U.S. ATLANTIC SALMON ASSESSMENT COMMITTEE — ANNUAL REPORT — 1999/11

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

REPORT NO. 11 - 1998 ACTIVITIES

GLOUCESTER, MASSACHUSETTS
MARCH 1 - 4, 1999

PREPARED FOR
U.S. SECTION TO NASCO

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1. INTRODUCTION

1.1. EXECUTIVE SUMMARY

The Annual Meeting of the U.S. Atlantic Salmon Assessment Committee was held in Gloucester, MA, March 1-4, 1999.

Stocking data, listed by age/life stage and river of release, and tagging and marking data are summarized for all New England programs. A total of 16,930,957 juvenile salmon (fry, parr, and smolts) were stocked. The Connecticut River received the largest percentage (54%); the majority of which was fry. Maine rivers received approximately 24% of the total, followed by the Merrimack River with 16%. The total release was an 11% increase over that of 1997.

In addition to the juveniles stocked, mature adults were stocked by the Maine, Merrimack, and Connecticut programs. In general, these fish are either spent broodstock or broodstock that are excess to hatchery capacity. All these adults are either river specific or domestic progeny of river specific programs. For 1998, a total of 6,628 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, Petersen disc tags, etc.). The salmon releases included about 53,000 marked and tagged salmon in 1998. Of the total, approximately 61% were released into Maine rivers, 19% were released into the Merrimack River drainage, 9% were released into the Connecticut River drainage, and 11% into the Pawcatuck River. Atlantic salmon of all life stages, except fry, were marked.

Documented total adult salmon returns to rivers in New England amounted to 1,775 salmon in 1998. The majority of the returns was recorded in the rivers of Maine with the Penobscot River accounting for nearly 68% of the total New England returns. The Connecticut River adult returns accounted for nearly 17% of the New England total and 70% of the adult returns outside of Maine. Overall, 20% of the adult returns to New England were 1SW salmon and 80% were MSW salmon; most (66%) 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 1998 was 270 fish, which was a 19 % decrease from the previous year.

The domestic brood stock fishery in the Merrimack River resulted in an estimated 1,528 salmon landed.

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 640 sea-run females, 2,892 captive/domestic females, and 183 female kelts contributed to the egg take. The number of females (3,715) contributing was considerably less than in 1997 (4,512). The total egg take, 19,790,975, was down from that of 1997 (25,299,700).

The role of the U.S. Atlantic Assessment Committee was discussed at some length. The Committee was convened to advise NASCO Commissioners on U.S. Atlantic salmon issues and to provide the participating agencies with access to the NASCO process. The Commissioners and later NEASC served as a sort of steering committee at one time. The role has since evolved to the extent that the Committee is no longer responding to specific agency or NASCO requests but is instead serving as a data keeper (historical reference, consolidating, analyzing and disseminating information) which is still an important and legitimate function.

The value of elevating the importance and status of the Committee by seeking additional terms of reference from the agency/policy makers was discussed. This option has the potential to increased involvement, develop additional support and interest, and increase participation. However, the option that was finally selected requires both scientific and management input through the existing Technical Committees and working groups. These groups will identify terms of reference that will be referred to the Assessment Committee at their respective policy meetings. The terms will then be discussed at the summer planning meeting (July 15) for guidance at the spring Assessment Committee meeting. Ultimately, the process may require additional ad hoc working groups to meet before the annual Assessment Committee meeting.

This option was viewed positively in that it could position the Assessment Committee to review issues like proposed program changes before they are implemented or to address a range of issues such as economic/cost analyses which may be less scientifically oriented.

It was proposed to schedule the "Connecticut River Migratory Fish Restoration" Research Forum the first day of the Assessment Committee meeting. This would permit the Committee to focus in depth on specific issues. While the Connecticut Program might find this less satisfactory in terms of direct feedback, it could be quite beneficial regionally. Still, logistics of such a forum may preclude maximum efficacy if the forum is piggy-backed onto the Assessment Committee meeting since it may not provide adequate time for review and development of terms of reference. In this case, a forum scheduled before the summer Assessment Committee meeting might be most helpful. No decision was reached on this issue.

1.2. BACKGROUND

The U.S. became a charter member of the 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 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, and 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 which 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. CHAIRMAN'S COMMENTS

I was extremely pleased with the working group's participation in this year's meeting. The strong presence of the statistical working groups added considerable depth to the meeting and their continued participation will provide the strong foundation the working group has lacked in this area.

Although I will miss interfacing with my colleagues in future meetings because of my impending retirement, I know that the group will receive excellent leadership from their new chairperson, Janice Rowan. And with Joe McKeon's assistance as vice-chair, the U.S. Atlantic Salmon Assessment Committee will be in capable hands.

I wish the entire group good luck in the future with the Atlantic salmon of New England.

Larry Stolte, Chair

2.e STATUSeOF PROGRAMe

2.1. GENERAL PROGRAM UPDATE

2.1.1. CONNECTICUT RIVER

Continued progress was made in restoring Atlantic salmon to the Connecticut River basin, and several exciting milestones were achieved this year:

Three hundred adult salmon returned to the river this year and for the first time in program history all of the returning fish originated from fry stocked in basin streams that migrated to the ocean and back again;

It is also the first time that a released kelt returned to spawn. One of the returning salmon was a repeat spawner that had been tagged and released, as a kelt, into the Salmon River in January of 1997;

Twenty-two salmon were radio tagged and released from Holyoke Dam by U.S. Generating Company (formerly New England Power Company). The tagged adults were monitored during upriver migration. As a result of the study, agencies were able to track adult salmon movements upstream of the Holyoke Dam, documenting spawning for the first time in Vermont's West River. Radio tagged salmon were also observed and documented in the Westfield, Deerfield, Saxtons, White and Ashuelot Rivers;

Agencies, with help from hundreds of volunteers, stocked over nine million fry (9.1M), the most ever, in 32 tributaries throughout the four state basin, nearly reaching the program goal of 10 million fry. The U.S. Fish and Wildlife Service resumed smolt production for the first time since 1994 at the PNFH;

And, the CRASC revised the *Strategic Plan for the Restoration of Atlantic Salmon to the Connecticut River* with public input. That Plan is available on the Internet at http://www.fws.gov/r5crc.

2.1.1.a. Adult Returns

A total of 300 sea-run Atlantic salmon adults was observed returning to the Connecticut River watershed including: 197 at the Holyoke fishway on the Connecticut River; 50 at the Rainbow fishway on the Farmington River; 47 at the Decorative Specialties International (DSI) fishway on the Westfield River; and, three at the Leesville fishway on the Salmon River. One salmon was seen below Rainbow fishway but was not captured. Two additional salmon were captured dead in gillnets set by researchers for shortnose sturgeon. The spring run lasted from April 21 to July 31. Two salmon returned in the fall, including one at Holyoke and one at DSI. A total of 259 salmon was retained for broodstock: 206 were held at the RCNSS, and 53 were held at the WSS.

A total of 24 salmon was released from the Holyoke fishlift (river km 138) and permitted to continue upstream. Twenty-two of the released salmon were radio tagged. Five salmon were observed passing Turners Falls (river km 198), seven were observed passing Vernon (river km 228), and three were observed passing Bellows Falls (river km 280). However, fishways were operated but not monitored for extended periods this year due to flooding, turbidity, and an extended operation season accommodating the presence of radio tagged salmon below dams. In addition, Wilder fishway (river km 350)ewas operated but not monitored for the entiree season. Based on radio tag data, 14 salmon passede Turners Falls, 12 passed Vernon, and three passede above Bellows Falls (one remained above). None aree believed to have passed Wilder. One of the salmone passed Turners Falls and Vernon in the fall. One of e the untagged salmon was reported angled and releasede in the Deerfield River. The location of the othere untagged salmon is unknown. A total of 13 salmone was released above the DSI dam on the Westfielde River (12 in support of a radio telemetry study, and 1e by accident).e

The Holyoke radio tagged fish were monitored; two were observed in the Westfield, five in the Deerfield, nine in the West, one in the White, one in the Saxtons and one in the Ashuelot Rivers. Mortalities and tag loss account for the remainder. The tags provided program biologists with the first-ever opportunity to follow their movements over the summer and to confirm fall spawning in the West River. This is the first documented spawning of sea-run salmon in Vermont since they were extirpated from the state by construction of the Turners Falls dam in 1798.

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. Sea-age information on released fish was generally determined by size. All of the 300 observed salmon were stocked as fry. Sea-age of fish was comprised of grilse (N=8) and 2 sea-winter salmon (N=290).

Additionally, two repeat spawners were documented. Known freshwater ages of wild salmon were 1^+(N=17), 2^+(N=259) and 3^+(N=16). The known sex ratio of the wild salmon was 185 females: 45 males, although this data is incomplete.

2.1.1.b. Hatchery Operations

Egg Collection

A grand total of 9,975,408 green eggs was produced at seven state and federal hatcheries within the basin. This is about 4.4 million fewer eggs than produced in 1997. Production of sea-run eggs was nearly double for 1998. A decline in the production of domestic eggs accounts for most of this difference and may be related to a number a factors including bad feed at federal hatcheries, delayed maturation in brood stock originating at the WRNFH and brood stock mortality in Connecticut. A decline in kelt production accounts for the remaining difference of about one-half million eggs. Aging kelts produce fewer viable eggs and many were taken out of production this year.

Sea-Run Brood Stock

A total of 1,452,468 eggs (14.6% of the grand total eggs produced) was taken from 185 sea-run females (12.5% of the grand total females spawned) held at the WSS and the RCNSS. A sample of the fertilized eggs from all sea-run crosses was again egg-banked at the WSS and WRNFH for disease screening and subsequent production of future domestic brood stock.

Domestic Brood Stock

A total of 7,029,486 eggs (70.5% of the grand total eggs produced) was taken from 1,140 domestic females (77% of the grand total females spawned) held at the WRNFH, RRSFH, KSSH, and RFCS.

Kelts

A total of 1,493,454 eggs (15% of the grand total eggs produced) was taken from 156 kelt females (10.5% of the grand total females spawned) held at the WSS, RCNSS, and NANFH.

2.1.1.c. Stocking

Volunteers made a successful stocking season possible in the four state basin. Vermont alone utilized over 100 volunteers with similar numbers organized in the other basin states with the exception of Massachusetts. Massachusetts relied upon Americorps to stock Atlantic salmon fry.

Juvenile Atlantic Salmon Releases. A record total of 9,131,090 Atlantic salmon was stocked into the Connecticut River watershed in 1998. Fish were released into 32 tributary systems throughout the basin. The total consisted of 8,519,800 unfed fry (93%), 598,984 fed fry (6.6%), 2,950-0+ parr (0.03%), 7,306 1+ parr (0.08%), 400 2+parr (0.004%) and 1,650 smolts (0.02%). Additionally, the Connecticut River Atlantic Salmon Commission agreed to provide just under 400,000 unfed fry to the RDFW Pawcatuck River program when the fry at the NHFG's WSFH required early stocking due to warm winter incubation temperatures.

2.1.1.d. Juvenile Population Status

Smolt Monitoring

NUSCO, the USFWS's SOFA and SOCNFWR contracted with GCC to conduct a mark-recapture smolt population estimate in 1998. This was the sixth 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 population estimate of about 65,400 smolts (95% CI 54.700-72,600) passing Holyoke is about double last year's estimate.

Based on expanded electrofishing data from index stations and assumed overwinter mortality, it was estimated that 285,000 smolts were produced in tributaries basin wide, of which 210,000 (74%) were produced above Holyoke in 1998. 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. Also, recent research suggests overwinter survival may be lower than previously assumed.

Index Station Electrofishing Surveys

Juvenile salmon populations were assessed by electrofishing in late summer and fall at nearly 200 index stations throughout the watershed. Sampling was conducted by CTDEP, MAFW, NHFG, USFS, USFWS, and VTFW. Data are used to evaluate fry stocking, estimate survival rates, and estimate smolt production. All of the data have not been analyzed yet. Preliminary information indicates that while densities and growth of parr varied widely throughout the watershed as usual, it was generally a good survival and excellent growth year. A record smolt class is expected in 1999 with an expanded index station estimate of 340,000 smolts. Most smolts produced are again expected to be two year olds, with some yearlings and three olds.

2.1.1.e. Fish Passage

The FERC expects to have a draft ruling available this winter with a Holyoke Dam license awarded next summer. The Connecticut River Atlantic Salmon Commission submitted general comments for the preliminary deadline and endorsed final comments provided by the USFWS, NMFS and MAFW.

NUSCO, contracted with Alden Research Laboratory, Inc. to develop a physical model of a downstream passage facility to pass adult and juvenile shad at the Hadley Falls Station. The design will convey fish to the tailrace, a better route. Design is complete except for resolution on how to handle the flow (where to direct it). Construction is targeted for 1999, but relicensing may interfere.

Preliminary results from NUSCO's Northfield Mountain Pumped Storage study indicate that the longer, partial depth net deployed this year was more effective than previous nets. Entrainment was reduced to about 9% of the radio-tagged fish which is about half that from previous tests. The longer net seems to prevent most fish from becoming entrained though fish can and do enter the area. A report from NUSCO is forthcoming.

USGen (formerly New England Power Company) is in the process of installing downstream passage at its Projects 2, 3, and 4 on the Deerfield River. NUSCO is completing its downstream passage facilities at the Gardners Falls Project, also on the Deerfield River. All four facilities will be tested in 1999.

NUSCO placed the Gardners Falls Project, West Springfield Steam Plant and Chicopee River Projects on the auction block and Consolidated Edison of New York was selected as the high bidder. Early this coming year, other projects including Turners Falls/Cabot and Northfield will be sold.

USGen / Normandeau Associates, Incorporated conducted a Deerfield River tag release Study in which 22 sea-run salmon were radio tagged and released above Holyoke from May 13-31. Three fish made it to the base of Dam #2 on the Deerfield River (1 short of what is needed to trigger fishway construction).

NUSCO and USGen were requested to operate fishways at Turners Falls and Vernon through November 15, or until the last radio-tagged fish passed. One of the tagged salmon had been monitored below Turners in the mouth of the Fall River. The salmon successfully passed both fishways and entered the West River.

The barrier fence that directs salmon to the fish trap at Townshend Dam on the West River was over-topped by a flood in early June. A second flood later the same month damaged the fence. The USACOE removed the fence but did not repair it in time to be of use this season. Since, the USACOE has determined that it will replace the barrier fence next spring and erect an electric barrier to resolve the problem but not until after the spring run.

Rexam DSI complied with a USFWS request that the downstream passage screen and bypass be operated after the scheduled November 1 shut-down date to facilitate downstream migration of post-spawning adult sea runs and brood stock. The automatic leaf-raker worked well. The bypass remained open until December 22nd.

International Paper provided interim downstream fish passage at the Woronoco Dam on the Westfield River. After some initial difficulties, the bypass was modified and worked well.

The USGen/Normandeau smolt release study results at the Moore and Comerford Reservoirs (15 Mile Falls) are not yet available. Preliminary discussions revealed that the fish did not move well. Researchers had problems with the smolts, timing, and temperature.

Smolt passage studies were repeated on the Black River at Cavendish following poor results last year with landlocked salmon. Similar studies at the Lower Village Project on the Sugar River were postponed until 1999. Studies were also conducted at the Lower

Robertson Project on the Ashuelot River employing a non-screen flow inducer system. Despite success with this system on a Merrimack River tributary project, it did not work well on the Ashuelot. The licensee is reverting to a more traditional passage system.

Downstream passage facilties were installed in late 1998 at the Fellows and Lovejoy Projects on the Black River in Vermont. In addition, the owner of the Gilman Project, also on the Black River, has proposed to go ahead and install downstream facilities instead of monitoring existing facilities first.

2.1.1.f. Genetics

Genetic brood stock management protocols, established in 1997, were continued in 1998. Each sea-run salmon was tissue sampled upon arrival at the salmon stations. The objective during subsequent spawning was not to mate fish that were closely related to each other and a numerical value of relatedness was established as a threshold to aid egg-takers in determining when a mating should not occur.

Although the sea-run population of brood stock (<259) exceeded the minimum recommended levels for stock conservation (50 pairs), the mating process was complicated by the uneven sex ratio (skewed heavily in favor of females) and the fact that some potential crosses had to be avoided due to the "relatedness guide" described it the previous paragraph. This year, wild precocious parr were electrofished from the West River in Vermont and the Farmington River in Connecticut to provide milt for sea-run females and minimize repeated spawning of male sea runs.

Approximately 1,140 female domestic broodstock were spawned at the WRNFH (USFWS), RRSFH (MA), RFCS (VT), and KSSH (CT) following protocols established in the past. They were spawned with one male each.

The genetic initiative described in the first paragraph is part of a larger study that will test the feasibility of using microsatellite DNA markers as a "genetic tag" for stocked fry in order to subsequently identify salmon by their origins. Doctors Letcher and King worked with the CRASC Genetic Subcommittee to develop a pilot study initiated this past spring in the Farmington River. About 450,000 fry of sea-run parentage were grouped with unique genetic tags and released into the Farmington River. Survival of these fry was unexpectedly low prompting an inconclusive investigation into the reason for poor survival of the DNA-marked fry in the Farmington River.

2.1.1.g. General Program Information

Mr. John Prescott, Public Commissioner for Massachusetts, passed away this year. The Commission position remains vacant. Mr. Al Elser, Commissioner for the VTFW retired at the end of 1998 and is succeeded by Mr. Ron Regan.

The revised *Strategic Plan for the Restoration of Atlantic Salmon to the Connecticut River* was completed and distributed in July 1998. The final product was developed subsequent to public informational meetings held in each of the basin states. Public comments were incorporated in the final Plan. A Technical Committee workgroup began drafting the Action Plan in November 1998.

A sea-run and domestic brood stock study on the Westfield River Massachusetts, permitted successful, natural, in-stream spawning in that watershed for the third consecutive season.

The USFWS initiated production of 100,000 two-year smolts at the PNFH in Vermont (first smolt release expected in spring of 1999). This will enable the program to annually release both smolts and fry, providing a buffer against poor instream smolt production years.

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 1998 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 Salmon Runs

Dennys River. A picket-type weir was operated on the

Dennys River from September 5 to October 12; the weir washed out during a high flow event and the facility was not reinstalled. Only one salmon was captured in the weir and that fish was an escapee from aquaculture operations, as evidenced by fin deformities and scale analysis. Anglers fishing the Dennys River did not report catching and releasing any salmon in 1998. One wild (2SW) salmon return to the Dennys River was documented in 1998; unfortunately, vandals (juveniles) killed the fish. A total of 32 redds were counted in the Dennys River in the fall of 1998, a slight decrease from the 33 redds counted the previous year. As in previous years, many of the redds undoubtedly originated from the captive brood stock (126 in 1998) that were stocked into the river from CBNFH.

East Machias River. There was no reported rod catch in the East Machias River in 1998. The number of redds counted in 1998 increased by nearly 600 % over the previous year (74 vs.11). This was the highest redd count in the East Machias River since 1987, and it is likely that the increase was a result of the release of 119 captive broodstock from CBNFH, since concentrations of redds were found in the vicinity of stocking sites.

Machias River. Anglers caught an estimated five salmon in Machias River in 1998, some of which may have been captive brood stock (246 released) from CBNFH. The number of redds counted in 1998 increased by 28% over the previous year (74 vs. 59), primarily as a result of the brood stock releases.

Pleasant River. Only two salmon redds were observed in the fall of 1998 (compared to one in 1997); however, due to the dark, tea-colored waters of the Pleasant River it is likely that additional redds went undetected. There were no reported rod catches of Atlantic salmon in the Pleasant River in 1998.

In 1995, 1996 and 1997 age 0+ and 1+ parr were collected from the Pleasant River in Washington County for the purpose of rearing them for captive broodstock. The 1995 and 1996 collections were sent to the NANFH, and in 1997 collections were sent to the Connors Bros. Inc. facility in Deblois, Maine. Mortalities occurred in the older fish at NANFH in May 1997. Tumors were observed in the air bladders in October 1997.

Specialists at Cornell University identified the pathogen as a retrovirus that had not been previously identified in the U.S., and appears to resemble a virus identified only in Scotland in 1978. The virus has been named Salmon Swimbladder Sarcoma Virus (SSSV).

Samples of eggs and milt have been taken from the Pleasant River fish at NANFH and sent to Cornell to determine if the virus is vertically transmitted. On January 20, 1999 thirty-eight brood stock from NANFH were sent to Leetown Science Center to determine such characteristics of the virus as, detection techniques, seasonality, potential horizontal categories, threats to other species and wild Atlantic salmon. The remainder of the Pleasant River brood stock held at NANFH were sacrificed to prevent spread of the disease.

Program cooperators are in the process of working with specialists from Leetown and Cornell to develop a plan to assess the prevalence of SSSV in the natural and wild environs.

Narraguagus River. Twenty-two adult salmon were counted at the Cherryfield fishway trapping facility in 1998 - the smallest number of adult salmon counted in the Narraguagus River since the first fish trapping facility was installed in 1960. The 1998 salmon count was about 41% less than the number counted in 1997, and 64% below the 5-year (1993-1997) average. No farmed fish escapees were captured in 1998, although three captive brood stock from 1996 and 1997 releases from CBNFH were recaptured. Anglers fishing the Narraguagus River were known to have caught and released 15 salmon during 1998 - two more that the number reported in 1997. A total of 63 redds was counted in the drainage in 1998, a decrease of 19% from the previous year. Some of the redds constructed in 1998 were from the 227 captive brood stock released into the river from CBNFH.

Ducktrap River. There was no reported rod catch in the Ducktrap River. A total of nine redds was found in 1998, vs. only two in the previous year.

Sheepscot River. There was no reported rod catch of Atlantic salmon in the Sheepscot River in 1998, and only two redds were found (vs. eight the previous year) in November.

Other Maine Restoration Rivers

Penobscot River. Total adult returns to the Penobscot River fish trapping facility at the Veazie Dam was

1,210 salmon, an 11% decrease from 1997. About 50% of the Penobscot salmon run (620 fish) in 1998 were transported to CBNFH for brood stock purposes in 1998.

1SW returns (269) were about 9% lower than the previous year, and 15% and 46% below the 5-year and 10-year averages, respectively. MSW returns (941) ine 1998 declined by 15% from the previous year, ande were 21% and 41% below the 5-year and 10-yeare averages, respectively. Reduced MSW salmon returnse in 1998 were expected, due to the previouslye documented low marine survival for the 1996 smolte class. (DFO Science. 1998. Atlantic salmone abundance overview for 1997. Canadian Departmente of Fisheries and Oceans,. Science Stock Status Reporte DO-02, 21p.)e

Returns of native ("wild-origin" salmon, which includes those salmon originating from natural spawning and fry stocked from federal hatcheries) were 10% lower than 1997 and 9% and 27% lower than the 5-year and 10-year averages, respectively. The composition of native salmon in the Penobscot returns continues to gradually increase, with 13.5% of the run composed of wild salmon in 1998. Comparable figures for 1997 and the 5-year and 10-year averages, respectively, were 13.5%, 11.9%, and 10.7%.

Approximately 250 salmon were estimated to have been caught and released by anglers throughout the angling season, which was closed during the months of July and August in an effort to reduce the potential for mortality of salmon caught and released during the period when water temperatures are highest.

Eight salmon redds were observed in two lower Penobscot River tributaries (Souadabscook and Kenduskeag streams) in 1998; redd counts were not conducted above Veazie due to the paucity of female salmon (63) released to spawn naturally in the drainage. More than 85% of the MSW female salmon captured at the Veazie Dam in 1998 were retained for broodstock at CBNFH.

St. Croix River. A total of 41 salmon was captured at the Milltown Dam fishway during 1998 – two less than the previous year. As in 1997, 13 salmon were retained for brood stock purposes. The 1998 trap catch of both 1SW and MSW salmon were relatively unchanged (32 1SW and 9 MSW in 1998 vs. 33 1SW and 10 MSW in 1997) The brood stock that were spawned in November at the Mactaquac Hatchery (Frederick, N.B.) by Department of Fisheries and Oceans personnel, provided about 39,000 eggs for future restocking programs in the St. Croix River. An additional 24 farm fish escapees (37% of the total trap catch) were documented in 1998. Seventeen of these fish were sacrificed for fish health/genetics background information and about 30% (five salmon) exhibited evidence of sexual maturation that year.

Androscoggin River. One salmon was captured at the Brunswick Dam fishway in 1997, compared to 38 the previous year. This was the fewest number of salmon captured at that facility since trapping operations began in 1981.

Saco River. A total of 28 adult salmon was enumerated at the Cataract Dam fish passage facilities (one fish lift, one fishway) in 1998. Overall, salmon returns declined by 48% from the previous year.

Union River. Operations of the trapping facility on the Union River at Ellsworth resulted in the capture of 8 salmon, all of which were transported upstream and released. The sporadic releases of fry and parr in recent years undoubtedly contributed to the reduced numbers of salmon in the Union River in 1998 (69 salmon).

Aroostook River. The trap catch at the Tinker Dam in 1998 was 30 salmon, a 250% increase from the number (12) captured in 1997. Returns to the Aroostook were reflective of the entire Saint John drainage, which experienced an increase in 1SW salmon returns compared with the previous year. Since Atlantic salmon returns to the Aroostook River eare initially counted in the returns to the Saint Johne River in Canada, they are not included in the annuale totals for USA rivers.e

2.1.1.b. Hatchery Operations

Brood stock from six Maine rivers produced the following egg takes at CBNFH in November [1997 egg take noted in ()]:

Dennys River	443,170	(493,650)
East Machias River	362,985	(394,000)
Machias River	570,750	(602,600)
Narraguagus River	490,020	(509,800)
Penobscot River	2,804,085	(2,223,000)
Sheepscot Rivere	542,820	(375,750)
	5,312,830	(4,598,800)

Collections of native (wild) parr in the Downeast rivers of Maine resumed in 1999. A total of 946 Atlantic salmon parr was collected from the following rivers: Dennys (151); East Machias (142); Machias (250); Narraguagus (260); Sheepscot (143). 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

Most of the four million salmon stocked into 10 Maine rivers in 1998 were released as fry that had started feeding prior to release. A complete stocking summary is presented in Table 2.2.1. in Appendix 9.3.

Native Atlantic salmon parr have been collected from the Maine native salmon rivers since 1992. These parr were raised to maturity at CBNFH, and have been producing eggs for the river-specific program since 1994. The increasing number of adult 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 brood stock (750 salmon) was returned to their rivers of origin in 1998. An additional 3,217 captive brood stock (domestic Penobscot-origin from GLNFH) were released into the Penobscot drainage in 1998.

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) were low and often far below historical averages in most rivers, except for the Narraguagus River and at 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 suboptimal survival of stocked fry.

Based on preliminary data analysis, the drainage-wide population of age 1+ and older parr on the Narraguagus River in 1998 was approximately 25,382 ± 2,832, a 5% decrease over the 1997 estimate.

Estimates are based upon electrofishing data from up to 45 sites that are sampled annually. Drainage-wide parr population estimates, which have been conducted on Narraguagus River since 1991, were as follows:

1998	25,382 ±2,832
1997	26,775 ±4,016 (1998 smolt est.= 2,925 ± 273)
1996	11,073 ±1,196 (1997 smolt est.= 2,871 ± 539)
1995	12,737 ±2,962
1994	9,536 ± 660
1993	22,901 ±6,916
1992	14,915 ±1,815
1991	15,863 ±1,687

The 1998 parr population estimate, which is 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 1998. Four rotary drum, screw-type traps were used to capture about 974 smolts at two sites in the lower river, which produced an estimated smolt run of about 2,800 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 was 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 second year of smolt estimates supports the 1997 findings, with overwinter mortality (99% probability survival was <30%) higher than observed in other studies and likely impacting this population.

2.1.2.e. Fish Passage

No information was reported in 1998.

2.1.2.f. Genetics

Tissues samples from Atlantic salmon have been collected in Maine, Canada and Europe since 1990 in order to characterize the genetic composition of Maine salmon stocks. Analyses of many of the earlier samples were inconclusive because of lack of proper and standard analytical techniques and/or limited temporal and geographic sampling collections. In 1994, program cooperators began a comprehensive study with the USGS-BRD in Leetown to study the mitochondrial and nuclear DNA of European and North American stocks. A great deal of the initial effort was expended on refining standardized analytical techniques.

Preliminary results based on analyses of samples in 1994, 1995 and 1996 indicate that some distinct populations exist in Maine, specifically in the lower Penobscot River (Cove Brook and Kenduskeag Stream) and the lower Kennebec River (Bond Brook and Togus Stream). Results also indicate that geographic differences exist among years based on allelic frequencies of the various populations, and that these populations have not been "homogenized" by previous stocking efforts. Significant difference was also shown to exist between salmon stocks found in Maine, Canada and Europe.

During 1998, tissue samples (adipose punches) were collected from captive brood stock prior to release in the spring from CBNFH: East Machias (38); Machias (47); Narraguagus (172); Sheepscot (40). The purpose of these samples is to be able to measure the contribution of these fish to the adult populations by sampling both parent and the offspring (as returning adults) in the years 2000 through 2002. These samples were sent to NMFS's Woods Hole Laboratory for analysis.

Tissues samples consisting of ventral fins were collected several tributaries of the lower Penobscot River: Kenduskeag Stream (42); Eaton Brook (11); Felts Brook (9). Tissue samples were also collected from Passagassawakeag River (3) and sea-runs adults collected at the Cherryfield trap on the Narraguagus River (21). Seventeen aquaculture escapees captured at the Milltown Dam on the St. Croix River were also sampled for both fish health and genetics.

2.1.2.g. General Program Information

No new information available.

2.1.3. MERRIMACK RIVER

2.1.3.a. Adult Returns

Total Atlantic salmon returns to the Merrimack River in 1998 amounted to 123 fish; 52 more fish than were recorded in 1997. Included within the total returns was a single multi-sea-winter salmon angled in the tailrace of the Essex Dam in Lawrence, MA. This fish was taken during the striped bass predation study that was being conducted by UMASS. Also included within the total were seven adults captured immediately downstream from the Essex Dam by electro-fishing.

Interestingly, 33 of the returns were captured at the Essex Dam fish-lift during the fall (19 in September and 14 in October). This was the largest number of adult salmon ever captured during the fall fish passage season.

The returns are broken down as follows:

Fry Stocking Origin Adults

Grilse	2SW	3SW	RS
19	47	0	0

Parr Stocking Origin Adults

Grilse	2SW	3SW	RS
0	0	0	0

Smolt Stocking Origin Adults

Grilse	2SW	3SW	RS
11	45	1	0

Nearly the entire grilse component (93% of river returns - 28 fish) was comprised of males. The virgin multi-sea-winter component (76% of river returns - 93 fish) was comprised of 34% males (31 fish) and 66% females (62 fish).

The rate of return (adults produced per 1,000 juveniles stocked) for fry-origin adults continued to be severely low for the seventh consecutive cohort. The rate of return, 0.0188, for the 1994 fry plant/cohort (ages 2.3, 3.2., and 3.3 not yet accounted for) although low, was nearly double that recorded for the 1993 cohort

The rate of return (adults produced per 1,000 juveniles stocked) for smolt-origin adults increased for the fourth consecutive cohort. The rate for the 1996 cohort (age 1.3 adults not yet accounted for) amounted to 1.06, an increase of 36% above the rate for the 1995 cohort.

2.1.3.b. Hatchery Operations

The majority of the Atlantic salmon fry produced for stocking purposes were provided by the NANFH and the WSFH and were primarily of domestic brood stock parentage. A few fed fry were produced by the NNFH. Smolts produced for stocking purposes in 1998 were provided by the GLNFH and were of Penobscot River sea-run parentage.

Egg Collection

Sea-Run Brood Stock

Sixty-four females were captured at, or immediately downstream from, the Essex Dam fish-lift and transported to the NNFH, where 63 produced 518,000 eggs. The majority of the eggs (92%) were transported to the NANFH to be hatched and released as fry. Some eggs, approximately 8%, were retained at the NNFH for brood stock development. Due to the low numbers of available Merrimack River sea-run eggs, 7,000 eyed-eggs of Penobscot River sea-run parentage were imported from CBNFH for future domestic brood stock development.

Thirty-one post-spawners were marked with Floy tags and released back into the Merrimack River downstream from the Essex Dam in January. These fish originated entirely from fish captured during the fall fish passage season.

