U.S. ATLANTIC SALMON
ASSESSMENT COMMITTEE

ANNUAL REPORT 2000/12

ANNUAL REPORT OF THE U.S. ATLANTIC SALMON ASSESSMENT COMMITTEE

REPORT NO. 12 - 1999 ACTIVITIES

GLOUCESTER, MASSACHUSETTS
MARCH 6 - 9, 2000

PREPARED FOR
U.S. SECTION TO NASCO

TABLE OF CONTENTS

Section

1. INTRODUCTION

1.1. EXECUTIVE SUMMARY

The Annual Meeting of the U.S. Atlantic Salmon Assessment Committee was held in Gloucester, MA, March 6-9, 2000.

Stocking data (listed by age/life stage and river of release), tagging and marking data are summarized here for all New England programs. A total of 13,664,000 juvenile salmon (fry, parr, and smolts) was stocked. The Connecticut River received the largest percentage (47.2%), the majority of which was fry. Maine rivers received approximately 33.1% of the total, followed by the Merrimack River with 13.3%. The total release was a 19.3% decrease over that of 1998.

In addition to the juveniles stocked, adults were stocked by the Maine, Merrimack, and Connecticut programs. These fish were wild and domestic broodstock that were either spent or in excess to hatchery capacity. All these adults were released back into the same river from which they originated. For 1999, a total of 5,800 captive and domestic adults were released into the rivers of New England.

Throughout New England juvenile and adult salmon were marked with a variety of marks and/or miscellaneous external tags (e.g., PIT tags, VI tags, elastomer tags, radio tags, etc.). The salmon releases included about 119,000 marked and tagged salmon in 1999. Of the total, approximately 70% were released into Maine rivers, 10% were released into the Merrimack River drainage, and 20% were released into the Connecticut River drainage. Marked fish included parr, smolts, and adults.

Documented total adult salmon returns to rivers in New England amounted to 1,452 salmon in 1999, 18% fewer than in 1998. The majority of the returns were recorded in the rivers of Maine with the Penobscot River accounting for nearly 67% of the total New England returns. Overall, 26% of the adult returns to New England were 1SW salmon and 74% were MSW salmon; most (65%) of these fish were of hatchery smolt origin. Of the total returns, approximately 34% were of wild origin (from natural reproduction and from fry plants).

Directed sea-run Atlantic salmon fishing is not allowed in New England, with the exception of a catch and release fishery in Maine. The estimated number of salmon caught and released in 1999 was 212 fish, which was a 22 % decrease from the previous year.

The domestic broodstock fishery in the Merrimack River resulted in an estimated 2,700 salmon caught (kept and released).

Egg sources for the New England Atlantic salmon culture programs included sea-run salmon, captive and domestic brood stock, and reconditioned kelts. A total of 463 sea-run females, 3,162 captive/domestic females, and 258 female kelts contributed to the egg take. The number of females (3,883) contributing was slightly greater than that in 1998 (3,715). The total egg take (23,327,000) was up from that of 1998 (19,791,000).

1.2. BACKGROUND

The U.S. became a charter member of the North Atlantic Salmon Conservation Organization (NASCO) in 1984. NASCO is charged with the international management of Atlantic salmon stocks on the high seas. Three Commissioners for the U.S. are appointed by the President and work under the auspices of the U.S. State Department. The Commissioners felt they needed advice and input from scientists involved in salmon research and management throughout New England and asked the New England Atlantic Salmon Committee (NEASC) to create such an advisory committee. NEASC is comprised of State and Federal fishery agency chiefs who designated personnel from their staff to serve on the "NASCO Research Committee", which was formed in 1985.

The NASCO Research Committee met semiannually to discuss the terms of reference for upcoming meetings of the International Council for the Exploration of the Seas (ICES) and NASCO, as well to respond to inquiries from NASCO Commissioners. In July of 1988, the Research Committee for the U.S. section to NASCO was restructured and called the U.S. Atlantic Salmon Assessment Committee, to focus on 1) annual stock assessment, 2) proposal and evaluation of research needs, and 3) serving the U.S. Section to NASCO.

A key element of the proposal was the development of an annual Assessment Meeting with the main goal of producing an assessment document for the U.S. Commissioners. Additionally, the report would serve as guidance, regarding research proposals and recommendations to the State and Federal fishery agency chiefs through the NEASC.

1.3. RELATIONSHIP OF ICES TO NASCO

ICES, the official research arm of NASCO, is responsible for providing scientific advice to be used by NASCO members as a basis for formulating biologically sound management recommendations for the conservation of North Atlantic salmon stocks. ICES delegates responsibilities for the collection and analysis of scientific data on salmon to various study groups. The Working Group on North Atlantic Salmon that is composed of representatives of member countries is an example.

"Terms of Reference" constitute the task assignments given to the North Atlantic Salmon Working Group by ICES from recommendations received from NASCO, the EEC, and member countries of ICES. Opportunities for development of Terms of Reference are available to the Atlantic Salmon Assessment Committee by submission of issues of interest through the U.S. Commissioners to NASCO or the appropriate channels.

1.4. CHAIRWOMAN'S COMMENTS

The New England Salmon Program was honored by a visit from Dr. Malcom Windsor and Dr. Peter Hutchinson, North Atlantic Salmon Conservation Organization, in the autumn. The NASCO Secretariat carried the pragmatic perspective that U.S. biologists should have to work harder at restoring Atlantic salmon because we as a nation have allowed so many of the U.S. salmon stocks to decline or disappear. The current state of the salmon runs and the efforts required to restore these runs are simply the cost of our past decisions. These efforts are also inextricably tied to the decisions of other nations and the whims of nature. Thus restoration remains an arduous task. Only the future will tell whether we as a nation have the fortitude to continue to address the many emerging and remaining management, habitat, biological, and political issues swirling around the fate of Atlantic salmon. Regardless of future considerations, the tremendous efforts of U.S. biologists in 1999 are clearly reflected in this year's report.

Janice N. Rowan, Chair

2. STATUS OF PROGRAM

2.1. GENERAL PROGRAM UPDATE

2.1.1. CONNECTICUT RIVER

2.1.1.a. Adult Returns

A total of 154 sea-run Atlantic salmon adults was observed returning to the Connecticut River watershed in 1999 including: 91 at the Holyoke fishway on the Connecticut River; 36 at the Rainbow fishway on the Farmington River; 18 at the Decorative Specialties International (DSI) fishway on the Westfield River including one fish that was hooked below the DSI dam and live-captured by State personnel; and, nine at the Leesville fishway on the Salmon River. The spring run lasted from May 2 to June 29. One of the Leesville salmon returned in the autumn on October 17, 1999. The Westfield River Watershed Association volunteered to operate the DSI fishway in autumn 1999, contributing 40 hours of volunteer time.

One salmon was released above the DSI dam on the Westfield. A total of 21 salmon was released from the Holyoke fishlift (river km 138) and permitted to continue upstream. Twenty of these released salmon were surgically fitted with radio-tags as part of a PGE Generating fish passage study on the Deerfield River; of these, eight passed the fishway at Turners Falls, MA (river km 198), eight passed the fishway at Vernon, VT (river km 228), two passed Bellows Falls (river km 280), and one passed above Wilder (river km 350). One salmon was trapped and released above the Townshend Dam on the West River. Redds were observed in the Sawmill River. Radio-tagged salmon were documented in the Mill (Hatfield), Sawmill, Deerfield, West, Cold, Saxtons, Williams, and Ammonoosuc river systems.

A total of 132 salmon was retained for broodstock: 87 sea runs were held at the Richard Cronin

National Salmon Station (RCNSS), and 45 sea runs were held at the Whittemore Salmon Station (WSS).

Age and origin information was derived from scales and physical examination of each fish. Origin information on released salmon was determined by examination for presence or absence of adipose fins and sea-age was generally determined by size. All of the 154 observed salmon were stocked as fry. Sea-age of fry was comprised of eleven grilse, 142 -2 sea-winter, and one repeat spawner. Freshwater ages of salmon were 15 age-1^+, 117 age-2^+, and 15 age-3^+ (with eight unknowns). The sex ratio was 84 females: 48 males, with 22 unknowns (mostly released fish).

2.1.1.b. Hatchery Operations

Smolt stocking was resumed in the Connecticut River basin for the first time since 1994 to provide a buffer against poor instream smolt production years. The U.S. Fish and Wildlife Service (USFWS) released 21,136 yearling smolts from its first year class at the Pittsford National Fish hatchery (PNFH). The remainder of the year class will be stocked as two-year smolts in 2000. Annual production of 100,000 two-year smolts is expected to continue into the future.

The PNFH 1+ parr experienced an epizootic of furunculosis this summer. Medicated feed was utilized to manage the disease.

Egg Collection

A grand total of 13,607,659 green eggs was produced at seven state and federal hatcheries within the basin. This is about 3.6 million more eggs than produced in 1998.

<u>Sea-Run Broodstock</u>
A total of 621,544 eggs (4.6% of the grand total eggs produced) was taken from 83 sea-run females (3.9% of the grand total females spawned) held at the WSS and the RCNSS. A sample of 41,747 fertilized eggs from 70 sea-run females crossed with 30 sea-run males and 37 wild parr was egg-banked at the WSS for disease screening and subsequent production of future domestic broodstock.

<u>Domestic Broodstock</u>
A total of 11,172,872 eggs (82.1% of the grand total eggs produced) was taken from 1,862 domestic females (87.1% of the grand total females spawned) held at the RCNSS, White River National Fish Hatchery (WRNFH), Roger Reed State Fish Hatchery (RRSFH), Kensington State Salmon Hatchery (KSSH), and Roxbury Fish Culture Station (RFCS).

<u>Kelts</u>
A total of 1,813,243 eggs (13.3% of the grand total eggs produced) was taken from 193 kelt

females (9% of the grand total females spawned) held at the WSS, RCNSS, and North Attleboro National Fish Hatchery (NANFH).

2.1.1.c. Stocking

Juvenile Atlantic Salmon Releases. A total of 6,451,688 Atlantic salmon was stocked into the Connecticut River watershed in 1999. Fish were released into 32 tributary systems throughout the basin. The total consisted of 5,947,556 unfed fry (92%), 480,497 fed fry (7.4%), 1,000 0+ parr (<1%), and 22,635 one-year smolts (<1 %).

Over 4,600 volunteer hours or 586 volunteer-days were contributed to the program in 1999, making a successful fry stocking season possible in the four state basin. Americorps contributed 1,499 hours and volunteers added another 588 hours stocking fry in Massachusetts' waters. Vermont Department of Fish and Wildlife (VTFW) used 179 volunteers for a total of 953 hours of fry stocking. New Hampshire Fish and Game (NHFG) tallied 400 hours of fry stocking time from volunteers. Connecticut Department of Environmental Protection (CTDEP) logged 850 hours of volunteer time in fry stocking. The U.S. Forest Service (USFS) utilized 400 volunteer hours for fry stocking.

Kelt Releases. Fourteen post-spawned sea-run Atlantic salmon were returned to the river in 1999. Ten 1998 kelts from the RCNSS were released at the Chicopee boat launch below the Holyoke dam in January. The salmon were PIT tagged, adipose clipped, and floy tagged (blue). One of these fish retained a radio-tag from the Deerfield passage study. Three 1999 kelts were released at the same site in December. These salmon were PIT tagged and floy tagged (yellow). An additional male salmon was released in East Haddam on the Salmon River in December. This salmon was PIT tagged, and triple floy tagged (yellow).

2.1.1.d Juvenile Population Status

Smolt Monitoring

Northeast Utilities Service Company (NUSCO), the Silvio O. Conte National Fish and Wildlife Refuge (SOCNFWR), and the Sunderland Office of Fisheries Assistance (SOFA) contracted with Greenfield Community College (GCC) to conduct a mark-recapture smolt population estimate in 1999. This was the seventh consecutive year that a study has been conducted by marking smolts at the Cabot Station bypass facility and recapturing them at the bypass facility in the Holyoke Canal. The estimated number of smolts migrating past Holyoke was 60,700 (+/- 14,100) smolts. This estimate is similar to last year's estimate.

Based on expanded electrofishing data from index stations and assumed overwinter mortality, it was estimated that 340,300 smolts were produced in tributaries basin wide in 1999, of which 244,900 were produced above Holyoke. Actual overwinter mortality is unknown and the estimate does not include smolt mortality during migration. Differences between the two smolt estimates reflect potential errors in each of the estimates and mortality of smolts between tributary of origin and Holyoke. Most smolts have to travel long distances and pass multiple dams before reaching Holyoke. River flows during much of the smolt migration were very low which likely increased mortality. Recent research in Connecticut River tributaries and Maine suggests that overwinter survival may be lower than assumed in the electrofishing estimate.

Index Station Electrofishing Surveys

Juvenile salmon populations were assessed by electrofishing in late summer and fall at 186 index stations throughout the watershed. Sampling was conducted by CTDEP, Massachusetts Division of Fish and Wildlife (MAFW), NHFG, USFS, USFWS, and VTFW. Data are used to evaluate fry stocking, estimate survival rates, and estimate smolt production. Densities of juvenile salmon vary widely throughout the watershed. Generally, growth and survival of fry stocked in 1999 was lower than normal. Yearling parr density and growth was near normal in most tributary systems. The smolt estimate for 2000 obtained by expanding electrofishing data and assuming overwinter survival is 295,600. This estimate is 13% lower than last year's record high. Smolt production estimates for 2000 are substantially lower in tributaries below Holyoke than in 1999. Most smolts are expected to be two year olds, with some yearlings and three year olds.
PG&E Generating Company/Normandeau Associates, Inc. continued to study the need for upstream passage on the Deerfield River. Twenty sea-run salmon were radio-tagged and released above the Holyoke dam in May 1999. Nine of the salmon reached the base of the #2 dam, which is the lowermost dam on the Deerfield River. Fishway construction will be triggered next year if four salmon are documented at the base of that dam.

Low summer flows necessitate repeating the downstream smolt passage study on the Sugar River at the Lower Village project despite relatively good passage results in 1999.

Downstream passage was constructed on the Lower Robertson dam on the Ashuelot River in 1999.

2.1.1.f Genetics

The U.S. Geological Survey - Biological Resources Division, through the Conte Anadromous Fish Research Center (USGS-CAFRC), again sampled tissue from all sea-run broodstock for genetic monitoring (microsatellite analysis). The work was conducted in cooperation with the National Fish Health Research Lab-Leetown (USGS-NFHRC-L).

All of the sea runs were PIT tagged to ensure individual identification at spawning. Spawning was managed utilizing a breeding protocol developed last year to prevent pairings of closely related fish. It was also utilized to establish a known family mark for progeny. Similarly marked families from last year's egg take were batched and stocked in the Farmington River (445,441 fry) and the West River (357,041 fry) in order to assess family survivability in various streams and develop a technique to assess and identify productive tributaries through tissue sampling of smolts and returning adults.

The population of spawning sea-run salmon did not meet the minimum requirement for 50 pairs of parents. Although over 100 salmon were spawned, the sex ratio of sea runs was heavily skewed in favor of females at the RCNSS. This predominance of females has been typical in runs dominated by fry-stocked salmon and it is unknown why the population at the WSS had an even sex ratio this year. The use of mature parr collected in Massachusetts' streams helped maintain a 1:1 spawning ratio at the RCNSS.

The 1:1 spawning ratio was observed for all domestic broodstock spawned at the WRNFH, KSSH, and RRSFH.

The Genetics Subcommittee continued to plan for the expansion of the Genetics Marking Project into the domestic broodstock reared at WRNFH. Future broodstock were segregated by families into separate tanks and a complicated mating scheme is under development for use for the first time in the fall of 2000. This initiative will allow the program to genetically mark the majority of all fry (both sea run and domestic). This will facilitate comprehensive evaluation and monitoring of both the fry stocking program and adult returns.

2.1.1.g General Program Information

Mr. Ernie Beckwith, CTDEP, was replaced on the Connecticut River Atlantic Salmon Commission by Mr. James C. Moulton. Mr. Moulton passed away on December 22, 1999. This position along with the MAFW Public Commissioner is currently vacant.

The Action Plan for implementing the revised *Strategic Plan for the Restoration of Atlantic Salmon to the Connecticut River* was completed and approved in November 1999.

The Connecticut River Atlantic Salmon Commission (CRASC) Technical Committee established a new Fish Culture Subcommittee to address issues pertaining to production and fish health. The Subcommittee also serves to improve communication among fish culturists within and outside the Connecticut River basin.

The CRASC hosted a scientific forum to bring fisheries managers, fish culturists, researchers, administrators and academics together to hear and discuss research and activities pertaining to the restoration of salmon and shad in the Connecticut River basin. A total of 13 speakers and 87 participants attended the meeting.

The U.S. Army Corps of Engineers (USACE) has initiated a process to revise Environmental Assessments for the operation and maintenance of Corps owned flood control project in the basin. This is potentially significant in that most of the original EAs were written in the mid-1970s with no regard for Atlantic salmon. CRASC hopes to realize significant improvements to fish passage, flows, and salmon habitat affected by Corps dams as a result of the process.

Two chemical spills occurred in June of 1999. There was a chlorine spill from a town swimming pool in the Third Branch of the White River, VT, which killed juvenile salmon and resident fish. Latex from a derailed railroad tanker spilled into the Deerfield River, MA, without apparent negative impact. A sulfuric acid spill in September killed tens of thousands of fish in the North River, MA, with the total fish loss (including age-0 and age-1+ Atlantic salmon) valued by the MAFW at over $114,000.

The Connecticut River Joint Commissions is working with PG&E Generating (formerly New England Power and USGen), CRASC member agencies and others to update displays at fishway visitor centers in MA, NH, and VT. Meetings have already addressed revisions necessary at the Vernon, Bellows, Wilder, and Moore Visitor Centers on the mainstem Connecticut River. Many of the proposed changes will improve the exhibits and messages pertaining to migratory fish and salmon restoration. The updates will be phased in beginning with the fishway at the Wilder Dam.

The Connecticut River Salmon Association in Connecticut and the Deerfield/Millers River Chapter of Trout Unlimited together expanded their *Fish Friends* and *Atlantic Salmon Egg Rearing Programs* to 53 schools, and over 1,500 students in the watershed in 1999 with plans to expand the program in 2000. The CRASC supplies the eggs for classroom incubation, the member agencies provide technical support and facility tours, and the groups train the teachers, equip the classrooms, and stand by to help and to teach, as needed. This is an accomplishment that the CRASC and its member agencies could never manage without the generous support of these and other partners.

The USFWS signed a unique agreement with Hampshire College/Western Massachusetts Center for Sustainable Aquaculture to re-open the Berkshire NFH. The Center will operate and maintain the hatchery for educational purposes that potentially include assistance in production, stocking, and fishery management for the migratory fish restoration program. The CRASC provided the Center with 20 excess broodstock for display in time for the October Grand Re-Opening.

2.1.2. MAINE PROGRAM

2.1.2.a. Adult Returns

Adult Atlantic salmon counts were obtained at fishway trapping facilities on the Aroostook, St. Croix, Narraguagus, Penobscot, Androscoggin, and Saco rivers. Redd counts in November were also used to monitor and/or estimate adult returns to various Maine rivers.

Returns of adult spawners remained critically low in 1999 as evidenced by low documented adult returns and extremely low redd counts. A continuing trend of recruitment failures in some rivers poses a risk of extirpation of some Maine Atlantic salmon populations.

Rivers With Native Atlantic Salmon Runs

Dennys River. Anglers fishing the Dennys River reported catching and releasing three salmon in 1999; the age and origin of these fish is unknown. A total of 23 redds was counted in the Dennys River in the fall of 1999, a 28% decrease from the 32 redds counted the previous year. Captive broodstock (81 in December 1999 and 9 in January 2000) were again stocked into the Dennys River from Craig Brook National Fish Hatchery (CBNFH) in the fall, although those fish were stocked after redd counts had been made. Installation of the new, A-frame Dennys River weir was completed in late October; this facility will be operated on a daily basis beginning in the spring of 2000 in an effort to monitor adult returns and to remove aquaculture escapees.

East Machias River. There was no reported rod catch in the East Machias River in 1999. The number of redds counted in 1999 decreased by nearly 68% from the previous year (24 vs. 74). No captive broodstock were released into the East Machias River in 1999 because of concerns with SSSv, which was detected at very low levels in the broodstock at CBNFH.

Machias River. There was no reported rod catch in the Machias River in 1999. The number of redds counted in 1999 decreased by 38% from the previous year (46 vs.74). As with the East Machias River, no captive broodstock were released because of concerns with SSSv, which was also detected at very low levels in the Machias River broodstock at CBNFH.

Pleasant River. There was no reported rod catch in the Pleasant River in 1999, and no salmon redds were observed in the fall (compared to 2 in 1998 and 1 in 1997). However, due to the dark, tea-colored waters of the Pleasant River it is likely that redds went undetected. Installation of the new, A-frame Pleasant River weir was completed in late October; this facility will be operated on a daily basis beginning in the spring of 2000, in an effort to monitor adult returns and to remove aquaculture escapees.

Narraguagus River. Thirty-two adult salmon were counted at the Cherryfield fishway trapping facility in 1999, an increase of 10 salmon from the previous year. Additionally, three aquaculture escapees (all males) were captured late in the year. The 1999 adult salmon count was 46% below the 5-year (1994-1998) average. Anglers fishing the Narraguagus River were known to have caught and released 8 salmon during 1999, compared to 15 the previous year. A total of 43 redds was counted in the drainage in 1999, a decrease of 32% from the previous year. No captive broodstock were released into the Narraguagus River in 1999 because of concerns with SSSv, which was detected at very low levels in the Narraguagus River broodstock at CBNFH.

Ducktrap River. There was no reported rod catch in the Ducktrap River. The Ducktrap was one of the few Maine rivers that appeared to have increased adult salmon returns in 1999. A total of 29 redds was found in 1999, vs. 9 in the previous year.

Sheepscot River. There was no reported rod catch of Atlantic salmon in the Sheepscot River in 1999; however, there was a significant increase in the number of redds counted (21 vs. 2 the previous year) in November. Fifty (50) excess captive broodstock from CBNFH were released in January 2000.

Other Maine Atlantic Salmon Restoration Rivers

Penobscot River. Atlantic salmon returns to the Penobscot River continued the downward trend that began in the mid-1980s. Total adult returns to the Penobscot River fish trapping facility at the Veazie Dam was 968 salmon, a 20% decrease from 1998. Atlantic salmon returns to the Penobscot River in 1999 declined by 31%, 50% and 59% compared to the 5-year, 10-year, and 20-year averages, respectively. As in the previous year about 50% of the Penobscot salmon run (467 fish) was transported to CBNFH for broodstock purposes in 1999.

1SW returns to the Penobscot River (265) were about the same as in 1998 (269); however, 1SW returns were 11% and 41% below the 5-year and 10-year averages, respectively. MSW returns (703) in 1999 also declined by 25% from the previous year, and were 36% and 53% below the 5-year and 10-year averages, respectively.

Returns of native, wild-origin salmon (a combination of those salmon originating from natural spawning and fry stocked from federal hatcheries) were about 1% higher in 1999 (166 vs. 164), and 12% and 29% lower than the 5-year and 10-year averages, respectively. The composition of native salmon in the Penobscot returns continues to gradually increase, with 17% of the run composed of wild salmon in 1999, compared to 14% in 1998 and 13% and 12% for the 5-year and 10-year averages, respectively

Approximately 200 salmon were estimated to have been caught and released by anglers fishing the Penobscot River in 1999. In December 1999 the Maine Atlantic Salmon Commission promulgated a rule, which closed the entire State of Maine to angling for Atlantic salmon beginning in 2000.

Two redds were found in Cove Brook, a tributary to the lower Penobscot River, in December; high stream flows late in the year hampered efforts to look for salmon redds in other lower Penobscot River tributaries. Additionally, no redd counts were conducted in headwater areas due to the paucity of female salmon (90) released to spawn naturally in the drainage. As in recent years, it was necessary to transport most MSW females captured at Veazie to CBNFH for broodstock purposes.

St. Croix River. A total of 13 native Atlantic salmon was captured at the Milltown Dam fishway during 1999 - 68% fewer than the previous year. All but 2 of the 13 salmon captured were retained for broodstock purposes; one female died of a fungal infection during the summer, and one male was released at the trap because it was injured. The 1999 trap catch consisted of 8 1SW salmon and 5 MSW salmon, compared to 32 1SW and 9 MSW in 1998. The broodstock that were spawned in November at the Mactaquac Hatchery (Fredericton, N.B.) by Department of Fisheries and Oceans personnel, provided 23,590 eggs for future restocking programs in the St. Croix River.

An additional 23 aquaculture escapees (64% of the total trap catch) were captured in the Milltown fishway trap in 1999, compared to 24 aquaculture escapees the previous year. The number of native salmon returns has declined dramatically in recent years (previous 5-year average = 69), while the number of aquaculture escapees has remained relatively constant (5-year average = 36). Declining native salmon returns to the St. Croix may be attributed to the following: 1) recent changes in stocking practices (e.g., fewer Penobscot-origin smolts and 0+ parr from Green Lake NFH (GLNFH) and more fry and 0+ parr of "St. Croix strain" which may be a result of interactions between native and farmed salmon; 2) declining numbers of MSW spawners; 3) unfavorable marine survival conditions for Atlantic salmon stocks in the Gulf of Maine; 4) drought conditions in recent years that may have negatively impacted fish passage (and possibly predation by seals?) through the Milltown fishway; and 5) a 90% reduction in the St. Croix alewife run in recent years. Alewives are a major food source for estuarine predators of salmon smolts, and reduced alewife runs may result in increased predation in the lower river.

Androscoggin River. Five Atlantic salmon (and 1 LLS) were captured at the Brunswick Dam fishway in 1999, compared to one the previous year. The Androscoggin River is not stocked with hatchery-reared salmon; therefore all adult returns originate from natural reproduction and/or strays from other rivers.

Saco River. A total of 66 adult salmon was enumerated at the Cataract Dam fish passage facilities (East channel fish lift and West channel fishway) in 1999. Atlantic salmon returns to the Saco River in 1999 were the highest since 1990, and the 2nd highest in the time series salmon counts on the river, which began in 1985.

Overall, salmon returns increased by 136% from the previous year, and by 85% over the 5-year average. The significant increase in adult salmon returns to the Saco River in 1999 may be attributed primarily to increased stocking efforts during the period 1995-1997. For example, the Saco River Salmon Club stocked 376,000 fry in 1995 (only about one-half as many fry were stocked the previous year), and the USFWS stocked large numbers of 0+ parr in the drainage in both 1996 (45,000) and 1997 (63,300).

Union River. Operation of the trapping facility on the Union River at Ellsworth resulted in the capture of 72 salmon in 1999, compared to 13 salmon in 1998 and 8 in 1997. Unfortunately, the Union River salmon trap was operated by personnel with little training in identifying aquaculture escapees and fish handling techniques; therefore, data pertaining to the salmon captured in 1999 was severely limited. Analyses of the scale samples provided by the trap operator revealed that nearly all (10 of 11 samples, or 91%) of the salmon returns to the Union in 1999 were aquaculture escapees. Excluding the aquaculture escapees, there were 3 1SW and 6 MSW Atlantic salmon returns to the Union River in 1999.

The fact that most adult returns were aquaculture escapees can also be inferred from the large number of fish with deformed fins (dorsal, and paired fins), the seasonal pattern of adult returns (e.g., 22% of the total run was captured on one day and most fish were late-run), and the number of returns per 1,000 fry (or 0+ parr) stocked was exceedingly high (e.g., <2,000 fry required for 1 adult return, compared to 50,000/adult return in other New England rivers). Additionally, the salmon farmer with cages located in lower Union River Bay expressed the opinion that he thought that there was some unexplained attrition in the numbers of fish that he was rearing (note, the cage site(s) involved contain approximately 200,000 salmon). The salmon farmer also reported that in March 1996 (when the Union River experienced another unusually large (69) and unexplained number of salmon returns) he lost 10,000 small salmon (1-2 kg.) and 3,000 large salmon (4-5 kg.) from seal attacks to his cage(s).

Aroostook River. The trap catch of Atlantic salmon at the Tinker Dam (NB) in 1999 was slightly lower than the previous year (25 vs. 30). There were 17 1SW salmon returns and 8 MSW returns in 1999, vs. 14 and 16 in 1998. Returns to the Aroostook River continue to reflect trends observed for the entire Saint John Drainage, which also experienced a slight decrease in salmon returns (5,003 vs. 5,876) compared to the previous year. Since Atlantic salmon returns to the Aroostook River are initially counted in the returns to the Saint John River in Canada (at the Mactaquac Dam), they are not included in the annual totals for U.S. rivers.

2.1.2.b. Hatchery Operations

Broodstock from six Maine rivers produced the following egg takes at CBNFH in November [1998 egg take noted in ()]:

Dennys River	306,000	(443,170)
East Machias River	296,000	(362,985)
Machias River	550,000	(570,750)
Narraguagus River	542,000	(490,020)
Penobscot River	2,419,000	(2,804,085)
Sheepscot River	310,000	(542,820)
	=======	=======
Total	4,423,000	5,213,830

Collections of native (wild) parr in the Downeast rivers of Maine continued in 1999. A total of 854 Atlantic salmon parr was collected from the following rivers: Dennys (150); East Machias (125); Machias (238); Narraguagus (255); Sheepscot (86). These fish will be reared to maturity at CBNFH in order to provide river-specific hatchery stocks for future restocking programs in their rivers of origin.

2.1.2.c. Stocking Programs

Most of the 3.5 million salmon stocked into 10 Maine rivers in 1999 were released as fry that had started feeding prior to release. Atlantic salmon fry releases in selected Maine rivers since 1994 (rounded to nearest 1,000) are shown below; a complete stocking summary for all life stages and all Maine rivers may be found in Table 2.2.1.

Year	**Dennys**	**E. Machias**	**Machias**	**Narraguagus**	**Sheepscot**	**Penobscot**
1994	20,000	0	20,000	0	0	949,000
1995	84,000	0	150,000	105,000	0	617,000
1996	142,000	115,000	233,000	201,000	102,000	1,242,000
1997	192,000	113,000	236,000	196,000	64,000	1,472,000
1998	234,000	191,000	302,000	275,000	267,000	930,000
1999	172,000	210,000	169,000	155,000	302,000	1,500,000

Native Atlantic salmon parr have been collected from the Maine native salmon rivers since 1992. These parr have been raised to sexual maturity at CBNFH, and have been producing eggs for the river-specific program since 1994. The increasing number of adult brood fish, ranging in size from 1.4 to 4.5 kg each, resulted in an increased demand on the water supply at the hatchery. Therefore, as in previous years a portion of these broodstock (81 salmon) was returned to their rivers of origin in 1999. Unfortunately, most of the salmon that would ordinarily be released had to be destroyed as a precautionary measure to prevent the possible (though unlikely) spread of SSSv (see summary to follow). An additional 2,404 captive broodstock (F_2 Penobscot-origin) were released into the Penobscot drainage in 1999.

2.1.2.d. Juvenile Salmon Populations Status

Juvenile salmon population surveys were conducted at over 100 sites throughout the seven Maine drainages with wild salmon runs. Population surveys ranged from qualitative survival estimates throughout the drainages to quantitative population estimates at well-established index sites. Densities of young-of-year and parr (age 1+ and 2+ combined) remain at low levels, except for a few sites that had densities commensurate with long term averages due to the recent river-specific fry stocking program. The low juvenile salmon populations throughout many Maine rivers continues to be a direct result of insufficient spawning escapement in recent years, and sub optimal survival of stocked fry.

Narraguagus River parr population estimates are based upon electrofishing data from up to 45 sites that are sampled annually. The drainage-wide population estimate of age 1+ and older Atlantic salmon parr on the Narraguagus River for 1999 was not available for this meeting. Drainage-wide population estimates (historical data revised and updated in 1999), which have been conducted on the Narraguagus since 1991, are as follows:

1999	unavailable at this time		
1998	25,362	±2,976	(1999 smolt est.= 3,607 ± 345)
1997	27,040	±4,429	(1998 smolt est.= 2,925 ± 274)
1996	11,777	±1,181	(1997 smolt est.= 2,871 ± 539)
1995	12,901	±2,632	
1994	9,568	± 667	
1993	22,701	±6,796	
1992	14,985	±1,824	
1991	16,301	±1,802	

The 1998 parr population estimate, which was the second highest estimate in the time series of data, reflects the significant influence of the river-specific fry stocking program; in 1997 about 209,000 fry were scatter planted throughout the Narraguagus River drainage.

The intensive smolt studies in the Narraguagus River, a joint ASA-NMFS effort, continued in the spring of 1999. Five rotary drum, screw-type traps were used to capture about1, 136 smolts at two sites in the lower river, which produced an estimated smolt run of about 3,000 wild smolts. Ultrasonic pingers were surgically implanted into 112 wild smolts and 22 hatchery smolts, and median travel times and survival through the lower Narraguagus River and Bay were estimated. Data from juvenile salmon tagged with ultrasonic tags is still being analyzed, and detailed results from these studies may be found in other sections of this report. The third year of smolt estimates supports the previous findings that overwinter survival was <30% (probability 90%) lower than observed in other studies and likely impacting this population.

2.1.2.e. Fish Passage

Three obstructions to fish passage were removed in Maine during 1999. On the Kennebec River, the Edwards Dam was removed in July, providing all anadromous species of fish permanent access to 17 miles of riverine habitat for the first time in more than 150 years. Additionally, two (breached) dams were completely removed in the Penobscot River drainage, the FlourMill Dam on Souadabscook Stream and the Brownville Dam on the Pleasant River.

2.1.2.f. Genetics Collections and Broodstock Evaluation

Beginning in 1999 all broodstock at CBNFH were tagged with a PIT tag, and tissue samples were collected for genetic characterization. This activity will allow for the establishment of genetically marked families, which can be tracked through a non-lethal fin sample at various life stages. This type of marking, because it does not involve genetic manipulation or alteration, does not require US Food and Drug Administration or other agency approval, as is required with other non-lethal marks such as the calcein or bovine serum. The need to assess the contribution of fry stocking to the population of Atlantic salmon in Maine continues to be a high priority of this program.

During March and April 1999 all broodstock (2,116 salmon) at CBNFH were genetically sampled. This was done in order to allow for better management of the broodstock populations and to cull salmon with undesirable genetic material (e.g., any fish with evidence of European alleles). These samples were sent to the USGS-NFHRC-L for analysis prior to spawning in 1999.

All incoming river-specific parr broodstock were also genetically sampled and PIT tagged in 1999. Parr were tagged and sampled in the field to allow for identification of individual fish from each collection site. These samples are currently being archived at the Maine Fisheries Coordinators office.

Penobscot River broodstock (570) were genetically sampled at the Veazie fishway trap and/or during spawning operations in 1999. These samples were collected as part of the on-going genetic characterization studies that began in Maine in 1990, and also to initiate a genetic marking program for future releases of hatchery-reared salmon in the Penobscot River drainage.

In addition to Atlantic salmon broodstock sampling activities, several other genetic samples were collected in 1999. Samples of landlocked salmon (50 each) were collected from the Maine Department of Inland Fisheries and Wildlife's Casco and Grand Lake hatcheries. Tissue samples were also collected from brown trout in Bond Brook, a tributary to the lower Kennebec River. Additional samples were also collected from Cove Brook, Eaton Brook, Felts Brook, and Kenduskeag Stream, all tributaries to lower Penobscot River. Additional samples from the Ducktrap River were also collected.

Tissue samples for genetic characterization studies were also collected from emigrating smolts from the Pleasant River (354) and Narraguagus River (18) during April and May at smolt trapping facilities on those rivers. An additional 714 wild parr were captured, PIT tagged, tissue sampled and released in the Pleasant River during BGEST sampling.

Forty-seven parr, which are suspected of being escapees from a private hatchery on the Pleasant River, were also collected and those tissue samples were sent to the NBS Lab in Leetown for genetic analysis. Similarly, tissue samples from 28 parr were collected below a private hatchery on the East Machias River in October.

2.1.2.g. General Program Information

SSSv in Maine Atlantic salmon Stocks

In 1998, NANFH reported the presence of tumors in the swim bladders of the Pleasant River captive parr broodstock they were maintaining. Approximately one-third of the fish had died. Currently, the cause of these mortalities and tumors is believed by researchers at Cornell University to be a retrovirus and has been named Salmon Swimbladder Sarcoma Virus (SSSv). Plans to collect more broodstock from the Pleasant River have been postponed indefinitely pending further research concerning this virus.

To date, no clinical signs of the SSSv have been observed at the CBNFH. Blood samples taken from broodstock in March 1999 showed positive results in only 7 out of the 510 fish sampled using PCR (Polymerase Chain Reaction) sequencing. These fish, from three Maine salmon stocks (East Machias, Machias and Narraguagus), were removed from the spawning population.

Additional samples taken in September 1999, and 11 of 1,088 fish sampled tested positive for the virus. Two of these were from the Penobscot sea-run broodstock, while the others were from the Machias (2), Narraguagus (5) and Sheepscot (2). Broodstock that were positive for SSSv, and could be identified by PIT tag number, were removed from the spawning population in 1999.

Data to date from extensive testing at CBNFH does not support great concern for virulence, high transmissibility, or clinical disease under conditions at the facility. However, due to the complicated and elusive nature of the virus, research into the transmission and route of infection is needed, as well as determining the pathogenesis of the virus.

Pathogen and disease surveys

In addition to the broodstock and genetic protocols created for the CBNFH, all personnel follow the standard USFWS Fish Health Protocols and the New England Salmonid Fish Health Guidelines. The Lamar Fish Health Unit is ensuring adherence to these protocols through periodic updates to current policies. Current sampling includes tests for viral and bacterial infections, and, in addition to Service standards, follows guidelines established by the NASCO, New England Fish Health Committee, and the State of Maine.

Fish brought on to the hatchery for broodstock purposes are isolated pending the annual fish health inspection. Additionally, ovarian fluid is taken from all female salmon during spawning activities and analyzed for vertically transmittable diseases.

The Lamar Fish Health Unit wrote a complete update on Maine fish health sampling techniques and results entitled "Downeast Fish Health Surveillance History" in 1999.

Reconstruction of Craig Brook NFH

The CBNFH became a more integral part of the USFWS recovery efforts for Atlantic salmon in Maine in 1991, when the station was reprogrammed from a single-stock (Penobscot River) Atlantic salmon broodstock and smolt production facility to a multiple (river-specific) broodstock and fry production facility.

The CBNFH began a major construction project to accomplish this program change. The construction was split in two phases. Phase I, which began in the summer of 1998, consists of the replacement of both water supply pipelines (from Alamoosook Lake and Craig Pond), plus a new shallow water intake and the creation of deep-water intake in Craig Pond. Additionally, a new broodstock and production building will be constructed, consisting of six broodstock holding bays, six incubation and fry rearing units, office space for hatchery personnel, a workshop, feed storage facilities, a library, a conference room and a visitor center. Phase I of the construction program is expected to be completed by June 2000.

In December 1999, the Phase II construction program began. This part of the CBNFH reconstruction project will provide additional offices and administrative space, plus an incubation and fry-rearing unit for the Penobscot River Atlantic salmon restoration program.

Creation of the Atlantic Salmon Commission

In June 1999, the Maine legislature passed legislation abolishing the Atlantic Salmon Authority, which had been in existence since September 1995, and establishing a new, 3-member Atlantic Salmon Commission. The Commission consists of the Commissioners of Inland Fisheries and Wildlife and Marine Resources, and a Public Member appointed by the Governor. The headquarters for the Salmon Commission is located in Augusta, Maine, and day-to-day operations of the agency will be the responsibility of a newly created position of Executive Director. The legislation also added additional staff to the Commission (2 on July 1, 1999 and one on July 1, 2000), and transferred responsibility for the Maine Atlantic Salmon Conservation Plan from the Land and Water Resources Council to the Atlantic Salmon Commission.

Maine Listing Status Update (presented by Mary Colligan, recorded by Dan Kircheis)

In 1997 the USFWS and National Marine Fisheries Service (NMFS) withdrew their initial proposal to list the Atlantic salmon under the Endangered Species Act based primarily on the implementation of the Maine State Conservation Plan, international regulation of harvest and evidence of improvement within current stocks. A law suit was subsequently filed by Trout Unlimited, the Atlantic Salmon Federation and ten other groups challenging the 1997 decision and requesting emergency listing.

In 1999, the Services received and reviewed the first Conservation Plan accomplishment report from the State. The draft Status Review was also updated confirming that a distinct population segment existed for eight river populations from the Kennebec River in the south to but not including the St. Croix River in the north. Atlantic salmon populations within that DPS include the seven rivers previously proposed for listing and Cove Brook. The Status Review established five listing factors:

- Current condition of existing freshwater habitat
- The impact of commercial, recreational and research utilization
- Disease and predation on current populations
    - Seals
    - Striped bass
    - ISA and SSSv
- Inadequacies of regulatory mechanisms
    - Water withdrawals
    - Aquaculture practices
- Other natural or man-made factors that threaten the existence of current populations

The July 1999 Status Review determined that current salmon populations are endangered and the Services proposed the Gulf of Maine DPS for listing.

In November 1999, it was officially announced that the salmon would be considered for listing. A public comment period was opened and is scheduled to end on March 15. Within the public comment period, public hearings were held in Machias, Ellsworth and Rockland Maine. The attendance far exceeded the anticipated turnout.

An estimated 75% of the speakers were opposed to a listing. Most of the opposition was focused on concerns of uncertainty and failure to provide enough time for the state to implement the plan. The support for the listing focused on strong data supporting the need for a listing, and criticism of Maine's implementation of and funding for the Conservation Plan.

In February 1999, Maine filed suit against the Services on the basis that the Services failed to comply with Freedom of Information Act Requests. Through this process, Maine is requesting an extension of the comment period.

The Services must determine if the species will be listed by November 17, 2000 though a six-month extension is possible. The Services' intention, if salmon are listed is to build a recovery plan based on the state conservation plan with some modifications.

State agencies or the Services are usually responsible for drafting recovery plans. The hope is to develop the plan cooperatively with all parties who may be impacted by the listing, including the agencies and industry.

The process will continue through November based on legal requirements. In the mean time, a federal judge can order an emergency listing at any time. This would trigger a 240 day listing during which the listing process would be implemented.

2.1.3. MERRIMACK RIVER

2.1.3.a. Adult Returns

A total of 185 Atlantic salmon returned to the Merrimack River in 1999. This represented an increase of 62 fish compared to the total number that returned in 1998. In addition, six domestic broodstock were captured at the dam and transported to the Nashua National Fish Hatchery (NNFH). These fish were identified as broodstock through scale analyses. Also included within the total were five adults captured immediately downstream from the Essex Dam by electrofishing.

Interestingly, only one fish was captured at the Essex Dam fishlift during the fall on 27 September. However, in fall 1998, 33 fish were captured at the fishlift.

The returns are categorized as follows:

Fry Stocking Origin Adults

Grilse	2SW	3SW	RS
9	64	0	0

Parr Stocking Origin Adults

Grilse	2SW	3SW	RS
0	0	0	0

Smolt Stocking Origin Adults

Grilse	2SW	3SW	RS
46	65	1	0

The virgin multi-sea-winter component (70% of river returns - 129 fish) was comprised of 27% males (34 fish) and 73% females (94 fish).

The rate of return (adults produced per 1,000 juveniles stocked) for fry-origin adults continued to be quite low for the eighth consecutive cohort. The current rate of return for the 1995 fry cohort was 0.0290, an increase of 35% above the rate for the 1994 fry cohort. Fry-origin age classes 2.3, 3.2, and 3.3 have not yet returned. When fish return from these age classes the reported rate of return will be revised.

