eleven on another day in about two hours."

The adult Atlantic salmon that returned to the Merrimack River were usually first observed at the fish passage facility at the Essex Dam during late May and early June. Although counts in the fall were observed during several years, counts normally stopped during late July or early August. Salmon were normally observed in the Livermore Falls area of the Pemigewasset River in late June and early July.

The sizes of the adults that were recorded at the fish passage facility at the Essex Dam ranged from less than five pounds to as large as 20 pounds (Stolte 1981). It was reported that the majority of the fish were in the 8 to 12 pound size category. The fish sizes recorded suggest that the population contained grilse as well as multi-sea-winter salmon. Repeat spawners may also have occurred; in the fall of 1879, a salmon weighing 28 pounds was reported dead within the Pemigewasset River, above Livermore Falls (New Hampshire Fish and Game Commission 1880).

A period of rather intense drought and high summer water temperatures (mid to late 1870s) prompted the Fisheries Commissioners of Massachusetts and New Hampshire to experiment with chinook salmon originating from the Sacramento River in California (NH Fish and Game Commission 1878). According to records, these salmon were better able to withstand warmer water than the Atlantic salmon. During 1876, 1878, 1879, and 1880 chinook salmon eggs were obtained from California and the fry released into the Contoocook, Baker, and Pemigewasset Rivers. However, this effort was short-lived and abandoned because of poor results. The New Hampshire Fish and Game Commission (1882) reported:

> "The attempt to propagate California salmon has so far been a failure, and your commissioners do not propose to carry the experiment any farther. Several lots have been consigned to New Hampshire in previous years, but after hatching and depositing them in the rivers, nothing more has been seen of them; and this, so far as we can learn, has been the experience of all fish-culturalists on the Atlantic coast. Our native salmon are doubtless the best fish for propagation with us."

During the early years of the restoration program it appears that Atlantic salmon were continually harvested in the lower Merrimack River. This was an important concern to the Fish Commissioners. In the late 1880s, and early 1890s, increases in the number of salmon returning to the river encouraged a greater number of individuals to fish for salmon even though salmon were protected by law. In the New Hampshire Fish and Game Commission reports of 1881 and 1889, and the report of the Commissioners on Inland Fisheries and Game of MA in 1890, the following passages occurred, respectively:

> "The fish wardens at Lowell and Lawrence are men of character, and have faithfully discharged their duties; but many of the wardens below Lawrence are as useless as the fifth wheel to a coach. If they exercise an influence, it is in favor of the violation of the law; and in some instances they are known to have directly aided in the destruction of the salmon."

> "A great loss of fish belonging to the river takes place every year by weir fishermen on the coast. One weirman reported nearly eighty salmon taken in his nets, and as he was liable to a fine of fifty dollars for each fish, it is not at all likely that he reported more than were actually taken."

> "Although the number of salmon taken at Livermore Falls was larger than ever before, yet many of them ran very small, some not giving over 3,500 to 4,000 eggs. This is a good showing, considering the great numbers which are annually unlawfully destroyed by the gill nets and weirs before they have time to enter the river for spawning .... If the weirmen would cooperate with the commissioners by liberating the salmon taken in their traps, the greatest impediment to the increase of salmon would be removed."

Although the illegal harvest of Atlantic salmon was undoubtedly taking its toll, the fate of this species, to a large extent, came down once again to the construction of an impassable dam. In 1892, a complete dam was constructed at Sewalls Falls without a fish passage facility. Unfortunately, this coincided with the last release of salmon fry into the river system. The Fish Commissioners believed that the salmon runs had become strong enough to support themselves. Fish passage at the Sewalls Falls Dam was provided in late 1895. However, during the early spring of 1896, a large flood destroyed the fish passage facility at the Essex Dam. This facility was not replaced until 1898.

During the latter part of the 1890s, the New Hampshire Fish and Game Commission began to occupy itself with the propagation of trout, the management of upland birds, and the management of deer. These new pursuits, an apparent shift of focus by the Commission, likely replaced the effort to continue with restoration of the Atlantic salmon since no further work in that area was conducted after 1895.

In summary, approximately 6.3 million salmon fry had been released into the river system and a fish hatchery had been constructed, 839 adults had been counted passing upstream at the fish passage facility at the Essex Dam, 438 adults had been captured at Livermore Falls from which approximately 1.3 million eggs had been taken, and five fish passage facilities had been constructed.

SECTION V

THE PRESENT RESTORATION PROGRAM

THE PRESENT RESTORATION PROGRAM

Initial restoration efforts in New England were directed at the Atlantic salmon and occurred in Maine, the only state with salmon populations of any magnitude. The efforts commenced prior to the second World War. However, early in the 1940s, the Bureau of Sport Fisheries and Wildlife (now the United States Fish and Wildlife Service (USFWS)) and the fisheries agencies of the four basin states containing the Connecticut River drainage met for several days in the Westboro, MA in order to discuss the possibility of restoring Atlantic salmon to the Connecticut River (unpublished correspondence 1943). The discussions did not lead to active restoration efforts. In the early 1960s, the Maine Atlantic Sea-run Salmon Commission (now the Maine Atlantic Salmon Authority) joined forces with the Bureau of Sport Fisheries and Wildlife and the hydroelectric power producers on the Penobscot River in initiative termed the "Model River Program". The intent of the cooperative was to restore the Atlantic salmon to the river and provide a "blueprint" for restoring the salmon to other large rivers in New England. The first efforts on the Merrimack River began shortly after the initiation of the Model River Program.

THE INITIAL EFFORTS

The first work in the current anadromous fish restoration effort came in 1963 when the New Hampshire Fish and Game Department (NHFG) conducted a survey in their portion of the watershed to determine the potential for salmon restoration and the obstacles that might prevent such an effort (Newell and Nowell 1963). The survey concluded that excellent potential for salmon restoration existed, approximately 60,000 units (one unit = 100 square yards) of juvenile salmon habitat existed within the New Hampshire portion of the watershed. The obstacles to restoration that were identified in that study were the dams located on the river's mainstem and the major tributaries.

In 1968, the Massachusetts Division of Fisheries and Wildlife (MADFW) initiated a survey encompassing a survey of resident fish populations, water chemistry, physical characteristics of the river, American shad restoration potential, anadromous fish habitat, and obstructions to fish passage in the Massachusetts portion of the Merrimack River watershed (Bridges and Oatis 1969). This work concluded that excessively warm water temperatures precluded the establishment of a coldwater sport fishery, except possibly during the spring and fall months, and that the portion of the watershed within Massachusetts had no Atlantic salmon spawning or nursery habitat.

THE FORMAL RESTORATION COOPERATIVE

Anadromous fish restoration efforts commenced on a more formal basis in 1969 when the fishery agencies of Massachusetts and New Hampshire, the Bureau of Sport Fisheries and Wildlife, and the Bureau of Commercial Fisheries (now the National Marine Fisheries Service (NMFS)) mutually agreed to support a fisheries program for the Merrimack River (Appendix I). The objectives of that agreement were, and continue to be, two-fold: to strive for the realization of the full potential of the anadromous and resident fishery resources of the river in order to provide the public with high quality sport fishing opportunities, and to assist in providing for the long-term needs of the human population for food through development and management of the commercial fishery resources. The United States Forest Service (USFS) formally joined the effort in 1982 when the cooperating agencies voted unanimously to give the USFS voting rights on the two administrative committees.

Program Administration

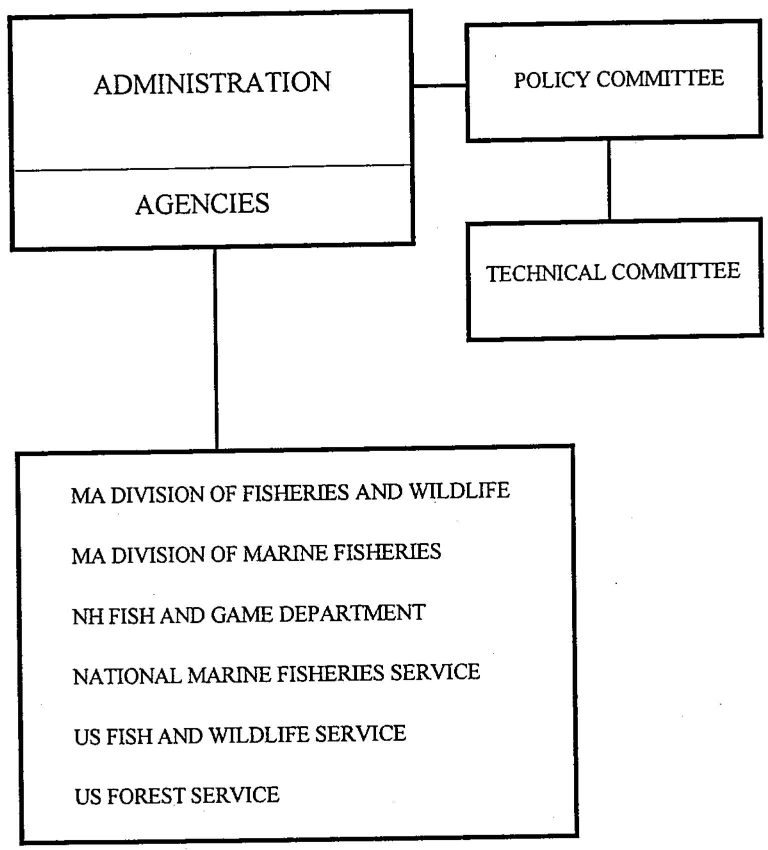


FIGURE 3. MERRIMACK RIVER ANADROMOUS FISH PROGRAM STRUCTURE.

The Anadromous Fish Restoration Program (Program) is administered by the cooperating agencies through two committees (Figure 3). The Policy Committee for Anadromous Fishery Management of the Merrimack River (Policy Committee) provides overall program direction and resolves policy issues. The Technical Committee for Anadromous Fishery Management of the Merrimack River (Technical Committee) provides oversight of program implementation and advises the Policy Committee on technical issues. The Policy Committee is composed of the Directors of the Massachusetts Division of Marine Fisheries (MADMF), the MADFW, and the NHFG, the Regional Directors of the USFWS (Region 5), and the NMFS (Northeast Region), and the Forest Supervisor for the White Mountain National Forest. Each member of the Policy Committee assigns a staff member to the Technical Committee. There is also an advisory committee, the Sport Fishery Advisory Board, established by the Policy Committee in 1989. It is made up of members from the public (three representatives from Massachusetts and four representatives from New Hampshire) and advises the Policy Committee on sport fishery issues.

A Program Coordinator, an employee of the USFWS, acts as Secretary for the committees, organizes necessary meetings, provides program assessment and planning documents, and maintains contact with interested public. The Coordinator also maintains the Program's data base.

Policy Committee and Technical Committee meetings are held periodically during each year. These meetings are open to the public and input into the decision-making process can be provided.

RESTORATION PROGRAM SUMMARY

General Activities

A year following the development of the formal inter-agency cooperative (1970), the NHFG, MADFW, and MADMF initiated a joint project to restore anadromous fish to the Merrimack River. During the first five years of the cooperative project, the work conducted by Massachusetts in 1968 was expanded into the New Hampshire portion of the Merrimack River basin. Three maps delineating the bottom composition and depths of the mainstems of the Merrimack and Pemigewasset Rivers were prepared (Greenwood 1976). Two additional maps, one depicting the bottom composition of the Baker River and another identifying potential Atlantic salmon holding pools and nursery habitat from Plymouth, NH to North Woodstock, NH were also prepared (Kuzmeskus et al 1982)

In 1969, and continuing through 1978, the fisheries agencies of MA and NH obtained American shad eggs from adult shad returning to the Connecticut River. The eggs were released from the Sewalls Falls area downstream to the Lawrence/Lowell reach within the Merrimack's mainstem. The effort was initiated in order to begin the development of adult shad returns.

The USFWS, in cooperation with the NHFG, initiated a 5-year salmon study in 1975. The study's objective was to determine the nursery habitat potential of the Mad River for producing Atlantic salmon smolts from stocked fry (Marancik 1975). Although parr production (survival and growth) was documented, no smolt production estimates were obtained. In 1975, fry were released into the headwaters as part of the joint USFWS/NHFG Mad River salmon study. Beginning in 1976, the Merrimack River received annual releases of fry and smolts.

In summary, the first decade of Program activities focused on describing and quantifying Atlantic salmon and American shad habitat, testing the quality of the salmon nursery habitat, releasing juvenile Atlantic salmon, transferring American shad eggs from the Connecticut River to the Merrimack River, and describing fish passage requirements.

In 1979, the fisheries agencies of MA and NH initiated the transfer of live adult American shad from the Connecticut River to the Merrimack River. The adult shad transfer program replaced the shad egg transfer effort. Adult shad were transported from the Connecticut River to the Merrimack River from 1979 through 1985 and from 1990 through 1995. Releases into the mainstem occurred upstream from the Pawtucket Dam in Lowell and downstream from the Eastman Falls Dam in Franklin. Intra-basin transfers have also occurred utilizing the fish-lift and trapping facility at the Essex Dam as the source location.

In 1995, the transfer of river herring from coastal rivers in New Hampshire to the Merrimack River was initiated. River herring were released into the river's mainstem and into ponded areas of the Concord River, Nashua River, the Piscataquog River, the Suncook River, the Soucook River, the Contoocook River (including the Warner River), and the Winnipesaukee River. Intra-basin transfers have also occurred utilizing the fish passage and trapping facilities at the Essex Dam and the Amoskeag Dam as source locations.

Total program costs (agencies' expenditures) from 1968 through 1992 amounted to 13.1 million dollars (USFWS 1993). From 1993 through 1996 the estimated expenditure of the six fisheries agencies collectively was 5.2 million dollars. Thus, total program costs through 1996 are estimated at 18.3 million dollars. These expenditures must be viewed in the context of incalculable resource losses that occurred prior to the present restoration program. These losses would be directly related to the extirpation of the shad and salmon populations and the loss of any associated benefits that would have accrued to the public.

Planning Efforts

In late 1978, a Strategic Plan (Plan) for the restoration of Atlantic salmon to the Merrimack River basin was prepared and subsequently endorsed by the Policy Committee in 1979. The Plan was to be revisited, at a minimum, every five years.

In 1980 the New Hampshire Fish and Game Department prepared an environmental assessment report relative to anadromous fish restoration in the Merrimack River.

In 1980-1981 the Technical Committee developed a Fish Passage Action Plan (FPAP) that the Policy Committee adopted in 1981 (Appendix II). This document addressed fish passage requirements for salmon and shad throughout the entire basin. The Plan was revised in 1982 in order to incorporate the FPAP.

The revision of the Plan in 1982, addressed restoring a self-sustaining salmon population to the Pemigewasset River system. The tributaries downstream from the Pemigewasset River would be utilized to produce salmon smolts from fry plants (no natural reproduction was expected nor would be managed for). Although a formal plan wasn't written for American shad (and river herrings) the fish passage requirements proposed by the FPAP outlined the direction that shad restoration was to take. The direction of shad restoration was consistent with a draft Strategic Plan outline that had been developed earlier in 1980 (Kuzmeskus et al 1982). Shad were to be restored to the mainstem of the Merrimack River and portions of the Concord River, the Nashua

River, the Souhegan River, the Piscataquog River, the Soucook River, and the Contoocook River.

Additional revisions to the Plan occurred in 1985 and in 1990. The 1990 Plan incorporated a revised FPAP and in addition, a domestic Atlantic salmon broodstock sport fishery that was to be implemented in 1993.

Fish Passage Development

A critical component of the restoration program is providing effective upstream passage and salmon trapping capability at the lowermost impassible barrier dams. This led to the development of a fish lift concurrent with hydroelectric development at the Essex Dam in Lawrence, MA in the fall of 1982 and the construction of both a fish lift and fish ladder at the Pawtucket Dam in Lowell, MA in 1986. A fish ladder was constructed at the Amoskeag Dam in Manchester in 1989 under the provisions of "A Comprehensive Plan for Provision of Anadromous Fish Passage Measures and Facilities at Public Service Merrimack-Pemigewasset River Hydroelectric Dams, agreed to by the Policy Committee and Public Service Company of New Hampshire (PSNH) on June 10, 1986. These three facilities now provide upstream passage to the base of the Hooksett Dam in Hooksett, NH, and at some high flow conditions river herring have been observed successfully negotiating this dam, thus gaining access to the base of the Garvins Falls Dam in Bow, NH.

Upstream passage at other mainstem Merrimack and Pemigewasset River projects are currently deferred to a future date dependent upon Program progress. The 1986 agreement establishes a timetable for installation of upstream passage facilities at PSNH's upstream projects based on trigger numbers of shad passing the Amoskeag fishway.

Upstream passage facilities on tributaries are limited at this time to the Jackson Mills and Mines Falls dams on the Nashua River and the Centennial Island Dam on the Concord River. Facilities at these sites were constructed primarily for shad and herring passage.

All constructed upstream passage facilities have successfully passed the targeted anadromous species. The efficiency of most of these facilities, however, is unknown. At the Lawrence Project fish lift, investigations in 1993-1995 identified problems in the entrance area of the fishway which likely affected passage numbers in past years. Measures to correct these deficiencies are scheduled for implementation in 1996. The Lawrence fish lift efficiency will remain variable, however, being very sensitive to river flow and dam spillage conditions. High river flows, flow fluctuations and spill over the dam adversely affect the attraction of fish to the lift entrance.

In addition to upstream passage, providing safe downstream passage for Atlantic salmon smolts, and adult and juvenile shad and herring is critical to the restoration programs for these species. Shad must pass up to four hydro dams and most salmon smolts have to negotiate many more. Smolts leaving the upper Pemigewasset River must negotiate seven hydro dams while

Contoocook River smolts may pass as many as eleven. Downstream fish passage measures are needed to reduce turbine-induced injury and mortality and to reduce migration delays. Passage delays can affect long term survival of salmon smolts that have a limited period of time in which they are physiologically capable of transition from fresh to salt water. Late emigrating smolts are also exposed to greater threats from predators and elevated water temperatures and must migrate under generally reduced flows. Losses or delays of smolts at each site can cumulatively affect subsequent returns.

Downstream passage measures have traditionally consisted of fish screens and bypass sluices, but could include non-structural measures such as changes in hydro project operations. Downstream fish passage facilities have been developed at many of the mainstem and tributary hydroelectric projects pursuant to federal hydro licensing proceedings and downstream passage agreements between hydroelectric project owners and the fisheries agencies. Effective downstream passage facilities, however, are not yet in place throughout the basin.

Downstream passage facilities were not in place at the Lawrence Project located at the Essex Dam until a new bypass facility was operable and a plan to seasonally close the South Canal, which diverts flow from the Merrimack at the Essex Dam, was established in 1993. The bypass facility has been shown to be reasonably effective in passing juvenile and adult clupeids, but has not proven effective for salmon smolts. The canal closure plan, which bases canal closure on date and river temperature triggers has alleviated a major downstream passage problem at this site, however the adequacy of the date and temperature triggers has not been fully evaluated.

At the Lowell Project, the original downstream bypass installed during project construction proved ineffective in passing emigrating salmon and clupeids. Modification of the bypass sluice were made in 1993 and subsequently tested. Test results from 1994 and 1995 indicated reasonable passage success for clupeids but poor salmon smolt passage. Most smolts pass through the project turbines, although some also enter the elaborate Pawtucket Canal system, that diverts flows from the river at the Pawtucket Dam.

Passage facilities that were initially constructed at the Ayers Island, Eastman Falls, Garvins Falls, Hooksett and Amoskeag projects on the Pemigewasset and Merrimack river mainstems were not effective in protecting salmon smolts. As a result, further passage investigations were undertaken and alternatives were tested at some of these sites, leading to the development in 1995 of a five year plan by PSNH that was subsequently concurred with by the Policy Committee, to establish a schedule for downstream passage studies and passage facility development at their projects (Appendix II).

Downstream passage facilities development on tributary hydro projects have resulted from federal hydro licensing proceedings or by petition by the USFWS and other agencies that the Federal Energy Regulatory Commission (FERC) require downstream passage implementation. Except for the Nashua and Concord rivers, where some passage facilities for herring and shad are in place, tributary facilities have been targeted at salmon smolt passage. Designs of facilities at these sites differ from project to project, although a number of projects have a one-inch-spaced angled bar racks and adjacent bypass sluices to convey fish downstream. One such facility, at the Pine Valley Project on the Souhegan River has been tested, with bypass efficiency for smolts of 95%. Similar passage efficiency is expected at similar sites. However, projects with different designs have been constructed with limited or unknown success. With the failure of some installed facilities, solutions to passage are still being attempted at the lower Contoocook River projects (Rolfe Canal, Penacook Upper Falls and Penacook Lower Falls). At the Greggs Falls Project on the Piscataquog River, although a bypass facility is in place, passage effectiveness is uncertain and smolt emigration delays are possible. On the Suncook River, no passage facilities are in place at any of the hydro projects downstream from salmon fry stocking at this time.

Documentation of Anadromous Fish Returns

Prior to the construction of the fish-lift at the Essex Dam, efforts were made to document shad and salmon returns to the lower Merrimack River by the fisheries agencies. Some shad were captured downstream from the Essex Dam utilizing gill-nets. Whether these fish had resulted from the egg transfer program is unknown. Three salmon were captured in the lower river in 1979, two by anglers and one from the antiquated fish ladder at the Essex Dam.

Sporadic counts of American shad and river herring also occurred at the old fish ladders at the Essex Dam and the Pawtucket Dam when flow conditions allowed passage. In 1976, an estimated 3,225 river herring utilized the fish ladder at the Essex Dam and a single shad was found in the ladder when it was dewatered (Iwanowicz and Gil 1976).

In 1982, the fisheries agencies increased their efforts to document salmon returns and during the fall, with the completion of the fish-lift at the Essex Dam, adult salmon were captured. Beginning in 1983 river herring, American shad, and Atlantic salmon were counted at the fish-lift at the Essex Dam by the fisheries agencies. Total counts from 1982 through 1996, amounted to approximately 1,735,000 river herring, 159,000 shad, and 1,827 salmon. Fish passage at upstream passage facilities on the mainstem has also been monitored.

Program Successes

Atlantic salmon and American shad were extirpated from the river in the 1800s and only a remnant river herring population persisted. Now, Atlantic salmon return to the river annually as a direct result of the restoration program as a product of hatchery smolt and fry releases. Although the numbers are small, the restocking initiatives are one measure of success. In addition to the salmon, tens of thousands of American shad and river herring return to the river annually with a portion utilizing the fish passage facilities at Lawrence, Lowell, Nashua, and Manchester.

Progress made to date also reflects the informal and/or formal partnerships that exist between the fisheries agencies, private industry (PSNH, Consolidated Hydro, Inc., Essex Hydro, etc.), and the private sector. These partnerships are, in themselves, success stories. Effective upstream and downstream fish passage exist at a number of the hydroelectric dams within the basin and refinements are occurring regularly. The fry stocking program wold not be possible without the contribution of volunteers from the private sector.

The Amoskeag visitor center partnership, involving PSNH, NH Audubon, NHFG, and the USFWS, provides environmental education and interpretation as well as restoration program information to the public. This partnership exists because of the anadromous fish restoration program.

The Adopt-A-Salmon Family outreach program developed by the USFWS is directly related to anadromous fish restoration, not only in the Merrimack River, but throughout New England. This highly acclaimed program now exists in five of the New England states, has grown from two schools to 46, and is limited only by available funding. This program uses the Atlantic salmon as a focus in order to facilitate the development of a watershed stewardship ethic among the region's youth, their parents, and the associated communities. The program has lead to strong partnership development with organizations/agencies such as The Nature Conservancy, National Park Service, White Mountain National Forest, Atlantic Salmon Federation, National Wildlife Federation, Penobscot Indian Nation, Merrimack River Watershed Council, Piscataquog Watershed Association, Lakes Environment Association, Portland Water District, UNH Sea Grant, Lake Champlain Basin Program, Holcomb Farm Environmental Learning Center, the Seacoast Science Center, and Consolidated Hydro, Inc.

A significant success for the recreationalist along the mainstem of the river within New Hampshire has been the Atlantic salmon broodstock sport fishery, initiated in 1993. This initiative provides exciting sport angling opportunities; led to the development and improvement of access sites along the river for anglers and many other recreational users; heightened awareness of anadromous fishery resources among public and political constituents; and increased economic support for the anadromous fishery initiatives through the development of a stamp and print program.

An important result of the anadromous fish restoration program has been the acquisition and development of the Sewalls Falls recreation area. This multi-use area, managed by the NHFG in partnership with the city of Concord exists only because of the anadromous fish restoration program. In addition, the acquisition of critical Atlantic salmon habitats within the Pemigewasset River system, purchased through the NH Land Conservation Program, also resulted due to the restoration program.