Captive/Domestic Brood Stock

A total of 560 female brood stock reared at the NNFH provided an estimated 2,669,300 eggs. Eggs were transported to the Powder Mill SFH (less than 1%), and the NANFH (97%) to be held for fry stocking within the Merrimack River basin. Approximately three percent were held at the NNFH for future brood stock development. Approximately 500,000 of the eggs were transported to the NANFH are being incubated for the Pawcatuck River salmon restoration program.

2.1.3.c. Stocking

Approximately 2.65 million juvenile Atlantic salmon were released in the Merrimack River basin during the period, April - June of 1998. The release included approximately 2.55 million unfed fry, 37,000 fed fry, 6,900 1+parr, and 51,900 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 captured fish. Scale analyses is therefore used to differentiate between fish stocked as fry or smolts.

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

Smolts were primarily released into the main stem of the Merrimack River a short distance downstream from the Essex Dam in Lawrence, MA.

2.1.3.d. Juvenile Population Status

Fry/Parr Assessment

Parr were collected at 25 sites in 17 rivers throughout the basin in 1998. A stratified scheme was again implemented in 1998 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 include 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 rivers (40,289 ≥ da ≤ 200,000 ha), and small rivers and brooks where da < 40,500 ha. Sampling was directed at age 1+ parr 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 25 sample sites included a total of 352 units (one unit = 100 m^2) of juvenile habitat. The estimated number of habitat units within the basin increased slightly in 1998 following cursory survey work on several tributaries to the Smith River. As a result, the estimated number of available habitat units increased from 64,899 to approximately 65,742. Units sampled represent about 0.54% of the total available. In contrast, 24 sites representing 339 units were sampled in 1997, 28 sites representing 366 units in 1996, 28 units representing 380 units in 1995, 21 sites representing 265 units in 1994, and during the period 1984-1993, units sampled ranged from 132 to 153. Of the 65,742 known units, approximately 50,947; 47,029; 32,142; 38,085 and 45,354 were stocked with fry during the period 1994-1998, respectively.

Natural reproduction of Atlantic salmon is not known to occur in the Merrimack river basin. In recent years, sexually mature brood stock salmon have been released in headwater areas, but due to low numbers released, their contribution to the production of fry is assumed to be negligible.

Results of the parr assessments in 1998 indicate a strong year class of age 1+ parr throughout the basin. Age 1+ parr estimates increased in 24 of the 25 sites sampled in 1998 over those compiled in 1997. Five of those 24 showed less than a twofold increase but with one exception, the remaining 19 sites had increases of at least threefold. Estimates for the Smith River and the Souhegan River increased significantly. Densities of age 1+ parr in the Smith River were estimated at 8.7 parr per unit in 1998, as opposed to 0.7 parr per unit in 1997. Densities of 1+ parr at sites in the Souhegan River were estimated at 8.8-11.4 parr per unit as opposed to 0.1 to 0.3 parr per unit in 1997. Assessments in 1998 indicate high numbers of age 0+ parr in the Smith River, but extremely low numbers of age 0+ parr in the Souhegan River.

A preliminary comparison of the 1997 and 1998 parr densities at sites within each region indicate that in Region 1, age 1+ parr densities may be double the numbers estimated for 1997. Region 1 is located in the headwaters and represents about 32% of the total juvenile rearing habitat stocked in the basin in 1997. Included in this region are the Beebe River, Eastman Brook, Mill Brook, the East Branch Pemigewasset River and the Mad River. The East Branch Pemigewasset River estimates for 1+ and 0+ parr are extremely low while estimates for the remaining sites increased substantially.

Region 2 has the largest number of sample sites at 12, and represents 49% of the total juvenile rearing habitat stocked in the basin in 1997. Sites are located in the Baker River watershed, the Pemigewasset River, Hubbard Brook, Needle Shop Brook and the Smith River. Preliminary data indicate substantial increases in numbers of age 1+ parr over those estimated in 1997 at all sites except the Pemigewasset River where numbers appear to be comparable. Age 1+ parr population estimates in the Smith River are greater than 10 times those of 1997.

Region 3 contains only one sample site which is located on Beards Brook, but the site was not stocked in 1996 to allow a population estimate comparison with age 1+ parr in 1997. A comparison of data from 1996 with data obtained in 1998, indicates a twofold increase in parr per unit in 1998. This region includes the Contoocook, Suncook, and Soucook River watersheds as well as the Merrimack River and some smaller tributaries. This region represents approximately 2% of the stocked waters in the basin in 1997.

Region 4 showed the greatest increase in parr density estimates for age 1+ parr in 1998. With the exception of the site on the Middle Branch Piscataquog River, the remaining sites showed that estimates of parr densities increased significantly over estimates for 1997. This region contains approximately 17% of the habitat stocked in 1997 and encompasses the South Branch Piscataquog River and Souhegan River watersheds as well as Black Brook, a small tributary to the Merrimack River in Manchester.

The increased numbers of age 1+ parr observed at nearly all of the sample sites may be the result of a decrease in extreme environmental perturbations in recent years. Floods and high flows may have adversely affected the survival of parr in 1995 and 1996. Stocking the Souhegan River during extreme high flow conditions in 1996 resulted in an extremely poor year class of age 1+ parr in 1997. Consequently, fry stocked in the Souhegan River in 1997 had virtually no competition from 1+ parr which likely resulted in the strong 1997 year class.

2.1.3.e. Fish Passage

Downstream Fish Passage

PSNH continued to conduct downstream fish passage studies utilizing Atlantic salmon smolts at the Ayers Island Dam and the Garvins Falls 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 the fall at the Ayers Island project, and assessing the effectiveness of the louver weir in the power canal at the Garvins Falls hydro project.

The initial results obtained at the Ayers Island hydro indicated a high degree of success in capturing smolts in the sampler. Additional work will be carried out in 1999 to determine the effectiveness of passing wild smolts. The fall operation of the facility commenced on October 2nd and concluded on November 6th. A total of 21 parr were captured. Fisheries agencies and PSNH will be developing a plan for future fall operations.

The results at the Garvins Falls hydro project were not conclusive and additional studies are planned for 1999. A smolt bypass with capture capability was constructed in late 1998 (at the end of the louver weir) and will be tested in 1999.

Upstream Fish Passage

Continued upstream fish passage problems associated with the Lowell fish passage complex occurred. Fisheries agencies and Consolidated Hydro, Inc. (owner of the hydro power station and fish passage complex) are attempting to resolve the fish passage issues. The entire matter may be presented to the FERC for resolution in 1999.

2.1.3.f. Genetics

No work, other than the maintenance of the existing Atlantic salmon spawning protocols, was conducted in this area in 1998.

2.1.3.g. General Program Information

Domestic Atlantic Salmon Brood Stock Releases

In the mid-winter, spring and late fall of 1998, 1,888 surplus brood stock at the NNFH were released to provide angling opportunities in the main stem of the Merrimack River and a small reach of the main stem of the Pemigewasset River. The late fall and mid-winter releases (October and December) were comprised of 358 kelts and non-spawners. The spring (April and May) release included 1,530 re-conditioned kelts.

An additional 146 adults (pre-spawners) were released into the Pemigewasset River in the spring and late summer. These fish were part of a study to investigate spawning success by domestic brood stock in the wild.

Pre-spawner Releases / Natural Reproduction Study

Domestic Atlantic salmon brood stock were released in the Baker River (a headwater tributary) in 1998 as part of an evaluation to determine if brood stock would successfully spawn in the wild. Shore and water craft-based surveys were conducted to visually observe and locate fish and redds. Surveys began in fall and continued into winter.

Radio telemetry was used to assist in evaluating the movement and behavior of fish. Radio transmitters were surgically implanted in the abdominal cavity of ten salmon, which were held at the NNFH for approximately one month prior to release. Digitally encoded transmitters provided unique numerical identification offish, and stationary and mobile receivers were used to determine the locations and movement of tagged fish.

In total, 146 brood stock were released for this evaluation. All fish released, including those with radio transmitters, were affixed with a Floy tag. The tags were color coded grey, and carried alphanumeric text denoting summer (1998) as the time of release. These tag attributes also denoted the upper Merrimack River watershed as the release site. Radio transmitters used in the evaluation had a battery duration that exceeded 300 days. Riverine habitat at release sites included large, deep (> 3.0 m in depth) pools, and long (≥ 100 m in length) riffle/run complexes. Substrate in riffle/runs was composed of cobble and gravel, characteristics that denote preferred salmon spawning habitat.

Extensive surveys and telemetry reconnaissance were conducted during fall to document spawning and to locate redds. Although brood stock were observed in runs, they often sought cover in pools when disturbed. Deep pools provide cover, and fish were often found in pools during daylight surveys.

Redds were initially observed on 9 November. Redd construction occurred when water temperature was near 4°C, and river discharge at approximately 80 cfs or about 38% of the mean annual flow for the month of November. A total of 21 redds was documented throughout a 5.82 mile reach ofriver. A few redds were constructed near release points, with one located about 0.81 miles downstream from a primary release site. While a number of brood stock were observed near redds, only one was observed on a redd, and one radio tagged fish was observed constructing a redd at a location approximately 2.59 miles downstream from its release site. On 16 December, two redds were partially excavated, and samples indicated that 36% of the eggs excavated from the first redd were fertilized, whereas 100% of the eggs excavated from the second were fertilized.

Fish that did not carry transmitters were observed throughout the river downstream from release sites. No mortalities were documented. Six of the ten radio tagged salmon remained in the river near spawning areas until ice-up, when field reconnaissance ceased. One tagged fish was found dead 43 days post release, one was lost, and two were located downstream at Ayers Island Dam, a distance of approximately 36 and

39 miles, respectively, from their release sites.

Future evaluations will focus on similar release sites for brood stock. If spawning success continues, then evaluations of parr survival and abundance will be initiated. In addition future proposals will be developed to support the release of sea-run salmon at similar sites to evaluate spawning success and juvenile production.

Atlantic Salmon Domestic Brood Stock Sport Fishery

The NFHG via a permit system manages the Atlantic salmon brood stock 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 1997 and the spring of 1998, 2,878 surplus brood stock were released for the sport fishery. The winter release included 1,348, age 3+ and age 4+, fish that were spawned prior to release. The early spring release included 1,530 reconditioned, age 3+ and age 4+, fish that had been spawned the previous fall.

The results of the 1998 sport fishery are presented in Table 2.1.3.g. (1993-1997 results are included for comparison). A total of 1,939 salmon permits were sold in 1998, of this number, 1,203 anglers reported they had participated in the Atlantic salmon brood stock fishery. The majority of the anglers were NH residents, 11% were nonresidents. Anglers fished a estimated 21,413 hours during 7,459 fishing trips. They caught an estimated 1,528 fish, released 1,071, and kept 457 salmon. Catch per unit effort was .071 salmon per hour (anglers fished about 14 hours before catching a salmon). The 1,203 anglers spent an average of $245.00 during the season for an estimated total expenditu re of $294,735.

It was anticipated that the total number of salmon permits and fishing effort for the 1998 season would be lower than 1997 due to unfavorable angling conditions in 1998. The river was at flood stage from the middle of May through the end of June. However, the total number of permits sold was only 3% less than the number sold in 1997. Total fishing effort, the number of angler trips, and catch decreased slightly from the previous season. Catch per unit effort (.071 salmon per hour) was approximately the same as CPUE in 1997.

Education/Outreach

Adopt-A-Salmon Family

1998 was indeed a banner year for the station's Adopt-A-Salmon Family (AASF) watershed education program. In its fifth year of operation, the program broke the one hundred school mark. Although funding for the program remained static, the number of participating schools continued to increase. Some particularly newsworthy accomplishments follow:

1. Volunteers from two local companies (PSNH and Sanders, Inc.), lead school groups on tours of the NNFH during the busy fall spawning season. After being provided with a half day of training and "o-fish-al" AASF ballcaps, the volunteers jumped right in. They all did a great job and most indicated an interest in providing further help during the 1998/99 school year, as well as repeating their tour leading stints in the fall of 1999. Beyond providing the AASF program with much needed help, the volunteers provided the station (and Service), with a highly successful means for reaching out to the local community.

2. Several watershed associations and other non-profit organizations in such places as central Vermont and New York state have taken an interest in coordinating their own local AASF programs. This local investment in watershed education, far beyond the borders of the Merrimack River basin, significantly extends the reach of AASF at no cost to the Service! After being trained by the AASF program coordinator, these local groups provide all the logistical and material support for new school programs.

3. Several AASF partners are developing new curricula to be used in conjunction with the existing program materials. An elementary level educator in Amherst, NH, is developing activities for grades one-three. This is welcome as the original materials were developed for upper elementary and

middle school students. A watershed association in New York state (near Lake Champlain), wrote a grant proposal to fund development of an Adopt-A-Trout program. The new materials will complement those of the AASF program and will, again, extend the educational impact of this Service outreach program.

4. In the fall of 1998 the AASF coordinator launched a new educational initiative at a local elementary school. Part of the Service's national Earth Stewards program, the project builds upon AASF by involving fifth and sixth grade students in extended interdisciplinary watershed studies. The idea behind Earth Stewards is for students to participate in real environmental stewardship activities. In addition to raising and releasing Atlantic salmon fry into a local river, students will tag and release salmon smolts, publish a watershed newsletter, mark local storm drains with environmental warning messages (e.g., "drains to river"), build a working watershed model, and visit the local water and wastewater treatment plants. Two local watershed associations have partnered with the Service for this project.

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 in that the NHFG and the USFWS were given a role in the decision making process at the management committee level. Until that time, the two agencies were advisors at the management level.

Anadromous Fish Program Evaluation

The entire anadromous fish program was scrutinized by both the Technical and Policy Committees during 1998. The program evaluation primarily centered around Atlantic salmon activities and the low rate of return for adult salmon of fry stocking origin. General conclusions drawn were: 1) fry stocking densities were too high; and 2) lower river predation on smolts by striped bass was significant. These two factors are believed to be the major reason why the rate of return for adult salmon of fry stocking origin have declined severely beginning with the 1988 fry cohort.

The evaluation process will be completed early in 1999 and future restoration direction determined for Atlantic salmon as well as the American shad and river herrings.

2.1.4. PAWCATUCK RIVER

2.1.4.a. Adult Returns

Two salmon were captured at the Potter Hill Fishway on the Pawcatuck River in May and June of 1998 respectively (one adult female and one male grilse). An additional adult male was captured as bycatch in a commercial trap net in June. By scale analysis, it was determined that both adult fish had spent two years at sea after migrating as a two year smolts and were stocked as fry. The grilse had spent one year at sea after migrating as a two year smolt and also originated from fry stocking.

2.1.4.b. Hatchery Operations

Fish Cultural Changes

The Arcadia Research Hatchery (ARH) was reopened and remains the primary hatchery for the salmon restoration program. Losses of 1998 sea-run returns resulted in efforts to address problems with the water supply well. Hiring of additional personnel at the trout hatcheries has allowed smolt culture to continue.

Egg Collection

Sea-Run Brood Stock

No eggs were taken due to the mortality of the two adult salmon at ARH.

Captive/Domestic Brood Stock

The NANFH will continue to allocate up to 500,000 eggs per year (including 1998) for the Pawcatuck River. None of the eggs supplied by NANFH in 1998 will be incubated at ARH.

2.1.4.c. Stocking

Fry Stocking

The WSFH supplied 394,000 fry in March. These surplus fish were stocked in areas outside the established 4,500 habitat units by RIFW. The fry were stocked immediately because no staff or facility was available to start the fry on feed. NANFH supplied 305,000 fry in April. The fry were stocked by volunteers over a two day period. NANFH supplied an additional 210,612 fry 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 909,612.

Parr Stocking

An estimated 6,100 1parr (produced from domestic brood stock and supplied by Down East Salmon Co.) were stocked in the Pawcatuck River in January of 1998. An additional 8,573 1parr were released from ARH in April.

Smolt Stocking

An estimated 5,700 (5672) age 1 pre-smolts produced from domestic brood stock were stocked in the Pawcatuck River in January of 1998.

2.1.4.d. Juvenile Population Status

Fry/Parr Assessment

Fry and parr assessments were repeated in 1998. Nine index stations (48.45 total habitat units) were sampled in March and thirteen index stations (60.1 total habitat units) were sampled during October in the watersheds of two major tributaries of the Pawcatuck River. The 1997 fry cohort was surveyed for growth but insufficient data was obtained to reliably evaluate the survival and abundance (100,000 fry were originally 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, and 153.3 mm (SE=1.73) by October of 1998. 20.4% of the 1998 1^+ parr sampled were precocious males. The 1998 fry cohort attained a mean length of 76.9 mm (SE=0.65) by October. Over-winter survival percentages of 1997 1^+ parr to 2 smolt at the sample stations ranged from 5.5% to 100% and averaged 38.8%.

Smolt Abundance

Potential smolt output from stocked fry was estimated by sampling nine index stations during March of 1998. Smolt density ranged from 0.0/100 m^2 to 2.2/100 m^2 and averaged 0.6/100 m^2 (SE=0.13). The larger and more typically more productive stations could not be sampled due to high water. The estimated amount of juvenile habitat units in the Pawcatuck River watershed is 4,490 units. Total wild smolt output based upon expansion of sample density over area stocked was only 2,694 fish. Mean length of smolts captured while electrofishing in 1998 was 158.6 mm (SE=6.86). Scale analysis of a sub-sample of captured smolts produced from fry stocking, indicates that all were age 2.

Migrating smolts were monitored approximately 2.4 km upstream of tidal waters on the mainstem of the Pawcatuck River using a modified fyke net from April 1 through May 31, 1998. Smolt origin was determined from scale analysis and observations of adipose fin-clips. 115 smolts were captured during the sample period. 30% were adipose fin-clipped hatchery smolts. 70% were produced from fry stocking. It is assumed the migration commenced prior to the sample period because of immediate success after only 1 trap night. High water limited the sampling due to trap damage or potential for trap damage. Applying the 0.62% recapture rate of adipose-clipped smolts to the entire sample captured results in an estimated migration of 18,700 (18,637) for 1998.

Tagging

5,700 (5,672) parr were adipose fin clipped in October of 1997 as a prerequisite to 1998 smolt release and fyke net monitoring. This allowed differentiation between hatchery smolts and smolts produced from fry stocking in fyke net sampling.

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.

High water throughout the 1998 migration period (particularly in May) would have allowed passage of salmon around the trap in the Potter Hill Fishway, and at times prevented monitoring of the trap.

Downstream Fish Passage

No work was conducted on this topic during 1998.

2.1.4.f. Genetics

No work was conducted on this topic during 1998

2.1.4.g. General Program Information

Domestic Atlantic Salmon Domestic Brood Stock Releases

No adult domestic brood stock were available for release in 1998.

Education/Outreach

The educational program developed in 1995 continued in 1998. Westerly Public Schools in cooperation with the RIFW and the Wood-Pawcatuck Watershed Association conducted a fourth/fifth grade program teaching about the Industrial Revolution, dams, hydropower, mills, and effects on anadromous populations. The students toured the Bradford Dyeing Association Mill, visited the Potter Hill Fishway, observed the tending of a smolt trap, toured the ARH, and stocked Atlantic salmon fry as part of the restoration efforts.

2.1.5. NEW HAMPSHIRE COASTAL RIVERS

2.1.5.a. Adult Returns

Fish ladders on the Lamprey and Cocheco Rivers were monitored for returning adult salmon from mid-April through June. The Lamprey River was also monitored from mid-August to late November. The Cocheco River fish ladder is not operated during the fall.

No adult Atlantic salmon were observed at either fishway during 1998.

2.1.5.b. Hatchery Operations

No adult Atlantic salmon were transported to hatcheries from coastal rivers in 1998.

2.1.5.c. Stocking

A total of 190,500 Atlantic salmon fry were stocked into the Lamprey (95,000 fry) and Cocheco (95,500 fry) River systems during April of 1998. Fry were stocked at densities of 40-50 fry/100 yd^2 unit. The stocked fry were produced using eggs from Lake Winnipesaukee landlocked salmon fertilized with milt from Merrimack domestic males of sea run parental origin (Mer F1) held at the NNFH. The fertilized eggs were incubated to hatching at the WSFH.

The Lamprey River was also stocked with approximately 3,300 smolts donated by the D.E. Salmon Co. of Bristol, NH. The stock origin of these smolts was Penobscot.

2.1.5.d. Juvenile Population Status

Electrofishing surveys of juvenile salmon at four index sites on the rivers produced population density estimates for young-of-the-year (YOY) fry ranging from 4.4 - 6.6 fish/100 yds^2 unit. Surveys at sites supplemental to the index sites produced YOY density estimates of 0.3 and 7.8 fish/100 yds^2 unit. Mean lengths and weights of YOY ranged from 82-92 mm and 5-7 gms. Estimates of parr densities at index sites ranged from 1.1 - 3.8 fish/100 yds^2 unit. Parr ranged in size from 159-170 mm and 28 - 40 gms. Parr densities at the supplemental survey sites were 0.4 and 1.5 fish/100 yds^2 unit.

Density estimates at the two index sites in the Cocheco River system were similar. The density estimates for YOY at the Mad River site was 5.8 fish/100 yds^2 unit as compared to 4.6 fish/100 yds^2 unit at the Cocheco mainstem location. Parr density estimates at the two sites were 2.5 and 1.8 fish/100 yds^2 unit, respectively. The Mad River index site had below average density estimates for YOY and parr compared to the previous eight years. The Cocheco mainstem index site density estimate for YOY were slightly above the long term mean while parr density remained average. Mean length and weight for YOY were above average at both locations while parr were larger than the previous seven year average.

Results of surveying the Lamprey River index site indicated a slightly higher average density for YOY as well as parr. On the other hand, the North River site had the highest density estimate for YOY recorded while the parr density remained about average. At the Lamprey River, mean length and weight was about average for YOY but above average for parr compared to the previous seven years.

In 1998, the Isinglass River, a supplemental survey site in the Cocheco River system, showed a population density estimate for parr of 0.4 fish/100 yds^2 unit compared to the 1997 density estimate of 1.6 fish/100 yds^2 unit. The variability in this data may have been influenced by the lack of a second electrofishing backpack that was available at the Isinglass River in 1997.

2.1.5.e. Fish Passage

The NHFG has petitioned theFERC to reopen the operating license of SNHHDC's hydroelectric facility at Cocheco Falls on the Cocheco River. The petition requests three changes to the license: 1) to provide sufficient attraction water for summer and fall operation of the NHFG fish ladder at Cocheco Falls, 2) to increase the required operation time of the SNHHDC's downstream fish passage facility during 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 NHFG's petition and the Department is still awaiting a final decision.

In addition, the NHFG and the USFWS are working 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 1998.

2.1.5.g. General Program Information

Volunteers continue to be used to conduct all fry plantings in the spring. The NHFG draws from a database of more than 200 individuals that have expressed an interest in assisting the Department. 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 1998, the participating agencies released approximately 17,000,000 juvenile salmon into 18 river systems (Table 2.2.1.a in Appendix 9.3). In past years, Canada has stocked fish into some of the listed river systems but such stockings did not occur in 1998. The number of fish released represented an approximate 12% increase over the 1997 level.

In addition to juveniles, mature adults were also stocked in some river systems (Table 2.2.1.b in Appendix 9.3). 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 1998, 6,458 adult salmon were released into the rivers of New England.

2.2.2. SUMMARY OF TAGGED AND MARKED FISH

A total of 52,952 salmon released into New England waters in 1998 was marked or tagged in some manner. Tag types included: Floy, Carlin, PIT, radio and acoustical ("ping"). Fin clips, fin punches, and elastomer visual impplants were also used. Parr, smolts and adults were marked. About 8% of the marked fish was released into the Connecticut River system, 11% into the Pawcatuck River, 18% into the Merrimack River system, 1% into the Penobscot River, and 61% was stocked into five other rivers in Maine.

A comprehensive summary of marked and tagged Atlantic salmon released in New England rivers during 1998 is presented in Tables 2.2.2.a and 2.2.2.b (Appendix 9.3).

2.3. ADULT RETURNS

2.3.1. TOTAL DOCUMENTED RETURNS

A total of 1,776 adult salmon was documented to have returned to rivers in New England in 1998 (Table 2.3.1. in Appendix 9.3). The majority of the returns was recorded in the rivers of Maine with the Penobscot

River accounting for nearly 68% of the total New England returns. The Connecticut River adult returns accounted for nearly 17% of the New England returns and 70% of the adult returns outside of Maine. Overall, 20% of the adult returns to New England were 1SW salmon and 80% 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 rivers (360) were up slightly from 1997 (316). MSW returns in 1998 (1,416) were slightly down from 1997 (1,442). Overall, the total returns were very similar (1,776 in 1998 vs. 1,758 in 1997). Changes from 1997 by river program are: Connecticut(+151%), Merrimack (+173%), Penobscot (-11%), Saco (0%), Narraguagus (-40%), St. Croix (-5%), Aroostook (+250%).

2.3.2. ESTIMATED TOTAL RETURNS

The Assessment Committee recommends that the estimate of total stock size for US rivers previously provided to the ICES Working Group for its run reconstruction model for North American stocks be reviewed during the Working Group's 2000 annual meeting.

2.3.3. RETURNS OF TAGGED SALMON

Very few of the adult sea-run salmon that returned to New England rivers were marked or tagged. On the Connecticut River, one repeat spawner captured at the Holyoke Dam had a VIA (visual implant-alphanumeric) tag and was part of a group of sea-run salmon kelts released into the estuary from the RCNSS in 1996. These fish were also tagged with Petersen disc tags but this fish shed its Petersen tag prior to recapture. On the Merrimack River, five adult salmon carried a loop of monofilament line (through the dorsal musculature) which is believed to have carried a "dangler-type" tag that was shed prior to the fish's return. These "tags" were not affixed to salmon by the Merrimack program and biologists are investigating their origin. In Maine, returns to the Penobscot River included 21 fish with Carlin tags and 42 fish with visual implant /elastomer (VIE) marks.

2.3.4. SPAWNING ESCAPEMENT, BROOD STOCK COLLECTION, AND EGG TAKE

Connecticut River- A total of 36 wild sea-run adult salmon was permitted to ascend the rivers upstream of fishway traps where brood stock are captured. Twenty-two were radio-tagged as part of a utility company sponsored study on the main stem and 11 were radio-tagged as part of a university study on the Westfield River. The movements of these fish are summarized in section 2.1.1.a. Many of these fish were confirmed to have spawned in the West (VT) and Westfield (MA) rivers.

Pawcatuck River- Some fish in the Pawcatuck River may have eluded capture by leaping over the first dam during high flows but it is considered unlikely that natural reproduction occurred.

Merrimack River- All sea-run salmon were captured at the Essex Dam Fishlift. Natural reproduction by domestic brood stock released into the river was documented during the fall of 1998. These spring releases of pre-spawned brood stock were part of a study, which is summarized in section 2.1.3.g.

Maine Rivers- Natural reproduction was documented by redd counts in the seven rivers with natural populations and in some tributaries of the Penobscot River. Details can be found in section 2.1.2.a. There is no consistent trend relative to last year, but the redd counts remain well below appropriate levels.

Egg sources for the New England Atlantic salmon culture programs included sea-run salmon, captive salmon (fish collected as wild parr and grown to maturity in hatcheries), domestic brood stock (fish grown to maturity in hatcheries from eggs), and reconditioned sea-run kelts. The total number of females spawned in 1998 from each category is as follows: sea-run= 640, captive= 632, domestic= 2,260, kelts= 183. The grand total of brood stock spawned (3,715) was less than that in 1997 (4,512) mostly due to a significant drop in the number of domestic brood stock available in the Connecticut River program and, to a lessor extent, the Merrimack and Penobscot programs. The total egg take (19,790,975) was considerably lower than that in 1997 (25,299,700) for the same reason. A more detailed accounting of the egg production is contained within Table 2.3.4 in Appendix 9.3.

2.3.5. 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 1998 was 270, as compared to 333 in 1997 (Table 2.3.5, Appendix 9.3).

The domestic brood stock fishery in the Merrimack River resulted in an estimated catch of 1,528 fish (1997= 1,705). This fishery is described in more detail in section 2.1.3.g.

3.t TERMStOF REFERENCE

3.1. PROGRAM SUMMARIES FOR CURRENT YEAR

- a.t current year's stocking program witht breakdownst by time, location, marks and lifestage.t
- b.t current year's returns by sea age, marked vs.t unmarked, and wild vs. hatchery. t
- c.t general summary of program activitiest including regulation changes, angling catch,t and program direction.t

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

3.2. 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 9.3. and in Section 5. (sub-sections 5.1. and 5.2.) of this document.

3.3. Term of Reference 3 - (Kevin Friedland lead the discussion related to this term.) **The assessment committee recommends that the estimate of total stock size for US rivers provided to the ICES Working Group for the run reconstruction model for North American stocks be reviewed during the 1999 meeting.**

The working group did not review the estimate of total stock size for US rivers. The Assessment Committee opted for a broader perspective, however, and chose to review procedures used to estimate the pre-fishery abundance of the two seawinter stock component of all North American salmon.

The abundance forecast is a multiple regression model that uses a sea surface temperature index and a spawning stock size index to predict abundance in the current fishery year. The relationship between spawning stock and recruitment is obvious, but the underlying factors related to the environmental factors are not well understood. The return of salmon from the ocean phase is affected by survival during the post-smolt year at sea and maturation at the end of the first winter which sends part of the cohort to natal rivers to spawn as grilse. The winter environmental signal has been hypothesized to be related to migration patterns and their effect on maturation variation (Friedland et al. 1998b). However, further work on this area is required before this can be generally accepted. Post-smolt survival factors are equally difficult to assess due the difficulties in capturing and studying post-smolts. Recent investigations in the Northeast Atlantic suggest that spring temperature conditions may be important to post-smolt survival, which supports a range of possible mechanisms affecting feeding, growth, and predation (Friedland et al. 1998a). These investigations have been extended by the examination of post-smolt growth for a stock in the area which shows that growth during the post-smolt year is correlated with the thermal conditions (Friedland et al., in press, b). The same phenomena have proven to be elusive for North American stocks, in part which appears to be due to fundamental differences in the distribution of the post-smolt nursery area along the Atlantic coast of Canada and the United States. Reports of inshore nursery areas (Dutil and Coutu, 1988) are in stark contrast to the ocean distributions of post-smolts reported in Europe. Using scale growth signals, Friedland et al. (in press, a) suggests that the North American post-smolt nursery area shifts in location annually and may include both offshore in estuarine waters. Considering the growth and catch rates for the three collection years, the first year, 1982, clearly supported higher growth and abundance in the Gulf of St Lawrence. The following years, 1983 and 1984, support slower growth and lower local abundance. The Assessment Committee considered temperature and chlorophyll abundance data as indicators of the nursery habitat suitability for the same years. From the analysis, 1982 was cooler in the Gulf during summer than the other years (Figure 3.3. in Appendix 9.3), suggesting warm conditions may move fish out of inshore areas. In addition, chlorophyll abundance in spring, which was taken as an indicator of likely requirement success of the forage base, showed gradients between the Gulf and other areas that were consistent with the observed abundance patterns. This preliminary work suggests that nursery areas may be defined by optimal thermal conditions for post-smolts and production conditions for forage species.

Discussion

It was noted that while sea surface water temperature in the Northeast Atlantic may be favorable for hatchery smolt growth and abundance, natural smolt production in US waters has been depressed, in part, due to the low number of homewater returns or reduced spawning stock biomass. It was suggested that the increase in the number of fry stocked in US watersheds has increased the abundance of smolts. Smolt production in the Connecticut River has likely increased largely due to an enhanced fry stocking program. However, on the Merrimack River, recent findings suggest that the increase in the number of fry stocked has resulted in slower growth of underyearling and yearling parr. In addition, return rates of adults for high fry stocking density cohorts have been significantly depressed for the last seven years. The observed reduction in size of parr and the poor rate of return has prompted managers to reduce the density at which fry are stocked in the Merrimack River. For the Merrimack River there is reasonable coherence between the rate of return for hatchery smolts and the sea surface temperature index, but the rate of return for hatchery smolts in the Penobscot River has not exhibited a similar trend. The observed return rate for Penobscot River hatchery smolts in recent years is among the lowest in the year time series.