The rate of return (adults produced per 1,000 juveniles stocked) for smolt-origin adults increased for the fifth consecutive cohort. The rate for the 1997 cohort (age 1.3 not yet counted) was 1.31, an increase of 19% above the rate for the 1996 cohort.

2.1.3.b. Hatchery Operations

The majority of the Atlantic salmon fry produced for release in the watershed were provided by the NANFH and the WSFH and were primarily of domestic broodstock parentage. A few fed fry were produced by the NNFH. Smolts produced for stocking purposes in 1999 were provided by the GLNFH and were of Penobscot River sea-run parentage.

Egg Collection

Sea-Run Broodstock

Eighty-eight females were captured at, or immediately downstream from the Essex Dam fishlift and transported to the NNFH, where 88 produced 736,572 eggs. The majority of the eggs were transported to the NANFH to be hatched and released as fry. Some eggs, approximately 1.2 %, were retained at the NNFH for broodstock development.

Thirty pre-spawners were marked with Floy tags and released into the Baker River watershed to evaluate the potential for spawning and natural reproduction of fry. Eight of theses fish were also tagged with radio transmitters.

Captive/Domestic Broodstock

A total of 520 (452 age 3^+ and 68 age 2^+) female broodstock reared at the NNFH provided an estimated 2,658,755 eggs. Eggs were transported to the Powder Mill SFH, and the NANFH (99%) to be held for fry stocking within the Merrimack River basin. Approximately 500,000 of the eggs transported to the NANFH are being incubated for the Pawcatuck River salmon restoration program.

2.1.3.c. Stocking

Approximately 1.76 million juvenile Atlantic salmon were released in the Merrimack River basin during the period, April - June of 1999. The release included approximately 1.73 million unfed fry, 28,211 fed fry, 6,740 1^+ parr, and 56,407 yearling smolts. Although the majority of the smolts were not marked or tagged, it is possible to determine the origin of adult returns by analyzing the pattern or signature on the scales of fish. Scale analyses are therefore used to differentiate between fish stocked as fry or smolts.

All major tributaries upstream from the Nashua River in NH, excluding the Soucook and Winnipesaukee rivers, were stocked with fry. Numerous small tributaries to the Merrimack River and its principal tributary system, the Pemigewasset River watershed, also were stocked.

The majority of smolts were released into the mainstem of the Merrimack River a short distance downstream from the Essex Dam in Lawrence, MA. Approximately 500 smolts were released in the mainstem of the river in New Hampshire as part of studies to test the effectiveness of downstream fish passage facilities at hydroelectric sites.

2.1.3.d. Juvenile Population Status

Yearling Fry / Parr Assessment

Parr were collected at 26 sites in 18 rivers, streams or brooks throughout the basin in 1999. A stratified sampling scheme was used to determine the abundance of parr. Parr estimates were determined for the basin, regions and geostrata. Habitat was stratified into four regions, where each region has different characteristics that included climate, geography, geology, hydrology, and land use. Estimates derived for geostrata involved sampling within regions in very large rivers [drainage area (da) > 200,000 ha, in large river (40,289 da 200,000 ha), and small rivers and brooks where da < 40,500 ha]. Sampling was directed at yearling and parr (age 1^+) and involved electrofishing during late summer and early fall. Data collection involved a cooperative effort and included staff from the NHFG, USFS, USFWS, and volunteers.

The 26 sample sites included a total of 80 units (one unit = 100 m^2) of juvenile habitat. The estimated number of available habitat units in the basin is 65,742 and of the total units available, approximately 50,947 were stocked with fry in 1998. Units sampled represent about 0.57% of the total available and 0.74% of those stocked with fry.

Natural reproduction of Atlantic salmon is not known to occur in the Merrimack River basin. In recent years, sexually mature broodstock salmon have been released in headwater areas, but due to low numbers released, their contribution to the production of fry is assumed to be minimal. In 1998 broodstock released in the Baker River constructed approximately 28 redds. In spring 1999, inspections revealed that fry were present in two redds. These fry will be represented in the estimates of yearling parr in fall 2000.

Results of assessments in 1999 generally show a below average abundance of yearling parr at seven key index rivers located throughout the watershed. A time series of estimated parr abundance is available for the East Branch Pemigewasset, Pemigewasset, Mad, Baker, Smith, South Branch Piscataquog, and Souhegan rivers. In recent years the stocking density of fry has been increased two fold in these rivers to maximize production of smolts. Low stocking densities had previously ranged from 18 fry/unit to 48 fry/unit, but in recent years the numbers have ranged from 36 fry/unit to 96 fry/unit. The results of evaluations of yearling parr abundance at these and other sites in the watershed suggest that the recent high stocking densities may be resulting in density dependent factors that adversely affect the growth and survival of parr. Given the result of these evaluations, fry stocking densities in the noted index rivers in 1999 was reduced to the previous low levels.

The average number of parr per unit during years of high fry stocking densities ranged from a low of 1.0 parr/unit to a high of 5.7 parr/unit. However, yearling parr/unit at sample sites in index rivers ranged from a low of 0.3 to a high of 4.7 in 1999.

The total number of fry released in the watershed increased in 1998 and the number approached 2.58 million. In years 1994 and 1995 the number of fry released in the watershed was approximately 2.82 million fry. The number released 1999 was about 1.76 million and it is expected that total releases in the watershed in future years will not exceed 1.7 million fry. The majority of fry are released within watershed Region 1, 2 and 4. The headwaters of the watershed are located within Region 1, which is forested with rugged terrain and high peaks. This region represents approximately 32 % of the habitat stocked with fry. Region 2 is forested, interspersed with agricultural lands, large lakes and less mountainous terrain and represents 42% of the total juvenile rearing habitat in the watershed. Region 3 is agricultural with broad valleys and moderately rolling hills and represents 2 % of the habitat stocked in the watershed. Region 4 contains about 17 % of the habitat stocked and is an area interspersed with ponds, wetlands, and sluggish streams with widespread agricultural and developed lands.

Results of assessments for 1999 generally indicate that parr abundance at index rivers in each region is below the average for high density stocking years. In particular, yearling parr abundance in Region 4 is considerably lower in the Souhegan River (0.3 parr/unit) than that observed in the river in 1998 (11.7 parr/unit). This is clearly attributable to a loss in a year class within that river. Under-yearling abundance in 1998 in the Souhegan River was extremely poor likely due to low summer water levels.

2.1.3.e. Fish Passage

Downstream Fish Passage

PSNH continued to conduct downstream fish passage studies using hatchery reared Atlantic salmon smolts at the Garvins Fall Dam. The studies were directed at assessing the fish bypass and smolt sampler constructed at the Ayers Island project, documenting downstream movement of parr in fall at this project, and assessing the effectiveness of the louver weir in the power canal of the Garvins Fall hydroelectric project.

Results previously obtained at Ayers Island Dam showed success in capturing fall parr in the sampler. It was previously not know whether parr moved or migrated in rivers in the watershed in fall. Additional work will be carried out in 2000 to determine the timing of migration of wild smolts. Fishery agencies and PSNH are further developing plans for future fall and spring operation of the sampler at Ayers Island Dam.

The results at the Garvins Falls hydroelectric project were inconclusive and additional studies are planned for 2000. A smolt bypass with capture capability was constructed in late 1998 and was tested in 1999. Preliminary results suggest that domestic broodstock released for sport angling opportunities may be congregating in the weir and adversely affecting the downstream movement of smolts. Measures will be implemented in spring 2000 to exclude or purge broodstock from the louver weir using an electric barrier.

Upstream Fish Passage

Upstream fish passage problems associated with the Lowell fish passage complex have continued to occur. Fishery agencies and Consolidated Hydro, Inc., owner / operator of the Lowell hydroelectric facility are attempting to resolve fish passage issues. The matter may be referred to FERC for resolution in 2000.

Impacts of River Obstructions

Approximately 60% of the juvenile production habitat in the Merrimack River watershed is located in the headwaters of the basin in the Pemigewasset River watershed. Migrating smolts from this region encounter seven hydroelectric facilities and one earthen flood control dam. The tributaries throughout the watershed also have numerous obstructions impeding the migration of fish with greater than 100 dams located in these smaller watersheds. The number of smolts that successfully exit the watershed is based in large part on the survival of fish as they pass successive dams. Studies and evaluations of fish passage efficiency and effectiveness at most mainstem and a number of tributary dams is ongoing, and these studies have demonstrated that smolt mortality occurs at dams and that seaward migration is impeded or delayed at dams. Water regimes during the period of seaward migration are also altered due to the presence of dams that can delay migration and reduce smolt survival. All returning adult salmon are currently captured at the first dam upstream from tidewater, and the construction of upstream fish passage facilities at dams to provide fish access to upriver spawning habitat is not likely in the near term. The number of adult returns has been low, and target levels have not been reached to trigger the need for upstream fish passage facilities. Considerable work is required at both main stem and tributary dams to improve the effectiveness and efficiency of downstream fish passage facilities. Fishery resource agencies will continue to consult and coordinate with hydroelectric facility owner/operators to improve downstream passage and survival of salmon.

2.1.3.f. Genetics

No work except the maintenance of existing Atlantic salmon spawning protocols was conducted in this area in 1999.

2.1.3.g. General Program Information

Domestic Atlantic Salmon Broodstock Releases. In the spring and fall of 1999, 3,275 surplus broodstock at the NNFH were released to provide angling opportunities in the mainstem of the Merrimack River and a small reach of the Pemigewasset River. The spring releases included both age 3^+ and 4^+ fish. Approximately 90% of the age 3^+ fish were non-spawners, and all of the age 4^+ fish had been held and reconditioned in the hatchery prior to release in spring. A total of 401 age 3^+ fish were released in November and all were non-spawners.

Pre-spawner Releases / Natural Reproduction Study

Sea-run Atlantic salmon were released into the Baker River in 1999 to evaluate the potential for spawning and natural production of fry within the watershed. The Baker River is a major tributary of the Pemigewasset River. The Pemigewasset River and Winnipesaukee River form the headwaters of the Merrimack River watershed. On 13 October thirty sea-run and one domestic broodstock salmon were released at two locations in the Baker River. Seven sea-run female and the one domestic female were equipped with externally mounted radio transmitters to monitor their behavior and movement.

All radio tagged sea-run fish displayed distinct downstream movement within a short period following release in 1999. The seven radio-tagged sea-run fish moved out of the Baker River system and down the Pemigewasset River. They were located at Ayers Island Dam (the first downstream dam) within four days following their release, a distance of 53.7 to 61.9 river kilometers. Of the four fish that passed Ayers Island Dam two fish also passed other downstream hydroelectric facilities. Another of the seven tagged fish located at Ayers Island Dam swam upstream to Livermore Falls, a distance of 29.4 river kilometers. The remaining two radio tagged fish were never located again.

The radio tagged domestic fish held position over spawning gravel near the release site for about one month. Shore based site inspection did not reveal redd construction in proximity to that location. In addition, canoe reconnaissance two weeks after the release of fish did not reveal redds or fish near suitable spawning habitat in the Baker River with the exception of the one radio tagged domestic broodstock.

Current findings suggest that sea-run fish become widely distributed in the watershed perhaps seeking out their natal river. Once fish pass over Ayers Island Dam or other downstream dams they are unable to move upstream and access upriver spawning habitat. Future management strategies should involve releases of sea-run fish at earlier times in the season to provide fish a longer period.
of in-river acclimatization, and releases of sea-run fish at lower river sites to better understand the importance of site fidelity to natural reproduction.

Atlantic Salmon Domestic Broodstock Sport Fishery

The NHFG via a permit system manages the Atlantic salmon broodstock fishery. Angled Atlantic salmon that are retained must be tagged. Creel limits are; one fish per day, five fish per season with a minimum length of 15 inches. The open season for salmon is April 1 through September 30. The river is divided into two management areas: (1) a fly fishing only section, and (2) a single hook artificial lure or fly section.

In the early winter of 1998 and the spring of 1999, 3,232 surplus broodstock were released for the sport fishery. The winter release included 358, age 3+ and age 4+, fish that were spawned prior to release. The early spring release included 2,874 reconditioned, age 3^+ and age 4^+, fish that had spawned the previous fall.

The results of the 1999 sport fishery are presented in Table 2.1.3.g. (1993 - 1998 results are included for comparison). A total of 1,698 salmon permits were sold in 1999, of this number, 1,182 anglers reported they had participated in the Atlantic salmon broodstock fishery. The majority of the anglers were NH residents, 10% were nonresidents. Anglers fished an estimated 21,276 hours during 8,274 fishing trips. They caught an estimated 2,707 fish, releases 2,104, and kept 603 salmon. Catch per unit effort was .127 salmon per hour (anglers fished about 8 hours before catching a salmon). The 1,182 anglers spent an average of $184.00 during the season for an estimated total expenditure of $217,488.

The total number of permits sold in 1999 decreased .013% from the 1998 season and was below the six year mean. However, total effort remained nearly the same as in 1998, and the total angler trips and sport catches increased substantially. This indicates that those anglers who participated in the fishery were more successful in catching salmon than in previous years. The catch per unit effort (0.127 salmon per hour) is the highest recorded for the fishery since the inception of the program in 1993.

Education / Outreach

Adopt-A-Salmon Family

Adopt-A-Salmon Family (AASF) concluded its sixth highly successful year in June 1999. Membership in the program was held at about one hundred schools. While demand for inclusion in AASF by additional schools continues, the program coordinator feels that increasing the number of schools beyond the present complement, without additional funding and personnel to support program expansion, would result in a diminution in the level of support the USFWS would be able to provide to existing participants. Admission of additional schools to the program is now contingent upon others dropping out. The drop-out rate for AASF is low, not surprising give the program's popularity.

AASF continues to draw high profile positive attention to the USFWS's effort to restore anadromous fish species to New England rivers. *New Hampshire Crossroads*, a very popular public television news magazine, profiled the AASF program in its May broadcast. The six minute story - a lot of time for a television news story - chronicled the year long AASF experience of a class of fifth grade students at a school in Derry, New Hampshire. The story was re-aired a number of times. The AASF coordinator lost track of the number of people, from both Massachusetts and New Hampshire - who viewed the story. Great free advertising for the USFWS!

The AASF coordinator continued to work collaboratively with the Nashua River Watershed Association to conduct an Earth Stewards conservation education program at the Broad Street

Elementary School in Nashua, New Hampshire. Fifth and sixth grade students participate in this two year program, learning about a host of watershed-related issues through hands-on experiences with Atlantic salmon fry and parr. Earth Stewards is a national Service outreach program in which individual field stations partner with local natural resource organizations to develop unique conservation education programs, focusing on locally-relevant natural resource issues, for neighborhood schools.

During the 1999/2000 school year the AASF coordinator worked on new AASF curriculum materials for students in the early elementary grades. The existing curriculum materials were developed for upper elementary and middle schools students. As more and more early elementary educators have taken on the AASF program in recent years, the need for new age-appropriate materials has become apparent.

Several schools within the Merrimack River basin are raising Atlantic salmon parr in the classroom during the 1999/2000 school year. This activity is a departure from the traditional AASF program, where salmon eggs are hatched in a classroom incubator and the resulting fry released into a stream in the spring. Because parr are released into the main stem of the Merrimack River, participating students are typically exposed to a very urban landscape bordering the river; they witness a much different land use pattern than when they released salmon fry into a remote tributary. Such exposure has great educational value as the students consider the impacts of human culture on watershed health.

Amoskeag Partnership

The anadromous fish program continued to be represented in the Amoskeag Partnership. The partners (PSNH, NHFG, the Audubon Society of NH, and the USFWS) continued to create and implement a broad-based educational outreach program, based at the Amoskeag Fishways facility in Manchester, NH. With the Merrimack River as a general focus, the partnership is offering educational outreach programming to school groups, teachers, the general public, and other targeted audiences.

The partnership was modified in 1998 where the NHFG and the USFWS were given a role in the decision making process at the management committee level. The two agencies now participate as active members of the management committee.

Anadromous Fish Program Evaluation

The anadromous fish program was scrutinized by both the Technical and Policy Committees during 1999. The evaluation centered on Atlantic salmon activities and the low rate of return for adult salmon of fry stocking origin. General conclusions drawn were that fry stocking densities may be too high, and lower river predation on smolts by striped bass may be significant. These two in-river factors were identified as potentially affecting the rate of return for adult salmon of fry stocking origin. While the aspect of striped bass predation on smolts is difficult to address with respect to the implementation of corrective management actions, actions that include evaluation components are now being implemented relative to the number of fry released in habitat throughout the watershed. The total number of fry released has been reduced from a high of approximately 3.0 million to about 1.7 million fry.

2.1.4. PAWCATUCK RIVER

2.1.4.a. Adult Returns

Eleven salmon were captured at the Potter Hill Fishway on the Pawcatuck River from May through July of 1999 (nine adult females, one adult male, and one male grilse). By scale analysis, it was determined that four adult females had spent two years at sea after migrating as a two year smolts and were stocked as fry. All six remaining adults and the single grilse were stocked as age 1 (adipose fin-clipped) hatchery smolts. The six adults had spent two years at sea.

2.1.4.b. Hatchery Operations

Fish Cultural Changes

Some changes were implemented at the Arcadia Research Hatchery (ARH). An air compressor was incorporated into the aeration system as a backup measure in the event of water supply problems protecting both adult broodstock and juvenile stages. Nine female kelts were retained and successfully rejuvenated after spawning.

Egg Collection

<u>Sea-Run Broodstock</u>

A total of 61,300 eggs were taken from the nine adult females at ARH.

<u>Captive/Domestic Broodstock</u>

The NANFH incubated 500,000 eggs for the Pawcatuck River.

2.1.4.c. Stocking

<u>Fry Stocking</u>

The NANFH provided 349,000 for the volunteer fry stocking effort in May. NANFH supplied an additional 198,500 fry surplus to the Merrimack Program in June. The Warren State Fish Hatchery, NH, (WSFH) supplied 43,800 fry in April, from eggs originally taken at Roger Reed State Fish Hatchery, MA (RRSFH). These fish were placed on feed and subsequently stocked in June. All fry were transported directly from the respective hatcheries to central distribution locations within the Pawcatuck watershed. The total number of fry stocked was 591,000.

Parr Stocking

No parr were stocked in 1999.

Smolt Stocking

No smolts were stocked in 1999.

2.1.4.d. Juvenile Population Status

Fry/Parr Assessment

Fry and parr assessments were repeated in 1999. Eleven index stations (51.87 total habitat units) were sampled in March and thirteen index stations (64.7 total habitat units) were sampled during September in the watersheds of two major tributaries of the Pawcatuck River. The 1998 fry cohort was surveyed for growth, survival, and abundance. 540,000 fry were originally stocked in the established 4,792 habitat units at a density of 113/100 m^2. The 1998 fry cohort reached a mean length of 76.9 mm (SE=0.65) by October of 1998, 91.3 mm (SE=0.69) by March of 1999, and 146.6 mm (SE=2.42) by September of 1999. The 1998 fry cohort had a mean density of 6.71/100 m^2 (SE=2.64) by October of 1998, 3.54/100 m^2 (SE=1.33) by March of 1999, and 3.05/100 m^2 (SE=0.80) by September of 1999. 38.9% of the 1998 fry cohort sampled as 1^+ parr were precocious males. The 1999 fry cohort stocked at a density of 98/100 m^2 attained a mean length of 67.0 mm (SE=0.70) and a mean density of 6.26/100 m^2 (SE=2.12) by September.

Smolt Abundance

Potential smolt output from stocked fry (1997 cohort) was estimated by sampling eleven index stations during March of 1999. Smolt density ranged from 0.0/100 m^2 to 6.4/100 m^2 and averaged 1.59/100 m^2 (SE=0.21). The most productive stations could not be sampled due to high water. When the 1997 fry cohort was originally stocked, only 100,000 fry were available. Approximately 1,800 of the 4,792 juvenile habitat units in the Pawcatuck River watershed were stocked as a result (including established index stations). The number of juvenile habitat units was recalculated as part of the update to the Strategic Plan for the Restoration of Atlantic Salmon to the Pawcatuck River. Total wild smolt output based upon expansion of sample density over area stocked was 2,862 fish. Scale analysis of a sub-sample of captured smolts produced from fry stocking, indicates that all were age 2. The 1997 fry cohort was surveyed for growth and survival within the 1,800 habitat units stocked. The 1997 fry cohort reached a mean length of 76.9 mm (SE=0.62) by October of 1997, 89.3 mm (SE=0.92) by March of 1998, 153.3 mm (SE=1.73) by October of 1998 and 163.4 mm (SE=6.69) by March of 1999. The 1997 fry cohort had a mean density of 5.80/100 m^2 (SE=0.33) by October of 1997, 2.22/100 m^2 (SE=0.43) by March of 1998, 2.61/100 m^2 (SE=0.75) by October of 1998, and 1.59/100 m^2 (SE=0.21).

Overwinter survival from 1+ parr to 2 smolt ranged from 0.0% to 100.0% in index stations and averaged 52.01%.

Migrating smolts were not sampled with the modified fyke net in 1999 because marked hatchery smolts were unavailable for the Peterson Index.

Tagging

No tagging was conducted in 1999.

2.1.4.e. Fish Passage

Upstream Fish Passage

Problems with upstream fish passage remain at Potter Hill Dam. While salmon have no difficulty ascending the fishway into the trap, attraction flow coming from broken gates on the opposite side of the dam draws migrating fish away from the fishway entrance. The broken gates are thought to detrimentally affect all anadromous species present in the river. It does not appear that salmon are able to pass upstream through the broken gates. The dam is under private ownership by Renewable Resources Inc. The owners have been cited by the State of RI Dam Safety Section to effect repairs but the owners have refused to do so. The dam is not a hydropower dam thus regulatory authority to force the owners to repair the dam is severely limited. It is clear that new legislation increasing the ability of the State of RI to deal with the problem is necessary.

Downstream Fish Passage

No work was conducted on this topic during 1999.

2.1.4.f. Genetics

No work was conducted on this topic during 1999.

2.1.4.g. General Program Information

Domestic Atlantic Salmon Domestic Broodstock Releases

No surplus captive broodstock were released in 1999.

Education/Outreach

Educational assistance in 1999 allowed Chariho Middle School science students to observe electrofishing sampling techniques and analysis. Press releases and contacts resulted in enhanced volunteer interest in the fry stocking effort. 21,900 fry produced at NANFH were donated to the University of Rhode Island for educational and research purposes.

2.1.5. NEW HAMPSHIRE COASTAL RIVERS

2.1.5.a. Adult Returns

The Lamprey River fish ladder was monitored for returning adult salmon from mid-April until the end of June and from mid-September to mid-November. The Cocheco River fish ladder was monitored for returning adult salmon from mid-April until the end of June. The Cocheco River fish ladder has not been operated during the fall since 1993 due to a continuing dispute between the company operating the hydroelectric facility at the Cocheco Falls dam and NHFG.

Nine adult Atlantic salmon returned to fish ladders in 1999; three to the Cocheco in the spring and six to the Lamprey in September and October. Two grilse (both 2.1) and one salmon (2.2) returned to the Cocheco. All of the returns to the Lamprey were grilse (three 1.1 and three 2.1). Given the proximity of these rivers to the Merrimack River watershed, there is a potential that some of these returns are of Merrimack River origin.

2.1.5.b. Hatchery Operations

One adult male Atlantic salmon from the Lamprey River fish ladder was transported to the NHFG Milford hatchery in October 1999 for spawning purposes. Due to the absence of a returning female, the male was returned to the Lamprey River after a quarantine period.

2.1.5.c. Stocking

In March and April of 1999, approximately 283,000 Atlantic salmon fry were scatter stocked by volunteers into the Lamprey (126,700 fry) and Cocheco (157,100 fry) River systems. Fry were stocked at a density 60 fry/100 m^2 unit in the Cocheco River and 36 fry/100 m^2 unit in the Lamprey River.

Eggs for the 1999 fry stocking were obtained in the fall of 1998 from landlocked females in Lake Winnipesaukee. Approximately 446,000 eggs were fertilized with milt from Merrimack domestics (Mer F1) from the NNFH. All eggs were raised at WSFH. Unfortunately, due to increased temperature units at the hatchery the fry developed more quickly than usual and absorbed their yolk sacs by the first of March. The fry were replaced with a donation of 300,000 yolk sac fry from the NANFH.

2.1.5.d. Juvenile Population Status

Electrofishing surveys for juvenile salmon at four index sites on the rivers produced population estimates for young-of-the-year (YOY) fry ranging from 0.5 – 12.7 fish/100 m^2 unit. Mean length and weight of YOY at index sites ranged from 64-70 mm and 2-3 g. Estimates of parr abundance at index sites ranged from 1.3 – 6.5 fish/100 m^2 unit. Parr ranged in size from 135-144 mm and 19 - 24 g.

Population estimates at the two index sites in the Cocheco River contrasted significantly. The population estimate for YOY at the Mad River site was 12.7 fish/100 m^2 unit as compared to 1.9 fish/100 m^2 unit at the Cocheco River location. Parr population estimates at the two sites were 6.5 and 1.3 fish/100 m^2 unit, respectively. The Mad River index site had above average population estimates for YOY and parr compared to the previous eight years. Population estimates for the Cocheco River index site were roughly half the long term mean while the parr population estimate was the lowest ever measured at that site. Mean length and weight for YOY and parr were some of the lowest ever observed.

Population estimates for YOY and parr at both index sites in the Lamprey River system were the lowest ever observed. At the North River index site no YOY and only one parr were captured during electrofishing. Mean length and weight at the Lamprey index site for YOY and parr was the lowest ever observed while the size of the lone fish captured at the North River index site was well below average.

2.1.5.e. Fish Passage

The NHFG has petitioned the FERC to reopen the operating license of Southern New Hampshire Hydroelectric Development Corporations (SNHHDC) hydroelectric facility at Cocheco Falls on the Cocheco River. The petition requested three changes to the license:
1) to provide for summer and fall operation of the NHFG fish ladder at Cocheco Falls with sufficient attraction water, 2) to increase the required operation time of the SNHHDC's downstream fish passage facility into the spring to allow for downstream migration of Atlantic salmon smolts, and 3) modification of the downstream passage facility to increase the passage efficiency. In 1997, the FERC provided preliminary approval for the department's petition and NHFG is still awaiting a final decision.

In addition, NHFG and the USFWS worked with the owners of the Wyandotte Hydro on the Cocheco River to facilitate the installation of a downstream passage at that facility.

2.1.5.f. Genetics

No work was conducted in this area in 1999.

2.1.5.g. General Program Information

As has been done in the past, volunteers were used to conduct all fry plantings in the spring. We draw from a database of more than 200 individuals that have expressed an interest in assisting us and generally 50 to 100 individuals show up to work on a given day of stocking during the spring.

2.2. STOCKING

2.2.1. TOTAL RELEASES

During 1999, the participating agencies released approximately 13.7 million juvenile salmon into 18 river systems (Table 2.2.1.a in Appendix 10.3). Canada stocked an additional 22,500 0+ parr into the St. Croix River from the Canadian side. These fish were from St. Croix sea-run broodstock. The number of fish released represented an approximate 20% decrease from the 1998 level.

In addition to juveniles, mature adults were also stocked in some river systems (Table 2.2.1.b in Appendix 10.3). In general, these fish were either spent domestic brood stock or pre-spawned domestic brood stock in excess to hatchery capacity and were of river-specific origin. Sea-run kelt releases are not included in this table. In 1999, 5,827 adult salmon were released into the rivers of New England.

2.2.2. SUMMARY OF TAGGED AND MARKED FISH

A total of 119,000 salmon released into New England waters in 1999 was marked or tagged in some manner. Tag types included: Floy, PIT, radio, and acoustical (ping). Fin clips, fin punches, and elastomer visual implants were also used. Parr, smolts and adults were marked. About 20% of the marked fish was released into the Connecticut River system, 10% into the Merrimack River system, <1% into the Penobscot River, and 70% was stocked into six other rivers in Maine.

A comprehensive summary of marked and tagged Atlantic salmon released in New England rivers during 1999 is presented in Tables 2.2.2.a and 2.2.2.b (Appendix 10.3).

2.3. ADULT RETURNS

2.3.1. TOTAL DOCUMENTED RETURNS

A total of 1,452 adult salmon was documented to have returned to rivers in New England in 1999 (Table 2.3.1. in Appendix 10.3). The majority of the returns were recorded in the rivers of Maine with the Penobscot River accounting for nearly 67% of the total New England returns. The Connecticut River adult returns accounted for nearly 11% of the New England returns and 43% of the adult returns outside of Maine. Overall, 26% of the adult returns to New England were 1SW salmon and 74% were MSW salmon. Most of these fish (66%) originated from hatchery smolts and the balance (34%) were of wild origin (natural reproduction and fry plants).

Documented returns of 1SW salmon to New England (380) were up slightly from 1998 (360). MSW returns in 1999 (1072) were slightly down from 1998 (1,415). Overall, the total returns declined in 1999 (1,452 in 1999 vs. 1,775 in 1998). Changes from 1998 by river are: Connecticut (-51%), Merrimack (+50%), Penobscot (-20%), Saco (+135%), Narraguagus (+45 %), St. Croix (-68%), Aroostook (-17%).

2.3.2. RETURNS OF TAGGED SALMON

Few marks or tags were reported on adult sea-run salmon that returned to New England waters in 1999. Fin Clips (right ventral) on two Merrimack sea runs indicate the fish had been stocked as juveniles from the Nashua NFH. Adipose fin clips on six Pawcatuck sea runs, including one grilse, indicate that these fish were hatchery smolts while the other five were originally stocked as fry.

2.3.3. SPAWNING ESCAPEMENT, BROODSTOCK COLLECTION, AND EGG TAKE

Connecticut River- Twenty-two salmon were released upstream. One unmarked salmon was released above the DSI dam on the Westfield River. Twenty-one salmon were released above the Holyoke dam. Twenty of these salmon were radio-tagged by PG&E Generating as part of a fish passage study on the Deerfield River. Radio-tagged salmon were documented in eight tributaries including the Ammonoosuc River. Salmon redds were documented in the Sawmill River.

Merrimack River- Thirty sea run and one domestic broodstock were released into the Baker River. Seven of the sea-run females and one domestic female were radio-tagged. The sea runs moved downstream with four passing the Ayers Island dam and two passing other dams further downstream. No spawning was documented from fish released this year. A similar release involving domestic broodstock in 1998 resulted in successful fry production in the spring of 1999.

Maine Rivers - Natural reproduction was documented by redd counts, in seven coastal rivers and two tributaries to the lower Penobscot River in 1999. Detailed redd numbers are documented in Table 2.1.2.a. Redd counts remain well below optimum numbers.

During 1999, only one Maine river, the Dennys, received surplus captive broodstock. Surplus captive broodstock are fish collected as parr and brought to Craig Brook NFH for use in the river specific fry stocking effort. After several years of contributing to the spawning populations these fish have exceeded the capacity of the hatchery to hold them, and they are returned to their rivers of origin. While these fish may have contributed to spawning activities in the river, they were released after redd counts on this river were complete, and their contribution, if any, was undocumented. Additional releases of captive broodstock for the Dennys (9) and Sheepscot (50) rivers occurred in January 2000. These are also reported in Table 2.1.2.a. These fish are assumed to not have contributed to in river spawning.

The balance of the Maine river specific surplus captive broodstock could not be released back to their rivers of origin. These populations had tested positive for a new virus (Salmon Swimbladder Sarcoma virus), and fish health guidelines precluded releasing the fish back into the wild.

Egg sources for the New England Atlantic salmon culture programs include sea-run salmon, captive salmon, domestic broodstock, and reconditioned sea-run kelts. The total number of females spawned in 1999 from each category is as follows: 463 sea run, 3,162 captive or domestic broodstock, and 258 kelts. The grand total of broodstock spawned (3,883) was more than that in 1998 (3,715). The total egg take (23,326,900) was higher than in 1998 (19,790,975). Details are provided in Appendix 10, Table 2.3.4.

2.3.4. SPORT FISHERY

Directed fishing for sea-run Atlantic salmon is not currently allowed in New England, with the exception of a catch-and release fishery in Maine. The estimated number of salmon caught and released in Maine in 1999 was 212, as compared to 273 in 1998 (Table 2.3.5, Appendix 10.3).

The domestic brood stock fishery in the Merrimack River resulted in an estimated catch of 2,707 fish (1999= 2,707). This fishery is described in more detail in section 2.1.3.g.

3. EMERGING ISSUES

This is a new section to the U.S. Atlantic Salmon Assessment Committee Report that the Committee determined would be valuable. The purpose of this section is to proactively identify issues, opportunities, or problems, and thereby bring them to the attention of the U.S. Section to NASCO and State and Federal agency directors. Because the Committee meeting acts as an annual forum for discussion of projects and activities throughout New England, it provides unique opportunities for communication among individuals that work on Atlantic salmon on a daily basis.

The U.S. Atlantic Salmon Assessment Committee has identified the capacity to process genetic samples and perform statistical and modeling analyses on these data as a critical concern. In recent years, new genetic techniques have been developed and used for a variety of purposes: description of stock and sub-stock structure; assessment of genetic health; broodstock management; parentage analysis of stocked fry; evaluation of genetic/environmental interactions on growth and survival; and discrimination of hatchery and naturally-produced salmon. The application of genetic techniques as summarized above, addresses a number of management priorities such as conservation of genetic diversity (of both wild and hatchery fish) and evaluation of management actions such as stocking. These tools are possible because of the large degree of collaboration and interaction among state and federal agency personnel.

As a result of the utility of these genetic techniques and their widespread application throughout New England, the demand for sample processing and statistical analysis has increased greatly in the past five years, and will continue to increase. The Committee estimated that within one to three years, the number of genetic samples collected annually could exceed 12,000. At present, to ensure consistency and accurate comparisons among studies, most of the samples are processed at one laboratory. However, the Committee is concerned that the demand for sample processing and analysis in the next year will overshoot available equipment, expertise, and funds. It is imperative that the federal and state agencies of the Committee work together to determine how to address these shortfalls. Additionally, as multiple laboratories begin to analyze samples, it will be extremely important that laboratories produce comparable data.

The Committee believes that it is incumbent upon all the cooperating agencies to commit more resources toward these shortfalls. The Committee believes that these techniques offer a unique opportunity to provide quantitative answers to key questions that managers have been unable to answer for three decades. Failure to embrace and adequately implement a comprehensive plan to address the projected workload will perpetuate the uncertainties associated with many of our management actions, and will hinder restoration efforts.

4. TERMS OF REFERENCE

4.1. PROGRAM SUMMARIES FOR CURRENT YEAR

a. current year's stocking program with breakdowns by time, location, marks and lifestage.
b. current year's returns by sea age, marked vs. unmarked, and wild vs. hatchery.
c. general summary of program activities including regulation changes, angling catch, and program direction.

This information can be found in Sections 2.1., 2.2., 2.3., and their sub-sections of this document.

4.2. HISTORICAL DATA

The historical data were validated by the Assessment Committee and the information can be found in Tables 3.2.a. and 3.2.b. in Appendix 10.3. and in Section 6 (sub-sections 6.1. and 6.2.) of this document.

4.3. Term of Reference 3 – (Mary Colligan, Jan Rowan, Jay McMenemy and Russell Brown lead this discussion) **U.S. Atlantic Salmon Assessment Committee Research Program Proposal**

At the 1999 meeting of the U.S. Section, Section members noted an increase in identified research needs that state and federal resource agency personnel are unable to address due to lack of available resources. These needs include a comprehensive assessment of existing data to generate a list of research deficiencies and information gaps. This type of assessment will facilitate a risk analysis to prioritize information gaps and research needs. Critical issues such as early marine survival and aquaculture impacts could be more thoroughly addressed through focused, cooperative efforts between state, federal and international agencies, academic institutions, industry interests, and private stakeholders. A Term of Reference was established for the 2000 meeting to identify unfunded research priorities and identify the resources required to address these priorities. Assessment Committee members, researchers, and other salmon stakeholders were canvassed to identify and priorities research needs. The identified needs were consolidated into six broad research priorities:

- Evaluate the role of marine mammal, bird and fish predation in determining smolt and post smolt survival and identify critical times and locations where predation is significant
- Evaluate the riverine movements, behavior and spawning success of Atlantic salmon adults (aquaculture, hatchery and sea run)
- Evaluate the effects of furunculosis, SSSv, and ISA on survival, health and reproduction of Atlantic salmon (hatchery, wild, and aquaculture)
- Evaluate the effects of contaminants (including endocrine disruptors) on survival, health and reproduction of Atlantic salmon (hatchery, wild)
- Identify stock-related characteristics that influence genetic fitness and contribute to broodstock management in both wild and cultured Atlantic salmon stocks; this may include developing and quantitatively evaluating river specific stocking strategies and evaluating strategies to maintain genetic isolation and minimize interaction between wild and aquaculture populations
- Evaluate factors affecting early marine survival

To evaluate potential research ideas that could be funded and the financial resources required to establish and administer this type of research program, the Assessment Committee circulated a request for pre-proposals to agency, academic, industry, and private organization investigators interested in Atlantic salmon issues. This request generated six projects to address issues with predation, one project on movement and behavior, a couple of fish health projects, three proposals on the effects of contaminants, and four proposals on genetics and stock related characteristics.

Under this research initiative, the Assessment Committee is also interested in establishing a fellowship program to support 2-3 Masters or Ph.D. graduate students to support Assessment Committee activities. The positions would be supervised by individual Assessment Committee members and participate in research and analysis activities that support committee objectives. Research projects would focus on integrative studies and/or meta-analyses of datasets produced and compiled by the assessment committee. This fellowship program would ensure that priority data management and analysis of available datasets is completed to address identified research needs. In addition, these research fellows assist in tracking research activities support by and reported to the U.S. Assessment Committee.

Conceptual Model of the Research Program

The Assessment Committee developed a conceptual research program that would be administered by the committee. Research priorities would be establish by the committee, in consultation with Section members and other salmon stakeholders, and re-evaluated periodically to remove priorities that have been adequately addressed and address newly identified research priorities. The Assessment Committee would be responsible for administering the research program, including solicitation of pre and full proposals, overseeing an external peer review and funding decisions for submitted proposals, tracking research progress, and receiving and incorporating research results into the assessment process.

Request for Assistance from the U.S. Section
At the 2000 U.S. Section meeting, the Assessment Committee will present a conceptual plan for establishment of the research program and request assistance from section members to secure funding support for the program. Based on the results of the call for pre-proposals conducted by the assessment committee, the committee estimates that $750,000 will be required annually to provide administrative and research support to fully support current research needs. The committee will emphasize that this initiative cannot be supported within existing agency budgets. The committee will recommend that U.S. Section members explore funding opportunities including a new federal initiative and private or foundation sources. The Assessment Committee anticipates that establishment of the research program will represent a cooperative effort between the committee and the U.S. Section.

4.4. Term of Reference 4 – (Ben Letcher lead the discussion) **Optimum Fry Stocking Levels**
Datasets from the states were collected and archived. Archiving was simplified this year with the use of a standardized datasheet. Keith Nislow has agreed to work with Ben Letcher to develop the smolt production simulation model.

4.5. Term of Reference 5 - (Dave Perkins , John Kocik, Michelle Babione and Phil Herzig lead the discussion) **Fry Stocking Life Tables**
The river specific life tables were updated with 1999 wild return and fry stocking data. It is important to note that these tables do not account for wild fry production. The committee decided to update these tables annually, including them as standard part of the report in Appendix 10.0. The Connecticut data were re-worked this year because of a difference in assigning unknown ages. Previously, the unknowns (such as upstream releases at Holyoke) were assigned ages based upon available information, including adipose clips and relative size. However, last year's term of reference called for all unknown assignments to be re-assigned based upon a standard percentage. Because upstream releases at Holyoke were not always random, this new method resulted in fewer wild fish than were previously reported. This year, the unknowns were again re-assigned based on the historic returns table in the report (Appendix 10.0), which takes into account available information about the unknowns. The committee discussed the value of providing fed vs. unfed fry totals and/or fry size information, and decided to continue reporting fed/unfed data in the same format. The committee decided not to include fry size data. The committee discussed the mean stocking densities, deciding to develop a measure of the area stocked, calculated from the stocking densities. These data will be added to the life tables next year.

4.6. Term of Reference 6 - Program Summary of Historical Smolt Runs – This Term was not addressed in 1999.

4.7 Term of Reference 7 – (Mike Millard and Joe McKeon lead this discussion) **Fecundity Trends**

The subgroup was tasked with exploring fecundity trends in relation to age structure, adult size, adult origin, and other pertinent variables of early life and marine history. The group was directed to begin the assessment of Merrimack River fish, as this system provided a favorable time series of individual egg count data dating back to 1983. Individual-based data employed in the analysis included eggs spawned, adult length and weight, sea age, smolt age, back-calculated smolt length, stocking phase, stocking density, and the associated ocean thermal habitat index for years 1983-1997. Fecundity was standardized as eggs per unit weight of spawning adult and examined for correlative relationships. The regressed relationship between eggs spawned and adult weight was also employed in some comparative analyses.

An obvious finding for the Merrimack River data was that total fecundity was directly proportional to adult weight, and adult weight was directly proportional to age of the spawner. The ratio of egg count per unit adult weight, however, did not appear to be change over ages. There was no evidence that smolt size, as back-calculated from adult scale morphology, was related to the size of the returning spawners. This suggests that smolt size does not influence subsequent fecundity of the adults. This was further corroborated by the finding that the regression relationship between eggs produced and adult weight did not differ among fish which smolted at different ages.

The Jan-Mar total ocean thermal habitat was overlain on the eggs per adult weight time series, and correlations were approximately 0.3. This was true for both OTI during the year of return and OTI for the year previous to return. This suggested that fecundity was not significantly influenced by the ocean thermal habitat index.

The eggs per unit body weight was compared for fry-origin returns which were stocked at high (~65 per unit) and low (~30 per unit) densities. While the mean smolt size for fish stocked at low densities was larger, they appeared to exhibit a smaller egg per body ratio. This result suggests that the smaller smolt produced more eggs on per weight basis.

Initial comments from a few members of the Committee centered on the data used in the analyses. Size of three-sea-winter fish was questioned. Observed weight at age was thought to be too low, but small sample sizes may have affected results.

The Committee discussed what aspects of egg quantity and quality were fruitful areas for further analysis, and what stocking protocols may be manipulated in order to maximize the fitness of fry and subsequent parr and smolt. The logistics of releasing fry into habitat at times coincident with available food items was discussed and explored. A discussion regarding the importance of micro-nutrients in juvenile life stage diets ensued, and the aspect that the physiological state and health of yearling parr could be compromised due to poor nutrition. However, it was noted that reasonable yearling parr abundance at sites would suggest that competition for food was not a limiting factor.

The Committee agreed that this avenue of analyses would not be pursued in future years, however the analyses and discussion at this meeting with respect to age, weight and fecundity of sea-run salmon in a Gulf of Maine watershed would be provided to ICES.

4.8. **Term of Reference 8** – (Ed Baum and John Kocik lead the discussion) **Aquaculture and freshwater hatchery escapees**

8.3.1 Description of the Maine Aquaculture Industry

The aquaculture industry in Maine is currently composed of about 50 finfish site leases, with most cage sites located in the Cobscook Bay area, near the Maine – New Brunswick border. Atlantic salmon is the primary species of finfish under cultivation, with rainbow trout a distant second. The number of cages used to rear salmon has more than doubled (to about 800) since 1989. Site intensity has also increased markedly in recent years; today, Maine salmon farms deploy as many as 82 cages per site, with an average of about 25 deployed per lease site. A detailed history and description of the Atlantic salmon aquaculture industry in Maine may be found in Baum (1998).