SECTION VI

STATUS OF THE ATLANTIC SALMON, THE AMERICAN SHAD, AND THE RIVER HERRINGS

STATUS OF THE ATLANTIC SALMON, THE AMERICAN SHAD, AND THE RIVER HERRINGS

ATLANTIC SALMON (*Salmo salar*)

General Life History Information

Much of the following information was taken directly from a chapter dealing with Atlantic salmon (Stolte 1986) in the National Audubon Society's Wildlife Report of 1986.

Life History

The Atlantic salmon lives as an adult in the sea but spawns in freshwater rivers and small streams. After the eggs hatch, the young salmon remain in freshwater for one or more years, then descend to the sea to feed and grow for at least a year before returning to freshwater to reproduce. After breeding they return to the sea. While in the sea, Atlantic salmon are silvery on their sides, silvery white underneath, and brown, green, or blue on their backs. For a short time after they enter rivers and streams to spawn, salmon remain quite silvery and often referred to as "fresh and bright fish." They gradually lose the silvery color and become darker, taking on a bronze and brown coloration as spawning approaches.

The Atlantic salmon's range extends from Portugal to the Arctic Circle in the eastern Atlantic, includes Iceland and southern Greenland, and encompasses the Ungava region of northern Quebec southward to the Connecticut River of New England in the western Atlantic. Salmon from both the eastern and western Atlantic live in the feeding grounds off Greenland. Salmon of the eastern Atlantic also feed in the Baltic, in areas near the Faroe Islands, and elsewhere in the eastern Atlantic. Food items principally consist of fishes such as herring, capelin, and sand eels. Large zooplankton such as euphausiids and amphipods also are important in the salmon diet. Salmon are themselves preyed upon by seals, sharks, pollack, tuna, skates, halibut, cod, striped bass, bluefish, and other predators. Man, too, is a significant predator.

Anadromy and Homing

One of the most intriguing of all aspects of the salmon's life history is its homing instinct. The fact that salmon return to their parent stream has been known for several hundred years. The importance of stream odors in the orientation of fish also has been well demonstrated. Research indicates that, in salmon, the smell of the parent stream is imprinted during a short period before the young descend to the sea. Thus, as maturing salmon approach the coastal areas from the open ocean, they probably locate parent streams by smell. How the salmon navigate in the ocean, far from their parent streams, still remains a mystery.

Atlantic salmon may leave the sea to spawn in their parent stream during any month of the year.

In New England, adult Atlantic salmon enter their parent streams from May through October with May, June, and July being the most important time periods. After entering freshwater, adult salmon cease to feed. They will not eat again until they re-enter the sea some six months to a year later.

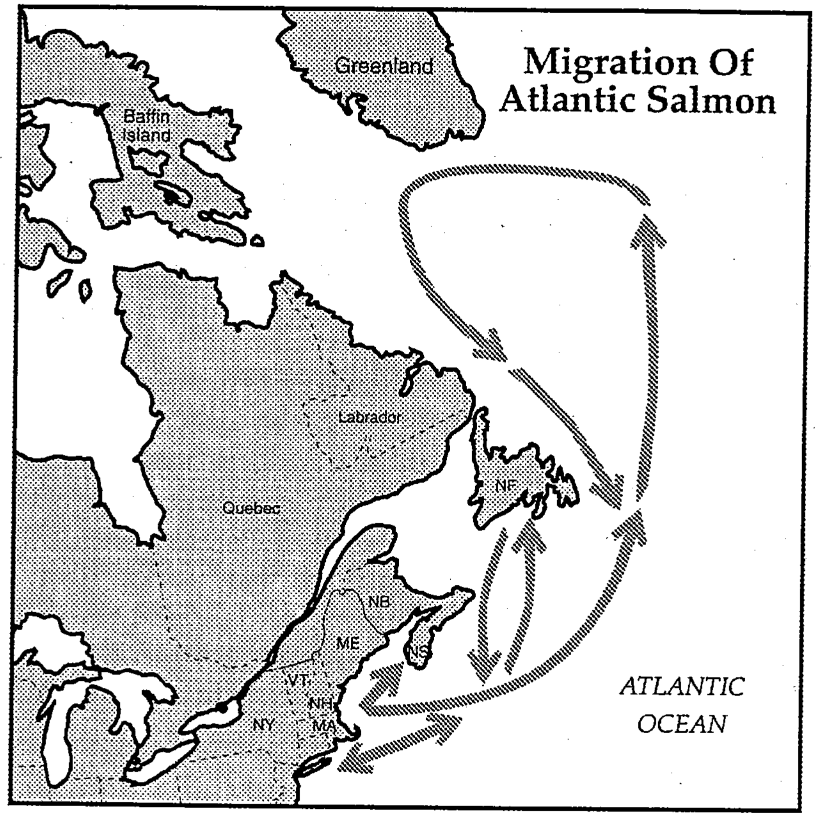
Returning salmon usually are between three and six years old, but individuals up to 11 have been reported. In New England returning salmon range in age from two to at least six years, with four being the predominate age - two years in freshwater and two years (winters) in the ocean. Salmon that return after one year (one-sea-winter) at sea are called grilse and will usually weigh between two and six pounds. Those returning after two years (winters), often called multi-sea winter salmon (MSW) or two-sea-winter (2SW) salmon, weigh between six and 15 pounds. Those returning after three years (winters) at sea, often called MSW salmon or three-sea-winter (3SW) salmon, may weigh more than 20 pounds. Of course, older individuals and repeat spawners (salmon that have spawned in (a) previous year(s)) may weigh even more. Throughout its range, the Atlantic salmon spawns during the fall and early winter months. Spawning typically occurs in late October through November in New England.

The female chooses the nest site, usually a gravel-bottom riffle area above or below a pool, and with her caudal fin excavates a pit into which eggs are deposited. More than one male usually participates with a single female in fertilizing the eggs. This process is repeated again and again until all or nearly all of the female's eggs have been deposited. The series of pits into which the eggs have been deposited and covered with gravel is called a "redd." The female deposits roughly 700 eggs per pound of body weight, from 2,000 to 15,000 eggs. The adult fish after spawning are called "kelts" and may return to the sea immediately or during the following spring, as is typical in New England. Kelts that return to the sea in the spring are often called black salmon or slinks. Only a small percentage of the kelts, primarily females, will reach the sea and return in later years as repeat spawners.

Eggs normally hatch in late March and April, depending on water temperature. Water temperatures below 50 degrees F are desirable for normal egg development, and temperatures in the low 40s are considered optimum. The sac fry or "alevins", as the newly hatched salmon are called, remain buried in the gravel until the yolk sac has been absorbed. Actual emergence of the alevins, now called "fry", from the gravel occurs from March through June. The fry disperse from the redd site and rapidly assume the coloring of the life stage referred at as "parr". These young salmon have eight to 11 narrow, vertical, pigmented bands on their sides (parr marks) with a single red spot between each band. In New England, the young salmon (after hatching from the eggs) spend between one and three years in freshwater, the norm being two years.

During their freshwater residency, young salmon are opportunistic feeders, preying on the most abundant food items. Aquatic insect larvae and nymphs (chironomids, mayflies, caddis flies, black flies, and stone flies) are the principal food items. However, terrestrial insects are eaten and probably are an important part of the diet during certain periods of the year. Young salmon are also prey to a number of predators, including kingfishers, American mergansers, eels, various trout species, pike, and pickerel.

At a size of five to eight inches, the parr undergo physiological and morphometric transformations that prepare them for migration to the sea and the transition from a stream-bottom animal to a pelagic ocean fish. This transformation is known as "smoltification", and in the migratory stage, which normally occurs during the spring, the parr are more properly called "smolts". After entering the sea the smolts, now referred to as "post-smolts", migrate to the distant oceanic feeding grounds. Salmon originating from New England rivers will be found in the Greenland waters and along the Labrador and Newfoundland coasts.



Freshwater Habitat

The size of Atlantic salmon populations, especially in New England rivers, is governed to a large degree by the quality, quantity, and accessibility of the spawning and nursery habitats. Good spawning habitat includes beds of stones measuring one-half to four inches in diameter. These gravel beds promote the movement of clean, well-oxygenated water through the redd, which is critical since salmon eggs may be deposited as deep as 12 inches. Spawning habitat should be well dispersed throughout the nursery habitat.

Salmon nursery habitat typically is composed of shallow riffle areas interspersed with deeper riffles and pools. The substrate pebbles, ranging from one-half to greater than nine inches in diameter, afford adequate cover for the juvenile salmon. Clean, well-oxygenated water is a necessity. The young salmon also require relatively warm water for growth. They grow very slowly at temperatures below 45 degrees F and experience optimal growth in streams with daily peaks of 72 to 77 degrees F.

Returning adult salmon must have access to the spawning grounds. An open, unobstructed river is ideal. Where obstructions, such as impassable dams, occur, fish passage facilities must be provided. The distance traveled upriver may range from 10 to 600 miles. Once in the river, adult salmon making long migrations require refuge from the swift current and will periodically stop and lie in resting pools. Upon nearing the spawning grounds adult salmon will take up residence in holding pools. Holding pools have the cover, depth, temperature regime, and water velocities preferred by the adults.

Status of the Atlantic Salmon in New England

Atlantic salmon returns to the rivers of New England have declined significantly in the last six years (USASAC 1996). From a high of nearly 4,500 adult salmon recorded in 1990, returns reached lows of between 1,600 and 1,800 fish in 1994 and 1995. The declines have been directly related to declining rates of return during the period 1988 through 1993. Results are not yet available for salmon smolts that entered the ocean during 1994 and 1995, but they are not expected to show significant improvement. Several hypotheses have been put forward suggesting that increased predation on salmon by cormorants, striped bass, and marine mammals as well as hostile ocean conditions for post-smolts (water temperatures being colder than normal) are the major factors influencing the decline.

In the words of Baum et al (1995), "It is important to understand and keep in perspective the changes that have occurred in early maturation and natural mortality at sea over recent years. During the past decade, declines in salmon runs have occurred in both North America and Europe despite aggressive efforts to protect and revitalize the stocks. Though activities such as fishing have contributed to these trends, it is evident that natural factors have lowered the survival rates and changed the age structure of many stocks. Retrospective analyses of U.S. salmon stocks have shown that fishing mortality can cause 100 percent changes in homewater returns whereas natural mortality can account for changes of a magnitude of 300 - 400 percent. The historical catch record suggests that there have been changes of this magnitude before. The current pattern of decline is not endemic to U.S. salmon stocks and the historical record suggests that this trend will eventually reverse."

Restoration Program Background

From its inception, the Atlantic salmon restoration program has focused on producing juvenile salmon in state and Federal hatcheries that will survive in the Merrimack River watershed. The unique stock of Atlantic salmon which evolved in the Merrimack River was extirpated in the 1800s. Biologists are working to develop a salmon stock well-suited to the environmental conditions of the Merrimack River without the benefit of original Merrimack River genetic material. This may well be the biggest challenge to the restoration effort.

Initially, hatcheries produced fry, parr, and smolts for release into the river. However, the program has been modified to emphasize fry and smolt production. The parr stocking program has been a minor bi-product of the smolt program. Fish that were reared to be smolts but did not meet the smolt requirements (size and physiological criteria) were released as parr. Adult returns from parr releases have been minimal.

Efforts have been underway to provide salmon smolts, whether produced from fry stocking or produced entirely within the hatchery, safe downstream passage. Safe passage requires the provision of alternative routes around hydroelectric dams and their associated turbines. Passage through the turbines can cause high smolt mortalities. In some cases, excellent passage facilities have been provided, but in most cases alternative passage routes have not worked well. This will be a continuing issue as new technologies are developed and more is learned about smolt migrational behavior.

As adult salmon return to the Merrimack River from the sea they are captured in the trapping facility associated with the fish-lift at the Essex Dam in Lawrence. Captured salmon are transported to an adult holding facility at the Nashua National Fish Hatchery (NNFH) in Nashua, NH until they mature sexually in the fall and eggs can be taken. The facility is capable of holding 300 adult salmon and any number greater than 300 would be transported to the spawning grounds within the headwaters. Since 1982, there has been only one occasion, in 1991, when the number of returning fish exceeded 300.

At the present time, the salmon program requires six million eggs annually for the fry stocking program. At maximum capacity the searun adult holding facility has the potential to produce approximately 25% of the projected need. In addition, approximately 4.5 million eggs are produced by hatchery broodstock. The fish are spawned and are then released for the interim broodstock sport fishery and for research purposes.

Since 1993, many of the surplus domestic broodstock have been re-conditioned and released into the mainstem of the Merrimack River to provide anglers the opportunity to catch large salmon. This is an interim program that will be phased out as sea run returns increase sufficiently to provide angling opportunities. Present fisheries regulations within the Merrimack River basin make it unlawful to take a sea run salmon or juvenile salmon by any means. The only salmon that can be taken within the Merrimack River from the Essex Dam to the Eastman Falls Dam in Franklin, NH, are domestic broodstock.

The Atlantic Salmon Fish Cultural Program

Evolution of the Hatchery Program

Prior to 1992, Atlantic salmon smolts were reared at the NNFH and the North Attleboro National Fish Hatchery (NANFH) located in North Attleboro, MA. Atlantic salmon fry were produced at the NANFH and the Berlin State Fish Hatchery (BSFH) located in Berlin, NH. Initially, salmon eggs for the culture program came from a variety of sources; sea run salmon of Penobscot River origin, a number of stocks originating from Canadian rivers, and re-conditioned kelts of Merrimack River origin (Rideout and Stolte 1988). By the mid-1980s, eggs for the program were provided by adult salmon returning to the Merrimack River and domestic broodstock of Penobscot River and Merrimack River origins. Since 1994, when Merrimack River adult returns declined to fewer than 100 fish, eggs from Penobscot River adult returns were used to produce domestic broodstock at the NNFH to prevent inbreeding. Currently eggs for program needs are provided by salmon returning to the Merrimack River and domestic broodstock of Merrimack and Penobscot origin.

With the initiation of the domestic broodstock program at the NNFH in 1989, the smolt program was eliminated. The smolt production program at the NANFH was increased in order to compensate for the loss of the smolt production at the NNFH. In 1993, the NHFG began producing fry at the Warren State Fish Hatchery (WSFH) in Warren, NH in addition to the fry produced at the BSFH. In 1994, the BSFH ceased producing salmon fry for the Merrimack River. Because of funding inadequacies at the NANFH in 1994, the smolt program was eliminated. Beginning in 1994, salmon smolts were provided by the Green Lake National Fish Hatchery (GLNFH) in Ellsworth, ME. These smolts are of Penobscot River salmon origin. Salmon fry for the Program are now produced at the NANFH and the WSFH, and salmon smolts are provided by GLNFH.

Juvenile Atlantic Salmon Releases

The release of juvenile Atlantic salmon into the basin commenced in 1975 when 36,000 fed fry were released into the Mad River. Atlantic salmon parr and smolts were first released into the basin in 1976. Through 1996, approximately 17.8 million fry (7% fed and 93% unfed), 796,100 parr (28% 0^+parr, 52% 1parr, and 20% 1^+parr), and approximately 1.7 million smolts (61% yearlings and 39% two-year-olds) have been released into the Merrimack River basin (Table 2 and Appendix III).

The majority of the fry has been released into the Pemigewasset River system, the Souhegan River, and the Piscataquog River. Other tributaries or river reaches that have been stocked with fry are the mainstem reaches in the Concord and Franklin, NH areas, Nashua River (NH), Cohas Brook, Black Brook, Suncook River, Soucook River, Hayward Brook, Contoocook River, Bryant Brook, Stirrup Iron Brook, Punch Brook, and the Winnipesaukee River. Fry are normally scatter planted (dispersed throughout tributaries or river reaches) at densities of 25 to 50 fry per each unit of nursery habitat. Fry releases occur during April through June and involve fisheries agency personnel from the NHFG, the USFWS, and the USFS. Volunteers from conservation organizations, such as Trout Unlimited, play an extremely important role in the stocking efforts.

Parr are released during the spring, summer, and/or fall, into habitats similar to those into which fry are stocked. In some cases parr are released into the river's mainstem. As indicated earlier, parr releases have been minimized whenever possible.

The smolt stocking program occurs in late March through April. Although smolts are released into the river's mainstem from Manchester, NH downstream, the majority of smolts has been released downstream from the Essex Dam to eliminate the need for the fish to pass hydroelectric dams. However, in 1995, smolts were released in the Manchester area with an expectation that they would acclimate to the river, become more adept at avoiding predators, migrate out of the river more naturally, and return as adults in 1996, 1997, and 1998 in greater numbers than in the past.

TABLE 2. NUMBER OF JUVENILE ATLANTIC SALMON RELEASED INTO THE MERRIMACK RIVER FROM 1975 THROUGH 1996.

Year	Number of Fry	Number of Parr	Number of Smolts
1975	36,000	0	0
1976	63,100	92,500	2,100
1977	72,000	700	31,000
1978	106,100	0	47,200
1979	76,900	0	39,700
1980	125,500	0	31,000
1981	57,000	0	100,900
1982	50,000	177,100	71,000
1983	8,400	25,000	109,900
1984	525,500	33,100	68,200
1985	148,400	5,800	189,300
1986	524,600	31,500	104,000
1987	1,078,300	99,300	141,600
1988	1,717,800	129,600	94,400
1989	1,033,500	148,600	58,600
1990	975,200	35,300	116,900
1991	1,458,300	0	120,100
1992	1,117,500	100	96,400
1993	1,157,500	0	59,000
1994	2,816,500	0	85,000
1995	2,827,200	12,700	70,800
1996	1,794,600	4,900	50,000
Total	**17,769,700**	**796,100**	**1,687,100**

Beginning in 1982, smolts were marked by removal of a fin (usually the adipose fin) and tagged with coded-wire-nose tags (CWT). The CWT are coded such that the fish can be identified by river of origin, release year, and production hatchery. The marking program has been used to evaluate smolt stocking methods and hatchery diets, provide a means to differentiate adults of fry stocking origin from adults of smolt stocking origin and to assist the North Atlantic Salmon Conservation Organization (NASCO) in identifying the origin of salmon caught in the ocean commercial fishery. Since the ocean fishery has been reduced significantly due to quotas on commercial harvest and closures of some high seas fisheries, the practice of coded-wire-tagging the smolts may require re-evaluation.

Juvenile Atlantic Salmon Habitat and Production

Assessments to quantify juvenile salmon rearing habitat (nursery habitat) were initiated in the 1960s and continued into the 1990s. To date, the total quantity of nursery habitat within the basin is estimated to be 77,632 units. As shown in Table 3 and Appendix IV, the greatest percentage of the nursery habitat occurs within the headwaters, specifically the Pemigewasset River and its tributaries.

Optimum fry stocking densities have not been validated. However, evaluation work conducted at sample sites throughout the basin has provided limited data relative to survival of stocked fry to the 1^+parr life stage. These estimates have ranged from near zero to as high as 44% (USASAC 1995, McKeon and McLaughlin 1993, Knight et.al. 1982). Significant 1^+parr production variation has occurred among years, among tributaries (index sites), and within tributaries (index sites). The limited estimates of 1^+parr production for the basin have ranged from approximately 78,000 to 115,000 (USASAC 1995 and 1996), representing a production of approximately 1 to 1.5, 1^+parr per unit of habitat.

Atlantic salmon smolt production derived from fry plants has not been quantified, and thus, any relationship between the number of fry stocked and smolt production is unavailable. However, smolt production that might be derived from 1^+parr production has been estimated utilizing an over-wintering mortality rate of 65%; a rate that is well within the range (40 to 74%) reported by the U. S. Atlantic Salmon Assessment Committee (1996). This estimate is based on the assumption that all parr survivors smoltify at age two. Production estimates in the Merrimack River drainage range from 51,000 to 75,000 two-year-old smolts, with a smolt production per unit of habitat ranging from approximately 0.7 to 1. These estimates should be viewed with caution because of the data limitations.

Adult Atlantic Salmon River Returns

From 1982 - 1996, a total of 1,827 returning salmon have been recorded (Table 4). Included within the run totals are the documented sport catches (legal and illegal) in which the fish were actually landed and killed downstream from the fish-lift at the Essex Dam, salmon mortalities found downstream from the Essex Dam, and counts at the fish-lift.

Timing of Adult Returns

Atlantic salmon usually enter the Essex Dam fish-lift from early May through July, and then again from mid-September through October. As shown in Figure 4 and Appendix V, the largest number of salmon recorded at the fish-lift occur during June, followed by May and July. Fish

TABLE 3. ESTIMATED NUMBER OF 100 SQUARE YARD UNITS OF JUVENILE ATLANTIC SALMON HABITAT WITHIN THE MERRIMACK RIVER BASIN.

Tributary	Number of 100 Square Yard Units
Nashua River	Undetermined
Souhegan River	4,309
Cohas Brook	Undetermined
Piscataquog River	5,014
Black Brook	218
Suncook River	701 (partial estimate)
Soucook River	982 (partial estimate)
Merrimack River (main stem) Sewalls Falls reach	3,000
Hayward Brook	45
Contoocook River	5,117
Bryant Brook	Undetermined
Stirrup Iron Brook	80
Punch Brook	120
Winnipesaukee River	1,400
Pemigewasset River (includes main stem and appropriate tributaries)	56,646 (partial estimate)
TOTAL	**77,632**

lifting operations are normally suspended from August through mid-September because of low river flows and high water temperatures.

However, in August of 1990 and 1991, fish-lifting operations at the Essex Dam were initiated following an increase in river flows due to significant rainfall events. The efforts resulted in the capture of eight additional salmon in 1990 and six in 1991.

The sea-age components of the adult returns recorded at the fish-lift have shown different patterns of upstream movement with respect to time. The grilse return component is greatest during late June and July. The 2SW component is strongest during June. The 3SW component is strongest in July.

TABLE 4. TOTAL NUMBER OF ATLANTIC SALMON OBSERVED RETURNING TO THE MERRIMACK RIVER.

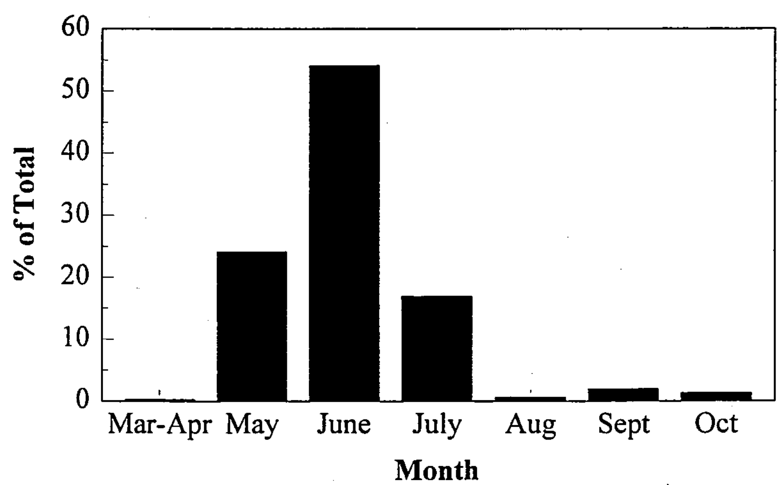
Year	Number of Adult Salmon - Counts at Fish-lift in ( )
1982	23 (15)
1983	114 (88)
1984	115 (107)
1985	213 (212)
1986	103 (99)
1987	139 (136)
1988	65 (64)
1989	84 (84)
1990	248 (242)
1991	332 (327)
1992	199 (199)
1993	61 (61)
1994	21 (19)
1995	34 (32)
1996	76 (74)
Total	**1,827 (1,759)**

Sea-Age Structure of Adult Returns

Atlantic salmon returns to the Merrimack River have contained grilse (13%), 2SW salmon (85%), 3SW salmon (2%), and less than 1% repeat spawners. The percentages vary considerably among years (Table 5). Five repeat spawners have been recorded as well as one 4SW salmon.

The sea-age structure of the adult returns differs slightly

FIGURE 4. ATLANTIC SALMON RETURNS
BY MONTH (ALL YEARS COMBINED)



with respect to juvenile stocking origin. Adults of fry stocking origin have exhibited a sea-age structure of 9% grilse, 89% 2SW salmon, and 2% 3SW salmon. Adults of smolt stocking origin have exhibited a sea-age structure of 15% grilse, 83% 2SW salmon, and 2% 3SW salmon.

TABLE 5. ATLANTIC SALMON RETURNS TO THE MERRIMACK RIVER AS RELATED TO SEA-AGE.