Chlorophyll was also identified as an environmental variable useful in examining smolt survival and production, particularly with respect to its importance in predicting trends in abundance of marine larvae. Marine larval life stages are among the prey of smolts and post-smolts. In New England coastal environments chlorophyll blooms are likely to occur prior to April, and given their importance in predicting larval trends, examination of this variable may prove useful in understanding factors affecting the growth, abundance and survival of post-smolts.

The question was posed whether it was possible to examine riverine environmental variables with similar satellite imaging techniques. Although no known analyses have been implemented to date, it was agreed that riverine growth characteristics in response to environmental variables may be extremely important for US salmon stocks.

References and Figures

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Figure 3.3. Temperature (èC) and chlorophyll (mg/m^3) distributions from satellites data during 1982-1984. (This figure can be found in Appendix 9.3.)

3.4. Term of Reference 4 - (Jay McMenemy lead the discussion for this term.) **Examples of fry stocking techniques through video and written media.**

A.eA 30 minute video was shown to the group. Thee video included three fry stocking activities on thee Connecticut River. In addition, a paper was presentede that provided an overview of Atlantic salmon frye stocking throughout the Connecticut River system.e

B.e<u>Atlantic salmon fry stocking in the Connecticute River basin</u> / James R. McMenemye

Fry stocking is an important strategy in the program to restore Atlantic salmon to the Connecticut River. Numbers of fry stocked have increased from less than 200,000 fry in 1986 to over 9.1 million fry in 1998. The current program fry stocking target is at least 10 million fry stocked in all available habitat. It is estimated that the basin contains 243,000 100 m^2 units of salmon habitat which would result in an average stocking density of 41 per 100 m^2.

Each of the four basin state fishery agencies and the USFS lead fry stocking and evaluation activities under their jurisdiction. The NHFG and the VTFW are organized on a district basis so there are two NHFG and three VTFW biologists that organize separate stocking efforts.

Fry are produced at five state and two federal (USFWS) facilities with the majority of fry being produced at the WRNFH. Fry produced at state facilities are stocked by the home state and fry from the federal hatcheries are allocated cooperatively to all states. A meeting is scheduled early each spring to allocate the federal hatchery fry. Each Agency requests fry to meet their needs beyond any fish that they produce themselves. Adjustments are made after discussion so that requests equal available fry. Once these final allocations are made, a schedule is developed. Agencies attempt to schedule streams when water temperatures are anticipated to be above 7 C, but stocking at cooler temperatures is sometimes required. At WRNFH, incubation temperatures are manipulated so that fry reach a developmental index of 92 on their scheduled stocking date. This allows some flexibility if it is necessary to postpone stocking due to stream conditions.

The major constraints in scheduling include availability of transport vehicles and completing fry stocking before streams get too warm. Fry are stocked from WRNFH at least six days a week for about six weeks from mid April to late May. During peak times both WRNFH transport vehicles along with two other transport vehicles are used on a daily basis plus additional fry are transported in cubitainers. Additional crews are stocking fry from state facilities at the same time. If an extended period of flooding requiring postponements occur it can create major logistical problems.

Most fry (93% in 1998) produced at basin hatcheries are unfed, but KSSH produces fed fry and RFCS produces a mix of fed and unfed fry in some years depending on incubation temperatures. Most fry are transported in large tanks either on standard hatchery trucks or on pickup trucks. Water is oxygenated and/or aerated. Fry are held within cages in the tanks. At WRNFH, fry are loaded directly from incubation trays into the cages on the trucks. Some fry are transported in coolers and cubitainers. Fry are enumerated at streamside by weight or volume. Fry stocking density varies from 20 to 100 per 100 m^2 of habitat with most fry stocked at densities of 30-75 per 100 m^2. Area of habitat is quantified by habitat surveys which have been completed on most stocked areas. Stocking densities are adjusted based on past performance of the stream. Fry are stocked from buckets by walking the entire length of streams and scatter planting the fry into appropriate habitat.

Fry are stocked by a mixture of agency crews and volunteers. Volunteers have become increasingly important as fry stocking has expanded and provide most of the stocking labor in CTDEP, NHFG and VTFW efforts and major contributions to other agencies. Volunteers are recruited through a variety of efforts. Organized clubs participate in some stockings (e.g. Trout Unlimited chapters). Public service announcements to recruit volunteers are sent to newspapers, interested organizations, and colleges. In southern Vermont, a volunteer coordinator maintains a database of volunteers and stocking schedules are mailed to past volunteers with sign-up sheets that they return. The Coordinator's office recruits volunteers for all the stocking agencies through brochures, the program web page, and other outreach efforts. Hundreds of volunteers stock fry in the basin and many stock on multiple days.

Fry stocking is evaluated by electrofishing at about 200 sites throughout the basin annually. Salmon populations are estimated by the removal method. Density, survival, and size of salmon are estimated by age class. This information is used to adjust stocking densities and strategies. In addition, the data are expanded by habitat area and then reduced by expected overwinter mortality to estimate basinwide smolt production. This technique has obvious limitations, but in the absence of smolt trapping, it provides managers with reasonable information about production trends by tributary and year.

Summary reports of evaluations are issued by the agencies annually. Several papers on fry stocking evaluation have been presented at past Assessment Committee Meetings as well as in the literature.

Discussion

There were several questions from the Assessment Committee requesting further clarification of specific aspects of fry stocking in the Connecticut River Basin. These included fry loading and transportation, recruiting volunteers for stocking, parr evaluations, and smolt assessment.

Related to the fry loading process, hatchery personnel bulk load fry from incubators directly into waiting distribution trucks. All fry are weighed stream-side based on the number of units and desired stocking density for the particular stream. The distribution trucks currently used for stocking can safely handle up to 180,000 fry per trip. Stocking trips routinely cover long distances and fry can be on the truck for 10 hours or more.

Most fry stocked in the Connecticut River program are unfed fry with a target D.I. of approximately 92%. Some fed fry are stocked in the State of Connecticut. They are produced at hatcheries in that state. Severe weather and high water can result in some stocking cancellations which increases D.I. levels of fry held at the hatchery. These are the primary reasons why stocking would be postponed. Stocking dates are not altered based on water temperatures. However, most streams in Connecticut are stocked when stream temperatures reach 10 C, while at least 75% of Vermont streams are stocked at temperatures above 7 C.e Based on follow-up electrofishing surveys, frye appear to be doing well when stocked at this D.I. level.e

Each cooperating agency responsible for stocking fry has a designated fry stocking coordinator. This person is also responsible for recruiting volunteers and NGO's for their geographic area. A couple of examples were cited to demonstrate creative ways to recruit volunteers and how some groups take a key role in recruiting. These techniques include the use of mail-back cards and a pre-recorded hot line with stocking schedules and river conditions.

There was a question asked on how the program will measure success from increasing stocking levels from 5 to 10 million fry? The program goals still remain to saturate available habitat and recreate a stock of salmon with natural selection acting upon the population and to add a future genetic identity to Connecticut River stocks. However, in the near term, most of the 10 million stocked fry will be evaluated based on numbers of surviving parr, and hopefully, improved home water returns. Currently all adult salmon returning to the Connecticut River are from fry origin but smolt production has resumed at the PNFH. Pre-smolt estimates are also based on fall parr estimates although these estimates do not include any out migration mortality. It was suggested that a cost:benefit analysis also be considered in the future and to possibly include a comparison of costs for fry stocking versus rearing hatchery smolts.

A discussion of salmon parr and pre-smolt over-winter mortality also occurred. There was general agreement that this is an area we have limited information and needs further attention. Recent findings in Maine and in the Connecticut River program indicate overwinter mortality appears higher than we have projected or estimated in the past. Stream sedimentation of critical juvenile salmon habitat was cited as a factor for poor overwinter survival in a Connecticut stream. Habitat impacts also appear to be factors in low overwinter survival estimates in Maine's Narraguagus River based on smolt assessments conducted in 1997 and 1998. It was also suggested that pre-smolt movements to downstream river reaches in late fall should be investigated since historical data from Maine in the 1960's indicates 3-6% of pre-smolts moved to lower river reaches in early November. Removal of beaver dams to improve fish passage in Maine rivers was another topic discussed. It was noted that some studies from other parts of the country found that beaver dams and debris dams are often minor obstructions for downstream passage for anadromous salmonids, but can pose upstream passage problems for adults migrating upstream. Much of the dam removal projects being done in Maine are to enhance upstream migration for adult salmon.

3.5. Term of Reference 5 - (Mike Millard, Ben Letcher, and Russell Brown lead the discussion for this term.) **The assessment committee agreed to update the previous work of Mark Gibson (RDFW) relative to optimum fry stocking levels throughout New England.**

A subgroup was formed and data were solicited from appropriate agencies in February 1999. Data analyzed for this term of reference included fry stocking dates and densities, YOY sampling dates and densities, and mean lengths of YOYs at time of sampling. Data from 1994 to 1998 were most consistent with respect to temporal and spatial coverage and were used in the initial exploratory stock-recruit and length-based analyses. Analyses of age 1+ and older fish were not included in this workshop effort due to the time required for data standardization.

Stock-recruit plots and associated Ricker stock-recruit curves were generated for data pooled over states, and on a per state basis. Analysis of variance was used to explore the primary sources of variability in mean length of YOYand survival of YOY, employing state and year as explanatory variables. Survival was calculated as the ratio of YOY density to stocking density. Linear regression was used to investigate trends in mean YOY length as a function of both stocking density and YOY density.

The stock-recruit curves explained between 4% and 14% of the variance. Mean length of YOY varied by state and year. The interaction effect between states and years was not significant. The coherence of mean YOY length between CT and VT across years was striking. No relationship was seen between mean YOY length and fry stocking density. However, a significant inverse relationship existed between YOY length and YOY density. Survival varied among states, but not across years. Survival rates in Connecticut waters were significantly higher than those for other states.

The subgroup agreed to continue exploring the newly contributed stock-recruit data, as well as combine the data with that from the 1992 Gibson report for a more complete time series. Draft recommendations for reporting future data relevant to stocking and subsequent sampling were put forth, and are supplied below in the Discussion section.

Discussion

There was extensive discussion on the ideas put forth by the Working Group that addressed Term of Reference 5.

The Committee expressed some concerns on comparing 0+ densities only by state, due to the differences between states and individual streams. Confounding environmental variables between years could be attributed to variance in 0+ densities between states and years. An additional variable which may contribute to the difference in 0+ densities is the fact that some states are primarily targeting 1+ and 2+ parr. This also may lead to inflated survival rates for 0+ parr in Connecticut as they are able to target them specifically. The 0+ are typically not targeted in New Hampshire and Maine due to their small size. The Committee is primarily interested in pursuing the densities of 1+ parr as related to fry stocking.

The Working Group stressed the importance of reporting stocking dates as they relate specifically to the growth analyses. Growth of 0+ parr, as illustrated in the Working Groups presentation, is a new component that was not originally done by Gibson.

The Committee discussed the types of habitat which the agencies sample, as it may relate to different densities dependant on habitat type. Most agencies are sampling sites which represent the habitat in the entire river; sites may include several habitat types. However, Maine sites typically consist of discrete habitat types; riffle sites and run sites are sampled separately. Although many of the recommendations made by the Working Group related to standardized reporting, the standardization of sampling sites (by habitat type) was not considered an option.

An additional data set that will be required from Maine will be redd counts. The number of redds in a given reach can often confound efforts to evaluate fry stocking in certain rivers. There is a need to develop a formula based on egg deposition and egg survival which can equate the number redds (by reach) to the dispersal of fry. This would then be added to the hatchery component. Fry of natural spawning are being contributed not only by sea-run adults, but by river-specific captive brood stock. The development of this formula will need to take into account the egg deposition of sea-run adults (~7,000) can be vastly different than the captive brood stock (~4,500). Another element needed is an estimated date of emergence which can be related back to the growth indices (in place of a stocking date). This data could be generated by development indices based on water temperature data available from most of the Maine rivers.

The bottom line of the discussion was that for this project to be valuable, the data needs to be able to link fry stocking densities, parr growth and survival to adult returns. The members of the Working Group and the Committee felt confident that this will be possible. This database will be able to predict the quality and quantity of juveniles in the river, which will then be used as a predictor of adult returns. Additionally, this database may help management agencies recognize threshold sizes that parr must achieve to survive. The Working Group agreed to: maintain the database; potentially link current data back with the historical database (Gibson's work); provide templates to the appropriate agency representative for reporting needs; send out a draft plan for review, with a frystocking template, prior to the 1999 fry stocking season; develop a "test run" using a complete set of data to review whether this data can be linked. This final item may be developed as a Term of Reference for the 2000 meeting.

The Working Group presented the following recommendations for the Committee to consider:

1.e USASAC should develop & distribute ane acceptable data template and standardizatione guidelines. Submit electronic files in Excel or Lotus.e
2.e Both stocking and sampling dates needed in somee consistent format.e
3.e Consistent labeling of sampling sites / reachese /tribs / stations.e
4.e Lat/longs for each station needs to be on record – eventual GIS applications?e
5.e Each record should follow a year-class (YOY ine year x, 1+ in year x+1, 2+/pre-smolts in year x+2)e
6.e YOY & 1+/2+pre-smolts length data should bee recorded/reported.e

The Working Group and Committee considered meeting in July to develop Terms of Reference for the 2000 meeting, and to put particular emphasis on this subject.

3.6. Term of Rerence 6 - (John Kocik lead the discussion for this term.) **Program summary of historical smolt runs to include:**

a. smolt run timing
b. smolt size distribution
c. smolt age distribution

The goals of this term of reference were: 1) to assemble a comprehensive database of all Atlantic salmon smolt studies that have been conducted throughout New England; and 2) to conduct a preliminary examination of these data to evaluate geographic trends in Atlantic salmon smolt ecology throughout their southern range in North America. This investigation has compiled a relatively comprehensive database of smolt data from all six New England states at five mainstem sites and four tributary sites in the Connecticut, Pawcatuck, Merrimack, Penobscot, and Narraguagus River systems. While developing these databases in electronic format, we have become aware of some additional studies that were not included in this preliminary synthesis because data were not available in electronic formats, principal investigators deferred distribution, or we became aware of the availability of data just recently. As such, this initial aggregate of data is incomplete but represents the largest and most spatially diverse assemblage of Atlantic salmon smolt data from the U.S. to date. Our preliminary work with these data suggests that such a comprehensive examination may be useful to rehabilitation and restoration programs throughout New England. We believe that such comprehensive summaries will provide clues related to factors that may determine optimal smolt quality and ultimately marine survival success. We will continue to expand this database in order to assemble all available data from this region in 1999.

Our preliminary examination of Atlantic salmon smolt data focused on describing smolt timing and size distribution. We deferred analysis of smolt age distribution until we can compile a more comprehensive database on smolt age. Our database contained data from 12 trapping or observation sites in the Connecticut, Pawcatuck, Merrimack, Penobscot, and Narraguagus Rivers or their tributaries. The longest dataset was from the Rainbow Dam on the Farmington River in Connecticut (13 years) and four observations were from a single site for one year. A total of 47 sampling events (years and locations) were available for run timing analysis. For this exploratory investigation, all available smolt data was used to investigate general trends. As such, data from a tributary with a smolt production capacity of only 1% of the Connecticut or Penobscot Rivers was treated as an equivalent data points. In addition, we made no assumptions of differential data quality. These datasets represent quite closely the geographic extremes of Atlantic salmon distribution in the U.S.A.; the southernmost smolt trap being located on the Pawcatuck River in Rhode Island (41.41° N and -71.80° W) and the northernmost trap on the Penobscot River (45.54° N and –68.37° W). Extremes of ocean entry are Connecticut River (41.26° N and -72.34° W) and the Narraguagus River (44.54° N and -67.87° W; Figure 1). For these 47 events, the average median migration time is 16 May and ranges from 24 April to 1 June.

To compare these observations to a standard location and common event, we attempted to standardize these median migration dates for trapping locations to ocean entry. As such, we determined the estimated time lag between the trapping site and ocean entry based on the distance from the ocean and average migration speed. The average migration speed of 0.88 km/hour (21 km/day) was developed from an average of our data for the Narraguagus River in 1997 and 1998 (Kocik, Beland and Sheehan, unpublished data) and data reported for the Penobscot River in 1995 – 1996 and 1991 - 1992 (Fried et al. 1978; LaBar et al. 1978; Spicer et al. 1995). The average date of ocean entry was 21 May and ranges from 24 April to 9 June. We then compared run timing to latitude to examine geographic trends. The relationship between median run timing and latitude at trapping sites was significant ($P < 0.01$; $y = 0.0777x - 2778.5$; $r^2=0.23$), with later run median dates at more northern collection sites. However, a when these data were standardized to median ocean arrival date, comparison of ocean entry and latitude were not significant. This appears to be further evidence of a stock ecology – environmental mismatch in most southern restoration programs. We also examined the additional smolt migration parameter of the duration of migration. No significant relationship to drainage size or latitude was evident in these analyses. Average duration of migration was 43.5 days overall ranging from a minimum run duration of 17 d in the West River and a maximum duration of 71 days in the Narraguagus River.

Preliminary analysis of Atlantic salmon smolt size was conducted based upon samples from 25 sampling events for length data and 10 sampling events for weight data. Differences in total length are variable between systems and within a system between years but geographic and time-series trends in size are minimal showing a nonsignificant trend. Over the systems and years sampled the average total length is 177 mm and average minimum and maximum were 129 mm and 238 mm. Average weight was 39.3 g with minimum and maximums of 16 g and 75.8 g

Discussion

Topics discussed were the use of alternate freshwater rearing indices to latitude for describing the environmental rearing/smolting conditions that could trigger movement from the system such as degree-days, altitude, and discharge. The committee encouraged continued expansion and exploration of these databases to develop long term trends in biological and ecological parameters. The committee particularly expressed a trend to expand these analyses to Canadian datasets to develop a comprehensive examination of North American smolt ecology.

3.7. Term of Reference 7 - (John Kocik, Michelle Babione, Phil Herzig, and Dave Perkins lead the discussion for this term.) **Historical data on returns by age structure related back to fry stocking programs for use in development of comparative river specific life tables.**

Summary and life tables (Tables 3.7.a - 3.7.l) were created for the Pawcatuck River, Farmington River, Salmon River, Westfield River, Connecticut River, Merrimack River, Penobscot River, Dennys River, Narraguagus River, and Saco River.

Maine recommended removal of Narraguagus River from analysis because of 1983 data and wild spawning component. Stolte recommended inclusion of size, sex, and age data and supported continuance provided the combined data sets would evaluate past stocking practices and result in future recommendations. The group decided to maintain and update the data set annually. The group also agreed to include information on individual fish. Kocik pointed out that future increases in smolt monitoring by individual programs will also benefit evaluations. Individual tables are to be regularly updated as differing freshwater/sea age groups return to river. It was decided fed vs. unfed fry data needs to be included. It was also suggested to include individual years on tables that will be available on the internet. CNEAFC should include home page address in full document (this will be done on the Connecticut River Coordinator's home page). Release of rejuvenated kelts as potential spawners needs to be noted in tables. It was also noted that with the inclusion of released captive brood stock, releases may exceed the number of returns on a given year. Different spreadsheets for individual rivers should be maintained. It was decided that estimated rate of returns should be included in table.

3.8. Term of Reference 8 - Historical SST data for the Gulf of Maine (April - July).

This Term was not addressed by the working group.

3.9. Term of Reference 9 - (Tim King lead the discussion for this term.) **Atlantic salmon genetics overview.**

One paper was presented regarding this Term. The abstract is included.

<u>Microsatellite DNA Variation in Atlantic Salmon with Emphasis on the Downeast Rivers of Maine /</u> T.L. King, W.B. Schill, B.A. Lubinski, M.S. Eackles, and M.C. Smith

Executive Summary

In October 1993, all anadromous U.S. Atlantic salmon were included in a petition to the Services for a Rule to List the species under the Endangered Species Act (ESA). In lieu of listing the Atlantic salmon as a "Threatened Species" under the ESA, the U.S. Fish and Wildlife Service and National Marine Fisheries Service (the Services) and the State of Maine agreed upon an Atlantic Salmon Conservation Plan. This cooperative recovery program includes continued broodstock development and stocking of Atlantic salmon in the Downeast rivers and changes in commercial aquaculture and agriculture operations to reduce potential threats to salmon survival. To allow the most informed planning and implementation of biologically sound management efforts, knowledge of the amount of genetic diversity present and a thorough understanding of the evolutionary relationships (e.g., levels of gene exchange) among geographic populations of Atlantic salmon are essential.

This report summarizes an extensive, range-wide (Maine to Spain) population genetics survey of mitochondrial and nuclear DNA variation in Atlantic salmon with emphasis on selected rivers of Maine. We observed heterogeneity of both mitochondrial and nuclear markers at all classification (i.e., continent, country, and river) levels. Within North America (NA), we found highly significant differences in haplotype and allele frequencies between pooled (within country) Maine and Canadian collections. Frequency comparisons also indicated haplotypes and microsatellite genotypes were heterogeneous among and within several rivers. These findings are described in more detail below.

Mitochondrial DNA. The D-loop and NADH-1 dehydrogenase (ND-1) regions of mitochondrial (mt) DNA were amplified by the polymerase chain reaction (PCR) in 951 Atlantic salmon and digested with 40 restriction endonucleases. Variation was detected with 10 enzymes, resulting in 30 composite haplotypes. Composite mtDNA haplotypes were strongly patterned geographically with a major discontinuity observed between most North American (NA) and European salmon. Of the 30 observed haplotypes, eight were exclusive to NA, 12 were restricted to Europe, two were shared between the continents (at low frequencies), and eight are believed to be from brown trout. In Maine, unique haplotypes (one each) were observed in the Sheepscot, Narraguagus, and East Machias Rivers. Haplotype diversity (*h*) was slightly higher in European and Canadian collections on average than in salmon from Maine. Among Maine localities, haplotype diversity was absent from Cove Brook of the lower Penobscot River, the Ducktrap River, and Bond Brook, a tributary of the Kennebec River. The collections from the Narraguagus, East Machias, and Sheepscot Rivers as well as from Togus Stream, a tributary of the Kennebec River exhibited higher than average *h* values.

Microsatellite DNA. Multilocus genotypes at 12 microsatellite DNA loci were determined for 1,762 Atlantic salmon sampled from 66 collections. The total number of fish surveyed were 1,130 from North America (NA), 380 from Europe, and 252 from three captive aquaculture strains and their hybrids. Study-wide, considerable genetic diversity was observed. Loci yielded between four (Ssa14) and 37 (Ssa171) alleles with a total of 264 alleles recorded. Among Maine rivers, the numbers of alleles per locus ranged from three (Ssa14) to 32 (Ssa171) with 144 total alleles recorded.

Qualitative analysis. Due to the hypervariability at some loci, numerous unique alleles were observed. Alleles unique to specific Maine rivers were found in Cove Brook (lower Penobscot R.), Narraguagus River, Pleasant River, E. Machias River, and Dennys River. Atlantic salmon from Cove Brook were observed to possess a large number of unique alleles, alleles only found in Maine rivers, and allele frequencies greatly different from other Maine rivers. Rare alleles were recorded in certain collections from wild Maine rivers that were only otherwise observed in landlocked strains, European rivers, or various aquaculture collections including the European-origin Landcatch strain. For example, at the SSLEEN82 locus, the 228 base pair allele was only observed in salmon from the Pleasant River (2%) in NA, but was found throughout Europe and recorded in all three captive commercial aquaculture strains tested. At locus SSOSL25, the 158 allele was only observed in the East Machias river in NA, Spain and the St. John and Landcatch aquaculture strains. At locus SSOSL311, allele 142 was only observed in Togus Stream in NA, Europe, and in the Landcatch aquaculture strain. Similarly, three instances were observed where alleles only found in European rivers (and the Landcatch strain) were found in the St.John aquaculture strain maintained by the Solon facility. These were the 115 allele at locus Ssa289 and the 128 and 152 alleles at locus SSOSL311. These findings suggest that some Maine rivers and/or captive river-specific broodstocks have already been impacted by human actions past or present.

Quantitative analysis. Analysis of molecular variance (AMOVA) for mtDNA and microsatellite DNA at the range-wide scale suggested that the majority of the total genetic differentiation among populations was due to variation between continents. Within continents, most variation was due to differentiation within collections. Similarly, the relative magnitude of overall population subdivision, F_{ST}, suggested that much of the observed variance occurred between NA and European populations. Pair-wise comparisons between collections within Maine rivers and between 1994 and 1995 samples suggested temporal stability accompanied by little readily detectable population subdivision.

Pheniograms based on the Cavalli-Sforza and Edwards chord distance matrix depicted an unequivocal, evolutionarily significant division between NA and European collections. Within each continent, shallower, but significant, genetic structures were observed. In Europe, at least three major management units appear among the European rivers surveyed: 1) Icelandic, 2) Baltic, and 3) southern European which was comprised of Irish, Scottish, and Spanish river collections. In North America, the degree of differentiation is not as great as that observed in Europe; however, significant structuring does exist among rivers and collections within rivers. The Stewiacke River, the sole Bay of Fundy population (which does not migrate to west Greenland), appears to be the most divergent collection in the western Atlantic Ocean. A close relationship between the Dennis Stream collections is strongly supported, as is the relationship among the three Cove Brook collections (1994-1996), the two Labrador rivers (the Michaels and Sand Hill Rivers), the three Newfoundland collections (Soulis Brook and Jonathan's Brook in the Gander River, and the Conne River), the two NA landlocked strains (Sebago and Grand Lake), and the two Kenduskeag Stream collections. Less strongly supported groups were observed between the Narraguagus River and the Machias River collections, the three year-classes from both Togus Stream and Bond Brook. Collections possessing certain unique alleles are depicted as relatively distinct entities (e.g., Sheepscot, Ducktrap, and Dennys Rivers).

Assignment tests. In addition to the standard analyses of genetic differences, we performed several analyses of the microsatellite data using assignment. Assignment methods offer the advantage that the results are straightforward. Individuals are either classified correctly or misclassified to similar populations. The clarity of the assignment results is in contrast to analyses based on various genetic distance measures that may be difficult to conceptualize. Assignment also yields a perspective different from that obtained from the usual methods of population genetics that are often used to analyze microsatellite data. This is because assignment is genotype-based whereas most measures of genetic variation in common usage are based on gene frequency comparisons of one sort or another. Three analyses are reported: 1) the assignment of Atlantic salmon populations by country and/or province; 2) the assignment of US populations of Atlantic salmon; and 3)ethe assignment of various selected Atlantic salmone aquaculture strains as compared to other Northe American and European populations.e

Every North American Atlantic salmon was correctly classified to continent of origin (1130 of 1130) as were all European Atlantic salmon (380 ofe380). Within continents, misclassifications were as might be expected due to geography and/or history. Most misclassified USA fish were assigned to New Brunswick and fewer were assigned to Nova Scotia, Newfoundland, and Labrador, in general accord with the geographic distances involved. Within North America, Canadian fish were correctly assigned to Canada 93.9 (246/262) percent of the time. Correct classification of USA fish to the United States was somewhat lower (671/868 or 77.3 percent). The correct classification rates of Canadian fish to province and European fish to countries were 77.1 percent (202/262) and 86.3 percent (328/380) respectively.

The results of the second analysis again showed that most of the classifications to year class level were higher than expected by chance. The exceptions being the Penobscot Hatchery strain (Green Lake National Fish Hatchery), the 1994 and 1995 Narraguagus collections, and the 1994 Machias collection. Pooling year classes and (separately) landlocked samples increased classification accuracy. Only the Penobscot Hatchery strain and Machias samples were not correctly classified more often than expected by chance before or after pooling. The correct classification rates after pooling ranged from 7.1 (Penobscot Hatchery strain) to 94.9 (Landlocked) percent and averaged 41.5 percent (350/843). The correct classification rate for Canadian fish to population was 67.7 percent (176/260). Graphical analysis of the relationships of the US Atlantic salmon populations studied revealed that repetitive collections from sampling in different

years tend to cluster closely. When three samples from different year classes were available, alternate year class samples were most similar.
Finally, we tested various selected Atlantic salmon aquaculture strains to determine if their ancestry (in terms of continent of origin) and any other defining features were discernable. Once again, assignments, in general, agree with expectations. Aquaculture strains of North American origin were most similar to (least different from) North American wild populations while those of European ancestry were most similar to wild European Atlantic salmon. North American-European crosses demonstrated intermediate similarities to North American and European wild Atlantic salmon. Classifications of aquaculture fish were generally high, and misclassifications were in accordance with ancestry.

Conculsions. Numerous glacial advances and retreats characterized the Pleistocene Epoch, apparently leaving biogeographic imprints of varying degrees of depth on the population structure of Atlantic salmon. Analyses of mitochondrial and nuclear microsatellite DNA variation in Atlantic salmon confirmed the existence of a deep phylogeographic discontinuity in genetic structure between NA and European populations. Knowledge concerning these deeper phylogenetic structures is important for conservation biology . If the discontinuity has resulted in the absence of gene exchange and populations collectively encompass a substantial fraction of a species' genetic diversity, they should be considered as distinct population segments or evolutionarily significant units (or ESUs). Based on the overwhelming evidence presented in this study, we believe the Atlantic salmon inhabiting North America and Europe are sufficiently divergent and reproductively isolated to warrant ESU status. Although no such rich phylogenetic disjunctions were readily observed within North America or Europe, shallower genetic subdivisions worthy of management consideration (i.e., management units) have been identified. data do not support the hypothesis that Atlantic salmon have been totally "homogenized" by migration (introgression), stocking, and aquaculture operations. The discovery of highly divergent populations (Cove Brook and Kenduskeag Stream of the lower Penboscot River, Bond Brook and Togus Stream of the Kennebec River) existing in an apparent sympatric manner is remarkable. In addition, the landlocked salmon strains are divergent from anadromous salmon in Maine. Large allelic differences in microsatellite DNA and large frequency differences in mtDNA haplotype frequencies were observed. Aquaculture operations have the potential to change for good or ill thestatus of wild salmon populations. The captive aquaculture strains examined in this study exhibited levels of genetic diversity equivalent to the other wild or broodstock populations tested and thus appear to be generally well managed. However, given the deep evolutionary division between North American and European Atlantic salmon demonstrated by this study and others, the introduction of Atlantic salmon of European origin into North American aquaculture may pose a serious threat to native fish. The potential for inadvertent mixing of native and non-native fish by escapement is obvious. The observation of "European" alleles in some Maine rivers seems to suggest that some mixing has in fact already occurred. Coupled with the potential for the introduction of diseases exotic to North America, it seems that the cost to benefit ratio of contravening 10,000 plus years of isolation should be carefully examined. Restoration efforts should take into account inter- and intra-river diversity and utilize supplementation if needed to boost effective population sizes. When supplementation is applied, it should be in a manner that does not significantly perturb the recipient pulation by shifting gene frequencies, influencing demographic and physiological parameters, or introducing disease.

3.10. Term of Reference 10 - Striped Bass on the East Coast and potential implications to Atlantic salmon restoration.

Several papers were presented relative to this Term. Their abstracts and any discussion are included.

Stock Status of Atlantic Striped Bass

G. R. Shepherd* (Northeast Fisheries Science Center,e 166 Water St. Woods Hole, MA 02543; 508/4952368;e FAX 508/495-2393; gshepherd@noaa.gov)e

Abstract

The coastal migratory group of Atlantic striped bass consists primarily of fish from the Chesapeake, Delaware and Hudson stocks. Populations of striped bass along the Atlantic coast reached a low in the early 1980's, prompting legislative action to encouragee sound management. A reduction in fishing mortalitye and improvements in spawning habitat has resulted ine a dramatic increase in striped bass abundance. Thee stock complex was declared restored to historic levelse in 1995 and fishing restrictions were changed to reache

a target F level. The ASMFC Striped Bass Technical Committee examined striped bass stock abundance using a virtual population analysis model. Since current knowledge did not allow us to distinguish stock-specific catches in the mixed stock coastal fisheries, the analysis was conducted on a mixed stock complex of Hudson River, Delaware Bay, andChesapeake Bay fishes. The times series of data was 1982 through 1996. Results indicate a steady increase since 1983 in both spawning stock biomass and total abundance. Recruitment of the 1989, 1993, and 1996 cohorts was very successful and will contribute to future spawning biomass. Increased abundance has lead to increases in recreational and commercial catches. Fishing mortality has now reached the level targeted by fishery managers of F = 0.31. Long term projections indicate that fishing at the target mortality levels will maintain biomass at the 1995 level.