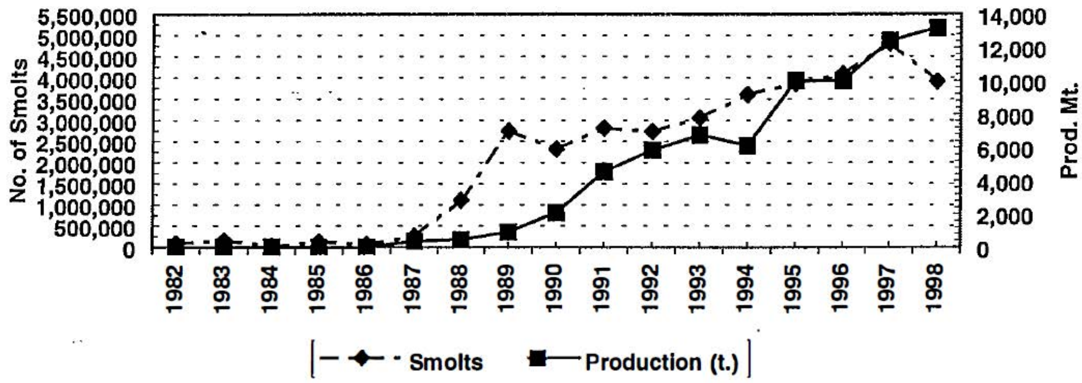
The Maine aquaculture industry operates four freshwater smolt-rearing hatcheries, which produce up to four million Atlantic salmon smolts annually. Additional smolts are often imported from New Brunswick and New Hampshire. Although several European stocks (from Iceland, Scotland, Norway, and Finland1) were initially reared in Maine, there are three current stocks under production. Penobscot River stocks were originally provided to the industry by the State of Maine (100,000 smolts in 1983 and 50,000 smolts in 1985), while Saint John River stocks were originally provided to the industry by the Canadian government (Department of Fisheries and Oceans). The third stock commonly referred to as the Landcatch strain – which is a mixture of several Norwegian stocks – was originally imported to Maine from Scotland in 1989. Hybrids from previously used European stocks also probably exist in Maine. Approximately 30-50% of all salmon currently under production are either pure or hybridized Landcatch strains, with either of the other two stocks. The exact percentage of Landcatch hybrids being reared in Maine is difficult to ascertain due to incomplete and/or inadequate record keeping by a rapidly changing industry. Since 1997 the salmon farming industry has also imported milt (the Bolak strain from Norway) from Iceland. Milt from European-origin stocks was allowed to be imported because Maine law specifically prohibits the importation of "live fish or eggs" from Europe.

---

1 Icelandic stocks were: Eldi and Isno river stocks; Norwegian stocks (via Scotland) were the Mowi strains (from the Landcatch Company); Finnish (Baltic Ocean) stocks originated from the Moorum River (Baum 1998).

More than 4 million Atlantic salmon smolts are now stocked annually in Maine waters (Figure 8.3.1). Cage rearing to harvest requires about 18 months, yielding an average standing crop of about 6 million salmon in two-year classes. Most salmon are harvested from October through March, and the total harvest has increased from 20 mt in 1984 to more than 15,000 mt in 1998 (Figure.3.2).

Figure 8.3.1 Number of Atlantic salmon smolts stocked into sea cages and production of farmed salmon in Maine.



8.3.2 Information Pertaining to Escapes from Salmon Farms and Hatcheries

The number of salmon that escape from Maine aquaculture sites is unknown and there is no legal requirement to report such occurrences. Generally speaking, industry representatives in Maine and New Brunswick tend to keep such information confidential for business and/or insurance reasons. Additionally, salmon farmers may also be hesitant to publicly acknowledge accidental escapes for fear of overreaction by government regulatory agencies. However, storm-related, accidental escapes are sometimes reported in the media. Escapes of juvenile and adult Atlantic salmon from sea cages in eastern Maine are usually concentrated in the winter months (December-April) when threats to equipment integrity from storm damage and seal attacks are most common (McGonigle et al 1997). Escapes of salmon from farms are inevitable and are usually a result of storms, predator damage, equipment failures, and accidental human error. It is also likely that some fish are intentionally released, because some operators may be reluctant to dispose of culls and/or surplus production in the belief that they are benefiting the resource or enhancing sport-fishing opportunities. It should be emphasized that there is no evidence that this practice occurs to any great degree or extent in Maine.

8.3.4 Identification of Aquaculture Escapees in Maine Rivers

Aquaculture escapees are identified in Maine rivers by a combination of their physical appearance and by scale analysis. Tissue samples can also be used to identify Atlantic salmon with European genes. Many escapees can be readily identified by the poor condition of their fins; for example, the dorsal fin is almost always deformed, and often in combination with deformities to the paired fins (usually the pectoral fins). Another commonly observed characteristic of farmed salmon is the small, shortened caudal fin, often referred to as a "broom tail." Additionally, the length-weight relationship of aquaculture escapees is also often dissimilar to wild salmon, with most fish larger and heavier than 1SW wild salmon, but smaller and lighter than MSW wild salmon in Maine. Other physical deformities characteristic of cultured salmon are shortened operculum's on one or both sides of the fish, and caudal peduncles that are shorter and thicker than those of wild salmon. Scale analysis (circuli spacing) is another method used to identify aquaculture escapes, since the industry produces 1-year smolts. Unlike growth patterns of wild salmon (fast in summer, with little or none over winter), hatchery smolt growth is very uniform. The marine growth pattern of cage-reared salmon (more uniform, with many growth checks) is also very different from marine growth of salmon at sea (rapid in summer and very slow in winter).

The Maine Atlantic Salmon Commission has developed standardized protocols for the identification and disposition of aquaculture escapees in Maine rivers. Escapees are identified by a minimum of two characteristics (e.g., dorsal fin condition, condition of paired fins, broom tail, peduncle shape and size, shortened gill covers, length-to-weight relationship, scale analysis when possible). Due to fish health and genetic concerns, all positively identified escapes are sacrificed and biological data is collected (length, weight, state of sexual maturity, scale sample, etc.) along with tissue samples for fish health and genetics studies. A photograph of each individual fish is also taken for historical purposes.

8.3.5 Documented Adult Aquaculture Escapees in Maine Rivers

The first documented incidence of adult farmed salmon in Maine rivers occurred in 1990, when a minimum of 17 percent (14 of 83 fish) of the rod catch in the East Machias River was of farmed origin (Baum 1991). There were few reports of farm origin salmon in Maine rivers in 1991 and 1992, although in 1993 there was an estimated 20 aquaculture strays in the Dennys River (which had a documented run of 40-50 wild salmon). In 1994, of a total of Dennys River weir catch of 47 salmon, all but five were farmed origin; one aquaculture stray was also observed in the Narraguagus River. Trap catch results for 1995 identified four farm escapees in a total of nine salmon on the Dennys River. Anglers fishing the Dennys and East Machias Rivers have also reported catching (and releasing) farmed-origin salmon annually since 1995.

Those rivers in close proximity to the Maine - New Brunswick aquaculture cage sites (e.g., St. Croix, Dennys and East Machias) have shown the highest incidence of escapees, with farmed salmon comprising >50% of adult returns in some rivers in recent years. Most aquaculture escapees observed in Maine are sexually immature; however, beginning in 1996, a small number of sexually mature escapees have been documented annually in 3 Maine rivers. In the St. Croix River, 17 escapees were sacrificed in September 1998, and 5 (30%) exhibited evidence of sexual maturation, and in 1999 all 3 escapees in the Narraguagus River were sexually mature. A summary of documented aquaculture escapees identified in Maine rivers is presented in Table 8.3.5.1 (data from Baum et al. 1997; Horton et al. 1998; ICES 1999).

Table 8.3.5.1 Documented adult Atlantic salmon of farmed-origin in Maine rivers.

River	1994		1995		1996		1997		1998		1999	
	No.	% Of Run	No.	% Of Run	No.	% Of Run	No.	% Of Run	No.	% Of Run	No.	% Of Run
St. Croix	98	54	13	22	20	13	27	39	25	38	23	64
Dennys[1]	42	89	4	44	21	68	2	100	Unk	-	Unk.	-
Narraguagus	1	2	0	0	8	22	0	0	0	0	3	9
Union	-	-	-	-	-	-	-	-	-	-	63	91
Total[2]	141		17		49		29		25		89	

[1] Incomplete counts
[2] Additional Maine rivers where aquaculture escapees have been observed: Boyden Str., Pennamaquan R., Hobart Str., E. Machias R., and Penobscot R.

8.3.6 Documented Juvenile Salmon Escapees in Maine Rivers

Pleasant River. In 1999, the smolt run on the Pleasant River was monitored using a rotary screw smolt trap deployed near the head of tide in Columbia Falls. A total of 676 smolts (mean length 174 mm) were captured between 22 April and 29 May, and about 5% (31 fish) were observed with fin deformities, coloration, and body form suggesting that they were of hatchery origin. The last year that the Pleasant River was stocked with hatchery-reared stocks by state and federal fishery agencies was 1991, indicating that these salmon originated from a private aquaculture hatchery in Deblois. Interestingly, the hatchery-origin fish were most common in the first quarter and last quarter of the smolt run. Scale samples and tissue samples for DNA were collected from all of these fish, as well as a representative sample of wild fish. Preliminary analysis of growth patterns suggests that scale characteristics are distinct enough to facilitate identification of other hatchery-origin smolts in the run. These investigations are ongoing and results should be completed in mid-2000. Given the results to date, the percentage of hatchery origin fish is expected to be greater than 5% but less than 25%.

After hatchery-origin smolts were captured in the smolt trap in the lower Pleasant River in the spring of 1999, electrofishing surveys were conducted at the Deblois Hatchery outflow, in Beaver Meadow Brook, a secondary order tributary to the Pleasant River. A total of 31 age 0+ salmon and three age 1+ parr were captured. Beaver Meadow Brook flows into Bog Stream which discharges into a deadwater area of the mainstem of the Pleasant River. One age 1+ parr was also captured in Bog Stream by electrofishing. A second electrofishing effort in Beaver Meadow Brook at a later date resulted in the capture of nine age 0+ parr, ranging from 44 to 53 mm in length. The Deblois Hatchery is located at the upstream end of a beaver-infested "gunk hole," and the section of stream where the salmon were captured is not Atlantic salmon spawning or rearing habitat. Considering the fact that the nearest reach of the Pleasant River is a deadwater area (i.e., there is no salmon habitat in the area where Bog Stream enters the Pleasant River), there can be little doubt that the origin of these salmon was the Deblois Hatchery.

Two additional electrofishing surveys were conducted in Beaver Meadow Brook in September and October. On the first trip (9/28), 29 of the 40 salmon captured were tagged with PIT tags and released. On the second trip (10/7), four of the tagged salmon were recaptured and an additional 47 parr were captured. The four PIT tagged parr were released, however, the 47 new parr that were captured were lethally sampled for fish health and genetics analysis. Lengths of parr captured in the vicinity of the Deblois Hatchery outflow in the fall ranged from 53 to 128 mm.

East Machias River. Since 1989, annual population assessments conducted by Maine fishery scientists on Chase Mill Stream, a tributary to the East Machias River, have resulted in the capture of suspected aquaculture-origin juvenile salmon in the vicinity of a private aquaculture hatchery discharge. These fish have frequently been noted for their deformed fins and (occasionally) their large size, compared to wild parr. Until 1999 no attempt has ever been made to assess the origin of these fish. In October 1999, Chase Mill Stream was specifically electrofished in the vicinity of the hatchery outlet, and 28 suspected aquaculture origin salmon (with fin deformities) were collected. These parr consisted of 13 age 0+ parr and 15 age 1+ parr, ranging from 75-162 mm in length and 3-40 g. in weight. All 28 salmon were lethally sampled for fish health and genetics analysis.

Literature Cited

Baum, E.T. 1991. History and status of the Atlantic salmon farming industry in Maine, USA. ICES North Atlantic Salmon Working Group: Study Group on North Atlantic Salmon, Leetown, West Virginia. 25 February -1 March 1991. 4p.

Baum, E.T. 1998. History and description of the Atlantic salmon aquaculture industry in Maine. Canadian Stock Assess. Res. Doc. 98/152. 29p.

Baum, E., M. Evers, G. Horton and R. Spencer. 1997. 1996 Endangered species project report. Maine Atlantic Salmon Authority, Bangor, Maine. 33p.

Horton, G., M. Evers, R. Spencer, and E. Baum. 1998. 1997 Endangered species project report. Maine Atlantic Salmon Authority, Bangor, Maine. 78p.

ICES. 1999. Report of the Working Group on North Atlantic salmon. Quebec City, Canada. ICES CM 1999/ACFM: 14. 239 p.

McGonigle, J., S. Swartz and D. Miller. 1997 Atlantic salmon task force; aquaculture working group, loss control subgroup report, pp. 295-303. *In:* Atlantic Salmon Conservation Plan for Seven Maine Rivers, State of Maine, Augusta, Maine. 434 p.

4.9 Term of Reference 9 – (John Kocik lead this discussion) **Modeling Assumptions**

Assumptions on the survival of Atlantic salmon from one life history stage to another are a critical element of modeling exercises related to the estimate of prefishery abundance in the Greenland fishery. Additionally, these data are important for partitioning mortality between life stages such as fry, parr, smolts, postsmolts, and adult salmon. This partitioning facilitates stage-specific modeling that enables identification of population bottlenecks in discrete habitats.

The Assessment Committee initiated a Term of Reference in 1999 to take a preliminary look at these data. We found that data for this exercise are still somewhat limited but recently published studies as well as preliminary data from ongoing studies within the group have provided new information for parameterization of models. An important caveat of this summary is that the broad geographic range of Atlantic salmon likely results in geographically based differences in these rates. Given the limited number of studies and lack of multiple sampling years, partitioning these studies geographically is not yet feasible. To address this question, we reviewed the literature and identified 229 datapoints from 95 studies that examined the survival rates of salmonids with extended stream rearing, e.g. Atlantic salmon, steelhead, and coho salmon. This summary provides some useful reference points for future modeling exercises because it includes a summary of the stages analyzed and the number of months between samples.

Using these data we generated the following summary of three important inter-stage survival rates: pre-smolt overwinter survival, survival to 1SW, and survival to 2SW. Additionally, these data are in a form that can easily be queried to summarize by various parameters. These data are available in their complete form at the Connecticut River Coordinator's web site (http://www.fws.gov/r5crc).

An often-used range for pre-smolt overwinter survival in the US has been 30-70 %, as cited in a comprehensive summary by Bley and Moring (1988). Research conducted in the 1990's and additional pre-1990's studies in this summary suggest that this range is too high, particularly for New England streams. These reports suggest that survival between these stages average 20%. Ongoing studies in Maine (12-24%) and Massachusetts (44%) suggest that populations in New England may be functioning within a range of 10-45%. At present, it is unknown if these data are similar to historical rates in the region.

Marine survival is measured from the smolt stage to returns as either 1SW or 2SW adults. Return rates for 1SW salmon ranged from 0.01 to 12%. However, these values are extremes and the median value is 3.5%. For two sea winter fish, return rates average 0.5 % in these studies and are similar in the Penobscot River. In the southern rivers return rates average 0.1 %. These return rates have been in a general decline over the past two decades as evidenced by the prefishery abundance of the North American stock complex. Since return rates used to estimate population potential are often much higher, it is important for individual programs to readjust for these long-term declining trends.

The complexities of these data warrant further examination because of differences in methods and variability in time between samples. An especially important problem with these data is that the number of months between samples of discrete stages is quite variable. We have made an attempt to quantify these time periods but it may be necessary to contact authors in some cases. We recommend continuing the development of this database with the addition of days between samples. This approach would facilitate comparisons between studies using instantaneous rates. Further analysis of these data and historical data within New England would be useful and should be pursued in the coming year.

5. RESEARCH

5.1. RESEARCH PRESENTATIONS

5.1.1. Growth, survival and maturity of individual Atlantic salmon parr in West Brook, MA, USA

Ben Letcher (A), Gabe Gries, and Francis Juanes, as recorded by Steve Gephard.

This study has been conducted on a small tributary of the Connecticut River during the past three years. PIT tags were utilized to identify and track individual salmon parr. The goals include analysis of survival, size, and growth of individual fish, which can then be averaged to compare across year classes, life history strategies, and years. The study site included 47 contiguous 20 m sections within a 1 km stretch of river where there is abundant salmon habitat upstream and downstream of the site. There is no natural reproduction of salmon in this stream and the population was established by the annual stocking of Connecticut River fry at a rate of 50 per 100 sq. m. Fish were initially captured and tagged as parr (>60 mm, 2 g) using electrofishing and night-seining and later were also captured in traps as emigrating smolts. PIT tags (12 mm, type 'A' and 'B') were inserted into all captured fish that did not already possess a tag.

Analysis of data is not yet complete but observed trends between years look similar. Catches were high early each season and then dropped as the season progressed. The proportion of recaptures was high, but approximately half of the fish that were captured were captured only once. Those fish either emigrated or died subsequent to first capture. Other results included:

- Survival from spring to fall by 0+ and 1+ parr approximated 75%,
- Survival to spring (overwinter) by parr was 57% for 0+ and 44% for 1%,
- Parr generally lost weight (and maintained length) during the summer, presumably due to lack of flow and drift,
- Parr experienced a major growth period in the spring (74% of all growth occurred during this 13% of total stream residence time),
- 50% of all 1+ fish (~100% of all males) expressed milt,

- ~100% of female parr emigrated as smolts as 2-year smolts,
- 100% of 2+ parr were male,
- 1+ parr that were destined to mature began the growing season slightly heavier than 1+ parr that were destined to remain immature and smoltify but by summer the immature parr were larger,
- Notwithstanding the previous bullet, there is a subgroup of mature parr that emigrated as smolts in the following spring and these fish were about the same size or slightly heavier than the immature fish destined to smoltify,
- In addition, the mature, non-migrant parr experienced rapid growth during the winter and caught up in size with the migrants,
- There is considerable concern by the investigators and the committee about the potential impact of repeated handling on growth and maturation of parr. There is no evidence of this but it is assumed to have occurred and there were efforts to minimize this.

Future work on this project will include the installation of streambed PIT antennae to monitor movements of fish, the use of genetically-marked families to investigate variability of these performance traits within families, and the expansion into two new streams (Shorey Brook, Pleasant River system in Maine and Catamaran Brook in New Brunswick) to address variability in differences in habitat, latitude, and stream size.

5.1.2. An evaluation of striped bass (*Morone saxatilis*) predation on Atlantic salmon (*Salmo salar*) smolts in the Merrimack River below the Essex Dam. Peter Mac Neil (U), Francis Juanes and Joseph F. McKeon

We examined striped bass (*Morone saxatilis*) predation on several diadromous fish species, including Atlantic salmon (*Salmo salar*), river herring (*Alosa aestivalis* and *Alosa pseudoharengus*) and American eel (*Anguilla rostrata*) in the Merrimack River, Massachusetts, USA during 1998 and 1999. Field sampling was conducted below the Essex Dam, in the tailrace to evaluate the potential for high predation mortality to occur directly after fish passage over the dam. Striped bass were collected during spring (April-June) each year, a period coinciding with the seasonal migration period of Atlantic salmon smolts. Fish were captured by using angling gear and boat electrofishing in the tailrace and areas immediately downstream of the dam (approximately 35 angling and 5 electrofishing sampling dates per year). Gastric lavage techniques were used to collect stomach contents from individual fish. Nearly 1600 striped bass were captured and stomach contents examined during both years combined, of which approximately half contained food items. River herring (percent wet weight) and American eels (percent number) were the dominant prey during both years. The contribution of Atlantic salmon smolts to striped bass diets below the dam was minimal, with 22 and 16 individual prey recovered in 1998 and 1999, respectively. This result contrasts with those of a small study conducted previously (1997), which indicated that Atlantic salmon smolts may represent an important prey (45% by weight) for striped bass feeding below the dam. However, differences in Atlantic salmon smolt stocking locations and timing among the study years may have influenced the spatial and temporal overlap between striped bass and Atlantic salmon during each year.

Further, interannual variation in abiotic conditions (e.g., river temperature, river flow) may have impacted smolt migration timing. Lower river temperatures (e.g., 1997) may have resulted in delayed migration of Atlantic salmon smolts causing increased temporal overlap with bass, which predictably enter the river from the ocean in early May. The availability of alternative prey may also have varied among study years, perhaps due to variation in abiotic factors, resulting in lower feeding rates on Atlantic salmon smolts in 1998 and 1999. Our results indicate that striped bass diets may be strongly influenced by local abiotic and biotic conditions and that the contribution of Atlantic salmon smolts to the diet may not be as significant as previous work suggested. The availability of alternative prey (e.g., river herring and American eels) in northeast US rivers in late spring may have a significant impact on survival of Atlantic salmon smolts during the migration period.

Discussion

Members of the audience asked many questions concerning this presentation. Some of these involved the prey species content over time. It was evident during the analysis that prey composition did change over time. The results presented at this meeting also did not allow for partitioning of the data to demonstrate consumption of the smolts during the peak migration. The entire sampling period was averaged. Mr. Mac Neil will be partitioning the data prior to completion of his report.

A question was asked concerning the fry stocking activities on which outmigrating smolts are dependent. The 1998 smolt year would come from the 1996 stocking season, which was approximately half that of previous years. This may have led to fewer smolts during the migration.

Mr. Mac Neil has been unable to identify hatchery versus wild smolts from the samples analyzed. The state of decomposition has impeded this activity. There was no observed difference in diet between those striped bass that were angled, and those that were caught using electrofishing equipment; although a slight size difference of captured fish was observed between the two methods. No regurgitation of gut contents was observed on fish captured by either method.

The 1999 attempt to assess whether or not the bypass spillway affected smolt mortality was unsuccessful. Problems arose during the release (timing and manner). Mr. Mac Neil was not able to replicate the effort. Many participants were very interested in this study, as it does seem to offer the opportunity to assess how smolts may handle the effects of being stocked upstream of dams with bypass structures. Mr. Mac Neil felt that it was beyond the scope of his current study to continue to address this issue, but did recognize that it offered the opportunity for a different study.

5.1.3 Seals and Seal Predation on Atlantic salmon; Joint presentation by Dr. Jim Gilbert (T), Dr. Gordon Waring (G), and Ed Baum (S) as recorded by Denise Buckley and Russell Brown.

Dr. Gordon Waring presented information on seal stocks in the Atlantic Ocean including abundance trends and distributions and discussed the potential impact on Atlantic salmon. NMFS currently completes stock assessment reports using broad spatial stock definitions. Dr. Waring specifically discussed populations of Grey and Harbor seals in the North Atlantic.

The populations of Grey and Harbor seals that are of direct interest to this group are generally distributed between Sable Island and Cape Cod. Grey and Harbor seals may move into the Gulf of Maine during winter, and have been identified as yearlings (pups) originating from the Sable Island colony through a freeze brand marking program on Sable Island.

As the occurrences of Grey seal sightings in the Gulf of Maine/Cape Cod area increase, it appears that Grey seals are re-colonizing historic areas that were extirpated in the 1950's. There is currently a colony of several hundred Grey seals in the Monomy Bay area. The historic range for both Grey and Harbor seals may extend as far as the mid-Atlantic.

The majority of the Harbor seal populations in this region is located in the Bay of Fundy, but may extend as far south as coastal New Jersey in winter. Population surveys for Harbor seals are conducted primarily in the Downeast areas of Maine during the pupping season. Counts are based on aerial photos (taken from 400-500 feet) of pupping ledges. Additional surveys are also conducted during August during the annual molt. This is a particularly good time to conduct surveys as all adults are on land during the molt. There may be attempts in the future to capture and tag individual seals for tracking and to study abundance.

The populations of both Grey and Harbor seals have experienced steady growth since the early 1980's. In 1981 the population of Harbor seals (including pups), as recorded from aerial photograph surveys, was estimated at 10,540. In 1997, the populations had increased to 30,990 seals. Harbor seals in the vicinity of the Maine coast have experienced an 8.9% annual increase in their population. This growth has been similarly experienced in the British Isles and along the Danish coast. However, these populations did experience a decrease in size (56%) during 1988 as a result of an epizootic event (distemper virus) that was primarily responsible for mortality in virtually all pups and males in 1988. However, populations rebounded within a matter of a few years, which demonstrates the seal's ability to recover and grow rapidly. It is estimated that the lifespan of Harbor seals, although it can vary considerably due to environmental conditions, can be 20 years. Populations of Grey seals experienced a 7.4% annual growth in the Gulf of St. Lawrence and a 12.6% increase at Sable Island. Much of this growth can be attributed to the passage of the Marine Mammal Act in 1972, and the subsequent cessation of programs to reduce seal numbers relative to commercial fishing operations. Seal populations are controlled naturally by shark (primary) and killer whale (minor) predation and epizootic events.

Grey seals are significantly larger than Harbor seals, and while both species often utilize the same nursery habitat, their pupping seasons are spatially segregated. Grey seals are known to displace Harbor seals into the less desirable habitat and this behavior may account for the reduction of Harbor seals at Sable Island. Recent surveys in the Monomy Bay area have seals are recolonizing habitat currently occupied by Harbor seals. Grey seals have been documented to kill Harbor seal pups in Europe.

Dr. Jim Gilbert, of the University of Maine, expanded the growth of seal populations in this region to include the potential impact on Atlantic salmon, specifically in Maine. As stated previously, populations of both Harbor and Grey seals have increased significantly. Additionally, other species of seal not traditionally found in the Gulf of Maine/Cape Cod areas have had an increased presence in the last few years. These species are Hooded, Harp, Ringed and, to a lesser extent, Bearded seals. These seals are typically found in this region during winter, and are a by-catch of commercial gill netting operations.

Seals that are caught in gill nets are typically first year juveniles. There have also been some documented strandings of Hooded seals. Harp seal populations have been increasing similar to Harbor and Grey, since pup culling in the 1970's ceased. There are now approximately 5,000,000 Harp seals in the North Atlantic.

The food habits of Harbor, Grey, and Harp seals were reviewed (specific lists of prey items can be found in handouts provided by Jim Gilbert prior to this presentation). It was noted that seals are basically opportunistic feeders, but will target both benthic and schooling pelagic fish species. Fifty percent of all seal stomachs are empty at any given time during sampling. The majority of the stomachs sampled were taken from seal caught in gill nets during commercial fishing operations. Fish were identified by hard parts found in the seal stomachs (such as bones, otoliths, etc.). It was also noted there was little correspondence in the size distribution or species composition between the stomach contents of gillnet-caught seals and the gear catch, indicating that net feeding by gillnet-caught seals may not be occurring.

Primary diet items of Harbor seals include herring, cod, pollock, squid, and hake. There have been no documented events identifying salmon in Harbor seal stomachs. Grey seals primarily feed on squid, herring, hake and cod. There are two documented events of Grey seal predation on Atlantic salmon in the Gulf of St. Lawrence. Harp seals feed primarily (adults) shrimp, capelin and sandlance. Even studies that were conducted near-shore demonstrate no evidence of Atlantic salmon predation.

The interaction of Atlantic salmon and seals were then discussed. It was pointed out that in addition to representing a predator of Atlantic salmon in both the open ocean and in the estuarine environments, there may be a significant diet overlap between seals and Atlantic salmon. Aquaculture facilities may act as an attractant for seals, as will any commercial fishing operation (trawls, gill nets, weirs, etc.). It is likely that seals could be attracted by the activity as much as the proximity of high densities of fish. However, it is speculated that smolts exiting river systems may not be attractive enough for seals (due to the low numbers of smolts leaving individual rivers), with the exception of rogue seals which may ascend the rivers specifically to target smolts. If specific individual seals are responsible for significant amounts of predation, this represents a wildlife damage issue than a population level concern. It is also likely that attacks on aquaculture net pens may be the result of individual seals specializing in this type of predation.

A specific research paper was cited (Thompson and Mackay, 1999) regarding damage to Atlantic salmon in Scotland. It was found that approximately 20% of returning salmon were damaged, and the majority of this damage was actually caused by odonocetes (primarily porpoises), rather than seals. It was noted that seal injuries are usually inflicted in the area of the anal fin and vent on adult Atlantic salmon, indicating that attacks on salmon are usually initiated from below. It was noted that pinniped management has been recommended in the Pacific Northwest as part as of restoration of Pacific salmon.

Ed Baum, Maine Atlantic Salmon Commission, expanded on many of these topics, directly related to assumed predation of Atlantic salmon. A Department of Fisheries and Oceans biologist conducted a literature search on seal predation and out of 5680 seal stomachs examined in a multitude of studies, only nine records exist for Atlantic salmon predation. After further examination of these nine records, it was further determined that only two of these records were valid. These included one stomach that contained six Atlantic salmon otoliths and one stomach which contained one Carlin tag. As a point of discussion, it was note that if all five million Harp seals consumed 100% of Atlantic salmon biomass in the Atlantic Ocean, Atlantic salmon would be only 0.01% of their annual diet. Therefore, documenting Atlantic salmon predation is exceedingly difficult.

During trapping operations in Maine (permanent adult trapping facilities on the Penobscot and Narraguagus rivers; semi-permanent trapping facility on the Dennys River) incidents of scarring and injury on adult Atlantic salmon have been observed. Two general categories of injuries have been recorded. Old or healed injuries are generally observed around the belly/vent/peduncle, these fish often demonstrate a severe growth check upon examination of scales and are generally smaller fish (as compared to those of a similar age class). Fresh injuries (assumed to have occurred in the river or estuary) are often observed all over the body and may actually be the result of catch-and-release angling, injuries sustained during attempts to ascend the fishway or rocks around the Veazie dam, or fish that have been recaptured (meaning they went back downstream either through the turbines or over the dam). There is a significant need to verify assumed seal scars and injuries.

The Maine Atlantic Salmon Commission has recorded suspected seal bit injuries since the late 1960s, and has recent begun to photograph suspected injuries. The number of recorded seal injuries (in Maine) rose from an average of 1-2% during the late 1960s through the early 1990s to12% of returning two-sea-winter adults in 1998, although there are significant questions concerning the consistency of wound identification over this period.

Marine Mammal Predation Discussion:

During a discussion of spatial distributions of seal colonies, it was noted that there were little or no correspondence between spatial distributions of haul out areas along the coast and food sources or habitat characteristics. Spatial distribution of colonies along the coast appears to be regulated by spatial distance between colonies, which decreases as overall population levels increase.

The committee discussed current efforts to rehabilitate stranded pinnipeds, noting that stranding mortalities are insignificant relative to current population sizes and growth rates. New England Aquarium is currently the only facility that rehabilitates orphaned pups, although there is a new facility proposed to be located around the Saco River. These facilities receive federal funding for marine mammal strandings, usually for whales, but also including pinnipeds.

Questions were raised concerning the management targets for restoration of U.S. seal populations. Because no baseline estimates of seal populations are available, there is a great deal of uncertainty relative to the optimal population sizes for seal populations. Relative compatibility with human activities may be limiting factor governing habitat utilization. The Marine Mammal Protection Act states that marine mammals should be restored to levels where they are functioning components of marine ecosystems. The act is unclear in the sense that it fails to provide guidance relative to populations that exceed either optimal population levels or carrying capacity.

The committee discussed the correlation between the growth of the harp seal population and the correlated decline in Atlantic salmon populations. It was noted that this correlation would be less evident if Atlantic salmon and seal numbers were tracked back further in time.

The committee discussed the issue of seal attacks on salmon net pen aquaculture operations, noting that net damage during these attacks may facilitate the release of net pen Atlantic salmon into the marine environment. It was noted that frequency of attacks on net pen facilities is highest during late winter (February and March), and a few individual seals may specialize in this type of behavior. Additional studies, including visible marking studies of are needed to characterize spatial distribution patterns of individual seals in the vicinity of net pen operations.

A request was distributed through the ICES North Atlantic Salmon Working Group to complete salmon scarring reports for returning adults with detectable scarring. David Cairns (DFO - Prince Edward Island) developed this initiative to track trends in wounding rates among North American salmon stocks. Ed Baum will coordinate this effort including distribution of forms and contact information for D. Cairns. Completed forms should be returned directly to D. Cairns.

The committee discussed the possibility of photo documentation of adult returns with visible wounds, noting that photo documentation would allow for standardization of wound classification among river programs. Questions were raised concerning the use of data, and the need for digital vs. conventional photographs. It was suggested that photo documentation would ensure consistency between river programs allow for the development of standard characteristics for classifying wounds. It was suggested that considerable documentation of known seal damage could be collected by photo documenting a seal attack at a net pen facility, but concerns were raised about whether seals exhibit natural attack behavior while feeding within a net pen environment. Several river programs indicated a willingness to photo document wounds, if sufficient resources were available to support the effort.

5.2. CURRENT RESEARCH ACTIVITIES

The following includes Atlantic salmon research abstracts that were submitted to the assessment committee in 1999. The capital letters (codes) following the authors names refer to the address of the research facility or office of the first author. These addresses are listed at the end of the Section.

SMOLTIFICATION AND SMOLT ECOLOGY

Effects of acidity and aluminum on Atlantic salmon smolts in Maine

Terry Haines (J)

In Sweden, Norway, and Nova Scotia, Canada, atmospheric deposition of strong acids ("acid rain") has results in rivers with acidic, aluminum-rich waters that are toxic to early lifestages of Atlantic salmon (Rosseland et. al. 1986; Watt 1987). Extensive research in Maine rivers has demonstrated that such toxic conditions are not common there, occurring only occasionally in smaller tributary streams (Haines et. al. 1990). Therefore, mortality in freshwater resulting from acid rain cannot account for the decline in Atlantic salmon stocks in these rivers. After spending two to three years in fresh water, Atlantic salmon juveniles begin their downstream smolt migration in spring. Prior to their movement from freshwater to seawater, juvenile Atlantic salmon undergo morphological and physiological changes (collectively known as the parr-smolt transformation or smolting) that includes development of salinity tolerance (McCormick and Saunders, 1987; Hoar 1988). Reorganization of osmoregulatory mechanisms makes this developmental stage sensitive to external stressors such as acid and aluminum exposure. It has been known for some time that long-term exposure of smolts to pH 5.0, which has little impact earlier in development, will completely inhibit development of salinity tolerance and thus result in death when fish are moved from freshwater to seawater (Saunders et. al. 1983). Recently, however, Norwegian scientists have discovered that smolt saltwater survival is affected at levels of pH (about 6) and aluminum (150 ug/L) at spring runoff when salmon are beginning to smolt (Haines 1987). Atlantic salmon survival in freshwater was not affected by these conditions, but saltwater survival of out-migrating smolts has not been previously been investigated in Maine, and may be affected by acidity levels not affecting freshwater survival. Chemical conditions similar to those in the Maine rivers have been found in some of the tributary streams in the Connecticut and Merrimack river systems as well (Haines and Akielaszek 1984), and delayed mortality may also occur there. The objectives of the study are: 1. Determine the physiological changes associated with smoltification in Atlantic salmon parr exposed to natural river water (Narraguagus River, Maine) and a reference water (ground water) to elucidate the effects of acidity and aluminum in river water on fish physiology. 2. Determine if morphological changes in gill tissue consistent with exposure to acidity and aluminum occur in Atlantic salmon smolts exposed to Narraguagus River water as compared to smolts reared in reference water. 3. Compare migratory behavior in Atlantic salmon smolts exposed to Narraguagus River water and to reference water by tracking movement of fish using ultrasonic tags. Results show that wild Atlantic salmon smolts have impaired osmoregulatory ability as compared to hatchery smolts. A salt challenge test caused elevated blood chloride levels, lethargy, and death in a few individuals of wild origin, but had no effect on hatchery fish. Fish implanted with transmitters had high survival, but wild and hatchery fish had different migratory behavior patterns. Hatchery fish left the river quickly, making very few reverse movements in the river. Wild fish moved more slowly and made numerous reverse movements in the river, avoiding entering saltwater for an extended period. These results suggest that wild smolts are exposed to some condition in the river environment that impairs their ability to adapt to seawater, and may contribute to increased mortality.

An individual-based approach to evaluating the relationship between habitat choice, life history strategies, and smolt production

Benjamin H. Letcher (A)

Most previous studies examining growth and survival of fishes have focused on population-level phenomena. In this study we use an individual-based approach to examine the mechanisms regulating growth and survival of Atlantic salmon. Our goal is to assess the relationship among growth, survival, habitat choice, maturation and migration timing of individual juvenile Atlantic salmon in three different watersheds of the Connecticut River basin. Our specific objectives are to 1) establish growth trajectories by resampling individual juvenile salmon; 2) compare growth trajectories of individuals within and between year classes among stream and years; 3) assess relationship among individual growth trajectories, subsequent growth, survival, habitat choice, maturation and migration timing; 4) evaluate extent of site fidelity of individuals; 5) conduct monthly mark-recapture population estimates during spring, summer and fall for two years; and 6) develop a mechanistic model of juvenile salmon growth and survival using data from individual salmon. Identifying and understanding the mechanisms regulating growth and survival of juvenile Atlantic salmon should assist managers in making decisions about stocking strategies, habitat restoration and manipulation as well as strategic effort planning, and could lead to a better understanding of smolt production and ultimately adult returns. By tagging and resampling Atlantic salmon parr in a small stream (1 km study section of West Brook, Whatley, MA), we are developing a record of the growth, movement and maturity of individual fish. From 5/14/97 to 10/9/97 we tagged 556 age-one and age-two parr during seven sampling sessions. We used electroshocking to sample the study stream the first and seventh session and used kick seines at night during the other sessions. By the seven sample, 96.7 percent of the parr were recaptures. Twenty percent of the fish (111 fish) were tagged and captured three times, 17 percent once and three percent all seven times. Fish grew rapidly during the early summer (0.28d) but most fish lost mass (-0.03d) during the summer and early fall. The first mature fish were observed on 8/6 and by 9/29 50.8 percent of the fish in the stream were mature (expressing milt). In spring, fish that eventually matured were 13 percent heavier (25.6 g vs. 22.6 g) than fish that did not mature, but by fall maturing fish grew slower and were 5% lighter than non-maturing fish. Movement of individual fish was minimal over the course of the summer; over 95 percent of the fish were recaptured each time in the same 20-m stream section.

Impact of stream habitat improvement on smolting, maturation and survival of Atlantic salmon

Stephen McCormick, Mark Shrimpton, and Kevin Whalen (A)

Recently, enhancement of Atlantic salmon in New England has changed from a strategy of smolt production to a colonization program which stocks fry in tributaries. This change in strategy has placed a greater importance on stream habitat. Atlantic salmon have a very flexible life history pattern and rate of development, which is controlled by environmental variables. Consequently, the rearing environment will regulate important changes in developmental physiology of the animals. There are many areas that will impact on success of the fry stocking program. Areas of interest to this study are parr maturation, overwinter mortality, smolt production and the timing of smolt migration. These three factors are not mutually exclusive as available energy reserves (primarily as lipids) affect developmental patterns in juvenile Atlantic salmon. Parr maturation is believed to directly impair smolt development. The metabolic cost of maturation may also reduce overwinter survival. We intend to investigate how environmental variables affect energy reserves for overwinter survival and maturation, and how these will in turn affect smolt production from fry stocked into tributaries of the Connecticut River. The U.S. Forest Service has taken an active role in upgrading rearing habitat for fry stocked into small tributaries of the Connecticut River. Habitat manipulations have been made in an attempt to increase productivity within some reaches of small streams. It is not known whether such habitat management will have an impact on smolt production and parr maturation in these rivers. It is important, therefore, to monitor physiological development of juvenile salmon from different rearing habitats within natal streams and identify which habitats enhance the production of smolts. Our project will compare tributaries that have been improved with streams that have not been improved to identify conditions optimal for proper development of smolt physiology. Ultimately physiological condition of the fish will determine maximum smolt productions. Research Objectives: 1. Determine growth rates and biochemical indices of growth for juvenile Atlantic salmon from different tributaries of the Connecticut River, including manipulated and non-manipulated sections. 2. Determine the role of energy acquisition as total lipids on parr grow ht rates, maturation and survival. Compare for different tributaries of the Connecticut River. 3. Determine what effect size, maturation and energy reserves have on overwinter survival and smolt development. 4. Examine physical and biological factors that affect winter energy reserves in mature and immature Atlantic salmon. In order to understand the possible impact of energetics on winter survival, we have been examining growth and energetics of juvenile Atlantic salmon in several tributaries of the Connecticut River, and comparing fish that mature as parr to immature fish. In the fall immature and mature Atlantic salmon parr did not differ significantly in size, although the mature fish had significantly greater condition factor. Testes of mature males comprised up to 10% of body weight in October. Testes reabsorption over the winter was gradual, and was still approximately 2% by the end of March Plasma androgens were significantly greater in mature male parr than immature parr in October, but had declined by January and did not differ from immature fish for the duration of the study. In the mature fish gonadal regression was linear with time over the winter, however, condition factor declined significantly in early winter. In contrast immature fish showed a small and insignificant reduction in condition factor over the winter. Utilization of both proteins and lipids over the winter was higher in fish that had matured in the fall compared to their immature counterparts. The reduced lipid and protein content may lead to greater overwinter mortality and result in fewer males smolting the following spring. Laboratory studies are currently being conducted to determine the impact of temperature on winter energetics. Further field work relating individual size and energy content to overwinter survival is also being examined.

Bioenergetics of Age-1 Atlantic salmon in Vermont tributaries

Donna L. Parrish and James R. Olsen (B)

Past research has focused on energetics of age-0 salmon as related to survival during the first summer of life. In contrast, this study will provide a bioenergetics perspective to the age class of salmon that can potentially become smolts the following spring. By using a bioenergetics modeling approach, this study will tease apart the influence of external factors (e.g. water temperature, velocity, and food) and reproductive costs of maturing parr, which affect growth and subsequent smolting of age-1 salmon in selected Vermont tributaries.

Expected results from this study would include: 1) predictions of individual growth and numbers of smolts leaving study tributaries, 2) determination of the contribution of variables (e.g. water temperature, velocity, food, and maturation) to salmon growth, 3) through sensitivity analysis of model parameters, determination of which factors contribute the greatest variability to the model, and 4) making recommendations of future data needs on highly sensitive model parameters.

This research will provide management agencies with more detailed information on which tributaries provide salmon with faster growth and possible, more become smolts, and which factors are likely responsible for those patterns. Through bioenergetics modeling, we also will be able to better direct future sampling such that we can focus on gathering data that will provide the greatest benefits. With this added understanding, there is potential for management agencies to modify stocking strategies such that smolt numbers can be maximized for each tributary regardless of the limitations to overall productivity in specific tributaries.