Year	Grilse	2SW	3SW	Other
1982	7	16	0	0
1983	8	95	11	0
1984	80	32	2	1
1985	13	197	3	0
1986	23	77	3	0
1987	10	120	9	0
1988	8	54	3	0
1989	3	79	2	0
1990	27	219	2	0
1991	1	330	1	0
1992	31	166	0	2
1993	2	57	1	1
1994	1	20	0	0
1995	2	32	0	0
1996	14	57	0	5
Total	**230**	**1551**	**37**	**9**

Sex Ratios of Adult Returns and Egg Production

Sex Ratios

The overall sex ratio of the adult returns favors females (56% versus 44% males). The grilse returns are predominantly males (84%), the 2SW returns favor females (60%), and the 3SW returns slightly favor males (52%).

The larger female component of the total adult returns is the result of the significantly larger female component from 2SW adults of fry stocking origin (62% versus 38% males). Two-sea-winter adults of smolt stocking origin have exhibited a female component of 51% and a male component of 49%. The number of females and males for the 2SW adult returns is quite variable from year to year (Table 6).

TABLE 6. KNOWN MALE AND FEMALE COMPONENTS OF 2SW ATLANTIC SALMON RETURNS TO THE MERRIMACK RIVER FROM ADULTS OF FRY STOCKING AND SMOLT STOCKING ORIGINS.

Year	Females of Fry Stocking Origin	Males of Fry Stocking Origin	Females of Smolt Stocking Origin	Males of Smolt Stocking Origin
1982	1	1	7	5
1983	15	18	10	35
1984	6	3	9	5
1985	53	30	42	64
1986	18	17	13	9
1987	16	9	43	39
1988	23	12	7	8
1989	28	26	10	14
1990	60	39	60	47
1991	160	76	43	29
1992	51	49	38	28
1993	23	6	17	10
1994	8	6	2	0
1995	11	4	12	5
1996	8	10	23	33
Total	**481**	**306**	**336**	**331**

Egg Production

From 1982 through 1996, approximately 5.6 million eggs were taken from 781 sea run females (Table 7). The mean fecundity for the female grilse component (13 females from which eggs were taken) is approximately 5,400 eggs. The mean fecundity for the female 2SW component (735 females from which eggs were taken) is approximately 7,200 eggs. The mean fecundity for the female 3SW component (18 females from which eggs were taken) is approximately 9,100 eggs.

Contribution of Fry, Parr, and Smolt Releases to Adult Returns

All components of the juvenile release program have contributed adult returns to the river. From the total adult returns that have been recorded (1,827) since 1982, 52% have originated from fry releases, 2% from parr releases, and 46% from smolt releases. As shown in Table 8, the contributions of the three life-history stages have varied considerably from year to year.

Back-calculated Smolt Lengths of Atlantic Salmon Adults

The back-calculated smolt sizes of adults from fry stocking origin differ remarkably from those of adults derived directly from hatchery smolt stockings (Figure 5). This suggests that smolts

TABLE 7. ATLANTIC SALMON EGG PRODUCTION FROM SEA RUN RETURNS TO THE MERRIMACK RIVER.

Year	No. of Females Spawned	No. of Eggs Taken (Rounded to Nearest 100)	Mean No. of Eggs Per Female
1982	7	26,000	3,714
1983	25	176,900	7,076
1984	19	140,100	7,373
1985	71	480,000	6,760
1986	46	288,800	6,278
1987	67	532,600	7,949
1988	31	244,200	7,877
1989	39	302,200	7,748
1990	117	855,100	7,308
1991	168	1,244,000	7,404
1992	84	538,100	6,405
1993	42	321,600	7,657
1994	10	67,500	6,750
1995	24	187,600	7,816
1996	31	212,500	6,855
Total / Average	**781**	**5,613,200**	**7,187**

produced from fry plants do not have to be as large (length) as hatchery smolts in order to survive. The 6.3 inch line in the hatchery smolt portion of the graph shows the minimum size that is considered a smolt for stocking purposes. The hatchery smolt information in Figure 5, when viewed with Figure 6, suggests that a larger minimum length, perhaps 8 inches, would result in increased adult returns.

Atlantic Salmon Adult Return Rates

The rate of return for juvenile Atlantic salmon released into the Merrimack River (number of adults returned per each 1,000 fish stocked) has varied considerably from year-class to year-class (Table 9). For fry plants, the rate of return has varied from a low of 0.02 to as high as 2.74 adults and for smolt plants the rate of return has varied from a low of 0.02 to as high as 1.42 adults.

Beginning with the 1988 fry release the rate of return has declined. Three current hypotheses relative to the observed decline suggest that 1) there has been a significant increase in the number of cormorants, striped bass and marine mammals in the lower Merrimack River and predation on salmon may be significant, 2) fry stocking densities may be too high, and 3) the ocean conditions for post-smolts during their first winter is not conducive to good survival (Baum, et al 1995).

TABLE 8. ATLANTIC SALMON RETURNS TO THE MERRIMACK RIVER AS RELATED TO JUVENILE STOCKING ORIGIN.

Year	Fry Origin	Parr Origin	Smolt Origin
1982	6	0	17
1983	48	0	66
1984	32	16	67
1985	92	9	112
1986	51	5	47
1987	33	10	96
1988	43	0	22
1989	56	1	27
1990	129	5	114
1991	255	1	76
1992	114	0	85
1993	32	0	29
1994	19	0	2
1995	14	0	20
1996	18	0	58
Total	**942**	**47**	**838**

FIGURE 5. ATLANTIC SALMON RETURNS AS RELATED TO TOTAL LENGTH AT SMOLT (BACK-CALCULATED LENGTHS)

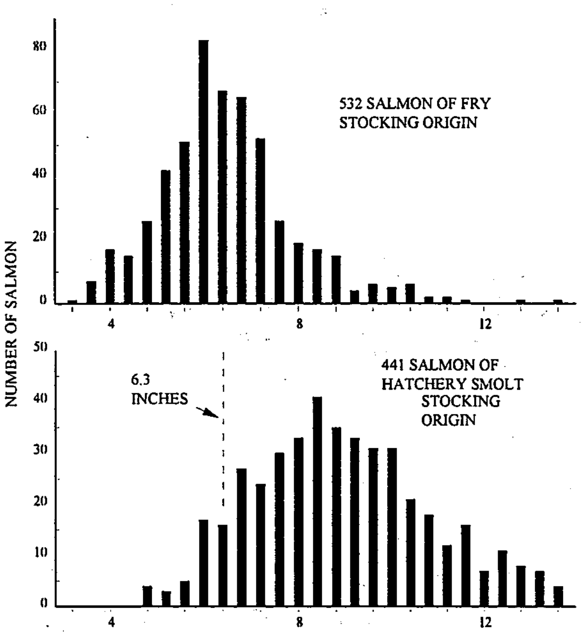


FIGURE 6. ATLANTIC SALMON RETURNS AS RELATED TO TOTAL LENGTH AS SMOLTS.

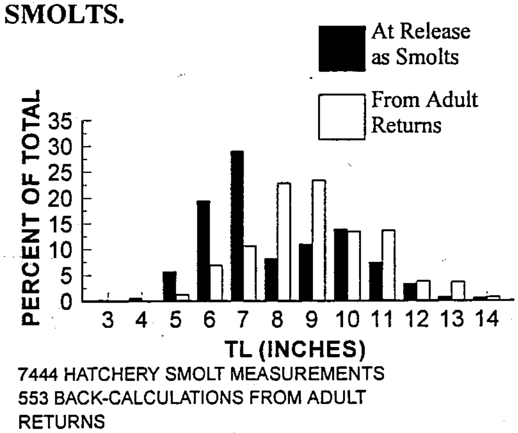


TABLE 9. RATES OF RETURN FOR ATLANTIC SALMON OF FRY STOCKING AND SMOLT STOCKING ORIGINS.

Year-class (Year of Release)	# Fry Released in 1,000s	# Adult Returns	Adults per each 1,000 Fry Stocked	# Smolts Released in 1,000s	# Adult Returns	Adults per each 1,000 Smolts Stocked
1978	106.1	18	0.17	47.2	Not Available	Not Available
1979	76.9	43	0.56	39.7	Not Available	Not Available
1980	125.5	43	0.34	31.0	20	0.65
1981	57.0	81	1.42	100.9	57	0.56
1982	50.0	48	0.96	71.0	26	0.37
1983	8.4	23	2.74	109.9	156	1.42
1984	525.5	47	0.09	68.2	37	0.54
1985	148.4	59	0.40	189.3	105	0.55
1986	524.6	110	0.21	104.0	23	0.22
1987	1,078.3	278	0.26	141.6	27	0.19
1988	1,717.8	95	0.06	94.4	114	1.21
1989	1,033.5	43	0.04	58.6	81	1.38
1990	975.2	21	0.02	116.9	68	0.58
1991	1,458.3	18	0.01[1]	120.1	44	0.37
1992	1,117.5	13	0.01[1]	96.4	2	0.02
1993	1,157.5	3	0.001[1]	59.0	21	0.36
1994	2,816.8	Not Available	Not Available	85.0	46	0.54[1]

[1] Life cycle not yet completed.

Harvest of Atlantic Salmon of Merrimack River Origin

Ocean Harvest

From 1986 through 1992, a total of 69 1SW salmon bearing CWT of Merrimack River origin was recovered in the ocean fishery (26 from the Canadian fishery and 43 from the West Greenland fishery) (Appendix VI and Stolte 1995). These numbers represented a CWT recovery rate of 0.101 per each 1,000 smolts released. The range in rates varied from a low of 0.0 to a high of 0.254.

Estimated harvest of 1SW salmon from the West Greenland fishery in 1987, 1989, 1990, and 1991 was 51, 243, 1,072, and 384, respectively (ICES 1993). The estimated harvest of 1SW salmon exceeded the following year's adult return of 2SW salmon to the river in three of the four years. During 1988, 1990, 1991, and 1992, the 2SW salmon river returns were 54, 219, 330, and 166, respectively. During the four years of CWT recoveries, no harvest estimates for the Canadian commerical fishery were available.

River Harvest

Total known harvest by angling (legal and illegal) was 61 salmon from 1982 through 1996 (3.3% of the total river returns recorded at the fish-lift at the Essex Dam). Known harvest in any one year ranged from a low of 0% to as high as 25% of the total returns.

From 1982 through 1984, when the taking of Atlantic salmon by angling was allowed downstream from the Essex Dam, the known harvest was 41 salmon (19% of the river returns recorded at the fish-lift). Following the change in regulations in 1985 which made it illegal to catch and kill an Atlantic salmon downstream from the Essex Dam to the river mouth, only 20 salmon were known to have been taken by angling. These 20 fish represented 1% of the river returns recorded at the fish-lift from 1985 through 1996.

Records have also been kept with regard to fish returning to the Essex Dam fish-lift with terminal gear (i.e., flies, lures, shad darts) still attached and/or showing signs of hooking scars. One percent of all known returns from 1982 through 1995 have shown signs of having been hooked. It is assummed that the harvest downstream from the Essex Dam is equal to 3% of the count at the fish-lift (USASAC 1994).

Domestic Atlantic Salmon Broodstock Program

Egg Production

The domestic Atlantic salmon broodstock program was initiated in 1988 in order to develop an additional egg supply to meet the fry stocking target of 3.1 million for the Merrimack River salmon restoration effort. Eggs were first obtained in 1991. From 1991 through 1996, approximately 32.8 million eggs were taken from 6,047 females (Table 10).

TABLE 10. EGG PRODUCTION FROM ATLANTIC SALMON DOMESTIC BROODSTOCK.

Year	No. of Females Spawned	No. of Eggs Taken (Rounded to Nearest 100)	Mean No. of Eggs Per Female
1991	1,297	5,170,000	3,986
1992	536	2,432,800	4,539
1993	1,573	9,664,600	6,144
1994	1,035	5,720,800	5,527
1995	694	4,353,200	6,270
1996	912	5,469,000	5,997
Total / Average	**6,047**	**32,810,400**	**5,426**

Not all of the domestic broodstock eggs were utilized within the Merrimack River salmon program. A portion, usually 500,000 eggs, was provided to the Pawcatuck River salmon program in Rhode Island annually, and a much smaller number provided for research activities.

Disposition of Surplus Broodstock

As indicated earlier, the domestic Atlantic salmon broodstock program was initiated in order to develop the egg production necessary to meet the fry stocking target for the Program. Once mature broodstock have been spawned artificially they become surplus since supplemental year-classes are being produced simultaneously. In addition, some maturing broodstock become surplus simply because more broodstock are reared than would be necessary in order to account for any unexpected mortalities. Thus, each year the NNFH must remove some broodstock prior to and following artificial spawning because of rearing space capacity. A total of 10,363 surplus Atlantic salmon domestic broodstock has been released into the Merrimack River system (1,591 in 1993, 3,330 in 1994, 3,031 in 1995, and 2,411 in 1996). The majority of the releases (9,291) was comprised of post-spawner males and females. Approximately 10 % of the releases were pre-spawner (sexually mature) males and females (1,072).

The pre-spawners are released into the Pemigewasset River system as part of a study to determine if the fish would spawn naturally in the wild. The post-spawners were released to support the broodstock sport fishery in the mainstem of the Merrimack River.

Pre-spawner Releases / Natural Reproduction Study

The prospect of releasing salmon into habitat that once supported adult salmon offered numerous benefits to the program. The objectives of the study were to provide information about the quality and quantity of suitable spawning and juvenile rearing habitat in the watershed; provide information about the effects of environmental variables and human activities on the survival of large salmon in the watershed; and to assess the feasibility of decreased dependence on hatchery produced and distributed juvenile salmon.

In 1994, 218 domestic broodstock pre-spawners (primarily females) were released into the Pemigewasset River system (mainstem and Baker River). Eleven days following the release of the fish into the Baker River, six redds and many test redds were located in the vicinity of the release site. Two of the redds contained salmon eggs of which approximately 30% had been fertilized.

In 1995, a formal study was initiated when 554 domestic broodstock pre-spawners were released at sites in the Pemigewasset River watershed proximal to spawning habitat in mid-October. Extreme weather events, including floods and early snow and ice, hampered the efforts to locate the salmon. No spawning was documented nor redds located.

A similar study was conducted in 1996. Spawning was documented (redds located). However, extreme flooding negated additional work and the success of spawning is unknown.

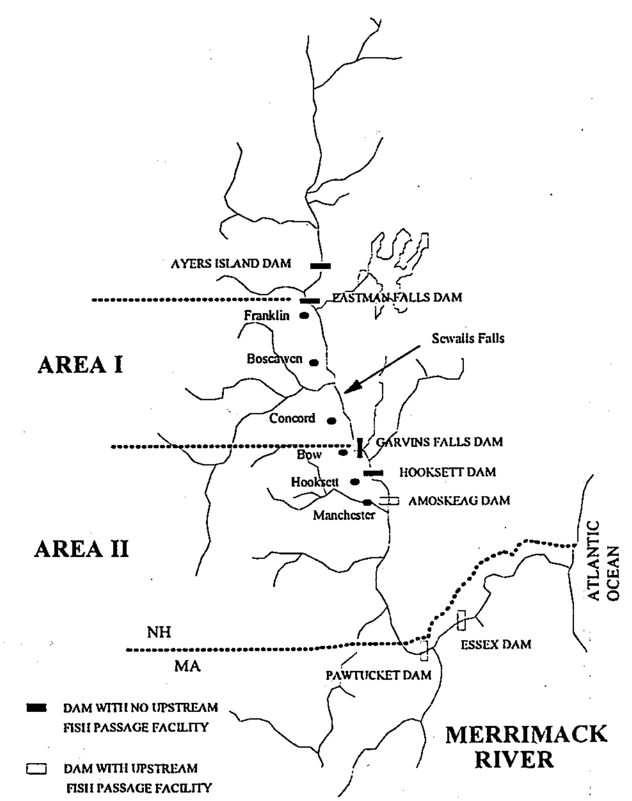
<u>The Sport Fishery</u>

The Atlantic salmon domestic broodstock sport fishery, managed by the NHFG in NH waters, was initiated in 1993. The fishery is an interim fishery that will be eliminated when the number of sea run adults is sufficient to provide for angling. The primary objectives of the fishery are to allow the fisheries agencies the opportunity to develop the skills necessary to manage a fishery for large salmon and to provide for constituency development.

The NHFG administers the sport fishery through a permit system and special regulations. Revenues accrued from the purchase of permits (by the anglers) are placed into a dedicated account to be utilized for managing the Atlantic salmon fishery and associated restoration activities. A reporting system was implemented as part of the program. Anglers who purchase a salmon permit are issued a diary which should be returned to the NHFG following seasonal closure of the fishery.

The basic fishery regulations are uniform throughout the river reach in which the fishery is managed. Anglers are permitted to take one salmon per day and a maximum number of five salmon per season. Anglers can only take and kill a salmon having a Petersen disc tag affixed to the base of the dorsal fin. This serves to identify and distinguish any adult sea run salmon (which are not tagged) from tagged domestic broodstock.

FIGURE 7. MANAGEMENT AREAS FOR BROODSTOCK SPORT FISHERY.



The fishery is directed at broodstock released into six mainstem locations each spring. Some releases have also occurred in the fall. The river was partitioned into two management areas (Figure 7). More restrictive angling methods occur in Area I than in Area II.

An overview of the sport fishery during 1993 through 1996 is presented in Table 11 and detailed information pertaining to the 1993-1995

TABLE 11. RESULTS OF THE DOMESTIC ATLANTIC SALMON BROODSTOCK SPORT FISHERY FOR 1993, 1994, 1995, and 1996.

Category	1993	1994	1995	1996
Total Permits Sold	930	1708	2,387	2,066
% Non-residents	3	9	7	10
Diary Reporting Rate (%)	61	61	60	27
Estimated No. of Anglers that Fished	715	1250	1,683	1,355
% of Anglers Utilizing Fly Fishing	76	77	69	76
% of Anglers Utilizing Artificial Lures	24	14	20	16
% of Anglers Utilizing Both Fly Fishing and Artificial Lures	0	9	11	8
Angler Success in Fly Fishing Area (% catching at least 1 salmon)	35	26	30	27
Angler Success in Fly Fishing / Artificial Lure Area (% catching at least 1 salmon)	28	24	31	30
Estimated Total Hours of Fishing Effort	14779	21726	29,205	22,206
Estimated Catch per Unit of Effort (hours per salmon landed)	14.9	23.5	15.9	14.4
Estimated No. of Angler-Trips	4651	6258	9,746	6,958
Estimated No. of Salmon Caught and Released	594	577	1,105	1,080
Estimated No. of Salmon Caught and Kept	400	345	737	461
Estimated Total Catch (Released and Kept)	994	922	1,841	1,541
Estimated Expenditures Per Angler ($)	92	84	132	131
Estimated Total Expenditures by Anglers ($)	66000	105000	221,584	177,506

seasons can be found in Greenwood and Stolte (1996).

During the four years the fishery has occurred, domestic broodstock released in one location are often caught or observed in another location. The movement of broodstock following release appears to be in a downstream direction but movement upstream has also been recorded. Domestic broodstock have also been observed downstream from the Essex Dam and have been passed upstream at the fish-lift. This has also occurred regularly at the fish-lift at the Pawtucket Dam in Lowell. Some fishing has occurred in the mainstem of the Merrimack River in MA (Lowell area). However, the fishing that occurred in MA has not been monitored.

The sport fishery has been well-received, has generated substantial economic and recreational benefits, and is meeting the objectives. However, some illegal fishing activities have occurred in both of the management areas. The illegal activities have taken the form of poaching, fishing for broodstock without a salmon permit, and using illegal terminal gear. The latter activitiy has been the most prevalent problem.

Present Status of the Atlantic Salmon and Needs

Status

1. The native Atlantic salmon population has been extirpated.

2. Homewater returns from the juvenile stocking program range from a low of 21 to a high of 332.

3. Fry stocking protocols that optimize smolt production have not been determined.

4. The survival of stocked fry to age 1^+ parr is consistent wih other New England rivers.

5. Estimates of basin smolt production are not available.

6. The extent and impacts of predators in riverine, estuarine, and marine environments are not known.

7. Atlantic salmon rates of return from the marine environment are low.

8. The annual production of hatchery fry is extremely variable which limits the ability to meet the production target.

9. The annual production of hatchery smolts is stable but at a minimum level.

10. The efficiency of upstream fish passage facilities is not known. The development of additional facilities is on schedule. Modification and improvement to facilities and associated studies are ongoing.

11. Downstream fish passage development is ongoing. The efficiency of most existing downstream fish passage facilities is not known. Modification and improvement to facilities and associated studies are ongoing.

12. There exist adequate federal, state, and municipal statutes and laws to facilitate restoration of the Atlantic salmon.

13. The capability exists for adequate coordination and cooperation among regulators, resource managers, the public, and research scientists to restore the Atlantic salmon population.

14. The Fish Passage Action Plan is out of date.

Needs

The 1994, U.S. Atlantic Salmon Assessment Committee working group addressed Atlantic salmon research needs in a comprehensive discussion. Although the research areas discussed relate to New England as a whole, many of the needs are directly applicable to the Merrimack River program. The outcome of that discussion can be found in the 1994 annual report of the U.S. Atlantic Salmon Assessment Committee. The reader is referred to that report for specific research needs. In addition, the following items should be addressed:

1. Evaluate the fry stocking program to determine optimum stocking procedures (fry handling, locations of fry releases, stocking densities, timing of releases, etc.) for maximum smolt production (quantification).

2. Identify and quantify sources of smolt losses in riverine and the estuarine environments and post-smolts in the marine environment.

3. Monitor the timing of smolt migration throughout the basin.

4. Utilize existing facilities to increase hatchery smolt production to meet the target of 200,000. Based on past performance this number should provide approximately 50 to 100 pairs of adults back to the river, adequate numbers for artificial spawning operations.

5. Refine hatchery production targets as required.

6. Continue to pursue improved upstream and downstream fish passage through regulatory mechanisms and through cooperation with hydro project owners.

7. Revise FPAP, incorporating a monitoring plan and any new programmatic direction.

8. Determine the success of the pre-spawner domestic broodstock releases.

9. Quantify and qualify the Atlantic salmon spawning habitat in the basin, with emphasis in the headwaters.

10. Provide a stable source of Atlantic salmon eggs for the program

AMERICAN SHAD (*Alosa sapidissima*)

Life History

American shad (shad) is the largest member of the herring family, averaging between 17 and 24 inches in length and between 3 and 6 pounds in weight at sexual maturity. It is a schooling species and highly migratory. Shad are found along the Atlantic seaboard from Labrador to Florida. Most abundant on the East Coast from Connecticut to North Carolina, shad have spawned, historically, in almost every major river along the Atlantic Coast. Shad are river-specific; each major river along the Atlantic Coast appears to have a discrete spawning stock.

Shad spawning can occur as early as November in southern states and as late as July in New England and Canada. Shad that spawn in the northern part of the range may survive to spawn again. Spawning begins in the spring as rising water temperatures signal a return to freshwater. Water temperature at the time of upstream migration is typically 56-66 °F. Males arrive at the spawning grounds first, soon followed by the females. A female shad may produce from 100,000 to 600,000 eggs, depending on size, each spawning season.

The transparent, fertilized eggs measure one-tenth to two-tenths of an inch in diameter and range from pale pink to amber. Carried along by the current, the eggs hatch in about four to twelve days, depending on water temperature. Shad spend their first summer in tributary and river nursery areas. By autumn, when they are three to five inches long, most juveniles migrate to near-shore coastal wintering areas. Immature shad remain in the ocean before returning to spawn. Males are smaller than females and generally mature earlier.

After spawning , adult shad return to the sea and migrate northward to summer feeding grounds in the Gulf of Maine, feeding primarily on zooplankton and small fishes. As water temperatures decline in the fall, particularly October and November, shad migrate southward and offshore. Overwintering occurs along the Mid-Atlantic coast, particularly from Maryland to North Carolina.

East Coast Stock Status

Historically, shad was an extremely important resource, supporting large commercial fisheries, along the East Coast of both the United States and Canada. However, the status of shad stocks is depressed compared to historical levels. At the turn of the century, coastwide landings were approximately 50 million pounds. By 1980, landings decreased dramatically to 3.8 million pounds, and by 1994, commercial landings were only 1.5 million pounds. Currently, the coastwide commercial harvest is divided equally between ocean and in-river landings.

Recreational fisheries for shad are poorly documented in most states. Intensive fisheries occur in the Delaware River and in the Connecticut River, where recreational harvest accounts for approximately 10% of total shad landings. The only known recreational fishery that exists in the ocean occurs in the New York Bight area.