Discussion

Discussion after this presentation touched on several topics. The outlook is good for continuation of the striped bass tagging program in the future because most tagging is part of other sampling efforts. The impact of the increasing striped bass population on condition factor was addressed. Condition factors are lower than when abundance was very low in the 1980s, but the current values may be more like historical values.

Historically, there is no evidence that striped bass spawned in the Connecticut or Merrimack rivers. Striped bass are now spawning in the Kennebec and it is possible that spawning could expand to other river systems. In recent years, bass may be arriving in New England waters earlier and more fish may be overwintering in New England.

Striped bass have been blamed by some for declines in blue crabs, lobsters, shad, salmon, river herring, menhaden, and bluefish. However, there is no talk of changing striped bass regulations to benefit other species.

<u>An Evaluation of striped bass (*Morone saxatilis*) predation on diadromous species in the Merrimack River below the Essex Dam</u> / Mac Neil, P.J., and F. Juanes

Abstract

Predation on diadromous species, specifically, Atlantic salmon (*Salmo salar*), alewife (*Alosa aestivalis*), blueback (*Alosa pseudoharengus*) and American eel (*Anguilla rostrata*) could negatively impact the successful restoration of these species in the Merrimack River. We document striped bass (*Morone saxatilis*) predation on these species during our 1998 field season, which coincided with the seasonal migration period of Atlantic salmon smolts (April-June). We also compare the results of the 1998 season with the pilot study conducted in 1997 by Blackwell and Juanes (*in press*).

In 1997 there were 212 striped bass collected over six sampling dates (May 6, 8, 13, 14, 21 and 28) in the tailrace of the Essex Dam using angling equipment. Of the 212 fish collected 41 (19 %) contained stomach contents. Atlantic salmon and suspected Atlantic salmon smolts were the main prey items identified, appearing in half of the stomachs analyzed. The large proportion of smolts (n = 32, 45.8 % wt.) and suspected smolts (n = 28, 36.2 % wt.) in the diet of striped bass in 1997 was the impetus for the expanded 1998 work.

The 1998 fieldwork was initiated March 31 and continued until June 12. The methods were changed to increase sample size and to reduce the bias associated with using only angling gear. Working with the U. S. Fish and Wildlife Service Office of Fishery Assistance in Laconia, NH, we were able to also use electrofishing gear in the tailrace and immediate downriver area (40 angling/ 5 electrofishing dates). Sampling began before the Atlantic salmon migration period to document whether there were any resident striped bass in the tailrace area below the dam. We did not collect a striped bass until April 26; positively identified smolts first appeared in gut contents on April 27.

The contribution of smolts to the diet was greatly reduced, as compared to 1997. Of the 873 striped bass collected 389 (45%) contained gut samples, of those, 16 stomachs contained positively identified smolts (n = 22) and another 7 stomachs contained suspected smolts (n = 9). The majority of the smolts were consumed before May 8th, after this date, river herring (alewife and blueback) and American eel were the dominant fish prey identified. River herring were found in 167 stomachs (42.9 %) and constituted the majority of wet weight (85.6%, n = 228) of recovered items. American eels were also well represented in striped bass gut contents, appearing in 84 (21.6 %)

stomachs. In the striped bass that contained eels, the number of individual eels ranged from one to twenty-nine (average +/- SE, 3.13 +/-0.49), the total number collected was 263. Overall, we identified twenty-one different categories of stomach contents. Preliminary results suggest that striped bass opportunistically feed on what is available below the dam.

Direct comparisons between the two years are difficult, abiotic factors (river temperature, flow data) and biotic factors (river herring availability, smolt stocking and fry-stocked smolt numbers) differed between the two years. The availability of river herring in the tailrace in early May could lessen the impact from striped bass predation on Atlantic salmon smolts and the possible negative impact on adult returns. An additional field season is planned for 1999.

Discussion

The first question asked pertained to upstream (of the Essex dam) sampling of striped bass predation behavior. The reason behind the question was to determine how efficient striped bass are at catching prey, outside of the bottleneck created by a spillway/tailrace. This question has not been addressed during this study. It was suggested, by another member of the audience, that the bass likely move upstream to the next dam, stack in that tailrace and exhibit similar feeding behavior. Similarly, there was interest expressed in further downstream sampling (i.e., beyond the tailrace). There is no active sampling beyond the tailrace, however, since very few tagged fish were recaptured at the dam, it is assumed that the striped bass are foraging somewhere downstream. There are no dam facilities further downstream of the Essex dam.

Because of the state of digestion of the samples, and lack of scales from the prey fish, the researcher has not been able to determine whether the Atlantic salmon recovered from the stomach contents were hatchery smolts, or smolts arising from fry stocking efforts. Additionally, the speaker reported that no regurgitation was observed as the striped bass were electrofished or angled. This leads to the assumption that the gut contents sampled were complete.

Several questions were asked concerning the timing of the sampling. The period of time sampled was chosen to maximize the overlap of outmigrating Atlantic salmon smolts, upmigrating river herring, and the northerly migration of striped bass. It was also noted that no night sampling occurred in 1997 but did occur in 1998 (3 AM until 10 PM). Fishing effort was mostly expended during the day, with several attempts made in the early morning (4:00 a.m.).

A member of the audience observed that the small size (length) of the bass responsible for the predation would be immature. The presenter noted that the smallest striped bass to consume an Atlantic salmon was just under 400mm. The average size smolt would be in the 190 mm range.

4. RESEARCH

4.1. CURRENT RESEARCH ACTIVITIES

The following includes Atlantic salmon research abstracts that were submitted to the assessment committee in 1998. 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.

STOCK IDENTIFICATION

Biochemical marking for stock identification of Atlantic salmon marked at yolk absorption

William F. Krise, John L. Sternick, and John W. Fletcher (E)

The study is designed to evaluate bovine serum albumin (BSA) as a protein carrier mark in fish blood used to mark Atlantic salmon fry for later identification of stocks as juveniles or adults. We used three BSA systems, which are: BSA at 3-20 mg/L concentration (tagged with biotin, horseradish peroxidase or fluorescent tags), *in vitro* chemical complex formation of BSA and avidin in blood, and BSA hapten-carrier protein. We measured BSA rather than the hapten in the third method. Atlantic salmon pre-feeding fry were given bath treatments of each protein mixture either 8 days or 1 day prior to yolk absorption. Salmon given 5 to 10 minute baths in biotinylated BSA (B-BSA) had 90% positive identification through 27 months after exposure as fry. Fry marked with B-BSA/avidin had lower percent positive responses for BSA after 12, 16, and 21 months (40, 45, and 54%), indicating that this process of *in vitro* formation of a large chemical complex in the blood is not useful for mass marking ofefish. Interactions of BSA and avidin resulted in loss of avidin and much of the BSA from the serum. We tested for BSA in the hapten-carrier method, and because this form of BSA modified for a hapten carrier protein was applied at much lower concentrations (0.3 mg/L or less) than B-BSA. We found it less effective (83, 75, and 31% positive fish at 15, 27, and 30 months after exposure) than B-BSA at 3 mg/L in the bath. We conclude that BSA, used alone, or with some form of tag attached at 3 mg/L or more in baths, is an effective protein for planting an internal, recoverable tag into the blood. Research continues toward improving the method through the use of tags that do not require immune assays (ELISAs) to identify the fish.

SMOLTIFICATION AND SMOLT ECOLOGY

Photoperiod and temperature control of downstream migration of Atlantic salmon smolts

G.P. Barbin, S.D. McCormick, and A.J. Haro (A)

The major management practice currently used for restoration of Atlantic salmon in the Connecticut River is fry stocking. This type of management assumes that smolts raised in the wild will survive and successfully migrate to the seawater environment. However, there is primarily correlative and indirect evidence of successful expression of migratory behavior in wild raised or hatchery smolts. Parr and pre-smolts of Atlantic salmon were PIT tagged in Mar 1997 and Feb 1998, placed in simulated stream conditions and continuously monitored from Apr - Jul and Feb - Jun, respectively. Downstream movements of parr were much lower than smolts in all environmental treatments. Artificially advanced photoperiod and temperature regimes advanced the increase in downstream activity by two weeks and one week, respectively, relative to controls. Once downstream movements were initiated peak activities occurred for approximately 2 weeks in ambient and advanced temperature groups. In contrast, when fish were subjected to cooler temperatures in the spring, peak activity was lower and sustained for approximately 4 weeks. Physiological changes associated with smolting (measured as gill Na^+, K^+ - ATPase activity) were coincident with changes in behavior. Initiation of migration is strongly influenced by daylength, and temperature can modify the expression of migratory behavior. Absolute temperature does not seem to provide a threshold for the release of downstream migration but, the number of degree days experienced appears to be important. The 2 week migratory period at ambient Connecticut River temperatures indicates a limited period of smolt migratory behavior, indicating that delays in migration should be minimized in order to increase smolt survival.

Evaluation of a PIT-tag ‘electronic weir’ to examine smolt migration and winter survival

S.D. McCormick, G.P. Barbin, K. Whalen, A.J. Haro (A)

Recent advances in passive integrated transponder (PIT) tag technology, including the low cost of PIT tags, offer the opportunity to locate and individually identify large numbers of fish without disrupting their natural habitat choice, activity, and behaviors. Because PIT tags are passive, remain viable for a number of years, and have a high retention rate when implanted peritoneally, tagged fish can be both recaptured within rearing habitats or detected as they emigrate downstream without trapping or handling the fish. Larger PIT tags (marketed by Texas Instruments) have allowed larger read ranges (1.5 m) and permitted us to construct large antennae which can monitor the width of an entire stream. With these tags and antenna-systems we have developed a method for passively monitoring movements of individuals in the natural environment with only one initial handling. In 1997 and 1998 a monitoring system was operated on the Mill River in Hawley, MA. Releases of hatchery smolts in the spring of 1998 resulted in detection rates of 95% for hatchery smolts. Wild parr (9-17 cm, n=160) from Smith Brook, VT (a tributary of the West River) were PIT tagged in the fall of 1997 and monitored with a PIT system from April through May of 1998. Of the 27 smolts detected by the field antenna, 9 were captured in a smolt trap 1 km downstream. All PIT-tagged smolts captured in the smolt trap had been detected by the antenna, indicating a very high detection rate. Only fish > 11 cm in autumn were detected migrating the following spring. It is expected that application of PIT tag technology as a research tool would add significantly to the understanding of the effectiveness of current salmon restoration efforts in the Connecticut River.

Effects of acidity and aluminum on Atlantic salmon smolts in Maine

Terry Haines and John Magee (J)

We sampled hatchery smolts exposed to ambient, acidified, and limed Narraguagus River water and wild smolts caught from the Narraguagus River for gill ATPase activity, blood chloride concentration, and hematocrit value both before and after twenty-four hour exposure to seawater. We examined gills by scanning electron microscopy to determine the extent of acid-induced damage. Using ultrasonic transmitting technology, we tracked seaward migrating hatchery smolts exposed to ambient and acidified Narraguagus River water and wild smolts caught from the Narraguagus River from fresh to sea water. Statistical analysis is nearly complete and a final manuscript is expected in May, 1999.

Influence of winter temperature and feeding on energetics and smolt development of juvenile Atlantic salmon

K.eWhalen, S.D. McCormick, G.P. Barbin, A.J. Haroe (A)

We examined the influence of water temperature and feeding on winter survival and the parr to smolt transformation of a captive population of wild-reared Atlantic salmon. Mature and immature parr were collected by electrofishing in November and exposed to one of four replicated water temperature x feeding regime treatments over the winter: i) < 2 °C x starved; ii) < 2 °C x fed; iii) 4-5 °C x starved; and iv) 4-5 °C xe fed. Parr exhibited a capacity to survive long periodse of food deprivation at higher than normal wintere temperatures (98% of all parr remained alive throughe early April). Starved parr held at <2 °C lost lesse weight than starved parr held at 4-5 °C demonstratinge a postive compensatory effect of low water temperaturee on weight loss. Within each water temperature group,e fed parr had higher gill Na^{+}, K^{+}-ATPase activitye earlier in spring than starved parr suggestinge starvation delayed the onset of smolting. Alle immature parr completed the parr-smolte transformation, whereas smolting for mature parr wase dependent upon water temperature and feeding. Thee probability of smolting for mature parr wase significantly enhanced only for individuals in the 4-5°C group that were fed and significantly restricted for individuals in the 4-5 °C group that were starved. Our study demonstrated a direct link between winter energetics and the timing of smolt development and illustrated a mechanisms by which environmental conditions in winter (water temperature and feeding) can influence smolt recruitment variability.

FRESHWATER SURVIVAL

Growth, mortality, and movement of Atlantic salmon, results from an intensive PIT tag study

Benjamin H. Letcher, and Gabe Gries (A)

By tagging and resampling individual Atlantic salmon parr in a small stream (1 km study section of West Brook, Whately, MA), we are developing a record of the growth, movement and maturity ofeindividual fish. From 14 May 1997 to 11 December 1998, we tagged and resampled approximately 2500 age-0 through age-2 parr during 17 sampling sessions. We used electroshocking to sample the study stream for one-half of the samples and used seines at night during the other samples. By the seventh sample, 96.7 percent of the parr were recaptures. Individual fish grew rapidly during the early summer (instantaneous growth = 0.28 d-1) but most fish lost mass (-0.03 d-1) during the summer and early fall. The first mature fish were observed on 6 August 1997 and by 29 September 1997 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. Spring growth of all fish was rapid. Previously mature smolts grew exceptionally fast (4% BW/d) during the month before migrating. Non-migrating, previously mature residents also grew rapidly in the Spring and were the same size as the smolts 2-3 weeks following migration. Approximately one-half of the smolts caught in the smolt trap were previously mature and all of the age-2 fish remaining in the stream had been previously mature. Movement of individual fish was minimal over the course of the summer; but more fish, especially those that had been mature, moved during the fall.

Assessing large-scale patterns in the distribution, abundance, and size of juvenile Atlantic salmon in the Connecticut River watershed

C.A. Campbell, and M.E. Mather (M)e

An examination of interactions between organisms and their environment at larger spatial and temporal scales is necessary for a comprehensive understanding of the species-habitat relationship. Herein, we seek to document large-scale patterns in the distribution, abundance, and size of juvenile Atlantic salmon *(Salmo salar)*, in the Connecticut River watershed and investigate processes responsible for those patterns. By incorporating existing environmental and juvenile Atlantic salmon population data from the Connecticut River at 290 index sites, 125 tributaries, 23 basins, from 1990-1996 into a Geographic Information System (GIS), we examined: (1) distribution and abundance of juvenile salmon within and across basins, (2) possible relationships among juvenile production variables (survival, density, size, change in length), (3) possible relationships between salmon production and large-scale physical factors such as temperature, elevation, drainage area, stream order, gradient, stream bank slope, and (4) the effect of spatial scale on these patterns and relationships. Based on this analysis, juvenile salmon do not perform equally everywhere in the watershed. Specifically, each basin had sites with exceptionally good and poor performance but these sites differed by life stage, and juvenile production variable examined. In addition, some sites showed consistently high survival, while others exhibit consistently low survival. Finally, sites were better suited for high densities of small individuals or low densities of large individuals but not both. To explain these patterns, relationships between salmon production and physical variables were examined. Temperature, drainage area, and stream order were inversely related to survival and growth in the southern part of the watershed and postively related to size and growth basin-wide. Thus, different mechanisms appear to be controlling survival and density than length and growth. Furthermore, some factors appear to influence fish performance at small, within-basin scales, while the effect of others is at the larger, across-basin scale. Thus, multi-scale analysis proved a useful tool for illustrating patterns, assessing possible relationships underlying these patterns, and suggesting relevant, future studies that can test mechanisms these patterns and relationships.

Effects of a major flood on Atlantic salmon reintroduction streams in the White River basin, Vermont

K.H. Nislow, K.H., F.J. Magilligan, C.L. Folt, and B.P. Kennedy (C)

We used a hydrologic model, combined with stream fish, invertebrate, and habitat surveys, to assess the effects of a major summer flood in the White River basin, Vermont in 100 m study plots on three tributaries that differed greatly with respect to observable flood effects. We found the least evidence of negative impacts on fish, invertebrates, or substratum in the study site that experienced bankful discharge conditions. The two other sites experienced significantly greater than bankful flows that produced similar bed shear stress and flood elevation. They differed considerably, however, in flood impacts on biota and habitat. Flood impacts were more extreme in the site underlain by glacial till, which contributed large amounts of coarse and fine substratum to the stream channel, than in the site underlain by bedrock, which did not experience catastrophic bed movement. In the till site, located in one of the best salmon streams in the White River basin, aquatic invertebrate and under yearling salmonid abundance was dramatically reduced. However, over yearling salmonids exhibited record high abundance. These results reinforce the importance of geologic setting in determining the impact of floods, and provide direct evidence that particular species and age-classes are resistant to the most extreme floods expected in a given region.

The energetic basis for a critical period for survival in age-0 Atlantic salmon: extensions in space and time

K.H. Nislow and C.L. Folt (C)

The ability of stream reaches to provide favorable foraging locations for newly stocked age-0 Atlantic salmon has been strongly associated with first-year survival and production among index sites in two tributaries of the Connecticut River basin. We are currently extending this approach in two ways. First, we are constructing models relating stream gage data to micro habitat determinants of foraging location quality, to test whether habitat quality is associated with variation in survival among years within individual rearing streams. Second, by identifying and surveying rearing tributaries which span the range of stream conditions in the Connecticut River basin, we are testing whether differences in these conditions affect the magnitude and timing of a critical period in age-0 salmon. Modeling results found that hydrologic and climate regimes of southerly, coastal streams shifted the timing and severity of a potential critical period. We are currently conducting a field test of these predictions.

Use of cesium to measure consumption and metabolic rates of juvenile Atlantic salmon

B.P. Kennedy, C.L. Folt, and K.H. Nislow (C)

Accurate measurements of consumption and metabolic rates are critical for understanding the environmental determinants of growth and survival for juvenile salmon. Fluxes of radioisotopes in fish tissue have previously been used to estimate these rates for several fish species. We are developing a technique that would allow us to apply this method using more globally abundant stable isotopes of cesium. This technique, based upon the turnover and mass balance of nonessential trace elements in tissues, allows us to quantify rates of consumption and metabolism in juvenile Atlantic salmon throughout the growing season. We are currently using the trace element approach to (1) test and calibrate our existing models of juvenile salmonid consumption which are based upon relationships between prey availability, capture success, and micro habitat current velocities, and (2) derive independent relationships between individual consumption rates and site differences in food availability, micro habitat availability, temperature and salmon growth rates.

Multiple stable isotopes in Atlantic salmon rearing streams in the Connecticut River basin: implications for determining the natal origin of Atlantic salmon

C.P. Chamberlain, J. Blum, B.P. Kennedy, and C.L. Folt (K)

As part of our ongoing effort to track natal origins of Atlantic salmon using isotopic tracers, we collected both nitrogen and carbon isotopic data for > 150 age-0 salmon collected at weekly to semiweekly intervals from just after stocking through August of 1991 and 1992. These salmon were from six long-term study sites in the White and West Rivers. Our goals are to 1) determine if nitrogen and carbon isotopes could discriminate among stocking streams; 2) determine the rate at which newly-stocked salmon acquire the isotopic signature of their rearing streams, and 3) determine whether the nitrogen and carbon isotopes can be used to identify particular feeding habits of juvenile salmon. In addition, we collected water samples from all of the major tributaries in the Connecticut River system from its headwaters in the Connecticut Lakes to its outlet in Long Island Sound. These waters were collected, in part, to determine whether the isotopes of hydrogen, carbon and nitrogen differed on a regional, as well as a local scale. We also collected additional water samples from the White River tributaries to determine the stability of the nitrogen, carbon and hydrogen isotopes in the streams in which we are conducting our current research. Analyses of all samples are ongoing, and will be completed in 1999.

Use of strontium isotopes to determine movements and natal origin of juvenile Atlantic salmon

B.P. Kennedy, J.D. Blum, C.L. Folt, K.H. Nislow, and C.P. Chamberlain (C)

Determining the factors affecting growth and survival of dispersing organisms requires a marking technique that can trace movements and identify rearing habitats. We have previously demonstrated the utility of strontium stable isotopes for distinguishing salmon populations in tributaries of the White and West Rivers. In order to construct a complete isotopic map of the two basins, we have analyzed strontium isotopic signatures of fish vertebrae and otoliths and water from 24 juvenile salmon habitats. Within each basin, 75% of the tributaries have unique signatures, with no signature being shared by more than two streams. We are currently using these isotope maps to answer the following ecological questions: 1) how frequently do juvenile salmon move between rearing tributaries? 2) what is the role of between-tributary movement in salmon response to catastrophic flood disturbance?

Atlantic Salmon Overwinter Survival and Smolt Production in the Narraguagus River

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

Ongoing Project

We monitored outmigration of Atlantic salmon smolts in the Narraguagus River from 20 April to 31 May 1998 using four rotary screw fish traps. Two traps were located at river km 14 (Crane Camp) and two were located at river km 17 (Little Falls). We marked smolts with fin clips at Little Falls and recaptured them at Crane Camp to perform a stratified population estimate. These sites are downstream of approximately 85% of juvenile rearing habitat in the basin. We captured a total of 974 smolts. All were in excellent condition upon removal from the traps, and no trap mortalities were observed. Smolts averaged 176 ± 1.8 mm total length and 41 ± 1.4 g wet weight ($n = 254$), significantly shorter and lighter than observed in 1996 or 1997. The timing of outmigration for wild smolts was normally distributed with 6 May being the date of 50% outmigration; this was 4 d later than 1996 and 17 days earlier than 1997. Utilizing a Darroch maximum likelihood model, we estimated the emigrant smolt population in 1998 to be 2,925 (± 273 SE) which was significantly ($P < 0.01$) higher than the 1997 estimate of 2,871 (± 539 SE). Modifications in trap placement and more favorable discharge resulted in an average 5% increase in capture efficiency; trap efficiencies averaged 21% at Little Falls and 13% at Crane Camp in 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 11.1% (range 6.9% - 16.3%). Overwinter survival in 1998 was significantly lower than observed in 1997 (24.4%, range 12% - 38%). In addition, we identified that a 126% increase in large parr production resulted in only a 1.9% increase in smolt production.

MARKING

Estimating small and large scale movements of age-0 Atlantic salmon using genetic and isotopic tags

C.L. Folt, B.H. Letcher, K.H. Nislow, and B.P.e Kennedy (C)e

Understanding the spatial scale at which juvenile Atlantic salmon sample their environment is critical for successful restoratlon and management, However, due to the inability of newly stocked salmon to bear physical tags, little is known about spring and summer movements of age-0 individuals. In this study, we use genetic and isotopic identification marks to quantify immigration in three study sections at three spatial scales: 1) within reaches (<200 m), 2) within tributaries, and 3) between tributaries. We are currently in the process of analyzing results from the study, which will yield the first quantitative measures of age-0 salmon movements during this life stage.

Evaluation of strontium marking for nonlethal detection of hatchery reared Atlantic salmon fry

Ruth Haas-Castro, F. Trasco, K. Friedland, and J. F. Kocik (G)

The goal of this study is 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 are 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. Initial results show that these marks are identifiable in otoliths and investigations into nonlethal samples of scales and fin rays are ongoing with expected completion in March 1999.

CULTURE / LIFE HISTORY

Broodstock spawning and natural reproduction study, Baker River - fall and winter 1998

Joseph F. McKeon (I)

Domestic Atlantic salmon brood stock were released in the Baker River in 1998 as part of an evaluation to determine if brood stock would spawn in the wild. The Baker River is a headwater tributary in the Merrimack River watershed, and brood stock were released at five sites in 1998. In total, 61 brood stock were released for this evaluation, and radio telemetry was used to document the movement and behavior of 10 fish. Riverine habitat at release sites included large, deep (> 3.0 m in depth) pools, and long ($100 m in length) riffle/run complexes composed of cobble and gravel.

Brood stock were released on 23 September and redds were initially observed on 9 November. Redd construction occurred when water temperature was near 4 °C, and river discharge at 80 cfs, or about 38% of the mean annual flow for the month of November. A total of 21 redds was documented throughout a 5.82 mile reach of river. On 16 December, two redds were partially excavated and samples indicated that 36% of the eggs excavated from the first redd were fertilized, whereas 100% of the eggs excavated from the second were fertilized. Six of ten radio tagged salmon remained in the river near spawning areas until ice-up, when field reconnaissance ceased. One tagged fish was found dead 43 days post release; one was lost, and its whereabouts remained unknown; and two were located downstream at Ayers Island Dam, a distance of approximately 36 and 39 miles, respectively, from their release sites.

Future evaluations will focus on similar release sites for brood stock. If spawning success continues, then evaluations of parr survival and abundance will be initiated. In addition, future proposals will be developed to support the release of sea-run salmon at similar sites to evaluate spawning success and juvenile production.

Effect of two Atlantic salmon *(Salmo salar)* diets upon reproductive success

Bill Fletcher, Dale Honeyfield, Mike Hendrix, Jerre Mohler, Bill Krise, Vic Segarich, Bob Groton, and Larry Lofton (D)

The Atlantic Salmon Restoration Program relies heavily upon fish cultural facilities to produce fry, parr, and smolts for restoration stocking which in turn leads to an increased demand for quality eggs. Broodstock nutritional requirements are poorly documented but are important to reproductive success. This study examined the effect of diet on gamete quality and reproductive performance of Nashua NFH domestic Atlantic salmon. The objective is to determine the effect of diet on reproductive performance of Atlantic salmon broodstock fed the current standard pellet diet (ASD2-30) or a nutritionally updated extruded diet (ATS-5). The ATS-5 diet was formulated to : improve feed digestibility, have ingredients which may effect reproductive performance, and change the form of some nutrients vs. those used in the standard ASD2-30 diet. Experimental diets were fed at Nashua NFH and egg incubation was performed at North Attleboro NFH, for 6 months (April - September 1997). Reproductive success was measured by evaluating 15 spawns from each diet treatment over three spawning days. Data were collected for the following parameters: fin erosion indices, milt motility/viability via flow cytometry at Penn State Univ., egg shock sensitivity, and egg color. Egg samples were collected prior to fertilization for laboratory analysis of selected nutrients.

Both sexes of salmon fed standard ASD2-30 diet gained more weight over the study than their counterparts (males=22% more, females=28% more). Fin condition was similar between treatments. Milt volumes were not different between treatments and egg fecundity was similar as was egg weight. Females fed the ATS-5 diet had more eggs per Kg but fish weights were lower. Percent egg eye-up was also similar between treatments (ATS-5=39.7%; ASD2-30=42.3%). Future studies of this nature should be designed so experimental diets are fed for at least one year prior to spawning to allow greater time for diet effect on spermiation and oogenesis.

Effect of density on mortality of green and eyed Atlantic salmon eggs in vertically-stacked incubator trays at White River National Fish Hatchery

Jerre W. Mohler and Ken Gillette (D)

The Atlantic salmon program of the US Fish and Wildlife Service relies heavily upon restoration stocking. A large proportion of eggs produced in salmon hatcheries are fertilized then shipped to White River National Fish Hatchery for incubation due to favorable water temperatures and facilities. It is necessary to optimize existing incubation space by determining maximum egg density per incubation tray while maintaining acceptable mortality levels. The effects of density on eggs and alevins has not been studied. We propose to test the effect of density on mortality of both green and eyed eggs at WRNHF. Our objectives: (1) compare effects of three egg densities on mortality of 150,000 green and 127,500 eyed Atlantic salmon eggs at White River NFH during the 1997/98 incubation period. (2) Based on results of this pilot-scale study, perform a production-scale study at WRNFH the following incubation season.

After disinfection, at least 150,000 fertilized eggs were composited and gently mixed. Eggs were enumerated by displacement and placed into Heath trays at densities of 8000, 10,000, and 12,000 per tray. There were five replicates of each density. Throughout the incubation period, experimental egg trays were subject to similar treatment concerning periodic examination, shocking, and removal of dead eggs. Numbers of dead eggs in experimental trays were recorded and once production eggs reached the eyed stage, percent mortality was compared between treatments. Once eggs reached the eyed stage, they were composited, mixed, enumerated, and placed into trays at densities of 6,500, 8,500, and 10,500 per tray. The study concluded after performing final larval counts/tray and measuring 30 individuals from each tray.

Our results showed that at White River, elevated egg incubation densities did not adversely impact percent eye-up, alevin survival, size, or incidence deformities. Our highest density of 10,500 eyed eggs/tray (1.70 eggs/cm^3) was not high enough to cause deleterious effects to be observed. We found no effect of tray position on mortality, but at the 8,500 eyed-egg density, alevins were smaller with decreasing tray position. Results indicate that in the event egg take exceeds normal incubation densities at White River (8,000-10,000 green eggs/tray), increasing densities to 12,000 green eggs per tray reduced to 10,500 at eye-up, may not be detrimental to alevin survival and quality. This study showed that oxygen levels were depleted in lower position trays maintained at high alevin densities. Therefore, additional experimentation is necessary using a number of full incubation stacks before WRNFH can safely scale up to higher egg densities such as used in this study.

Evaluation of the toxicity of various means of iodophor disinfection to Atlantic salmon (*Salmo salar*) eggs

Wade Jodun and Michael Millard (D)

The eggs of Atlantic salmon and other salmonids have routinely been administered prophylactic treatments with iodine compounds to prevent transmission of viral and bacterial pathogens. In 1995, the USFWS protocol called for all salmonid eggs shipped or received at Service facilities to be water-hardened in 50 ppm active iodine for 30 minutes. Additionally, any eggs being received at Service facilities must undergo an additional 10 minute at 100 ppm active iodine. Previous studies evaluating impacts of water hardening Atlantic salmon eggs in iodophor have yielded inconclusive results, but suggest a trend towards lower egg survival with increasing time of exposure to iodophor during water-hardening.

This study asked: (1) Does egg disinfection with iodophor - either during or after the water hardening process result in higher mortalities? (2) Does water hardening in various concentrations of iodophor for varying lengths of time adversely impact survival of eggs when compared to water hardening eggs for one hour in plain water prior to a 10 minute exposure to 100 ppm iodophor, (3) Is egg mortality affected by an interaction between concentration and exposure time during iodophor treatments? (4) Does a second exposure to iodine adversely impact egg survival?

Statistical analysis demonstrated that time of exposure had the greatest impact on egg survival. Across all treatments, including the controls, a significant (26.2 %) decline in survival was found between 30 and 60 minutes, strongly suggesting that losses may be attributed to an increased sensitivity to handling of eggs during that post-fertilization time period. Interaction between iodophor concentration and exposure time was most evident at the high (150 ppm) iodophor concentration with significantly greater egg mortality with each increase in exposure time. Only at the 30-minute exposure did control eggs display significantly greater survival (88.3%) than iodophor treated eggs (79.7 %). Our study demonstrated that mortality of Atlantic salmon eggs was not excessive when treatments ranged from 50 - 150 ppm for 30 minutes, but longer exposure times may require concentrations of 100 ppm or less. We also found that no excessive mortality resulted from a subsequent 10 minute 100 ppm disinfection five hours following the initial treatment.

Fin development in wild and hatchery Atlantic salmon

R. Pelis, S.D. McCormick, G.P. Barbin, and A.J. Haro (A)

We measured fin lengths of Atlantic salmon from two hatcheries and two tributaries of the Connecticut River in order to determine how and when fin development is affected within the hatchery environment. The measurements were made in July and October for wild fish and in August (four months after first feeding), October and April for hatchery fish. There was a linear relationship between the dorsal, caudal, and anal fins against fork length, while the pectoral, pelvic and adipose fins exhibited a curvilinear relationship with fork length. These regression equations were used to calculate the percent change (observed fin length/expected X 100) for Atlantic salmon in hatcheries. Fin lengths were shorter for all of the fins except for the pelvic and adipose fins. The pectoral and dorsal fins of hatchery fish were the most severely eroded (14-65% of the expected), and fin erosion increased with time. The pattern of changes in fin lengths were similar in the two hatcheries, indicating a common cause of fin erosion.