Environmental and hormonal regulation of sensory biology and behavior of hatchery and wild populations of Atlantic salmon smolts

Stephen McCormick and Gayle Barbin (A)

Environmental and endocrine factors that regulate sensory and behavioral changes during the parr-smolt transformation of Atlantic salmon are virtually unknown. Naturally migrating wild and hatchery fish will be examined to monitor environmental and endocrine changes which influence sensory biology and migratory behavior. In the laboratory, environmental conditions will be manipulated to determine how sensory biology, migratory behavior, and hormone levels are affected. The olfactory morphology of some naturally migratory and hatchery-reared smolts will be examined to determine changes in morphology occurring during the downstream migration. Hatchery releases will be conducted to provide information on the efficiency of the smoltification process of hatchery-reared versus wild fish. This will have implications for release of salmon as fry, parr or smolt and vastly improve currently used hatchery rearing and release practices. The determination of environmental and hormonal changes affecting smoltification and migratory behavior may provide salmon restoration programs information about hormone levels required for appropriate migratory behavior and imprinting to increase return rates of hatchery fish and minimize the negative effects of imprinting to increase return rates of hatchery fish and minimize the negative effects of barriers to downstream migration in both hatchery and wild fish. This research program will entail the following objectives: 1. Laboratory maintained and wild smolts will be examined to determine behavioral changes exhibited on a seasonal basis as they relate to environmental and hormonal changes. 2. Olfactory morphology of wild and hatchery reared smolts will be examined to monitor changes in sensory biology which might be linked with ultimate homing and migratory success. 3. Naturally migrating wild and hatchery smolts will be monitored to examine the impacts of dams on hormonal changes. 4. Estuarine migration of smolts will be examined to determine the connection between physiology, behavior, and the loss of smolt physiological characters during estuarine migration. 5. Laboratory maintained smolts treated with hormones will be examined to monitor endocrine changes which influence migratory behavior. Effective restoration of Atlantic salmon necessitates an understanding of survival through critical periods of the life cycle. A major assumption of fry stocking, a management practice that has expanded considerably, is that smolts reared in the wild can successfully migrate from the freshwater to seawater environment. However, we know little about the behavioral aspects associated with successful movement downstream while we have a fairly good understanding of the physiology associated with transition between these two environments. Using passive integrated transponder (PIT) technology, a system was developed to continuously monitor downstream behavior in both laboratory and field settings. PIT tags, with individual codes, were implanted in all fish before they were placed in experimental tanks. We used five and eight foot diameter annular tanks to continuously monitor downstream migratory behavior from 12 April - 24 July 1997. Changes in daily activity rhythms were evident and parr (control fish) demonstrated significantly less movement than smolts under the same conditions. An advanced temperature regime 1¶o9C increase every 3 d) induced increased activity earlier in the season than the ambient (control, 1¶o9C increase every 4 d) temperature regime. The delayed regime (1¶o9C increase every 9 d) delayed behavioral and physiological activity relative to the ambient regime, indicating that cooler temperature extends the period of downstream migration. Experiment conducted in 1998 examined the influence of changes in day length (photoperiod) on downstream migratory behavior. Short days results in no downstream migratory activity, whereas long days administered early advanced the cycle of migratory behavior. These results indicate that increased daylength is necessary for normal development of downstream migratory behavior in Atlantic salmon smolts. Files analyses of downstream migratory behavior have ben initiated in Massachusetts and Vermont.

Smolt production dynamics of an Atlantic salmon population in eastern Maine

J. F. Kocik, K. F. Beland, T. Sheehan (G)

US anadromous Atlantic salmon populations with a substantial naturally reproducing component are restricted to less than ten rivers in eastern Maine. Population dynamics modeling conducted from 1990-1996 has indicated that these populations are declining. To identify causes for this decline, we initiated a program to quantify smolt production in the Narraguagus River, Maine. We conduct annual geographically-stratified basinwide estimates of large parr (>130 mm) abundance using electrofishing in late summer. The following spring, we monitor the emigration of Atlantic salmon smolts using rotary screw fish traps to obtain stratified mark-recapture population estimates. Since 1996, large parr estimates have ranged from 11,700 to 27,000 and while corresponding emigrating smolt estimates ranged from 2,800 to 3,600. Even in years with substantial increases in large parr production (126%), smolt production has increased only modestly (3%). By using spatially and temporally explicit growth data from scale analysis, we are able to adjust our pre-smolt population estimates to exclude parr too small to emigrate the following year. These corrections will provide a more accurate assessment of winter mortality for comparison with climate data. Total smolt production in this watershed is well below the estimated production capacity (18,000) and warrants further examination.

Atlantic salmon overwinter survival and smolt production in the Narraguagus River

J. F. Kocik, K. F. Beland, T. Sheehan and L. Suslowicz (G)

We monitored the emigration of Atlantic salmon smolts in the Narraguagus River from 14 April to 03 June 1999 using five rotary screw fish traps. Two traps were located at river km 14 (Crane Camp), two were located at river km 17 (Little Falls), and one was located at river km 8 (Cable Pool). We marked smolts with partial fin clips at Little Falls and recaptured them at Crane Camp to perform a stratified population estimate. These sites are downstream of approximately 80% of juvenile rearing habitat in the basin. A trap was set at Cable Pool to evaluate production and overwinter pre-smolt residence in the lower river below the Crane Traps. Additionally this trap allowed us to document migration of hatchery smolts released just upstream of this trap. We captured a total of 1,136 smolts in the Narraguagus River. All were in excellent condition upon removal from the traps, and no trap-related mortality was observed. Smolts averaged 175 mm total length and 48 g wet weight (n =509). While these smolts were shorter than those observed in the previous three years, they were also heavier indicating a higher condition factor. We collected scale samples from a sub-sample of 234 smolts. Age-2 individuals (96%) dominate Narraguagus River smolt population with a small percentage of age-3 fish (4%) present. The timing of emigration for wild smolts was normally distributed with 6 May being the date of 50% emigration, the earliest peak in our 4-year time series. This emigration timing was 17 days earlier than 1998 and 4/5 d earlier than 1996/1997. Utilizing a Darroch maximum likelihood model, our preliminary estimate of the emigrant smolt population in 1999 is 3,607. This preliminary estimate is significantly ($P < 0.01$) higher than previous estimates of smolt production from 1996-1998. We used simulation modeling of the error bounds on this estimate and basinwide estimates of large parr abundance to calculate an average overwinter survival of 14.3% (range 8.6% - 22.3%). Overwinter survival in 1999 was significantly lower than observed in 1997 (24.4%, range 12% - 38%) and not statistically different from 1998 estimates. There was a 99% probability that overwinter survival was below 30%, a minimum value often reported in the literature for this species.

Atlantic salmon smolt production in the Pleasant River.

To determine if recent pre-smolt and marine survival estimates on the Narraguagus River are representative of other downeast Maine Atlantic salmon rivers, we initiated a similar study on the Pleasant River. From April 22, 1999 to June 01, 1999 smolts were caught on the Pleasant River. A 5' diameter rotary screw smolt trap was deployed near the head of tide in Columbia Falls on 21 April, and it was tended daily through early June. A total of 676 smolts (mean length 174 cm) most of apparent wild origin were captured between 22 April and 29 May. The smolt catch exceeded expectations and suggested that this trap was intercepting a higher proportion of the smolts leaving the Pleasant River than any individual trap on the Narraguagus River, where trap efficiency is consistently less than 20 percent. Tissue samples for DNA analysis and scale samples were systematically collected from the Pleasant River smolt run. Small numbers of smolts were also systematically sacrificed on several dates for disease sampling and physiology testing. In addition to the probable wild fish, we also captured 31 smolts with fin deformities, coloration, and body form suggesting that they were of hatchery origin. Scale samples and tissue samples for DNA were collected from these fish, which were also sacrificed for disease analysis. NEFSC staff measured all scales and conducted image analysis to determine if scale characteristics are distinct enough to facilitate identification of other hatchery origin fish. These investigations are ongoing and results should be completed in mid-2000. Plans for sampling in 2000 will include the addition of marking sites at the Pleasant River weir which will enable a population estimate of smolts emigrating from this system.

MARKING

Reproduction and alevin marking techniques for Atlantic salmon.

William F. Krise (E)

This project has two separate parts: 1) testing methods to improve gamete handling and fertilization of eggs, and 2) development of a fry marking method for Atlantic salmon. Losses of salmon eggs fertilized and transported to incubation facilities precipitated the first study, to determine whether short-term gamete storage methods could be improved, and whether transportation of eggs or hatchery handling procedures were the main cause of mortalities. We intended to determine how routine egg handling procedures affected mortality and to find improved sperm storage methods for varying situations which occur within the Atlantic salmon restoration program. Eggs were tested with a mechanical egg shock device to determine susceptibility to breakage over the first six hours after fertilization. The second portion of study deals with development of an inexpensive method of biochemical marking with nonlethal sampling procedures for Atlantic salmon fry. There are several outcomes. Improvement over current sperm storage methods, which allow for safe handling of gametes, and high fertilization rates after 4 to 24 hours of storage before egg fertilization. We also are investigating unusable males due to their production of non-motile sperm. If possible, we will do the same for infertile kelts (Atlantic salmon females which have spawned once). We hope to determine causes of the problem and manage for more fertile broodstock. Hatchery personnel are already handling eggs with greater care than before, after results of an initial test showing that low mechanical egg shocks increase egg mortality. Currently no inexpensive method of stock identification is in use for recovery of tags (or marks) in juveniles or adults marked as fry. Because of this, managers cannot differentiate wild from domestic fish nor determine fish origins. We expect to provide a marking method and a simple method of mark identification. Atlantic salmon marked as fry have been tested through 30 months after application of the mark in fry. We are able to detect protein in blood 30 months after exposure as fry. Under development is a method of mark identification which will allow detection of protein and its tags using a hand held meter rather than a blood test. We are currently constructing this device. The marking process should be useful for identification for groups of several types of fish stocked as larvae or fry, or for other identification purposes. Results of effects of mechanical egg shock on eggs showed that greater care was needed in handling of eggs through the disinfection and initial incubation stages. We found effects of urine dilution on sperm and found two sperm diluent useful for the short term storage of sperm. A successful biochemical fry marking method has been developed.

Use of fast balneation (osmotic induction) techniques to induce a calcein mark in Atlantic salmon sac-fry

Jerre W. Mohler (G)

We explored the use of osmotic shock techniques on Atlantic salmon sac-fry to induce permanent calcein marks. We used a combination of salt baths followed by immersion in concentrated calcein solutions to rapidly induce a calcein mark in caudal fin tissue in February 1999 Atlantic salmon sac-fry. Immersion trials will consist of calcein static baths with three replicated in 6.5 liter jars each containing non-feeding Atlantic salmon fry of Connecticut River domestic origin. Salinity tolerance for 3.5 minutes will be tested at levels ranging from 0.5-5.0%. Once salinity tolerances were determined, the information was used to set up the osmotic shock or osmotic induction of calcein at concentrations ranging from 1.0-2.0%. Results showed: 1) Fish which received 5% salt for 3.5 minutes had great 5- day survival than all others (including controls) suggesting that salt had some therapeutic effect. 2) Fish behavior appeared to be unaffected when exposed to salinities of 0.5-5.0%.

Calcein mark induction: batches of salmon were marked in effectively in seven minutes using immersion i 1% salinity for 3.5 minutes followed by a 3.5 minute immersion in 1% calcein.

Development of prototype hand-held calcein detection device

Jerre W. Mohler (G)

As part of the continuing development of fry marking and mark-detection techniques, the Northeast Fishery Center, of the U.S. Fish and Wildlife Service, completed a U.S. Department of Interior Report of Invention form for a potential patent concerning both a bench-top and hand-held calcein detection device which will make it feasible to quickly and efficiently detect fluorescent marks on individual fish such as Atlantic salmon under rigorous field conditions without the need for a microscope. Preliminary results show promise that fish marked as fry can be identified for the batch-mark as two year olds. The prototype device was field tested on emergent chum salmon in Alaska by the U.S. Geological Service-Biological Resources Division in April 1999.

Examining the feasibility of using strontium to mark Atlantic salmon fry

Ruth E. Haas-Castro (G)

The goal of this study was to evaluate the usefulness of a strontium chloride immersion bath to mark Atlantic salmon fry for subsequent identification in river collections as parr, smolts, or adults. This technology has been successfully used to mark chum and sockeye salmon with identification of fish still possible 21 months after marking. Investigators found these marks in Pacific salmon through sampling of otoliths, vertebrae, and opercula. These lethal forms of sampling will be of limited utility for Atlantic salmon given present low abundance. Specific objectives of this project were to 1) confirm the presence of these chemical marks in lethally sampled boney parts of Atlantic salmon and 2) to investigate the detection of these marks in nonlethal samples of scales and fin rays using scanning electron microscopy. Young salmon fry immersed in strontium chloride solutions absorbed and deposited visible strontium rings in otoliths, thus supporting the findings of other researchers. However, it was not possible to distinguish a visible strontium mark in the scales or fin rays of the same fish. The lack of a visible strontium mark in the scales and fin rays could have one of several possible meanings: (1) The marks are there but the samples were not prepared in a sufficient manner to detect them, (2) the fish were not immersed long enough for the strontium to be taken up by these structures, or (3) strontium is not taken up in the structures in the same manner as in the otolith. I believe the second theory is probably the explanation. Although it has been shown that fish immersed in relatively low levels of strontium chloride for 24 h reveal strong marks in otoliths, studies analyzing scales have immersed fish for a much longer period of time, i.e. 30 or 60 days. Brian Mckeown of Simon Fraser University indicated (personal communication) that it would be unlikely for scales to take up enough strontium in a 24 h period to create a recognizable mark. Due to the lack of promising results, we have no current plans to continue research on this topic.

Investigations into striped bass ultrasonic tag retention rates

T.F. Sheehan, J. F. Kocik, and K. F. Beland (G)

We have documented predation by a striped bass Morone saxatilus on an ultrasonically tagged Atlantic salmon Salmo salar smolt. Ultrasonic telemetry transmitters continue to function after ingestion by predators, causing researchers to unknowingly gather data from non-targeted organisms. An understanding of intragastric tag retention rates and movement patterns for these predators is essential for discriminating between false-target versus true-target species. We compared pinger retention rates for striped bass that had: 1) voluntarily ingested smolts which contained surgically implanted sham pingers (n=20); 2) received sham pingers by manual insertion into the gastric cavity (n=6); and 3) received sham pingers by surgical implantation into the body cavity (n=20). We found a maximum intragastric retention of 58 days for ingested pingers and 76 days for inserted pingers, with medians of 17 and 24 days, respectively. An intraperitoneal tag retention rate of 100% was observed with the surgically implanted pingers after 22 days, at which time the experiment was terminated. These data, coupled with movement information for striped bass, will allow investigators to differentiate between normal smolt behavior and predation events that result in false-target data. (American Fisheries Society 1999 Meeting Poster Presentation- Contributed Paper)

Evaluation of successful migration, nearshore marine growth rates, and adult returns using marked hatchery smolts stocked at specific locations in the Penobscot River

R. Brown, F. Trasko, M. Loughlin, R. Haas-Castro

Adult returns from hatchery stocked age 1+ smolts are critical to maintaining a suitable supply of sea-run broodstock for future restoration efforts in the Penobscot River. Return rates from age 1+ smolt stocking have declined significantly since the late 1980s. To evaluate successful smolt migration, nearshore marine growth rates, and adult returns, we elastomer marked 166,000 hatchery smolts at Green Lake National Fish Hatchery to be released in Spring 2000. Unique batch marked lots of 24,000 smolts each will be released at each of three primary release sites (Piscataquis River, Mainstem – Howland area, and Mainstem – Mattawamkeag area) on two different release dates. In addition, 16,000 marked smolts will be stocked in smolt ponds managed by the Penobscot Indian Nation.

Emigrating smolts will be sampled through a smolt trapping program in the lower Penobscot River. Recovery of elastomer marks will allow for relative comparisons of overall migration success, transit times, and temporal patterns in migration among smolts stocked at major stocking locations. Comparison of length frequency distributions between stocked groups and successfully migrating smolts will allow for evaluation of size related trends in migration success. Elastomer marks will also be recovered from returning 1SW and 2SW adult fish captured at Veazie Dam. Scale samples collected from elastomer marked adults will be analyzed to derive nearshore marine growth rates and backcalculate size at release. Comparison of adult scales to scales collected from marked hatchery smolts just prior to release will allow for confirmation of hatchery and freshwater growth zones.

CULTURE/LIFE HISTORY

Growth pattern of Labrador Sea Atlantic salmon post-smolts and temporal scale of recruitment synchrony for North American salmon stocks

Kevin Friedland (P)

We examined scale samples from historical collections of post-smolts made in the Labrador Sea with the aim of comparing their post-smolt growth patterns with those for returns from stocks at the southern end of the range of Atlantic salmon in North American. Since Labrador Sea post-smolts are believed to represent the juvenile nursery for the entire stock complex, the growth variation for southern stocks may yield insights on the time scale of stock mixing during the post-smolt year. Circuli spacing patterns were extracted from the scales of 1,525 salmon for three smolt years. For two of the three years, growth trajectories for fish from the southern stocks intersected the trajectories for Labrador Sea post-smolts after 4-5 circuli pairs. The data stocks begin to experience similar environmental conditions by June or July of the post-smolt year, or one to two months after their migration to sea. In some years, however, it would appear this mixing does not occur until fall. These data provide the first indication of the time scale during the post-smolt year that regional effects may be acting on stocks to produce synchronous recruitment.

Evaluation of alkalinity enhancement of Craig Brook National Fish Hatchery water on Atlantic salmon production

Terry Haines, Benjamin Spaulding, Stephen McCormick, Barnaby Watten, and William F. Krise (J)

The Craig Brook National Fish Hatchery, East Orland, Maine, is the oldest Atlantic salmon production hatchery in the United States. This facility is scheduled for significant expansion and modernization to support the hatching and rearing of river-specific Atlantic salmon fry (and possible smolts in the Future) for enhancement of stocks in Natal rivers. The present Hatchery water supply, Craig Pond, is generally of high quality except that alkalinity (acid neutralizing capacity, ANC) is relatively low. During dry periods when alkalinity is expected to be at the maximum for the year, the water had a total alkalinity of 4 mg/L as CaCO,3. (80 ueq/L ANC); during spring runoff alkalinity is likely to be less than half this value. Although this exceeds the estimated critical minimum of 20 ueq/L for this species (Lien et. al. 1996), the margin of error is low. Further, this low NAC may allow pH values to fluctuate greatly, in response to acidic inputs from rainstorms or snowmelt. In 1996 a snowmelt event caused mortality of 2.5 million Atlantic salmon fry at the North Attleboro National Fish Hatchery, and some fry from Craig Brook showed clear evidence of gill damage consistent with low pH/high aluminum. In addition, the geologic formation in this area, the Lucerne Granite, is high in fluoride and beryllium, and therefore the water supply is likely enriched in these minerals also. Fluoride enhances solubility of aluminum and can increase fish mortality (Hamilton and Haines 1995). Beryllium affects fish gills in a manner analogous to that of aluminum, but at much lower concentrations (Jagoe et. al. 1993). The alkalinity of the hatchery water can be increased by addition of calcium carbonate, which would provide protection from fluctuation in pH and would reduce solubility of aluminum. However, the effects of rearing Atlantic salmon fry or smolts in high alkalinity water and then stocking them in rivers that are relatively low in alkalinity are unknown. The optimal alkalinity for the various lifestages of Atlantic salmon is also unknown, although current practice in Norway recommends a water pH of 6.5 (or about 100 ueq/L ANC) during smoltification. This study will evaluate fish quality and survival under three water quality conditions (control, low, and high alkalinity), including monitoring for growth, survival, and physiological parameters.

Relative survival of hatchery Atlantic salmon fry released at different stages of development and from different maternal origin

Benjamin H. Letcher (A)

Fry stocking is a major component of the Atlantic salmon restoration effort. Yet methods to maximize survival of fry have not been evaluated. Two major sources of potential variability in survival are developmental stage at stocking and maternal origin (domestic, kelt, searun). Results from these experiments will allow managers to fine-tune stocking schedules (developmental stage studies) and to evaluate relative success of programs stocking fry from domestic, kelt, or searun mothers. Results will contribute significantly to increasing the effectiveness of the Atlantic salmon restoration effort.

Molecular mechanism of olfactory transduction in Atlantic salmon

Weiming Li (R)

The population of a number of anadromous fish species which form the basis for economically important sport and commercial fisheries (value ranging into the billions of dollars) are currently being managed or augmented by fish reared in federal hatcheries. Upon leaving the hatchery environment, these fish are exposed to a large number of environmental perturbations (heavy metals, pesticide residues, thermal plumes, etc.) which may have a direct impact on the chemosensory (taste and olfaction) organs. The impact of many of these perturbations on these tissues has not been extensively studied. More specifically, what role impaired chemosensory function may have on the ability of the fish to recognize a home stream and its ability to return to this area to spawn, or to recognize and locate food or danger has been mostly ignored in the literature. This is of particular importance for the success of continued hatchery operations directed towards enhancing or reestablishing a fishery in a particular area for those commercial operation involved in ocean ranching. This particular research project will examine the physiological and morphological impacts of environmental perturbations on the chemosensory organs of Atlantic salmon and will also attempt to identify factors (both environmental and chemical) which may serve to enhance the imprinting and homing of hatchery reared fishes. Identification of chemosensory cells has been completed for Atlantic salmon. Some genetic study has been completed on the G-proteins. The application of known chemicals found in Atlantic salmon rivers will be used to challenge fish taste cells.

Physiological and endocrine changes during hatchery rearing and release of Atlantic salmon in hatchery and in the wild

Stephen McCormick (A)

The parr-smolt transformation is a complex series of developmental events that prepares migratory salmonids for downstream migration and seawater entry. Failure to complete this developmental process can result in poor seawater survival, growth and return rates. This development is responsive to a number of environmental factors, including photoperiod, temperature and stress. The precise role and interaction of these environmental factors is important for altering the timing of the parr-smolt transformation, determining whether complete smolt development occurs in hatcheries, and assessing the possible impact of dams on smolt migration. New methods for increasing adult returns will be explored in these studies, along with assessment of the physiological impact of these treatments. Objectives: 1) Determine the physiological stress response of juvenile Atlantic salmon and the impact of stress on the parr-smolt transformation and salinity tolerance. Monitor stress during stocking of Atlantic salmon for its possible impact on adult returns. 2) Determine whether acclimation to an estuarine net pen will decrease stress, increase physiological changes associated with the parr-smolt transformation, and increase adult returns. 3) Determine whether photoperiod can be used to alter the timing of the parr-smolt transformation in a hatchery so as to increase adult returns. 4) Compare physiological and endocrine changes in hatchery and fry released or wild fish to determine if differences exist that could serve as guidelines for improving hatchery rearing. 5) Determine whether dams or impoundments have a negative impact on normal development or survival of hatchery and fry-released Atlantic salmon during the smolt migration.

River-specific egg size for Downeast Maine Atlantic salmon: a pilot study

Ruth E. Haas-Castro (G)

Egg size and fry development were examined in Atlantic salmon from six Maine rivers: the Narraguagus, Dennys, Machias, East Machias, Sheepscot, and Penobscot. Atlantic salmon in the Penobscot River are from sea-run progeny of fish stocked as smolts. The other populations are from captive-reared parr collected from remnant stocks of Atlantic salmon. Growth of Atlantic salmon was monitored from newly spawned eggs in November 1998 to sac fry in May 1999. Egg diameters, perimeters, and areas were extracted from digital photographs of the eggs by using image analysis software. Penobscot River eggs were significantly smaller ($P<0.05$) than the eggs of the other populations except for the Narraguagus eggs. However, non-invasive sampling (i.e., photographic documentation) of production-scale egg trays is not a viable option for accurately measuring eggs and larvae. Images at the fry stage were so crowded that even exploratory analysis could not be completed. Eggs and fry need to be photographed in less crowded conditions with a more contrasting background. I am developing new methods for measuring egg and larval properties and briefly discuss these. (Oral Presentation at the American Fisheries Society Southern New England Chapter Meeting, January 12, 2000)

ATLANTIC SALMON CONSERVATION/MANAGEMENT

Comparison of Atlantic salmon marine growth and scale characteristics for three Maine rivers

T. F. Sheehan, J. F. Kocik, E. Atkinson, G. Horton, and D. Ouellette

The goal of this project is to evaluate the marine growth rates, scale morphology, and visual implant elastomer (VIE) tag retention rates for Atlantic salmon from Dennys, East Machias and Machias River raised in commercial netpen operations at two marine sites. Specific objectives are to 1) assess the marine growth rates for individual Atlantic salmon and compare these rates among stocks and two net pen sites; 2) evaluate circuli and annuli formation and timing of deposition for Atlantic salmon raised in captivity within the marine environment; 3) assess retention rates for the visual implant elastomer (VIE) tags applied to these smolts; 4) and to investigate the empirical relationships between fish growth and scale growth for Atlantic salmon from these three stocks. In March 1998, we marked 6,090 of the smolts that were designated for grow-out in marine netpens with double VIE in the right eye and the right jaw in addition to the adipose fin clip. These fish were comprised of two stocks, Dennys (2,020) and East Machias (2,020), reared at the Solon facility and one stock, Machias (2,050), reared at the Oquossoc facility. Each of these stocks were divided into two approximately equal lots and transferred to commercial netpen operations at Cross Island and Deep Cove. We collected biological data on these smolts in May 1988 prior to transfer from hatcheries and on postsmolts in June, July, October, and November 1998 from netpen facilities. Data collection is continuing through early and preliminary data analysis is ongoing.

Northeastern watersheds and rivers

Mark Anderson and Michelle Babione (Q)

Land and water use within northeastern ecosystems has been significantly affected by spreading urbanization, increasing demands for recreational opportunities, timber harvest and management, and, in particular, a long history of damming of streams for hydroelectric power generation. The results of these activities have been fragmentation and deterioration of forest and wetland habitats within the watershed, severe loss and degradation of aquatic habitat, and creation of barriers to fish passage within many of the interjurisdictional river basins of the Northeast. Information on the characteristics of instream habitat required for successful fish productivity and restoration efforts is currently limited. Use of existing information for ecosystem management is further restricted until insight is gained on the linkages with landscape features that ultimately control water quality, quantity, and flow regimes. In the terrestrial realm, attendants issues concerning species dependence on specific habitats and the continuity and availability of these habitats over areas sufficient to meet life history requirements need further investigation. Declines in neotropical species of birds using northeastern watersheds and riverine resources demonstrates the connectivity of these environments and the need to integrate land and water use management. To effectively meet information needs for holistic management of the northeastern rivers an watersheds, an ecosystem-based approach for information collection and analysis is needed. This approach requires identification and integration of existing ecological data into a geographical information system (GIS), linkage of aquatic and terrestrial attributes that define habitat quality and quantity, and generation of new database appropriate to enhance ecosystem management decisions. Focusing on the Connecticut River Basin, this task outlines a process to create partnerships, coordinate and develop a database of geoecological information to advance ecosystem management in northeastern watersheds, and foster client involvement and education. Objectives: 1) Establish a network of partnerships to identify, acquire, and evaluate extant data and information sources for biological resources within the Connecticut River Basin; 2) Develop an up-to-date inventory of existing obstructions to fish passage in the basin; 3) Enhance effective resource management by incorporating appropriate ecological data into a GIS to permit determination of landscape attributes that influence instream habitat and access by migratory fish and, provide significant resources for terrestrial migrants such as neotropical birds. The data system will be used by managers and decision-makers to more effectively plan and implement resource management (e.g. Conte Refuge system) and restoration efforts (e.g. Atlantic salmon) in the Connecticut River basin. An inventory will describe the type (including small licensed and unlicensed dams) and location of current barriers to fish migration. Impoundment size and other relevant physical, chemical and biological characteristics required to evaluate and generate base maps defining habitat potential will be included in the database. Understanding the linkage and importance of scale between the aquatic and terrestrial system is critical for total ecosystem management.

Assessment of triploidy as a tool for mitigating impacts of commercially cultured Atlantic salmon on wild stocks

Howard J. Kerby (H)

The Atlantic salmon has been in decline since the mid 1800's, primarily due to damming waterways, industrial and municipal waste spillage, and overfishing. Efforts to restore Atlantic salmon in the northeastern United States began in the late 1960's, but have met with limited success. In 1993, the U.S. Fish and Wildlife Service was petitioned to list anadromous Atlantic salmon as endangered or threatened under the Endangered Species Act. Commercial culture of Atlantic salmon is a large industry in Europe and is a substantial and growing industry along the Atlantic coasts of Canada and the United States (Maine). The industry is economically important to the state of Maine, as well as to the Canadians. Most North American commercial culture occurs in intensively stocked net pens located in Atlantic coastal waters. As a result of cage damage by storms and predators (such as seals), a significant number of the cultured fish escape to the wild. Fisheries managers on both sides of the Atlantic are concerned about the potential adverse effects of commercially cultured Atlantic salmon on wild populations, as a result of their use in restoring wild populations and from impacts of escapees of fish grown for commercial markets. There is concern that cultured fish may impact wild stocks both genetically and competitively. As a result of these concerns, the North Atlantic Salmon Conservation Organization (NASCO) concluded that production of sterile fish for aquaculture might be useful in mitigating any effects of cultured fish, and that triploidy is a promising method for achieving that goal. Because triploid Atlantic salmon are functionally sterile, their use would prevent undesirable genetic interactions with wild stocks. The aquaculture industry currently opposes a mandatory use of triploids, citing: (1) insufficient research; (2) research indicating that triploid Atlantic salmon have lower survival rates than diploids; (3) a relatively high percentage (10-30%) of triploids produced in Canada have lower haw deformities that would render their product less desirable to consumers, which would reduce value; (4) production of triploids would require additional resources and expense; and (5) use of triploids would require maintaining separate stocks of broodfish for breeding purposes. To address these concerns, a laboratory-scale comparative study of performance characteristics of diploid and triploid Atlantic salmon is being conducted in facilities at the Leetown Science Center (WV). The study will compare diploids and triploids from a commercial (St. John's River) and a native (Penobscot) stock. Atlantic salmon from the St. John's River, Canada, and the Penobscot River, Maine, were successfully spawned and treated to induce triploidy. The resulting eggs were incubated and hatched, and a study to assess relative performance characteristics is ongoing, To date, experimental fish from these crosses average in excess of 600 grams. Penobscot and St. John's diploids are exhibiting the fastest growth, although the growth of Penobscot triploids is almost as rapid as that of the St. John's diploids; St. John's triploids have exhibited significantly slower growth than the other three groups. Survival is greatest for Penobscot diploids and triploids, and is almost identical for these two groups. Survival of St. John's fish is significantly lower than that of the Penobscot strain, with the St. John's triploids exhibiting the greatest mortality. Both growth and survival data have been adversely affected by the onset of furunculosis and continuing treatments for the disease.

STOCK IDENTIFICATION

Stock identification of Atlantic salmon captured during the local use fishery in Greenland

D. Reddin, R. Brown, T. King, P. Kannenworff

Although mixed stock fisheries for Atlantic salmon in Canada have largely been closed and the Greenland fishery has been reduced significantly, the Greenlandic fishery continues to harvest North American and European origin Atlantic salmon. Determination of the continent of origin of fish captured in the West Greenland salmon fishery is important to assess the impact of the fishery on restoration efforts of North American stocks. Most salmon capture at West Greenland are one-sea-winter (1SW) in age, and if not caught would have returned to homewaters in Europe and North America as two-sea-winter (2SW) salmon. An international sampling program is conducted annually to obtain randomized scale and genetic samples from fishery landings. In 1999, the Greenland fishery opened in mid-August and the fishery was sampled at multiple ports during the first four weeks of the season. Microsatellite DNA analysis of a subsample of 423 genetic samples resulted in continent of origin determinations for 407 fish. Based on the microsatellite analysis, 85.5% of analyzed samples were of North American origin and 14.5% were of European origin. Discriminate analysis of scale characteristics will result in continent of origin determinations from additional fish where genetic samples were either not collected or analyzed. Although the percentage of North American fish in the Greenlandic catch has risen from 50% to over 80% since the mid 1980's, the vast majority of these fish are of Canadian origin.

GENETICS

Genetic stock identification of Atlantic salmon inhabiting North American with emphasis on the Downeast rivers in Maine

Tim L. King (H)

As a results of low and declining spawning runs and low juvenile densities, Atlantic salmon in five Maine rivers were designated at "Category 2" candidates for listing under the Endangered Species Act (ESA) in 1991. In October 1993, all anadromous U.S. Atlantic salmon were included in a petition to the U.S. Fish and Wildlife Service (FWS) for a rule to List the species under the ESA. To provide the most informed response to this petition and for planning and implementing biologically sound management programs, knowledge of intraspecific genetic structure and a thorough understanding of the evolutionary relationships among naturally reproducing populations of Atlantic salmon are essential. The increased use of hatchery-reared

Atlantic salmon intended for supplemental stocking and commercial aquaculture has underscored the need to understand the genetic composition of natural populations. Moreover, monitoring the commercial marine harvests of Atlantic salmon is problematic in that a major mixed-stock fishery exists off the west coast of Greenland; the fishery is composed both of North American and European origin one-sea-winter age fish. It is essential to the proper management of this valuable resource that the relative contributions of these diverse stocks to the West Greenland fishery are determined. The identification of genetic differences between North American and European stocks could augment stock delineation. The objects of these studies are to: 1) Develop and evaluate techniques to identify and assess genetic variability in Atlantic salmon nuclear and mitochondrial DNA at the population level. Specifically, variation in selected regions of mitochondrial DNA and internal spacer regions of ribosomal DNA genes will be assessed. If funding is available multilocus probes will be used to generate DNA fingerprints, 2) identify genetic variation among juvenile Atlantic salmon from eleven Maine rivers, five rivers in the Maritime Provinces of Canada, and two European rivers to quantify population differentiation between and among intercontinental, North American, and Maine river populations. 3) Determine the extent of spatial/temporal genetic variability of parr collected from two to three sites each in the Narraguagus, Dennys, and East Machias Rivers, ME, to assess the amount of intra-river variation and to determine the potential for distinct spawning populations within each of these rivers, 4) develop a gene marker or markers that can be used to distinguish selectively bred (i.e., hatchery produced) and wild Atlantic salmon, 5) ascertain that selected gene markers are inherited in a Mendelian fashion, 6) test archived DNA samples for presence or absence of diagnostics markers, 7) establish frequency distributions of the markers where differences do no exist in the populations, 8) assist the Fish and Wildlife Service in developing a genetically distinguishable hatchery product to assist in assessing the Atlantic salmon fry stocking program, and 9) assist in testing fish for presence/absence of diagnostic genetic markers to determine contributions of hatchery fish to wild populations. The purpose of the research is: 1) to augment management of Atlantic salmon by identifying previously undetected breeding structure and providing knowledge of the evolutionary relationships among naturally reproducing populations, and 2) to develop reliable genetic markers for Atlantic salmon which can be used by fishery managers to assess survival, growth, and movement of salmon reared in Federal and State hatcheries. Research efforts focused on methods development and sample collection. Methods development included investigations into: 1) development of primers for polymerase chain reaction to amplify selected regions of the mitochondrial DNA molecule, internal transcribed spacer regions of ribosomal DNA, and randomly amplified polymorphic DNA markers; 2) testing of microsatellite DNA markers; 3) use of multi- and single-locus probes for DNA fingerprinting; and 4) the determination of inheritance patterns for all new genetic markers using progeny and progenitors from multiple paired matings. Significant progress on each technique was observed. All genetic variation identified in the stock identification phase of this study will be applied towards managing and supplementing river-specific or U.S.-wide populations of salmon by developing markers for delineating and tracking hatchery-reared fish released into the wild. Multi-locus fingerprints, which can provide individual specific banding patterns, appears to be a leading candidate for providing a viable genetic marking technique. Hypervariable microsatellite loci surveyed to date could provide several robust gene markers. Screening of variation in wild populations of Atlantic salmon is ongoing. The search for new markers is ongoing. These markers appear to provide the characteristics of ideal genetic tags (e.g. selectively neutral, highly polymorphic, resolvable from fin clips). A summary report with recommendations for implementing a pilot gene marking study on Atlantic salmon fry in the highly controlled Connecticut River program in begin prepared for Region 5, U.S. Fish and Wildlife Service. The Connecticut River Atlantic salmon supplemental stocking program was chosen to apply the gene marking technology. Two additional microsatellite markers were screened for variation in salmon from the Connecticut River program bringing the number of loci screen to 25. Levels of genetic diversity were determined to be sufficiently high in the Connecticut River broodstock to allow selective breeding without reducing the amount of genetic variability. Adult salmon returning to the Connecticut River drainage in summer 1997 were genotyped using 12 microsatellite markers. Offspring from each paired mating will be stocked into a different tributary in 1998. Subsequent sampling will determine which tributaries are contributing the largest numbers of emigrating fish. Further screening will be performed to increase the number of loci.

Technical assistance in population dynamics and fish culture

Tim L. King (H)

Molecular genetics has recently achieved an important place in contemporary conservation biology as it has proven to be a robust tool for identifying reproductive isolation among populations, permitting the delineation of management units (MUs) and allowing assessment of conservation priorities from an evolutionary perspective (i.e. evolutionarily significant units, ESUs). Recently, the use of DNA polymorphisms assayed by the polymerase chain reaction has gained wider acceptance and application in defining population structure and to estimate relative contributions of individual stocks to mixed fisheries. Initially, DNA based investigations focused on analysis of mitochondrial DNA variation because of the rapid rate of evolutionary change compared to coding nuclear DNA. More recently, the application of co-dominantly inherited variable number of tandem repeat (VNTR) loci with simple sequence repeat motifs (205 bp), termed microsatellites, have provided the advantage of high levels of allelic variation per locus. The primary objective of this study unit are to: 1) develop molecular genetic markers in fish species of concern; 2) survey existing genetic variation among geographic populations with developed markers; and 3) identify any management and/or evolutionarily significant units which may occur with the species' known range. This research supports regional and national technical assistance needs by transferring information and maintaining professional interactions on a variety of issues dealing with fishery biology, population dynamics, and aquatic ecology. A genetics laboratory capable of surveying mitochondrial DNA variation from PCR amplified fragments was established. Atlantic salmon from Connecticut River were surveyed for allozyme variation. Results indicated no net increase in genetic variation at selected loci as a result of efforts to maximize heterozygosity by selective breeding.

Evaluating the Connecticut River Atlantic salmon restoration effort: genetic variability, stocking success and habitat quality

Benjamin H. Letcher (A)

Currently, there is no information on the genetic structure of the Connecticut River Atlantic salmon population. Among managers and researchers there is consensus that the population was probably bottlenecked by the relatively small founder population, but he initial fish originated from a wide variety of stocks and may be less homozygous than predicted by found population number along. An assessment of the genetic variability of the population is required to indicate how present hatchery mating practices may be influencing the level of inbreeding. Methods proposed here will allow virtual elimination of matings of closely-related individuals and will maximize available genetic variability. More information exists on smolt production from index sites on selected tributaries, but it is unknown which tributaries are providing the greatest number of fish to the restoration effort and which tributaries are not as effective. If stocking resources were limited, stocking effort could be adjusted accordingly. The ability to assess tributary-specific production depends critically on a non-lethal, permanent, fairly simple (batch marking), and easily-read fry mark. Many tags exist for larger fish (>50 mm), but appropriate tags for small fry (~ 25 mm) are rare. With the work in the proposal we will assess the applicability of two promising tags; a genetic mark and an immunological mark. Use of genetics is providing tools which address several critical research needs: development of a fry mark, genetically-based broodstock management and assessing the genetic variability of the Connecticut River population. By using the inherent genetic variability within the Connecticut River population, we have developed protocols that allow the identification of family membership (family-level DNA fingerprint using microsatellites) of fish produced in a hatchery. Fish from the different families will be stocked into selected tributaries. By determining the family membership of smolts and returning adult fish, we will also be able to determine tributary of stocking. We are using this fry mark in a pilot study in the Farmington River in Connecticut, into which we will be stocking almost 500,000 fry from 160 known families in the spring of 1998. We are using genetic information on individual Connecticut River broodstock to limit matings of closely related fish. This approach maximizes available genetic variability and virtually eliminates the possibility of inbreeding in this small population. Using it in 1997, we decreased the relatedness among the searun progeny by about 20% compared to previous random mating protocols. Managers have adopted the genetic broodstock management protocols developed in this plan. Pilot studies on fry marking are underway. Genetic variability of 1996, 1997, 1998 searun returns has been analyzed. Fry marking using genetic 'familyprint' has been implemented. In 1998 and 1999 approximately 1.5 million marked fry were stocked into various tributaries.

Assessing the risk posed to native Atlantic salmon in Maine by escapement of European salmon with emphasis on the potential for outbreeding depression

Philip E. McAllister and Clifford E.Starliper (H)

This research ascertains the risk for erosion of genetic diversity and local adaptation from aquaculture escapees by: 1)characterizing the genetic diversity of the Atlantic salmon broodstocks maintained by the Maine aquaculture industry for commercial use; 2) comparing the genetic characteristics of the aquaculture stocks to that observed in the range-wide genetic comparison; 3) assessing the fitness of outbred individuals by challenging North American, European, and F1 hybrid Atlantic salmon with disease (viral and bacterial) pathogens and physiological tolerance testing; and 4) quantitative risk assessment, utilizing all existing genetic and life history information (including temporal, spatial, and probabilistic estimators) to model the risk of significant impact to native salmon populations from aquaculture escapees consisting of European-origin salmon. The U.S. Fish and Wildlife Service and the State of Maine must make management decisions regarding Atlantic salmon based on the threat posed by the introduction of evolutionarily divergent (i.e. European) stocks. The information generated by this study will allow these agencies to make more informed management decisions.

Assessment of spatial and temporal distribution of genetic diversity in Atlantic salmon (*Salmo salar*)

William B. Schill (H)

The eastern coastal rivers of North American have historically supported anadromous populations of Atlantic salmon (Salmo salar). Numbers of these animals have declined due to overfishing and loss of habitat, and population numbers have been supplemented by stocking efforts that span at least the last hundred years. Often, these stockings used fish of diverse origins. This is exemplified by the fact that several Maine rivers were stocked with Canadian fish from at least two locations. Because of this stocking history, it is not known if significant remnants of native Atlantic salmon stocks exist in the coast rivers of Maine. Atlantic salmon in five Maine rivers were designated at 'Category 2' candidates for listing under the Endangered Species Act in 1991, in response to the precipitous decline in population numbers. In October 1993, all anadromous U.S. Atlantic salmon were included in a petition to the U.S. Fish and Wildlife Service (FWS) for a Rule to List the species under the Endangered Species Act. Knowledge of intraspecific genetic structure and a thorough understanding of the evolutionary relationships among naturally reproducing populations of Atlantic salmon is essential to provide an informed response to the petition for listing this animal as endanger and for planning and implementing biologically sound management programs. The increased use of hatchery-reared Atlantic salmon intended for supplemental stocking and commercial aquaculture has also focused attention on the need to understand the genetic composition of natural populations.

Although stocking programs have been implemented for nearly a century to augment wild population abundances, the genetic effects induced by hatchery operations (e.g. genetic drift, inbreeding) and the genetic interaction of hatchery produced fish (including those escaped from commercial aquaculture facilities) and wild stocks are unknown. The purpose of this study is to extend the preliminary studies described above to examine spatial and temporal components of genetic diversity in Atlantic salmon populations. This will be accomplished by 1) institution of a much more detailed sampling scheme than possible previously, 2) determination of frequencies of known genetic markers in these populations, and 3) development of new genetic markers that are robust, standardized, and that can easily be used by other researchers. Samples were collected, and DNA "fingerprinting" using alkaline phosphatase labeled oligonucleotide probes was evaluated. Hybridization of Southern blots of Atlantic slam on DNA samples yielded patterns that were too complex for routine analysis. The appears to be due to high levels of repeated DNA sequences. Several Atlantic salmon genomic DNA libraries were produced by cloning size-fractionated DNA into E. coli. Bacterial colonies (approximately 1400) containing inserts were transferred to grided culture plates and nylon filters. Filters were probed by hybridization to identify (1) cloned sequences containing microsatellites, and (2) low and single copy sequences. Plasmid DNA containing cloned microsatellites were sequenced and primers for the polymerase chain reaction amplification of each locus were obtained and tested on salmon pedigrees. During fiscal year 1996, additional salmon samples were collected. Microsatellite loci developed by others were screened for utility and oligonucleotide primers were adjusted so as to allow amplification and analysis of multiple loci simultaneously. Analysis of Atlantic salmon samples using 12 microsatellite loci was begun. During fiscal year 1997 additional salmon samples were collected and analysis of samples continued. A total of 915 Atlantic salmon from North America and Europe were characterized. Several computer programs were written to assess genetic variation of microsatellite loci.