Several hypotheses have been offered to explain the stock decline (ASMFC 1995). They include overharvest within the natal rivers as well as the ocean-intercept commercial fisheries, water quality degradation, and loss of essential spawning and nursery habitat due to blockage by dams and other impediments. Stock displacement or enhanced mortality due to colder than normal ocean water temperatures has also been suggested; a decline in ocean temperatures since 1990 during winter and spring months could have caused a disruption of normal spring migration patterns resulting in direct mortality or displacement of stocks in the ocean to areas of high predation and/or poor food availability. Increased predation mortality on either adults or juveniles may also explain the recent decline.

Recently, an evaluation of shad stock status from 21 river systems from New Hampshire to South Carolina was conducted based on trends in commercial landings catch-per-unit-effort, fishway counts, population estimates, and juvenile abundance estimates (Crecco 1995). The evaluation concluded that there is no evidence of a recent stock decline in 13 out of the 21 stocks examined (New Hampshire coastal rivers, the Merrimack, Hudson, Delaware, Susquehanna and Altamaha Rivers, and rivers in South Carolina), even though stocks have suffered a long term decline from historic levels. There was no evidence of recruitment failure for any of the shad stocks for which a time series of juvenile indices was available. In the rivers where a stock decline was evident (Pawcatuck, Connecticut, and Nanticoke Rivers and Virginia and North Carolina rivers), recent fishing mortality rates were low and stable, as well as being below the current overfishing definition. In fact, the highest fishing mortality rates took place on stocks which did not exhibit a decline. These low fishing mortality rates suggest that the cause of stock declines in these 8 rivers is not related to in-river or coastal intercept fisheries.

Restoration Program Background

Prior to the development of the current fish passage facilities at the Essex Dam in Lawrence, MA, and the Pawtucket Dam in Lowell, MA, American shad restoration activities centered around collecting shad eggs from adults of Connecticut River origin. The eggs were transported and broadcast into the Merrimack River at various mainstem locations. This practice ceased in 1979 when adult shad of Connecticut River origin were transported and released into the river's main stem. The transportation of adult shad from the Connecticut River to the Merrimack River has continued from 1982 - 1996, even after the fish-lift at the Essex Dam was constructed in 1982.

During the early 1970s, several of the fisheries agencies made attempts to capture adult shad in the lower river utilizing floating gill-nets. Although these efforts met with very limited success, adult shad were observed at the base of the Essex Dam in the mid-1970s.

American shad restoration efforts now include both active and "passive" actions. The active portion, the transportation of adults from the Connecticut River, continues to a limited degree even today. The "passive" portion of the effort involves providing passage for adult and juvenile shad at the hydroelectric dams. The production of juveniles has been observed for both the active and passive restoration efforts. The extent of juvenile production (spawning success and production rates) are unknown.

The Transfer of American Shad Eggs to the Merrimack River

From 1969 through 1978, the MADMF, MADFW and the NHFG transported 25.5 million American shad eggs to the Merrimack River (Table 12). These eggs were obtained from adult shad that were gill-netted downstream from the Holyoke Dam on the Connecticut River. The

TABLE 12. AMERICAN SHAD EGG STOCKING HISTORY FOR THE MERRIMACK RIVER.

Release Year	Number Of Eggs	River Of Origin	Release Location
1969	940,000 1,420,000	Connecticut Connecticut	Above Hooksett Dam Above Pawtucket Dam
1970	450,000 540,000	Connecticut Connecticut	Above Sewalls Falls Dam Above Pawtucket Dam
1971	1,330,000 568,000	Connecticut Connecticut	Above Sewalls Falls Dam Above Pawtucket Dam
1972	3,200,000	Connecticut	Above Sewalls Falls Dam
1973	1,900,000	Connecticut	Above Sewalls Falls Dam
1974	4,300,000	Connecticut	Above Sewalls Falls Dam
1975	3,970,000	Connecticut	Above Essex Dam
1976	4,430,000	Connecticut	Above Hooksett Dam
1977	1,700,000	Connecticut	Above Pawtucket Dam
1978	780,000	Connecticut	Above Garvins Falls Dam
Total	**25,528,000**		

majority of the eggs was broadcast into the Merrimack River upstream from Concord, NH in the Sewalls Falls reach of the mainstem. The production of juvenile shad from the egg stocking efforts was documented visually during the fall months (during out-migration) within the NH portion of the mainstem but rarely observed in the MA portion of the mainstem.

Adult Shad Transfers

With the exception of 1987 - 1989, adult shad were transported from the Connecticut River and released into the Merrimack River from 1979 through the present (Table 13). Adult shad were

TABLE 13. ADULT AMERICAN SHAD RELEASES - MERRIMACK RIVER.

Year	Number	River Of Origin	Release Location
1979	690	Connecticut	Above Hooksett Dam
	370	Connecticut	Above Pawtucket Dam
1980	1,231	Connecticut	Above Pawtucket Dam
1981	400	Connecticut	Above Garvins Falls Dam
	700	Connecticut	Above Pawtucket Dam
1982	770	Connecticut	Above Garvins Falls Dam
1983	1,079	Connecticut	Above Garvins Falls Dam
1984	98	Connecticut	Above Garvins Falls Dam
	77	Merrimack	Above Garvins Falls Dam
	1,433	Connecticut	Above Sewalls Falls
1985	110	Merrimack	Nashua River in Hollis
	979	Connecticut	Above Garvins Falls Dam
1986	214	Merrimack	Concord River
	127	Merrimack	Nashua River in Pepperell
	673	Merrimack	Above Garvins Falls Dam
1990	750	Connecticut	Above Garvins Falls Dam
	250	Connecticut	Above Sewalls Falls
1991	251	Connecticut	Above Sewalls Falls
	754	Connecticut	Above Garvins Falls Dam
1992	2,082	Connecticut	Above Garvins Falls Dam
	180	Connecticut	Nashua River Above Mines Falls
1993	1,282	Connecticut	Above Garvins Falls Dam
1994	1,173	Connecticut	Above Garvins Falls Dam
1995	250	Connecticut	Manchester Reach
	292	Merrimack	Manchester Reach
1996	640	Connecticut	Manchester Reach
	40	Merrimack	Manchester Reach
Total	**16,895**		

also captured in the lower Merrimack River and transported and released into upriver areas. Approximately 91% of the 16,895 adult shad released originated from the Connecticut River. The remainder, 1,533 adults, was of Merrimack River origin.

Visual and limited netting efforts to document shad production from the adult transfers were successful in most years within the NH portion of the mainstem. In some years, visual documentation was difficult because juvenile river herring were migrating at the same time, masking species identification.

American Shad River Returns

Early Observations

During the early 1970s, limited numbers of adult shad were gill-netted in the lower Merrimack River downstream from the Essex Dam. The few shad netted in 1973 and 1974 and the lack of any visual observations at the base of the Essex Dam and downstream, suggested that the population entering the river was extremely small. In 1976 and 1977, adult shad were observed at the base of the Essex Dam. Although counts of adult shad were not obtained, the visual observations indicated that more shad were in the lower river than in the past. A few shad managed to negotiate the ineffective fish ladder at the dam.

Fish Passage Counts

Beginning in 1983, with the completion of the modern-day fish passage facility at the Essex Dam the previous summer, adult shad were able to ascend the river beyond Lawrence. In 1986, adult shad were able to ascend the river upstream from the Pawtucket Dam with the completion of a fish-lift and a ladder. For the first time in nearly a century, adult shad were able to reach Manchester, NH. In 1989, fish passage was provided at the Amoskeag Dam in Manchester allowing shad access to the Hooksett Dam in Hooksett, NH (river mile, 81).

From 1983 through 1996, a total of 159,974 adult shad were counted at the fish-lift at the Essex Dam (Appendix VII), approximately 22,500 were estimated passing the fish passage facilities at the Pawtucket Dam, and 23 were counted at the Amoskeag Dam (Table 14 and Figure 8). American shad passage counts at the Pawtucket Dam fish passage facilities are estimates, derived by expanding visual counts and video recordings.

Fish passage counts may not be indicative of the size of the shad population that enters the river annually. The number of shad counted at the Essex Dam fish-lift has varied from year to year. The variation may be related to environmental conditions, fish passage effectiveness, and the size of the population entering the river and reaching the Essex Dam. Adult shad are known to spawn in the river downstream from the Essex Dam. High river flows can retard upstream movement of the adults and reduce fish passage effectiveness because of competitive flows. Low river temperatures, often associated with high river flows, can also retard upstream movement of the adults and may increase the incidence of downriver spawning.

Major changes in the entrance to the fish-lift occurred in 1995 and studies suggest that the changes increased the effectiveness of the facility. Continued improvements are ongoing.

TABLE 14. AMERICAN SHAD FISH PASSAGE COUNTS AT THE ESSEX DAM FISH-LIFT, THE PAWTUCKET DAM FISH PASSAGE COMPLEX, AND THE AMOSKEAG FISH LADDER.

Year	Counts at the Essex Dam Fish-lift	Estimated Counts at the Pawtucket Dam Fish Passage Complex	Counts at the Amoskeag Dam Fish Ladder
1983	5,629	Not in operation	Not in operation
1984	5,497	Not in operation	Not in operation
1985	12,793	Not in operation	Not in operation
1986	18,173	1,630	Not in operation
1987	16,909	3,926	Not in operation
1988	12,359	1,289	Not in operation
1989	7,875	940	4
1990	6,013	443	0
1991	16,098	428	12
1992	20,796	6,491	7
1993	8,599	1,679	0
1994	4,349	383	No counts made
1995	13,861	5,255	1
1996	~~11,023~~ 11,322	400 (incomplete) 400	0
Total	**159,974**	**22,864**	**24**

97 22586 4446
98 27891 4159

There has not appeared to be a relationship between the juvenile production resulting from adult shad transfers and/or adult spawning upstream from the Essex Dam and subsequent fish passage counts. However, the data necessary to make a definitive judgement are not available.

1999 56465 16341
2000 72,571 12,716

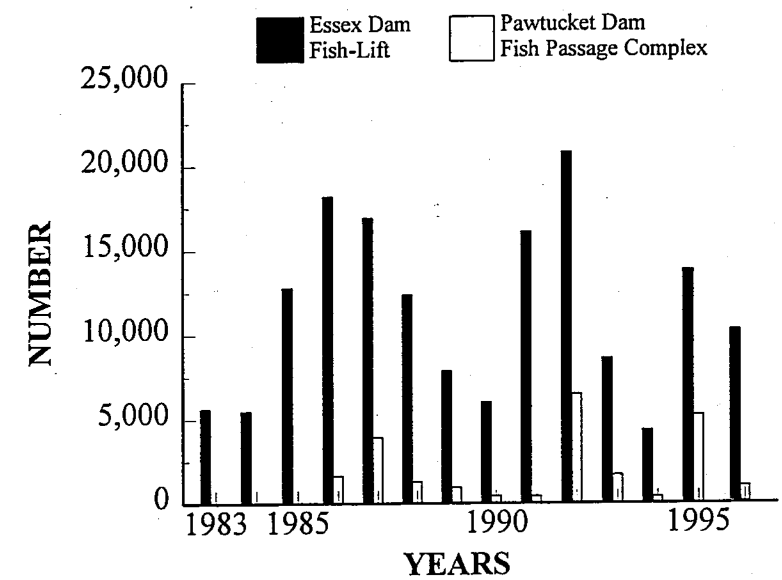
Timing of Shad Passage Counts

American shad counts at the Essex Dam fish-lift reflect a peak passage during early June (Figure 9 and AppendixVII). On average, over 70% of any particular shad run occurs by June 15.

The timing of shad passage is related to the environmental conditions within the river that influence upstream movement as well as the fish passage effectiveness. Passage timing at the Pawtucket Dam fish passage complex is directly dependent on passage at the Essex Dam fish-lift, while the passage at the Amoskeag Dam fish ladder is dependent on passage at the Pawtucket Dam fish passage complex.

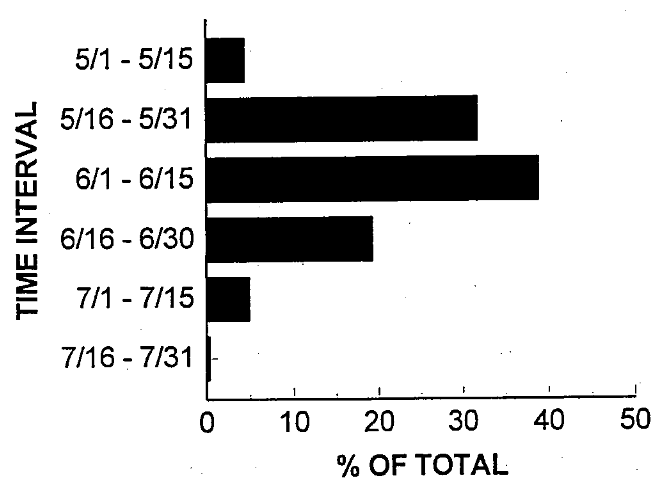
Normally, shad that pass the Essex Dam fish-lift will arrive at the Pawtucket Dam fish passage complex within a seven day period. On occasion adult shad that pass the Essex Dam fish-lift have reached the Pawtucket Dam fish passage complex within a 24-hour period. Shad have reached Manchester, immediately downstream from the Amoskeag Dam fish ladder, as early as three days following the first documented passage at the Pawtucket Dam fish passage complex.

FIGURE 8. AMERICAN SHAD FISH PASSAGE COUNTS (1983 THROUGH 1996)



Counts at the Amoskeag Dam fish ladder not included because of the low numbers

FIGURE 9. TIMING OF AMERICAN SHAD FISH PASSAGE AT THE ESSEX DAM FISH-LIFT.



Age, Growth, and Sexual Composition of Adult Shad Returns

At various times during the period of 1983 - 1995, the MADFW and the

MADMF collected limited data on shad age, growth, and sexual composition (Appendix VIII).

The ages identified through scale analyses were IV, V, VI, and VII. Repeat spawners were also identified within some of the age categories. The age structure of the sampled populations are consistent with other shad populations that have been studies.

Sport Fishery

During the period, 1984 through 1988, the MADFW obtained sport fishery data for American shad from the Essex Dam downstream (Appendix IX). The creel census was conducted only in the Lawrence area. This river reach was known to have a relatively strong shad fishery. American shad are also sought by anglers in the Lowell area of the river's mainstem. More recently anglers have shifted their efforts to the large influx of striped bass.

Present Status of the American Shad and Needs

Status

1. The number of adult American shad entering the Merrimack River annually is unknown.

2. The effectiveness of adult shad intra- and inter-basin transfers in enhancing the shad population is unknown.

3. Estimates of juvenile production derived from adult shad returns and/or adult shad intra- and inter-basin transfers are not available.

4. The extent and impacts of predators in riverine, estuarine, and marine environments are not known.

5. The exploitation of adult shad is poorly documented.

6. Population statistics (age, sex, growth, etc.) for returning adult shad are inadequate.

7. The efficiency of upstream fish passage facilities is not known. The development of additional facilities is on schedule. Modification and improvement to facilities and associated studies are ongoing.

8. Downstream fish passage development is ongoing. The efficiency of most existing downstream fish passage facilities is not known. Modification and improvement to facilities and associated studies are ongoing.

9. There exist adequate federal, state, and municipal statutes and laws to facilitate restoration of the American shad.

10. The capability exists for adequate coordination and cooperation among regulators, resource managers, the public, and research scientists to restore the American shad population.

11. The Fish Passage Action Plan is out of date

Needs

1. Develop an annual population index for adult shad.

2. Develop an annual population index for juvenile shad.

3. Develop and implement formalized data collection protocol to characterize the adult run by age, sex, repeat spawners, etc.

4. Evaluate the feasibility and/or desirability of implementing fish cultural operations for American shad.

5. Identify and quantify exploitation of adult shad within the Merrimack River basin.

6. Assess the success of adult transfers in enhancing juvenile production.

7. Continue studies and develop the technologies for improved upstream and downstream fish passage.

8. Revise FPAP, incorporating a monitoring plan and any new programmatic direction.

9. Quantify and map shad spawning and nursery habitat within the Merrimack River basin.

10. Develop a management plan for American shad.

THE RIVER HERRINGS (*Alosa pseudoharengus* and *Alosa aestivalis*)

Life History

Alewife and blueback herring, collectively referred to as river herring, are relatively small members of the herring family. Distinguishing between the two species externally is difficult. The most reliable identifying characteristic is the color of the tissue lining the body cavity, dark brown or blackish in the blueback herring and grey or silvery in the alewife. The alewife occurs from Newfoundland to South Carolina, while the blueback herring occurs from Nova Scotia to the St. Johns River in Florida. Both are a schooling species; adult blueback herring typically occupy a narrow band of coastal water entering fresh or brackish water to spawn while adult alewife oceanic movements are apparently restricted to coastal areas proximal to natal estuaries.

The onset of spring spawning is related to temperature, and thus varies with latitude. Alewife spawn in rivers and tributaries from northeastern Newfoundland to South Carolina, but are most abundant in the mid-Atlantic and northeastern states. Blueback herring spawn from Nova Scotia to northern Florida, but are most numerous in warmer waters from Chesapeake Bay south. Alewife usually spawn three to four weeks earlier than blueback herring in the same watershed. Alewife initiate spawning when water temperatures reach 51 ° F while blueback herring commence spawning at water temperatures of 57 ° F. Alewife spawn in a diversity of habitats that includes large rivers, small streams, and ponds, over a range of substrates such as gravel, sand, detritus, and submerged vegetation. Blueback herring prefer to spawn in swift flowing sections of freshwater tributaries, channel sections of fresh and brackish tidal rivers, and coastal ponds, over gravel and clean sand substrates, especially in northeastern rivers where alewife and blueback herring coexist. Mature river herring broadcast their eggs and sperm simultaneously into the water column and over the substrate. Larvae begin to feed externally three to five days after hatching, and transform gradually into the juvenile stage. Juveniles remain in freshwater nursery areas in spring and early summer, feeding mainly on zooplankton. As water temperatures decline in the fall, juveniles move downstream to more saline waters and eventually to the sea. Little information is available on the life history of subadult and adult river herring after they emigrate to the sea as young-of-year or yearlings, and before they mature and return to freshwater to spawn.

Immediately after spawning adults migrate rapidly downstream. While in the ocean, both species migrate seasonally, possibly in conjunction with changing water temperatures. Alewife are most abundant at depths greater than those where the largest concentrations of blueback herring are found. The alewife is captured most often at depths of 184 -361feet at a temperature range of 37 to 63 °F, while the blueback herring is more frequently captured at 86 - 180 feet. In summer and fall, both species are confined to areas north of 40 degrees north latitude, particularly to Nantucket Shoals, Georges Bank, and the Gulf of Maine. Winter catches are made between 40 and 43 degrees north latitude and spring catches over the entire continental shelf area.

For both species, growth rates, age at sexual maturity, and longevity vary greatly according to geographic location. Few individuals of either species exceed 12 inches in length or about 2/3 of a pound in weight. Throughout their ranges, alewife tend to be longer than blueback herring of the same age. Within each species, females tend to grow somewhat faster than males. Age at sexual maturity for both species is primarily ages 3-5 in the northern portion of their ranges. Fecundity increases with size and age. Alewife produce 48,000-360,000 eggs per season and blueback herring produce a similar amount (45,000 to 350,000 eggs per season). River herring suffer relatively high rates of mortality throughout their life cycles. Fewer than 1% of the eggs survive early life stages to migrate to the sea as juveniles. Total annual mortality of adults is about 70%. As many as 90% of all adults die annually during, or after, spawning migrations and reproduction.

East Coast Stock Status

River herring commercial landings have declined in recent years. Landings ranged from a high of 75 million pounds in 1958, declined during the 1970s, and have dropped to a low of less than 5 million pounds in recent years. Maine, Virginia, and North Carolina reported the bulk of in-river commercial landings from 1978-1987. Commercial ocean harvest of river herring occurs mainly as bycatch in other fisheries (i.e., mackerel); the estimated level of this bycatch does not appear to be problematic. However, bycatch levels should continue to be monitored as fisheries for underutilized species develop.

There are extensive recreational fisheries for river herring in many rivers along the East Coast. While some are hook and line fisheries, many states permit various types of dip nets and seines. The total quantities of fish landed by these recreational netters for personal use (i.e., bait and consumption) may be quite large. These landings are unreported and may represent a potential error in recorded river herring harvests.

The status of fifteen river herring stocks along the East Coast were examined ASMFC and nine were judged to be either overfished or severely depleted (ASMFC, 1990). These overfished stocks were confined to the northern (St. John blueback and alewife and Damariscotta alewife) and mid-southern end (Nanticoke alewife, Potomac alewife and blueback, Rappahannock alewife, and Chowan alewife and blueback) of the geographic range for river herring. The factors causing the decline in river herring stocks are similar to those discussed for American shad. The river herring of the Merrimack River was not specifically examined.

Restoration Program Background

Prior to the construction of the Essex Dam fish-lift in Lawrence, MA efforts were made in the 1970s, to maintain (clean out debris, etc.) the fish ladders at the Essex and Pawtucket Dams such that given adequate flow conditions fish could utilize the facilities. River discharge conditions in some years allowed for fish passage through the fish ladders. River herring were able to pass these obstructions and were observed in Manchester, NH near the power house at the Amoskeag

Dam.

In 1976, the MADMF implemented a sampling program at the Essex Dam fish-ladder during the spring river herring run (Iwanowicz and Gil 1976). During the sampling period an estimated 3,225 river passed the fish ladder. These run contained both alewives and bluebacks with alewives making up a significant portion of the counts. Some observations were also made at the fish ladder at the Pawtucket Dam but no river herring were observed passing.

With the construction of the present-day fish passage facility at the Essex Dam in late 1982, river herring have been able to ascend the river past Lawrence. In 1986, river herring were able to utilize the newly constructed fish passage facilities at the Pawtucket Dam and, in 1989, river herring were able to reach Hooksett, NH by using the new fish ladder at the Amoskeag Dam. Under certain flow conditions river herring have passed the Hooksett Dam on the west side of the river.

River Herring Returns

Fish Passage Counts

From 1983 through 1996, approximately 1,735,000 river herring were counted passing the Essex Dam fish-lift (Table 15 and Appendix X). The majority of the river herring passed the fish-lift during mid-May, with 62% of the run usually completed by the end of May. As shown in Appendix X, a majority of river herring counted at the fish-lift can occur over a very short period of time during the spring spawning run. In 1987, 59% of the total was counted in four days, and in 1988 and 1994, over 70% of the totals was counted in three days and one day, respectively. In 1996, only 51 river herring were counted at the fish-lift. Reasons for this drastic decline are unknown.

The number of river herring counted at the Essex Dam fish-lift has varied from year to year. The variation may be related to environmental conditions, fish passage effectiveness, and/or the size of the population entering the river and reaching the Essex Dam. Adults are known to spawn in the river downstream from the Essex Dam. High river flows can retard upstream movement of the adults and reduce fish passage effectiveness because of competitive flows. Low river temperatures, often associated with high river flows, can also retard upstream movement of the adults and may increase the incidence of downriver spawning.

The river herring passage counts at the Pawtucket Dam and the Amoskeag Dam fish passage facilities are estimates, derived by expanding visual counts and video recordings.

Alewife - Blueback Herring Components

The alewife and blueback herring counts that were recorded at the Essex Dam fish-lift in 1989, 1990, 1991, and 1995, indicate that the abundance of alewives considerably exceeds that of the blueback herring. The recorded percentages are presented in Table 16.

As shown in Figures 10 and 11, alewives were observed at the Essex Dam fish-lift before the blueback herring in 1989 and 1991.

TABLE 15. RIVER HERRING FISH PASSAGE COUNTS AT THE ESSEX DAM FISH-LIFT, THE PAWTUCKET DAM FISH PASSAGE COMPLEX, AND THE AMOSKEAG FISH LADDER.

Year	Counts at the Essex Dam Fish-lift	Counts at the Pawtucket Dam Fish Passage Complex	Counts at the Amoskeag Dam Fish Ladder
1983	4,794	No fish passage	No fish passage
1984	1,769	No fish passage	No fish passage
1985	23,112	No fish passage	No fish passage
1986	16,265	Counts Not Available	No fish passage
1987	77,209	Counts Not Available	No fish passage
1988	361,012	56,739	No fish passage
1989	387,973	137,296	23,837
1990	254,242	9,888	10,708
1991	379,588	6,920	33,282
1992	102,166	32,501	4,481
1993	14,027	4,315	300
1994	88,913	33,735	No counts made
1995	33,425	11,848	4,147
1996	51	Counts unavailable	0
Total	**1,744,495**	**293,242**	**76,755**

River Herring Transfers

Adult river herring have been transferred between locations within the river system and transported from out-of-basin sources and released into the river at various locations (Table 17).