Prespawning movements of mature Atlantic salmon adults stocked in the Narraguagus River system during spring and fall

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

To evaluate the pre-spawning movements and spawning behavior of captive reared fish, we worked with excess broodstock from Craig Brook National Fish Hatchery. These fish are of a similar size and rearing history to that anticipated for netpen adults, except they are reared in freshwater. We released fish in the spring and fall of 1997. These studies were successful, and suggest a difference in the behavior of spring (large movements) and fall (limited movements) released fish. These efforts suggested that these adults contribute to the spawning population, offering a new management tool for the conservation of these fish. In 1998, we examined only the fall released fish. On 7 October, we manually inserted ultrasonic pingers into the gastric cavity of 14 mature females. These fish were released on 9 October 1998 in the Stillwater Dam headpond to determine spawning location. Monitoring of the fall release group by both automated units and manual searches continued until 20 November, 1998. Data auditing and analysis are ongoing.

Evaluation of Atlantic salmon smolts and parr reared by the Maine Aquaculture industry

J. F. Kocik, E. Baum, K. Beland, G. Horton, T. F. Sheehan, and E. Atkinson (G)

We fin clipped a total of 41,189 juvenile Atlantic salmon at the Oquossoc and Solon Hatcheries of Atlantic Salmon Maine, Inc. and Deblois Hatchery of Connors Brothers, Inc. in the early spring of 1998. These Atlantic salmon are progeny of river-specific broodstock from the Dennys, East Machias, and Machias Rivers. In addition to fin clips, we administered visual implant elastomer (VIE) tags in 21,958 of these fish. Each river has been assigned a color code: Dennys (orange), East Machias (yellow), Machias (red), and Narraguagus (green). Marking site will vary with year. For 1998 marking, all fish released in the wild received a single right eye VIE tag in addition to an adipose fin clip. Following marking, we stocked Atlantic salmon smolts at two sites per river between 16 April 1998 and 1 May 1998. Because of genetic concerns, these fish were not culled as in typical production hatcheries. This practice produces a size/developmental mix of Atlantic salmon that includes fish that are physiologically smolts and others that are large parr. Evaluations are occurring opportunistically during routine juvenile and adult assessment work.

Fry development and endogenous growth in six Atlantic Salmon stocks in Maine

R. Haas-Castro, T. King, and J. F. Kocik (G)

The goal of this study is to evaluate the meristics and morphometrics of Atlantic salmon fry among stocks and mating groups from six rivers in Maine. These six stocks are being held at the Craig Brook National Fish Hatchery and are from the Penobscot, Dennys, East Machias, Machias, Narraguagus, and Sheepscot Rivers. Specific objectives are to 1) assess the growth rates for salmon fry and compare these rates among stocks and mating groups; 2) determine what the differences are, if any, in growth rates among stocks and mating groups; and 3) explore potential reasons for differing growth rates among stocks and mating groups. A better understanding of the differences in these parameters should help to better explain some of the ecological importance of subtle genetic differences among these stocks. Initial sampling of eggs using digital photography was initiated in November and December 1998. These data are currently being evaluated in the image analysis lab at the NEFSC. Additional, digital sampling will continue through May1999.

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 (G)

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 1999 and preliminary data analysis is ongoing.

Growth patterns in Atlantic salmon post-smolts and the nature of the marine juvenile nursery

K.eFriedland, Jean-Denis Dutil, and Teresa Saduskye (P)e

We examined scale samples from historical collections of post-smolts made in the Gulf of St. Lawrence with the aim of understanding the role of estuarine habitat as juvenile nursery for Atlantic salmon. Circuli spacing patterns were extracted from the scales of 580 post-smolts collected in the Gulf of St. Lawrence during three seasons, 1982-1984. Post-stratification of the samples by collection date within year suggests that in some years post-smolts remain in the Gulf throughout the entire summer growth season whereas in other years only slower growing fish are retained in these areas. Comparing the growth patterns for Gulf of St. Lawrence post-smolts to returns for three southern Atlantic stocks believed to utilize oceanic post-smolt habitat suggests that the Gulf may serve as an important part of the post-smolt nursery range in some years. The conceptualization of the post-smolt nursery as a continuum between neritic and oceanic areas is essential to evaluating ocean climate and productivity effects impacting salmon recruitment.

Regional variation in post-smolt growth patterns and the temporal scale of recruitment coherence in North America

K. Friedland and D. Reddin (P)e

We examined scale samples from historical collections of post-smolts made in the Labrador Sea with the aim of understanding the growth dynamics of stocks at the southern end of the range versus what is hypothesized to be the juvenile nursery for post-smolts from the entire stock complex. Circuli spacing patterns were extracted from the scales of 1,525 salmon collected from 1SW and 2SW returns to southern rivers and post-smolts collected in the Labrador Sea for three smolt years: 1988, 1989, and 1991. For two of the three years, growth trajectories for fish from the southern stocks intersected the trajectories for post-smolts from the Labrador Sea collections after 4-5 circuli pairs. Since circuli pairs are laid down at a rate of approximately one per fortnight, the data suggests that distribution patterns for regional groups begin to overlap and stocks begin to experience similar environmental conditions by July of the post-smolt year or two months after their migration to sea. In some years, it would appear regional groups do not mix until fall. These data provide the first indication of the mixing processes between stocks and may be useful in understanding regional patterns of recruitment coherence in salmon versus coherence patterns associated with the entire North American stock complex.

Linkage between ocean climate, post-smolt growth, and survival of Atlantic salmon (*Salmo salar* L.) In the North Sea area

K.eFriedland, L.P. Hansen, D.A. Dunkley, and J.C.e Maclean (P)e

We examined two long-term tagging studies with wild salmon stocks in the North Sea area. The salmon stocks, the Figgjo in southern Norway and the North Esk in eastern Scotland, reside in relatively un-impacted rivers that continue to sustain healthy runs of salmon. The return rates for one seawinter fish (1SW), the predominant age at maturity for both stocks, were highly correlated. An analysis of sea surface temperature distributions for periods of high versus low return rate showed that when low sea surface temperatures dominate the North Sea and southern coast of Norway during May, salmon survival has been poor. Conversely, when high sea surface temperatures extend northward along the Norwegian coast during May, survival has been good. Ocean conditions can be further related to the recruitment process through growth studies with the North Esk stock. Post-smolt growth increments for 1SW fish returning to the North Esk showed that enhanced growth was associated with years having favorable temperature conditions, which in turn resulted in higher survival rate. The implicit linkage between growth and survival suggests that growth mediated predation is the dominant source of recruitment variability. Mechanisms by which ocean climate may affect post-smolt growth are discussed.

Interactions between Atlantic salmon and trout

Donna L. Parrish and Matthew Raffenberg (B)

Our objectives are: 1. To determine how a limited prey base is partitioned by juvenile Atlantic salmon and brook and rainbow trout in tributaries of the West and White rivers.; and 2. To relate food acquisition to individual growth rates and survival in all three salmonids in varying degrees of interspecific concentrations.

This research investigated broad scale patterns by sampling across two watersheds at many sites containing varying densities of salmon and trout. At each site, fish diet and abundance data were collected from three size classes (0-100 mm; 100-130 mm; >130 mm)eof each species; and, growth and survival weree estimated for Atlantic salmon. Drifting and benthice prey were collected at each site. During the samplinge time ofdate-summer and early-fall, salmon dietse consisted primarily of the orders Ephemeroptera,e Diptera, and Trichoptera. Trout diets, as those ofe salmon, contained common aquatic prey orders, bute had a larger percentage of terrestrial items thane Atlantic salmon at all size classes; therefore, diete overlaps were generally not significant. Simple lineare and multiple regressions were run to determine thee effects of trout or total salmonids on salmon successe (i.e. abundance, feeding, growth, and survival).e Results indicate trout do not negatively affect salmone success. Paradoxically, a positive relation existede between small salmon survival and trout abundance,e suggesting that smaller salmon survive better at sitese where trout also do well. There was no lineare association between salmon success and benthice macroinvertebrates, suggesting that streame productivity is not a limiting factor for salmon in thesee streams. All multiple regressions were not significant, further indicating no effect of trout on salmon. These results provide evidence that species interactions at smaller spatial scales may not transfer to larger scales. Two possible explanations are: 1) short-term interactions deemed to be negative (i.e. habitat shifts or feeding less optimally) do not affect long-term life patterns, or 2) events at smaller spatial scales cannot be detected at larger scales because of increased complexity of variables. Regardless, to enhance our understanding of salmonid species interactions, future studies need to be conducted on multiple scales to encompass the variability of the interactions occurring at both small and large scales.

Predation by resident salmonids on Atlantic salmon (*Salmo salar*) fry in Southern New England Streams

Nate Henderson, and Benjamin H. Letcher (A)

It is important to understand the relative impact predators have on fry survival to Atlantic salmon in the Connecticut River. We studied predator-prey interactions between juvenile Atlantic salmon and trout in Massachusetts streams and in artificial streams. Brook trout (*Salvelinus fontinalis*), brown trout (*Salmo trutta*), rainbow trout (*Oncorhynchus mykiss*), and post-young-of-the-year salmon are known to consume stocked fry, but studies quantifying the rate of predation are unavailable. We sampled stomach contents of PYOY salmon and trout following fry stocking in the spring of 1997 and 1998. Between 4.27 and 34.62 % of the salmon fry were consumed within the first 2 days after stocking and mortality due to predation varied from 4.27 to 40.37%. Variability between streams may be due to differences in the timing of stocking or density of the predator population. Experiments in artificial stream sections tested how habitat complexity and predator species composition affect predation rate. Fry consumption rates were not different between brook trout and brown trout ($p = 0.59$). Predation rate tended to decrease as the percentage of riffle habitat increased but the decrease was not significant ($p = 0.22$). This information should help partition mortality sources of young salmon both in the Connecticut River basin and in other restoration programs.

Atlantic salmon and trout interactions related to abiotic and biotic factors

Donna L. Parrish, Matthew J. Raffenberg, and Ethan J.eHawes (B)e

Our objective is to determine what abiotic (e.g., percent canopy) and biotic variables (e.g., trout and macroinvertebrate numbers, percent terrestrial insects) can be related to salmon success.
In this study, we collected salmon and trout in areas of varying canopy to determine how canopy affects the numbers of terrestrial organisms in the diets of these fish. We were interested in knowing specifically: 1) how the amount of canopy contributes to the terrestrial component in salmon and trout diets, 2) how differences in stream canopy affect instream temperatures, and 3) how instream temperature affect salmonid community structure.

The results indicated that Atlantic salmon diet composition was not directly influenced by riparian canopy; i.e. diets were similar at high and low canopy sites. Salmon were not affected by changes in terrestrial inputs related to stream canopy because they fed primarily on aquatic organisms. However, trout frequently ate terrestrial prey at high canopy sites. Stream canopy also influenced daily temperature fluctuations. Streams with low canopy experienced large variations in temperature that result from prolonged exposure to sunlight. Salmon were abundant at both low and high canopy sites and therefore were able to tolerate large temperature fluctuations. However, brook trout are not able to persist in streams with low canopy. Our results suggest that the quantity of stream canopy can influence salmonid stream communities. In particular, stream canopy can influence trout diets, instream temperatures, and salmonid community structure.

Overwinter Atlantic salmon habitat use and parr maturity in experimental stream channels

Donna L. Parrish and Ethan J. Hawes (B)

Our objectives are: 1. To determine if differing habitats affect condition (caloric content and weight loss) and survival of parr overwinter; and 2. To determine if maturing male parr experience greater mortality than immature parr. Freezing water temperatures, variable ice dynamics, snow accumulation, reduced solar radiation and photoperiod, pH depression, anoxia, ice surges, mechanical break-up events, flooding and extremely low river flows are some physio-chemical characteristics of the winter environment. To deal with this harsh environment, stream fishes respond with a variety of tactics, including altering diel activity patterns, selecting different microhabitats, moving variable distances to wintering areas, physiologically adapting to changing temperature and feeding regimes and reducing energy expenditure to conserve depleted energy stores until the replenishment of lipids in spring. During the winter period, it is critical to maintain adequate lipid stores to survive the entire winter.

Fish were stocked into raceways in early November 1997 and removed in April 1998. Of the 374 salmon stocked, 352 survived. Of those that died, 77% (N=17) were mature. Both immature and mature parr experienced the weight loss in the high depth treatments and mature parr experienced the greater weight loss, regardless of depth. Immature parr in the low depth treatment actually gained weight. Correspondingly, the greatest caloric content was by parr in the low depth treatment.

GENETICS

Microsatellite DNA analysis of Connecticut River sea-run salmon: The class of 1998 and a temporal comparison among the 1996-1998 returns

Tim L. King, Barbara A. Lubinski, and Michael Eackles (H)

The USGS-BRD Leetown Science Center's Aquatic Ecology Laboratory and S.O. Conte Anadromous Fish Research Center have been surveying genetic diversity in Atlantic salmon adult sea-run returns to the Connecticut River since 1996. The genetic variation identified in these surveys has been used to maximize genetic diversity in this captive population and to develop a family-level marking system using unique multilocus genotypes. In this presentation, characteristics of the genetic variation detected among the individuals returning to the Connecticut River in 1998 will be discussed. In addition, levels of genetic variation and diversity at seven microsatellite DNA markers (Ssa85, Ssa171, Ssa197, Ssa202, SSOSL85, SSOSL417, SSLEEN82) will be compared among the 1996 (N=189), 1997 (162), and 1998 (410) salmon used during the family-level marking study. Specifically, this presentation will discuss the use of this relatively large, "captive" population to provide a unique perspective on temporal stability and statistical behavior of microsatellite DNA markers in Atlantic salmon.

FISH HEALTH / NUTRITION

Influence of phytase in low-phosphorus diets on growth, feed efficiency and waste discharges by hatchery reared Atlantic salmon

H.eGeorge Ketola, Roger Foster, and Ed Grant (F)e

In response to a need by the New York State Department of Environmental Conservation (NYS-DEC) Adirondack Fish Hatchery and many other hatcheries to reduce discharges of phosphorus (P) in effluents, the following study with fingerling landlocked Atlantic salmon *(Salmo salar)* was conducted. The study was designed to measure the effect of feeding the standard NYS-DEC diet (0.94% P)eand an experimental low-phosphorus diet (0.64%P)e containing only 10 % fish meal and 1,808 units ofe phytase activity per kilogram to aid in digestion ofe phytin phosphorus in plant protein sources. Each diete was fed for 40 days to each of three tanks of 26,000e fish (initial mean weight, 14.4 g/fish) each. Eache tank had a capacity of 10,000 gallons and wase supplied with lake water at a rate of about 125e gallons/minute. In this study, we measured growth,e feed conversion, and the levels of waste phosphoruse discharged in hatchery effluents. Average bodye weights for fish in each tank were determined at thee beginning of each experiment and every 2 weekse thereafter. At the beginning and end of thee experiment, whole carcass samples from fasted fishe were analyzed for total phosphorus. The amount ofe waste phosphorus discharged was determined bye calculation from the amount of phosphorus fed duringe the study less the amount retained in fish carcassese during the study. The study showed that diet did note significantly influence weight gain, feed conversion, ore mortality. However, the phytase diet significantlye reduced discharges by 43 to 47% compared to thee control diet (NYS), when expressed as grams of Pe discharged per kilogram of feed fed or weight gained.e In conclusion, the study showed that while growth,.e feed conversion, and mortality did not significantlye differ for the control and experimental salmon feeds,e the phytase diet markedly improved retention of plante phosphorus and reduced discharges.e

Thiamine remediation of natural reproduction in landlocked Atlantic salmon

H. George Ketola, Paul R. Bowser, Greg A. Wooster,e Leslie R. Wedge, Steven S. Hurst, Tom Chiotti, ande Ken Osika (F)

Atlantic salmon *Salmo salar*, once abundant in the Finger Lakes of New York State, are now stocked to sustain a fishery. Salmon stocked in Cayuga Lake (New York) readily grow to adults and spawn but their fry do not survive. Previous work demonstrated that mortality in Cayuga Lake salmon fry (called Cayuga syndrome) associated with low levels of thiamine (vitamin B1) was prevented by thiamine injections of gravid female Atlantic salmon from Cayuga Lake, while fry from control females (not injected with thiamine) all died before feeding. Signs of deficiency included lethargy, exophthalmia, hemorrhages, pericardial congestion, opacities in the yolk, edema of the yolk sac, and foreshortened premaxilla. As a test of practical application, five male and five female pre-spawning salmon were captured from the Inlet during the following year and transferred to a hatchery where they were held (9°C) until spawned. Each gravid female was injected twice with thiamine 2 to 3 weeks before spawning. Five females spawned a total of 12,105 eggs which produced normal fry without signs of deficiency. After feeding fry for 12 weeks, 10,500 healthy fry (0.4 g mean weight, 33 mm computed length) were stocked in a tributary of Cayuga Lake on April 2. On September 30, 1998, single-pass electro-fishing in 35% of the area stocked resulted in a capture of 109 lively fingerlings (range 91-140 mm length) and an estimated 3.4% capture for the stocked area.

We conclude that landlocked salmon from Cayuga Lake are thiamine deficient resulting in mortality of their fry. The deficiency is believed to be related to the consumption of forage fishes (probably alewives or smelt) containing thiaminase that destroys much of the thiamine resulting in eggs severely deficient in thiamine. Injecting gravid females prior to spawning increases the thiamine content of their eggs and prevents fry mortality. Male salmon were fertile without injection. Fry from thiamine-injected pre-spawning females captured from Cayuga Inlet thrived in the hatchery and after stocked in a tributary to Cayuga Lake. Therefore, thiamine-injection and release of thiamine-deficient feral female pre-spawning landlocked salmon may enhance natural recruitment.

POPULATION ESTIMATES / TRACKING

A Night-Seining Technique to Capture Juvenile Atlantic Salmon, *Salmo salar*

Gabe Gries, and Benjamin H. Letcher (A)

To improve understanding of population dynamics and movement of juvenile Atlantic salmon (*Salmo salar*) it is necessary to tag and resample individuals. While individual tagging methods exist (e.g. PIT tags), a technique that allows the recapture of large numbers of tagged individuals multiple times with minimal impact to growth and survival is lacking. We developed such a technique by sampling at night with hand-held seines. We evaluated this night-seining technique in the West Brook, Whately, Massachusetts by sampling PIT-tagged salmon in 47 contiguous 20-meter sections four times during summer. Alle untagged post young of the year (PYOY) salmone captured during seining samples were tagged and bye the third sample, 93% of the salmon (n = 240) weree recaptures. The total number of PYOY (age one ore older; > 90 mm FL) salmon captured during seininge samples was consistent (mean + 1 SE = 252.8 + 6.0),e but seining population estimates were 28% lower thane electrofishing estimates. We did not commonlye capture brook trout (*Salvelinus fontinalis*), brown troute (*Salmo trutta*), or young-of-the-year salmon (<<50e mm FL) in seines, although their densities weree comparable to those of PYOY salmon. Night-seininge is limited to PYOY salmon in small (<< 10 meterse wide) streams, but may prove useful whene electrofishing is impractical, threatened or endangerede species exist, or multiple recaptures of individuals aree desired.e

Ultrasonic tracking of Atlantic salmon smolts to determine early marine movements and survival in Narraguagus Bay

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

We evaluated the timing and survival of smolts passing ecological transition zones in the Narraguagus River, Estuary, and Bay systems with ultrasonic telemetry. We implanted pingers in 112 wild Atlantic salmon smolts from 27 April to 19 May 1998 (23 d). An additional 22 pingers were implanted in hatchery smolts in two experimental releases to evaluate the impact of acid stress on smolt movements (see Magee et al.). We retrieved the full telemetry array by 18 June and data from units have gone through initial analysis and correction. Detection percentages (DP-number detected/number detected at adjacent upriver site) between transects averaged 90% in the riverine section, 91% in the estuary, and dropped to 83% at the marine array, suggesting a zone of increased mortality in the Bay. Of the 53 pingers that did not exit the marine array, we located 13 of them in the upper river system utilizing active searches. Of those recovered by snorkeling, the resting place of these pingers suggests predation losses or scavenging of dead smolts. The median transit time for wild smolts from the first unit to the marine array (21 km) was 83.6 hours yielding a median speed of 0.25 km/h. This is slower than observed in 1997 and may be a result of lower stream flows and warmer temperatures.

Westfield River adult salmon radio-tag study results

Don Pugh (A)

Returning adult sea-run and domestic broodstock salmon were radio-tagged and released in the Westfield River. Habitat selection, movement, spawning success, and passage at mainstem hydro dams were monitored.

Sea-run salmon (1996 n=9, 1997 n=11, 1998 n=12) were trapped at the lowermost dam (DSI, Inc. Dam, West Springfield) radio-tagged, and released above Knightville dam on the East Branch, the uppermost mainstem dam. Fish were tracked from time of release in late spring until leaving the Westfield system, as late as May of the following year.

Broodstock salmon, domestically raised 4-year-old fish, were released in both the East and West Branch of the Westfield River in 1997 (n=16) and 1998 (n=16). Fish were released in October 1997 and in June (n=8) and September (n=8) 1998. Sea-run fish were present in the East Branch above the release point, but no sea-run fish were upstream of the broodstock fish in the West Branch. Monitoring of movement, habitat use and spawning was similar to that of the sea-run fish.

Results of this work will provide fisheries managers and agencies with information immediately applicable to the restoration of Atlantic salmon. Habitat use, timing of movement, and spawning behavior and production can be utilized by managers to protect critical habitat, adapt fry stocking practices, and regulate downstream fish passage.

Prespawning movements of mature Atlantic salmon adults stocked in the Narraguagus River system during spring and fall

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

To evaluate the pre-spawning movements and spawning behavior of captive reared fish, we plan to work with excess broodstock from Craigbrook National Fish Hatchery. These fish are of a similar size and rearing history to that anticipated for netpen adults, except they are reared in freshwater. We released fish in the spring and fall of 1997. These studies were successful and suggest a difference in the behavior of spring (large movements) and fall (limited movements) released fish. These efforts in 1997, suggested that these adults contribute to the spawning population offering a new management tool for the conservation of these fish. In 1998, we examined only the fall released fish. On 7 October, we manually inserted ultrasonic pingers into the gastric cavity of 14 mature females. These fish were released on 9 October 1998 in the Stillwater Dam headpond to determine spawning location. Monitoring of the fall release group by both automated units and manual searches continued until 20 November, 1998. Data auditing and analysis are ongoing.

Evaluation of nearshore and river movements of age-2+ Atlantic salmon released at netpen sites in the spring of and parr reared by the Maine Aquaculture industry

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

The deployment of automated pinger detection units in the Narraguagus River and Bay for smolt studies (April-June) and adult studies (October-November) provided an opportunity to monitor aquaculture fish released from netpens in close proximity (< 4 km) to the Narraguagus River and Bay ecosystems. To take advantage of this opportunity, we implanted pingers (stomach insertion) in ten Atlantic salmon (49 cm fork length) at the Flint Island Facility of Atlantic Salmon Maine, Inc. on 22 May 1997 and again on 20 May 1998. After a short recovery period these fish were released in the ocean adjacent to the netpens. We conducted active searches in the vicinity of the netpens at 24 and 48 after release and one week after release. In both years, all fish had dispersed from the netpen area. In our ultrasonic array deployed in Narraguagus Bay, we detected 8 and 9 of these Atlantic salmon in 1997 and 1998. No fish were detected entering the freshwater reaches of the Narraguagus River system. The movements of these fish near the marine array showed no definite pattern or directional orientation. The pingers on these fish were active through November, but none of these fish were detected entering the Narraguagus, Machias, or East Machias river systems.

Upstream migration and estuarine movements of captive reared river- specific Atlantic salmon released in a common estuary of two rivers

G.eHorton, J. F. Kocik, T. F. Sheehan, and E. Atkinsone (N)

As part of the ongoing river-specific fry stocking program, excess broodstock become available for release as a result of biomass limitations at Craig Brook National Fish Hatchery. Two stocks included in this program are from the East Machias and Machias River. Since these rivers share a common estuary, releases of adult broodstock in this estuary allows evaluation of both movements of these fish within the estuary and their migration up natal rivers. To evaluate these movements, we deployed an array of ultrasonic receivers within the estuary and lower river sections of both rivers. On 7 October, we manually inserted ultrasonic pingers into the gastric cavity of four mature females and four mature males from each stock. After recovery, these fish were released on 8 October 1998 at the head-of-tide in their natal river systems. Monitoring of the fall release group by automated units continued until 1 December 1998. Data auditing and analysis are ongoing.

ATLANTIC SALMON CONSERVATION / MANAGEMENT

Integrating across scales: effectively applying science for the successful conservation of Atlantic salmon

M.E. Mather, Parrish, D.L., Folt, C.L., and DeGraaf,e D.M. (L)e

Atlantic salmon *(Salmo salar)* is an excellent species on which to focus synthetic, integrative investigations because it is an economically important species that captures the public imagination, is heavily impacted by humans, uses several ecosystems over its life, and is the subject of a large body of extant literature. Twenty-four papers were published in a 1998 *Canadian Journal of Fisheries and Aquatic Sciences Supplement* that seek to provide the biological basis for effective and innovative approaches that biologists, managers, social scientists, and policy-makers can use to develop policies that sustain Atlantic salmon and related species. Together these papers highlight the need for and benefits of (a) synthesizing within populations, (b) choosing the appropriate scale, (c) comparing across populations using rigorous, focused, question-oriented methods, (d) integrating across disciplines, (e) incorporating the human perspective, (f) linking multiple ecosystems, and (g) applied problem solving. In this talk, we review the justification for the supplement and summarize the defining concepts that emerge from the volume.

Burst swimming performance of adult upstream migrant fishes

Alex Haro, Ted Castro-Santos, and Mufeed Odeh (A)

In order to ascend fishways or other structures where water velocities can be high, migratory fishes can swim in burst mode, which is characterized by limited duration, energetically demanding bouts of swimming at high tailbeat frequencies. However, knowledge of burst swimming performance (velocity and duration) of most adult anadromous and potamadromous fishes in incomplete, and is essential for effective design of future fish passage structures. We measured burst swimming performance of several species of anadromous and potamadromous fishes in a controlled environment at water velocities of 1.5 to 4.5 m/sec. Burst swimming speed and duration were dependent on water velocity, but may also be dependent on water temperature, fish size, and species-specific behaviors. Limits to burst swimming performance may be dependent on behavioral as well as physiological (exhaustion) factors.

Impacts of Atlantic Salmon Restoration on Businesses in the Westfield River Basin

Michelle Babione, and Mike Bunch (O)

Businesses often have an economic interest in the health of the environment and can be a untapped source of support for natural resource management programs. Recent surveys of businesses in the upper Connecticut River watershed show support for clean water improvements, increases in the provision of fish ladders, and increases in habitat restoration and protection (Northeast Natural Resource Center, 1996 and 1997). Businesses in the Westfield River basin, Massachusetts, were surveyed to determine the level of support for the current Atlantic salmon restoration program. Almost all respondents (94%) agree that Atlantic salmon should be restored to the Westfield River basin. More than half (55%) think that the restoration program would or could possibly provide economic benefits for their business. Support for the program was also measured using contingent valuation methods, which establish a willingness to pay for non-use environmental values. Westfield River business owners expressed a willing to pay $14.47-18.94 per year for the salmon program. This amount is twice as much as the general New England population, whose willingness to pay for Atlantic salmon restoration has been measured at $7.93 per year (Stevens, 1991).

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5. HISTORICAL DATA (1970 - 1998)

5.1. STOCKING

The historical stocking information is presented in Table 3.2.a. in Appendix 9.3. Approximately 135 million juvenile salmon have been released into the rivers of New England during the period, 1970 - 1998. Nearly 74% of the total have been fry. The majority of the juvenile releases have occurred in the Connecticut River (over 61 million), the Penobscot River (over 25 million), and the Merrimack River (over 24 million).

5.2. ADULT RETURNS

The historical return information is presented in Table 3.2.b. in Appendix 9.3. Total returns to New England rivers from 1970 through 1998 now equals 72,229. The majority of the returns have occurred in Maine rivers (90%) followed by the returns to the Connecticut River (6%), and the Merrimack River (3%). The Penobscot River alone accounts for 73% of the total.

6. TERMS OF REFERENCE FOR 2000 MEETING

The U.S. Atlantic Salmon Assessment Committee agreed to address the following Terms of Reference for the 2000 meeting:

1. Program summaries for current year (1999) 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. Additional Terms of Reference will be developed at a special meeting on July 15, 1999.

7. LITERATURE CITED

All references are located in previous sections.

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9. APPENDICES

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9.2 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 Specialities 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

9.3. TABLES AND FIGURES SUPPORTING THE DOCUMENT

TABLE 2.1.3.g. Results of the Domestic Atlantic Salmon Br00d Stock Sport Fishery - Merrimack River For 1993, 1994, 1995, 1996, 1997, and 1998.

Category	1993	1994	1995	1996	1997	1998
Total Permits Sold	930	1,708	2,387	2,066	1,989	1,939
% Non-residents	3	9	7	10	8	11
Diary Reporting Rate (%)	61	61	60	27	22	22
Estimated No. of Anglers that Fished	715	1,250	1,683	1,355	1,352	1,203
% of Anglers Utilizing Fly Fishing	76	77	69	76	74	83
% of Anglers Utilizing Artificial Lures	24	14	20	16	16	9
% of Anglers Utilizing Both Fly Fishing and Artificial Lures	0	9	11	8	10	8
Angler Success in Fly Fishing Area (% catching at least 1 salmon)	35	26	30	27	32	27
Angler Success in Fly Fishing / Artificial Lure Area (% catching at least 1 salmon)	28	24	31	30	31	37
Estimated Total Hours of Fishing Effort	14,779	21,726	29,205	22,206	24,802	21,413
Estimated Catch per Unit of Effort (hours per salmon landed)	14.9	23.5	15.9	14.4	14.6	13.9
Estimated No. of Angler-Trips	4,651	6,258	9,746	6,958	8,736	7,459
Estimated No. of Salmon Caught and Released	594	577	1,105	1,080	1,132	1,071
Estimated No. of Salmon Caught and Kept	400	345	737	461	573	457
Estimated Total Catch (Released and Kept)	994	922	1,841	1,541	1,705	1,528
Estimated Expenditures Per Angler ($)	$92.00	$84.00	$132.00	$131.00	$110.00	$245.00
Estimated Total Expenditures by Anglers ($)	$66,000.00	$105,000.00	$221,584.00	$177,506.00	$148,720.00	$294,735.00

Figure 3.3. Temperature (°C) and chlorophyll (mg/m^3) distributions from satellites data during 1982-1984.

Table 3.7.a. Rate of return of adult Atlantic salmon that had been stocked as fry. Return rates from 1994-1996 are biased low because additional adults may still return.

Year class	Merrimack	Pawcatuck	CT-mainstem	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	—	0.004	—	0.000	—	—	—	0.081	—
1980	0.034	—	0.019	—	0.000	—	—	—	—	—
1981	0.142	—	0.044	—	0.011	—	—	—	0.178	—
1982	0.096	—	0.024	—	0.010	—	—	—	0.076	—
1983	0.275	—	0.006	—	0.001	—	0.000	—	—	—
1984	0.009	—	0.006	—	0.002	—	—	—	0.154	—
1985	0.040	—	0.012	—	0.010	—	—	0.280	0.138	—
1986	0.021	—	0.005	—	0.001	—	—	—	0.219	—
1987	0.026	—	0.004	0.002	0.007	—	0.000	0.353	0.099	—
1988	0.006	—	0.010	0.007	0.004	0.000	0.000	0.200	0.031	0.002
1989	0.004	—	0.006	0.000	0.007	0.001	0.000	0.266	0.147	—
1990	0.002	—	0.007	0.000	0.004	0.001	0.000	—	0.097	—
1991	0.001	—	0.003	0.000	0.001	0.002	0.000	—	0.065	0.000
1992	0.001	—	0.009	0.003	0.003	0.004		—	0.016	0.000
1993	0.001	0.001	0.004	0.002	0.007	0.006	0.000	—	0.003	0.000
1994	0.002	0.000	0.005	0.002	0.005	0.006	0.000	—	0.001	0.000
1995	0.001	0.000	0.000	0.000	0.001	0.000	0.000	0.001	0.000	0.000
1996	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
Mean*	0.038	n/a	0.009	0.002	0.004	0.002	0.000	0.275	0.100	0.001
SD	0.068	n/a	0.010	0.003	0.004	0.002	0.000	0.063	0.065	0.001

*Does not include 1994-96 because additonal adults may still return.