FISH HEALTH/NUTRITION

Resistance of Atlantic salmon to major bacterial pathogens of Atlantic salmon

Rocco C. Cipriano and Clifford E. Starliper (H)

Many specific factors influence the resistance of an organism to disease. The natural barrier activity of skin and mucous proteases are critical in the initial defense against infection. Selection for specific characters may provide a crucial element in the development of genetic resistance of disease. Successful breeding programs have been developed in salmonids to select for resistance to furunculosis, but applications have been limited mostly to non-anadromous species. This research is intended to lead to the elucidation of disease resistance mechanisms in Atlantic salmon by providing an initial analysis of existing stocks to determine the innate variability of resistance markers. This work examines populations of Atlantic salmon used in the New England restoration effort. Initial study will concentrate upon populations within the Connecticut River basin, and then be expanded into the Merrimack and Penobscot River systems. This research could lead to the development of disease resistant strains of Atlantic salmon that would enhance survival and thereby be of direct benefit to the New England Atlantic salmon restoration effort. The development of disease resistance stocks would be of great benefit not only under conditions of intensive culture but during the free ranging riverine and ocean stages of these fishes. Final analysis of the susceptibility to different experimental challenges have indicated that there are indeed certain differences in susceptibility among families of fish to the major bacterial environments. These differences were only interfamilial and were not expressed with any degree of gradience among sea-run, kelt or domestic stocks of fish. Antibody titers evaluated during the course of this study indicate that each of the groups from the Penobscot, Merrimack, and Connecticut Rivers have uniformly and consistently encountered and presented a humoral immune response to *Aeromonas salmonicida* (furunculosis), and ***Vibrio anguillarum*** (Vibriosis). The immunological response of fish also showed more of a sporadic exposure to *Yersinia ruckeri* (enteric redmouth disease), and *Renibacterium salmoninarum* (bacterial kidney disease), that varied differentially with the population that was sampled and the year in which they were sampled. Further study also revealed that the fish from the Connecticut River and Downeast Rivers of Maine show a fairly high degree of susceptibility to *Flavobacterium psychrophilum* (bacterial coldwater disease). The most significant effects of this pathogen were size dependent. Acute mortality was most significant in sac fry, became chronic in juvenile fish where is was mostly express in runts, and was virtually non existent in adults. Problems associated with poor egg hatch revealed that the adults did indeed pass the bacterium vertically via intraovum infection.

Detection of covert *Aeromonas salmonicida* infection in Atlantic salmon and other salmonids

Rocco C. Cipriano (H)

While most diagnostic methods can detect pathogens reliably under overt conditions, the results are more equivocal when tests are pushed to their limits of sensitivity. It is, however, at these limits that one can achieve the most practical management to alleviate the deleterious effects of contagion and disease. It is, therefore, necessary to completely understand the limits of sensitivity and probability of detection of a pathogen not only in overt disease but among covertly infected, asymptomatic fish. Understanding the nature of detecting carrier fish asymptomatically infected with *Aeromonas salmonicida* not only assists with the management of furunculosis but also serves as a model for the covert detection of other bacterial pathogens. These results are especially important in the Northeastern Atlantic Salmon Restoration Program where asymptomatic carrier adult fish return from ocean migrations and are kept in communal aquaria. The enhanced ability to detect these "carriers" alleviates much of the additional contagion that leads to mortality among these fish from the time that they are captured at dams in the Spring until they are spawned in the following fall. Throughout the entire course of these studies, culture of *A. salmonicida* on Coomassie Brilliant Blue Agar has proven to be the most reliable and sensitive method of detection with a sensitivity as low as 100 colony forming units per gram of sample. In over fish, it does not matter whether analysis is made from either a systemic organ or from external surfaces including the mucus and gills. Among asymptomatic, covertly-infected fish, the external surfaces proved more reliable for detection of the pathogen. It must however, be emphasized that detection of low numbers of *A. salmonicida* equivalent to 1000 or fewer colony forming units per gram of sample was inconsistent even when the same sample was assayed repeatedly by culture. Estimation of statistical probabilities for valid detection at these lower levels is ongoing. In a one time analysis by bacterial culture of a given population where a few fish are infected with extremely low levels of the pathogen (100 cfu/g sample), one is realistically capable of assessing the presence or absence of a pathogen with a reliability within the population but not within individual fish. The probability of detection by culture enhances tremendously within repeated samplings of individual fish as the prevalence of the pathogen increases towards 10000 cfu/g of sample. Data collected in collaboration with researchers from Ireland and Australia showed that this prevalence (approximately 104 cfu/g of sample), however, appeared to be the lower limits of detection for more sophisticated methods of diagnosis including ELISA and PCR analysis, which were consequently not as sensitive as culture. Even culture was unreliable at the somewhat lower levels of detection. For these more advanced states of covert infection, it was shown that it was indeed necessary to conduct the stress mediated furunculosis test in order to ascertain the "true" state of infection relative to the carriage of the pathogen.

Enhanced survival of Atlantic salmon after vaccination against furunculosis

Rocco C. Cipriano (H)

Use of oxolinic acid combined with vaccination against *Aeromonas salmonicida* and *Yersinia ruckeri* has greatly enhanced the survival of searun Atlantic salmon upon their return to captive brood stock holding facilities in New England. Subsequent studies indicated that vaccination with commercial bacterins employed in the Atlantic salmon brood stock protocol did indeed elicit an immune response but the humoral elements of this response were not protective. Therefore, results were ambiguous and did not provide definitive clarification on the efficacy and subsequent importance of the individual components contained in the combined vaccination plus antibiotic protocol. During 1995/96, oxolinic acid was discontinued by ban of FDA and oxytetracycline was used in its stead. Oxytetracycline, however, is an immuno suppressant and may induce some liver pathology when injected into Atlantic salmon. Its relevance for combined use with immunotherapy by intraperitoneal injection is, therefore, questionable. This study was designed to improve the efficacy afforded by vaccination therapy in the sea-run Atlantic salmon brood stock protocol. This study was designed to (1) determine actual levels of efficacy afforded by commercial vaccine treatment of searun captive broodstocks of Atlantic salmon and (2) to modify existing bacterins to afford greater efficacy. Vaccination with commercially prepared bacterins alone appears to afford little protection to sea-run, captive brood stocks. Consequently, most of this study has involved re-development of a furunculosis-bacterin. An experimental bacterin has been produced that involves presentation of extracellular or soluble antigens of *Aeromonas salmonicida*. Laboratory trials with the furunculosis extracellular vaccine adsorbed onto particulate carriers (FEV-Ad) produced a highly dependent humoral and protective response that was dose dependent. If the FEV was administered without adsorption onto a particulate carrier both protection and immunologic stimulation was only moderately successful and did not vary with graded doses adjusted at 1.4, 14.0, and 140 ug of extracellular protein. The highest dose (140.0 ug of protein) adsorbed onto the particulate carrier stimulated the most significant levels of antibody production and protection from experimental challenge in laboratory studies. This level was used in all field studies. The adsorbed vaccine was then compared to results achieved with a commercially licensed product in field tests among Atlantic salmon that received natural, water-borne challenges with furunculosis. In two years of data collection, results with FEV-Ad were equivalent to those achieved with the commercial bacterin. In a third year of testing, the natural challenge level appeared to be too virulent and although both the experimental and commercial vaccine initially controlled the onset of mortality (as compared to non-vaccinated control fish) neither vaccine afforded adequate protection throughout the duration of the study. The latter results are significant in that it must be noted that even effective vaccines cannot be considered to be universal panaceas. Adhesions developed at the site of immunization in approximately 1% of the fish immunized throughout the course of the study. The reduced sensitivity of the FEV-Ad vaccine along the peritoneal wall may or may not be significant in terms of egg quality and production. This would be an important consideration for valuable brood stock, returning Atlantic salmon used in the Northeastern Atlantic salmon restoration program.

Prevalence and contagion of *Aeromonas salmonicida* based on interactions between hatchery and free-ranging fish

Rocco C. Cipriano (H)

Little information exists on the significance of a pathogen within the aquatic environment among free-ranging fish. Even less information exists upon the interaction and subsequent contagion of furunculosis between hatchery-reared Atlantic salmon and feral populations of fish within rivers used in the New England Atlantic salmon restoration effort. Historically, investigators who studied original outbreaks of furunculosis noted that epizootics in natural waters categorically correlated with the stocking of fish from infected farms. Some researchers have shown that shedding of the pathogen from infected fish, not survival in nature, is most important in the process of contagion. It has since become a matter of practice to avoid stocking fish clinically expressing furunculosis wherever possible. In some restoration rivers, however, this is not possible. Therefore, this study was designed to determine the impacts of furunculosis and contagion of *Aeromonas salmonicida* between hatchery-reared and free-ranging fishes within Atlantic salmon restoration rivers in New England. The use of several major rivers is essential to the Atlantic salmon restoration effort within New England. However, these rivers also support an important non-anadromous salmonid recreational fishery. Furunculosis, caused by *A. salmonicida*, in enzootic throughout the area encompassed by the Atlantic salmon restoration effort and the disease can be amplified by stocking infected fish. Many of the trout, stocked within New England rivers, are infected with this pathogen. Consequently, it is important to all fishery resource managers to understand the impacts and contagion of this pathogen by examining interactions between hatchery-reared and free-ranging fish. Decisions based upon such interactions will most assuredly affect the success of the restoration effort. The information provided by this study should provide biologists with the knowledge to evaluate the importance of furunculosis in the natural environment and adjust stocking policies accordingly. In the first year of study, populations of hatchery-reared salmonids from three hatcheries that stock three tributaries of the White River were assessed for infection due to *A. salmonicida*. Isolates obtained were libraried by biochemical reactions and antibiotic profiles. Two stress induced furunculosis tests were done on populations of fish from each of the tributaries in October and December 1997. There was an indication that there was no long-lasting interaction in terms of bacterial contagion between hatchery-reared and the free-ranging fish from any of the tributaries that were studied. In the second year of study, stress tests were conducted at three different times during the years on populations from the Tweed, Locust and Bethel-Gilead Rivers, all of which are tributaries of the White River near Bethel, Vermont. Salmonid production was limited in the Tweed River and it was determined to include non-salmonid test species in this river as well. Results were again similar to the first year of study with little to note in the way of either viral or bacterial detection among either native salmonids or hatchery-stocked salmon.

Further investigations on the nature of vertical transmission of *Aeromonas salmonicida*

Rocco C. Cipriano (H)

During production cycles of Atlantic salmon at the White River National Fish Hatchery (Bethel, VT), juvenile fish repeatedly sustained epizootics of furunculosis. Infection occurred despite continual and efficient operation of UV irradiation used to treat the hatchery water supply. During such periods, there was no additional transfer of fish into the facility. Disinfected eggs from sea-run Atlantic salmon, however, were routinely transported from several facilities to the White River hatchery. Such fish were known to harbor covert infections of *Aeromonas salmonicida* upon their return to the Connecticut River. Because iodine effectively kills many pathogens present on the surface of eggs, iodophor disinfection of eggs is routinely practiced by fish culturists as a precaution to prevent the spread of the disease. Due to the repeated outbreaks of furunculosis in young fish at the White River NFH, this study was designed to (1) determine if the disinfection of Atlantic salmon eggs for *A. salmonicida* as currently practiced is complete and (2) to further investigate if the pathogen might be transmitted vertically from parent to offspring via intra-ovum infection. In three years of study, using twenty families of Atlantic salmon in each year, *A. salmonicida* was repeatedly isolated from eggs of individual families prior to disinfection. The bacterium was rarely found in the ovarian fluid and sperm of parental females and males even among fish whose fertilized gametes tested positive. After individual lots of eggs were disinfected in 50 ppm iodophor for 30 minutes, the bacterium was not detected from the surface or internal contents of the contaminated egg lots. These data strongly support the hypothesis that *A. salmonicida* is not transmitted vertically from parent to offspring via intra-ovum infection. During the course of this study, however, it was noted that *Flavobacterium psychrophilum* was often associated with the surface of disinfected eggs. Subsequent sampling of eggs included this pathogen in our studies. In this case, it was noted that even after three disinfections in increasing concentrations and contact time of iodophor (50 ppm for 30 minutes followed by 100 ppm for 10 minutes, followed by 100 ppm for 60 minutes), the pathogen was still isolated from within the contents of the egg. Subsequently, it was noted that *F. psychrophilum*, cause of bacterial coldwater disease, was apparently transmitted vertically from parent to offspring via intra-ovum infection. These results could explain severe problems with poor egg quality and acute mortality sustained by emergent sac fry which has hitherto not been associated with any specific etiology.

Relationship between bacterial pathogens and survival among mature, sea-run Atlantic salmon

Rocco C. Cipriano (H)

A serious void of information exists regarding parameters that affect the ocean survival of Atlantic salmon. This is complicated by the inability to obtain adequate samples from free-ranging salmon in the Atlantic Ocean. Furunculosis and Vibriosis are common diseases causing significant mortality among captive populations of Atlantic salmon farmed in marine environments. *Aeromonas salmonicida* also causes significant infections of sea-run migrating populations of both Pacific salmon and Atlantic salmon. In addition, *A. salmonicida* has been isolated from the salmon louse and marine plankton which indicates that such organisms may serve as vectors for the marine transmission of this disease. This study was designed to assess (1) the nature of infection in sea-run fish returning to New England Rivers and (2) understand the potential for salmon lice to serve as reservoirs of infection. In this study, bacteriological samples will be taken from Atlantic salmon returning annually to the Penobscot, Merrimack and Connecticut Rivers. The humoral immune response will also be analyzed to provide an immunological surveillance to selected pathogens. In addition, sea lice will be obtained from returning fish and cultured for the presence of bacterial fish pathogens. This will be done in order to provide an analysis of the types of bacterial infections that fish may encounter in the ocean and during their returning searun migrations. To date, only *Aeromonas hydrophila* and *Vibrio anguillarum* have been isolated from salmon lice infesting fish upon their return. These isolations were made from fish returning to the Connecticut River. In 1996, *Aeromonas salmonicida* was the most significant pathogen encountered in fish returning to the Connecticut River, whereas *Yersinia ruckeri* was the most serious problem among Penobscot River returns. In fact, the latter pathogen was only isolated from mature salmon whereas culture from grilse in the same population was negative. In 1997, serious problems were encountered with *A. salmonicida* among fish returning to the Connecticut River which persisted during the holding period and necessitated antibiotic treatments. In both years, antibody responses from fish in each of the three river systems found a strong humoral response to *A. salmonicida, V. anguillarum* and, in 1996, to *Renibacterium salmoninarum.* In 1998, sea-run returns showed no evidence of specific bacterial problems associated with returns to any of the restoration rivers. However, Atlantic salmon swimbladder sarcoma virus was noted among fish obtained from the Pleasant River. This was of paramount concern since this is the first time that this pathogen has ever been reported from North America. In fact, there are only two known reports of this pathogen causing disease and they involve populations of Atlantic salmon commercially cultured in Scotland during the late 1970's. These findings necessitate an emergency response to this pathogen to develop sensitive diagnostic techniques, assess mode of infection, and analyze the presence/absence of the virus within the geographic area encountered within the Northeast Atlantic salmon restoration program.

Pathology and mortality associated with newly emergent fry from Penobscot and Downeast river stocks of Atlantic salmon

Rocco C. Cipriano (H)

In April 1998, mortality among newly emergent Atlantic salmon fry was investigated at the Craig Brook National Fish Hatchery (East Orland, ME). Clinically, dead or moribund fry displayed whitened heads with apparent erythema and hyperemia within yolk sacs. Affected trays of fry were randomly located throughout Heath incubators indicating something less than a uniform etiology. Although only Penobscot River fry were sampled, fry from other Downeast rivers were similarly affected. It was also indicated that this clinical picture has persisted since approximately 1990 and contributes to a severe and unacceptable level of mortality which curtails the numbers of fish stocked for the restoration effort. Bacteriological examination revealed an extremely high concentration of the pathogen, *Flavobacterium psychrophilum* in all of the affected fish that were sampled. This cursory evaluation provided the first evidence that the problems associates with early fry survival at the Craig Brook facility may be caused by an infectious agent and namely, *F. psychrophilum*, the cause of Bacterial Coldwater Disease. Previous work at the White River National Fish Hatchery (Bethel, VT) has shown the same pathogen associated with lots of eggs displaying poor eye-ups and fry survival. Most recent work at White River indicates that the bacterium is vertically transmitted from parent to the offspring via intra-ovum infection. These new findings at Craig Brook, further reflect clinical expression of the pathogen in newly emerged sac-fry but do not determine if the infection is vertically transmitted within the egg or merely associated with the external surfaces of eggs and fry due to environmental contamination. In light of these results and in consideration of the persistent problem that exists at Craig Brook, studies should be conducted to discern if this pathogen is vertically transmitted. This is especially important because the water supply at Craig Brook is treated by ultra-violet irradiation and, therefore, soul preclude environmental contamination of the eggs by this or any such pathogen. Incoming water can also be easily monitored to ensure that the pathogen is not entering the system through an environmental source. Once such determinations are made, solutions to eradicate transmission and alleviate mortality should be considered. In addition to the problems experienced within the hatchery, one must also consider that surviving fry will harbor the pathogen. These fish are stocked into rivers at times when water temperature favor the expression of clinical disease induced by this pathogen. Although many factors affect riverine survival we currently have no indication if such infection affects fry in the natural environment.

Detection and transmission of a retrovirus disease from valuable broodstock among Atlantic salmon from the Pleasant River

Rocco C. Cipriano (H)

Juvenile Atlantic salmon collected from the Pleasant River between 1995 and 1997 have been maintained at the North Attleboro National Fish Hatchery (North Attleboro, MA) for future broodstock to support the recovery of imperiled stocks of Pleasant River salmon. The Pleasant River fish held at North Attleboro have exhibited a clinical pathology that heretofore has not been reported among any other populations of salmon within the New England restoration program. In fact, preliminary results indicate that the pathology is caused by a retrovirus which had never been isolated in North American. This exotic pathogen produces symptoms that are essentially identical to a retrovirus that was only once before reported from Atlantic salmon in Scotland during 1978. Clinically, fish may exhibit skin discoloration and hemorrhaging of the fins which was first observed among the Pleasant River fish held at North Attleboro in 1997. These fish suffered a chronic but persistent mortality that was initiated in May 1997. In October 1997, tumors were observed on air bladders. Mortality among the affects lots of salmon peaked in late spring of 1998, but standard testing for parasitic, bacterial, and viral pathogens proved negative. The speculation that a retrovirus, which generally does not respond to standard laboratory cell culture techniques, was the etiologic agent of this pathology was demonstrated through the cooperation of specialists at Cornell University in June of 1998. Due to our lack of knowledge about this virus and its significance within highly valuable broodstock from the Pleasant River, the Maine Atlantic Salmon Authority requested that further research be conducted to assess the etiological nature of the virus and its potential impact within the overall restoration program. The research will provide a PCR-based assay for the detection of the virus, evaluate prevalence of infection with seasonality of disease, and determine the potential for horizontal contagion between infected and naive Atlantic salmon. These data will provide information necessary for the management of this valuable broodstock.

Use of Chloramine- T treatments as a topical disinfectant to reduce bacterial flora on the skin of mature, sea-run Atlantic salmon

Rocco C. Cipriano (H)

Upon their return from ocean migrations, mature Atlantic salmon enter their natal rivers in an extremely debilitated condition. They are often bruised, scarred and have open dermal lesions as a result of predators, fishing pressure, and physical injury. Because these fish are not feeding, they will remain in a state of poor nutrition. These conditions are further worsened during holding in hatcheries as captive broodstock as they become sexually mature and display aggressive behavior. The immunocompromised status of this fish is evidenced by the severity and degree of secondary infections that result from physical injury. Under these conditions, bacterial flora that is ordinarily of non-pathogenic nature may flourish in open wounds and cause secondary infections that result in significant mortality. Such situations exist at each of the three FWS Atlantic salmon holding facilities on the Connecticut, Merrimack and Penobscot rivers. The situation has, however, been extremely problematic at the Nashua National Fish Hatchery (Nashua, NH) which holds the captive brood fish for the Merrimack River. Timely intervention with topical disinfectants could theoretically be applied to curtail the prevalence of bacterial loads on these fish and prevent secondary infections that lead to mortality. Salt and formalin are commonly used on Atlantic salmon because of their therapeutic activity against external parasites and fungi (Piper et.al. 1982) but such compounds have not alleviated problems associated with secondary bacterial infections in captive Atlantic salmon. Chloramine-T is commonly used against external bacteria like those which cause Bacterial Gill Disease (from 1979, Bullock et. al. 1991) and Furunculosis (Cipriano et.al. 1996). The author has further noted a healing of open wounds caused by physical trauma following application of Chloramine T among adult salmon. This suggests that Chloramine T may be an effective generalized therapeutant which would reduce general bacterial loads and alleviate the severity of secondary infections found in captive broodstocks of Atlantic salmon. The work is designed to evaluate and develop Chloramine T as a topical disinfectant to reduce the prevalence of bacterial flora that invade and cause secondary infection with subsequent mortality in captive broodstock held for the Atlantic salmon restoration program in New England. Chloramine T is not cleared for use of food fish by the U.S. Food and Drug Administration. However, the FDA does allow the usage of non-registered drugs within the federal Atlantic salmon restoration program consistent with the requirements that these fish are held and maintained under the requirements listed for an endangered or threatened species. The author serves as an intermediary between the FWS and FDA in this regard. The information obtained will enable the FWS to justify use of Chloramine T as a topical disinfectant for such fishes and maximize the number of captive broodstock available to contribute their gametes to the restoration program.

Development of monoclonal antibodies to Infectious Salmon Anemia Virus (ISAV) and partial characterization of ISAV antigens recognized by Atlantic salmon (*Salmo salar*) antibodies

Chris Ottinger and Philip E. McAllister (H)

Infectious Salmon Anemia (ISA) is a highly infectious disease of Atlantic salmon first reported within Norwegian aquaculture facilities. This orthomyxo-like virus causes severe anemia and hemorrhage. Although originally restricted to Norway, the disease has since been described among pre-market Atlantic salmon in Canada and Scotland. Therefore, it is still possible to treat ISA as an exotic disease within the United States and failure to do so could have devastating impacts on the entire New England Atlantic salmon restoration program. Existing diagnostics for ISA require the sacrifice of the host. Sea-run Atlantic salmon that may harbor ISA infections are held within Federal facilities before they are spawned. Atlantic salmon restoration program mandates preclude the sacrifice of genetically important individuals to determine the status of infection. However, failure to detect infected hosts may result in contamination of facilities and the spread of ISA virus. The development of non-lethal ISA diagnostics is critical to a pro-active stance that would enable the U.S. Fish and Wildlife Service and cooperating agencies to minimize the deleterious effects of introducing ISAV restoration stocks of Atlantic salmon and contamination of facilities in which these fish are maintained. ELISA-based diagnostics to detect ISAV virons and anti-ISAV antibodies in the peripheral blood of Atlantic salmon could fulfill this need. This study will establish the diagnostic potential of ELISA based Atlantic salmon anti-ISAV antibody detection. Balb/c mice have been inoculated with Atlantic salmon immunoglobulin. Laboratory culture of ISAV has begun.

Production of monoclonal antibodies for immunoassay development and protein purification

Chris Ottinger (H)

The use of monoclonal antibodies (MAbs) provides for specific detection and purification of targeted compounds. The hybridoma cells that produce these antibodies permit production of consistent reagent antibodies over an indefinite period. Such product longevity ensures reproduction of results over a long-term (e.g. reproducibility of immunodiagnostics). Monoclonal antibodies against immunoglobulin (Ig) are an essential component of many assays that assess humoral immunity. These MAbs are used in ELISA and western blot procedures, in the isolation of Ig producing cells, fluorescence microscopy and fluorescence activated cell sorting (FACS). Research at the National Fish Health Research Laboratory (NFHRL) typically involves four salmonid species. Monoclonal antibodies against rainbow trout and Atlantic salmon Ig are currently available. To facilitate future immunologic research, anti-Ig MAbs will be produced for brook trout and char. Furunculosis is a major disease of salmonids and has had a significant impact on Atlantic salmon restoration in the northeastern Unites States. *Aeromonas salmonicida*, the causative agent of furunculosis, produces a number of virulence factors. To facilitate the study of the interactions between these factors and the immune system, MAbs will be produced against extracellular proteins and A-protein of this bacteria. The MAbs will be used for the purification and detection of virulence factors in support of on-going as well as future furunculosis research. The products of this study will be monoclonal antibodies against brook trout and char immunoglobulin, and A-protein and extracellular proteins of *A. salmonicida*. Primary inoculations of Babl/c mice have been given for *A. salmonicida* extracellular products and brook trout immunoglobulin.

POPULATION ESTIMATES / TRACKING

A comparison of night seining and day electrofishing to sample juvenile Atlantic salmon (*Salmo salar*) in streams

Gabe Gries and Benjamin H. Letcher (A)

To improve understanding of mechanisms responsible for population dynamics and movement of juvenile Atlantic salmon (*Salmo salar*) it is necessary to tag and resample individuals, but common sampling techniques such as electrofishing can result in physical injury and have negative effects on fish growth and survival. An alternative technique to electrofishing that allows for the repeated recapture of large numbers of individuals is needed. We describe such a technique that involves sampling at night with hand-held seines. We evaluated this night seining technique in the West Brook, Whately, Massachusetts during 1997 and 1998 by sampling PIT-tagged salmon in 47 contiguous 20 meter sections 15 times using night seining and day electrofishing. All untagged salmon captured were tagged and by the fourth sample, over 94% of the salmon were recaptures (age-classes: 1995, 1996 and 1997) with this percentage remaining at or exceeding this level in subsequent samples. The average percent of the population estimate caught during night seining samples was 47.0% and 76.3% for day electrofishing samples (all age-classes combined). Shorter salmon resulted in a significantly smaller percentage of the population estimate captured during night seining samples, but not during day electrofishing samples. Age 0 salmon were captured in substantially greater numbers during night seining samples after they attained a fork length of > 60 mm. Night seining is limited to small stream (< 15 m in width) and may prove useful when electrofishing is impractical, threatened or endangered species exist, or multiple recaptures of individuals are desired.

Estimation of Atlantic salmon smolt passage and outmigration in the Connecticut River by remote acoustic telemetry

Alex Haro, Stephen McCormick, and Benjamin H. Letcher (A)

Attempts to reintroduce Atlantic salmon to southern New England rivers in the 1960s resulted in initial success. In the Connecticut River, for example, approximately 200 to 500 adult salmon have returned annually since the inception of the program. However, the increased effort of smolt and fry stocking in the 1980s and 1990s has not resulted in increased adult returns, indicating decreases in return rates of hatchery and stream-reared smolts. The reason(s) for these low returns are unclear. Currently, fry and parr survival and production of smolts in headwater rearing habitats appear to be high. There are some indications of losses of smolts during downstream migration due to delays caused by dam impoundments, turbine mortality, or predation,yet these losses have not been quantified and summarized on a cumulative, basin-wide level. Several recent attempts to estimate these losses have included trapping, tracking of smolts via radio telemetry through the Connecticut River mainstem, estimation of numbers of smolts passing dams via mark-recapture methods, and conventional turbine mortality and passage studies. These studies have produced ambiguous results or outmigration estimates limited to only a portion of the basin or specific dam. There have been no studies to investigate the entry of Connecticut River smolts into the estuary or marine environment. Emigrant smolts leaving the river are believed to move eastward from the river mouth through Long Island Sound, but there are no data to verify this assumption or characterize specific migration routes. Transition from the freshwater to the marine environment is a critical phase in smolt migration. Physiological studies indicate that salmon smolts migrating at the end of the migratory period (late May and early June) lose the capacity for rapid seawater entry. Late migrants, especially those delayed by obstructions, may have poor survival upon arrival at the estuary. There is presently an urgent need to estimate losses of emigrant smolts from headwater habitats (or at least from Holyoke Dam, river km 138, the last significant obstruction within the mainstem) to the mouth of the Connecticut River. Although it is extremely difficult to quantify total outmigration of smolts from the entire river system, some estimate of the level of smolt outmigration in the lower river would be useful in determining whether or not low adult returns are due to smolt mortality during downstream migration, and in identifying factors within the freshwater, estuarine, and marine environments that affect smolt survival.

Movements and habitats of Atlantic adults in the Westfield River

Donald Pugh and Boyd Kynard (A)

There is no information on movements, spawning habitat, or spawning success of searun or broodstock Atlantic salmon adults that may return to the Connecticut River to spawn. Yet, the return of spawning adults is a major goal of restoration. Using radio-tagged fish, we hope to determine the value to the restoration program of natural spawning by sea-run and stocked brood adults, determine the spawning habitat selected by adults, and determine if the presence of odor form sea-run adults facilitates retention of broodstock. We also will track outmigrant fish past sever hydroelectric dams to determine passage time and conditions. The purpose of the research is to provide information of use to the Atlantic salmon restoration program. The tracking of fish during spawning will identify spawning areas and specific habitat conditions. Tracking of sea-run and broodstock will identify any differences in spawning success between the two groups of fish and show whether the odor of upstream sea-run fish facilitates retention of broodstock. Spawning success and the production of naturally spawned fry will enable comparison with stocked fry survival and growth. Tracking of adults as they pass downstream pass hydroelectric dams will provide information to agencies on behavior of fish that can be used to design fish passage facilities. In 1997, sea-run and broodstock adults were internally radio-tagged, and tracked during spawning and downstream movement. Eleven sea-run fish were radio-tagged. Summer movements were observed and eight noted for spawning habitat selection. Sixteen broodstock were tagged. Spawning by broodstock was only observed downstream of sea-run adults. Fifteen fish are being tracked for downstream movements past dams.

Movement and spawning activity of adult sea-run Atlantic salmon in the Merrimack River watershed - 1999

Douglas A. Smithwood, Joseph F. McKeon, and David F. Batchelder (I)

Sea-run Atlantic salmon were released into the Baker River in 1999 to evaluate the potential for spawning and natural production of fry within the watershed. The Baker River is a major tributary of the Pemigewasset River. The Pemigewasset River and Winnipesaukee River form the headwaters of the Merrimack River watershed. On 13 October, thirty sea-run and one domestic broodstock salmon were released at two locations in the Baker River. Seven sea-run female and the one domestic female were equipped with externally mounted radio transmitters to monitor their behavior and movement.

In 1998 a similar study was conducted using only domestic broodstock salmon from the Nashua National Fish Hatchery. These broodstock successfully spawned in the Baker River during late fall, and fry emergence was documented in the spring of 1999.

All radio tagged sea-run fish displayed distinct downstream movement within a short period following release in 1999. The seven radio tagged sea-run fish moved out of the Baker River system and down the Pemigewasset River. They were located at Ayers Island Dam (the first downstream dam) within four days following their release, a distance of 53.7 to 61.9 river kilometers. Of the four fish that passed Ayers Island Dam two fish also passed other downstream hydroelectric facilities. Another of the seven tagged fish located at Ayers Island Dam swam upstream to Livermore Falls, a distance of 29.4 river kilometers. The remaining two radio tagged fish were never located again.

The radio tagged domestic fish held position over spawning gravel near the release site for about one month. Shore based site inspection did not reveal redd construction in proximity to that location. In addition, canoe reconnaissance two weeks after the release of fish did not reveal redds or fish near suitable spawning habitat in the Baker River with the exception of the one radio tagged domestic broodstock.

Current findings suggest that sea-run fish become widely distributed in the watershed perhaps seeking out their natal river. Once fish pass over Ayers Island Dam or other downstream dams they are unable to move upstream and access upriver spawning habitat. Future management strategies should involve releases of sea-run fish at earlier times in the season to provide fish a longer period of in-river acclimatization, and releases of sea-run fish at lower river sites to better understand the importance of site fidelity to natural reproduction.

Addresses of Contributors

A U.S. Geological Survey - Biological Resources Division
Conte Anadromous Fish Research Center
P.O. Box 7963
One Migratory Way
Turners Fall MA 01376

VT Cooperative Fish and Wildlife Research Unit
School of Natural Resources
Aiken Center
University of VT
Burlington VT 05405

C Department of Biological Sciences
Dartmouth College
Hanover, NH 03755

D U.S. Fish and Wildlife Service
Northeast Fishery Center
P.O. Box 75
Lamar, PA 16848

E U.S. Geological Survey
Research and Development Laboratory
R.D. #4, Box 63
Wellsboro, PA 16901

F U.S. Geological Survey - Biological Resources Division
Tunison Laboratory of Fish Nutrition
3075 Gracie Road
Cortland, NY 13045-9357

G National Marine Fisheries Service
Northeast Fisheries Science Center
166 Water Street
Woods Hole, MA 02543

H U.S. Geological Survey - Biological Resources Division
Leetown Science Center
Aquatic Ecology Laboratory
1700 Leetown Road
Kearneysville, WV 25430

I U.S. Fish and Wildlife Service
Federal Building - Room 124
Laconia, NH 03246

J U.S. Geological Survey / BRD
Orono Field Station
University of Maine
5751 Murray Hall
Orono, ME 04469-5751

K Department of Earth Sciences
Dartmouth College
Hanover, NH 03755

L MA Cooperative Fish and Wildlife Research Unit
Department of Forestry and Wildlife
Holdsworth Natural Resource Center
University of MA
Box 34220
Amherst, MA 01003-4220

M Northwest Fisheries Science Center
FRAM Division
2725 Montlake Blvd. E.
Seattle WA 98112

N Maine Atlantic Salmon Commission
Campbell's Hill
RR 1, Box 287
Cherryfield, ME 04622

O US Fish and Wildlife Service
103 East Plumtree Road
Sunderland, MA 01375

P UMass/NOAA
CMER Program
Blaisdell Hall
University of Massachusetts
Amherst, MA 01003

Q The Nature Conservancy
Massachusetts Field Office
79 Mike Street, Suite 300
Boston, MA 02109

R Dept. of Fisheries and Wildlife
Michigan State University
13 Natural Resource Building
East Lansing, MI 48824-1222

S Maine Atlantic Salmon Commission
650 State Street
Bangor, ME 04401

T Dept. Wildlife Ecology
University of Maine
Orono, ME 04469

U Dept. of Forestry and Wildlife Management
University of Massachusetts
Amherst, MA 01003-4210

6. HISTORICAL DATA (1970 - 1999)

6.1. STOCKING

The historical stocking information is presented in Table 3.2.a. in Appendix 10.3. Approximately 151 million juvenile salmon have been released into the rivers of New England during the period, 1970 - 1999. Nearly 75% of the total have been fry. The majority of the juvenile releases have occurred in the Connecticut River (over 68 million), the Penobscot River (over 28 million), and the Merrimack River (over 27 million).

6.2. ADULT RETURNS

The historical return information is presented in Table 3.2.b. in Appendix 10.3. Total returns to New England rivers from 1967 through 1999 now equal 75,544. The majority of the returns have occurred in Maine rivers (90%) followed by the returns to the Connecticut River (6.4%), and the Merrimack River (2.9%). The Penobscot River alone accounts for 71% of the total.

7. TERMS OF REFERENCE FOR 2001 MEETING

The U.S. Atlantic Salmon Assessment Committee agreed to address the following Terms of Reference for the 2001 meeting:

1. Program summaries for current year (2000) to include:
   a. Current year's stocking program with breakdowns by time, location, marks and lifestage.

   b. Current year's returns by sea age, marked vs. unmarked, and wild vs. hatchery.

   c. General summary of program activities including regulation changes, angling catch, and program direction.

2. Update historical databases.

3. Optimum Fry Stocking Levels

4. Program Summary of Historical Smolt Runs

5. Modeling Assumptions

6. Additional Terms of Reference will be developed at a special meeting at 10:00 a.m. on July12, 2000 at the Central New England FRO in Nashua, NH.

8. LITERATURE CITED

All references are located in previous sections.

9. U.S. ATLANTIC SALMON ASSESSMENT COMMITTEE MEMBERS

Ed Baum	Maine Atlantic Salmon Authority
Ben Letcher	USGS -Biological Resources Division
Mary Colligan	National Marine Fisheries Service
Dennis Erkan	RI Div. of Fisheries and Wildlife
Russell Brown	National Marine Fisheries Service
Stephen Gephard	CT Dept. of Env. Protection
Jon Greenwood	N.H. Fish and Game Dept.
Rusty Iwanowicz	MA Div. Marine Fisheries
John Kocik	National Marine Fisheries Service
Jerry Marancik	U.S. Fish and Wildlife Service
Joe McKeon	U.S. Fish and Wildlife Service
Jay McMenemy	VT Fish and Wildlife Dept.
Dr. Mike Millard	U.S. Fish and Wildlife Service / Northeast Fishery Center
Janice Rowan	U.S. Fish and Wildlife Service
Steve Roy	U.S. Forest Service

RIVER	YEAR	HATCHERY ORIGIN 1-S-W	HATCHERY ORIGIN 2-S-W	HATCHERY ORIGIN 3-S-W	HATCHERY ORIGIN REPEAT	WILD ORIGIN 1-S-W	WILD ORIGIN 2-S-W	WILD ORIGIN 3-S-W	WILD ORIGIN REPEAT	TOTAL
SHEEPSCOT										
	Total, 1967-1984	0	0	0	0	21	293	9	0	323
	1985	0	0	0	0		5	0	0	6
	1986	0	0	0	0		10	0	0	11
	1987	2	7	0	0		5	0	0	15
	1988		0	0	0	0	0	0	0	
	1989			0	0	2		0	0	5
	1990		8	0	0	0	0	0	0	9
	1991	0	4	0	0	0	0	0	0	4
	1992		2	0	0		2		0	7
	1993	0	9	0	0	0	0	0	0	9
	1994	0	5	0	0	3	12	0	0	20
	1995	0	2	0	0	0	22	0	0	24
	1996	0	0	0	0		8	0	0	8
	1997	0	0	0	0	0	0	0	0	0
	1998									
	1999									
	Total, 1985-1999	6	38	0	0	9	65	1	0	119
	GRAND TOTAL	**6**	**38**	**0**	**0**	**30**	**358**	**10**	**0**	**442**
DUCKTRAP										
	1985	0	0	0	0	0	15	0	0	15
	1986	0	0	0	0	3	12	0	0	15
	1987	0	0	0	0	0	0	0	0	0
	1988	0	0	0	0	0	0	0	0	0
	1989	0	0	0	0	0	0	0	0	0
	1990	0	0	0	0	0	3	0	0	3
	1991	0	0	0	0	0	0	0	0	0
	1992	0	0	0	0	0	0	0	0	0
	1993	0	0	0	0	0	0	0	0	0
	Total, 1985-1999			0		3	30	0		33
	GRAND TOTAL	**0**	**0**	**0**	**0**	**3**	**30**	**0**	**0**	**33**

John Kocik	National Marine Fisheries Service Woods Hole Laboratory 166 Water Street Woods Hole, MA 02543-1097 Email: John.Kocik@noaa.gov	Tele: 508-495-2207 Fax: 508-495-2393
Russell Brown	National Marine Fisheries Service Woods Hole Laboratory 166 Water Street Woods Hole, MA 02543-1097 Email: russell.brown@noaa.gov	Tele: 508-495-2380 Fax: 508-495-2393
Denise Buckley	U.S. Fish and Wildlife Service Maine Anadromous Fish Coordinator's Office East Orland, ME 04431 Email: denise_buckley@fws.gov	Tele: 207-469-6701 Fax: 207-469-6702
Tracy Copeland	U.S. Fish and Wildlife Service Maine Anadromous Fish Coordinator's Office East Orland, ME 04431 Email: tracy_copeland@fws.gov	Tele: 207-469-6701 Fax: 207-469-6702
Joe McKeon	U.S. Fish and Wildlife Service 151 Broad Street Nashua, NH 03060 Email: joseph_mckeon@.fws.gov	Tele: 603-595-3586 Fax: 603-595-0957
Jay McMenemy	VT Dept of Fish and Wildlife 100 Mineral Street Suite #302 Springfield, VT 051561 Email: jmcmenemy@anrmail.anr.state.vt.us	Tele: 802-885-8829 Fax: 802-885-8890
Janice Rowan	U.S. Fish and Wildlife Service Connecticut River Coordinators Office 103 E. Plumtree Road Sunderland, MA 01375 Email: jan_rowan@fws.gov	Tele: 413-548-9138 Fax: 413-548-9622

Phil Herzig	U.S. Fish and Wildlife Service Sunderland Office of Fisheries Assistance 103 E. Plumtree Road Sunderland, MA 01375 Email: phillip_herzig@fws.gov	Tele: 413-548-8002 Fax: 413-548-9746
Michelle Babione	U.S. Fish and Wildlife Service Connecticut River Coordinators Office 103 E. Plumtree Road Sunderland, MA 01375 Email: michelle_babione@fws.gov	Tele: 413-548-9138 Fax: 413-548-9622
Mike Millard	Northeast Fishery Center P.O. Box 75 Lamar, PA 16848 Email: mike_millard @fws.gov	Tele: 570-726-4247 ext.28 Fax: 570-726-7247
David Perkins	U.S. Fish and Wildlife Service Fisheries 300 Westgate Center Drive Hadley, MA 01035 Email: david perkins@fws.gov	Tele: 413-253-8405 Fax: 413-253-8488
Gorden T. Waring	NMFS/NEFSC 166 Water Street Woods Hole, MA 02543 Email: Gorden.waring@noaa.gov	Tel: (508) 495-2311
Mariska Obenzinski	National Marine Fisheries Service 31 Ledgelawn Ave. Bar Harbor, ME 04609 Email: mariska@acadia.net	
Daniel Morris	National Marine Fisheries Service Gloucester, MA 01930 Email: Daniel.morris@noaa.gov	
Doug Beach	National Marine Fisheries Service-PRD Gloucester, MA 01930 Email: Doug.beach@noaa.gov	
Keith Nislow	U.S. Forest Service Dartmouth College Hanover, NH 03755 Email: Keith.ninslow@dartmouth.edu	Tel: (603) 646-2395 Fax: (603) 646-1347

Dan Kircheis	U.S. Fish and Wildlife Service Maine Anadromous Fish Coordinator's Office East Orland, ME 04431 Email: dan_kircheis@fws.gov	Tele: 207-469-6701 Fax: 207-469-6702
James R. Gilbert	University of Maine Dept. Wildlife Ecology Orono, ME 04469 Email: gilbert@umenfa.maine.edu	Tel: (207) 581-2866 Fax: (207) 581-2858
David Bean	U.S. Fish and Wildlife Service Craig Brook National Fish Hatchery East Orland, ME 04431	Tel: (207) 469 – 2803 Fax: (207) 469-6847
Pete Mac Neil	University of Massachusetts Dept. of Natural Resources Conservation Amherst, MA 01003-4210 Email: pmacneil@forwild.umass.edu	Tel: (413) 548-7008

10.2 GLOSSARY OF ABBREVIATIONS USED

Adopt A Salmon Family	AASF
Arcadia Research Hatchery	ARH
Atlantic Salmon Association	ASA
Biological Resource Division	BRD
Connecticut Dept of Environmental Protection	CTDEP
Connecticut River Atlantic Salmon Commission	CRASC
Craig Brook National Fish Hatchery	CBNF
Decorative Specialties International	DSI
Developmental Index	DI
Federal Energy Regulatory Commission	FERC
Greenfield Community College	GCC
Green Lake National Fish Hatchery	GLNFH
International Council for the Exploration of the Seas	ICES
Kensington State Salmon Hatchery	KSSH
Maine Atlantic Salmon Authority	ASA
Massachusetts Div Fisheries and Wildlife	MAFW
Massachusetts Div Marine Fisheries	MAMF
Nashua National Fish Hatchery	NNFH
National Marine Fisheries Service	NMFS
New England Atlantic Salmon Committee	NEASC
New Hampshire Fish and Game Dept	NHFG
North Atlantic Salmon Conservation Organization	NASCO

North Attleboro National Fish Hatchery	NANFH
Northeast Utilities Service Company	NUSCO
Pittsford National Fish Hatchery	PNFH
Public Service of New Hampshire	PSNH
Rhode Island Div Fish and Wildlife	RIFW
Richard Cronin National Salmon Station	RCNSS
Roger Reed State Fish Hatchery	RRSFH
Roxbury Fish Culture Station	RFCS
Salmon Swimbladder Sarcoma Virus	SSSV
Silvio O. Conte National Fish and Wildlife Refuge	SOCNFWR
Southern New Hampshire Hydroelectric Development Corp	SNHHDC
Sunderland Office of Fisheries Assistance	SOFA
University of Massachusetts / Amherst	UMASS
U. S. Army Corps of Engineers	USACOE
U. S. Atlantic Salmon Assessment Committee	USASAC
U. S. Generating Company	USGen
U. S. Geological Survey	USGS
U. S. Fish and Wildlife Service	USFWS
U. S. Forest Service	USFS
Vermont Fish and Wildlife	VTFW
Warren State Fish Hatchery	WSFH
White River National Fish Hatchery	WRNFH
Whittemore Salmon Station	WSS

10.3. TABLES AND FIGURES SUPPORTING THE DOCUMENT

TABLE 2.1.3.g. RESULTS OF THE DOMESTIC ATLANTIC SALMON BROODSTOCK SPORT FISHERY IN THE MERRIMACK RIVER FOR 1993 - 1999.