The inter-basin transfers, with the exception of stockings into Lake Winnisquam, were conducted in order to develop larger numbers of adults returning to the river. The releases into Lake Winnisquam (33,550) were solely an effort of the NHFG to establish a forage base in the lake.

TABLE 16. RIVER HERRING RUN COMPOSITION IN 1989, 1990, 1991, AND 1995 - ESSEX DAM FISH-LIFT.

Year	% Alewives (N)	% Bluebacks (N)	Total Run
1989	79.94	20.06	387,973
1990	98.69	1.31	254,242
1991	93.24	6.67	379,588
1995	81.94	18.06	33,425

The adult river herring releases into Lake Winnisquam (1984 - 1990) produced juvenile river herring which were observed leaving the lake via the Winnipesaukee River during the fall months. Biologists were able to observe significant numbers of juveniles entering the Merrimack River and continuing their out-migration. A significant increase in river herring counts at the Essex Dam fish-lift occurred in 1988, four years following the first release of adult river herring into Lake Winnisquam. Significant increases in the number of river herring counted at the fish-lift occurred in 1989 - 1992, and in 1994. Only the river herring counts at the fish-lift in 1993 did not follow the pattern that appeared to have developed. The data suggests that the effort by the NHFG to develop a forage base in Lake Winnisquam may also have been responsible for the large increases in alewives at the Essex Dam fish-lift.

FIGURE 10. ALEWIFE AND BLUEBACK HERRING COUNTS AT THE ESSEX DAM FISH-LIFT / 1989.

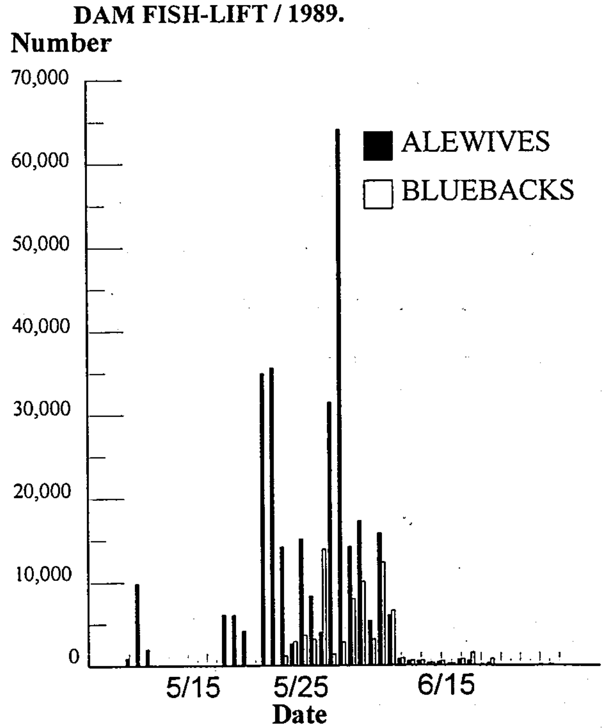


FIGURE 11. ALEWIFE AND BLUEBACK HERRING COUNTS AT THE ESSEX DAM FISH-LIFT / 1991.

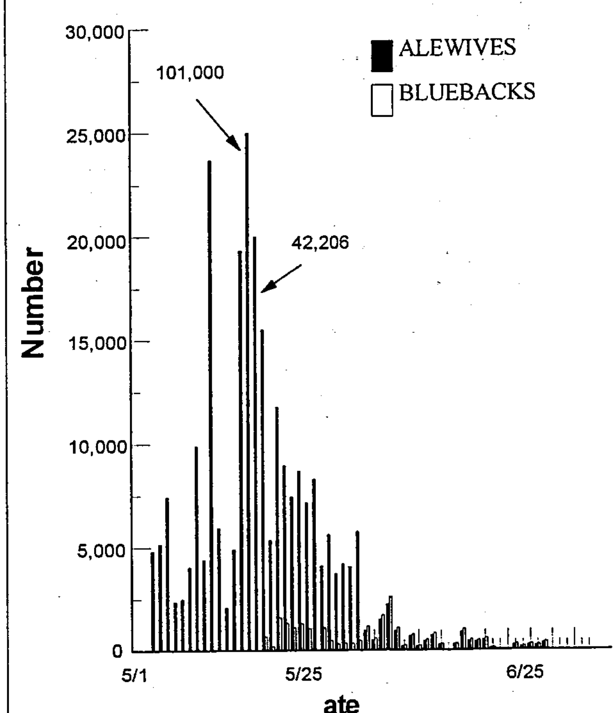


TABLE 17. ADULT RIVER HERRING TRANSFERS.

Year	Source	No.	Release Location
1984	Lamprey & Taylor Rivers (NH)	13,000	Lake Winnisquam
1985	Androscoggin & Royal Rivers (ME) and Charles River (MA)	5,500	Lake Winnisquam
1986	Androscoggin & Royal Rivers (ME)	5,000	Lake Winnisquam
1987	Androscoggin & Royal Rivers (ME)	4,350	Lake Winnisquam
1988	Androscoggin & Royal Rivers (ME)	2,000	Lake Winnisquam
1989	Androscoggin & Royal Rivers (ME)	700	Lake Winnisquam
1989	Merrimack River (Amoskeag Ladder)	377	Nashua River
1990	Androscoggin & Royal Rivers (ME)	3,000	Lake Winnisquam
1990	Androscoggin & Royal Rivers (ME)	3,000	Nashua River
1991	Merrimack River (Amoskeag Ladder)	600	Nashua River
1995	Merrimack River (Lawrence)	32	Fox Run Pond-Soucook River
1995	Cocheco River (NH)	1,200	Northwood Lake-Soucook River
1995	Oyster River (NH)	400	Suncook River in Pittsfield
1995	Cocheco River (NH)	800	Nashua River upstream from Mines Falls
1995	Oyster River (NH)	325	Lake Todd-Contoocook River
1995	Oyster River (NH)	900	Lake Massasecum-Warner River
1995	Merrimack River (Essex Dam fish-lift)	940	Glenn Lake-Piscataquog River
1995	Merrimack River (Essex Dam fish-lift)	390	Kelly Lake-Piscataquog River
1995	Merrimack River (Essex Dam fish-lift)	570	Merrimack River in Manchester
1995	Merrimack River (Essex Dam fish-lift)	303	Concord River upstream from Faulkner Dam
1995	Cocheco River (NH)	780	Merrimack River in Concord
1995	Oyster River (NH)	655	Contoocook River upstream from Hopkinton Dam
1995	Oyster River (NH)	936	Contoocook River upstream from York Dam
1995	Oyster River (NH)	150	Silver Lake-Winnipesaukee River
1995	Cocheco River (NH)	500	Silver Lake-Winnipesaukee River

TABLE 17 continued. ADULT RIVER HERRING TRANSFERS.

Year	Source	No.	Release Location
1996	Cocheco River (NH)	300	Fox Run Pond - Suncook River
1996	Cocheco River (NH)	2,000	Northwood Lake - Suncook River
1996	Cocheco River (NH)	400	Nashua River upstream from Mines Falls
1996	Cocheco River (NH)	2,000	Suncook Lake - Suncook River
1996	Cocheco River (NH)	200	Amoskeag Fishway - Merrimack River
1996	Oyster River (NH)	115	Amoskeag Fishway - Merrimack River
1996	Cocheco River (NH)	800	Horace Lake - Piscataquog River
1996	Oyster River (NH)	1,895	Boscaawen Boat Ramp - Merrimack River
1996	Cocheco River (NH)	1,250	Silver Lake-Winnipesaukee River

In 1990, the NHFG captured adult river herring from outside of the Merrimack River basin and released 3,000 into Nashua River. In 1995 and 1996, the USFWS and the NHFG jointly captured 6,646 and 8,960 adult river herring from outside of the Merrimack River basin. These adults were released into various locations within the basin.

In addition to the releases from out-of-basin sources, 3,212 adult river herring were captured within the Merrimack River (977 captured at the Amoskeag Dam fish ladder, and 2,235 taken from the fish-lift at the Essex Dam and/or captured downstream from the fish-lift by electro-fishing) and released into various locations within the basin.

Additonal Characteristics of the River Herrings

At various times during the period of 1983 - 1995, the MADFW and the MADMF collected limited river herring populations statistics (Appendix XI).

Present Status of the River Herrings and Needs

Status

1. The number of river herring entering the Merrimack River annually is unknown.

2. The effectiveness of adult river herring intra- and inter-basin transfers in enhancing the river herring population is unknown.

3. Estimates of juvenile production derived from adult river herring returns and/or adult herring

intra- and inter-basin transfers are not known.

4. The extent and impacts of predators in riverine, estuarine, and marine environments are not known.

5. The exploitation of river herring is not known.

6. Population statistics (age, sex, growth, etc.) for returning river herring are inadequate.

7. River herring habitat is under-utilized.

8. There exist adequate federal, state, and municipal statutes and laws to facilitate restoration of the river herring.

9. The capability exists for adequate coordination and cooperation among regulators, resource managers, the public, and research scientists to restore the river herring population.

10. The FPAP is out-dated.

Needs

1. Develop an annual population index for adult river herring by species.

2. Develop an annual population index for juvenile river herring by species.

3. Develop and implement formalized data collection protocol to characterize the population structure of river herring.

4. Identify and quantify exploitation of adult river herring within the Merrimack River basin.

5. Quantify and map blueback and alewife habitat througout the Merrimack River basin.

6. Continue to pursue upstream and downstream fish passage.

7. Revise FPAP, incorporating a monitoring plan and any new programmatic direction.

8. Assess the success of adult transfers in enhancing juvenile production.

9. Continue studies and develop the technologies for improved upstream and downstream fish passage.

10. Develop a management plan for river herring.

SECTION VII

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REFERENCES

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SECTION VIII

GLOSSARY

GLOSSARY

DEFINITIONS

GENERAL

Domestic Brood Stock	Salmon that are progeny of sea-run adults and have been reared entirely in captivity for the purpose of providing eggs for fish cultural activities.
Freshwater Smolt Losses	Smolt mortality during migration downstream, which may or may not be ascribed to a specific cause.
Spawning Escapement	Salmon that return to the river and successfully reproduce on the spawning grounds.
Egg Deposition	Salmon eggs that are laid (deposited) in gravelly reaches of the river.
Fecundity	The number of eggs a female salmon produces, often quantified as eggs per female or eggs per pound of body weight.
Fish Passage	The provision of safe passage for salmon around a barrier in either an upstream or downstream direction, irrespective of means.
Fish Passage Facility	A man-made structure that enables salmon to safely pass a dam in either an upstream or downstream direction. The term is synonymous with fish ladder, fish-lift, or bypass.
Upstream Fish Passage Efficiency	A number (usually expressed as a percentage) representing the proportion of the population approaching a barrier that will successfully negotiate an upstream or downstream fish passage facility in an effort to reach the spawning grounds.

Goal	A general statement of the end result that management hopes to achieve.
Harvest	The amount of fish caught and kept for recreational or commercial purposes.
Nursery Unit / Habitat Unit	A portion of the river habitat, measuring 100 square yards, suitable for the rearing of young salmon to the smolt stage.
Objective	The specific level of achievement that management hopes to attain towards the fulfillment of the goal.
Restoration	The re-establishment of a population that will optimally utilize suitable habitat for the production of young.
Salmon	A general term used here to refer to any life history stage of the Atlantic salmon from the fry stage to the adult stage.
Sea-run Brood Stock	Atlantic salmon that return to the river, are captured alive, and held in confinement for the purpose of providing eggs for fish cultural activities.
Strategy	Any action or integrated actions that will assist in achieving an objective and fulfilling the goal.
Wild Atlantic Salmon	Salmon that are the products of natural reproduction or the stocking of fry. Stocked fry are included because of the difficulty associated with discriminating between salmon produced through natural reproduction and those produced as a result of the stocking of fry.

LIFE HISTORY RELATED

Green Egg	The stage from spawning until faint eyes appear.

Eyed Egg	The stage from the appearance of faint eyes until hatching.
Fry	
Sac Fry	The period from hatching until end of primary dependence on the yolk sac.
Feeding Fry	The period from the end of the primary dependence on the yolk sac (initiation of feeding) to June 30 of the same year.
Fed Fry	Fry stocked subsequent to being fed an artificial diet. Often used interchangeably with the term, feeding fry, when associated with stocking activities.
Unfed Fry	Fry stocked without having been fed an artificial diet or natural diet. Most often associated with stocking activities.
Parr	Life history stage immediately following the fry stage until the commencement of migration to the sea as smolts.
0^+ Parr	The period from August 15 to December 31 of the year of hatching.
1 Parr	The period from January 1 to August 14 one year after hatching.
1^+ Parr	The period from August 15 to December 31 one year after hatching.
2 Parr	The period from January 1 to August 14 two years after hatching.
2^+ Parr	The period from August 15 to December 31 two years after hatching.
Smolt	An actively migrating young salmon that has undergone the physiological changes to survive the transition from freshwater to saltwater.

1 Smolt	The period from January 1 to June 30 of the year of migration. The migration year is one year after hatch.
2 Smolt	The period from January 1 to June 30 of the year of migration. The migration year is two years after hatch.
3 Smolt	The period from January 1 to June 30 of the year of migration. The migration year is three years after hatch.
Post Smolt	The period from July 1 to December 31 of the year the salmon became a smolt.
1SW Salmon	A salmon that has passed one December 31st since becoming a smolt.
Grilse	A one-sea-winter (1SW) salmon that returns to the river to spawn. These fish usually weigh less than five pounds.
Multi-Sea-Winter Salmon	All adult salmon, excluding grilse that return to the river to spawn. Includes terms such as two-sea-winter salmon, three-sea-winter salmon, and repeat spawners. May also be referred to as large salmon.
2SW Salmon	A salmon that has passed two December 31st's since becoming a smolt.
3SW Salmon	A salmon that has passed three December 31st's since becoming a smolt.
4SW Salmon	A salmon that has passed four December 32's since becoming a smolt.
Kelt	A stage after a salmon spawns. For domestic salmon, this stage lasts until death. For wild fish, this stage lasts until it returns to homewaters to spawn again.
Reconditioned Kelt	A kelt that has been restored to a feeding condition in captivity.

Repeat Spawners	Salmon that return to the river for the purpose of reproducing a second, third, etc. time. Previous spawner.

SECTION IX

CONVERSION TABLE (ENGLISH TO METRIC)

ENGLISH TO METRIC CONVERSION

Cubic feet per second =
0.28 cubic meters per second

Foot =
0.305 meters

Inch =
25.40 millimeters
2.540 centimeters

Miles =
1.609 kilometers

Ounce =
28.3495 grams

Pound =
453.592 grams
0.454 kilograms

Square mile =
2.590 square kilometers

Square yards =
0.836 square meters

°C =
(°F-32) x 5/9

SECTION X

APPENDICES

STATEMENT OF INTENT

FOR

A COOPERATIVE FISHERY RESTORATION PROGRAM

FOR THE

MERRIMACK RIVER BASIN

The states of Massachusetts, New Hampshire, and the United States Bureau of Sport Fisheries and Wildlife and Bureau of Commercial Fisheries agree to, and support, a fisheries program for the Merrimack River Basin. The following statement shall constitute the official intent of the above-named states and Federal agencies.

Objectives

The objectives of this program are to realize the full potential of the fishery resources of the river including both anadromous and resident species. The intent of this program is to provide the public with high quality sport fishing opportunities in a highly urbanized area as well as to provide for the long-term needs of the population for food through development and management of the commercial fishery resources.

Background

Historical records reveal Atlantic salmon and American shad ascended the Merrimack River to the confluence of the Pemigewasset and Winnipesaukee Rivers in Franklin, New Hampshire. The Atlantic salmon continued their ascent up the Pemigewasset to its headwaters while the American shad ran up the Winnipesaukee River to the lake. The salmon run was dealt a severe blow in 1820 when a dam was constructed near Bristol, New Hampshire, which denied access to the Pemigewasset River. In 1847, the closing of the Lawrence dam in Massachusetts dealt a death blow to further runs of both species beyond this point.

Although the magnitude of the annual runs was unknown, many fishing sites existed along the river. Fifteen years after the closure of the Pemigewasset River to salmon in 1835, the harvest to Patucket Falls (now Lowell, Massachusetts) amounted to 3,900 salmon and 306,000 shad which further indicated suitability of tributary streams other than the Pemigewasset to sustain a reduced salmon run.

In 1866, restoration attempts which included fish passage facilities were initiated with a recommendation of the Massachusetts Commissioner that live shad be taken from the river below the dam at Lawrence and placed in the river above. This was carried out in 1867 and, in addition, the stocking of large numbers of fry by the Massachusetts and New Hampshire commissioners commenced. Apparently, the fish ladders were inadequate for shad and few passed upstream to spawning grounds.

In 1867, salmon restoration attempts were also initiated with the stocking of 20,000 eggs. Eggs, fry, and parr were stocked repeatedly until the 1890's. This project met with some success for as many as 75 adults were taken in one year to meet hatchery needs at Livermore Falls above Plymouth, New Hampshire. Salmon did not remain in the river for long, for by 1898 the construction of more dams, severe pollution, and unregulated fishing at the mouth of the river prevented their passage and they disappeared.

At present, only limited stragglers of shad and salmon are found in the river. As recently as July 1968, an angler caught an Atlantic salmon--31 inches long, weighing 9 pounds 11 ounces--in the Merrimack River at Newburyport, Massachusetts. This salmon originated from introductions in Maine.

With advanced technology in fish passage facility design, fisheries biology and water quality improvement now being quite adequate, further restoration efforts for anadromous fish in the Merrimack River Basin are warranted with greater assured opportunity for successful culmination.

While many species of migratory fish once ascended the Merrimack, our efforts will initially be devoted to restoration of American shad and Atlantic salmon, and the maintenance and enhancement of striped bass, alewives and blueback herring.

American Shad

It is intended to develop the full potential for an American shad run. An evaluation of present major spawning and nursery habitat as far north as Franklin, New Hampshire, indicates that a run entering the mouth of the river of approximately one million adult fish can be realized. This is based on a minimum production figure for adult shad per 100 square yards of spawning habitat. A run of this magnitude will require adequately designed fish passage facilities for dams at Lawrence and Lowell, Massachusetts, and at Amoskeag, Hooksett, Garvin's Falls, and Sewalls Falls, New Hampshire.

The sustained run of shad resulting from establishment of adequate fish passage facilities should provide a minimum annual harvest to sport fishermen approaching 200,000 fish and yield an equivalent number recreational fishing days. It is presumed that a run of this size could also provide fish annually for commercial harvest without significantly affecting the adult spawners returning to this particular stream.

Atlantic Salmon

It is intended to develop a natural run of Atlantic salmon. An evaluation of major existing spawning and nursery habitat, coupled with the utilization of a unit area technique similar to that used with shad, reveals a potential run of adult salmon at the river's mouth of at least 11,000. This figure is based on the production of three smolts per unit area with a survival to maturity of five percent. A smolt stocking program is an essential prerequisite for the systematic development and establishment of a natural run of Atlantic salmon. Annual stocking requirements approximate the number of smolt expected from the basin's natural reproduction potential. After the natural run is established, smolt stocking can also be an important adjunct to the program.

Salmon passage on the main stem does not require lengthy discussion as facilities adequate for the anticipated large shad runs will readily pass the number of salmon involved.

Problems and Needs

To attain the objectives that have been discussed, many problems must be surmounted and much work must be done.

The water quality of the river must be maintained and improved. Both of the Merrimack River States have now classified their waters as to quality and by definition the classifications established will be suitable for salmon and shad.

The threat of thermal pollution is a very real one with two fossil-fueled steam electric stations in operation at Bow, New Hampshire. In addition, a nuclear-fueled steam electric station is being considered for a site in Salisbury, Massachusetts which could pose serious problems at the mouth of the Merrimack River. Although subject to future research findings, it appears that any increase in water temperatures will seriously hinder salmon and shad restoration in the Merrimack River Basin.

The Corps of Engineers is considering the construction of multi-purpose impoundments at four sites in the Pemigewasset Valley. While some of these sites are more harmful than others, they are all located on prime salmon spawning and nursery streams and are, therefore, all detrimental to salmon restoration plans. The current proposals for construction of these dams appear to be inconsistent with the aims of the fishery restoration program. Should flow augmentation for fishery purposes be necessary, as a result of further study, other alternate sites for fulfilling this objective should be considered.

Stream flow regulation resulting in insufficient flows at certain times is another problem, and planned studies propose to develop the needs to modify regulation procedures for compatibility with fishery management objectives.

Stream bed gravel mining, particularly in prime salmon spawning and nursery habitat, poses a serious threat. Because this gravel is a non-renewable natural resource and is essential for fishery maintenance, this practice must be opposed.

There are major problems to be solved for the passage of both upstream and downstream migrants over existing dams on the main stem and major tributaries. Fish passage technology currently exists that is capable of solving these problems.

When the proposed fisheries become a reality, the agencies involved will cooperate to establish necessary regulations that will perpetuate the fisheries as well as assure that each state receives its share of the fishery harvest.

In order to design and implement needed research programs as well as to develop and recommend sound fishery management procedures, we hereby establish a Technical Committee for Fisheries Management of the Merrimack River Basin. The Committee shall consist of representatives from the Massachusetts Division of Fisheries and Game, Massachusetts Division of Marine Fisheries, the New Hampshire Fish and Game Department, and United States Bureau of Sport Fisheries and Wildlife and Bureau of Commercial Fisheries.

James M. Shepard
Director, Massachusetts Division of Fisheries and Game

Frank Grice
Director, Massachusetts Division of Marine Fisheries

Bernard W. Corson
Director, New Hampshire Fish and Game Department

Russell T. Norris
Regional Director, U. S. Bureau of Commercial Fisheries

Richard E. Griffith
Regional Director, U. S. Bureau of Sport Fisheries & Wildlife

September 29, 1969

APPENDIX II

Fish Passage as Related to the Merrimack River Anadromous Fish Program

The table (Table A.I.) beginning on the following page should be reviewed in conjunction with the Merrimack River basin map that follows the table. The Fish Passage Action Plan that follows the table has guided the direction of fish passage development for the restoration program. The dates within the plan are no longer relevant since agreements with various power producers have subsequently been developed.

The agreements that now exist are: 1) "A Comprehensive Plan for Provision of Anadromous Fish Passage Measures and Facilities at PSNH's Merrimack - Pemigewasset River Hydroelectric Dams, FERC Projects No. 1893, 2456 and 2457", 2) "Merrimack River Downstream Fish Passage Plan", 3) "Comprehensive Fish Passage Plan for the Lawrence Hydroelectric Project", and 4) "Comprehensive Fish Passage Plan for the Lowell Hydroelectric Project".

The comprehensive plan (#1 above) was developed jointly by Public Service of NH (PSNH) and the cooperating fisheries agencies. The plan was completed and signed by all parties in June of 1986. This plan addressed upstream fish passage development at the Amoskeag, Hooksett, Garvins Falls, Eastman Falls and Ayers Island projects. The plan, although addressing downstream fish passage needs at these facilities did so only in a cusory manner. Therefore, the need to develop the Merrimack River Downstream Fish Passage Plan (#2 above) existed. This document, developed jointly by PSNH and the cooperating fisheries agencies, was completed after three years of effort and endorsed by all parties on October 19, 1995.

The plans addressing the Lawrence hydroelectric and the Lowell hydroelectric projects (#3 and #4 above) were also developed jointly by the power producer (Consolidated Hydro, Inc.) and the cooperating fisheries agencies. The two plans were completed and endorsed in 1992 and 1993, respectively.

TABLE A.I. STATUS OF FISH PASSAGE BARRIERS IN THE MERRIMACK RIVER WATERSHED AS RELATED TO ANADROMOUS FISH RESTORATION.