Table 3.7.b. Mean age distribution of adult Atlantic salmon that had been stocked as fry.

		Age class (smolt age.sea age) distribution (%)											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	13.1	65.4	4.4	3.3	9.6	0.6	0.1		0.3	15.9	69.1	14.0	0.7
CT-mainstem		0.0	3.3	0.0	1.0	89.9	1.2	0.0	4.6	0.0	0.0		0.0	4.3	89.9	5.8	0.0
Farmington		0.7	31.3	0.0	2.2	62.9	0.0	0.0	2.9	0.0	0.0		0.7	33.5	62.9	2.9	0.0
Westfield		0.0	0.0	0.0	0.8	93.7	0.0	0.0	5.5	0.0	0.0		0.0	0.8	93.7	5.5	0.0
Narraguagus		0.0	0.0	0.0	9.8	90.2	0.0	0.0	0.0	0.0	0.0		0.0	9.8	90.2	0.0	0.0
Penobscot		0.0	0.0	0.0	15.9	61.2	1.0	0.0	21.9	0.0	0.0		0.0	15.9	61.2	22.8	0.0

Table 3.7.c. Rate of return of adult Atlantic salmon that had been stocked as fry into the Merrimack River.

							Age class (smolt age.sea age) distribution (%)										Age (years) distribution (%)				
Year Class	Total no. fry stocked (1000s)	Unfed fry stocked (1000s)	Fed fry stocked (1000s)	Mean Density (no. fry per 100 m2)	Total returns	Return rate (% of fry)	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	53	0.002	0.0	0.0	0.0	15.1	84.9	0.0	0.0	0.0	0.0	0.0	0.0	15.1	84.9	0.0	0.0
1995	2827	2817	10	63.2	19	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	0.0
1996	1795	1782	13	63.2	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	16518	1251		1023																
Mean*						0.046	0.36	3.12	0.40	7.60	68.28	4.93	3.72	10.83	0.64	0.11	0.36	10.72	72.40	15.76	0.75

*Does not include 1994-96 because additonal adults may still return.

Table 3.7.d. Rate of return of adult Atlantic salmon that had been stocked as fry into the Pawcatuck River.

Year Class	Total no. fry stocked (1000s)	Mean Density (no. fry per 100 m2)	Total returns	Return rate (% of fry)
1993	383	85.0	2	0.001
1994	557	124.0	1	0.000
1995	367	82.0	0	0.000
1996	289	64.0	0	0.000
Total	1596		3.0	

Table 3.7.e. Rate of return of adult Atlantic salmon that had been stocked as fry into the Connecticut River (mainstem).

Year Class	Total no. fry stocked (1000s)	Unfed fry stocked (1000s)	Fed fry stocked (1000s)	Mean Density (no. fry per 100 m2)	CV	Total returns	Return rate (% of fry)	Age Class (smolt age.sea age) 1.1	1.2	1.3	2.1	2.2	2.3	3.1	3.2	3.3	4.2	Age (years) 2	3	4	5	6
1974	16	—	—	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
1975	32	—	—	134.0	180.9	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	—	—	16.0	12.0	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
1977	50	—	—	9.3	28.0	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
1978	50	—	—	9.3	28.0	7	0.014	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
1979	25	—	—	28.0	0.0	1	0.004	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	—	—	110.0	0.0	17	0.019	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	18.1	91.0	66	0.044	0.0	0.0	0.0	3.0	97.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	97.0	0.0	0.0
1982	128	—	—	74.7	33.9	30	0.024	0.0	0.0	0.0	0.0	90.0	10.0	0.0	0.0	0.0	0.0	0.0	0.0	90.0	10.0	0.0
1983	70	—	45	27.1	128.9	4	0.006	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
1984	455	91	—	45.9	66.9	28	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
1985	286	64	109	80.5	70.7	33	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	44.6	16.6	5	0.005	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
1987	981	643	110	28.5	8.0	38	0.004	0.0	2.6	0.0	0.0	78.9	2.6	0.0	15.8	0.0	0.0	0.0	2.6	78.9	18.4	0.0
1988	928	679	149	24.1	5.2	90	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	26.6	4.1	45	0.006	0.0	6.7	0.0	6.7	84.4	0.0	0.0	2.2	0.0	0.0	0.0	13.3	84.4	2.2	0.0
1990	765	558	206	24.1	8.8	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	24.6	3.8	26	0.003	0.0	19.2	0.0	0.0	65.4	0.0	0.0	15.4	0.0	0.0	0.0	19.2	65.4	15.4	0.0
1992	929	638	292	28.0	0.6	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	2.6	95	0.004	0.0	0.0	0.0	2.1	86.3	1.1	0.0	10.5	0.0	0.0	0.0	2.1	86.3	11.6	0.0
1994	3925	3885	40	35.3	6.4	183	0.005	0.0	0.0	0.0	1.1	98.9	0.0	0.0	0.0	0.0	0.0	0.0	1.1	98.9	0.0	0.0
1995	4507	4480	28	34.8	4.7	7	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	4780	4772	8	39.9	4.2	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	22625	19240	2019			812																
Mean*							0.009	0.00	3.58	0.00	0.98	89.17	1.33	0.00	4.94	0.00	0.00	0.00	4.56	89.17	6.27	0.00

*Does not include 1994-96 because additonal adults may still return.

Table 3.7.f. Rate of return of adult Atlantic salmon that had been stocked as fry into the Salmon River.

Year Class	Total no. fry stocked (1000s)	Mean Density (no. fry per 100 m2)	CV	Total returns	Return rate (% of fry)
1987	121	25.0	75.0	2	0.002
1988	43	41.0	1.6	3	0.007
1989	111	55.0	6.6	0	0.000
1990	38	45.0	1.7	0	0.000
1991	25	unknown	n/a	0	0.000
1992	124	26.8	10.1	4	0.003
1993	105	42.7	3.6	2	0.002
1994	241	46.6	3.7	4	0.002
1995	242	46.5	7.1	0	0.000
1996	247	50.8	6.7	0	0.000
Total	1298			15	
Mean*					0.002

*Does not include 1994-96 because additonal adults may still return.

Table 3.7.g. Rate of return of adult Atlantic salmon that had been stocked as fry into the Farmington River.

							Age Class (smolt age.sea age)										Age (years)				
Year Class	Total no. fry stocked (1000s)	Unfed fry stocked (1000s)	Mean Density (no. fry per 100 m2)	CV	Total returns	Return rate (% of fry)	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	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
1980	197	197	167.0	0.0	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
1981	18	18	17.0	0.0	2	0.011	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	145.0	0.0	16	0.010	0.0	18.8	0.0	0.0	81.3	0.0	0.0	0.0	0.0	0.0	0.0	18.8	81.3	0.0	0.0
1983	157	157	135.0	0.0	1	0.001	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
1984	128	128	113.0	0.0	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
1985	136	136	119.0	0.0	13	0.010	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	123.0	0.0	1	0.001	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
1987	68	unknown	25.0	75.0	5	0.007	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	333	unknown	55.7	7.3	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	unknown	46.0	0.9	20	0.007	0.0	60.0	0.0	10.0	30.0	0.0	0.0	0.0	0.0	0.0	0.0	70.0	30.0	0.0	0.0
1990	270	unknown	45.4	29.7	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	unknown			2	0.001	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	553	unknown	53.0	3.8	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	unknown	46.7	8.4	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	unknown	65.2	14.9	50	0.005	0.0	30.0	0.0	4.0	66.0	0.0	0.0	0.0	0.0	0.0	0.0	34.0	66.0	0.0	0.0
1995	1146	unknown	62.0	14.7	16	0.001	6.3	93.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.3	93.8	0.0	0.0	0.0
1996	912	unknown	57.6	12.5	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	6604	910			219																
Mean*						0.004	0.00	22.52	0.00	2.25	71.47	0.00	0.00	3.75	0.00	0.00	0.00	24.78	71.47	3.75	0.00

*Does not include 1994-96 because additonal adults may still return.

Table 3.7.h. Rate of return of adult Atlantic salmon that had been stocked as fry into the Westfield River.

Year Class	Total no. fry stocked (1000s)	Unfed fry stocked (1000s)	Fed fry stocked (1000s)	Mean Density (no. fry per 100 m2)	CV	Total returns	Return rate (% of fry)	Age Class (smolt age.sea age) 1.1	1.2	1.3	2.1	2.2	2.3	3.1	3.2	3.3	4.2	Age (years) 2	3	4	5	6
1988	6	6	0	36.0	0.0	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
1989	106	106	0	32.6	0.7	1	0.001	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	274	274	0	36.0	0.0	4	0.001	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	454	454	0			8	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
1992	402	402	0	26.3	0.6	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	147.3		41	0.006	0.0	0.0	0.0	0.0	90.2	0.0	0.0	9.8	0.0	0.0	0.0	0.0	90.2	9.8	0.0
1994	674	653	21	39.8	3.6	41	0.006	0.0	0.0	0.0	2.4	97.6	0.0	0.0	0.0	0.0	0.0	0.0	2.4	97.6	0.0	0.0
1995	885	861	24	40.9	12.2	3	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	706	681	25	43.4	5.2	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	4168	4092	76			113																
Mean*							0.002	0.00	0.00	0.00	0.00	91.79	0.00	0.00	8.21	0.00	0.00	0.00	0.00	91.79	8.21	0.00

*Does not include 1994-96 because additonal adults may still return.

Table 3.7.i. Rate of return of adult Atlantic salmon that had been stocked as fry into the Dennys River.

Year Class	Total no. fry stocked (1000s)	Unfed fry stocked (1000s)	Fed fry stocked (1000s)	Mean Density (no. fry per 100 m2)	Total returns	Return rate (% of fry)
1983	20	0	20	50-100	0	0.0
1984	0	0	0	unknown	0	0.0
1985	0	0	0	unknown	0	0.0
1986	0	0	0	unknown	0	0.0
1987	24	0	24	50-100	0	0.0
1988	30	0	30	50-100	0	0.0
1989	12	0	12	50-100	0	0.0
1990	20	0	20	50-100	0	0.0
1991	25	0	25	50-100	0	0.0
1992	0	0	0	unknown	0	0.0
1993	33	0	33	50-100	0	0.0
1994	20	0	20	50-100	0	0.0
1995	84	0	84	50-100	0	0.0
1996	142	0	142	50-100	0	0.0
Total	410	0	410			
Mean*						0.0

*Does not include 1994-96 because additonal adults may still return.

Table 3.7.j. Rate of return of adult Atlantic salmon that had been stocked as fry into the Narraguagus River.

							Age Class (smolt age.sea age)										Age (years)				
Year Class	Total no. fry stocked (1000s)	Unfed fry stocked (1000s)	Fed fry stocked (1000s)	Mean Density (no. fry per 100 m2)	Total returns	Return rate (% of fry)	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	unknown	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	unknown	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	unknown	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	unknown	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	unknown	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	unknown	1	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
1995	105	0	105	50-100	1	0.001	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	196	0	196	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	375	0	375		412																
Mean*						0.275	0.00	0.00	0.00	9.76	90.24	0.00	0.00	0.00	0.00	0.00	0.00	9.76	90.24	0.00	0.00

*Does not include 1994-96 because additonal adults may still return.

Table 3.7.k. Rate of return of adult Atlantic salmon that had been stocked as fry into the Penobscot River.

					Age Class (smolt age.sea age)										Age (years)				
Year Class	Total no. fry stocked (1000s)	Mean Density (no. fry per 100 m2)	Total returns	Return rate (% of fry)	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	6	0.001	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
1995	502	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	1242	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	7542		3063																
Mean*				0.100	0.00	0.00	0.00	15.92	61.24	0.99	0.00	21.86	0.00	0.00	0.00	15.92	61.24	22.84	0.00

*Does not include 1994-96 because additonal adults may still return.

Table 3.7.1. Rate of return of adult Atlantic salmon that had been stocked as fry into the Saco River.

Year Class	Total no. fry stocked (1000s)	Mean Density (no. fry per 100 m2)		Total returns	Return rate (% of fry)
1988	47	50-100		1	0.002
1989	0	unknown		0	n/a
1990	0	unknown		0	n/a
1991	111	50-100		0	0.000
1992	154	50-100		0	0.000
1993	167	50-100		0	0.000
1994	190	50-100		0	0.000
1995	376	50-100		0	0.000
1996	0			0	n/a
Total	1045				
Mean*					0.0005

*Does not include 1994-96 because additonal adults may still return.

TABLE 2.2.1.a. JUVENILE ATLANTIC SALMON STOCKING SUMMARY FOR NEW ENGLAND IN 1998 BY RIVER SYSTEM AND BY PROGRAM. [1]

RIVER SYSTEM	NUMBER OF FISH 2						TOTAL
	FRY	0+PARR	1PARR	1+PARR	1SMOLT	2SMOLT	
UNITED STATES							
Aroostook	142,000	0	0	0	0	0	142,000
St. Croix	2,000	31,700	0	200	0	0	33,900
Dennys	234,000	10,400	0	0	9,600	0	254,000
East Machias	190,000	0	0	0	10,800	0	200,800
Machias	300,000	5,900	0	0	14,400	0	320,300
Pleasant	0	0	0	0	0	0	0
Narraguagus	274,000	14,400	0	0	0	0	288,400
Union	165,000	0	0	0	0	0	165,000
Penobscot	936,000	337,400	13,400	0	571,800	0	1,858,600
Ducktrap	0	0	0	0	0	0	0
Sheepscot	256,000	9,300	0	0	0	0	265,300
Androscoggin	2,000	0	0	0	0	0	2,000
Saco	426,000	50,000	0	0	21,300	0	497,300
Cocheco	96,000	0	0	0	0	0	96,000
Lamprey	95,000	0	0	0	3,300	0	98,300
Merrimack	2,589,000	0	0	6,800	51,900	0	2,647,700
Pawcatuck	909,612	0	6,100	8,573	5,672	0	929,957
Connecticut	9,119,000	3,000	0	7,700	1,700	0	9,131,400
TOTAL	**15,735,612**	**462,100**	**19,500**	**23,273**	**690,472**	**0**	**16,930,957**
CANADA							
Aroostòok	0	0	0	0	0	0	0
St. Croix	0	0	0	0	0	0	0
TOTAL	**0**	**0**	**0**	**0**	**0**	**0**	**0**
PROGRAM							
Maine							
United States	2,927,000	459,100	13,400	200	627,900	0	4,027,600
Canada	0	0	0	0	0	0	0
Cocheco	96,000	0	0	0	0	0	96,000
Lamprey	95,000	0	0	0	3,300	0	98,300
Merrimack River	2,589,000	0	0	6,800	51,900	0	2,647,700
Pawcatuck River	909,612	0	6,100	8,573	5,672	0	929,957
Connecticut River	9,119,000	3,000	0	7,700	1,700	0	9,131,400
TOTAL	**15,735,612**	**462,100**	**19,500**	**23,273**	**690,472**	**0**	**16,930,957**

[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 1998 BY RIVER SYSTEM AND BY YEAR CLASS. *

RIVER SYSTEM	SEASON RELEASED AND YEAR CLASS									
	Spring / Early Summer				Autumn					
UNITED STATES	1993	1994	1995	1996	1993	1994	1995	1996	1997	**TOTAL**
Aroostook										0
St. Croix										0
Dennys					42	42	42			126
East Machias	36				44	39				119
Machias	47				98	100				245
Pleasant										0
Narraguagus	50				86	86				222
Union										0
Penobscot					2,017	1,200				3,217
Ducktrap										0
Sheepscot	37									37
Saco										0
Cocheco										0
Lamprey										0
Merrimack		971	1,044			3	644			2,662
Pawcatuck	0	0	0	0	0	0	0	0	0	0
Connecticut										0
TOTAL	**170**	**971**	**1,044**	**0**	**2,287**	**1,470**	**686**	**0**	**0**	**6,628**
CANADA										
Aroostook										0
St. Croix										0
TOTAL	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
PROGRAM										
Maine										
United States	170	0	0	0	2,287	1,467	42	0	0	3,966
Canada		0	0	0		0	0	0	0	0
Cocheco		0	0	0		0	0	0	0	0
Lamprey		0	0	0		0	0	0	0	0
Merrimack River		971	1,044	0		3	644	0	0	2,662
Pawcatuck River		0	0	0		0	0	0	0	0
Connecticut River		0	0	0		0	0	0	0	0
TOTAL	**170**	**971**	**1,044**	**0**	**2,287**	**1,470**	**686**	**0**	**0**	**6,628**

* Year-class refers to year of collection in the wild or egg take.

TABLE 2.2.2.a. SUMMARY OF JUVENILE AND ADULT ATLANTIC SALMON MARKING PROGRAMS NEW ENGLAND IN 1998.

Mark	Stage	Connecticut	Dennys	East Machias	Machias	Merrimack	Penobscot	Narraguagus	Sheepscot	Pawcatuck	Saco	Total
Clip	adult											0
	parr	2,950				6,840						9,790
	smolt					923				5,672		6,595
	Total	2,950	0	0	0	7,763	0	0	0	5,672	0	16,385
Disc	adult											0
VIE	parr				666		666					1,332
	smolt		9,600	10,800	10,800			22				31,222
Floy	adult					2,034						2,034
Ping	smolt						60	134				194
	adult			8	8			14				30
PIT	parr	1,536										1,536
Radio	smolt											0
Radio	adult	49										49
Carlin	adult			36	47			50	37			170
VIA	adult											0
All	adult	49	0	44	55	2,034	0	64	37	0	0	2,283
	parr	4,486	0	0	666	6,840	666	0	0	0	0	12,658
	smolt	0	9,600	10,800	10,800	923	60	156	0	5,672	0	38,011
	Total	4,535	9,600	10,844	11,521	9,797	726	220	37	5,672	0	52,952

Notes

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 - 1998.

PLACE OF RELEASE	MARKING AGENCY	AGE	LIFE STAGE	H/W	STOCK ORIGIN	TAG/ MARK	NUMBER MARKED	CODE OR SERIAL	AUX MARK	REL DATE	COMMENT
Connecticut R.	USGS	4	adult	W	Connecticut	Radio tag	9		PIT	May-98	Westfield R. Study
Connecticut R.	USGS	5	adult	W	Connecticut	Radiotag	2		PIT	May-98	Westfield R. Study
Connecticut R.	USGS	4	adult	H	Connecticut	Radio tag	8		PIT	Jun-98	Westfield R. Study
Connecticut R.	USGS	4	adult	H	Connecticut	Radio tag	8		PIT	Sep-98	Westfield R. Study
Connecticut R.	USGS	0	juvenile	H	Connecticut	PIT	1,325			all 1998	West Brook, MA
Connecticut R.	USGS	1	juvenile	H	Connecticut	PIT	120			all 1998	West Brook, MA
Connecticut R.	USGS	2	juvenile	H	Connecticut	PIT	8			all 1998	West Brook, MA
Connecticut R.	USGS	1	juvenile	H	Connecticut	PIT	83			May-98	Sawmill R., MA
Connecticut R.	USGS	2	juvenile	H	Connecticut	PIT	4			May-98	Sawmill R., MA
Connecticut R.	USGen	3	adult	W	Connecticut	Radio tag	2			May-98	Deerfield Study
Connecticut R.	USGen	4	adult	W	Connecticut	Radio tag	20			May-98	Deerfield Study
TOTAL TAG/MARK, CONNECTICUT RIVER							**1567**				
Pawcatuck R.	RIDFW	1	smolt	H	Merrimack	AD	5672			Jan-98	
TOTAL TAG/MARK, PAWCATUCK RIVER							**5672**				
Merrimack R.	NHFG	3+,4+	adult	D	Merrimack	Floy	482	98/S		4-5/98	Yellow
Merrimack R.	NHFG	3+,4+	adult	D	Merrimack	Floy	438	98/S		4-5/98	Green
Merrimack R.	NHFG	3+	adult	D	Merrimack	Floy	119	98/S		4/98	White
Merrimack R.	NHFG	3+	adult	D	Merrimack	Floy	125	98/S		4/98	Blue
Merrimack R.	NHFG	3+,4+	adult	D	Merrimack	Floy	311	98/S		4-5/98	Red
Merrimack R.	NHFG	3+	adult	D	Merrimack	Floy	55	98/S		4/98	Orange
Merrimack R.	NHFG	3+,4+	adult	D	Merrimack	Floy	149	98/S		5,7,10/98	Gray
Merrimack R.	NHFG	3+	adult	D	Merrimack	Floy	114	98/F		12/98	Gray
Merrimack R.	NHFG	3+	adult	D	Merrimack	Floy	241	98/F		12/98	Purple
Merrimack R.	NHFG	1	smolt	H	Merrimack	LV	923			6/98	
Merrimack R.	NHFG	1+	parr	H	Merrimack	LV	3290			6/98	
Merrimack R.	USFWS	1+	parr	H	Merrimack	RV	3550			4/98	
TOTAL TAG/MARK, MERRIMACK RIVER							**9797**				
Machias R.	USFWS	5	adult	C	Machias	Carlin	47	180-227	AP	10/98	green
Machias R.	ASA	0+	parr	W	Machias	VIE	81			08/98	red in left jaw
Machias R.	ASA	0+	parr	W	Machias	VIE	111			08/98	red in right jaw
Machias R.	ASA	0+	parr	W	Machias	VIE	343			08/98	blue in right jaw
Machias R.	ASA	0+	parr	W	Machias	VIE	81			08/98	blue in left jaw
Machias R.	ASA	1+	parr	W	Machias	VIE	50			08/98	blue in left jaw
Machias R.	USFWS/ASA	1	smolt	H	Machias	VIE	10800		AC	04/98	red in left eye
Machias R.	USFWS/ASA	5	adult	C	Machias	ping	8		AP	10/98	54-76.8 kHz
TOTAL TAG/MARK, MACHIAS RIVER							**11521**				
Penobscot R.	GNP	1	smolt	H	Penobscot	ping	60			04/98	40.6-40.69 mHz
TOTAL TAG/MARK, PENOBSCOT RIVER							**60**				
Dennys R.	USFWS/ASA	1	smolt	H	Dennys	VIE	9600		AC	04/98	orange in left eye
TOTAL TAG/MARK, DENNYS RIVER							**9600**				
Narraguagus R.	USFWS/ASA	4, 5	adult	C	Narraguagus	Carlin	50	120-173	AP	10/98	green
Narraguagus R.	USFWS/NMFS	2	smolt	W	Narraguagus	Ping	109			5,6/98	65.5-78.0 kHz
Narraguagus R.	USFWS/ASA	1	smolt	H	Narraguagus	VIE	22		Ping	06/98	65.5-78.o kHz; blue elas.
Narraguagus R.	USFWS/ASA	4, 5	adult	H	Narraguagus	Ping	14		AP	10/98	double adipose punch
TOTAL TAG/MARK, NARRAGUAGUS RIVER							**195**				

TABLE 2.2.2.b. ATLANTIC SALMON MARKING DATABASE FOR NEW ENGLAND - 1998.

PLACE OF RELEASE	MARKING AGENCY	AGE	LIFE STAGE	H/W	STOCK ORIGIN	TAG/ MARK	NUMBER MARKED	CODE OR SERIAL	AUX MARK	REL DATE	COMMENT
Sheepscot R.	USFWS/ASA	4, 5	adult	C	Sheepscot	Carlin	37	001-040	AP	04/98	green
TOTAL TAG/MARK, SHEEPSCOT RIVER							**37**				
East Machias R.	USFWS/ASA	4, 5	adult	C	East Machias	Carlin	36	041-077	AP	04/98	green
East Machias R.	USFWS/ASA	4, 5	adult	C	East Machias	ping	8		AP	10/98	54-76.8 kHz
East Machias R.	USFWS/ASA	1	smolt	H	East Machias	VIE	10800		AC	04/98	yellow in left eye
TOTAL TAG/MARK, EAST MACHIAS RIVER							**10844**				

Notes

UCP = upper caudal punch
LCP = lower caudal punch
CP = caudal punch
AD = adipose clip
AP=hole punched in adipose fin (AD punch)
Ping=internally implanted ultrasonic pinger
VIA=visual implant alpha-numeric
VIE=visual implant elastomers
LV=left ventral fin clip
RV=right ventral fin clip
H=hatchery
W=wild
C=captive, wild origin held in hatchery then released
D=domestic, entire life cycle in hatchery

TABLE 2.3.1. DOCUMENTED ATLANTIC SALMON RETURNS TO NEW ENGLAND RIVERS IN 1998. [1]

RIVER	NUMBER OF ATLANTIC SALMON BY SEA AGE								TOTAL FOR 1998
	1SW		2SW		3SW		RS		
	Hatchery	Wild	Hatchery	Wild	Hatchery	Wild	Hatchery	Wild	
Penobscot River	240	29	796	130	0	1	10	4	1,210
Aroostook River	2	2	13	13	0	0	0	0	30
Union River	2	0	7	0	0	0	4	0	13
Narraguagus River [2]	0	1	0	18	0	0	0	3	22
Pleasant River									unknown
Machias River									unknown
East Machias River									unknown
Dennys River [3]	0	0	0	1	0	0	0	0	1
St. Croix River	20	12	3	6	0	0	0	0	41
Kennebec River									unknown
Androscoggin River	0	0	4	0	0	0	0	0	4
Sheepscot River									unknown
Ducktrap River									unknown
Saco River	9	4	7	7	0	1	0	0	28
Cocheco River	0	0	0	0	0	0	0	0	0
Lamprey River	0	0	0	0	0	0	0	0	0
Merrimack River	11	19	45	47	1	0	0	0	123
Pawcatuck River	0	1	0	2	0	0	0	0	3
Connecticut River	0	8	0	290	0	0	0	2	300
TOTAL	284	76	875	514	1	2	14	9	1,775

[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 reproduction.

[2] Does not indluce 3 captive broodstock.

[3] Included in count: 1 in weir (weir operated for 10 days in Sept.); 1 taken (killed) by vandals.

TABLE 2.3.4. SUMMARY OF ATLANTIC SALMON EGG PRODUCTION IN NEW ENGLAND FACILITIES IN 1998. [1]

SOURCE RIVER	ORIGIN	FEMALES SPAWNED	TOTAL EGG PRODUCTION	NO. OF EGGS PER FEMALE
Sheepscot River	Sea-run	0		
Penobscot River	Sea-run	392	2,804,084	7,153
Dennys River	Sea-run	0		
Merrimack River	Sea-run	63	518,000	8,222
Pawcatuck River	Sea-run	0		
Connecticut River	Sea-run	185	1,452,500	7,851
TOTAL SEA-RUN		**640**	**4,774,584**	**7,460**
Penobscot River	Domestic	560	1,456,192	2,600
Merrimack River	Domestic	560	2,669,300	4,767
Connecticut River	Domestic	1,140	7,029,500	6,166
Dennys River	Captive [2]	79	337,571	4,273
East Machias River	Captive	103	362,284	3,517
Sheepscot River	Captive	98	343,337	3,503
Machias River	Captive	166	547,603	3,299
Narraguagus River	Captive	186	490,020	2,635
TOTAL CAPTIVE/DOMESTIC		**2,892**	**13,235,807**	**4,577**
Dennys River	Kelts	10	105,599	10,560
Merrimack River	Kelts	5	64,400	12,880
Connecticut River	Kelts	156	1,493,500	9,574
Sheepscot River	Kelts	17	181,485	10,676
Machias River	Kelts	0		
TOTAL SEA-RUN KELTS		**183**	**1,780,584**	**9,730**
GRAND TOTAL		**3,715**	**19,790,975**	**5,327**

[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 1998 SPORT CATCH OF ATLANTIC SALMON IN MAINE.