Category	1993	1994	1995	1996	1997	1998	1999
Total permits sold	930	1,708	2,387	2,066	1,989	1,939	1,811
% Non-residents	3	9	7	10	8	11	10
Diary reporting rate (%)	61	61	60	27	22	22	19
Estimated no. of anglers that fished	715	1,250	1,683	1,355	1,352	1,203	1,182
% of anglers utilizing fly fishing	76	77	69	76	74	83	81
% of anglers utilizing artificial lures	24	14	20	16	16	9	9
% of anglers utilizing both fly fishing and artificial lures	0	9	11	8	10	8	10
Angler success in fly fishing areas (% catching at least 1 salmon)	35	26	30	27	32	27	44
Angler success in fly fishing/artificial lure area (% catching at least 1 salmon)	28	24	31	30	31	37	41
Estimated total hours of fishing effort	14,779	21,726	29,205	22,206	24,802	21,413	21,276
Estimated catch per unit of effort (hours per salmon landed)	14.9	23.5	15.9	14.4	14.6	13.9	8
Estimated no. of angler trips	4,651	6,258	9,746	6,958	8,736	7,459	8,274
Estimated no. of salmon caught and released	594	577	1,105	1,080	1,132	1,071	2,104
Estimated no. of salmon caught and kept	400	345	737	461	573	457	603
Estimated total catch (released and kept)	994	922	1,841	1,541	1,705	1,528	2,707
Estimated expenditures per angler ($)	$92	$84	$132	$131	$110	$245	$184
Estimated total expenditures by anglers ($)	$66,000	$105,000	$221,584	$177,506	$148,720	$294,735	$217,488

TABLE 2.2.1.a. JUVENILE ATLANTIC SALMON STOCKING SUMMARY FOR NEW ENGLAND IN 1999. [1]

RIVER	FRY	0+PARR	1PARR	1+PARR	1SMOLT	2SMOLT	TOTAL
	NUMBER OF FISH STOCKED BY LIFESTAGE[2]						
UNITED STATES							
Aroostook	163,000	0	0	0	0	0	163,000
St. Croix	1,000	0	0	0	21,300	0	22,300
Dennys	172,000	3,000	0	0	0	0	175,000
East Machias	210,000	1,000	0	0	0	0	211,000
Machias	169,000	1,000	0	0	0	0	170,000
Pleasant	0	0	0	0	0	0	0
Narraguagus	155,000	18,200	0	0	1,000	0	174,200
Union	165,000	82,100	0	0	0	0	247,100
Penobscot	1,498,000	229,600	1,500	0	567,300	0	2,296,400
Ducktrap	0	0	0	0	0	0	0
Sheepscot	302,000	4,700	0	0	0	0	306,700
Androscoggin	0	0	0	0	0	0	0
Saco	688,000	47,000	0	0	20,100	0	755,100
Cocheco	157,000	0	0	0	0	0	157,000
Lamprey	127,000	0	0	0	0	0	127,000
Merrimack	1,756,013	0	0	4,350	56,407	0	1,816,770
Pawcatuck	591,000	0	0	0	0	0	591,000
Connecticut	6,428,000	1,000	0	0	22,600	0	6,451,600
	12,582,013	**387,600**	**1,500**	**4,350**	**688,707**	**0**	**13,664,170**
CANADA							
Aroostook	0	0	0	0	0	0	0
St. Croix	0	22,500	0	0	0	0	22,500
	0	**22,500**	**0**	**0**	**0**	**0**	**22,500**
PROGRAM							
Maine							
United States	3,523,000	386,600	1,500	0	609,700	0	4,520,800
Canada	0	22,500	0	0	0	0	22,500
Cocheco	157,000	0	0	0	0	0	157,000
Lamprey	127,000	0	0	0	0	0	127,000
Merrimack River	1,756,013	0	0	4,350	56,407	0	1,816,770
Pawcatuck River	591,000	0	0	0	0	0	591,000
Connecticut River	6,428,000	1,000	0	0	22,600	0	6,451,600
TOTAL	**12,582,013**	**410,100**	**1,500**	**4,350**	**688,707**	**0**	**13,686,670**

[1] The distinction between USA and Canadian stocking is based on the sources of the fish or eggs.

[2] The number of fry is rounded to the nearest 1000 fish. All other entries rounded to the nearest 100 fish.

TABLE 2.2.1.b. CAPTIVE AND DOMESTIC ADULT ATLANTIC SALMON STOCKING SUMMARY FOR NEW ENGLAND IN 1999 BY RIVER, SEASON, AND YEAR CLASS. [1]

	NUMBER RELEASED BY SEASON AND YEAR CLASS										
RIVER	**Spring / Early Summer**					**Autumn**					
UNITED STATES	1993	1994	1995	1996	1997	1993	1994	1995	1996	1997	**TOTAL**
Aroostook	0	0	0	0	0	0	0	0	0	0	0
St. Croix	0	0	0	0	0	0	0	0	0	0	0
Dennys [2]	0	0	0	0	0	8	15	56	0	0	79
East Machias	0	0	0	0	0	0	0	0	0	0	0
Machias	0	0	0	0	0	0	0	0	0	0	0
Pleasant	0	0	0	0	0	0	0	0	0	0	0
Narraguagus	0	0	0	0	0	0	0	0	0	0	0
Union	0	0	0	0	0	0	0	0	0	0	0
Penobscot	0	0	250	846	0	0	0	664	664	0	2,424
Ducktrap	0	0	0	0	0	0	0	0	0	0	0
Sheepscot [3]	0	0	0	0	0	0	20	19	10	0	49
Saco	0	0	0	0	0	0	0	0	0	0	0
Cocheco	0	0	0	0	0	0	0	0	0	0	0
Lamprey	0	0	0	0	0	0	0	0	0	0	0
Merrimack	0	0	378	2,496	0	0	0	0	401	0	3,275
Pawcatuck	0	0	0	0	0	0	0	0	0	0	0
Connecticut	0	0	0	0	0	0	0	0	0	0	0
	0	**0**	**628**	**3,342**	**0**	**8**	**35**	**739**	**1,075**	**0**	**5,827**
CANADA											
Aroostook	0	0	0	0	0	0	0	0	0	0	0
St. Croix	0	0	0	0	0	0	0	0	0	0	0
	0	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
PROGRAM											
Maine											
United States	0	0	250	846	0	8	35	739	674	0	2,552
Canada	0	0	0	0	0	0	0	0	0	0	0
Cocheco	0	0	0	0	0	0	0	0	0	0	0
Lamprey	0	0	0	0	0	0	0	0	0	0	0
Merrimack River	0	0	378	2,496	0	0	0	0	401	0	3,275
Pawcatuck River	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0
TOTAL	**0**	**0**	**628**	**3,342**	**0**	**8**	**35**	**739**	**1,075**	**0**	**5,827**

[1] Year class refers to year of collection in the wild or egg take.

[2] In the Dennys, the 1993 year class (8 total) was stocked in January, 2000.

[3] In the Sheepscot, all fish (49 total) were stocked in January, 2000.

TABLE 2.2.2.a. SUMMARY OF JUVENILE AND ADULT ATLANTIC SALMON MARKING PROGRAMS IN NEW ENGLAND, 1999.

Mark	Stage	Connecticut	Dennys	Pleasant	Merrimack	Penobscot	Union	Narraguagus	Sheepscot	Saco	Total
Clip	adult										0
	parr			695	4,350		82,100				87,145
	smolt	21,287			3,898						25,185
	Total	21,287	0	695	8,248	0	82,100	0	0	0	112,330
Disc	adult										0
VIE	parr										0
	smolt										0
Floy	adult	14			3,275						3,289
Ping	smolt	50									50
	adult										0
PIT	parr	1,824		829							2,653
PIT	smolt	151									151
PIT	adult	34	79						49		162
Radio	smolt	250				87		126		300	763
Radio	adult	20			8						28
Carlin	adult										0
VIA	adult										0
All	adult	68	79	0	3,283	0	0	0	49	0	3,479
	parr	1,824	0	1,524	4,350	0	82,100	0	0	0	89,798
	smolt	21,738	0	0	3,898	87	0	126	0	300	26,149
Grand Total		**23,630**	**79**	**1,524**	**11,531**	**87**	**82,100**	**126**	**49**	**300**	**119,426**

Notes:

Clip = all clips combined

VIA = visual implant alpha-numeric

VIE = visual implant elastomers

Ping = internally implanted ultra-sonic pinger

TABLE 2.2.2.b. ATLANTIC SALMON MARKING DATABASE FOR NEW ENGLAND - 1999.

PLACE OF RELEASE	MARKING AGENCY	AGE	LIFE STAGE	H, W, C, D	STOCK ORIGIN	TAG/ MARK	NUMBER MARKED	CODE OR SERIAL	AUX MARK	RELEASE DATE	COMMENTS
Connecticut R.	USGS		smolt	H	Connecticut	PIT	74		AD	May-99	Smith Bk. Study VT
Connecticut R.	USGS		smolt	H	Connecticut	PIT	77		AD	May-99	CTR mainstem MA
Connecticut R.	USFWS	4	adult	W	Connecticut	PIT	10		Floy	Jan-99	CTR mainstem MA
Connecticut R.	USFWS		smolt	H	Connecticut	AD	21,136			Apr-99	Farmington River CT
Connecticut R.	USFWS	4	adult	W	Connecticut	PIT	2		Floy	Dec-99	CTR mainstem MA
Connecticut R.	USFWS	5	adult	W	Connecticut	PIT			Floy	Dec-99	CTR mainstem MA
Connecticut R.	PGE Gen	4	adult	W	Connecticut	Radio tag	16		PIT	May-99	Deerfield R. study MA
Connecticut R.	PGE Gen	5	adult	W	Connecticut	Radio tag	4		PIT	May-99	Deerfield R. study MA
Connecticut R.	CTDEP		adult	W	Connecticut	PIT			Floy	Dec-99	Salmon R. CT
Connecticut R.	PGE Gen		smolt	H	Connecticut	Radio tag	150			May-99	Deerfield R. study MA
Connecticut R.	NUSCO		smolt	H	Connecticut	Radio tag	100			May-99	Deerfield R. study MA
Connecticut R.	USGS	2	smolt	W	Connecticut	Ping	50			May-99	Holyoke Windsor Locks
Connecticut R.	USGS		parr	W	Connecticut	PIT	400			Oct-99	Smith Bk. Study VT
Connecticut R.	VTCFWRU	1+, 2+	parr	W	Connecticut	PIT	260		Paint	Jul-99	UVM Black Willms West study VT
Connecticut R.	USGS	1-2	parr	W	Connecticut	PIT	1,023			Mar-99-Dec-99	West Brook Study, MA
Connecticut R.	USGS	1-2	parr	W	Connecticut	PIT	141			Mar-99-Dec-99	Sawmill River Study, MA
TOTAL TAG/MARK, CONNECTICUT RIVER							23,445				
Merrimack R.	NHFG	3+, 4+	adult	D	Merrimack	Floy	700			Apr-May-99	Yellow
Merrimack R.	NHFG	3+, 4+	adult	D	Merrimack	Floy	797			Apr-May-99	Green
Merrimack R.	NHFG	3+	adult	D	Merrimack	Floy	309			Apr-99	White
Merrimack R.	NHFG	3+	adult	D	Merrimack	Floy	365			Apr-99	Blue
Merrimack R.	NHFG	3+, 4+	adult	D	Merrimack	Floy	703			Apr-May-99	Red
Merrimack R.	NHFG	3+	adult	D	Merrimack	Floy	190			Nov-99	Gray
Merrimack R.	NHFG	3+	adult	D	Merrimack	Floy	211			Nov-99	Purple
Merrimack R.	USFWS	1	smolt	H	Merrimack	RV	3144			Apr-99	
Merrimack R.	NHFG	1+	parr	H	Merrimack	LV	2130			Jun-99	
Merrimack R.	USFWS	1+	parr	H	Merrimack	RV	2220			Apr-99	
Merrimack R.	USFWS	3+	adult	W	Merrimack	Radio tag	7			Oct-99	Baker R. Study
Merrimack R.	USFWS	3+	adult	D	Merrimack	Radio tag				Oct-99	Baker R. Study
Merrimack R.	NHFG	1	smolt	D	Merrimack	LV	754			Jun-99	Essex Dam Strp Bass study
TOTAL TAG/MARK, MERRIMACK RIVER							11531	c			

PLACE OF RELEASE	MARKING AGENCY	AGE	LIFE STAGE	H, W, C, D	STOCK ORIGIN	TAG/ MARK	NUMBER MARKED	CODE OR SERIAL	AUX MARK	RELEASE DATE	COMMENTS
Penobscot R.	GNP		smolt	H	Penobscot	Radio tag	87	40.6-40.69 mHz		Apr-99	
TOTAL TAG/MARK, PENOBSCOT RIVER							**87**				
Dennys R.	USFWS/MASC	7	adult	C	Dennys	PIT	8			Jan-00	surplus broodstock, stkd Jan-00
Dennys R.	USFWS/MASC	5	adult	C	Dennys	PIT	15			Nov-99	
Dennys R.	USFWS/MASC	4	adult	C	Dennys	PIT	56			Nov-99	surplus broodstock, 1 stkd Jan-00
TOTAL TAG/MARK, DENNYS RIVER							**79**				
Union R.	USFWS	0+	parr	D	Penobscot	LV	82100			Sep-99	
TOTAL TAG/MARK, UNION RIVER							**82100**				
Narraguagus R.	MASC/NMFS	2	smolt	W	Narraguagus	Radio tag	102	65.5,67.3,69,72,75,76.8 kHz		Apr-99	smolt survival study
Narraguagus R.	MASC/NMFS		smolt	H	Narraguagus	Radio tag	24	65.5,67.3,69,72,75,76.8 kHz		Apr-99	smolt survival study
TOTAL TAG/MARK, NARRAGUAGUS RIVER							**126**				
Saco R.	FLP	1	smolt	H	Penobscot	Radio tag	300	149.32 mHz		May-99	15 day transmitter
TOTAL TAG/MARK, SACO RIVER							**300**				
Sheepscot	USFWS/MASC	4-6	adult	C	Sheepscot	PIT	49			Jan-00	
TOTAL TAG/MARK, SHEEPSCOT RIVER							**49**				
Pleasant	MASC/NMFS	0+	parr	W	Pleasant	PIT	134			Aug-99	parr to smolt prod. est.
Pleasant	MASC/NMFS	1+	parr	W	Pleasant	PIT	695		AD	Aug-99	parr to smolt prod. est.
TOTAL TAG/MARK, PLEASANT RIVER							**829**				

GRAND TOTAL TAG/MARK **118,546**

Notes:

H=hatchery

W=wild

C=captive, wild origin held in hatchery then released

D=domestic, entire life cycle in hatchery

VIA=visual implant alpha-numeric

VIE=visual implant elastomers

AD = adipose clip

AP=hole punched in adipose fin (AD punch)

LV=left ventral fin clip

RV=right ventral fin clip

Ping=internally implanted ultrasonic pinger

TABLE 2.3.1. DOCUMENTED ATLANTIC SALMON RETURNS TO NEW ENGLAND RIVERS IN 1999.

	NUMBER OF RETURNS BY SEA AGE AND ORIGIN[1]								
	1SW		2SW		3SW		RS		
RIVER	**Hatchery**	**Wild**	**Hatchery**	**Wild**	**Hatchery**	**Wild**	**Hatchery**	**Wild**	**TOTAL**
Penobscot River	220	45	573	111	0	0	9	10	968
Union River	3	0	3	3	0	0	0	0	9
Narraguagus River	0	6	2	23	0	0	0		32
Pleasant River									Unknown
Machias River									Unknown
East Machias River									Unknown
Dennys River									Unknown
St. Croix River		7	2	3	0	0	0	0	13
Kennebec River									Unknown
Androscoggin River	0			3	0	0	0	0	5
Sheepscot River									Unknown
Ducktrap River									Unknown
Saco River	10	12	11	31	0	2	0	0	66
Cocheco River	0	2	0		0	0	0	0	3
Lamprey River	0	6	0	0	0	0	0	0	6
Merrimack River	46	9	65	64		0	0	0	185
Pawcatuck River	1	0	6	4	0	0	0	0	11
Connecticut River	0	11	0	142	0	0	0		154
TOTAL	**281**	**99**	**663**	**385**	**1**	**2**	**9**	**12**	**1,452**

[1] These are considered minimum numbers, reflecting only trap counts and rod catches. Fish are considered to be wild if they originated from fry plants or natural production.

Note: An additional 17 1SW and 8 MSW salmon returned to the Aroostook River in 1999. These salmon were originally counted in the St. John River in Canada.

TABLE 2.3.4. SUMMARY OF ATLANTIC SALMON EGG PRODUCTION IN NEW ENGLAND FACILITIES IN 1999. [1]

SOURCE RIVER	ORIGIN	FEMALES SPAWNED	TOTAL EGG PRODUCTION	NO. OF EGGS PER FEMALE
Penobscot River	Sea-run	286	2,418,500	8,456
Merrimack River	Sea-run	88	736,600	8,370
Pawcatuck River	Sea-run	6	61,300	10,217
Connecticut River	Sea-run	83	621,500	7,488
TOTAL SEA-RUN		**463**	**3,837,900**	**8,289**
Penobscot River	Domestic	371	1,300,300	3,505
Merrimack River	Domestic	520	2,658,800	5,113
Connecticut River	Domestic	1,862	11,172,900	6,000
Dennys River	Captive [2]	48	248,800	5,183
East Machias River	Captive	57	296,000	5,193
Sheepscot River	Captive	49	218,200	4,453
Machias River	Captive	121	549,600	4,542
Narraguagus River	Captive	134	542,100	4,046
TOTAL CAPTIVE/DOMESTIC		**3,162**	**16,986,700**	**5,372**
Dennys River	Kelt	7	57,500	8,214
Merrimack River	Kelt	50	539,500	10,790
Connecticut River	Kelt	193	1,813,200	9,395
Sheepscot River	Kelt	8	92,100	11,513
TOTAL KELT		**258**	**2,502,300**	**9,699**
GRAND TOTAL		**3,883**	**23,326,900**	**6,007**

[1] Egg production rounded to nearest 100 eggs.

[2] Captive refers to adults produced from wild parr that were captured and reared to maturity in the hatchery.

Table 2.3.5. ESTIMATED 1999 SPORT CATCH OF ATLANTIC SALMON IN MAINE.

RIVER	TOTAL HARVEST	EST. NO. RELEASED	TOTAL ANGLED 1999	TOTAL ANGLED 1998
St. Croix	0	0		0
Dennys	0	3		0
East Machias	0	1		5
Machias	0	0		0
Pleasant	0	0		15
Narraguagus	0	8		0
Union	0	0		0
Penobscot	0	200		250
Ducktrap	0	0		0
Sheepscot	0	0	0	3
Kennebec	0	0	0	0
Saco	0	0	0	0
Aroostook	0	0	0	0
Misc.	0	0	0	0
TOTAL	**0**	**212**	**212**	**273**

Note: Information on age and origin is not available.

Table 3.2.a. ATLANTIC SALMON STOCKING SUMMARY FOR NEW ENGLAND BY RIVER.

NUMBER OF FRY ROUNDED TO NEAREST 1000 - ALL OTHER ENTRIES ROUNDED TO NEAREST 100

RIVER / YEAR	FRY	0+PARR	1PARR	1+PARR	1SMOLT	2SMOLT	TOTAL
	NUMBER OF FISH STOCKED BY LIFESTAGE						
UPPER ST. JOHN							
Total, 1979-1984	0	2,100	0	0	0	2,700	4,800
1985	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0
1987	306,000	60,000	0	0	0	0	366,000
1988	128,000	779,400	4,800	0	0	0	912,200
1989	66,000	0	0	0	0	10,300	76,300
1990	110,000	21,000	9,900	0	0	9,600	150,500
1991	228,000	139,300	0	0	5,100	5,100	377,500
1992	400,000	136,100	0	0	0	0	536,100
1993	361,000	102,800	0	0	0	0	463,800
1994	566,000	216,000	0	0	0	0	782,000
1995	0	0	0	0	0	0	0
1996	0	0	0	0	0	0	0
1997	0	0	0	0	0	0	0
1998	0	0	0	0	0	0	0
1999	0	0	0	0	0	0	0
Total, 1985-1999	2,165,000	1,454,600	14,700	0	5,100	25,000	3,664,400
GRAND TOTAL	**2,165,000**	**1,456,700**	**14,700**	**0**	**5,100**	**27,700**	**3,669,200**
AROOSTOOK							
Total, 1978-1984	0	28,300	20,400	0	5,200	2,600	56,500
1985	0	0	0	0	0	0	0
1986	84,000	0	0	1,800	0	0	85,800
1987	41,000	0	0	0	0	0	41,000
1988	43,000	0	0	0	0	0	43,000
1989	313,000	242,200	0	0	0	10,000	565,200
1990	69,000	0	0	0	27,400	7,600	104,000
1991	74,000	46,600	0	0	0	9,600	130,200
1992	0	0	16,400	0	0	0	16,400
1993	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0
1995	4,000	0	0	0	0	0	4,000
1996	0	0	0	0	0	0	0
1997	578,000	0	0	0	0	0	578,000
1998	142,000	0	0	0	0	0	142,000
1999	163,000	0	0	0	0	0	163,000
Total, 1985-1999	1,511,000	288,800	16,400	1,800	27,400	27,200	1,872,600
GRAND TOTAL	**1,511,000**	**317,100**	**36,800**	**1,800**	**32,600**	**29,800**	**1,929,100**

RIVER / YEAR	FRY	0+PARR	1PARR	1+PARR	1SMOLT	2SMOLT	TOTAL
	NUMBER OF FISH STOCKED BY LIFESTAGE						
ST. CROIX							
Total, 1981-1984	155,000	20,900	89,300	0	132,400	20,100	417,700
1985	178,000	46,400	12,900	0	59,600	0	296,900
1986	193,000	0	0	0	73,500	0	266,500
1987	255,000	0	41,000	0	59,800	0	355,800
1988	0	0	0	0	78,700	0	78,700
1989	0	0	0	0	50,600	0	50,600
1990	255,000	0	0	0	65,800	0	320,800
1991	51,000	40,000	0	0	60,200	0	151,200
1992	85,000	56,500	14,900	0	50,300	0	206,700
1993	0	101,000	0	0	40,100	0	141,100
1994	87,000	38,600	0	0	60,600	0	186,200
1995	1,000	0	0	0	0	0	1,000
1996	0	52,100	0	0	15,600	0	67,700
1997	1,000	400	0	0	0	0	1,400
1998	2,000	31,700	0	200	0	0	33,900
1999	1,000	22,500			21,300		44,800
Total, 1985-1999	1,109,000	389,200	68,800	200	636,100	0	2,203,300
GRAND TOTAL	**1,264,000**	**410,100**	**158,100**	**200**	**768,500**	**20,100**	**2,621,000**
DENNYS							
Total, 1975-1984	20,000	0	3,000	0	48,900	28,300	100,200
1985	0	0	0	0	4,500	0	4,500
1986	0	8,300	0	0	5,400	0	13,700
1987	24,000	0	0	0	9,000	0	33,000
1988	30,000	0	0	0	25,700	0	55,700
1989	12,000	0	0	0	12,100	0	24,100
1990	20,000	0	0	0	25,800	0	45,800
1991	25,000	0	400	0	11,700	0	37,100
1992	0	0	0	0	0	0	0
1993	33,000	0	0	0	0	0	33,000
1994	20,000	0	0	0	0	0	20,000
1995	84,000	0	0	0	0	0	84,000
1996	142,000	0	0	0	0	900	142,900
1997	213,000	0	0	0	0	0	213,000
1998	234,000	10,400	0	0	9,600	0	254,000
1999	172,000	3,000	0	0	0	0	175,000
Total, 1985-1999	1,009,000	21,700	400	0	103,800	900	1,135,800
GRAND TOTAL	**1,029,000**	**21,700**	**3,400**	**0**	**152,700**	**29,200**	**1,236,000**

RIVER / YEAR	FRY	0+PARR	1PARR	1+PARR	1SMOLT	2SMOLT	TOTAL
	NUMBER OF FISH STOCKED BY LIFESTAGE						
PLEASANT							
Total, 1975-1984	**0**	**0**	**0**	**0**	**8,300**	**18,100**	**26,400**
1985	33,000	0	0	0	4,100	0	37,100
1986	25,000	0	0	0	6,500	0	31,500
1987	25,000	0	0	0	7,500	0	32,500
1988	25,000	0	1,800	0	10,500	0	37,300
1989	26,000	2,500	0	0	7,300	0	35,800
1990	30,000	0	0	0	10,500	0	40,500
1991	23,000	0	0	0	0	0	23,000
1992	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0
1995	0	0	0	0	0	0	0
1996	0	0	0	0	0	0	0
1997	0	0	0	0	0	0	0
1998	0	0	0	0	0	0	0
1999	0	0	0	0	0	0	0
Total, 1985-1999	**187,000**	**2,500**	**1,800**	**0**	**46,400**	**0**	**237,700**
GRAND TOTAL	**187,000**	**2,500**	**1,800**	**0**	**54,700**	**18,100**	**264,100**
EAST MACHIAS							
Total, 1973-1984	**0**	**0**	**8,700**	**0**	**17,400**	**30,400**	**56,500**
1985	13,000	0	0	0	4,500	0	17,500
1986	8,000	0	0	0	5,300	0	13,300
1987	10,000	0	0	0	9,000	0	19,000
1988	10,000	0	7,500	0	20,700	0	38,200
1989	30,000	6,500	8,000	0	15,300	0	59,800
1990	42,000	0	10,100	0	10,100	0	62,200
1991	27,000	0	8,300	0	15,300	0	50,600
1992	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0
1995	0	0	0	0	0	0	0
1996	115,000	0	0	0	0	0	115,000
1997	111,000	0	0	0	0	0	111,000
1998	190,000	0	0	0	10,800	0	200,800
1999	210,000	1,000	0	0	0	0	211,000
Total, 1985-1999	**766,000**	**7,500**	**33,900**	**0**	**91,000**	**0**	**898,400**
GRAND TOTAL	**766,000**	**7,500**	**42,600**	**0**	**108,400**	**30,400**	**954,900**

RIVER / YEAR	FRY	0+PARR	1PARR	1+PARR	1SMOLT	2SMOLT	TOTAL
	NUMBER OF FISH STOCKED BY LIFESTAGE						
MACHIAS							
Total, 1970-1984	**0**	**12,500**	**0**	**0**	**60,600**	**42,200**	**115,300**
1985	0	0	7,000	0	5,100	0	12,100
1986	8,000	8,000	0	0	0	0	16,000
1987	0	12,500	12,300	0	13,600	0	38,400
1988	30,000	0	31,500	0	30,900	0	92,400
1989	49,000	13,800	28,000	0	23,100	0	113,900
1990	75,000	10,100	17,600	0	26,100	0	128,800
1991	13,000	30,000	21,400	0	21,100	0	85,500
1992	14,000	0	0	0	0	0	14,000
1993	0	0	0	0	0	0	0
1994	50,000	0	0	0	0	0	50,000
1995	150,000	0	0	0	0	0	150,000
1996	233,000	0	0	0	0	1,900	234,900
1997	237,000	0	0	0	0	0	237,000
1998	300,000	5,900	0	0	10,800	0	316,700
1999	169,000	1,000	0	0	0	0	170,000
Total, 1985-1999	**1,328,000**	**81,300**	**117,800**	**0**	**130,700**	**1,900**	**1,659,700**
GRAND TOTAL	**1,328,000**	**93,800**	**117,800**	**0**	**191,300**	**44,100**	**1,775,000**
NARRAGUAGUS							
Total, 1970-1984	**0**	**7,800**	**0**	**0**	**15,300**	**79,100**	**102,200**
1985	10,000	0	0	0	4,500	0	14,500
1986	0	0	0	0	7,500	0	7,500
1987	15,000	0	0	0	9,000	0	24,000
1988	20,000	13,000	5,600	0	15,700	0	54,300
1989	29,000	9,500	7,000	0	22,100	4,900	72,500
1990	0	0	0	0	16,800	0	16,800
1991	0	0	0	0	15,200	0	15,200
1992	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0
1995	105,000	0	0	0	0	0	105,000
1996	196,000	0	0	0	0	0	196,000
1997	209,000	0	2,000	0	700	0	211,700
1998	274,000	14,400	0	0	0	0	288,400
1999	155,000	18,200	0	0	1,000	0	174,200
Total, 1985-1999	**1,013,000**	**55,100**	**14,600**	**0**	**92,500**	**4,900**	**1,180,100**
GRAND TOTAL	**1,013,000**	**62,900**	**14,600**	**0**	**107,800**	**84,000**	**1,282,300**

NUMBER OF FISH STOCKED BY LIFESTAGE

RIVER / YEAR	FRY	0+PARR	1PARR	1+PARR	1SMOLT	2SMOLT	TOTAL
UNION							
Total, 1971-1984	**0**	**0**	**0**	**0**	**174,000**	**251,000**	**425,000**
1985	7,000	0	0	0	45,800	0	52,800
1986	7,000	0	0	0	48,400	0	55,400
1987	7,000	0	0	0	40,100	0	47,100
1988	0	0	0	0	30,600	0	30,600
1989	0	0	0	0	20,400	0	20,400
1990	0	0	0	0	20,400	0	20,400
1991	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0
1993	60,000	111,700	0	0	0	0	171,700
1994	0	0	0	0	0	0	0
1995	0	54,800	0	0	0	0	54,800
1996	0	53,500	0	0	0	0	53,500
1997	12,000	69,300	0	0	0	0	81,300
1998	165,000	0	0	0	0	0	165,000
1999	165,000	82,100	0	0	0	0	247,100
Total, 1985-1999	**423,000**	**371,400**	**0**	**0**	**205,700**	**0**	**1,000,100**
GRAND TOTAL	**423,000**	**371,400**	**0**	**0**	**379,700**	**251,000**	**1,425,100**
PENOBSCOT							
Total, 1970-1984	**754,000**	**135,700**	**550,100**	**9,100**	**1,658,800**	**2,061,000**	**5,168,700**
1985	197,000	59,500	17,600	0	476,500	104,400	855,000
1986	226,000	25,700	58,600	0	520,200	69,000	899,500
1987	333,000	58,100	101,100	0	456,800	82,400	1,031,400
1988	431,000	0	51,400	0	599,900	87,100	1,169,400
1989	77,000	104,100	179,600	0	351,300	65,300	777,300
1990	317,000	166,500	155,300	0	413,200	15,900	1,067,900
1991	398,000	202,600	104,100	0	657,800	15,000	1,377,500
1992	925,000	278,200	106,600	0	816,600	8,100	2,134,500
1993	1,320,000	202,300	9,600	0	580,400	0	2,112,300
1994	949,000	0	2,400	0	567,600	0	1,519,000
1995	502,000	325,000	5,600	0	568,400	0	1,401,000
1996	1,242,000	226,000	17,500	0	552,200	0	2,037,700
1997	1,472,000	310,900	4,200	0	580,200	0	2,367,300
1998	936,000	337,400	13,400	0	571,800	0	1,858,600
1999	1,498,000	229,600	1,500	0	567,300	0	2,296,400
Total, 1985-1999	**10,823,000**	**2,525,900**	**828,500**	**0**	**8,280,200**	**447,200**	**22,904,800**
GRAND TOTAL	**11,577,000**	**2,661,600**	**1,378,600**	**9,100**	**9,939,000**	**2,508,200**	**28,073,500**

RIVER / YEAR	FRY	0+PARR	1PARR	1+PARR	1SMOLT	2SMOLT	TOTAL
	NUMBER OF FISH STOCKED BY LIFESTAGE						
DUCKTRAP							
1985	15,000	0	0	0	0	0	15,000
1986	8,000	0	0	0	0	0	8,000
1987	15,000	0	0	0	0	0	15,000
1988	10,000	0	0	0	0	0	10,000
1989	17,000	0	0	0	0	0	17,000
1990	18,000	0	0	0	0	0	18,000
1991	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0
1995	0	0	0	0	0	0	0
1996	0	0	0	0	0	0	0
1997	0	0	0	0	0	0	0
1998	0	0	0	0	0	0	0
1999	0	0	0	0	0	0	0
Total, 1985-1999	83,000	0	0	0	0	0	83,000
GRAND TOTAL	**83,000**	**0**	**0**	**0**	**0**	**0**	**83,000**
SHEEPSCOT							
Total, 1971-1984	0	0	0	0	19,500	3,500	23,000
1985	20,000	0	0	0	3,900	3,600	27,500
1986	10,000	11,600	0	0	7,500	0	29,100
1987	15,000	8,200	0	0	9,000	0	32,200
1988	40,000	12,300	0	0	10,200	0	62,500
1989	29,000	13,600	10,000	0	10,200	0	62,800
1990	27,000	10,100	10,000	0	17,500	0	64,600
1991	18,000	15,000	600	0	14,400	0	48,000
1992	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0
1995	0	0	0	0	0	0	0
1996	102,000	0	0	0	0	0	102,000
1997	64,000	0	0	0	0	0	64,000
1998	256,000	9,300	0	0	0	0	265,300
1999	302,000	4,700	0	0	0	0	306,700
Total, 1985-1999	883,000	84,800	20,600	0	72,700	3,600	1,064,700
GRAND TOTAL	**883,000**	**84,800**	**20,600**	**0**	**92,200**	**7,100**	**1,087,700**

NUMBER OF FISH STOCKED BY LIFESTAGE

RIVER / YEAR	FRY	0+PARR	1PARR	1+PARR	1SMOLT	2SMOLT	TOTAL
SACO							
Total, 1975-1984	0	47,100	0	0	25,400	9,500	82,000
1985	0	0	23,600	0	5,100	0	28,700
1986	0	0	10,000	0	35,200	0	45,200
1987	0	0	69,800	0	22,000	0	91,800
1988	47,000	0	0	0	25,100	0	72,100
1989	0	37,800	49,600	0	9,900	0	97,300
1990	0	30,100	47,800	0	10,600	0	88,500
1991	111,000	0	0	0	10,300	0	121,300
1992	154,000	50,200	400	0	19,800	0	224,400
1993	167,000	0	0	0	20,100	0	187,100
1994	190,000	0	0	0	20,000	0	210,000
1995	376,000	0	0	0	19,700	0	395,700
1996	0	45,000	0	0	20,000	0	65,000
1997	97,000	63,300	0	0	20,200	0	180,500
1998	426,000	50,000	0	0	21,300	0	497,300
1999	688,000	47,000	0	0	20,100	0	755,100
Total, 1985-1999	2,256,000	323,400	201,200	0	279,400	0	3,060,000
GRAND TOTAL	**2,256,000**	**370,500**	**201,200**	**0**	**304,800**	**9,500**	**3,142,000**
COCHECO							
1988	2,000	0	0	0	0	0	2,000
1989	106,000	0	0	0	0	0	106,000
1990	32,000	50,000	9,500	0	0	0	91,500
1991	138,000	0	0	0	0	0	138,000
1992	128,000	0	0	0	0	0	128,000
1993	127,000	0	0	1,000	0	0	128,000
1994	149,000	0	0	0	5,300	0	154,300
1995	114,000	0	0	0	0	0	114,000
1996	126,000	0	0	0	0	0	126,000
1997	128,000	0	0	0	0	0	128,000
1998	96,000	0	0	0	0	0	96,000
1999	157,000	0	0	0	0	0	157,000
Total, 1988-1999	1,303,000	50,000	9,500	1,000	5,300	0	1,368,800
GRAND TOTAL	**1,303,000**	**50,000**	**9,500**	**1,000**	**5,300**	**0**	**1,368,800**

NUMBER OF FISH STOCKED BY LIFESTAGE

RIVER / YEAR	FRY	0+PARR	1PARR	1+PARR	1SMOLT	2SMOLT	TOTAL
LAMPREY							
Total, 1978-1984	0	0	0	0	118,300	32,800	151,100
1985	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0
1989	146,000	0	0	0	0	0	146,000
1990	50,000	87,000	11,400	0	0	0	148,400
1991	110,000	68,200	0	0	0	0	178,200
1992	127,000	12,700	0	0	0	0	139,700
1993	68,000	56,500	28,800	1,100	15,000	0	169,400
1994	98,000	56,300	7,800	0	0	0	162,100
1995	91,000	57,100	0	0	4,800	0	152,900
1996	115,000	37,000	8,400	1,000	0	0	161,400
1997	141,000	52,900	0	0	0	0	193,900
1998	95,000	0	0	0	3,300	0	98,300
1999	127,000	0	0	0	0	0	127,000
Total, 1985-1999	1,168,000	427,700	56,400	2,100	23,100	0	1,677,300
GRAND TOTAL	**1,168,000**	**427,700**	**56,400**	**2,100**	**141,400**	**32,800**	**1,828,400**
MERRIMACK							
Total, 1976-1984	1,085,000	162,500	38,300	127,600	118,000	383,000	1,914,400
1985	148,000	0	5,800	0	64,000	125,300	343,100
1986	525,000	0	31,500	0	39,900	64,100	660,500
1987	1,078,000	0	99,300	0	141,600	0	1,318,900
1988	1,718,000	0	129,600	0	94,400	0	1,942,000
1989	1,034,000	60,000	88,600	0	58,600	0	1,241,200
1990	975,000	0	5,600	29,700	116,900	0	1,127,200
1991	1,458,000	0	0	0	62,000	58,100	1,578,100
1992	1,118,000	0	100	0	96,400	0	1,214,500
1993	1,157,000	0	0	0	59,000	0	1,216,000
1994	2,816,000	0	0	0	85,000	0	2,901,000
1995	2,827,000	0	12,700	0	70,800	0	2,910,500
1996	1,795,000	0	0	4,900	50,000	0	1,849,900
1997	1,977,000	5,000	4,700	5,300	52,500	5,400	2,049,900
1998	2,589,000	0	0	6,800	51,900	0	2,647,700
1999	1,756,013	0	0	4,350	56,407	0	1,816,770
Total, 1985-1999	22,971,013	65,000	377,900	51,050	1,099,407	252,900	24,817,270
GRAND TOTAL	**24,056,013**	**227,500**	**416,200**	**178,650**	**1,217,407**	**635,900**	**26,731,670**

NUMBER OF FISH STOCKED BY LIFESTAGE

RIVER / YEAR	FRY	0+PARR	1PARR	1+PARR	1SMOLT	2SMOLT	TOTAL
PAWCATUCK							
Total, 1979-1984	**2,000**	**163,700**	**108,000**	**0**	**800**	**0**	**274,500**
1985	8,000	51,000	1,400	0	0	0	60,400
1986	0	50,700	15,000	0	0	0	65,700
1987	3,000	46,200	4,700	0	1,000	0	54,900
1988	150,000	59,600	7,100	0	5,400	0	222,100
1989	0	379,900	35,800	0	6,500	0	422,200
1990	0	83,500	55,000	0	7,500	0	146,000
1991	0	101,000	1,000	0	2,000	500	104,500
1992	0	70,800	2,500	0	5,000	0	78,300
1993	383,000	14,500	4,000	0	2,300	0	403,800
1994	557,000	0	0	0	0	0	557,000
1995	367,000	52,200	0	0	0	0	419,200
1996	289,000	136,100	0	0	5,000	0	430,100
1997	100,000	0	14,000	0	11,500	0	125,500
1998	910,000	0	6,100	8,600	5,700	0	930,400
1999	591,000	0	0	0	0	0	591,000
Total, 1985-1999	**3,358,000**	**1,045,500**	**146,600**	**8,600**	**51,900**	**500**	**4,611,100**
GRAND TOTAL	**3,360,000**	**1,209,200**	**254,600**	**8,600**	**52,700**	**500**	**4,885,600**
CONNECTICUT							
Total, 1967-1984	**1,988,000**	**516,100**	**591,500**	**218,700**	**466,700**	**963,200**	**4,744,200**
1985	422,000	130,500	110,700	0	255,000	0	918,200
1986	176,000	188,400	267,100	0	290,500	0	922,000
1987	1,180,000	383,200	345,100	0	206,000	0	2,114,300
1988	1,310,000	72,200	75,200	0	395,300	0	1,852,700
1989	1,243,000	268,700	76,800	0	217,700	0	1,806,200
1990	1,271,000	341,600	25,400	0	475,900	0	2,113,900
1991	1,725,000	306,200	33,100	0	351,000	0	2,415,300
1992	2,009,000	313,900	11,500	0	313,300	0	2,647,700
1993	4,147,000	237,100	28,700	0	382,800	0	4,795,600
1994	5,979,000	37,000	2,300	12,900	375,100	0	6,406,300
1995	6,818,000	4,500	0	0	1,300	0	6,823,800
1996	6,675,000	12,400	0	3,600	11,500	0	6,702,500
1997	8,526,000	8,800	0	0	1,400	0	8,536,200
1998	9,119,000	3,000	0	7,700	1,700	0	9,131,400
1999	6,428,000	1,000	0	0	22,600	0	6,451,600
Total, 1985-1999	**57,028,000**	**2,308,500**	**975,900**	**24,200**	**3,301,100**	**0**	**63,637,700**
GRAND TOTAL	**59,016,000**	**2,824,600**	**1,567,400**	**242,900**	**3,767,800**	**963,200**	**68,381,900**

RIVER / YEAR	FRY	0+PARR	1PARR	1+PARR	1SMOLT	2SMOLT	TOTAL
	NUMBER OF FISH STOCKED BY LIFESTAGE						
Upper St. John	2,165,000	1,456,700	14,700	0	5,100	27,700	3,669,200
Aroostook	1,511,000	317,100	36,800	1,800	32,600	29,800	1,929,100
St. Croix	1,264,000	410,100	158,100	200	768,500	20,100	2,621,000
Dennys	1,029,000	21,700	3,400	0	152,700	29,200	1,236,000
Pleasant	187,000	2,500	1,800	0	54,700	18,100	264,100
East Machias	766,000	7,500	42,600	0	108,400	30,400	954,900
Machias	1,328,000	93,800	117,800	0	191,300	44,100	1,775,000
Narraguagus	1,013,000	62,900	14,600	0	107,800	84,000	1,282,300
Union	423,000	371,400	0	0	379,700	251,000	1,425,100
Penobscot	11,577,000	2,661,600	1,378,600	9,100	9,939,000	2,508,200	28,073,500
Ducktrap	83,000	0	0	0	0	0	83,000
Sheepscot	883,000	84,800	20,600	0	92,200	7,100	1,087,700
Saco	2,256,000	370,500	201,200	0	304,800	9,500	3,142,000
Cocheco	1,303,000	50,000	9,500	1,000	5,300	0	1,368,800
Lamprey	1,168,000	427,700	56,400	2,100	141,400	32,800	1,828,400
Merrimack	24,056,013	227,500	416,200	178,650	1,217,407	635,900	26,731,670
Pawcatuck	3,360,000	1,209,200	254,600	8,600	52,700	500	4,885,600
Connecticut	59,016,000	2,824,600	1,567,400	242,900	3,767,800	963,200	68,381,900
TOTAL	**113,388,013**	**10,599,600**	**4,294,300**	**444,350**	**17,321,407**	**4,691,600**	**150,739,270**

GRAND TOTAL BY RIVER

Note: Stocking data prior to 1970 are not presented for the Machias, Narraguagus, and Penobscot Rivers.