Dam No.	Project / Dam Name	River	FERC No.	Owner	Upstream Passage		Downstream Passage	
					Type	Effective	Type	Effective
I	Lawrence / Essex	Merrimack	2800 *	Consolidated Hydro, Inc.	Lift	Yes	Bypass	Yes for clupeids Unknown for smolts
II	Lowell / Pawtucket	Merrimack	2790 **	Consolidated Hydro, Inc.	Lift & Vertical Slot Ladder	Yes	Bypass	Yes for clupeids Unknown for smolts
III	Amoskeag	Merrimack	1893	Public Service of NH	Vertical Slot Ladder	Yes	Bypass - Interim	No
IV	Hooksett	Merrimack	1893	Public Service of NH	None	--	Bypass - Interim	No
V	Garvins Falls	Merrimack	1893	Public Service of NH	None	--	Bypass - Interim	No
VI	Eastman Falls	Pemigewasset	2457	Public Service of NH	None	--	Bypass	Unknown
VII	Franklin Flood Control	Pemigewasset	--	U.S. Army Corps of Engineers	Not Needed	--	Not Needed	--
VIII	Ayers Island	Pemigewasset	2456	Public Service of NH	None	--	Spill Gate	Yes
1	??	Shawsheen	--	??	None	--	Not Needed	--
2	Centennial Island	Concord	2998	Mass. Bay Power	Denil Ladder	Unknown - Falls downstream may be barrier to passage	Bypass	Yes
3	??	Concord	--	??	None	--	Not Needed	--
4	Jackson Mills	Nashua	7590	Nashua Hydro Assoc.	Denil Ladder	Yes	Bypass	Yes
5	Mines Falls	Nashua	3442	City of Nashua et al.	Lift	Yes	Bypass	Yes
6	??	Nissitissit	--	??	None	--	Not Needed	--
7	Pepperell	Nashua	None	??	None	--	??	Not Need At This Time
8	Merrimack Village	Souhegan	None	??	None	--	Not Needed	--
9	McLane Dam	Souhegan	8294	Northeast Hydro	None	--	Not Needed Hydro Not Built	-- --
10	Pine Valley	Souhegan	9282	Winslow MacDonald	None	--	Angled Screen & Bypass	Yes - 95%
11	Wilton	Souhegan	11055	Wilton Hydro	None	--	Angled Screen & Bypass	Yes
12	??	Souhegan	??	??	None	--	Not Needed	--
13	Kelley's Falls	Piscataquog	3025	Consolidated Hydro, Inc.	None	--	Bypass - Interim	Unknown
14	Greggs Falls	Piscataquog	3180	National Hydro	None	--	Bypass	Not Likely Effective
15	Hadley Falls / Bobbin Shop	Piscataquog	5379	Hydro Dynamics	None	--	Screen and Bypass	Yes
16	Everett	Piscataquog	--	U.S. Army Corps of Engineers	None	--	None	--
17	China Mill	Suncook	Unlicensed Hydro	Thomas Hodgson and Sons	None	--	None	No
18	Webster-Pembroke	Suncook	3185	Pembroke Hydro	None	--	None	No

TABLE A.I. STATUS OF FISH PASSAGE BARRIERS IN THE MERRIMACK RIVER WATERSHED AS RELATED TO ANADROMOUS FISH RESTORATION.

Dam No.	Project / Dam Name	River	FERC No.	Owner	Upstream Passage		Downstream Passage	
					Type	Effective	Type	Effective
19	Pittsfield	Suncook	6338	Suncook Leathers	None	–	None	No
20	??	Suncook	None	??	None	–	??	??
21	??	Suncook	None	??	None	–	??	??
22	??	Suncook	None	??	None	–	??	??
23	Penacook Lower Falls	Contoocook	3342	New Hampshire Hydro	None	–	Bypass	No
24	Penacook Upper Falls	Contoocook	6689	Briar Hydro	None	–	Bypass	No
25	Rolfe Canal / York Dam	Contoocook	3240	Briar Hydro	None	–	Bypass	No
26	Blackwater Flood Control	Blackwater	–	U.S. Army Corps of Engineers	None	–	Not Needed	–
27	Hopkinton	Contoocook	5735	Town of Hopkinton	None	–	Angled Screen & Bypass	Yes
28	Hogue-Sprague	Contoocook	4337	EHC Hydro	None	–	Angled Screen & Bypass	Yes
29	West Henniker	Contoocook	None	??	None	–	Not Needed	–
30	Hosiery Mills	Contoocook	6116	Town of Hillsborough	None	–	Angled Screen & Bypass	Yes
31	Jackman	North Branch Contoocook	Unlicensed Hydro	Public Service of NH	None	–	None	–
32	Franklin Falls	Winnipesaukee	6950	Franklin Falls Hydro	None	–	None	–
33	Stevens Mills	Winnipesaukee	3760	Franklin Industrial Complex	None	–	None	–
34	Profile Falls (Natural Barrier)	Smith	–	–	None	–	Not Needed	–
35	Campton Dam	Mad	3253	Mad River Power	None	–	Screen and Bypass	Yes

MERRIMACK RIVER BASIN FISH PASSAGE ACTION PLAN FOR ANADROMOUS FISH

January, 1988 (Revised)
Updated with this Strategic Plan

The Fish Passage Action Plan (hereafter referred to as the Plan), was initially adopted by the Policy Committee for Anadromous Fishery Management of the Merrimack River[1)] on January 27, 1981. It was revised in May, 1985 and January, 1988.

The Plan relates directly to the Atlantic salmon and American shad restoration program that has been ongoing since 1969 and addresses the period 1988-1999. It does not address river flow requirements that might be needed for existing or future aquatic resources throughout the basin or at particular sites. The Plan is a guideline for providing anadromous fish access to portions of their historical spawning and juvenile rearing areas and ensuring safe downstream passage of anadromous fish at hydroelectric and other water development projects. The stocking of Atlantic salmon fry in certain tributaries and headwater areas where natural reproduction is not an objective will also require measures to protect downstream migrants from hydroelectric units even though upstream fish passage facilities have been deferred.

Figure 1 highlights those areas (tributaries and dams) of importance to the anadromous fish program. The construction schedule for mainstem dams owned by Public Service Company of New Hampshire (PSNH) is based on a 1986 agreement negotiated between PSNH and the Policy Committee (See Appendix A).

UPSTREAM FISH PASSAGE REQUIREMENTS

Although much of the basin was once accessible to anadromous fish, only the darkened reaches in Figure 1 are to be made available to anadromous fish spawners within the present planning horizon. Fish passage needs and timing are orientated to anticipated program development. Thus, completed fish passage faciliies may or may not be required throughout the indicated reaches during the period covered by this document. Fish passage may become desirable in areas outside the indicated reaches at some time in the future.

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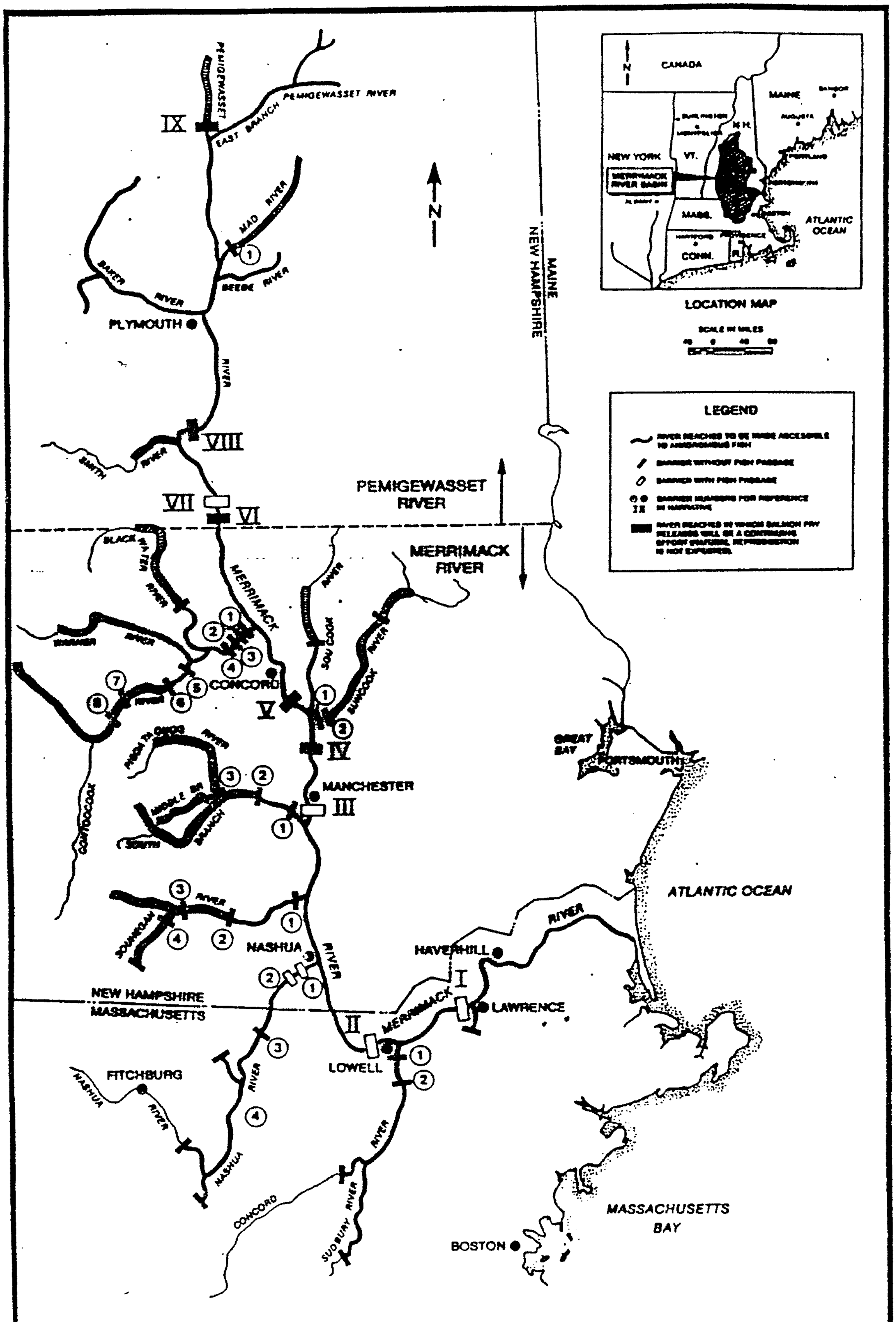
1) The Committee structure for the Merrimack River Anadromous Fishery Management Program consists of a:
Policy Committee--comprised of State Directors (Commissioners), or their designees, from the Mass. Divisions of Fisheries and Wildlife and Marine Fisheries respectively, the New Hampshire Fish and Game Department, the Regional Director (U.S. Fish and Wildlife), the Northeast Regional Director (National Marine Fisheries Service), and the Supervisor for the White Mountain National Forest (U.S. Forest Service). The Policy Committee is advised by a Technical Committee, composed of staff-level biologists from the participating State and Federal agencies.



FISH PASSAGE ACTION PLAN
FOR ANADROMOUS FISH - 1988 (REVISED)

MERRIMACK RIVER BASIN

FIGURE 1

Five Merrimack River mainstem dams (fish passage facilities at Essex and Pawtucket dams are operational) will require fish passage facilities for American shad. This is expected to provide enough suitable spawning and nursery habitat to provide for adult population development of 800,000 fish. In addition, five tributaries (the Concord, Nashua, Souhegan, Piscataquog, and Contoocook Rivers) contain enough habitat to produce an additional 80,000 shad. In order to realize the tributary production, fish passage construction will be needed at 12 dams (Concord River-2, Nashua River-4, Souhegan River-1, Piscataquog River-1, Contoocook River-4). The construction of fish passage facilities at the 5 mainstem and 12 tributary dams will permit the adult shad population to approach 900,000 fish. Much of the American shad planning documentation, habitat quantification data, and population estimates and estimation criteria can be found in Special Report, Anadromous Fish: Water and Land Resources of the Merrimack River (prepared by the USFWS, Federal Building, Laconia, NH -- 1982).

The Plan addresses the Atlantic salmon restoration goal which is to develop an Atlantic salmon population that will utilize the spawning and nursery habitat of the river's main stem and indicated reaches (Figure 1) of the Pemigewasset River system. This habitat is projected to be able to support a salmon population in excess of 3000 adults. Fish passage facilities at the 5 Merrimack River mainstem dams and two dams on the main stem of the Pemigewasset River are required to meet the restoration goal.

Upstream fish passage requirements for American shad and Atlantic salmon are outlined in Table 1. The dam numbers in the table correspond to the numbers in Figure 1.

TABLE 1. UPSTREAM FISH PASSAGE REQUIREMENTS FOR ANADROMOUS FISH IN THE MERRIMACK RIVER BASIN, 1988-2005.

RIVER/TRIBUTARY	DAMS REQUIRING FISH PASSAGE (DAM NAME OR NUMBER)	REMARKS
Merrimack River (main stem)	I Essex Dam (Lawrence, MA)	Fish passage facility completed in 1982.
	II Pawtucket Dam (Lowell, MA)	Fish passage facility completed in 1985.

TABLE 1. CONTINUED

RIVER/TRIBUTARY	DAMS REQUIRING FISH PASSAGE (DAM NAME OR NUMBER)	REMARKS
Merrimack River (main stem) (continued)	III Amoskeag Dam (Manchester, NH)	Fish passage facilities completed in 1989. For a more detailed description of fish passage require- at those dams operated and maintained by the Public Service Company of New Hampshire, the reader is referred to Appendix IIIa - addresses Amoskeag, Hooksett, Garvins Falls, Eastman Falls, and Ayers Island dams).
	IV Hooksett Dam (Hooksett, NH)	Fish passage facilities to be operational 5 years following the passage of 15,000 shad at the Amoskeag dam.
	V Garvins Falls Dam (Bow, NH)	Fish passage facilities to be operational 5 years following the passage of 15,000 shad at the Hooksett dam.
Shawsheen River	________________	Fish passage deferred.
Concord River	1 Centennial Island (Lowell, MA)	Fish passage facility to be operational upon completion of the hydro-electric facility.

TABLE 1. CONTINUED

RIVER/TRIBUTARY	DAMS REQUIRING FISH PASSAGE (DAM NAME OR NUMBER)	REMARKS
Concord River (continued)	2 East Billerica (Billerica, MA)	Fish passage facility to be operational 5 years following the passage of 500 shad at Centennial Island.

Construction of the Centennial Island and East Billerica fish passage facilities will provide anadromous fish access to the base of the Saxonville dam on the Sudbury River and to the base of the Damondale dam on the Assabet River. Construction of Fish passage facilities at these structures and all dams upstream will be deferred.

RIVER/TRIBUTARY	DAMS REQUIRING FISH PASSAGE (DAM NAME OR NUMBER)	REMARKS
Nashua River	1 Jackson Mills (Nashua, NH)	Fish passage facility completed in 1986.
	2 Mine Falls (Nashua, NH)	Fish passage facility completed in 1987.
	3 Pepperell Paper (Pepperell, MA)	Fish passage facility to be operational 5 years following the passage of 500 shad at Mine Falls.
	4 Mitchelville Dam (Ayer, MA)	Fish passage facility to be operational 5 years following the passage of 1100 shad at Pepperell Paper.

TABLE 1. CONTINUED

RIVER/TRIBUTARY	DAMS REQUIRING FISH PASSAGE (DAM NAME OR NUMBER)	REMARKS
Nashua River (continued)		

Construction of the four fish passage facilities described above will provide anadromous fish access to the base of the Lancaster Mills dam, to the base of the Leominster dam on the North Branch of the Nashua River, and to the base of Turner Pond dam on the Nissitissit River. Provisions for fish passage facilities at these three structures and all dams upstream will be deferred.

RIVER/TRIBUTARY	DAMS REQUIRING FISH PASSAGE (DAM NAME OR NUMBER)	REMARKS
Souhegan River	1 Merrimack Village (Merrimack, NH)	Fish passage facility to be operational 2 years following the passage of 15,000 shad at the Amoskeag dam.

Construction of the Merrimack Village dam fish passage facility will provide anadromous fish access to the base of the Milford dam. Fish passage at the Milford dam and all dams upstream will be deferred.

RIVER/TRIBUTARY	DAMS REQUIRING FISH PASSAGE (DAM NAME OR NUMBER)	REMARKS
Piscataquog River	1 Kelleys Falls (Manchester, NH)	Fish passage facility to be operational 2 years following the passage of 15,000 shad at Amoskeag dam.

Construction of the Kelleys Falls dam fish passage facility will provide anadromous fish access to the base of Greggs Falls dam. Fish passage at the Greggs Falls dam and all dams upstream will be deferred.

RIVER/TRIBUTARY	DAMS REQUIRING FISH PASSAGE (DAM NAME OR NUMBER)	REMARKS
Suncook River	________________	Fish passage deferred.
Soucook River	________________	Fish passage deferred.
Contoocook River	1 Penacook 1 (Penacook, NH)	Fish passage facilities to be operational 5 years following the passage of 49,000 shad at the Garvins Falls dam.

TABLE 1. CONTINUED

RIVER/TRIBUTARY	DAMS REQUIRING FISH PASSAGE (DAM NAME OR NUMBER)	REMARKS
Contoocook River (continued)	2 Penacook 2 (Penacook, NH)	Fish passage facilities to be operational 5 years following the passage of 49,000 shad at the Garvins Falls dam.
	3 Rolfe Canal (Penacook, NH)	Fish passage facilities will not be required at Briar Park hydro in the canal provided the canal is screened to prevent anadromous fish from entering. Screening is to be in place 5 years following the passage of 49,000 shad at the Garvins Falls dam.
	4 York Dam (Penacook, NH)	Fish passage facilities to be operational 5 years following the passage of 49,000 shad at the Garvins Falls dam.
	5 Hopkinton Hydro-electric Project (Contoocook, NH)	Fish passage facilities to be operational 5 years following the passage of 10,000 shad at the York dam.

Construction of fish passage facilities at the four existing structures will provide anadromous fish access to the base of the dam located immediately downstream from the Hopkinton-Everett Flood Control structure, to the base of the Blackwater Flood Control structure (Blackwater River), and the Warner River from its mouth to the breached dam in Warner. Provisions for fish passage facilities at all mainstem Contoocook River dams upstream from Dam No. 5, the Blackwater River Flood Control structure, and dams upstream are deferred.

TABLE 1. CONTINUED

RIVER/TRIBUTARY	DAMS REQUIRING FISH PASSAGE (DAM NAME OR NUMBER)	REMARKS
Pemigewasset River	VI Eastman Falls Dam (Franklin, NH)	Atlantic salmon trapping facility to be operational for the spring run of the second year following the passage or trapping of 50 multi-sea-winter Atlantic salmon at the Amoskeag dam. Public Service Company of New Hampshire will provide for the transportation of Atlantic salmon from the Eastman Falls trap to river reaches upstream of the Eastman Falls dam and/or Ayers Island dam.

Full upstream fish passage facilities will be deferred to the year 2010 or later. In the year 2010 the need for fish passage will be re-evaluated.

	VII Franklin Falls Dam (Franklin, NH)	Fish passage facilities will not likely be required under present conditions.
	VIII Ayers Island Dam (Bristol, NH)	Fish passage facilities will be deferred until the year 2010 or later. In the year 2010 the need for an Atlantic salmon trapping facility will be evaluated by the fisheries resource agencies and Public Service Company of New Hampshire.
	IX -- (North Woodstock, NH)	This dam will not require a fish passage facility.

TABLE 1. CONTINUED

RIVER/TRIBUTARY	DAMS REQUIRING FISH PASSAGE (DAM NAME OR NUMBER)	REMARKS
Baker River	____________________	Fish passage facilities are not required at existing structures.
Mad River	1 Campton Dam (Campton, NH)	Fish passage facilities will not be required.

DOWNSTREAM FISH PASSAGE REQUIREMENTS

Upstream fish passage facilities allow adult anadromous fish to reach their spawning grounds but often do not provide for the safe return (minimizing the passage of fish through the hydroelectric turbines) of the adults and young to the marine environment. The lack of downstream fish passage facilities or inadequate facilities could have a significant negative impact on fish populations. All hydroelectric dams wholly within the darkened reaches depicted in Figure 1 will require downstream fish passage facilities.

There are also a number of dams outside of the darkened reaches in Figure 1 that will require downstream fish passage facilities because juvenile salmon are stocked upstream from those dams. The present salmon plan calls for the release of 3.1 million fry into the Merrimack River basin annually. A good portion of these fry will be released into areas in which natural reproduction is not an objective. These stocking areas contain excellent salmon nursery habitat and will contribute significantly to the overall salmon population. In order to protect these out- migrating smolts, fish passage facilities will be necessary.

Streams in which fry-releases will occur outside the darkened reaches of Figure 1 are as follows:

Mad River
Smith River
Contoocook River
   Blackwater River
   Warner River
   Beards Brook
   North Branch
Soucook River
Suncook River
Piscataquog River
   Middle Branch
   South Branch
Souhegan River
   Stony Brook

Downstream fish passage facilities at all water development projects within the nursery areas contained in the above systems are necessary. This will become critically important in the next several years. Outmigrations of large numbers of smolts will occur in 1988 and continue each year. The largest fry stocking effort to date occurred in 1988 (over 1,700,000 fry) and it is expected that the fry stocking program target of 3,100,000 will be reached in 1993.

A tabulation of the downstream fish passage requirements is provided in Table 2. It should be understood that hydroelectric development within the darkened reaches and salmon nursery habitats depicted in Figure 1 but not identified within Table 2 would require downstream fish passage facilities upon project completion.

TABLE 2. DOWNSTREAM FISH PASSAGE REQUIREMENTS FOR ANADROMOUS FISH IN THE MERRIMACK RIVER BASIN, 1988-2005.

RIVER/TRIBUTARY	DAMS REQUIRING FISH PASSAGE (DAM NAME OR NUMBER)	REMARKS
Merrimack River	I Essex Dam (Lawrence, MA)	To be operational in 1991.
	II Pawtucket Dam (Lowell, MA)	Operational. However, additional facilities in relation to the Pawtucket Canal are pending based on further study.

TABLE 2. CONTINUED

RIVER/TRIBUTARY	DAMS REQUIRING FISH PASSAGE (DAM NAME OR NUMBER)	REMARKS
Merrimack River (continued)	III Amoskeag Dam (Manchester, NH)	Operational. (for a more detailed description of fish passage requirements at those dams operated and maintained by the Public Service Company of New Hampshire, the reader is referred to Appendix A- addresses Amoskeag, Hooksett, Garvins Falls, Eastman Falls, and Ayers Island dams).
	IV Hooksett Dam (Hooksett, NH)	Operational
	V Garvins Falls Dam (Bow, NH)	Operational
Concord River	1 Centennial Island (Lowell, MA)	To be operational on completion of hydro-electric project.
	2 East Billerica (Billerica, MA)	To be operational on completion of hydro-electric project.
Nashua River	1 Jackson Mills (Nashua, NH)	Operational
	2 Mines Falls (Nashua, NH)	Operational
	3 Pepperell Paper (Pepperell, MA)	To be operational on completion of hydro-electric project.
	4 Mitchelville Dam (Ayer, MA)	To be operational on completion of hydro-electric project.

TABLE 2. CONTINUED

RIVER/TRIBUTARY	DAMS REQUIRING FISH PASSAGE (DAM NAME OR NUMBER)	REMARKS
Souhegan River	1 Merrimack Village (Merrimack, NH)	To be operational on completion of hydro-electric project.
	2 Mclane Dam (Milford, NH)	To be operational on completion of hydro-electric project.
	3 Pine Valley Hydro (Wilton, NH)	Operational
	4 Wilton Project (Wilton, NH)	To be operational on completion of hydro-electric project.
Piscataquog River	1 Kelleys Falls (Manchester, NH)	Interim measures operational. Permanent facilities to be in place in accordance with upstream fish passage completion.
	2 Greggs Falls (Goffstown, NH)	Operational
	3 Hadley Falls (Goffstown, NH)	To be operational in 1988.
Suncook River	1 China Project (Suncook, NH)	To be operational in 1995.
	2 Webster-Pembroke (Suncook, NH)	To be operational in 1995.
	3 Pittsfield Mill Dam (Pittsfield, NH)	To be operational in 1995.
Contoocook River	1 Penacook 1 (Penacook, NH)	Interim measures operational. Permanent facilities to be completed in 1990.
	2 Penacook 2 (Penacook, NH)	Interim measures operational. Permanent facilities to be completed in 1990.

TABLE 2. CONTINUED

RIVER/TRIBUTARY	DAMS REQUIRING FISH PASSAGE (DAM NAME OR NUMBER)	REMARKS
Contoocook River	3 Rolfe Canal (Penacook, NH)	Interim measures operational. Permanent facilities to be completed in 1990.
	5 Hopkinton Hydro-electric (Contoocook, NH)	Operational.
	6 Hoague-Sprague (West Hopkinton, NH)	Interim measures operational. Permanent facilities to be completed in 1990.
	7 Henniker (Henniker, NH)	To be operational on completion of hydro-electric project.
	8 Hosiery Mill (Hillsboro, NH)	Interim measures operational. Permanent facilities to be completed in 1990.
Pemigewasset River	VI Eastman Falls Dam (Franklin, NH)	Operational.
	VIII Ayers Island Dam (Bristol, NH)	Operational.
Mad River	1 Campton Dam (Campton, NH)	Operational.