RIVER	TOTAL HARVEST	EST. NO. RELEASED	TOTAL ANGLED 1998		TOTAL ANGLED 1997
St. Croix	0	0	0		0
Dennys	0	0	0		10
East Machias	0	5	5		0
Machias	0	0	0		10
Pleasant	0	15	15		0
Narraguagus	0	0	0		13
Union	0	0	0		0
Penobscot	0	250	250		300
Ducktrap	0	0	0		0
Sheepscot	0	0	0		0
Kennebec	0	0	0		0
Saco	0	0	0		0
Aroostook	0	0	0		0
Misc.	0	0	0		0
TOTAL	**0**	**270**	**270**		**333**

* 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							
	NUMBER OF FISH						
RIVER / YEAR	FRY	0+PARR	1PARR	1+PARR	1SMOLT	2SMOLT	TOTAL
UPPER ST. JOHN							
1970	0	0	0	0	0	0	0
1971	0	0	0	0	0	0	0
1972	0	0	0	0	0	0	0
1973	0	0	0	0	0	0	0
1974	0	0	0	0	0	0	0
1975	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0
1979	0	2100	0	0	0	0	2100
1980	0	0	0	0	0	2700	2700
1981	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0
1987	306000	60000	0	0	0	0	366000
1988	128000	779400	4800	0	0	0	912200
1989	66000	0	0	0	0	10300	76300
1990	110000	21000	9900	0	0	9600	150500
1991	228000	139300	0	0	5100	5100	377500
1992	400000	136100	0	0	0	0	536100
1993	361000	102800	0	0	0	0	463800
1994	566000	216000	0	0	0	0	782000
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
TOTAL	**2165000**	**1456700**	**14700**	**0**	**5100**	**27700**	**3669200**
AROOSTOOK							
1970	0	0	0	0	0	0	0
1971	0	0	0	0	0	0	0
1972	0	0	0	0	0	0	0
1973	0	0	0	0	0	0	0
1974	0	0	0	0	0	0	0
1975	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0
1978	0	0	0	0	5200	0	5200
1979	0	3100	0	0	0	0	3100
1980	0	0	0	0	0	2600	2600
1981	0	25200	20400	0	0	0	45600
1982	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0
1986	84000	0	0	1800	0	0	85800
1987	41000	0	0	0	0	0	41000
1988	43000	0	0	0	0	0	43000
1989	313000	242200	0	0	0	10000	565200
1990	69000	0	0	0	27400	7600	104000
1991	74000	46600	0	0	0	9600	130200
1992	0	0	16400	0	0	0	16400
1993	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0
1995	4300	0	0	0	0	0	4300
1996	0	0	0	0	0	0	0
1997	578000	0	0	0	0	0	578000
1998	142000	0	0	0	0	0	142000
TOTAL	**1348300**	**317100**	**36800**	**1800**	**32600**	**29800**	**1766400**

	NUMBER OF FISH						
RIVER / YEAR	FRY	0+PARR	1PARR	1+PARR	1SMOLT	2SMOLT	TOTAL
ST. CROIX							
1970	0	0	0	0	0	0	0
1971	0	0	0	0	0	0	0
1972	0	0	0	0	0	0	0
1973	0	0	0	0	0	0	0
1974	0	0	0	0	0	0	0
1975	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0
1979	0	0	0	0	0	0	0
1980	0	0	0	0	0	0	0
1981	0	0	0	0	0	20000	20000
1982	101000	20900	50000	0	19900	100	191900
1983	0	0	25500	0	20000	0	45500
1984	54000	0	13800	0	92500	0	160300
1985	178000	46400	12900	0	59600	0	296900
1986	193000	0	0	0	73500	0	266500
1987	255000	0	41000	0	59800	0	355800
1988	0	0	0	0	78700	0	78700
1989	0	0	0	0	50600	0	50600
1990	255000	0	0	0	65800	0	320800
1991	51000	40000	0	0	60200	0	151200
1992	85000	56500	14900	0	50300	0	206700
1993	0	101000	0	0	40100	0	141100
1994	87000	38600	0	0	60600	0	186200
1995	1000	0	0	0	0	0	1000
1996	0	52100	0	0	15600	0	67700
1997	1000	400	0	0	0	0	1400
1998	2000	31700	0	200	0	0	33900
TOTAL	**1263000**	**387600**	**158100**	**200**	**747200**	**20100**	**2576200**
DENNYS							
1970	0	0	0	0	0	0	0
1971	0	0	0	0	0	0	0
1972	0	0	0	0	0	0	0
1973	0	0	0	0	0	0	0
1974	0	0	0	0	0	0	0
1975	0	0	3000	0	0	4200	7200
1976	0	0	0	0	0	8900	8900
1977	0	0	0	0	0	0	0
1978	0	0	0	0	30200	0	30200
1979	0	0	0	0	10200	0	10200
1980	0	0	0	0	0	15200	15200
1981	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0
1983	20000	0	0	0	5200	0	25200
1984	0	0	0	0	3300	0	3300
1985	0	0	0	0	4500	0	4500
1986	0	8300	0	0	5400	0	13700
1987	24000	0	0	0	9000	0	33000
1988	30000	0	0	0	25700	0	55700
1989	12000	0	0	0	12100	0	24100
1990	20000	0	0	0	25800	0	45800
1991	25000	0	400	0	11700	0	37100
1992	0	0	0	0	0	0	0
1993	33000	0	0	0	0	0	33000
1994	20000	0	0	0	0	0	20000
1995	84000	0	0	0	0	0	84000
1996	142000	0	0	0	0	900	142900
1997	213000	0	0	0	0	0	213000
1998	234000	10400	0	0	9600	0	254000
TOTAL	**857000**	**18700**	**400**	**0**	**152700**	**25000**	**1053800**

	NUMBER OF FISH						
RIVER / YEAR	FRY	0+PARR	1PARR	1+PARR	1SMOLT	2SMOLT	TOTAL
PLEASANT							
1970	0	0	0	0	0	0	0
1971	0	0	0	0	0	0	0
1972	0	0	0	0	0	0	0
1973	0	0	0	0	0	0	0
1974	0	0	0	0	0	0	0
1975	0	0	0	0	0	3000	3000
1976	0	0	0	0	0	1000	1000
1977	0	0	0	0	0	0	0
1978	0	0	0	0	3100	0	3100
1979	0	0	0	0	0	0	0
1980	0	0	0	0	200	10000	10200
1981	0	0	0	0	0	4100	4100
1982	0	0	0	0	5000	0	5000
1983	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0
1985	33000	0	0	0	4100	0	37100
1986	25000	0	0	0	6500	0	31500
1987	25000	0	0	0	7500	0	32500
1988	25000	0	1800	0	10500	0	37300
1989	26000	2500	0	0	7300	0	35800
1990	30000	0	0	0	10500	0	40500
1991	23000	0	0	0	0	0	23000
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
TOTAL	**187000**	**2500**	**1800**	**0**	**54700**	**15100**	**261100**
EAST MACHIAS							
1970	0	0	0	0	0	0	0
1971	0	0	0	0	0	0	0
1972	0	0	0	0	0	0	0
1973	0	0	0	0	0	2000	2000
1974	0	0	0	0	0	0	0
1975	0	0	0	0	0	3000	3000
1976	0	0	0	0	0	3900	3900
1977	0	0	0	0	0	0	0
1978	0	0	0	0	12200	0	12200
1979	0	0	0	0	5200	0	5200
1980	0	0	0	0	0	15900	15900
1981	0	0	0	0	0	0	0
1982	0	0	0	0	0	5600	5600
1983	0	0	0	0	0	0	0
1984	0	0	8700	0	0	0	8700
1985	13000	0	0	0	4500	0	17500
1986	8000	0	0	0	5300	0	13300
1987	10000	0	0	0	9000	0	19000
1988	10000	0	7500	0	20700	0	38200
1989	30000	6500	8000	0	15300	0	59800
1990	42000	0	10100	0	10100	0	62200
1991	27000	0	8300	0	15300	0	50600
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	115000	0	0	0	0	0	115000
1997	111000	0	0	0	0	0	111000
1998	190000	0	0	0	10800	0	200800
TOTAL	**556000**	**6500**	**42600**	**0**	**108400**	**25400**	**738900**

RIVER / YEAR	NUMBER OF FISH						
	FRY	0+PARR	1PARR	1+PARR	1SMOLT	2SMOLT	TOTAL
MACHIAS							
1970	0	0	0	0	0	10700	10700
1971	0	0	0	0	5100	3400	8500
1972	0	0	0	0	8500	4400	12900
1973	0	0	0	0	0	6100	6100
1974	0	0	0	0	0	6500	6500
1975	0	0	0	0	0	0	0
1976	0	0	0	0	5300	11100	16400
1977	0	0	0	0	0	0	0
1978	0	0	0	0	10200	0	10200
1979	0	0	0	0	10200	0	10200
1980	0	0	0	0	0	0	0
1981	0	0	0	0	0	0	0
1982	0	0	0	0	5500	0	5500
1983	0	12500	0	0	0	0	12500
1984	0	0	0	0	15800	0	15800
1985	0	0	7000	0	5100	0	12100
1986	8000	8000	0	0	0	0	16000
1987	0	12500	12300	0	13600	0	38400
1988	30000	0	31500	0	30900	0	92400
1989	49000	13800	28000	0	23100	0	113900
1990	75000	10100	17600	0	26100	0	128800
1991	13000	30000	21400	0	21100	0	85500
1992	14000	0	0	0	0	0	14000
1993	0	0	0	0	0	0	0
1994	50000	0	0	0	0	0	50000
1995	150000	0	0	0	0	0	150000
1996	233000	0	0	0	0	1900	234900
1997	237000	0	0	0	0	0	237000
1998	300000	5900	0	0	10800	0	316700
TOTAL	**1159000**	**92800**	**117800**	**0**	**177700**	**13000**	**1560300**
NARRAGUAGUS							
1970	0	0	0	0	0	11800	11800
1971	0	0	0	0	0	2900	2900
1972	0	0	0	0	0	15700	15700
1973	0	0	0	0	0	5600	5600
1974	0	0	0	0	0	0	0
1975	0	0	0	0	0	5000	5000
1976	0	0	0	0	0	8400	8400
1977	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0
1979	0	0	0	0	10100	0	10100
1980	0	0	0	0	0	20400	20400
1981	0	0	0	0	0	4100	4100
1982	0	0	0	0	0	5200	5200
1983	0	7800	0	0	0	0	7800
1984	0	0	0	0	5200	0	5200
1985	10000	0	0	0	4500	0	14500
1986	0	0	0	0	7500	0	7500
1987	15000	0	0	0	9000	0	24000
1988	20000	13000	5600	0	15700	0	54300
1989	29000	9500	7000	0	22100	4900	72500
1990	0	0	0	0	16800	0	16800
1991	0	0	0	0	15200	0	15200
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	105000	0	0	0	0	0	105000
1996	196000	0	0	0	0	0	196000
1997	209000	0	2025	0	700	0	211725
1998	274000	14400	0	0	0	0	288400
TOTAL	**858000**	**44700**	**14625**	**0**	**106800**	**43000**	**1067125**

NUMBER OF FISH							
RIVER / YEAR	**FRY**	**0+PARR**	**1PARR**	**1+PARR**	**1SMOLT**	**2SMOLT**	**TOTAL**
UNION							
1970	0	0	0	0	0	0	0
1971	0	0	0	0	8100	0	8100
1972	0	0	0	0	0	7700	7700
1973	0	0	0	0	0	19600	19600
1974	0	0	0	0	9900	20400	30300
1975	0	0	0	0	0	31300	31300
1976	0	0	0	0	1800	31800	33600
1977	0	0	0	0	13000	22500	35500
1978	0	0	0	0	0	31900	31900
1979	0	0	0	0	12900	29900	42800
1980	0	0	0	0	30600	0	30600
1981	0	0	0	0	0	29400	29400
1982	0	0	0	0	5900	26500	32400
1983	0	0	0	0	41600	0	41600
1984	0	0	0	0	50200	0	50200
1985	7000	0	0	0	45800	0	52800
1986	7000	0	0	0	48400	0	55400
1987	7000	0	0	0	40100	0	47100
1988	0	0	0	0	30600	0	30600
1989	0	0	0	0	20400	0	20400
1990	0	0	0	0	20400	0	20400
1991	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0
1993	60000	111700	0	0	0	0	171700
1994	0	0	0	0	0	0	0
1995	0	54800	0	0	0	0	54800
1996	0	53500	0	0	0	0	53500
1997	12000	69300	0	0	0	0	81300
1998	165000	0	0	0	0	0	165000
TOTAL	**258000**	**289300**	**0**	**0**	**361700**	**172000**	**1081000**
PENOBSCOT							
1970	0	25000	0	0	0	28500	53500
1971	0	0	15800	0	52600	0	68400
1972	129000	0	0	0	0	73800	202800
1973	0	0	0	0	12400	95800	108200
1974	0	0	0	0	34300	65900	100200
1975	0	0	35100	9100	15800	94800	154800
1976	0	0	83800	0	54700	180100	318600
1977	0	0	0	0	113800	224700	338500
1978	0	0	126800	0	61100	141400	329300
1979	95000	0	0	0	50000	246300	391300
1980	0	0	0	0	369000	215600	584600
1981	202000	25400	50300	0	24700	174800	477200
1982	248000	50900	206400	0	107400	222300	835000
1983	0	0	31900	0	281500	161400	474800
1984	80000	34400	0	0	481500	135600	731500
1985	197000	59500	17600	0	476500	104400	855000
1986	226000	25700	58600	0	520200	69000	899500
1987	333000	58100	101100	0	456800	82400	1031400
1988	431000	0	51400	0	599900	87100	1169400
1989	77000	104100	179600	0	351300	65300	777300
1990	317000	166500	155300	0	413200	15900	1067900
1991	398000	202600	104100	0	657800	15000	1377500
1992	925000	278200	106600	0	816600	8100	2134500
1993	1320000	202300	9600	0	580400	0	2112300
1994	949000	0	2400	0	567600	0	1519000
1995	502000	325000	5600	0	568400	0	1401000
1996	1242000	226000	17500	0	552200	0	2037700
1997	1472000	310900	4200	0	580200	0	2367300
1998	936000	337400	13400	0	571800	0	1858600
TOTAL	**9950000**	**2407000**	**1326200**	**0**	**9256600**	**2149400**	**25089200**

RIVER / YEAR	FRY	0+PARR	1PARR	1+PARR	1SMOLT	2SMOLT	TOTAL
	NUMBER OF FISH						
DUCKTRAP							
1970	0	0	0	0	0	0	0
1971	0	0	0	0	0	0	0
1972	0	0	0	0	0	0	0
1973	0	0	0	0	0	0	0
1974	0	0	0	0	0	0	0
1975	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0
1979	0	0	0	0	0	0	0
1980	0	0	0	0	0	0	0
1981	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0
1985	15000	0	0	0	0	0	15000
1986	8000	0	0	0	0	0	8000
1987	15000	0	0	0	0	0	15000
1988	10000	0	0	0	0	0	10000
1989	17000	0	0	0	0	0	17000
1990	18000	0	0	0	0	0	18000
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
TOTAL	**83000**	**0**	**0**	**0**	**0**	**0**	**83000**
SHEEPSCOT							
1970	0	0	0	0	0	0	0
1971	0	0	0	0	1000	0	1000
1972	0	0	0	0	0	0	0
1973	0	0	0	0	0	1000	1000
1974	0	0	0	0	0	0	0
1975	0	0	0	0	0	2500	2500
1976	0	0	0	0	3000	0	3000
1977	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0
1979	0	0	0	0	0	0	0
1980	0	0	0	0	0	0	0
1981	0	0	0	0	0	0	0
1982	0	0	0	0	5300	0	5300
1983	0	0	0	0	5200	0	5200
1984	0	0	0	0	5000	0	5000
1985	20000	0	0	0	3900	3600	27500
1986	10000	11600	0	0	7500	0	29100
1987	15000	8200	0	0	9000	0	32200
1988	40000	12300	0	0	10200	0	62500
1989	29000	13600	10000	0	10200	0	62800
1990	27000	10100	10000	0	17500	0	64600
1991	18000	15000	600	0	14400	0	48000
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	102000	0	0	0	0	0	102000
1997	64000	0	0	0	0	0	64000
1998	256000	9300	0	0	0	0	265300
TOTAL	**581000**	**80100**	**20600**	**0**	**91200**	**3600**	**776500**

	NUMBER OF FISH						
RIVER / YEAR	FRY	0+PARR	1PARR	1+PARR	1SMOLT	2SMOLT	TOTAL
SACO							
1970	0	0	0	0	0	0	0
1971	0	0	0	0	0	0	0
1972	0	0	0	0	0	0	0
1973	0	0	0	0	0	0	0
1974	0	0	0	0	0	0	0
1975	0	0	0	0	0	9500	9500
1976	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0
1979	0	0	0	0	0	0	0
1980	0	0	0	0	0	0	0
1981	0	0	0	0	0	0	0
1982	0	47100	0	0	0	0	47100
1983	0	0	0	0	20300	0	20300
1984	0	0	0	0	5100	0	5100
1985	0	0	23600	0	5100	0	28700
1986	0	0	10000	0	35200	0	45200
1987	0	0	69800	0	22000	0	91800
1988	47000	0	0	0	25100	0	72100
1989	0	37800	49600	0	9900	0	97300
1990	0	30100	47800	0	10600	0	88500
1991	111000	0	0	0	10300	0	121300
1992	154000	50200	400	0	19800	0	224400
1993	167000	0	0	0	20100	0	187100
1994	190000	0	0	0	20000	0	210000
1995	376000	0	0	0	19700	0	395700
1996	0	45000	0	0	20000	0	65000
1997	97000	63300	0	0	20200	0	180500
1998	426000	50000	0	0	21300	0	497300
TOTAL	**1568000**	**323500**	**201200**	**0**	**284700**	**0**	**2377400**
COCHECO							
1970	0	0	0	0	0	0	0
1971	0	0	0	0	0	0	0
1972	0	0	0	0	0	0	0
1973	0	0	0	0	0	0	0
1974	0	0	0	0	0	0	0
1975	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0
1979	0	0	0	0	0	0	0
1980	0	0	0	0	0	0	0
1981	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0
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	2000	0	0	0	0	0	2000
1989	106000	0	0	0	0	0	106000
1990	32000	50000	9500	0	0	0	91500
1991	138000	0	0	0	0	0	138000
1992	128000	0	0	0	0	0	128000
1993	127000	0	0	1000	0	0	128000
1994	149000	0	0	0	5300	0	154300
1995	114000	0	0	0	0	0	114000
1996	126000	0	0	0	0	0	126000
1997	128000	0	0	0	0	0	128000
1998	96000	0	0	0	0	0	96000
TOTAL	**1146000**	**50000**	**9500**	**1000**	**5300**	**0**	**1211800**

NUMBER OF FISH							
RIVER / YEAR	FRY	0+PARR	1PARR	1+PARR	1SMOLT	2SMOLT	TOTAL
LAMPREY							
1970	0	0	0	0	0	0	0
1971	0	0	0	0	0	0	0
1972	0	0	0	0	0	0	0
1973	0	0	0	0	0	0	0
1974	0	0	0	0	0	0	0
1975	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0
1978	0	0	0	0	19600	0	19600
1979	0	0	0	0	8600	5800	14400
1980	0	0	0	0	39900	8400	48300
1981	0	0	0	0	19500	12200	31700
1982	0	0	0	0	30700	6400	37100
1983	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0
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	146000	0	0	0	0	0	146000
1990	50000	87000	11400	0	0	0	148400
1991	110000	68200	0	0	0	0	178200
1992	127000	12700	0	0	0	0	139700
1993	68000	56500	28800	1100	15000	0	169400
1994	98000	56300	7800	0	0	0	162100
1995	91000	57100	0	0	4800	0	152900
1996	115000	37000	8400	1000	0	0	161400
1997	141000	52900	0	0	0	0	193900
1998	95000	0	0	0	3300	0	98300
TOTAL	**1041000**	**427700**	**56400**	**2100**	**141400**	**32800**	**1701400**
MERRIMACK							
1970	0	0	0	0	0	0	0
1971	0	0	0	0	0	0	0
1972	0	0	0	0	0	0	0
1973	0	0	0	0	0	0	0
1974	0	0	0	0	0	0	0
1975	0	0	0	0	0	0	0
1976	63000	75900	0	16600	0	2100	157600
1977	72000	0	0	700	0	31000	103700
1978	106000	0	0	0	21300	25900	153200
1979	77000	0	0	0	15000	24700	116700
1980	126000	0	0	0	2300	28700	157000
1981	57000	0	0	0	2600	98300	157900
1982	50000	81600	0	95500	5400	65600	298100
1983	8000	5000	15000	5000	47000	62900	142900
1984	526000	0	23300	9800	24400	43800	627300
1985	148000	0	5800	0	64000	125300	343100
1986	525000	0	31500	0	39900	64100	660500
1987	1078000	0	99300	0	141600	0	1318900
1988	1718000	0	129600	0	94400	0	1942000
1989	1034000	60000	88600	0	58600	0	1241200
1990	975000	0	5600	29700	116900	0	1127200
1991	1458000	0	0	0	62000	58100	1578100
1992	1118000	0	100	0	96400	0	1214500
1993	1157000	0	0	0	59000	0	1216000
1994	2816000	0	0	0	85000	0	2901000
1995	2827000	0	12700	0	70800	0	2910500
1996	1795000	0	0	4900	50000	0	1849900
1997	1977000	5000	4700	5300	52500	5400	2049900
1998	2589000	0	0	6800	51900	0	2647700
TOTAL	**22300000**	**227500**	**416200**	**174300**	**1161000**	**635900**	**24914900**

	NUMBER OF FISH						
RIVER / YEAR	FRY	0+PARR	1PARR	1+PARR	1SMOLT	2SMOLT	TOTAL
PAWCATUCK							
1970	0	0	0	0	0	0	0
1971	0	0	0	0	0	0	0
1972	0	0	0	0	0	0	0
1973	0	0	0	0	0	0	0
1974	0	0	0	0	0	0	0
1975	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0
1979	0	136000	0	0	0	0	136000
1980	0	1000	0	0	0	0	1000
1981	0	2000	108000	0	800	0	110800
1982	2000	1000	0	0	0	0	3000
1983	0	700	0	0	0	0	700
1984	0	23000	0	0	0	0	23000
1985	8000	51000	1400	0	0	0	60400
1986	0	50700	15000	0	0	0	65700
1987	3000	46200	4700	0	1000	0	54900
1988	150000	59600	7100	0	5400	0	222100
1989	0	379900	35800	0	6500	0	422200
1990	0	83500	55000	0	7500	0	146000
1991	0	101000	1000	0	2000	500	104500
1992	0	70800	2500	0	5000	0	78300
1993	383000	14500	4000	0	2300	0	403800
1994	557000	0	0	0	0	0	557000
1995	367000	52200	0	0	0	0	419200
1996	289000	136100	0	0	5000	0	430100
1997	100000	0	14000	0	11500	0	125500
1998	909612	0	6100	8573	5672	0	929957
TOTAL	**2768612**	**1209200**	**254600**	**8573**	**52672**	**500**	**4294157**
CONNECTICUT							
1970	0	0	0	0	0	0	0
1971	60000	15000	7800	2900	5600	12400	103700
1972	0	0	2700	2300	4600	13100	22700
1973	0	15000	1000	21100	1400	31900	70400
1974	16000	0	9400	15600	10400	44000	95400
1975	31900	0	1700	16400	2800	70000	122800
1976	26600	0	5000	24200	4000	30500	90300
1977	49500	0	0	15400	0	99200	164100
1978	50000	0	0	36600	0	94300	180900
1979	53500	0	0	38400	0	145100	237000
1980	286000	0	0	11500	0	51800	349300
1981	168000	182700	1900	3600	5300	73300	434800
1982	294000	9400	25100	9600	28100	180800	547000
1983	226000	115400	293800	400	89100	8900	733600
1984	625000	178600	241200	11400	312300	0	1368500
1985	422000	130500	110700	0	255000	0	918200
1986	176000	188400	267100	0	290500	0	922000
1987	1180000	383200	345100	0	206000	0	2114300
1988	1310000	72200	75200	0	395300	0	1852700
1989	1243000	268700	76800	0	217700	0	1806200
1990	1271000	341600	25400	0	475900	0	2113900
1991	1725000	306200	33100	0	351000	0	2415300
1992	2009000	313900	11500	0	313300	0	2647700
1993	4147000	237100	28700	0	382800	0	4795600
1994	5979000	37000	2300	12900	375100	0	6406300
1995	6818000	4500	0	0	1300	0	6823800
1996	6675000	12400	0	3600	11500	0	6702500
1997	8526000	8800	0	0	1400	0	8536200
1998	9119000	3000	0	7700	1700	0	9131400
TOTAL	**52378600**	**2793600**	**1542900**	**175300**	**3717300**	**683900**	**61291600**

NUMBER OF FISH							
RIVER / YEAR	FRY	0+PARR	1PARR	1+PARR	1SMOLT	2SMOLT	TOTAL
Upper St. John	2165000	1456700	14700	0	5100	27700	3669200
Aroostook	1348300	317100	36800	1800	32600	29800	1766400
St. Croix	1263000	387600	158100	200	747200	20100	2576200
Dennys	857000	18700	400	0	152700	25000	1053800
Pleasant	187000	2500	1800	0	54700	15100	261100
East Machias	556000	6500	42600	0	108400	25400	738900
Machias	1159000	92800	117800	0	177700	13000	1560300
Narraguagus	858000	44700	14625	0	106800	43000	1067125
Union	258000	289300	0	0	361700	172000	1081000
Penobscot	9950000	2407000	1326200	0	9256600	2149400	25089200
Ducktrap	83000	0	0	0	0	0	83000
Sheepscot	581000	80100	20600	0	91200	3600	776500
Saco	1568000	323500	201200	0	284700	0	2377400
Cocheco	1146000	50000	9500	1000	5300	0	1211800
Lamprey	1041000	427700	56400	2100	141400	32800	1701400
Merrimack	22300000	227500	416200	174300	1161000	635900	24914900
Pawcatuck	2768612	1209200	254600	8573	52672	500	4294157
Connecticut	52378600	2793600	1542900	175300	3717300	683900	61291600
TOTAL	**100467512**	**10134500**	**4214425**	**363273**	**16457072**	**3877200**	**135513982**

GRAND TOTAL BY RIVER (1970-1998)

Table 3.2.b. ATLANTIC SALMON RETURNS TO NEW ENGLAND RIVERS - (includes trap & rod caught salmon)

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

RIVER		HATCHERY ORIGIN				WILD ORIGIN				
	YEAR	1-S-W	2-S-W	3-S-W	REPEAT	1-S-W	2-S-W	3-S-W	REPEAT	TOTAL
PENOBSCOT										
	1970	7	124	1	2	0	2	0	0	136
	1971	21	89	1	1	0	2	0	0	114
	1972	11	311	4	1	0	10	0	0	337
	1973	10	290	2	7	0	2	0	0	311
	1974	31	516	24	9	0	1	0	0	581
	1975	45	917	11	19	0	8	0	0	1000
	1976	75	563	4	6	0	20	0	0	668
	1977	44	581	4	12	0	3	0	0	644
	1978	123	1547	12	26	0	55	0	0	1763
	1979	203	671	3	15	0	8	0	0	900
	1980	652	2570	2	38	0	18	2	0	3282
	1981	888	2454	12	24	3	18	2	0	340
	1982	155	3886	20	20	13	55	1	3	4153
	1983	179	705	6	13	5	51	1	1	961
	1984	239	1387	6	45	25	107	2	0	1811
	1985	244	2868	6	9	22	202	1	4	3356
	1986	534	3620	14	8	17	332	3	1	4529
	1987	749	1477	29	49	19	162	5	20	2510
	1988	716	1993	6	52	14	64	0	10	2855
	1989	867	2005	4	36	67	103	1	4	3087
	1990	430	2520	14	26	93	254	3	2	3342
	1991	176	1085	4	21	40	427	0	4	1757
	1992	932	1174	0	5	27	236	1	4	2379
	1993	349	1279	7	13	22	92	1	6	1769
	1994	265	630	2	5	48	93	0	6	1049
	1995	158	1077	7	9	6	84	0	1	1342
	1996	482	1187	6	14	13	335	3	5	2045
	1997	241	914	4	13	6	174	2	1	1355
	1998	240	796	0	10	29	130	1	4	1210
	TOTAL	**9066**	**39236**	**215**	**508**	**469**	**3048**	**29**	**76**	**52647**
UNION										
	1970									
	1971									
	1972									
	1973	3	72	0	0	0	0	0	0	75
	1974	6	13	1	0	0	0	0	0	20
	1975	23	56	0	0	0	0	0	0	79
	1976	90	158	0	0	0	0	0	0	248
	1977	13	222	1	8	0	0	0	0	244
	1978	4	147	2	4	0	0	0	0	157
	1979	6	38	0	1	0	0	0	0	45
	1980	42	197	0	1	0	0	0	0	240
	1981	10	284	1	0	0	0	0	0	295
	1982	30	118	1	7	0	0	0	0	156
	1983	25	116	1	2	0	4	0	0	148
	1984	3	37	0	0	0	0	0	0	40
	1985	3	79	0	0	0	0	0	0	82
	1986	7	59	1	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	1	0	0	0	0	0	30
	1990	1	20	0	0	0	0	0	0	21
	1991	1	1	0	0	1	5	0	0	8
	1992	0	4	0	0	0	0	0	0	4
	1993	0	0	0	0	0	0	0	0	0
	1994									
	1995									
	1996	6	62	0	0	0	1	0	0	69
	1997	0	8	0	0	0	0	0	0	8
	1998	2	7	0	4	0	0	0	0	13
	TOTAL	**298**	**1811**	**9**	**28**	**1**	**12**	**0**	**0**	**2159**

RIVER	HATCHERY ORIGIN				WILD ORIGIN				
YEAR	1-S-W	2-S-W	3-S-W	REPEAT	1-S-W	2-S-W	3-S-W	REPEAT	TOTAL
NARRAGUAGUS									
1970	1	13	0	0	0	120	7	5	146
1971	2	33	0	0	3	67	3	0	108
1972	1	81	7	0	3	211	17	13	333
1973	2	22	2	2	1	135	3	3	170
1974	3	20	2	1	1	118	6	12	163
1975	0	2	0	0	0	103	2	4	111
1976	0	4	0	0	0	25	0	3	32
1977	2	5	0	0	1	105	0	11	124
1978	0	35	0	0	0	94	2	2	133
1979	0	9	0	0	0	49	0	0	58
1980	0	0	0	0	0	112	0	3	115
1981	1	20	0	1	0	49	0	2	73
1982	0	11	0	1	0	57	0	10	79
1983	2	17	0	0	0	69	0	2	90
1984	0	10	0	0	0	57	0	1	68
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	1	10	0	0	2	24	0	1	38
1989	3	9	0	0	1	26	0	0	39
1990	1	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	1	0	0	0	4	42	0	4	51
1995	0	0	0	0	0	51	0	5	56
1996	1	7	0	0	9	42	0	5	64
1997	0	2	0	0	1	30	0	4	37
1998	0	0	0	0	1	18	0	3	22
TOTAL	**30**	**417**	**11**	**15**	**54**	**1885**	**40**	**110**	**2562**
PLEASANT									
1970	0	0	0	0	0	1	0	0	1
1971	0	0	0	0	0	1	0	0	1
1972	0	0	0	0	0	1	0	0	1
1973	0	0	0	0	0	2	0	0	2
1974	0	0	0	0	2	27	1	0	30
1975	0	0	0	0	1	6	1	0	8
1976	0	0	0	0	0	1	0	0	1
1977	0	0	0	0	0	3	0	0	3
1978	0	0	0	0	0	16	0	0	16
1979	0	0	0	0	0	8	0	0	8
1980	0	0	0	0	0	5	0	0	5
1981	0	0	0	0	0	23	0	0	23
1982	4	8	0	0	0	6	0	1	19
1983	0	0	0	0	2	35	0	1	38
1984	0	0	0	0	1	16	0	0	17
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									
TOTAL	**4**	**12**	**0**	**0**	**10**	**204**	**2**	**2**	**234**

RIVER	YEAR	HATCHERY ORIGIN				WILD ORIGIN				
	YEAR	1-S-W	2-S-W	3-S-W	REPEAT	1-S-W	2-S-W	3-S-W	REPEAT	TOTAL
MACHIAS										
	1970	0	13	1	0	0	211	6	9	240
	1971	2	26	1	0	1	137	5	4	176
	1972	5	69	4	0	3	180	5	3	269
	1973	0	7	0	0	0	28	0	0	35
	1974	4	6	0	0	0	26	0	0	36
	1975	0	10	0	0	5	36	0	0	51
	1976	2	5	0	0	0	18	0	0	25
	1977	2	8	0	0	0	15	0	0	25
	1978	0	15	0	0	0	87	0	3	105
	1979	0	8	0	0	0	58	0	0	66
	1980	0	13	0	0	0	58	0	7	78
	1981	0	19	0	0	0	31	0	3	53
	1982	0	0	1	0	1	52	0	2	56
	1983	0	0	0	0	0	16	0	1	17
	1984	0	8	0	0	2	21	0	2	33
	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	1	0	0	0	1	0	0	2
	1991	1	0	0	0	1	0	0	0	2
	1992	0	3	0	0	0	0	0	0	3
	1993	0	2	0	0	1	12	0	0	15
	1994									
	1995									
	1996									
	1997									
	1998									
	TOTAL	**21**	**238**	**7**	**0**	**20**	**1051**	**16**	**40**	**1393**
EAST MACHIAS										
	1970	0	0	0	0	0	1	0	0	1
	1971	0	1	0	0	0	5	0	0	6
	1972	0	1	0	0	0	3	0	0	4
	1973	0	1	0	0	0	5	0	0	6
	1974	0	1	0	0	0	1	0	0	2
	1975	0	8	0	0	0	20	0	2	30
	1976	2	16	0	2	0	0	0	0	20
	1977	0	9	1	0	0	19	0	1	30
	1978	0	13	0	0	0	46	0	0	59
	1979	0	7	0	0	0	18	0	0	25
	1980	0	24	0	0	2	34	0	2	62
	1981	4	67	0	0	4	24	0	1	100
	1982	0	15	0	0	0	22	0	0	37
	1983	0	3	0	0	0	5	0	0	8
	1984	0	9	0	0	3	33	0	2	47
	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	1	0	14
	1988	1	8	0	0	0	5	0	0	14
	1989	12	10	0	0	2	6	0	1	31
	1990	1	30	0	0	0	16	0	1	48
	1991	1	2	0	0	1	1	0	0	5
	1992	0	6	0	0	0	0	0	0	6
	1993	0	0	0	0	0	0	0	0	0
	1994									
	1995									
	1996									
	1997									
	1998									
	TOTAL	**21**	**244**	**1**	**2**	**12**	**307**	**1**	**10**	**598**

RIVER	HATCHERY ORIGIN				WILD ORIGIN				
YEAR	1-S-W	2-S-W	3-S-W	REPEAT	1-S-W	2-S-W	3-S-W	REPEAT	TOTAL
DENNYS									
1970	0	0	0	0	0	49	0	0	49
1971	0	0	0	0	0	19	0	0	19
1972	0	0	0	0	0	61	0	0	61
1973	0	0	0	0	0	40	0	0	40
1974	1	0	0	0	3	43	0	3	50
1975	0	0	0	0	0	40	0	0	40
1976	0	0	0	0	2	13	0	5	20
1977	0	0	0	0	0	26	0	0	26
1978	0	37	0	0	0	38	0	0	75
1979	0	0	0	0	0	36	0	2	38
1980	0	117	0	0	0	73	0	0	190
1981	6	74	0	0	0	43	3	0	126
1982	3	15	0	0	6	14	0	0	38
1983	0	0	0	0	0	28	0	0	28
1984	0	0	0	0	7	61	0	0	68
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	1	0	0	1
1988	0	3	0	0	0	6	0	0	9
1989	1	10	0	0	0	1	0	0	12
1990	1	20	0	1	0	11	0	0	33
1991	1	0	0	0	0	6	0	0	7
1992	1	3	0	0	0	1	0	0	5
1993	7	2	0	0	0	4	0	0	13
1994	0	0	0	0	1	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	1	0	0	1
TOTAL	**21**	**294**	**0**	**1**	**22**	**654**	**3**	**10**	**1005**
ST. CROIX									
1970									
1971									
1972									
1973									
1974									
1975									
1976									
1977									
1978									
1979									
1980									
1981	25	14	1	0	24	14	1	0	79
1982	28	1	0	0	56	13	1	0	99
1983	14	62	4	0	11	28	3	0	122
1984	138	50	5	0	39	11	1	0	244
1985	28	144	14	0	28	122	14	0	350
1986	34	116	13	0	33	116	13	0	325
1987	108	63	1	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	1	0	0	0	0	0	0	0	1
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
TOTAL	**671**	**1084**	**38**	**12**	**433**	**667**	**39**	**17**	**2961**