Table 3.2.b. DOCUMENTED ATLANTIC SALMON RETURNS TO NEW ENGLAND RIVERS

Documented returns include only trap and rod caught salmon. The number of returns are unknown where shaded.

Returns from juveniles of hatchery origin include 0+Parr, 1Parr, 1+Parr, 1Smolt, and 2Smolt releases.

Returns of wild origin include adults produced from natural reproduction and adults produced from fry releases.

		HATCHERY ORIGIN				WILD ORIGIN				
RIVER	YEAR	1-S-W	2-S-W	3-S-W	REPEAT	1-S-W	2-S-W	3-S-W	REPEAT	TOTAL
PENOBSCOT										
	Total, 1967-1984	2,703	16,673	115	242	46	361	8	4	20,152
	1985	244	2,868	6	9	22	202		4	3,356
	1986	534	3,620	14	8	17	332	3	1	4,529
	1987	749	1,477	29	49	19	162	5	20	2,510
	1988	716	1,993	6	52	14	64	0	10	2,855
	1989	867	2,005	4	36	67	103		4	3,087
	1990	430	2,520	14	26	93	254	3	2	3,342
	1991	176	1,085	4	21	40	427	0	4	1,757
	1992	932	1,174	0	5	27	236		4	2,379
	1993	349	1,279	7	13	22	92		6	1,769
	1994	265	630	2	5	48	93	0	6	1,049
	1995	158	1,077	7	9	6	84	0	1	1,342
	1996	482	1,187	6	14	13	335	3	5	2,045
	1997	241	914	4	13	6	174	2	1	1,355
	1998	240	796	0	10	29	130		4	1,210
	1999	220	573	0	9	45	111	0	10	[illegible]8
	Total, 1985-1999	6,603	23,198	103	279	468	2,799	21	82	33,553
	GRAND TOTAL	**9,306**	**39,871**	**218**	**521**	**514**	**3,160**	**29**	**86**	**53,705**
UNION										
	Total, 1973-1984	255	1,458	7	23	0	4	0	0	1,747
	1985	3	79	0	0	0	0	0	0	82
	1986	7	59		0	0	0	0	0	67
	1987	19	43	0	1	0	0	0	0	63
	1988	0	45	0	0	0	2	0	0	47
	1989	4	25		0	0	0	0	0	30
	1990		20	0	0	0	0	0	0	21
	1991			0	0		5	0	0	8
	1992	0	4	0	0	0	0	0	0	4
	1996	6	62	0				0		69
	1997	0	8	0		0	0	0		8
	1998	2	7	0		0	0	0		13
	1999	3	3	0		0	3	0		9
	Total, 1985-1999	46	356	2			11	0		421
	GRAND TOTAL	**301**	**1,814**	**9**	**28**		**15**	**0**	**0**	**2,168**

RIVER	YEAR	HATCHERY ORIGIN 1-S-W	2-S-W	3-S-W	REPEAT	WILD ORIGIN 1-S-W	2-S-W	3-S-W	REPEAT	TOTAL
NARRAGUAGUS										
	Total, 1967-1984	75	510	19	42	17	1,796	68	112	2,639
	1985	0	0	0	0	0	56	0	1	57
	1986	0	20	0	0	2	23	0	0	45
	1987	0	11	0	0	0	24	0	2	37
	1988		10	0	0	2	24	0	1	38
	1989	3	9	0	0		26	0	0	39
	1990		22	0	0	0	27	0	1	51
	1991	3	19	0	5	8	53	0	7	95
	1992	6	19	0	1	11	32	0	4	73
	1993	0	16	0	4	6	66	0	2	94
	1994		0	0	0	4	42	0	4	51
	1995	0	0	0	0	0	51	0	5	56
	1996		7	0	0	9	42	0	5	64
	1997	0	2	0	0		30	0	4	37
	1998	0	0	0	0		18	0	3	22
	1999	0	2	0	0	6	23	0	1	32
	Total, 1985-1999	16	137	0	10	51	537	0	40	791
	GRAND TOTAL	**91**	**647**	**19**	**52**	**68**	**2,333**	**68**	**152**	**3,430**
PLEASANT										
	Total, 1967-1984	5	8	0	0	7	161	2	2	185
	1985	0	0	0	0	3	28	0	0	31
	1986	0	0	0	0	0	19	0	0	19
	1987	0	4	0	0	0	5	0	0	9
	1988									
	1989	0	0	0	0	0	0	0	0	0
	1990	0	0	0	0	0	0	0	0	0
	1991	0	0	0	0	0	0	0	0	0
	1992	0	0	0	0	0	0	0	0	0
	1993	0	0	0	0	0	0	0	0	0
	1994	0	0	0	0	1	1	0	0	2
	1995									
	1996									
	1997	0	0	0	0	0	1	0	0	1
	1998									
	1999									
	Total, 1985-1999	0	4	0	0	4	54	0	0	62
	GRAND TOTAL	**5**	**12**	**0**	**0**	**11**	**215**	**2**	**2**	**247**

RIVER	YEAR	HATCHERY ORIGIN 1-S-W	HATCHERY ORIGIN 2-S-W	HATCHERY ORIGIN 3-S-W	HATCHERY ORIGIN REPEAT	WILD ORIGIN 1-S-W	WILD ORIGIN 2-S-W	WILD ORIGIN 3-S-W	WILD ORIGIN REPEAT	TOTAL
MACHIAS										
	Total, 1967-1984	26	298	9	2	25	1,515	41	125	2,041
	1985	0	5	0	0	0	25	0	2	32
	1986	2	16	0	0	2	24	0	2	46
	1987	0	0	0	0	0	4	0	0	4
	1988	0	0	0	0	0	6	0	2	8
	1989	3	4	0	0	4	5	0	0	16
	1990	0		0	0	0		0	0	2
	1991	1	0	0	0	1	0	0	0	2
	1992	0	3	0	0	0	0	0	0	3
	1993									
	Total, 1985-1999	6	31	0		8	77	0		128
	GRAND TOTAL	**32**	**329**	**9**	**2**	**33**	**1,592**	**41**	**131**	**2,169**
EAST MACHIAS										
	Total, 1967-1984	6	181		2	9	258	0	8	465
	1985	0	0	0	0	0	30	0	0	30
	1986	0	5	0	0	0	8	0	0	13
	1987	0	8	0	0	0	5		0	14
	1988		8	0	0	0	5	0	0	14
	1989	12	10	0	0	2	6	0	1	31
	1990		30	0	0	0	16	0	1	48
	1991		2	0	0	1		0	0	5
	1992	0	6	0	0	0	0	0	0	6
	1993	0	0	0		0	0	0	0	0
	Total, 1985-1999	15	69	0		3	71			161
	GRAND TOTAL	**21**	**250**		**2**	**12**	**329**		**10**	**626**

RIVER	YEAR	HATCHERY ORIGIN 1-S-W	HATCHERY ORIGIN 2-S-W	HATCHERY ORIGIN 3-S-W	HATCHERY ORIGIN REPEAT	WILD ORIGIN 1-S-W	WILD ORIGIN 2-S-W	WILD ORIGIN 3-S-W	WILD ORIGIN REPEAT	TOTAL
DENNYS										
	Total, 1967-1984	10	243	0	0	18	659	3	10	943
	1985	0	6	0	0	0	14	0	0	20
	1986	0	7	0	0	0	8	0	0	15
	1987	0	0	0	0	0		0	0	
	1988	0	3	0	0	0	6	0	0	9
	1989		10	0	0	0		0	0	12
	1990		20	0	1	0	11	0	0	33
	1991		0	0	0	0	6	0	0	7
	1992		3	0	0	0		0	0	5
	1993	7	2	0	0	0	4	0	0	13
	1994	0	0	0	0		5	0	0	6
	1995	0	0	0	0	0	5	0	0	5
	1996	0	0	0	0	3	7	0	0	10
	1997	0	0	0	0	0	0	0	0	0
	1998	0	0	0	0	0		0	0	1
	1999									
	Total, 1985-1999	11	51	0	1	4	70	0	0	137
GRAND TOTAL		21	294	0		22	729	3	10	1,080
ST. CROIX										
	Total, 1981-1984	205	127	10	0	130	66	6	0	544
	1985	28	144	14	0	28	122	14	0	350
	1986	34	116	13	0	33	116	13	0	325
	1987	108	63		0	94	103	6	0	375
	1988	76	229	0	3	18	61	0	1	388
	1989	78	66	0	1	44	44	0	8	241
	1990	6	59	0	7	12	26	0	2	112
	1991	41	90	0	0	16	38	0	4	189
	1992		0	0	0	0	0	0	0	
	1993	5	76	0	0	4	18	0	2	105
	1994	23	17	0	1	24	19	0	0	84
	1995	7	15	0	0	8	16	0	0	46
	1996	13	77	0	0	10	32	0	0	132
	1997	26	2	0	0	0	0	0	0	28
	1998	20	3	0	0	12	6	0	0	41
	1999		2	0	0	7	3	0	0	13
	otal, 1985-1999	467	959	28	12	310	604	33	17	2,430
ND TOTAL		672	1,086	38	12	440	670	39	17	2,974

RIVER	YEAR	HATCHERY ORIGIN 1-S-W	HATCHERY ORIGIN 2-S-W	HATCHERY ORIGIN 3-S-W	HATCHERY ORIGIN REPEAT	WILD ORIGIN 1-S-W	WILD ORIGIN 2-S-W	WILD ORIGIN 3-S-W	WILD ORIGIN REPEAT	TOTAL
KENNEBEC										
	Total, 1975-1984	**6**	**109**	**4**	**0**	**0**	**3**	**0**	**0**	**122**
	1985	0	0	0	0	0	0	0	0	0
	1986	0	0	0	0	0	0	0	0	0
	1987	0	2		0	0	2	0	0	5
	1988	4	15	0	1	0	0	0	0	20
	1989		16	0	0	0	0	0	0	17
	1990		41	0	0	0	4	0	0	46
	1991	0	4	0	0	0	0	0	0	4
	1992	0	0	0	0	0	0	0	0	0
	Total, 1985-1999		**80**			**0**	**6**	**0**		**94**
	GRAND TOTAL	**12**	**189**	**5**	**1**	**0**	**9**	**0**	**0**	**216**
ANDROSCOGGIN										
	Total, 1983-1984	**5**	**95**		**0**	**0**	**10**	**0**	**1**	**112**
	1985		18	0	0	0	2	0	0	21
	1986	0	72		0	0	8	0	0	81
	1987	2	20	3	0	0		0	0	26
	1988	2	11	0			0	0	0	14
	1989		17	0		0		0	0	19
	1990	6	168	0			9	0	0	185
	1991	0	9	0		0	12	0	0	21
	1992	2	9	0			3	0	0	15
	1993		33	0			9	0	0	44
	1994	2	16	0	1	0	6	0	0	25
	1995	2	12	0	0	0	2	0	0	16
	1996	2	19		0		16	0	0	39
	1997	0	0	0	0	0		0	0	
	1998	0	4	0	0	0	0	0	0	4
	1999	0		0	0		3	0	0	5
	otal, 1985-1999	**21**	**409**	**5**	**2**	**6**	**73**	**0**	**0**	**516**
	ND TOTAL	**26**	**504**	**6**	**2**	**6**	**83**	**0**	**1**	**628**

RIVER	YEAR	HATCHERY ORIGIN 1-S-W	2-S-W	3-S-W	REPEAT	WILD ORIGIN 1-S-W	2-S-W	3-S-W	REPEAT	TOTAL
SHEEPSCOT										
	Total, 1967-1984	0	0	0	0	21	293	9	0	323
	1985	0	0	0	0		5	0	0	6
	1986	0	0	0	0		10	0	0	11
	1987	2	7	0	0		5	0	0	15
	1988		0	0	0	0	0	0	0	
	1989			0	0	2		0	0	5
	1990		8	0	0	0	0	0	0	9
	1991	0	4	0	0	0	0	0	0	4
	1992		2	0	0		2		0	7
	1993	0	9	0	0	0	0	0	0	9
	1994	0	5	0	0	3	12	0	0	20
	1995	0	2	0	0	0	22	0	0	24
	1996	0	0	0	0		8	0	0	8
	1997	0	0	0	0	0	0	0	0	0
	1998									
	1999									
	Total, 1985-1999	6	38	0	0	9	65	1	0	119
	GRAND TOTAL	**6**	**38**	**0**	**0**	**30**	**358**	**10**	**0**	**442**
DUCKTRAP										
	1985	0	0	0	0	0	15	0	0	15
	1986	0	0	0	0	3	12	0	0	15
	1987	0	0	0	0	0	0	0	0	0
	1988	0	0	0	0	0	0	0	0	0
	1989	0	0	0	0	0	0	0	0	0
	1990	0	0	0	0	0	3	0	0	3
	1991	0	0	0	0	0	0	0	0	0
	1992	0	0	0	0	0	0	0	0	0
	1993	0	0	0	0	0	0	0	0	0
	Total, 1985-1999			0		3	30	0		33
	GRAND TOTAL	**0**	**0**	**0**	**0**	**3**	**30**	**0**	**0**	**33**

RIVER	YEAR	HATCHERY ORIGIN 1-S-W	HATCHERY ORIGIN 2-S-W	HATCHERY ORIGIN 3-S-W	HATCHERY ORIGIN REPEAT	WILD ORIGIN 1-S-W	WILD ORIGIN 2-S-W	WILD ORIGIN 3-S-W	WILD ORIGIN REPEAT	TOTAL
SACO										
	1986	0	36			0	0	0		37
	1987	4	34			0		0		40
	1988		37	0		0	0	0		38
	1989	2	16	0		0	0	0		19
	1990	4	68	0		0		0		73
	1991	0	4	0		0	0	0		4
	1992	0	0	0		0	0	0		0
	1993	4	54	0		0	0	0		59
	1994	6	17	0		0	0	0		23
	1995	0	34	0		0	0	0		34
	1996	11	39			0	0	0		54
	1997	5	23	0		0	0	0		28
	1998	9	7	0		4				28
	1999	10	11	0		12	31	2		66
	Total, 1985-1999	58	438	3		16	40	3		563
	GRAND TOTAL	**58**	**438**	**3**	**5**	**16**	**40**	**3**	**0**	**563**
COCHECO										
	1992									
	1993	0	0				2	0		
	1994	0	0	0		0	0	0		0
	1995	0	0	0		0		0		
	1996	0	0	0	0	2	0	0		2
	1997	0	0	0	0	0	0	0	0	0
	1998	0	0	0	0	0	0	0	0	0
	1999	0	0	0	0	2		0	0	3
	Total, 1990-1999	0	0		1	5	5	0	0	12
	GRAND TOTAL	**0**	**0**	**1**	**1**	**5**	**5**	**0**	**0**	**12**

RIVER	YEAR	HATCHERY ORIGIN 1-S-W	2-S-W	3-S-W	REPEAT	WILD ORIGIN 1-S-W	2-S-W	3-S-W	REPEAT	TOTAL
LAMPREY										
	Total, 1979-1984	**10**	**17**		**0**	**0**	**0**	**0**	**0**	**28**
	1985	0	0	0	0	0	0	0	0	0
	1986	0	0	0	0	0	0	0	0	0
	1987	0	0	0	0	0	0	0	0	0
	1988	0	0	0	0	0	0	0	0	0
	1989	0	0	0	0	0	0	0	0	0
	1990	0	0	0	0	0	0	0	0	0
	1991	0	0	0	0	0	0	0	0	0
	1992	0	0	0	0	0	2	0	0	2
	1993	0	0	0	0		7	0	0	8
	1994	0	0	0	0	0	3	0	0	3
	1995	0	0	0	0	0		0	0	
	1996	0	0	0	0	0		0	0	
	1997	0	0	0	0	0	0	0	0	0
	1998	0	0	0	0	0	0	0	0	0
	1999	0	0	0	0	6	0	0	0	6
	otal, 1985-1999	**0**	**0**	**0**	**0**	**7**	**14**	**0**	**0**	**21**
	ND TOTAL	**10**	**17**	**1**	**0**	**7**	**14**	**0**	**0**	**49**
MERRIMACK										
	Total, 1978-1984	**74**	**88**	**5**	**0**	**21**	**55**	**9**	**0**	**252**
	1985	8	112		0	5	85	2	0	213
	1986	19	33	0	0	4	44	3	0	103
	1987	8	94	4	0	2	26	5	0	139
	1988	4	16	2	0	4	38		0	65
	1989	3	24		0	0	55		0	84
	1990	3	115		0	24	104		0	248
	1991		76	0	0	0	254		0	332
	1992	17	66	2	0	14	100	0	0	199
	1993	0	27		1	2	30	0	0	61
	1994	0	2	0	0		18	0	0	21
	1995	2	18	0	0	0	14	0	0	34
	1996	11	44	0	3	3	13	0	2	76
	1997	9	43	0	4	9	5	0	1	71
	1998	11	45		0	19	47	0	0	123
	1999	46	65		0	9	64	0	0	185
	otal, 1985-1999	**142**	**780**	**14**	**8**	**96**	**897**	**14**	**3**	**1,954**
	ND TOTAL	**216**	**868**	**19**	**8**	**117**	**952**	**23**	**3**	**2,206**

RIVER	YEAR	HATCHERY ORIGIN 1-S-W	2-S-W	3-S-W	REPEAT	WILD ORIGIN 1-S-W	2-S-W	3-S-W	REPEAT	TOTAL
PAWCATUCK										
	Total, 1981-1984		101	0	0	0	0	0	0	102
	1985	0		0	0	0	0	0	0	
	1986	0	0	0	0	0	0	0	0	0
	1987	0		0	0	0	0	0	0	
	1988	0	5		0	0	0	0	0	6
	1989	0	6	0	0	0	0	0	0	6
	1990	0	8	0	0	0	0	0	0	8
	1991	0	5	0	0	0	0	0	0	5
	1992	0	69	0	0	0	0	0	0	6
	1993	0	2	0	0	0		0	0	3
	1994	0	2	0	0	0	0	0	0	2
	1995	09	2	09	0	0	0	0	0	2
	1996	0	2	0	0	0	0	0	0	2
	1997	0	0	0	0	0	3	0	0	3
	1998	0	0	0	0		2	0	0	3
	1999		6	0	0	0	4	0	0	11
	Total, 1985-1999		46		0		10	0	0	59
	GRAND TOTAL	**2**	**147**	**1**	**0**	**1**	**10**	**0**	**0**	**161**
CONNECTICUT										
	Total, 1969-1984	27	991	21	0	2	28	0	0	1,069
	1985	0	293	0	0	0	17	0	0	310
	1986	0	275	0	0	0	43	0	0	318
	1987	09	343	5	0	0	0	5	0	353
	1988		93	09	0	0		0	0	95
	1989		58	0	0		48		0	109
	1990		226	0	0	0	36	0	0	263
	1991	0	168		0	0	34	0	0	203
	1992	3	353		0	5	127		0	490
	1993	0	1369	0	0	0	61		0	198
	1994		263	0	1	0	61	0	0	326
	1995		158	0	0	0	29	0	0	188
	1996	0	143	0	0	5	111	0	1	260
	1997	0	0	0	1	6	191		0	199
	1998	0	0	0	0	10	288	0	2	300
	1999	0	0	0	0	11	142	0	1	154
	Total, 1985-1999	8	2,509	7	2	38	1,189	9	4	3,766
	GRAND TOTAL	**35**	**3,500**	**28**	**2**	**40**	**1,217**	**9**	**4**	**4,835**

RIVER	YEAR	HATCHERY ORIGIN 1-S-W	2-S-W	3-S-W	REPEAT	WILD ORIGIN 1-S-W	2-S-W	3-S-W	REPEAT	TOTAL
PENOBSCOT		9,306	39,871	218	521	514	3,160	29	86	53,705
UNION		301	1,814	9	28		15	0	0	2,168
NARRAGUAGUS		91	647	19	52	68	2,333	68	152	3,430
PLEASANT		5	12	0	0	11	215	2	2	247
MACHIAS		32	329	9	2	33	1,592	41	131	2,169
E. MACHIAS		21	250		2	12	329		10	626
DENNYS		21	294	0	1	22	729	3	10	1,080
ST. CROIX		672	1,086	38	12	440	670	39	17	2,974
KENNEBEC		12	189	5	1	0	9	0	0	216
ANDROSCOGGIN		26	504	6	2	6	83	0	1	628
SHEEPSCOT		6	38	0	0	30	358	10	0	442
DUCKTRAP		0	0	0	0	3	30	0	0	33
SACO		58	438	3	5	16	40	3	0	563
COCHECO		0	0		1	5	5	0	0	12
LAMPREY		10	17		0	7	14	0	0	49
MERRIMACK		216	868	19	8	117	952	23	3	2,206
PAWCATUCK		2	147		0		10	0	0	161
CONNECTICUT		35	3,500	28	2	40	1,217	9	4	4,835
TOTAL		**10,814**	**50,004**	**358**		**1,326**	**11,761**	**228**	**416**	**75,544**

GRAND TOTAL BY RIVER

Note: Returns are presented beginning 2 years after first stocking efforts or from earliest available records. For the Penobscot, Narraguagus, Pleasant, Machias, East Machias, Dennys, and Sheepscot, data are presented only since 1967.

TABLE 3.2.c. SUMMARY OF ATLANTIC SALMON EGG PRODUCTION IN NEW ENGLAND FACILITIES. [1]

Year	Sea-run No. Females	Sea-run Total Egg Production	Sea-run Eggs/ Female	Domestic No. Females	Domestic Total Egg Production	Domestic Eggs/ Female	Captive [2] No. Females	Captive [2] Total Egg Production	Captive [2] Eggs/ Female	Kelt No. Females	Kelt Total Egg Production	Kelt Eggs/ Female	Total No. Females	Total Total Egg Production	Total Eggs/ Female
Cocheco															
1993	3	21,400	7,133										3	21,400	7,133
Total	**3**	**21,400**	**7,133**										**3**	**21,400**	**7,133**
Connecticut															
1977-84		**1,803,300**			**1,510,000**						**1,190,300**			**4,503,600**	
1985		696,500			1,245,300						636,600			2,578,400	
1986		842,000			2,670,000						88,000			3,600,000	
1987		1,318,900			1,668,600						696,200			3,683,700	
1988		280,000			3,124,000						887,000			4,291,000	
1989		89,600			3,502,500						551,400			4,143,500	
1990	129	1,105,900	8,573	426	2,664,600	6,255				57	498,500	8,746	612	4,269,000	6,975
1991	79	651,000	8,241	637	3,455,500	5,425				52	486,100	9,348	768	4,592,600	5,980
1992	236	1,890,800	8,012	650	3,924,800	6,038				96	1,013,000	10,552	982	6,828,600	6,954
1993	121	1,053,800	8,709	714	3,878,700	5,432				164	1,767,600	10,778	999	6,700,100	6,707
1994	151	1,223,800	8,105	1,094	7,550,800	6,902				208	2,427,700	11,672	1,453	11,202,300	7,710
1995	101	945,500	9,361	1,258	7,555,400	6,006				183	2,159,300	11,799	1,542	10,660,200	6,913
1996	115	938,300	8,159	1,732	11,844,900	6,839				206	2,221,200	10,783	2,053	15,004,400	7,309
1997	110	770,700	7,006	1,809	11,602,300	6,414				188	2,003,300	10,656	2,107	14,376,300	6,823
1998	185	1,452,500	7,851	1,140	7,029,500	6,166				156	1,493,500	9,574	1,481	9,975,500	6,736
1999	83	621,500	7,488	1,862	11,172,900	6,000				193	1,813,200	9,395	2,138	13,607,600	6,365
1985-99	**1,310**	**13,880,800**	**8,133**	**11,322**	**82,889,800**	**6,243**				**1,503**	**18,742,600**	**10,568**	**14,135**	**115,513,200**	**6,878**
Total	**1,310**	**15,684,100**	**8,133**	**11,322**	**84,399,800**	**6,243**				**1,503**	**19,932,900**	**10,568**	**14,135**	**120,016,800**	**6,878**

Year	Sea-run No. Females	Sea-run Total Egg Production	Sea-run Eggs/ Female	Domestic No. Females	Domestic Total Egg Production	Domestic Eggs/ Female	Captive [2] No. Females	Captive [2] Total Egg Production	Captive [2] Eggs/ Female	Kelt No. Females	Kelt Total Egg Production	Kelt Eggs/ Female	Total No. Females	Total Total Egg Production	Total Eggs/ Female
Dennys															
1939	**12**	**113,000**	**9,417**										**12**	**113,000**	**9,417**
1992	5	38,000	7,600										5	38,000	7,600
1993	3	19,300	6,433							2	8,600	4,300	5	27,900	5,580
1994	2	14,800	7,400	56	110,200	1,968				6	30,500	5,083	64	155,500	2,430
1995							105	303,900	2,894	5	34,200	6,840	110	338,100	3,074
1996	4	28,800	7,200				86	311,000	3,616	3	29,200	9,733	93	369,000	3,968
1997							113	429,500	3,801	7	64,500	9,214	120	494,000	4,117
1998							79	337,600	4,273	10	105,600	10,560	89	443,200	4,980
1999							48	248,800	5,183	7	57,500	8,214	55	306,300	5,569
1992-99	**14**	**100,900**	**7,207**	**56**	**110,200**	**1,968**	431	**1,630,800**	**3,784**	40	330,100	**8,253**	**541**	**2,172,000**	**4,015**
Total	**26**	**213,900**	**8,227**	**56**	**110,200**	**1,968**	431	**1,630,800**	**3,784**	40	**330,100**	**8,253**	**553**	**2,285,000**	**4,132**
East Machias															
1995							65	143,700	2,211				65	143,700	2,211
1996							96	221,100	2,303				96	221,100	2,303
1997							111	394,000	3,550				111	394,000	3,550
1998							103	362,300	3,517				103	362,300	3,517
1999							57	296,000	5,193				57	296,000	5,193
Total							**432**	**1,417,100**	**3,280**				**432**	**1,417,100**	**3,280**
Kennebec															
1979	5	50,000	10,000										5	50,000	10,000
Total	**5**	**50,000**	**10,000**										**5**	**50,000**	**10,000**
Lamprey															
1992	1	2,400	2,400										1	2,400	2,400
1993	2	12,600	6,300										2	12,600	6,300
1994	3	17,000	5,667										3	17,000	5,667
Total	**6**	**32,000**	**5,333**										**6**	**32,000**	**5,333**

Year	Sea-run			Domestic			Captive [2]			Kelt			Total		
	No. Females	Total Egg Production	Eggs/ Female	No. Females	Total Egg Production	Eggs/ Female	No. Females	Total Egg Production	Eggs/ Female	No. Females	Total Egg Production	Eggs/ Female	No. Females	Total Egg Production	Eggs/ Female
Machias															
1941-71	**449**	**3,213,100**	**7,156**										**449**	**3,213,100**	**7,156**
1993	7	50,100	7,157										7	50,100	7,157
1994				88	195,500	2,222				2	11,700	5,850	90	207,200	2,302
1995							171	484,200	2,832	4	27,800	6,950	175	512,000	2,926
1996							141	513,200	3,640	2	12,800	6,400	143	526,000	3,678
1997							176	602,600	3,424				176	602,600	3,424
1998							166	547,600	3,299				166	547,600	3,299
1999							121	549,600	4,542				121	549,600	4,542
1993-99	**7**	**50,100**	**7,157**	**88**	**195,500**	**2,222**	**775**	**2,697,200**	**3,480**	**8**	**52,300**	**6,538**	**878**	**2,995,100**	**3,411**
Total	**456**	**3,263,200**	**7,156**	**88**	**195,500**	**2,222**	**775**	**2,697,200**	**3,480**	**8**	**52,300**	**6,538**	**1,327**	**6,208,200**	**4,678**
Merrimack															
1983-85	**44**	**317,000**	**7,205**										**44**	**317,000**	**7,205**
1985	71	480,000	6,761										71	480,000	6,761
1986	46	288,800	6,278										46	288,800	6,278
1987	67	532,600	7,949										67	532,600	7,949
1988	31	244,200	7,877										31	244,200	7,877
1989	39	302,200	7,749										39	302,200	7,749
1990	117	855,100	7,309										117	855,100	7,309
1991	168	1,217,800	7,249										168	1,217,800	7,249
1992	84	538,100	6,406	536	2,432,800	4,539							620	2,970,900	4,792
1993	42	321,600	7,657	1,573	9,664,600	6,144							1,615	9,986,200	6,183
1994	10	67,500	6,750	1,035	5,720,800	5,527							1,045	5,788,300	5,539
1995	24	187,600	7,817	694	4,353,200	6,273							718	4,540,800	6,324
1996	31	212,500	6,855	912	5,469,000	5,997							943	5,681,500	6,025
1997	31	284,300	9,171	754	4,641,700	6,156							785	4,926,000	6,275
1998	63	518,000	8,222	560	2,669,300	4,767				5	64,400	12,880	628	3,251,700	5,178
1999	88	736,600	8,370	520	2,658,800	5,113				50	539,500	10,790	658	3,934,900	5,980
1985-99	**912**	**6,786,900**	**7,442**	**6,584**	**37,610,200**	**5,712**				**55**	**603,900**	**10,980**	**7,551**	**45,001,000**	**5,960**
Total	**956**	**7,103,900**	**7,431**	**6,584**	**37,610,200**	**5,712**				**55**	**603,900**	**10,980**	**7,595**	**45,318,000**	**5,967**

Year	Sea-run			Domestic			Captive [2]			Kelt			Total		
	No. Females	Total Egg Production	Eggs/ Female	No. Females	Total Egg Production	Eggs/ Female	No. Females	Total Egg Production	Eggs/ Female	No. Females	Total Egg Production	Eggs/ Female	No. Females	Total Egg Production	Eggs/ Female
Narraguagus															
1962-71		**1,303,100**												**1,303,100**	
1994				59	145,700	2,469							59	145,700	2,469
1995							115	394,400	3,430				115	394,400	3,430
1996							117	434,300	3,712				117	434,300	3,712
1997							172	516,800	3,005				172	516,800	3,005
1998							186	490,000	2,634				186	490,000	2,634
1999							134	542,100	4,046				134	542,100	4,046
1994-99				**59**	**145,700**	**2,469**	**724**	**2,377,600**	**3,284**				**783**	**2,523,300**	**3,223**
Total		**1,303,100**		**59**	**145,700**	**2,469**	**724**	**2,377,600**	**3,284**				**783**	**3,826,400**	**3,223**
Orland															
1967	5	41,100	8,220										5	41,100	8,220
1968	31	207,900	6,706										31	207,900	6,706
1969	3	20,600	6,867										3	20,600	6,867
Total	**39**	**269,600**	**6,913**										**39**	**269,600**	**6,913**
Pawcatuck															
1992	4	35,600	8,900										4	35,600	8,900
1993	1	7,900	7,900										1	7,900	7,900
1994	1	7,000	7,000										1	7,000	7,000
1996	1	16,900	16,900										1	16,900	16,900
1997	1	8,200	8,200										1	8,200	8,200
1999	6	61,300	10,217										6	61,300	10,217
Total	**14**	**136,900**	**9,779**										**14**	**136,900**	**9,779**

Year	Sea-run No. Females	Sea-run Total Egg Production	Sea-run Eggs/ Female	Domestic No. Females	Domestic Total Egg Production	Domestic Eggs/ Female	Captive[2] No. Females	Captive[2] Total Egg Production	Captive[2] Eggs/ Female	Kelt No. Females	Kelt Total Egg Production	Kelt Eggs/ Female	Total No. Females	Total Total Egg Production	Total Eggs/ Female
Penobscot															
1871-1984	**12,312**	**110,761,700**	**8,037**										**12,312**	**110,761,700**	**8,037**
1985	239	1,838,900	7,694										239	1,838,900	7,694
1986	295	2,376,100	8,055										295	2,376,100	8,055
1987	271	2,150,200	7,934										271	2,150,200	7,934
1988	226	1,610,700	7,127										226	1,610,700	7,127
1989	316	2,427,200	7,681										316	2,427,200	7,681
1990	300	2,041,700	6,806										300	2,041,700	6,806
1991	340	2,427,000	7,138										340	2,427,000	7,138
1992	351	2,448,000	6,974	614	1,518,700	2,473							965	3,966,700	4,111
1993	255	1,881,900	7,380	886	2,292,000	2,587							1,141	4,173,900	3,658
1994	215	1,669,900	7,767	645	1,654,700	2,565							860	3,324,600	3,866
1995	380	2,735,600	7,199										380	2,735,600	7,199
1996	380	2,635,000	6,934										380	2,635,000	6,934
1997	313	2,224,900	7,108	639	1,381,100	2,161							952	3,606,000	3,788
1998	392	2,804,100	7,153	560	1,456,200	2,600							952	4,260,300	4,475
1999	286	2,418,500	8,456	371	1,300,300	3,505							657	3,718,800	5,660
1985-99	**4,559**	**33,689,700**	**7,390**	**3,715**	**9,603,000**	**2,585**							**8,274**	**43,292,700**	**5,232**
Total	**16,871**	**144,451,400**	**7,862**	**3,715**	**9,603,000**	**2,585**							**20,586**	**154,054,400**	**6,910**
Sheepscot															
1995	11	78,500	7,136				22	44,400	2,018				33	122,900	3,724
1996	7	46,800	6,686				36	66,000	1,833	7	66,100	9,443	50	178,900	3,578
1997							75	257,300	3,431	13	118,500	9,115	88	375,800	4,270
1998							98	343,300	3,503	17	181,500	10,676	115	524,800	4,563
1999							49	218,200	4,453	8	92,100	11,513	57	310,300	5,444
Total	**18**	**125,300**	**6,961**				**280**	**929,200**	**3,319**	**45**	**458,200**	**10,182**	**343**	**1,512,700**	**4,410**

Year	Sea-run			Domestic			Captive [2]			Kelt			Total		
	No. Females	Total Egg Production	Eggs/ Female	No. Females	Total Egg Production	Eggs/ Female	No. Females	Total Egg Production	Eggs/ Female	No. Females	Total Egg Production	Eggs/ Female	No. Females	Total Egg Production	Eggs/ Female
St. Croix															
1993	15	114,000	7,600										15	114,000	7,600
1994	11	80,000	7,273										11	80,000	7,273
1995	10	76,700	7,670										10	76,700	7,670
Total	**36**	**270,700**	**7,519**										**36**	**270,700**	**7,519**
Union															
1974-84	**490**	**3,702,200**	**7,556**										**490**	**3,702,200**	**7,556**
1985	37	285,700	7,722										37	285,700	7,722
1986	23	211,000	9,174										23	211,000	9,174
1987	18	161,100	8,950										18	161,100	8,950
1988	10	80,700	8,070										10	80,700	8,070
1989	8	67,200	8,400										8	67,200	8,400
1990	14	103,000	7,357										14	103,000	7,357
1985-90	**110**	**908,700**	**8,261**										**110**	**908,700**	**8,261**
Total	**600**	**4,610,900**	**7,685**										**600**	**4,610,900**	**7,685**
GRAND TOTAL	**20,340**	**177,536,100**	**7,837**	**21,824**	**132,064,300**	**5,423**	**2,642**	**9,051,900**	**3,426**	**1,651**	**21,377,400**	**10,224**	**46,457**	**340,030,100**	**6,546**

[1] Egg production rounded to nearest 100 eggs.

[2] Captive refers to adults produced from wild parr that were captured and reared to maturity in the hatchery.

Note: Totals of eggs/female include only the years for which information on number of females is available.

Note: Connecticut data are preliminary prior to 1990.

Table 3.7.a. SUMMARY RETURN RATES FOR NEW ENGLAND ATLANTIC SALMON THAT WERE STOCKED AS FRY.

Year Stocked	Merrimack	Pawcatuck	Connecticut (above Holyoke)	Salmon	Farmington	Westfield	Dennys	Narraguagus	Penobscot	Saco
1974	---	---	0.000	---	---	---	---	---	---	---
1975	0.000	---	0.000	---	---	---	---	---	---	---
1976	0.000	---	0.000	---	---	---	---	---	---	---
1977	0.000	---	0.000	---	---	---	---	---	---	---
1978	0.017	---	0.014	---	---	---	---	---	---	---
1979	0.056	---	0.000	---	0.010	---	---	---	0.081	---
1980	0.034	---	0.020	---	0.000	---	---	---	n/a	---
1981	0.142	---	0.013	---	0.000	---	---	---	0.178	---
1982	0.096	---	0.024	---	0.009	---	---	---	0.076	---
1983	0.275	---	0.001	---	0.001	---	0.010	---	n/a	---
1984	0.009	---	0.000	---	0.002	---	n/a	---	0.154	---
1985	0.040	---	0.012	---	0.009	---	n/a	0.280	0.138	---
1986	0.021	---	0.028	---	0.001	---	n/a	n/a	0.219	---
1987	0.026	---	0.004	0.002	0.007	---	0.021	0.353	0.099	---
1988	0.006	---	0.010	0.007	0.004	0.000	0.003	0.200	0.031	0.000
1989	0.004	---	0.006	0.000	0.007	0.001	0.042	0.266	0.147	n/a
1990	0.002	---	0.007	0.000	0.004	0.001	0.030	n/a	0.097	n/a
1991	0.001	---	0.003	0.000	0.001	0.002	0.028	n/a	0.065	0.000
1992	0.001	---	0.009	0.003	0.003	0.004	n/a	n/a	0.016	0.000
1993	0.001	0.000	0.004	0.002	0.007	0.006	0.009	n/a	0.003	0.001
1994	0.002	0.000	0.005	0.002	0.004	0.007	0.005	n/a	0.003	0.006
1995	0.003	0.001	0.002	0.000	0.004	0.002	0.000	0.022	0.019	0.009
1996	0.000	0.000	0.000	0.003	0.001	0.000	0.000	0.003	0.003	n/a
1997	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Mean*	**0.037**	**0.000**	**0.008**	**0.002**	**0.004**	**0.003**	**0.018**	**0.275**	**0.093**	**0.001**
SD	0.067	0.000	0.008	0.002	0.003	0.002	0.014	0.149	0.070	0.004

*Does not include 1995-97 because additional adults may still return.

Table 3.7.b. SUMMARY AGE DISTRIBUTIONS OF NEW ENGLAND ATLANTIC SALMON THAT WERE STOCKED AS FRY.

	Mean age class (smolt age.sea age) distribution (%)										Mean age (years) distribution (%)				
River	1.1	1.2	1.3	2.1	2.2	2.3	3.1	3.2	3.3	4.2	2	3	4	5	6
Merrimack	0.3	2.8	0.4	8.8	69.3	4.4	3.6	9.7	0.6	0.1	0.3	11.6	73.3	14.1	0.7
Connecticut	0.0	4.2	0.0	2.1	88.1	1.0	0.0	4.5	0.0	0.0	0.0	6.4	88.1	5.5	0.0
Farmington	0.2	29.6	0.0	4.1	61.9	1.3	0.0	2.8	0.0	0.0	0.2	33.7	61.9	4.2	0.0
Westfield	0.0	0.0	0.0	5.0	91.6	0.0	0.0	3.4	0.0	0.0	0.0	5.0	91.6	3.4	0.0
Dennys	0.0	0.0	0.0	9.5	77.1	0.0	0.0	13.3	0.0	0.0	0.0	9.5	77.1	13.3	0.0
Narraguagus	0.0	0.0	0.0	8.8	91.2	0.0	0.0	0.0	0.0	0.0	0.0	8.8	91.2	0.0	0.0
Penobscot	0.0	0.0	0.0	18.8	57.5	0.8	0.3	22.5	0.0	0.0	0.0	18.8	57.9	23.3	0.0
Mean	**0.1**	**5.2**	**0.1**	**8.2**	**76.7**	**1.1**	**0.6**	**8.0**	**0.1**	**0.0**	**0.1**	**13.4**	**77.3**	**9.1**	**0.1**

Note: Rivers with less than 100 total returns are not included in this table.

Table 3.7.c. MERRIMACK RIVER RETURN RATES FOR ATLANTIC SALMON THAT WERE STOCKED AS FRY.

Year Stocked	Total fry stocked (1000s)	Unfed fry stocked (1000s)	Fed fry stocked (1000s)	Mean density (fry/100m^2)	Total returns	Return rate (% of fry)	Age class (smolt age.sea age) distribution (%)										Age (years) distribution (%)				
							1.1	1.2	1.3	2.1	2.2	2.3	3.1	3.2	3.3	4.2	2	3	4	5	6
1975	36	0	36	unknown	0	0.000	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
1976	63	0	63	unknown	0	0.000	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
1977	72	0	72	unknown	0	0.000	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
1978	106	101	5	unknown	18	0.017	0.0	0.0	0.0	0.0	11.1	33.3	22.2	27.8	5.6	0.0	0.0	0.0	33.3	61.1	5.6
1979	77	32	45	unknown	43	0.056	0.0	0.0	0.0	0.0	83.7	4.7	2.3	9.3	0.0	0.0	0.0	0.0	86.0	14.0	0.0
1980	126	90	35	unknown	43	0.034	0.0	0.0	0.0	0.0	18.6	4.7	20.9	51.2	4.7	0.0	0.0	0.0	39.5	55.8	4.7
1981	57	57	0	unknown	81	0.142	0.0	0.0	0.0	9.9	77.8	0.0	4.9	7.4	0.0	0.0	0.0	9.9	82.7	7.4	0.0
1982	50	0	50	unknown	48	0.096	0.0	0.0	2.1	2.1	77.1	8.3	0.0	10.4	0.0	0.0	0.0	2.1	79.2	18.8	0.0
1983	8	0	8	unknown	23	0.275	0.0	4.3	4.3	17.4	65.2	4.3	0.0	4.3	0.0	0.0	0.0	21.7	69.6	8.7	0.0
1984	526	425	101	29.9	47	0.009	0.0	12.8	0.0	4.3	76.6	2.1	0.0	4.3	0.0	0.0	0.0	17.0	76.6	6.4	0.0
1985	148	0	148	31.6	59	0.040	0.0	1.7	0.0	6.8	69.5	1.7	0.0	20.3	0.0	0.0	0.0	8.5	69.5	22.0	0.0
1986	525	428	97	31.6	110	0.021	0.0	10.9	0.0	0.0	78.2	0.9	0.0	8.2	0.0	1.8	0.0	10.9	78.2	9.1	1.8
1987	1078	1034	44	31.6	278	0.026	0.0	2.2	0.0	8.3	85.6	0.0	0.0	4.0	0.0	0.0	0.0	10.4	85.6	4.0	0.0
1988	1718	1718	0	31.6	95	0.006	1.1	5.3	0.0	0.0	90.5	0.0	0.0	3.2	0.0	0.0	1.1	5.3	90.5	3.2	0.0
1989	1034	1034	0	31.4	43	0.004	0.0	7.0	0.0	30.2	62.8	0.0	0.0	0.0	0.0	0.0	0.0	37.2	62.8	0.0	0.0
1990	975	640	335	31.6	21	0.002	4.8	0.0	0.0	9.5	81.0	0.0	0.0	4.8	0.0	0.0	4.8	9.5	81.0	4.8	0.0
1991	1458	1458	0	38.4	17	0.001	0.0	5.9	0.0	5.9	76.5	11.8	0.0	0.0	0.0	0.0	0.0	11.8	76.5	11.8	0.0
1992	1118	982	136	38.4	14	0.001	0.0	0.0	0.0	0.0	92.9	7.1	0.0	0.0	0.0	0.0	0.0	0.0	92.9	7.1	0.0
1993	1157	1139	18	38.4	11	0.001	0.0	0.0	0.0	27.3	45.5	0.0	9.1	18.2	0.0	0.0	0.0	27.3	54.5	18.2	0.0
1994	2816	2782	34	69.2	54	0.002	0.0	0.0	0.0	14.8	83.3	0.0	0.0	1.9	0.0	0.0	0.0	14.8	83.3	1.9	0.0
1995	2827	2817	10	63.2	87	0.003	0.0	0.0	0.0	21.8	72.4	0.0	5.7	0.0	0.0	0.0	0.0	21.8	78.2	0.0	0.0
1996	1795	1782	13	63.2	4	0.000	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0
1997	2000	1811	189	33.0	0	0.000	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Total*	**17770**	**18329**	**1440**	**40.2**	**1096**	**0.037**	**0.3**	**2.8**	**0.4**	**8.8**	**69.3**	**4.4**	**3.6**	**9.7**	**0.6**	**0.1**	**0.3**	**11.6**	**73.3**	**14.1**	**0.7**

*The mean is shown for densities, return rates, and ages. The mean return rate does not include 1995-1997 because additional adults may still return. Mean ages only include years with 10 or more returns.