APPENDIX III

JUVENILE ATLANTIC SALMON STOCKING PROGRAM FOR THE MERRIMACK RIVER BASIN

LOCATION (RIVER, TRIB, OR SUBTRIB)	YEARS 1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	TOTAL
FRY																							
MERRIMACK RIVER																							
SEWALLS FALLS	0	0	0	0	0	0	0	0	0	0	0	0	0	79900	0	0	42600	0	0	0	0	0	122500
NASHUA RIVER																							
NISSITISSIT RIVER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	960	0	960
SOUHEGAN RIVER																							
MAINSTEM	0	0	0	0	0	0	0	0	0	47000	12600	53800	91200	110100	78200	78200	101900	82600	93800	184400	154280	154528	1242608
STONY BROOK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9175	8300	18400	18350	18350	72575
BLOOD BROOK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2875	2600	7000	6950	6950	26375
COHAS BROOK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10164	0	10164
PISCATAQUOG RIVER																							
MAINSTEM	0	0	0	0	0	0	0	0	0	0	0	8000	7600	11300	0	0	16600	7500	0	1300	0	450	52750
MIDDLE BRANCH	0	0	0	0	0	0	0	0	0	15000	0	11000	13900	16500	13800	13800	24100	16500	16500	33000	33000	26400	233500
SOUTH BRANCH	0	0	0	0	0	0	0	0	0	80000	16300	83700	88200	155600	76000	76000	157700	161100	159900	313100	313461	189587	1870648
BLACK BROOK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5200	8000	11035	5150	29385
SUNCOOK RIVER																							
MAINSTEM	0	0	0	0	0	0	0	0	0	30700	0	0	10000	10500	5400	0	7700	11180	11800	23600	22600	0	133480
LITTLE SUNCOOK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3900	7800	7800	0	19500
BLAKE BROOK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500	1000	1000	0	2500
GULF BROOK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1000	0	1000
SANBORN BROOK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SOUCOOK RIVER																							
MAINSTEM	0	0	0	0	0	2500	0	0	0	20400	1000	5000	13100	5000	0	1000	500	650	0	0	15931	0	65081
ACADEMY BROOK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8000	10164	0	1816
BOW BOG BROOK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1300	130
HAYWARD BROOK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2000	0	200
CONTOOCOOK RIVER																							
MAINSTEM	0	0	0	0	0	0	0	0	0	60300	0	0	73700	100000	54200	19400	101100	104000	92800	192400	186880	0	98478
BLACKWATER RIVER	0	0	0	0	0	0	0	0	0	18000	0	0	0	10000	0	0	0	0	0	3200	15000	0	4620
WARNER RIVER	0	0	0	0	0	0	0	0	0	43000	0	0	0	7200	0	0	0	0	0	12000	20775	800	8377
NORTH BRANCH	0	0	0	0	0	0	0	0	0	10200	0	0	5800	9000	3600	3600	3600	3600	2150	8000	12000	0	6155
BEARDS BROOK	0	0	0	0	0	0	0	0	0	10200	0	0	3200	3000	2300	2200	3800	5400	6450	10800	18000	0	6535
BRYANT BROOK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7544	0	754
FOREST BROOK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
HAZELTON BROOK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
STIRRUP IRON BROOK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9396	2450	11846
PUNCH BROOK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13552	1225	14777
WINNIPESAUKEE RIVER																							
MAINSTEM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	38400	0	0	38400

APPENDIX III

JUVENILE ATLANTIC SALMON STOCKING PROGRAM FOR THE MERRIMACK RIVER BASIN

LOCATION (RIVER, TRIB, OR SUBTRIB)	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	TOTAL
PEMIGEWASSET RIVER																							
EASTMAN FALLS																							
DOWNSTREAM	0	0	0	0	0	0	0	0	0	35000	0	0	0	76800	0	0	0	0	0	0	0	0	11180 (cut off)
EASTMAN FALLS TO																							
AYERS ISLAND DAM	0	0	0	0	0	0	0	0	0	0	0	50200	17200	186000	116400	100000	51800	25650	0	127600	173977	0	84882 (cut off)
BLAKE BROOK	0	0	0	0	0	0	0	0	0	0	0	0	0	12000	0	0	0	0	0	0	2000	0	1400 (cut off)
SMITH RIVER	0	0	0	0	0	0	0	0	0	55200	30000	48000	84100	70300	72000	69000	65000	70380	66400	135800	138700	138661	104354 (cut off)
KNOX	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 (cut off)
NEEDLESHOP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16747	10400	2714 (cut off)
HARPER BROOK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 (cut off)
WOODMAN BROOK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	(cut off)
AYERS ISLAND DAM																							
UPSTREAM	0	0	0	0	5100	35300	0	0	0	48300	34000	148100	372000	449700	310000	421700	476700	325400	398400	922900	834116	561000	534271 (cut off)
BAKER RIVER																							
MAINSTEM	0	0	0	33800	13100	37700	20000	0	0	20000	31450	58200	101200	101000	64700	65000	99000	96000	58500	195100	190000	146772	133152 (cut off)
SOUTH BRANCH	0	0	0	0	3000	0	0	0	0	0	0	0	15000	0	13200	0	13900	13200	13200	26400	20000	26400	14430 (cut off)
STINSON BROOK	0	0	0	0	0	0	0	0	0	0	0	0	7500	10000	10000	0	10000	10000	20000	20000	26400	20000	13390 (cut off)
HALLS BROOK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15000	9900	2490 (cut off)
POND BROOK	0	0	0	0	0	0	0	0	0	0	0	0	7500	5000	4300	0	5000	4600	6760	10000	10000	9900	6306 (cut off)
BEEBE RIVER	0	0	0	0	2000	5000	2000	5000	0	0	0	12375	8300	37000	0	0	40000	15000	8400	40400	71000	56144	30261 (cut off)
MAD RIVER																							
DOWNSTREAM OF																							
CAMPTON DAM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13000	21300	0	0	38000	40800	0	11310 (cut off)
WEST BRANCH BROOK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30500	3050 (cut off)
SMART BROOK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 (cut off)
UPSTREAM OF																							
CAMPTON DAM	36000	63100	51400	72300	53700	45000	35000	40000	4680	10000	13000	26250	72300	70000	70400	52000	121000	57700	121500	109700	101000	112500	133853 (cut off)
MOOSILAUKEE BROOK	0	0	0	0	0	0	0	0	0	0	0	0	0	6200	0	0	0	0	0	11500	12300	12500	4250 (cut off)
JACKMAN BROOK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5000	11500	0	1650 (cut off)
EASTMAN BROOK	0	0	0	0	0	0	0	0	0	0	0	0	0	5000	0	0	0	0	0	16500	18600	14500	5460 (cut off)
JOHNSON BROOK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4000	400 (cut off)
BOG BROOK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11000	9500	9500	3000 (cut off)
MILL BROOK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	27900	15000	12500	5540 (cut off)
HAZELTON BROOK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HUBBARD BROOK	0	0	0	0	0	0	0	0	0	0	0	0	0	2600	0	0	0	0	0	22700	27508	10000	62808
WEST BRANCH BROOK	0	0	0	0	0	0	0	0	0	0	0	0	0	2500	0	0	0	0	0	0	0	0	2500
BAGLEY BROOK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5808	6000	11808
EAST BRANCH																							
MAINSTEM / TRIBS	0	0	20600	0	0	0	0	5000	3690	22200	10000	19950	86500	165600	139000	60300	95000	95000	60400	225900	195400	196232	1400772

APPENDIX III

JUVENILE ATLANTIC SALMON STOCKING PROGRAM FOR THE MERRIMACK RIVER BASIN

LOCATION (RIVER, TRIB, OR SUBTRIB)	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	TOTAL
TOTAL FRY	36000	63100	72000	106100	76900	125500	57000	50000	8370	525500	148350	524575	1078300	1717800	1033500	975200	1458300	1117510	1157460	2816800	2827198	1794599	17770062
0+PARR																							
MERRIMACK RIVER																							
MANCHESTER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	60000	0	0	0	0	0	0	0	60000
SOUHEGAN RIVER																							
MAINSTEM	0	0	0	0	0	0	0	24000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24000
PEMIGEWASSET RIVER																							
AYERS ISLAND DAM																							
UPSTREAM	0	30400	0	0	0	0	0	27600	0	0	0	0	0	0	0	0	0	0	0	0	0	0	58000
BAKER RIVER																							
MAINSTEM	0	31500	0	0	0	0	0	30000	5000	0	0	0	0	0	0	0	0	0	0	0	0	0	66500
EAST BRANCH																							
MAINSTEM	0	14000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14000
TOTAL 0+PARR	0	75900	0	0	0	0	0	81600	5000	0	0	0	0	0	60000	0	0	0	0	0	0	0	222500
1PARR																							
MERRIMACK RIVER																							
MANCHESTER	0	0	0	0	0	0	0	0	0	0	0	0	29500	129641	70700	5600	0	0	0	0	1417	0	236858
SEWALLS FALLS	0	0	0	0	0	0	0	0	0	0	5779	14380	15800	0	0	0	0	0	0	0	0	0	35959
SOUHEGAN RIVER																							
MAINSTEM	0	0	0	0	0	0	0	0	15000	14200	0	0	0	0	0	0	0	0	0	0	1100	0	30300
COHAS BROOK																					1100	0	1100
SUNCOOK RIVER																							
MAINSTEM	0	0	0	0	0	0	0	0	0	0	0	0	4900	0	0	0	0	0	0	0	0	0	4900
CONTOOCOOK RIVER																							
MAINSTEM	0	0	0	0	0	0	0	0	0	0	0	0	4900	0	0	0	0	0	0	0	9100	0	14000
PENACOOK STUDY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100	0	0	0	0	100
PEMIGEWASSET RIVER																							
EASTMAN FALLS																							
DOWNSTREAM	0	0	0	0	0	0	0	0	0	0	0	17100	4100	0	0	0	0	0	0	0	0	0	21200
EASTMAN FALLS TO																							
AYERS ISLAND DAM	0	0	0	0	0	0	0	0	0	9051	0	0	40100	0	17900	0	0	0	0	0	0	0	67051
TOTAL 1PARR	0	0	0	0	0	0	0	0	15000	23251	5779	31480	99300	129641	88600	5600	0	100	0	0	12717	0	411468

APPENDIX III

JUVENILE ATLANTIC SALMON STOCKING PROGRAM FOR THE MERRIMACK RIVER BASIN

LOCATION (RIVER, TRIB, OR SUBTRIB)	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	TOTAL
1+PARR																							
MERRIMACK RIVER																							
NASHUA	0	0	0	0	0	0	0	0	0	9800	0	0	0	0	0	0	0	0	0	0	0	0	9800
MANCHESTER	0	0	0	0	0	0	0	24500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24500
SEWALLS FALLS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19100	0	0	0	0	0	0	19100
BOSCAWEN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10400	0	0	0	0	0	0	10400
SOUHEGAN RIVER																							
MAINSTEM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4880	4880
PEMIGEWASSET RIVER																							
SMITH RIVER	0	0	0	0	0	0	0	0	5000	0	0	0	0	0	0	0	0	0	0	0	0	0	5000
AYERS ISLAND DAM																							
UPSTREAM	0	2100	676	0	0	0	0	70950	0	0	0	0	0	0	0	0	0	0	0	0	0	0	73726
BAKER RIVER																							
MAINSTEM	0	14500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14500
MAD RIVER																							
UPSTREAM OF CAMPTON DAM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	200	0	0	0	0	0	0	200
TOTAL 1+PARR	0	16600	676	0	0	0	0	95450	5000	9800	0	0	0	0	0	29700	0	0	0	0	0	4880	162106
1SMOLT																							
MERRIMACK RIVER																							
LARRY'S MARINA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4449	0	0	0	0	4449
GROVELAND	0	0	0	0	0	0	0	0	0	0	48432	0	78100	0	21400	0	0	0	0	0	0	0	147932
LAWRENCE	0	0	0	0	0	0	0	0	0	0	0	0	0	43700	32200	116600	55600	79232	51701	81223	0	0	460256
LOWELL	0	0	0	0	0	0	0	0	0	0	0	0	0	3400	0	200	200	0	0	0	0	0	3800
NASHUA	0	0	0	21300	15000	2300	2600	705	0	0	15538	34812	31900	23000	0	0	0	0	0	0	0	0	147155
LITCHFIELD	0	0	0	0	0	0	0	0	0	0	0	5130	31600	24000	0	0	0	0	0	0	0	0	60730
MANCHESTER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4700	0	0	0	0	0	70837	49450	124987
GARVINS FALLS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	650	2020	1229	779	0	275	4953
SOUHEGAN RIVER																							
MAINSTEM	0	0	0	0	0	0	0	0	47000	24400	0	0	0	0	0	0	0	0	616	1000	0	0	73016
CONTOOCOOK																							
PENACOOK STUDY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	300	2003	2000	0	275	4578
PEMIGEWASSET RIVER																							
AYERS ISLAND DAM STUDY	0	0	0	0	0	0	0	0	0	0	0	0	0	300	300	100	200	5118	3437	0	0	0	9455
EASTMAN FALLS TO AYERS ISLAND DAM	0	0	0	0	0	0	0	4700	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4700

APPENDIX III

JUVENILE ATLANTIC SALMON STOCKING PROGRAM FOR THE MERRIMACK RIVER BASIN

LOCATION (RIVER, TRIB, OR SUBTRIB)	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	TOTAL
AYERS ISLAND DAM																							
UPSTREAM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500	2542	0	0	0	0	3042
BAKER RIVER																							
MAINSTEM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1002	0	0	0	0	0	1002
MAD RIVER																							
DOWNSTREAM OF CAMPTON DAM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1439	654	0	0	0	0	2093
UPSTREAM OF CAMPTON DAM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1893	0	0	0	0	0	1893
EAST BRANCH																							
MAINSTEM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	517	2086	0	0	0	0	2603
TOTAL 1SMOLT	0	0	0	21300	15000	2300	2600	5405	47000	24400	63970	39942	141600	94400	58600	116900	62001	96401	58986	85002	70837	50000	1056644
2SMOLT																							
MERRIMACK RIVER																							
GROVELAND	0	2100	0	0	0	0	0	0	0	0	14300	0	0	0	0	0	0	0	0	0	0	0	16400
LAWRENCE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	58075	0	0	0	0	0	58075
LOWELL	0	0	27000	25800	18200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	71000
NASHUA	0	0	4040	0	6500	28727	44390	32866	42033	0	53100	33600	0	0	0	0	0	0	0	0	0	0	245256
LITCHFIELD	0	0	0	0	0	0	0	0	20844	43800	57900	30500	0	0	0	0	0	0	0	0	0	0	153044
NASHUA RIVER																							
MAINSTEM	0	0	0	0	0	0	53900	32700	0	0	0	0	0	0	0	0	0	0	0	0	0	0	86600
PEMIGEWASSET RIVER																							
AYERS ISLAND DAM STUDY	0	0	0	0	0	0	0	0	0	0	0	0	0	35	0	0	0	0	0	0	0	0	35
EASTMAN FALLS TO AYERS ISLAND DAM	0	0	0	75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	75
TOTAL 2SMOLT	0	2100	31040	25875	24700	28727	98290	65566	62877	43800	125300	64100	0	35	0	0	58075	0	0	0	0	0	630485
TOTAL ALL SMOLTS	0	2100	31040	47175	39700	31027	100890	70971	109877	68200	189270	104042	141600	94435	58600	116900	120076	96401	58986	85002	70837	50000	1687129
TOTAL JUVENILE SALMON STOCKED	36000	157700	103716	153275	116600	156527	157890	298021	143247	626751	343399	660097	1319200	1941876	1240700	1127400	1578376	1214011	1216446	2901802	2910752	1849479	18403786

APPENDIX IV. ESTIMATED NUMBER OF 100 SQUARE YARD UNITS OF JUVENILE ATLANTIC SALMON HABITAT WITHIN THE MERRIMACK RIVER BASIN.

TRIBUTARY OR RIVER REACH	NUMBER OF 100 SQURE YARD UNITS	RUNNING TOTAL
Nashua River		
Nissitissit River		
Souhegan River (main stem)	3803	3803
Stony Brook	367	4170
Blood Brook	139	4309
Cohas Brook		
Piscataquog River (main stem)	440	4749
Middle Branch	660	5409
South Branch	3914	9323
Black Brook	218	9541
Suncook River (main stem)	472	10013
Little Suncook River	156	10169
Blake Brook	20	10189
Gulf Brook		
Sanborn Brook	53	10242
Soucook River (main stem)	671	10913
Academy Brook	311	11224
Bow Bog Brook		
Merrimack River (main stem)		
Sewalls Falls reach	3000	14224
Hayward Brook	45	14269
Contoocook River (main stem)	3890	18159
Blackwater River	247	18406
Warner River	380	18786
North Branch	240	19026
Beards Brook	360	19386
Bryant Brook		
Forest Brook		
Hazelton Brook		
Stirrup Iron Brook	80	19466
Punch Brook	120	19586
Winnipesaukee River	1400	20986
Pemigewasset River (main stem)		
Eastman Falls dam downstream	3000	23986
Pemigewasset River (main stem)		
Ayers Island dam to Eastman Falls dam	7000	30986
Needleshop Brook	202	31188
Knox Brook	53	31241
Smith River	2257	33498
Blake Brook	79	33577
Pemigewasset River (main stem)		
Ayers Island dam upstream to Profile Lake	18377	51954
Harper Brook	98	52052
Woodman Brook	77	52129
Clay Brook		
Glove Hollow Brook		
Baker River (main stem)	3800	55929
Stinson Brook	400	56329
Halls Brook		
South Branch	528	56857
Pond Brook	200	57057
Bog Brook	378	57435

APPENDIX IV. ESTIMATED NUMBER OF 100 SQUARE YARD UNITS OF JUVENILE ATLANTIC SALMON HABITAT WITHIN THE MERRIMACK RIVER BASIN.

TRIBUTARY OR RIVER REACH	NUMBER OF 100 SQURE YARD UNITS	RUNNING TOTAL
Pemigewasset River (main stem) continued		
Beebe River	2367	59802
Mad River		59802
Downstream from Campton dam	1350	61152
West Branch Brook	1474	62626
Smart Brook	296	62922
Upstream from Campton dam	3379	66301
Mill Brook	598	66899
Hazelton Brook	200	67099
Bagley Brook	143	67242
Hubbard Brook	867	68109
Eastman Brook	743	68852
Johnson Brook	120	68972
Moosilaukee Brook	450	69422
Jackman Brook	476	69898
East Branch of the Pemigewasset River (main stem)	5800	75698
Hancock Branch	970	76668
North Fork Han. Br.	219	76887
Franconia Brook	11	76898
North Fork E. Br.	645	77543
Norcross	45	77588
Shoal Pond	44	77632

APPENDIX V. KNOWN ATLANTIC SALMON RETURNS TO THE MERRIMACK RIVER - 1982 THROUGH 1996.

MONTH & DAY	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	TOTAL	% BY MONTH
3.22	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.05
4.09	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	3	0.16
5.01	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	
5.02	0	0	0	0	2	0	0	0	1	0	0	0	0	0	0	3	
5.03	0	0	0	2	0	0	0	0	1	0	0	0	0	0	0	3	
5.04	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	2	
5.05	0	0	0	0	3	0	0	0	0	1	0	0	0	0	0	4	
5.06	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	2	
5.07	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	
5.08	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
5.09	0	0	0	0	0	0	0	0	2	1	3	0	0	0	0	6	
5.10	0	6	0	1	0	0	0	0	0	1	2	2	0	0	0	12	
5.11	0	0	0	0	0	0	0	0	1	2	1	0	0	0	0	4	
5.12	0	0	0	0	0	0	0	0	0	1	0	2	0	0	0	3	
5.13	0	0	1	2	2	0	0	0	1	2	2	0	0	0	0	10	
5.14	0	2	0	3	1	0	1	0	0	0	3	1	0	0	0	11	
5.15	0	1	0	1	2	0	0	0	0	11	2	0	0	0	0	17	
5.16	0	1	0	0	4	1	0	0	0	3	0	0	0	0	0	9	
5.17	0	0	0	0	1	1	1	0	0	5	0	0	0	0	0	8	
5.18	0	2	0	2	3	1	0	0	0	0	1	2	0	0	0	11	
5.19	0	1	1	3	3	2	0	0	0	9	0	0	0	0	0	19	
5.20	0	0	1	7	0	0	0	0	0	11	2	0	0	0	0	21	
5.21	0	1	0	8	0	0	2	0	0	9	4	4	2	1	3	34	
5.22	0	1	0	2	1	2	0	1	0	13	6	0	0	0	0	26	
5.23	0	0	2	1	0	3	0	0	0	14	0	0	0	1	0	21	
5.24	0	0	0	4	0	1	0	0	0	11	3	0	0	0	0	19	
5.25	0	2	1	1	1	0	0	0	0	10	2	1	0	1	0	19	
5.26	0	0	0	3	0	1	1	1	0	13	2	1	0	0	0	22	
5.27	0	0	0	0	3	1	2	0	0	6	1	1	0	0	0	14	
5.28	0	1	0	4	1	2	0	0	0	13	5	0	1	1	0	28	
5.29	0	2	0	9	7	6	1	1	0	5	8	2	1	0	1	43	
5.30	0	0	0	1	0	0	1	3	0	12	3	2	0	1	0	23	
5.31	0	0	0	5	0	11	5	1	0	7	4	0	0	0	1	34	23.54
6.01	0	0	0	2	1	5	4	5	0	1	2	1	0	1	0	22	
6.02	0	0	0	8	1	5	2	3	0	9	0	1	0	0	2	31	
6.03	0	1	0	5	0	38	4	5	0	4	0	2	3	0	0	62	
6.04	0	0	0	4	0	6	1	7	2	2	0	4	0	1	3	30	
6.05	0	0	0	1	0	7	3	1	7	10	0	3	0	1	7	40	
6.06	0	1	0	8	0	0	1	2	5	7	1	1	0	2	0	28	
6.07	0	3	0	1	0	1	4	2	3	2	2	1	2	0	1	22	
6.08	0	11	0	1	0	0	4	0	14	6	0	2	0	2	0	40	
6.09	0	3	0	1	2	0	3	0	10	30	0	1	0	1	0	51	
6.10	0	1	0	5	2	2	0	0	3	6	1	1	1	1	0	23	
6.11	0	4	0	2	1	0	2	0	6	8	5	0	1	0	10	39	
6.12	0	2	0	1	0	2	2	0	8	5	12	4	0	2	3	41	
6.13	0	2	0	0	1	3	2	0	4	5	13	2	1	0	6	39	
6.14	0	3	0	0	0	5	2	0	7	5	11	4	0	0	5	42	
6.15	0	2	0	0	2	1	4	0	5	5	16	0	1	0	1	37	
6.16	1	14	0	0	5	2	1	0	5	2	6	0	0	2	5	43	

APPENDIX V. KNOWN ATLANTIC SALMON RETURNS TO THE MERRIMACK RIVER - 1982 THROUGH 1996.

MONTH & DAY	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	TOTAL	% BY MONTH
6.17	0	15	0	3	5	0	2	1	4	0	12	2	2	1	4	51	
6.18	0	7	0	3	3	1	0	1	7	2	2	1	0	0	0	27	
6.19	0	8	0	1	5	1	0	0	2	1	7	2	0	3	2	32	
6.20	0	4	0	6	4	0	1	1	1	4	2	0	0	2	1	26	
6.21	1	0	1	11	0	1	0	0	4	4	4	0	0	2	1	29	
6.22	0	0	2	4	1	1	0	0	19	3	3	0	1	1	1	36	
6.23	0	0	4	5	1	0	0	0	5	1	0	0	0	0	2	18	
6.24	1	0	2	13	1	0	0	5	16	3	5	0	0	1	2	49	
6.25	1	0	3	3	3	0	0	1	5	3	5	0	0	1	1	26	
6.26	0	0	2	1	2	0	0	4	8	4	0	0	1	0	1	23	
6.27	0	0	1	1	1	1	1	0	6	2	3	0	1	1	1	19	
6.28	0	2	4	0	4	0	0	0	2	3	7	3	0	0	0	25	
6.29	0	2	6	2	5	2	0	5	1	5	2	1	1	1	0	33	
6.30	0	1	5	4	1	1	0	1	3	0	6	0	1	0	0	23	55.12
7.01	0	1	11	3	1	2	3	3	1	0	2	0	1	0	0	28	
7.02	0	0	1	2	2	3	0	3	1	0	0	0	0	0	1	13	
7.03	1	4	7	3	0	1	0	8	0	0	0	0	0	0	1	25	
7.04	0	2	1	8	1	2	0	0	9	0	0	0	0	0	1	24	
7.05	1	0	4	5	2	3	0	1	3	2	0	0	0	0	1	22	
7.06	0	0	8	7	2	0	3	2	2	1	4	0	0	0	0	29	
7.07	0	0	1	10	1	0	0	1	5	3	0	0	0	1	0	22	
7.08	0	0	2	4	0	0	2	7	7	1	0	0	0	0	0	23	
7.09	0	0	0	1	2	2	0	0	2	1	0	0	0	0	1	9	
7.10	0	0	2	2	0	4	0	0	2	1	2	0	0	0	0	13	
7.11	0	0	0	1	1	0	0	1	2	2	2	0	0	0	0	9	
7.12	0	0	5	0	0	0	0	1	3	1	2	0	0	0	0	12	
7.13	0	0	2	0	1	2	0	0	1	1	0	0	0	0	0	7	
7.14	0	0	0	0	1	0	0	4	4	1	0	0	0	0	0	10	
7.15	0	0	0	1	0	0	0	1	8	0	0	0	0	0	0	10	
7.16	0	0	4	0	1	0	0	0	7	0	0	0	0	0	0	12	
7.17	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	5	
7.18	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	3	
7.19	0	0	4	0	0	0	0	0	1	0	0	0	0	0	0	5	
7.20	0	0	1	0	0	0	0	0	0	0	2	0	0	0	0	3	
7.21	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	2	
7.22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
7.23	0	0	3	0	1	0	0	0	0	0	0	0	0	0	0	4	
7.24	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	2	
7.25	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	2	
7.26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
7.27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
7.28	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	
7.29	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	
7.30	0	0	3	0	0	0	0	0	0	0	1	0	0	0	0	4	
7.31	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	3	16.58

APPENDIX V. KNOWN ATLANTIC SALMON RETURNS TO THE MERRIMACK RIVER - 1982 THROUGH 1996.