RIVER	HATCHERY ORIGIN				WILD ORIGIN				
YEAR	1-S-W	2-S-W	3-S-W	REPEAT	1-S-W	2-S-W	3-S-W	REPEAT	TOTAL
KENNEBEC									
1970									
1971									
1972									
1973									
1974									
1975	2	30	0	0	0	1	0	0	33
1976	0	2	2	0	0	0	0	0	4
1977	0	2	0	0	0	0	0	0	2
1978	0	2	0	0	0	0	0	0	2
1979	0	18	0	0	0	2	0	0	20
1980	1	3	0	0	0	0	0	0	4
1981	1	13	0	0	0	0	0	0	14
1982	1	22	1	0	0	0	0	0	24
1983	1	16	1	0	0	0	0	0	18
1984	0	1	0	0	0	0	0	0	1
1985	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0
1987	0	2	1	0	0	2	0	0	5
1988	4	15	0	1	0	0	0	0	20
1989	1	16	0	0	0	0	0	0	17
1990	1	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
1993	0	2	0	0	0	0	0	0	2
1994									
1995									
1996									
1997									
1998									
TOTAL	**12**	**189**	**5**	**1**	**0**	**9**	**0**	**0**	**216**
ANDROSCOGGIN									
1970									
1971									
1972									
1973									
1974									
1975									
1976									
1977									
1978									
1979									
1980									
1981									
1982									
1983	1	16	0	0	0	3	0	1	21
1984	4	79	1	0	0	7	0	0	91
1985	1	18	0	0	0	2	0	0	21
1986	0	72	1	0	0	8	0	0	81
1987	2	20	3	0	0	1	0	0	26
1988	2	11	0	0	1	0	0	0	14
1989	1	17	0	0	0	1	0	0	19
1990	6	168	0	1	1	9	0	0	185
1991	0	9	0	0	0	12	0	0	21
1992	2	9	0	0	1	3	0	0	15
1993	1	33	0	0	1	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	1	0	1	16	0	0	39
1997	0	0	0	0	0	1	0	0	1
1998	0	4	0	0	0	0	0	0	4
TOTAL	**26**	**503**	**6**	**2**	**5**	**80**	**0**	**1**	**623**

RIVER	HATCHERY ORIGIN				WILD ORIGIN				
YEAR	1-S-W	2-S-W	3-S-W	REPEAT	1-S-W	2-S-W	3-S-W	REPEAT	TOTAL
SHEEPSCOT									
1970	0	0	0	0	1	5	0	0	6
1971	0	0	0	0	2	27	1	0	30
1972	0	0	0	0	1	18	1	0	20
1973	0	0	0	0	1	18	1	0	20
1974	0	0	0	0	1	18	1	0	20
1975	0	0	0	0	1	10	0	0	11
1976	0	0	0	0	1	9	0	0	10
1977	0	0	0	0	1	22	1	0	24
1978	0	0	0	0	2	32	1	0	35
1979	0	0	0	0	1	7	0	0	8
1980	0	0	0	0	2	27	1	0	30
1981	0	0	0	0	1	14	0	0	15
1982	0	0	0	0	1	14	0	0	15
1983	0	0	0	0	1	11	0	0	12
1984	0	0	0	0	1	20	1	0	22
1985	0	0	0	0	1	5	0	0	6
1986	0	0	0	0	1	10	0	0	11
1987	2	7	0	0	1	5	0	0	15
1988	1	0	0	0	0	0	0	0	1
1989	1	1	0	0	2	1	0	0	5
1990	1	8	0	0	0	0	0	0	9
1991	0	4	0	0	0	0	0	0	4
1992	1	2	0	0	1	2	1	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									
TOTAL	**6**	**38**	**0**	**0**	**27**	**317**	**9**	**0**	**397**

RIVER	HATCHERY ORIGIN				WILD ORIGIN				
YEAR	1-S-W	2-S-W	3-S-W	REPEAT	1-S-W	2-S-W	3-S-W	REPEAT	TOTAL
DUCKTRAP									
1970									
1971									
1972									
1973									
1974									
1975									
1976									
1977									
1978									
1979									
1980									
1981									
1982									
1983									
1984									
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
1994									
1995									
1996									
1997									
1998									
TOTAL	**0**	**0**	**0**	**0**	**3**	**30**	**0**	**0**	**33**

RIVER		HATCHERY ORIGIN				WILD ORIGIN				
	YEAR	1-S-W	2-S-W	3-S-W	REPEAT	1-S-W	2-S-W	3-S-W	REPEAT	TOTAL
SACO										
	1970									
	1971									
	1972									
	1973									
	1974									
	1975									
	1976									
	1977									
	1978									
	1979									
	1980									
	1981									
	1982									
	1983									
	1984									
	1985	2	58	0	0	0	0	0	0	60
	1986	0	36	1	0	0	0	0	0	37
	1987	4	34	1	0	0	1	0	0	40
	1988	1	37	0	0	0	0	0	0	38
	1989	2	16	0	1	0	0	0	0	19
	1990	4	68	0	0	0	1	0	0	73
	1991	0	4	0	0	0	0	0	0	4
	1992	0	0	0	0	0	0	0	0	0
	1993	4	54	0	1	0	0	0	0	59
	1994	6	17	0	0	0	0	0	0	23
	1995	0	34	0	0	0	0	0	0	34
	1996	11	39	1	3	0	0	0	0	54
	1997	5	23	0	0	0	0	0	0	28
	1998	9	7	0	0	4	7	1	0	28
	TOTAL	**48**	**427**	**3**	**5**	**4**	**9**	**1**	**0**	**497**
COCHECO										
	1970									
	1971									
	1972									
	1973									
	1974									
	1975									
	1976									
	1977									
	1978									
	1979									
	1980									
	1981									
	1982									
	1983									
	1984									
	1985									
	1986									
	1987									
	1988									
	1989									
	1990									
	1991									
	1992	0	0	0	0	0	1	0	0	1
	1993	0	0	1	1	1	2	0	0	5
	1994	0	0	0	0	0	0	0	0	0
	1995	0	0	0	0	0	1	0	0	1
	1996	0	0	0	0	2	0	0	0	2
	1997	0	0	0	0	0	0	0	0	0
	1998	0	0	0	0	0	0	0	0	0
	TOTAL	**0**	**0**	**1**	**1**	**3**	**4**	**0**	**0**	**9**

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
LAMPREY										
	1970									
	1971									
	1972									
	1973									
	1974									
	1975									
	1976									
	1977									
	1978									
	1979	2	0	0	0	0	0	0	0	2
	1980	2	5	0	0	0	0	0	0	7
	1981	2	0	0	0	0	0	0	0	2
	1982	2	9	0	0	0	0	0	0	11
	1983	2	0	1	0	0	0	0	0	3
	1984	0	3	0	0	0	0	0	0	3
	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	1	7	0	0	8
	1994	0	0	0	0	0	3	0	0	3
	1995	0	0	0	0	0	1	0	0	1
	1996	0	0	0	0	0	1	0	0	1
	1997	0	0	0	0	0	0	0	0	0
	1998	0	0	0	0	0	0	0	0	0
	TOTAL	**10**	**17**	**1**	**0**	**1**	**14**	**0**	**0**	**43**
MERRIMACK										
	1970									
	1971									
	1972									
	1973									
	1974									
	1975									
	1976									
	1977									
	1978									
	1979									
	1980									
	1981									
	1982	3	14	0	0	4	2	0	0	23
	1983	7	54	5	0	1	41	6	0	114
	1984	64	20	0	0	16	12	3	0	115
	1985	8	112	1	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	1	0	65
	1989	3	24	1	0	0	55	1	0	84
	1990	3	115	1	0	24	104	1	0	248
	1991	1	76	0	0	0	254	1	0	332
	1992	17	66	2	0	14	100	0	0	199
	1993	0	27	1	1	2	30	0	0	61
	1994	0	2	0	0	1	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	1	0	19	47	0	0	123
	TOTAL	**170**	**803**	**18**	**8**	**108**	**888**	**23**	**3**	**2021**

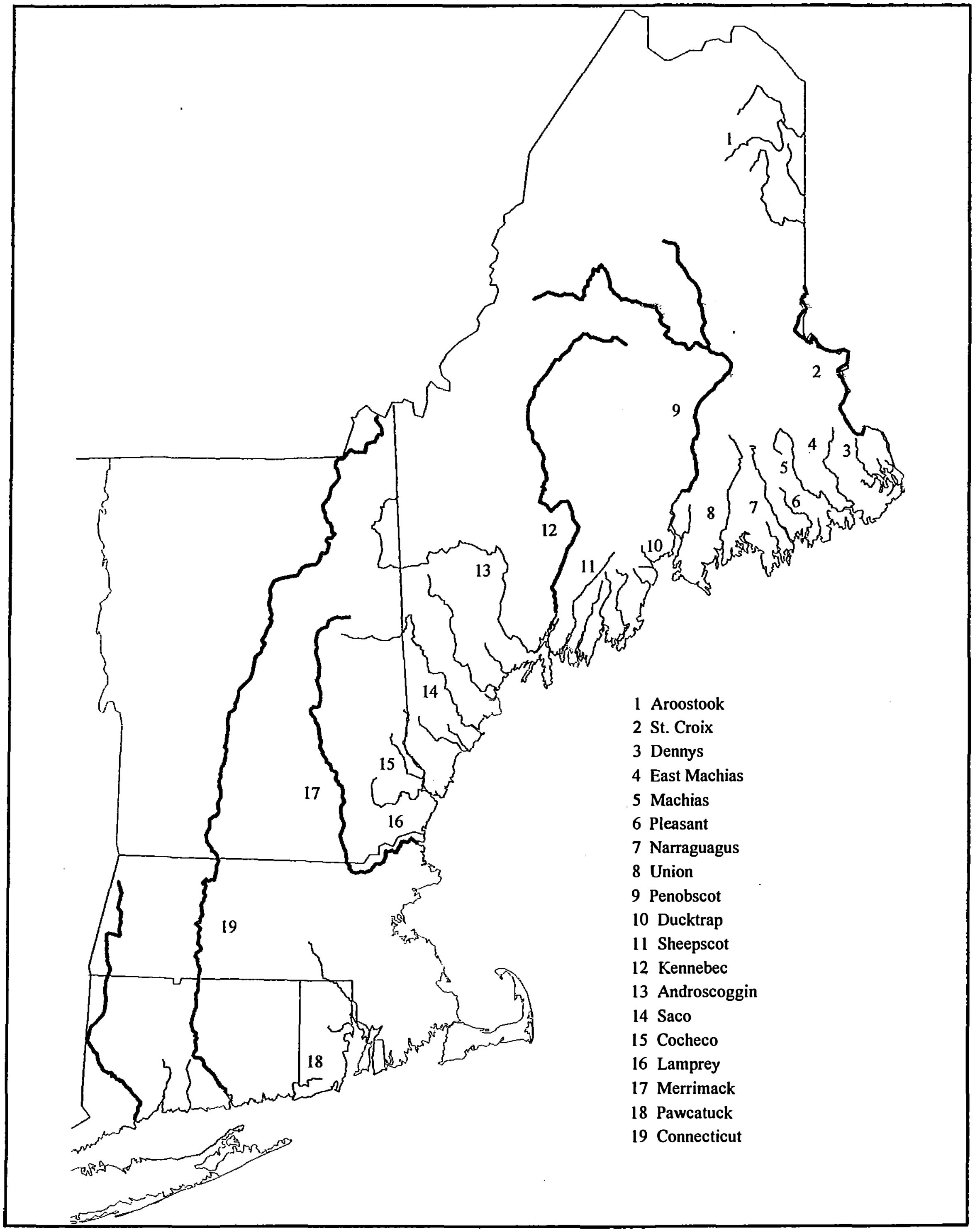
RIVER	HATCHERY ORIGIN				WILD ORIGIN				
YEAR	1-S-W	2-S-W	3-S-W	REPEAT	1-S-W	2-S-W	3-S-W	REPEAT	TOTAL
PAWCATUCK									
1970									
1971									
1972									
1973									
1974									
1975									
1976									
1977									
1978									
1979									
1980									
1981									
1982	0	38	0	0	0	0	0	0	38
1983	1	37	0	0	0	0	0	0	38
1984	0	26	0	0	0	0	0	0	26
1985	0	1	0	0	0	0	0	0	1
1986	0	0	0	0	0	0	0	0	0
1987	0	1	0	0	0	0	0	0	1
1988	0	5	1	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	6	0	0	0	0	0	0	6
1993	0	2	0	0	0	1	0	0	3
1994	0	2	0	0	0	0	0	0	2
1995	0	2	0	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	1	2	0	0	3
TOTAL	**1**	**141**	**1**	**0**	**1**	**6**	**0**	**0**	**150**
CONNECTICUT									
1970									
1971									
1972									
1973									
1974	0	1	0	0	0	0	0	0	1
1975	0	3	0	0	0	0	0	0	3
1976	0	2	0	0	0	0	0	0	2
1977	0	7	0	0	0	0	0	0	7
1978	3	90	0	0	0	0	0	0	93
1979	4	50	4	0	0	0	0	0	58
1980	4	164	7	0	0	0	0	0	175
1981	6	513	10	0	0	0	0	0	529
1982	3	57	0	0	0	10	0	0	70
1983	0	39	0	0	0	0	0	0	39
1984	7	65	0	0	2	18	0	0	92
1985	0	293	0	0	0	17	0	0	310
1986	0	275	0	0	0	43	0	0	318
1987	0	343	5	0	0	0	5	0	353
1988	1	93	0	0	0	1	0	0	95
1989	1	58	0	0	1	48	1	0	109
1990	1	226	0	0	0	36	0	0	263
1991	0	168	1	0	0	34	0	0	203
1992	3	353	1	0	5	127	1	0	490
1993	0	136	0	0	0	61	1	0	198
1994	1	263	0	1	0	61	0	0	326
1995	1	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	1	0	199
1998	0	0	0	0	8	290	0	2	300
TOTAL	**35**	**3500**	**28**	**2**	**27**	**1077**	**9**	**3**	**4681**
GRAND TOTAL	**10440**	**48954**	**344**	**585**	**1200**	**10262**	**172**	**272**	**72229**

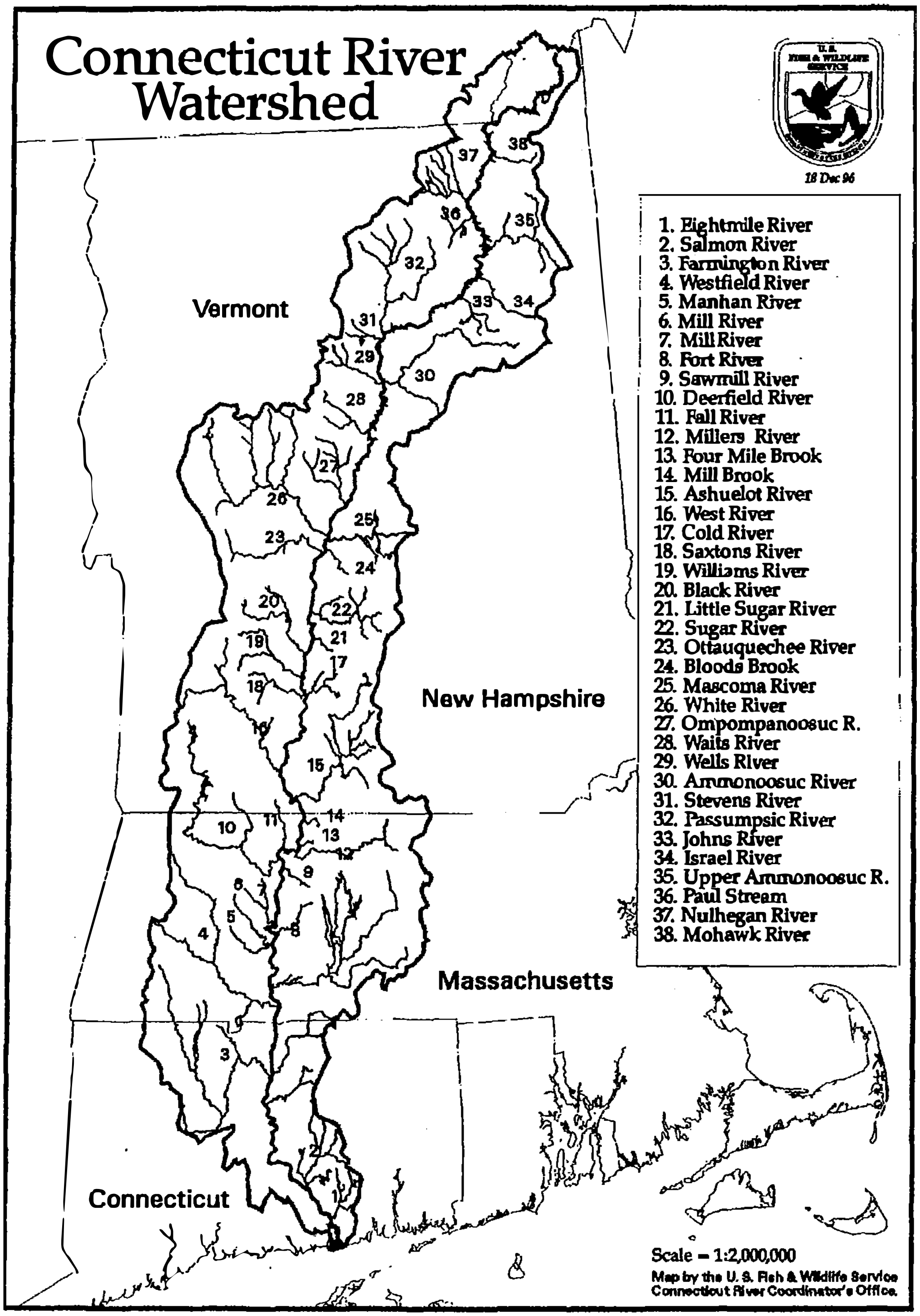
RIVER	HATCHERY ORIGIN				WILD ORIGIN				
YEAR	1-S-W	2-S-W	3-S-W	REPEAT	1-S-W	2-S-W	3-S-W	REPEAT	TOTAL
PENOBSCOT	9066	39236	215	508	469	3048	29	76	52647
UNION	298	1811	9	28	1	12	0	0	2159
NARRAGUAGUS	30	417	11	15	54	1885	40	110	2562
PLEASANT	4	12	0	0	10	204	2	2	234
MACHIAS	21	238	7	0	20	1051	16	40	1393
E. MACHIAS	21	244	1	2	12	307	1	10	598
DENNYS	21	294	0	1	22	654	3	10	1005
ST. CROIX	671	1084	38	12	433	667	39	17	2961
KENNEBEC	12	189	5	1	0	9	0	0	216
ANDROSCOGGIN	26	503	6	2	5	80	0	1	623
SHEEPSCOT	6	38	0	0	27	317	9	0	397
DUCKTRAP	0	0	0	0	3	30	0	0	33
SACO	48	427	3	5	4	9	1	0	497
COCHECO	0	0	1	1	3	4	0	0	9
LAMPREY	10	17	1	0	1	14	0	0	43
MERRIMACK	170	803	18	8	108	888	23	3	2021
PAWCATUCK	1	141	1	0	1	6	0	0	150
CONNECTICUT	35	3500	28	2	27	1077	9	3	4681
TOTAL	**10440**	**48954**	**344**	**585**	**1200**	**10262**	**172**	**272**	**72229**

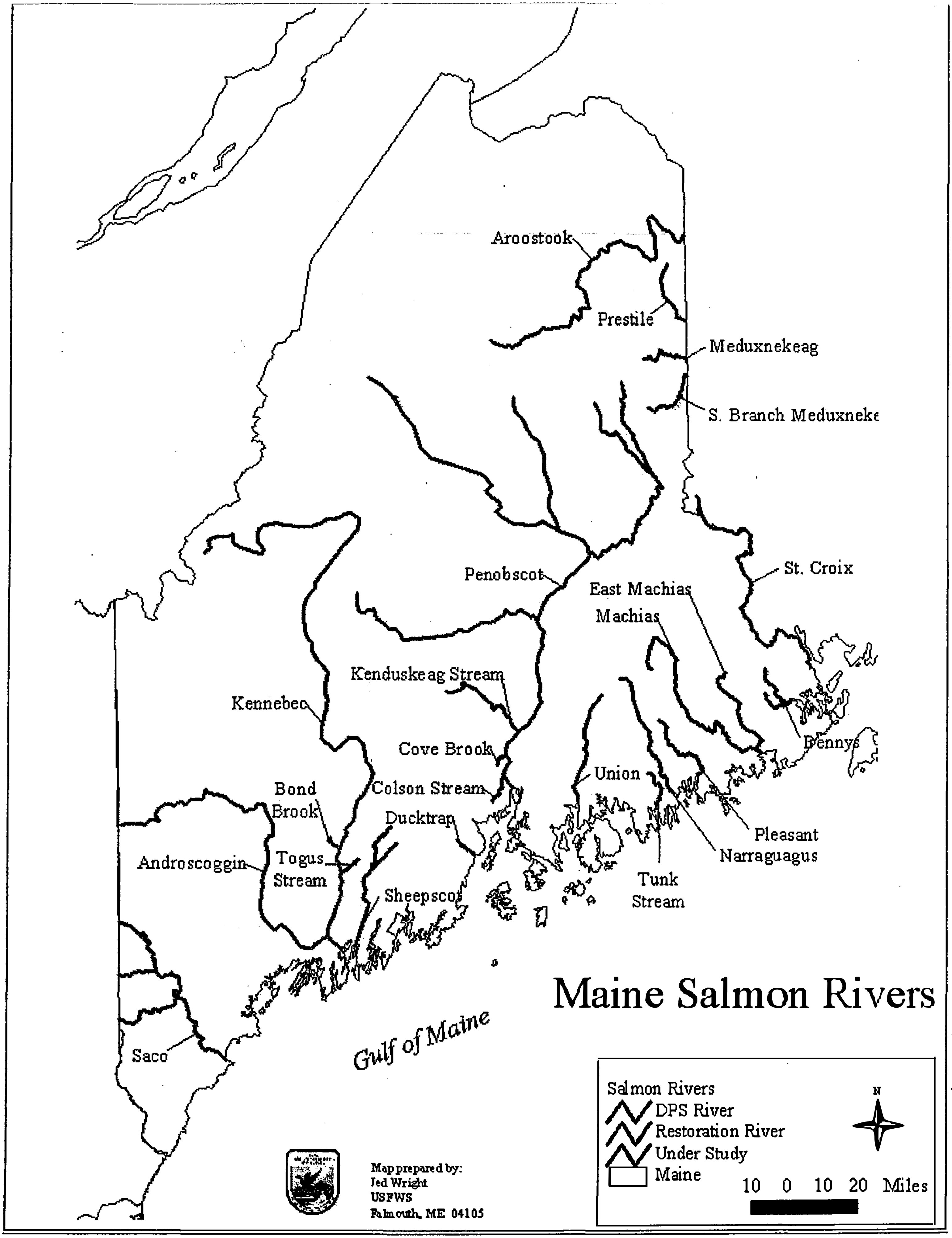
GRAND TOTAL BY RIVER (1970-1998)

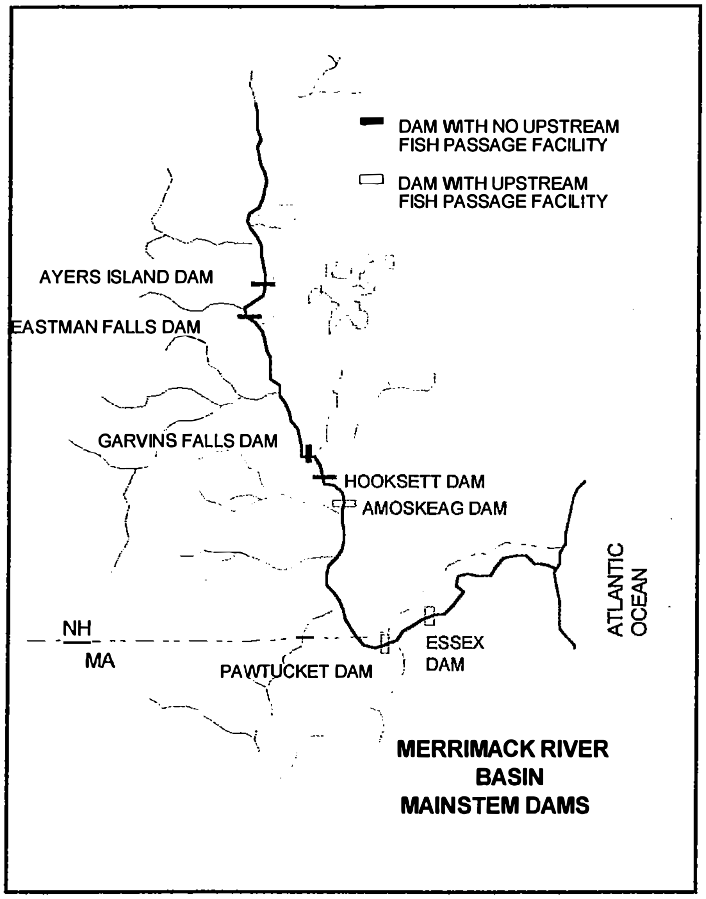
9.4. LOCATION MAPS

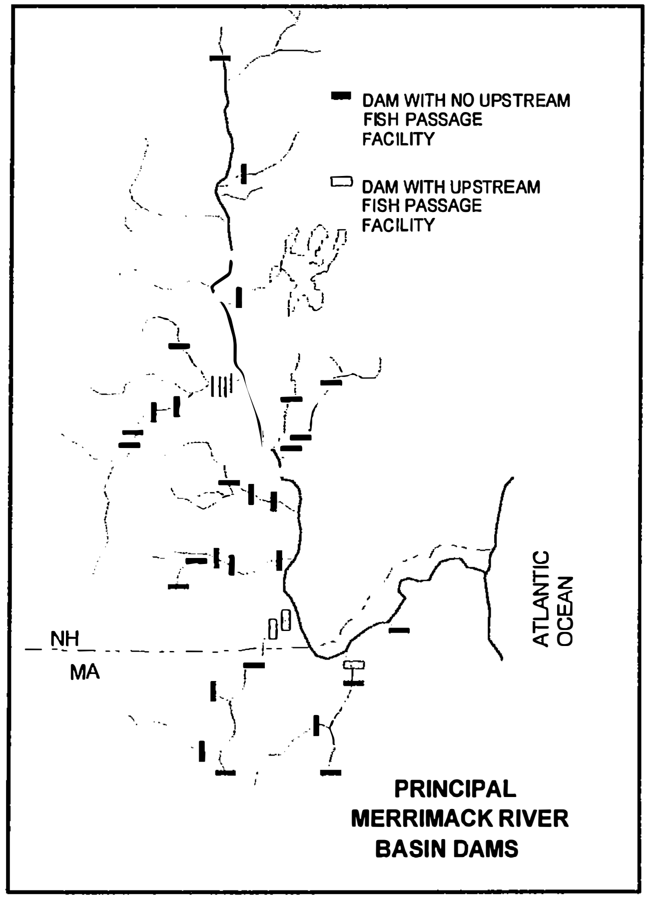
Important Atlantic Salmon Rivers of New England

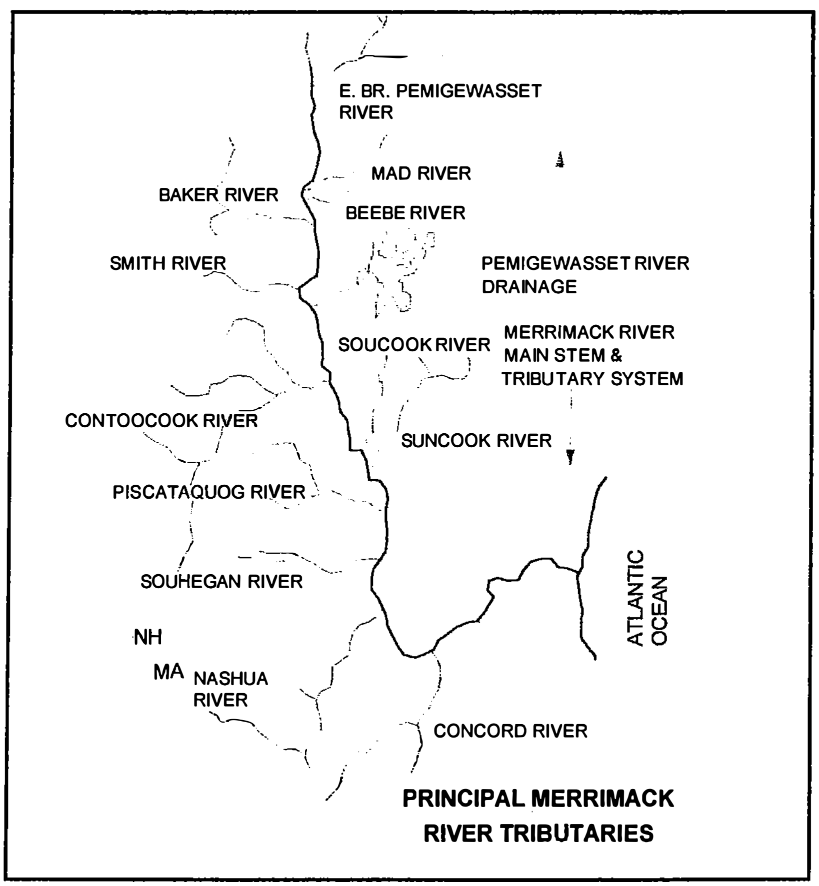



Connecticut River Watershed
U.S. FISH & WILDLIFE SERVICE
18 Dec 96
Vermont
New Hampshire
Massachusetts
Connecticut
1. Eightmile River
2. Salmon River
3. Farmington River
4. Westfield River
5. Manhan River
6. Mill River
7. Mill River
8. Fort River
9. Sawmill River
10. Deerfield River
11. Fall River
12. Millers River
13. Four Mile Brook
14. Mill Brook
15. Ashuelot River
16. West River
17. Cold River
18. Saxtons River
19. Williams River
20. Black River
21. Little Sugar River
22. Sugar River
23. Ottauquechee River
24. Bloods Brook
25. Mascoma River
26. White River
27. Ompompanoosuc R.
28. Waits River
29. Wells River
30. Ammonoosuc River
31. Stevens River
32. Passumpsic River
33. Johns River
34. Israel River
35. Upper Ammonoosuc R.
36. Paul Stream
37. Nulhegan River
38. Mohawk River
Scale = 1:2,000,000
Map by the U. S. Fish & Wildlife Service
Connecticut River Coordinator's Office.


Maine Salmon Rivers
Aroostook
Prestile
Meduxnekeag
S. Branch Meduxneke
St. Croix
Penobscot
East Machias
Machias
Kenduskeag Stream
Kennebec
Dennys
Cove Brook
Union
Bond Brook
Colson Stream
Ducktrap
Pleasant
Narraguagus
Androscoggin
Togus Stream
Tunk Stream
Sheepscot
Saco
Gulf of Maine
Salmon Rivers
DPS River
Restoration River
Under Study
Maine
N
10 0 10 20 Miles
Map prepared by:
Jed Wright
USFWS
Falmouth, ME 04105


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
ATLANTIC OCEAN
NH
MA
PAWTUCKET DAM
ESSEX DAM
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


E. BR. PEMIGEWASSET RIVER
MAD RIVER
BAKER RIVER
BEEBE RIVER
SMITH RIVER
PEMIGEWASSET RIVER DRAINAGE
SOUCOOK RIVER
MERRIMACK RIVER MAIN STEM & TRIBUTARY SYSTEM
CONTOOCOOK RIVER
SUNCOOK RIVER
PISCATAQUOG RIVER
SOUHEGAN RIVER
ATLANTIC OCEAN
NH
MA
NASHUA RIVER
CONCORD RIVER
PRINCIPAL MERRIMACK RIVER TRIBUTARIES