Note: Return rates are calculated from stocked fry and do not include natural fry production.

Table 3.7.d. PAWCATUCK RIVER RETURN RATES FOR ATLANTIC SALMON THAT WERE STOCKED AS FRY.

Year Stocked	Total fry stocked (1000s)	Mean density (fry/100m^2)	Total returns	Return rate (% of fry)	Age class (smolt age.sea age) distribution (%)									Age (years) distribution (%)				
					1.1	1.2	2.1	2.2	2.3	3.1	3.2	3.3	4.2	2	3	4	5	6
1993	383	79.9	1	0.000	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0
1994	557	116.2	2	0.000	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0
1995	367	76.6	4	0.001	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0
1996	289	60.3	0	0.000	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
1997	100	55.6	0	0.000	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Total*	**1696**	77.7	7	0.000	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0

*The mean is shown for densities, return rates, and ages. The mean return rate does not include 1995-1997 because additional adults may still return. Mean ages only include years with 1 or more returns.

Note: Return rates are calculated from stocked fry and do not include natural fry production.

Table 3.7.e. CONNECTICUT RIVER RETURN RATES FOR ATLANTIC SALMON THAT WERE STOCKED AS FRY ABOVE THE HOLYOKE DAM.

Year Stocked	Total fry stocked (1000s)	Unfed fry stocked (1000s)	Fed fry stocked (1000s)	Unfed and/or fed fry (1000s)	Mean density (fry/100m²)	Coefficient of variation	Total returns	Return rate (% of fry)	Age class (smolt age.sea age) distribution (%) 1.1	1.2	1.3	2.1	2.2	2.3	3.1	3.2	3.3	4.2	Age (years) distribution (%) 2	3	4	5	6
1974	16			16	unknown	n/a	0	0.000	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
1975	32			32	268.0	0.11	0	0.000	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
1976	27			27	24.0	0.00	0	0.000	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
1977	50			50	28.0	0.00	0	0.000	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
1978	50			50	28.0	0.00	7	0.014	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0
1979	25			25	28.0	0.00	0	0.000	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
1980	89			89	110.0	0.00	18	0.020	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0
1981	151		38	113	63.5	1.01	19	0.013	0.0	0.0	0.0	10.5	89.5	0.0	0.0	0.0	0.0	0.0	0.0	10.5	89.5	0.0	0.0
1982	128			128	89.6	0.43	31	0.024	0.0	0.0	0.0	0.0	90.3	9.7	0.0	0.0	0.0	0.0	0.0	0.0	90.3	9.7	0.0
1983	70		45	25	81.3	1.06	1	0.001	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0
1984	455	91		364	82.7	0.60	1	0.000	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
1985	286	64	109	113	126.4	0.41	35	0.012	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0
1986	97		89	8	51.0	0.43	27	0.028	0.0	0.0	0.0	3.7	96.3	0.0	0.0	0.0	0.0	0.0	0.0	3.7	96.3	0.0	0.0
1987	981	643	110	228	32.4	0.35	44	0.004	0.0	15.9	0.0	0.0	68.2	2.3	0.0	13.6	0.0	0.0	0.0	15.9	68.2	15.9	0.0
1988	928	679	149	100	26.6	0.31	92	0.010	0.0	0.0	0.0	0.0	96.7	1.1	0.0	2.2	0.0	0.0	0.0	0.0	96.7	3.3	0.0
1989	747	517	231		29.3	0.22	47	0.006	0.0	6.4	0.0	6.4	85.1	0.0	0.0	2.1	0.0	0.0	0.0	12.8	85.1	2.1	0.0
1990	765	558	206		29.9	0.30	53	0.007	0.0	13.2	0.0	0.0	86.8	0.0	0.0	0.0	0.0	0.0	0.0	13.2	86.8	0.0	0.0
1991	982	554	428		27.5	0.19	25	0.003	0.0	20.0	0.0	0.0	64.0	0.0	0.0	16.0	0.0	0.0	0.0	20.0	64.0	16.0	0.0
1992	929	638	292		28.0	0.14	84	0.009	0.0	1.2	0.0	0.0	84.5	1.2	0.0	13.1	0.0	0.0	0.0	1.2	84.5	14.3	0.0
1993	2607	2361	247		34.8	0.27	94	0.004	0.0	0.0	0.0	2.1	87.2	0.0	0.0	10.6	0.0	0.0	0.0	2.1	87.2	10.6	0.0
1994	3925	3885	40		36.2	0.39	197	0.005	0.0	0.0	0.0	1.0	93.4	0.0	0.0	5.6	0.0	0.0	0.0	1.0	93.4	5.6	0.0
1995	4507	4480	28		36.0	0.31	81	0.002	0.0	2.5	0.0	6.2	91.4	0.0	0.0	0.0	0.0	0.0	0.0	8.6	91.4	0.0	0.0
1996	4780	4772	8		39.9	0.33	5	0.000	0.0	40.0	0.0	60.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0
1997	5885	5867	18		43.8	0.26	0	0.000	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Total*	**22631**	**19246**	**2019**	**1365**	**58.5**	**0.31**	**861**	**0.008**	**0.0**	**4.2**	**0.0**	**2.1**	**88.1**	**1.0**	**0.0**	**4.5**	**0.0**	**0.0**	**0.0**	**6.4**	**88.1**	**5.5**	**0.0**

*The mean is shown for densities, variation, return rates, and ages. The mean return rate does not include 1995-1997 because additional adults may still return. Mean ages only include years with 10 or more returns.

Note: Return rates are calculated from stocked fry and do not include natural fry production.

Table 3.7.f. SALMON RIVER RETURN RATES FOR ATLANTIC SALMON THAT WERE STOCKED AS FRY.

Year Stocked	Total fry stocked (1000s)	Unfed fry stocked (1000s)	Fed fry stocked (1000s)	Mean density (fry/100m^2)	Coefficient of variation	Total returns	Return rate (% of fry)	Age class (smolt age.sea age) distribution (%)										Age (years) distribution (%)				
								1.1	1.2	1.3	2.1	2.2	2.3	3.1	3.2	3.3	4.2	2	3	4	5	6
1987	121	0	121	75.0	0.00	2	0.002	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
1988	43	0	43	41.0	0.20	3	0.007	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0
1989	111	0	111	55.0	0.35	0	0.000	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
1990	38	0	38	45.0	0.19	0	0.000	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
1991	25	0	25	unknown	n/a	0	0.000	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
1992	124	7	117	29.1	0.52	4	0.003	0.0	50.0	0.0	0.0	50.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0	50.0	0.0	0.0
1993	105	0	105	42.7	0.29	2	0.002	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0
1994	241	0	241	46.6	0.28	4	0.002	0.0	25.0	0.0	0.0	75.0	0.0	0.0	0.0	0.0	0.0	0.0	25.0	75.0	0.0	0.0
1995	242	0	242	46.5	0.39	1	0.000	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0
1996	247	0	247	50.8	0.36	8	0.003	0.0	37.5	0.0	62.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0
1997	223	0	223	56.0	0.25	0	0.000	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Total*	**1298**	**7**	**1514**	**48.0**	**0.3**	**24**	**0.002**	**0.0**	**18.8**	**0.0**	**10.4**	**70.8**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**29.2**	**70.8**	**0.0**	**0.0**

*The mean is shown for densities, variation, return rates, and ages. The mean return rate does not include 1995-1997 because additional adults may still return. Mean ages only include years with 1 or more returns.

Note: Return rates are calculated from stocked fry and do not include natural fry production.

Table 3.7.g. FARMINGTON RIVER RETURN RATES FOR ATLANTIC SALMON THAT WERE STOCKED AS FRY.

Year Stocked	Total fry stocked (1000s)	Unfed fry stocked (1000s)	Fed fry stocked (1000s)	Mean density (fry/100m^2)	Coefficient of variation	Total returns	Return rate (% of fry)	Age class (smolt age.sea age) distribution (%)										Age (years) distribution (%)				
								1.1	1.2	1.3	2.1	2.2	2.3	3.1	3.2	3.3	4.2	2	3	4	5	6
1979	29	29	0	unknown	n/a	3	0.010	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0
1980	197	197	0	167.0	0.00	0	0.000	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
1981	18	18	0	17.0	0.00	0	0.000	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
1982	166	166	0	145.0	0.00	15	0.009	0.0	0.0	0.0	0.0	86.7	13.3	0.0	0.0	0.0	0.0	0.0	0.0	86.7	13.3	0.0
1983	157	157	0	135.0	0.00	1	0.001	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0
1984	128	128	0	113.0	0.00	2	0.002	0.0	0.0	0.0	0.0	50.0	0.0	0.0	50.0	0.0	0.0	0.0	0.0	50.0	50.0	0.0
1985	136	136	0	119.0	0.00	12	0.009	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0
1986	79	79	0	123.0	0.00	1	0.001	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0
1987	68	0	68	75.0	0.00	5	0.007	0.0	0.0	0.0	0.0	80.0	0.0	0.0	20.0	0.0	0.0	0.0	0.0	80.0	20.0	0.0
1988	333	0	333	55.7	0.36	13	0.004	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0
1989	279	0	279	46.0	0.14	19	0.007	0.0	63.2	0.0	10.5	26.3	0.0	0.0	0.0	0.0	0.0	0.0	73.7	26.3	0.0	0.0
1990	270	0	270	60.5	0.46	11	0.004	0.0	45.5	0.0	0.0	45.5	0.0	0.0	9.1	0.0	0.0	0.0	45.5	45.5	9.1	0.0
1991	265	0	265	unknown	n/a	2	0.001	0.0	50.0	0.0	0.0	0.0	0.0	0.0	50.0	0.0	0.0	0.0	50.0	0.0	50.0	0.0
1992	553	147	407	53.0	0.27	15	0.003	0.0	20.0	0.0	0.0	66.7	0.0	0.0	13.3	0.0	0.0	0.0	20.0	66.7	13.3	0.0
1993	772	403	370	46.7	0.42	52	0.007	0.0	13.5	0.0	5.8	76.9	0.0	0.0	3.8	0.0	0.0	0.0	19.2	76.9	3.8	0.0
1994	1097	565	531	66.4	0.45	49	0.004	0.0	30.6	0.0	4.1	63.3	0.0	0.0	2.0	0.0	0.0	0.0	34.7	63.3	2.0	0.0
1995	1146	660	486	62.0	0.49	41	0.004	2.4	39.0	0.0	4.9	53.7	0.0	0.0	0.0	0.0	0.0	2.4	43.9	53.7	0.0	0.0
1996	912	515	397	57.6	0.47	13	0.001	0.0	84.6	0.0	15.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0
1997	1480	1003	476	63.5	0.45	0	0.000	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Total*	**8084**	**4203**	**3880**	**82.7**	**0.21**	**254**	**0.004**	**0.2**	**29.6**	**0.0**	**4.1**	**61.9**	**1.3**	**0.0**	**2.8**	**0.0**	**0.0**	**0.2**	**33.7**	**61.9**	**4.2**	**0.0**

*The mean is shown for densities, variation, return rates, and ages. The mean return rate does not include 1995-1997 because additional adults may still return. Mean ages only include years with 10 or more returns.

Note: Return rates are calculated from stocked fry and do not include natural fry production.

Table 3.7.h. WESTFIELD RIVER RETURN RATES FOR ATLANTIC SALMON THAT WERE STOCKED AS FRY.

Year Stocked	Total fry stocked (1000s)	Unfed fry stocked (1000s)	Fed fry stocked (1000s)	Mean density (fry/100m^2)	Coefficient of variation	Total returns	Return rate (% of fry)	Age class (smolt age.sea age) distribution (%)										Age (years) distribution (%)				
								1.1	1.2	1.3	2.1	2.2	2.3	3.1	3.2	3.3	4.2	2	3	4	5	6
1988	6	6	0	36.0	0.00	0	0.000	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
1989	106	106	0	32.6	0.15	1	0.001	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0
1990	274	274	0	36.0	0.00	4	0.001	0.0	25.0	0.0	0.0	75.0	0.0	0.0	0.0	0.0	0.0	0.0	25.0	75.0	0.0	0.0
1991	454	454	0	unknown	n/a	8	0.002	0.0	0.0	0.0	0.0	75.0	0.0	0.0	25.0	0.0	0.0	0.0	0.0	75.0	25.0	0.0
1992	402	402	0	26.3	0.15	15	0.004	0.0	0.0	0.0	0.0	93.3	0.0	0.0	6.7	0.0	0.0	0.0	0.0	93.3	6.7	0.0
1993	662	656	6	41.3	0.19	37	0.006	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0
1994	674	653	21	40.9	0.24	44	0.007	0.0	0.0	0.0	2.3	90.9	0.0	0.0	6.8	0.0	0.0	0.0	2.3	90.9	6.8	0.0
1995	885	861	24	48.5	0.30	17	0.002	0.0	0.0	0.0	17.6	82.4	0.0	0.0	0.0	0.0	0.0	0.0	17.6	82.4	0.0	0.0
1996	706	681	25	43.4	0.35	1	0.000	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0
1997	909	989	11	59.3	0.29	0	0.000	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Total*	**5077**	**5081**	**87**	**40.5**	**0.2**	**127**	**0.003**	**0.0**	**0.0**	**0.0**	**5.0**	**91.6**	**0.0**	**0.0**	**3.4**	**0.0**	**0.0**	**0.0**	**5.0**	**91.6**	**3.4**	**0.0**

*The mean is shown for densities, variation, return rates, and ages. The mean return rate does not include 1995-1997 because additional adults may still return. Mean ages only include years with 10 or more returns.

Note: Return rates are calculated from stocked fry and do not include natural fry production.

Table 3.7.i. DENNYS RIVER RETURN RATES FOR ATLANTIC SALMON THAT WERE STOCKED AS FRY.

Year Stocked	Total fry stocked (1000s)	Unfed fry stocked (1000s)	Fed fry stocked (1000s)	Mean density (fry/100m²)	Total returns	Return rate (% of fry)	Age class[1] (smolt age.sea age) distribution (%)										Age (years) distribution (%)				
							1.1	1.2	1.3	2.1	2.2	2.3	3.1	3.2	3.3	4.2	2	3	4	5	6
1983	20	0	20	50-100	2	0.010	0.0	0.0	0.0	0.0	50.0	0.0	0.0	50.0	0.0	0.0	0.0	0.0	50.0	50.0	0.0
1984	0	0	0	n/a	5	n/a	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0
1985	0	0	0	n/a	2	n/a	0.0	0.0	0.0	0.0	50.0	0.0	0.0	50.0	0.0	0.0	0.0	0.0	50.0	50.0	0.0
1986	0	0	0	n/a	11	n/a	0.0	0.0	0.0	0.0	90.9	0.0	0.0	9.1	0.0	0.0	0.0	0.0	90.9	9.1	0.0
1987	24	0	24	50-100	5	0.021	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0
1988	30	0	30	50-100	1	0.003	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0
1989	12	0	12	50-100	5	0.042	0.0	0.0	0.0	0.0	80.0	0.0	0.0	20.0	0.0	0.0	0.0	0.0	80.0	20.0	0.0
1990	20	0	20	50-100	6	0.030	0.0	0.0	0.0	0.0	83.3	0.0	0.0	16.7	0.0	0.0	0.0	0.0	83.3	16.7	0.0
1991	25	0	25	50-100	7	0.028	0.0	0.0	0.0	14.3	71.4	0.0	0.0	14.3	0.0	0.0	0.0	14.3	71.4	14.3	0.0
1992	0	0	0	n/a	6	n/a	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0
1993	33	0	33	50-100	3	0.009	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0
1994	20	0	20	50-100	1	0.005	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0
1995	84	0	84	50-100	0	0.000	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
1996	142	0	142	50-100	0	0.000	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
1997	213	0	213	50-100	0	0.000	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Total*	**623**	**0**	**623**	**50-100**	**54**	**0.018**	**0.0**	**0.0**	**0.0**	**9.5**	**77.1**	**0.0**	**0.0**	**13.3**	**0.0**	**0.0**	**0.0**	**9.5**	**77.1**	**13.3**	**0.0**

[1] Smolt age distribution is assumed to be 90% 2-year and 10% 3-year.

*The mean is shown for densities, return rates, and ages. The mean return rate does not include 1995-1997 because additional adults may still return. Mean ages only include years with 1 or more returns.

Note: Return rates are calculated from stocked fry and do not include natural fry production, which is considered to be significant in the Dennys River.

Table 3.7.j. NARRAGUAGUS RIVER RETURN RATES FOR ATLANTIC SALMON THAT WERE STOCKED AS FRY.

Year Stocked	Total fry stocked (1000s)	Unfed fry stocked (1000s)	Fed fry stocked (1000s)	Mean density (fry/100m^2)	Total returns	Return rate (% of fry)	Age class (smolt age.sea age) distribution (%)										Age (years) distribution (%)				
							1.1	1.2	1.3	2.1	2.2	2.3	3.1	3.2	3.3	4.2	2	3	4	5	6
1985	10	0	10	50-100	28	0.280	0.0	0.0	0.0	7.1	92.9	0.0	0.0	0.0	0.0	0.0	0.0	7.1	92.9	0.0	0.0
1986	0	0	0	n/a	28	n/a	0.0	0.0	0.0	3.6	96.4	0.0	0.0	0.0	0.0	0.0	0.0	3.6	96.4	0.0	0.0
1987	15	0	15	50-100	53	0.353	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0
1988	20	0	20	50-100	40	0.200	0.0	0.0	0.0	20.0	80.0	0.0	0.0	0.0	0.0	0.0	0.0	20.0	80.0	0.0	0.0
1989	29	0	29	50-100	77	0.266	0.0	0.0	0.0	14.3	85.7	0.0	0.0	0.0	0.0	0.0	0.0	14.3	85.7	0.0	0.0
1990	0	0	0	n/a	48	n/a	0.0	0.0	0.0	12.5	87.5	0.0	0.0	0.0	0.0	0.0	0.0	12.5	87.5	0.0	0.0
1991	0	0	0	n/a	55	n/a	0.0	0.0	0.0	7.3	92.7	0.0	0.0	0.0	0.0	0.0	0.0	7.3	92.7	0.0	0.0
1992	0	0	0	n/a	42	n/a	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0
1993	0	0	0	n/a	39	n/a	0.0	0.0	0.0	23.1	76.9	0.0	0.0	0.0	0.0	0.0	0.0	23.1	76.9	0.0	0.0
1994	0	0	0	n/a	2	n/a	0.0	0.0	0.0	0.0	50.0	0.0	0.0	50.0	0.0	0.0	0.0	0.0	50.0	50.0	0.0
1995	105	0	105	50-100	23	0.022	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0
1996	196	0	196	50-100	6	0.003	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0
1997	209	0	209	50-100	0	0.000	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Total*	**584**	**0**	**584**	**50-100**	**441**	**0.275**	**0.0**	**0.0**	**0.0**	**8.8**	**91.2**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**8.8**	**91.2**	**0.0**	**0.0**

*The mean is shown for densities, return rates, and ages. The mean return rate does not include 1995-1997 because additional adults may still return. Mean ages only include years with 10 or more returns.

Note: Return rates are calculated from stocked fry and do not include natural fry production, which is considered to be significant in the Narraguagus River.

Table 3.7.k. PENOBSCOT RIVER RETURN RATES FOR ATLANTIC SALMON THAT WERE STOCKED AS FRY.

Year Stocked	Total fry stocked (1000s)	Mean density (fry/100m²)	Total returns	Return rate (% of fry)	Age class (smolt age.sea age) distribution (%)										Age (years) distribution (%)				
					1.1	1.2	1.3	2.1	2.2	2.3	3.1	3.2	3.3	4.2	2	3	4	5	6
1979	95	50-100	77	0.081	0.0	0.0	0.0	16.9	53.2	2.6	0.0	27.3	0.0	0.0	0.0	16.9	53.2	29.9	0.0
1980	0	50-100	132	n/a	0.0	0.0	0.0	3.8	65.2	0.8	0.0	30.3	0.0	0.0	0.0	3.8	65.2	31.1	0.0
1981	202	50-100	360	0.178	0.0	0.0	0.0	6.9	73.9	0.8	0.0	18.3	0.0	0.0	0.0	6.9	73.9	19.2	0.0
1982	248	50-100	189	0.076	0.0	0.0	0.0	11.6	68.8	2.6	0.0	16.9	0.0	0.0	0.0	11.6	68.8	19.6	0.0
1983	0	50-100	81	n/a	0.0	0.0	0.0	21.0	63.0	0.0	0.0	16.0	0.0	0.0	0.0	21.0	63.0	16.0	0.0
1984	80	50-100	123	0.154	0.0	0.0	0.0	15.4	66.7	0.8	0.0	17.1	0.0	0.0	0.0	15.4	66.7	17.9	0.0
1985	197	50-100	271	0.138	0.0	0.0	0.0	5.2	74.9	1.1	0.0	18.8	0.0	0.0	0.0	5.2	74.9	19.9	0.0
1986	226	50-100	494	0.219	0.0	0.0	0.0	13.6	69.2	0.0	0.0	17.2	0.0	0.0	0.0	13.6	69.2	17.2	0.0
1987	333	50-100	330	0.099	0.0	0.0	0.0	28.2	57.3	0.3	0.0	14.2	0.0	0.0	0.0	28.2	57.3	14.5	0.0
1988	431	50-100	133	0.031	0.0	0.0	0.0	30.1	55.6	0.8	0.0	13.5	0.0	0.0	0.0	30.1	55.6	14.3	0.0
1989	77	50-100	113	0.147	0.0	0.0	0.0	23.9	59.3	0.0	0.0	16.8	0.0	0.0	0.0	23.9	59.3	16.8	0.0
1990	317	50-100	307	0.097	0.0	0.0	0.0	7.2	87.3	0.0	0.0	5.5	0.0	0.0	0.0	7.2	87.3	5.5	0.0
1991	398	50-100	260	0.065	0.0	0.0	0.0	18.5	53.5	1.2	0.0	26.9	0.0	0.0	0.0	18.5	53.5	28.1	0.0
1992	925	50-100	147	0.016	0.0	0.0	0.0	4.1	70.7	1.4	0.0	23.8	0.0	0.0	0.0	4.1	70.7	25.2	0.0
1993	1320	50-100	40	0.003	0.0	0.0	0.0	32.5	0.0	2.5	0.0	65.0	0.0	0.0	0.0	32.5	0.0	67.5	0.0
1994	949	50-100	26	0.003	0.0	0.0	0.0	0.0	23.1	0.0	0.0	76.9	0.0	0.0	0.0	0.0	23.1	76.9	0.0
1995	502	50-100	97	0.019	0.0	0.0	0.0	0.0	93.8	0.0	6.2	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0
1996	1242	50-100	39	0.003	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0
1997	1472	50-100	0	0.000	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Total*	**9014**	**50-100**	**3219**	**0.093**	**0.0**	**0.0**	**0.0**	**18.8**	**57.5**	**0.8**	**0.3**	**22.5**	**0.0**	**0.0**	**0.0**	**18.8**	**57.9**	**23.3**	**0.0**

*The mean is shown for densities, return rates, and ages. The mean return rate does not include 1995-1997 because additional adults may still return. Mean ages only include years with 10 or more returns.

Note: Return rates are calculated from stocked fry and do not include natural fry production, which is known to occur in the Penobscot River.

Table 3.7.l. SACO RIVER RETURN RATES FOR ATLANTIC SALMON THAT WERE STOCKED AS FRY.

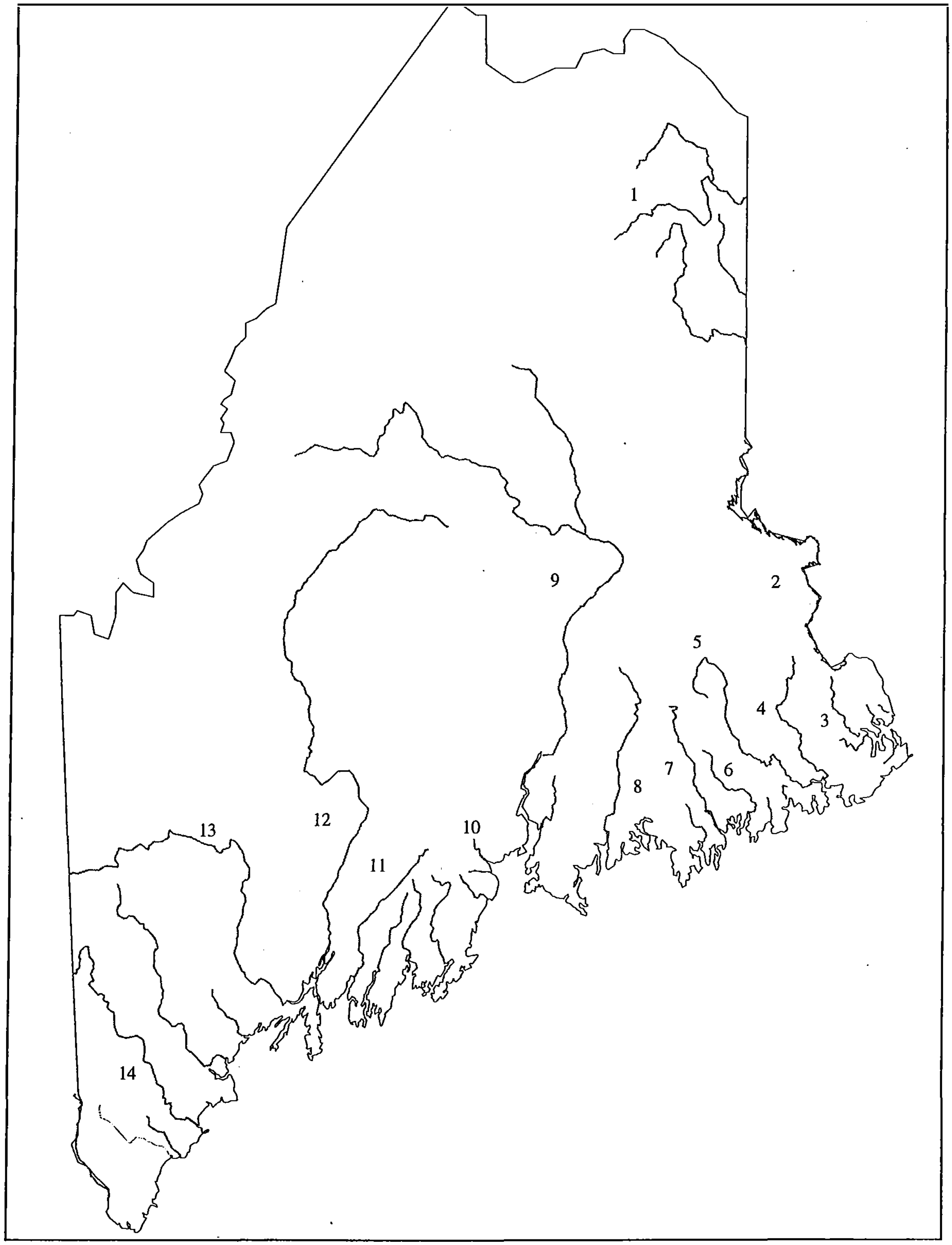
Year Stocked	Total fry stocked (1000s)	Mean density (fry/100m^2)	Total returns	Return rate (% of fry)	Age class[1] (smolt age.sea age) distribution (%)										Age (years) distribution (%)				
					1.1	1.2	1.3	2.1	2.2	2.3	3.1	3.2	3.3	4.2	2	3	4	5	6
1988	47	50-100	0	0.000	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
1989	0	n/a	0	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
1990	0	n/a	0	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
1991	111	50-100	0	0.000	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
1992	154	50-100	0	0.000	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
1993	167	50-100	1	0.001	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
1994	190	50-100	11	0.006	0.0	0.0	0.0	0.0	63.6	18.2	0.0	18.2	0.0	0.0	0.0	0.0	63.6	36.4	0.0
1995	376	50-100	33	0.009	0.0	0.0	0.0	12.1	87.9	0.0	0.0	0.0	0.0	0.0	0.0	12.1	87.9	0.0	0.0
1996	0	n/a	12	n/a	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0
1997	97	50-100	0	0.000	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Total*	**1142**	**50-100**	**57**	**0.001**	**0.0**	**0.0**	**0.0**	**37.4**	**50.5**	**6.1**	**0.0**	**6.1**	**0.0**	**0.0**	**0.0**	**37.4**	**50.5**	**12.1**	**0.0**

[1] Smolt age distribution is assumed to be 95% 2-year and 5% 3-year.

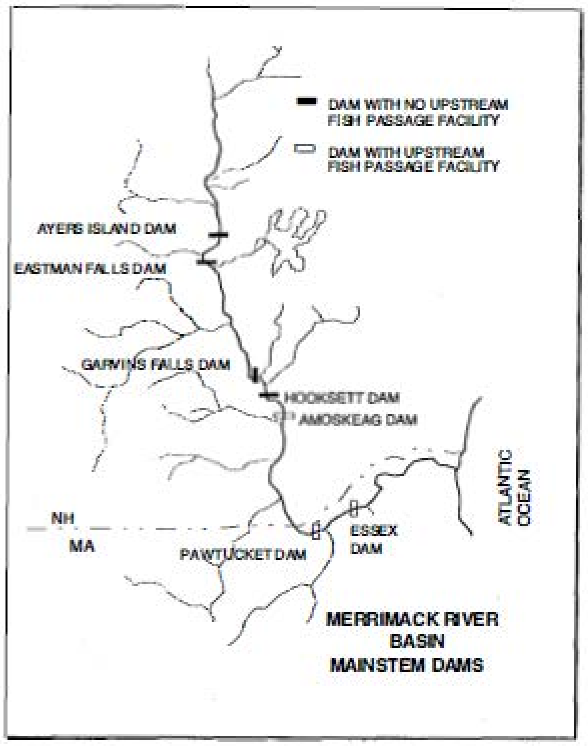
*The mean is shown for densities, return rates, and ages. The mean return rate does not include 1995-1997 because additional adults may still return. Mean ages only include years with 10 or more returns.

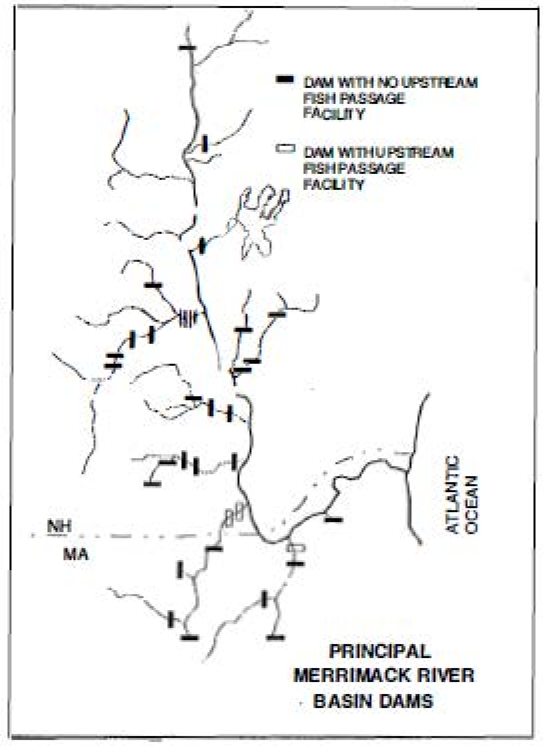
Note: Return rates are calculated from stocked fry and do not include natural fry production, which is known to occur in the Saco River.

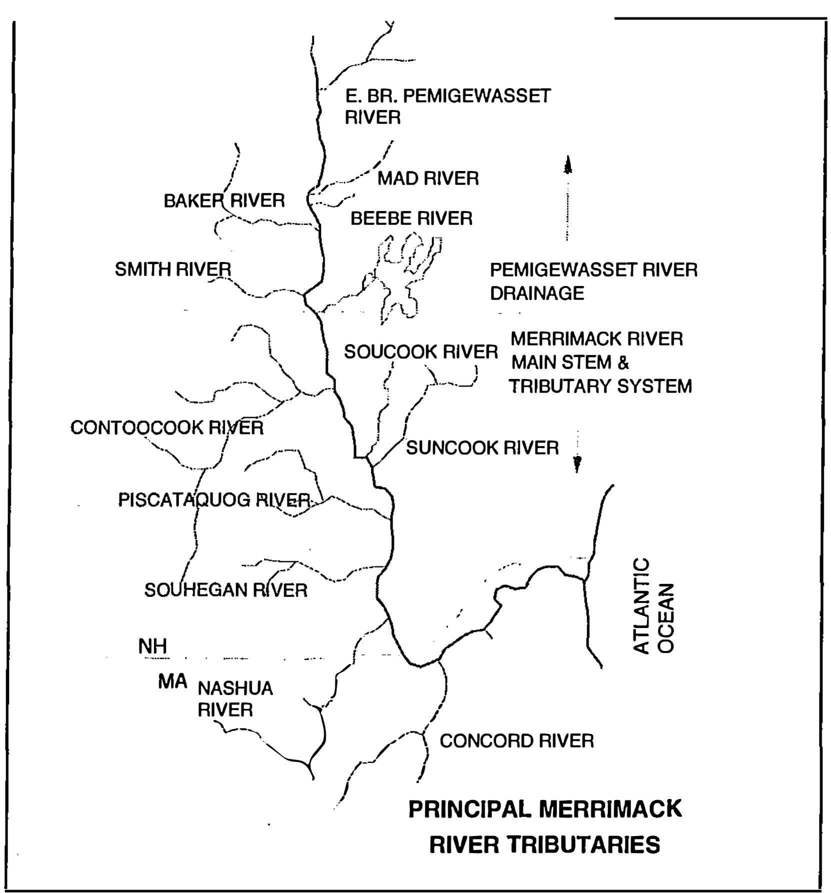
10.4. LOCATION MAPS



Important Atlantic Salmon Rivers of Maine

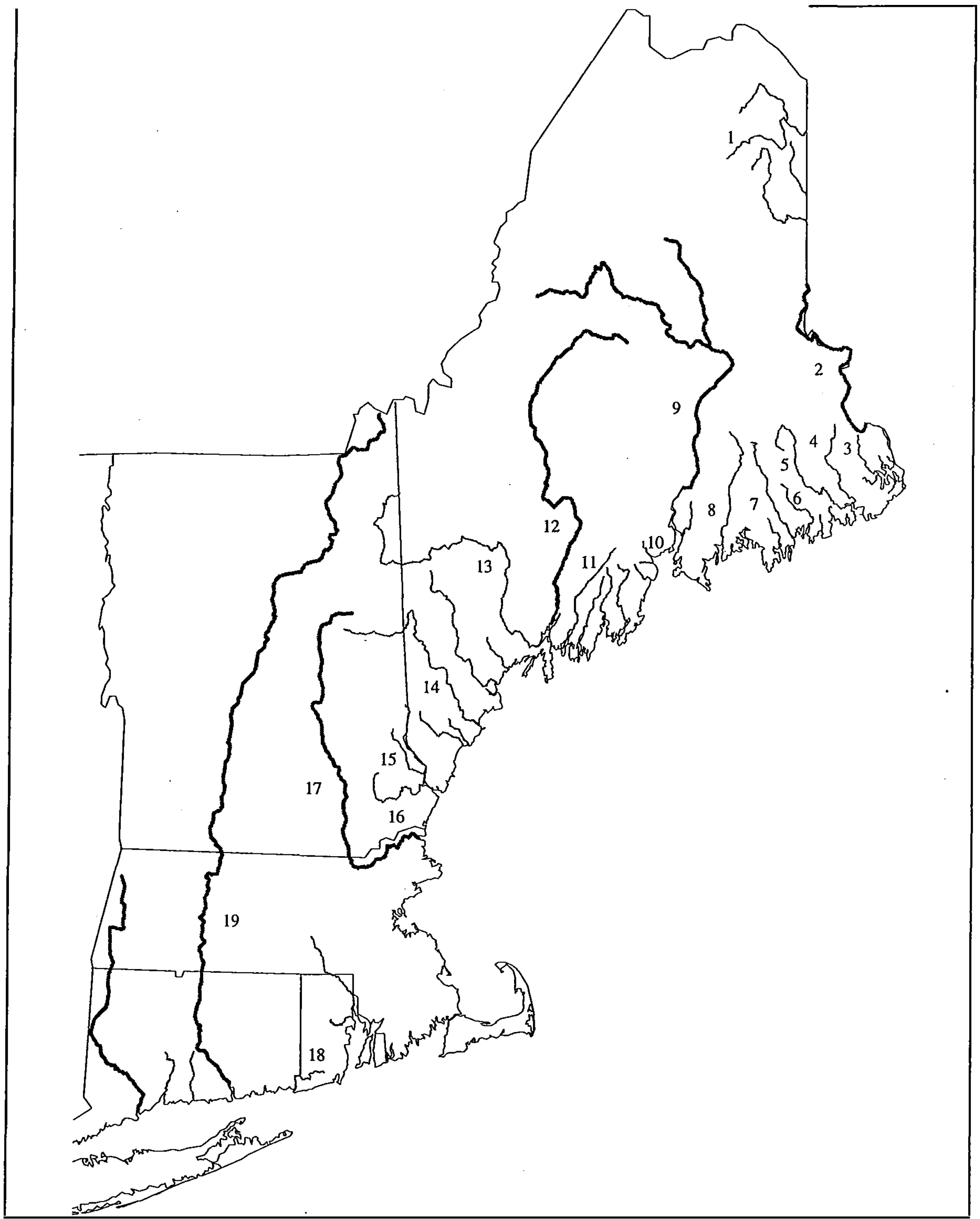

DAM WITH NO UPSTREAM FISH PASSAGE FACILITY
DAM WITH UPSTREAM FISH PASSAGE FACILITY
AYERS ISLAND DAM
EASTMAN FALLS DAM
GARVINS FALLS DAM
HOOKSETT DAM
AMOSKEAG DAM
NH
MA
PAWTUCKET DAM
ESSEX DAM
ATLANTIC OCEAN
MERRIMACK RIVER BASIN MAINSTEM DAMS

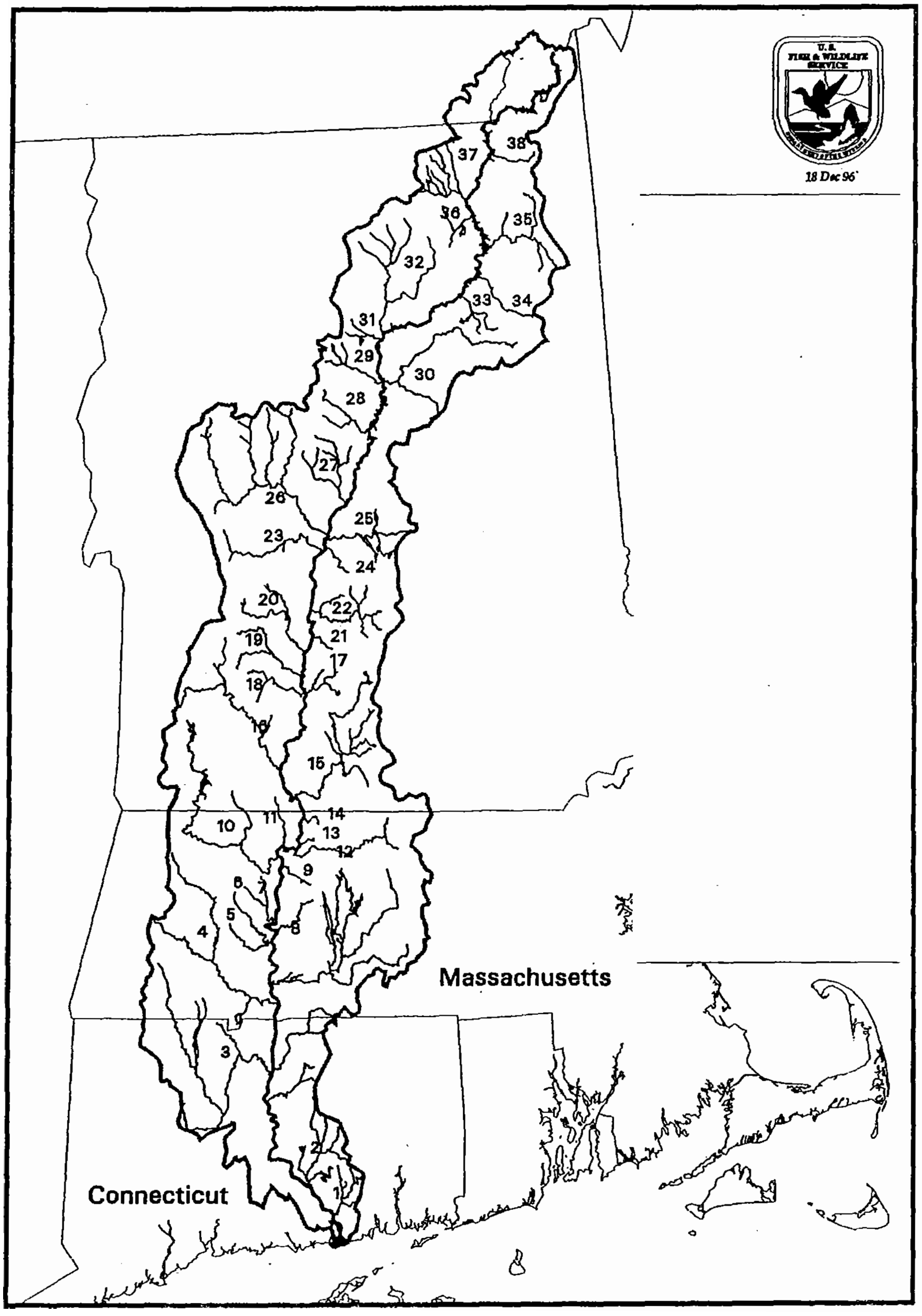

DAM WITH NO UPSTREAM FISH PASSAGE FACILITY
DAM WITH UPSTREAM FISH PASSAGE FACILITY
NH
MA
ATLANTIC OCEAN
PRINCIPAL MERRIMACK RIVER BASIN DAMS



PRINCIPAL MERRIMACK RIVER TRIBUTARIES

Important Atlantic Salmon Rivers of New England




U.S. FISH & WILDLIFE SERVICE
18 Dec 96
37
38
36
35
32
33
34
31
29
30
28
27
26
25
23
24
20
22
21
19
17
18
16
15
14
10
11
13
12
9
6
7
5
8
4
Massachusetts
3
2
1
Connecticut