MONTH & DAY	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	TOTAL	% BY MONTH
8.26	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	3	
8.27	0	0	0	0	0	0	0	0	2	3	0	0	0	0	1	6	
8.28	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	4	
8.29	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	2	0.66
9.07	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
9.10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
9.12	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
9.16	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	3	
9.17	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	
9.20	0	0	0	0	0	0	0	0	2	0	0	0	0	0	1	3	
9.21	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	
9.23	0	0	0	0	0	0	0	0	1	2	0	2	0	0	1	6	
9.24	0	0	0	0	0	0	0	0	2	1	0	0	0	0	0	3	
9.25	3	0	0	2	1	2	0	0	0	3	0	0	0	0	0	11	
9.26	2	0	2	0	0	0	0	0	0	0	0	1	0	0	3	8	
9.28	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	2.19
9.29	0	0	0	0	0	0	0	0	0	0	2	1	0	0	0	3	
9.30	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	
10.01	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	
10.02	2	0	0	1	0	0	0	0	0	1	0	0	0	0	0	4	
10.03	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
10.04	0	0	1	1	0	0	0	0	1	2	0	0	0	0	0	5	
10.05	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	2	
10.07	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	
10.08	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	
10.10	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	
10.11	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	
10.12	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
10.14	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	2	
10.18	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1.26
TOTAL	23	114	115	213	103	139	65	84	248	332	199	61	21	34	76	1827	

APPENDIX VI. SUMMARY OF CODED-WIRE-TAG RECOVERY INFORMATION FOR ATLANTIC SALMON OF MERRIMACK RIVER ORIGIN.

YEAR OF CWT RECOVERY	RELEASE YEAR AS JUVENILES	LIFE-STAGE AT RELEASE	NUMBER IN RELEASE	NO. CWT'S RECOVERED IN CANADIAN COMMERCIAL FISHERY FROM 1-S-W SALMON	CWT RECOVERY RATE / 1000 TAGGED FISH RELEASED	NO. CWT'S RECOVERED IN GREENLAND COMMERCIAL FISHERY FROM 1-S-W SALMON	CWT RECOVERY RATE / 1000 TAGGED FISH RELEASED	TOTAL CWT'S RECOVERED IN OCEAN COMMERCIAL FISHERY FROM 1-S-W SALMON	CWT RECOVERY RATE / 1000 TAGGED FISH RELEASED
1986	1985	2Smolt	125300	1	0.009	7	0.063	8	0.072
1987	1986	1Smolt	39900	0	0.000	0	0.000	0	0.000
1987	1986	2Smolt	64100	0	0.000	2	0.031	2	0.031
1988	1987	1Smolt	78100	0	0.000	0	0.000	0	0.000
1989	1988	1Smolt	90700	6	0.066	17	0.188	23	0.254
1990	1989	1Smolt	50900	4	0.071	9	0.160	13	0.231
1991	1990	1Smolt	116900	13	0.111	2	0.017	15	0.128
1992	1991	1Smolt	62000	2	0.032	5	0.081	7	0.113
1992	1991	2Smolt	58100	0	0.000	1	0.017	1	0.017
			686000	26	0.038	43	0.063	69	0.101

APPENDIX VII. AMERICAN SHAD RETURNS TO THE MERRIMACK RIVER - ESSEX DAM FISH-LIFT COUNT, 1983 THROUGH 1996.

MONTH	YEAR															% OF TOTAL
DAY	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	TOTAL	BY 15-DAY INTERVAL
5.01	0	0	15	0	0	0	1	0	8	0	0	0	0	0	24	
5.02	0	0	0	27	0	0	0	2	0	0	0	0	0	0	29	
5.03	0	0	8	0	0	0	0	0	3	0	0	0	0	0	11	
5.04	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	
5.05	0	0	0	1	0	0	0	0	3	0	0	0	0	0	4	
5.06	0	0	2	0	0	0	0	0	17	0	0	0	0	0	19	
5.07	0	0	0	1	0	0	0	1	15	0	0	0	0	0	17	
5.08	0	0	0	0	0	0	0	1	7	0	0	0	0	0	8	
5.09	0	0	0	8	0	0	0	1	20	1	0	0	12	0	42	
5.10	3	2	2	0	0	0	0	7	12	2	3	0	27	0	58	
5.11	0	0	0	0	0	1	0	11	13	22	1	0	11	0	59	
5.12	2	0	0	60	0	0	0	3	115	7	0	0	11	0	198	
5.13	0	0	209	30	0	0	0	0	753	29	11	0	2	0	1034	
5.14	2	0	81	67	0	2	0	0	1577	118	0	0	3	0	1850	
5.15	0	0	31	1132	3	0	0	2	1910	282	0	0	1	0	3361	4.19
5.16	4	0	48	203	26	23	0	8	1364	227	17	2	2	0	1924	
5.17	6	0	215	2058	124	35	0	5	364	627	10	1	26	0	3471	
5.18	0	0	260	1848	450	51	5	1	110	706	32	0	3	0	3466	
5.19	29	4	82	1048	495	34	12	2	107	314	7	0	2	0	2136	
5.20	2	23	23	1081	38	62	2	7	328	490	13	0	22	0	2091	
5.21	95	23	31	271	1155	52	4	3	352	903	67	0	73	0	3029	
5.22	257	36	19	59	584	54	15	0	731	323	101	1	346	4	2530	
5.23	58	205	229	612	936	50	53	1	297	795	108	4	308	2	3658	
5.24	27	108	2219	56	144	299	10	1	325	816	388	17	873	0	5283	
5.25	79	199	444	33	93	112	60	0	492	324	358	12	708	0	2914	
5.26	244	144	560	24	662	75	64	1	512	263	701	72	761	16	4099	
5.27	190	270	224	159	43	2	116	6	533	290	591	222	776	26	3448	
5.28	151	472	429	229	155	6	48	1	372	717	158	25	442	18	3223	
5.29	137	51	435	598	234	8	19	15	465	272	146	26	0	204	2610	
5.30	16	4	275	99	835	30	38	40	532	363	415	0	1142	0	3789	29.74
5.31	3	0	283	9	376	1243	138	26	450	1045	0	21	195	12	3801	
6.01	22	0	84	143	910	625	62	8	262	395	305	55	164	20	3055	
6.02	16	0	103	242	837	256	123	19	272	440	213	43	948	91	3603	
6.03	60	0	1452	111	531	18	230	113	247	345	250	368	552	515	4792	
6.04	9	0	855	238	486	418	808	186	330	689	117	270	749	929	6084	
6.05	103	0	489	357	666	73	104	364	350	595	156	138	140	1141	4676	
6.06	91	0	204	34	195	3	426	255	261	550	552	307	372	602	3852	
6.07	94	0	98	74	88	189	21	94	75	511	150	126	222	335	2077	
6.08	0	0	275	156	373	629	4	98	295	66	109	119	274	139	2537	
6.09	136	0	154	736	574	181	314	247	184	121	170	356	509	71	3753	
6.10	276	0	356	938	280	143	19	102	270	323	186	417	686	49	4045	
6.11	43	0	200	502	754	1268	8	27	200	1282	166	207	343	472	5472	
6.12	344	17	0	181	356	881	0	66	152	682	119	264	335	722	4119	
6.13	619	6	67	192	129	572	9	253	124	601	520	174	528	443	4237	
6.14	260	2	194	391	274	453	20	189	101	556	309	12	342	556	3659	
6.15	134	3	200	515	261	1186	277	60	78	1016	285	43	227	312	4597	40.16
6.16	402	3	139	605	312	675	140	55	73	662	503	47	156	387	4159	
6.17	1096	16	150	301	370	181	56	289	72	673	478	287	106	658	4733	
6.18	145	0	109	264	758	338	532	52	66	277	140	111	36	1814	4642	
6.19	49	4	99	226	416	194	341	315	39	297	119	154	287	465	3005	
6.20	80	522	138	106	227	112	169	157	91	130	120	46	356	616	2870	
6.21	101	404	141	138	224	167	59	136	90	254	53	29	213	108	2117	
6.22	11	121	74	152	231	166	365	545	120	330	18	40	176	45	2394	
6.23	19	505	15	98	118	89	438	239	77	46	101	21	112	29	1907	
6.24	33	91	26	174	57	44	431	409	50	128	42	12	52	9	1558	
6.25	6	6	68	81	31	81	575	365	43	152	44	39	23	0	1514	
6.26	4	40	44	59	0	26	32	218	99	103	23	23	61	0	732	
6.27	29	39	10	135	84	45	2	72	32	94	29	33	43	52	699	
6.28	12	23	39	78	148	91	0	76	35	112	34	41	13	32	734	

APPENDIX VII. AMERICAN SHAD RETURNS TO THE MERRIMACK RIVER - ESSEX DAM FISH-LIFT COUNT, 1983 THROUGH 1996.

MONTH DAY	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	TOTAL	% OF TOTAL BY 15-DAY INTERVAL
6.29	29	225	24	264	49	90	69	46	25	49	40	11	49	88	1058	
6.30	20	410	58	153	7	102	39	55	7	56	13	32	9	41	1002	20.67
7.01	15	73	30	106	1	40	493	103	23	86	29	32	0	83	1114	
7.02	17	61	140	52	112	106	274	39	20	23	2	0	0	104	950	
7.03	11	30	107	125	16	0	206	37	22	10	8	0	0	76	648	
7.04	11	149	120	20	14	0	0	43	10	6	0	0	0	10	383	
7.05	4	169	27	191	25	304	39	121	8	15	0	54	19	13	989	
7.06	9	99	117	60	97	172	240	82	4	20	47	1	2	6	956	
7.07	4	43	79	55	78	165	190	43	12	6	0	26	3	7	711	
7.08	10	78	25	21	179	98	55	37	25	13	11	1	4	0	557	
7.09	0	74	50	25	130	0	21	45	3	12	5	7	4	0	376	
7.10	0	183	37	46	66	0	8	15	6	9	0	0	0	0	370	
7.11	0	45	14	17	0	17	14	26	18	9	0	0	0	0	160	
7.12	0	36	30	32	1	0	5	46	18	6	0	0	0	0	174	
7.13	0	26	4	14	6	14	7	10	10	9	3	0	0	0	103	
7.14	0	22	2	23	10	0	29	22	12	25	0	0	0	0	145	
7.15	0	0	10	0	11	8	8	16	0	9	3	0	0	0	65	4.80
7.16	0	48	0	13	3	0	0	21	0	1	0	0	0	0	86	
7.17	0	101	7	0	13	0	3	3	0	10	0	0	0	0	137	
7.18	0	75	0	4	0	0	0	14	0	0	0	0	0	0	93	
7.19	0	100	2	0	0	0	6	1	0	0	0	0	0	0	109	
7.20	0	26	0	0	12	0	0	5	0	23	0	0	0	0	66	
7.21	0	8	0	2	8	0	16	0	0	1	0	0	0	0	35	
7.22	0	24	3	0	11	0	0	0	0	10	0	0	0	0	48	
7.23	0	5	0	3	17	0	0	0	0	5	0	0	0	0	30	
7.24	0	3	0	0	0	0	1	0	0	2	0	0	0	0	6	
7.25	0	5	0	7	0	0	0	1	0	0	0	0	0	0	13	
7.26	0	14	0	0	0	0	1	3	0	0	0	0	0	0	18	
7.27	0	10	0	0	0	0	0	7	0	9	0	0	0	0	26	
7.28	0	0	0	0	0	0	1	0	0	1	0	0	0	0	2	
7.29	0	0	0	0	0	0	0	0	0	2	0	0	0	0	2	
7.30	0	12	0	0	0	0	0	0	0	1	0	0	0	0	13	
7.31	0	0	0	0	0	0	0	2	0	2	0	0	0	0	4	0.43
8.27	0	0	0	0	0	0	0	4	0	0	0	0	0	0	4	
8.28	0	0	0	0	0	0	0	7	0	0	0	0	0	0	7	0.01
9.17	0	0	0	0	0	0	0	4	0	0	0	0	0	0	4	0.00
	5629	5497	12793	18173	16909	12359	7875	6013	16098	20796	8599	4349	13861	11322	160273	
TOTAL FOR LOWELL				1630	3926	1289	940	443	428	6491	1679	383	5255	400	22864	

APPENDIX VIII

TABLE VIIIa. AMERICAN SHAD AGE, GROWTH, AND SEX INFORMATION FOR ADULT RETURNS.

Year	No. in Sample	% Males	% Females	Mean Age		Mean Fork Length (inches)		Mean Weight (Pounds)	
				Males	Females	Males	Females	Males	Females
1983	43	67	33	4.27	5.14	16.8	19.3	2.2	3.8
1984	48	40	60	4.53	5.12	17.7	20.2	Unknown	
1985	75	55	45	4.37	4.88	17.6	19.5	Unknown	
1989	39	44	56	Unknown		17.9	19.7	2.7	3.9
1991	107	57	43	4.70	5.28	17.1	18.7	2.5	3.5
1992	48	46	54	4.40	5.20	Unknown		Unknown	
1993	32	19	81	4.50	5.00	Unknown		Unknown	
1995	160	63	37	Unknown		15.9	18.3	2.0	3.3

APPENDIX VIII CONTINUED.

TABLE VIIIb. AGE AND GROWTH INFORMATION FOR VIRGIN AMERICAN SHAD (all measurements in inches and pounds - number of fish in sample in ( ) - 0 age represents juveniles at time of outmigration). *

Year	Age Categories							
	0 Mean FL	I Mean FL	II Mean FL	III Mean FL	IV Mean FL	V Mean FL	VI Mean FL	VII Mean FL
Males								
1983	5.3 (29) TL	8.5 (29) TL	11.8 (29) TL	15 (1) TL	18 (19) TL	19.8 (9) TL		
1984					16.9 (8)	18.5 (9)		
1985				15.4 (3)	16.8 (20)	18.8 (18)		
1991				14.6 (2)	15.9 (12)	17.1 (18)	18.3 (5)	
1992	(22 males sampled)			15.2 (?)	16.5 (?)	16.6 (?)	17.9 (?)	
1993	(6 males sampled)			15.0 (?)	16.5 (?)	19.3 (?)	18.5 (1)	
Females								
1983	5.8 (9) TL	9.7 (9) TL	12.9 (9) TL	16.7 (9) TL	19.6 (4) TL	22 (3) TL	23 (2) TL	
1984					16.7 (2)	20.4 (19)	20.9 (5)	
1985					17.0 (7)	20 (24)	21.3 (3)	
1991					17.2 (7)	18.5 (17)	18.7 (12)	19.6 (3)
1992	(25 females sampled)			15.4 (?)	16.8 (?)	18.7 (?)	19.3 (?)	18.5 (1)
1993					16.8 (6)	18.2 (15)	18.2 (4)	18.1 (1)

* Those entries with TL are measurements that were taken in total length rather than fork length.

APPENDIX IX. CREEL SURVEY DATA FOR AMERICAN SHAD IN THE LOWER MERRIMACK RIVER (1984 - 1988).

Category	1984	1985	1986	1987	1988
Expanded Total Hours	9934	7516	4190	8947	6324
Average Angling Day (hours)	2.46	3.27	2.33	1.79	2.7
Expanded Total Anglers	4020	2239	1747	5011	2330
No. Shad Creeled	1642	870	148	0	474
No. Shad Released	4525	3763	1383	3668	3162
Total Shad Caught	6167	4633	1531	3668	3162
No. Shad Caught / Hour	0.62	0.62	0.37	0.41	0.5
No. Shad Caught / Angler	1.53	2.07	0.82	0.73	1.35

May 1 – May 10th

??
1998

APPENDIX X. RIVER HERRING RETURNS TO THE MERRIMACK RIVER - ESSEX DAM FISH-LIFT COUNT, 1983 THROUGH 1996. *

MONTH DAY	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1998	TOTAL	% OF TOTAL BY 15-DAY INTERVAL
5.01	0	0	613	0	0	0	914	8800	4830	0	0	0	0	0	0	15157	
5.02	0	0	0	627	0	0	9867	9904	5166	0	0	0	1	0		25565	
5.03	0	0	6	0	0	0	2001	14504	7435	0	0	2	9	0		23957	
5.04	0	0	0	0	0	0	0	25105	2360	241	0	35	23	0		27764	
5.05	0	0	0	36	0	0	0	0	2505	2977	0	297	2	0		5817	
5.06	0	0	0	0	0	0	0	0	4040	570	0	304	0	0		4914	
5.07	0	0	0	0	0	0	0	20000	9900	768	0	0	0	0		30668	
5.08	0	0	0	0	0	0	0	17200	4405	300	0	0	11	0		21916	
5.09	9	1	0	47	0	6003	0	11375	23675	280	0	1382	100	0		42872	
5.10	11	0	12	0	0	2624	0	17100	5950	196	1427	15	5298	0		32633	
5.11	22	0	0	0	0	945	6129	21050	2090	465	1795	30	144	0		32670	
5.12	4	0	0	23	0	11098	6072	7550	4912	240	1055	16	892	0		31862	
5.13	0	0	930	66	0	12247	4174	0	19317	3022	1121	4	672	0		41553	
5.14	0	0	87	17	0	19184	0	0	101000	6931	233	0	165	0		127617	
5.15	0	2	48	2486	5379	12862	34935	2455	42206	17413	0	0	68	0		117854	33.[illegible] 33.61
5.16	0	0	78	3941	2197	108780	35600	7935	16193	17496	2679	1028	2005	0		197932	
5.17	2	3	19	3049	2249	110388	15410	17925	5600	6635	105	249	548	0		162182	
5.18	10	0	1094	956	562	33054	5473	5837	13375	656	2881	14	4775	0		68687	
5.19	66	8	41	1629	12341	7669	18771	1581	10300	12479	100	13	2070	0		67068	
5.20	21	39	67	516	12260	926	11482	2530	8565	15088	43	0	1147	0		52684	
5.21	1253	36	501	158	8708	741	17967	3171	9985	6700	12	10	1407	0		50649	
5.22	568	96	2014	240	13060	2560	32828	148	8250	5441	253	0	3721	13		69192	
5.23	726	353	5352	580	4582	3320	66800	216	8300	1637	1525	304	530	6		94231	
5.24	32	72	2538	181	279	4751	22249	153	5247	1330	68	313	321	16		37550	
5.25	63	127	420	308	925	10347	27398	501	6125	53	472	66725	4406	8		117878	
5.26	145	424	1575	14	761	1915	8493	1130	4060	13	116	7926	3113	0		29685	
5.27	4	16	118	67	225	1419	28180	3256	4562	48	4	9300	1855	0		49054	
5.28	80	20	148	139	337	587	12655	7505	4425	253	0	150	25	0		26324	
5.29	17	167	348	254	5979	133	1717	7603	6275	38	3	79	0	0		22613	
5.30	13	14	435	90	4650	246	1181	12525	2167	307	30	0	26	0		21684	6[illegible]5 95.16
5.31	1	0	311	87	968	250	1141	7198	1110	344	0	8	20	0		11438	
6.01	196	0	3	25	138	1316	632	1705	3194	36	53	100	5	0		7403	
6.02	60	0	10	70	65	103	973	3085	4844	36	19	97	1	0		9363	
6.03	91	0	19	18	28	339	490	2420	2057	0	28	23	1	0		5514	
6.04	48	0	957	56	62	35	1486	1859	500	0	1	3	13	2		5022	
6.05	25	0	1046	60	22	72	2072	5217	1498	0	0	5	3	4		10024	
6.06	29	0	79	5	8	3	202	1823	474	0	1	1	34	1		2660	
6.07	17	0	6	1	2	46	1088		1020	0	0	67	0	0		2247	
6.08	0	0	79	5	7	574	35	935	1590	1	0	159	0	1		3386	
6.09	8	0	11	3	17	330	32	225	605	0	0	55	1	0		1287	
6.10	42	0	834	0	2	25	17	226	24	1	0	4	0	0		1175	
6.11	26	0	1158	18	0	56	13	47	635	0	0	77	0	0		2030	
6.12	1	1	322	0	12	37	94	96	1936	2	0	40	0	0		2541	
6.13	1	1	42	19	0	118	211	222	1005	1	0	1	0	0		1621	
6.14	1	0	31	8	0	22	57	272	921	37	2	2	0	0		1353	
6.15	1	0	9	1	2	380	6	128	1112	109	0	1	3	0		1752	3.97 99.13
6.16	17	0	62	10	1	101	1	124	275	22	0	25	0	0		638	
6.17	11	0	102	7	1	132	0	821	98	0	0	10	0	0		1182	
6.18	4	0	7	7	171	563	0	99	75	0	0	5	0	0		931	
6.19	27	3	68	2	314	0	1	41	562	0	0	21	0	0		1039	
6.20	5	0	15	4	16	0	3	12	360	0	0	0	0	0		415	
6.21	18	206	343	1	243	296	2	8	590	0	0	0	0	0		1707	
6.22	58	99	105	0	77	146	1	36	512	0	0	0	0	0		1034	
6.23	53	23	3	2	83	159	1	15	767	0	0	0	0	0		1106	
6.24	79	0	6	3	1	170	6	12	0	0	1	0	0	0		278	
6.25	21	0	220	4	79	9	1	7	0	0	0	0	0	0		341	
6.26	105	6	242	73	0	6	1	4	50	0	0	0	0	0		487	
6.27	51	0	38	30	2	237	1		60	0	0	0	0	0		419	

APPENDIX X. RIVER HERRING RETURNS TO THE MERRIMACK RIVER - ESSEX DAM FISH-LIFT COUNT, 1983 THROUGH 1996. *

MONTH DAY	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	TOTAL	% OF TOTAL BY 15-DAY INTERVAL
	YEAR															
6.28	6	9	1	0	0	207	0	22	70	0	0	0	0	0	315	
6.29	5	4	8	20	0	89	1	4	56	0	0	1	0	0	188	
6.30	93	4	1	86	101	4	0	1	5	0	0	12	0	0	307	0.60
Total	4146	1734	22582	16049	76916	357624	378864	253723	379225	102166	14027	88913	33415	51	1729435	
Yearly Total	4794	1769	23112	16265	77087	360738	378864	253723	379225	102166	14027	88913	33415	51	1734149	

* Column total and yearly total are not equal since some river herring were counted during July which is not included in the column total.

APPENDIX XI. SELECTED CHARACTERISTICS OF THE ALEWIFE AND BLUEBACK HERRING RETURNS AT THE ESSEX DAM FISH-LIFT FOR THE YEARS 1989, 1990, 1991, AND 1995.

Year	1989	1990	1991	1995
Alewife				
% Females	54	47	51	58
Ave. Wgt (lbs)	--	0.60	0.58	0.50
Ave. FL (in)	10.6	10.9	11.0	10.3
% Males	46	53	49	42
Ave. Wgt (lbs)	--	0.53	0.50	0.43
Ave. FL (in)	10.7	10.6	10.5	10.1
Blueback				
% Females	45	50	35	59
Ave. Wgt (lbs)	--	0.43	0.48	0.39
Ave. FL (in)	10.4	10.0	9.6	9.5
% Males	55	50	65	41
Ave. Wgt (lbs)	--	0.33	0.37	0.35
Ave. FL (in)	10.1	10.1	9.1	9.3