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

REPORT NO. 8 - 1995 ACTIVITIES

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PREPARED FOR
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1. INTRODUCTION

1.1. EXECUTIVE SUMMARY

The 1996 Annual Meeting of the U.S. Atlantic Salmon Assessment Committee, scheduled for February 5 - 9, was canceled because of the federal furlough situation in December and January and associated budgetary unknowns. The furlough of various members of the Committee resulted in inadequate support for the meeting. The Committee chairperson scheduled a one-day meeting in March to produce the annual report, although at a very basic level.

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 12,650,000 juvenile salmon (fry, parr, and smolts) were stocked. Of these, 1,141 parr and 2,124 smolts carried Visual Implant tags.

A total of 1,773 salmon was documented to have returned to U.S. waters in 1995, of which 87% (1,545) was counted in Maine rivers. Since many of Maine's rivers do not have counting facilities, and facilities that do operate throughout New England are not 100% effective, a system was implemented to estimate total adult returns in Maine and to New England rivers. The estimated returns using this method were 2,233 in Maine rivers and 2,489 in all New England rivers. There were 502 fish with CWT (47 one-sea-winter (1SW), 453 two-sea-winter (2SW) salmon), two repeat spawners (RP), and one with a Carlin tag (RP) which returned to U.S. rivers in 1995.

Prior to June 9, 1995, the sport fishery for Atlantic salmon in Maine was restricted to one salmon per angler per year, and no salmon longer than 64 cm could be retained. However, on June 9, the sport fishery regulations were modified to encompass only catch-and-release throughout the state. The estimated catch of salmon in Maine was 370 fish caught and released.

Atlantic salmon egg production for the New England program approached 19,362,000 (3,861,000 sea-run, 11,909,000 domestic, 1,371,000 captive, and 2,221,000 reconditioned kelts). The egg production was still less than the desired number.

As special topics, Dr. Steve McCormick and Kevin Whalen of the National Biological Service (NBS) submitted the papers included within section 4 of the report. These papers were not reviewed by the committee because of the cancellation of the working group meeting but were included because of their relevance.

1.2. BACKGROUND

The U.S. became a charter member of the North Atlantic Salmon Conservation Organization (NASCO) in 1984. NASCO is charged with the international management of Atlantic salmon stocks on the high seas. Three Commissioners for the U.S. are appointed by the President and work under the auspices of the U.S. State Department. The Commissioners felt they needed advice and input from scientists involved in salmon research and management throughout New

England and asked the New England Atlantic Salmon Committee (NEASC) to create such an advisory committee. NEASC is comprised of State and Federal fishery agency chiefs who designated personnel from their staff to serve on the "NASCO Research Committee", which was formed in 1985.

The NASCO research Committee met semiannually to discuss the terms of reference for upcoming meetings of the International Council for the Exploration of the Seas (ICES) and NASCO, as well as 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 annual stock assessment, proposal and evaluation of research needs and serve 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 New England Atlantic Salmon Committee (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 Atlantic Salmon and the Anadromous and Catadromous Fish Committee, which are composed of representatives of member countries are examples.

"Terms of Reference" constitute the task assignments given to the Atlantic Salmon Working Group by ICES from recommendations received from NASCO, the EEC, member countries of ICES, the ANACAT Committee or the Working Group itself. 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

Because of budgetary unknowns for the USFWS, NMFS, and USFS, as well as the furlough of employees of those agencies from mid-December through early January, the working group meeting was canceled. However, a one-day meeting was held on March 19, 1996 and the annual report was finalized by a number of the committee's members.

The annual report could not have been completed without the assistance of the entire committee as well as additional fisheries scientists from the participating agencies. I sincerely thank all those who were responsible for providing the necessary information such that this report could be drafted and reviewed on March 19. Plans are underway to hold a full working group meeting in 1997.

Lawrence W. Stolte, Chairman
U.S. Atlantic Salmon Assessment Committee

2. STATUS OF PROGRAM

2.1. GENERAL PROGRAM UPDATE

2.1.1. CONNECTICUT RIVER

2.1.1.a. Adult Returns

A total of 188 sea-run Atlantic salmon adults was documented to have returned to the Connecticut River watershed (Holyoke fishlift on the Connecticut River= 151; Rainbow fishway on the Farmington River= 22; Leesville dam on the Salmon River= 7; Decorative Specialties International dam on the Westfield River= 6 [netted below]; 1 was netted in Long Island Sound; and there was 1 lift mortality at the Holyoke fishlift). One of the fish was captured at the Holyoke fishlift on October 10 and the rest were part of a spring run that began April 25 and ended July 18. Peak return dates were May 21- June 20. A basin map is included within Appendix 11.2.

Fourteen of the salmon were released from the Holyoke fishlift (river km 138) and permitted to continue upstream. Four of these were observed to pass Turners Falls (MA) (river km 198), 5 passed Vernon (VT) (river km 228), and 1 passed Bellows Falls (VT) (river km 349). Two salmon were found dead in the river between Holyoke and Turners Falls, MA.

A total of 172 of the fish was retained for broodstock: 142 were transported to the Richard Cronin National Salmon Station (RCNSS) and 30 were transported to the Whittemore Salmon Station (WSS).

Age and origin information was derived from scales, CWT, and physical examination of each salmon. Origin information on salmon that were released at Holyoke was determined by presence or absence of an adipose fin clip. Of the 188 returning salmon 160 fish (85%) were stocked as smolts and 29 fish (15%) were stocked as fry. All wild salmon were 2 sea-winter fish as were 159 (99.4%) of the hatchery fish. One (0.6%) hatchery fish was a grilse. Freshwater age of fry-stocked salmon was comprised of 6 age 1+, 22 age 2+, and 1 age 3+ fish. The sex ratio of hatchery salmon was 84F:65M or 56% female. The sex ratio of wild salmon was 21F:5M or 81% female. The sex and ages of 11 hatchery and 3 fry-stocked fish is undetermined.

2.1.1.b. Hatchery Operations

U.S. Government furloughs due to a budget impasse in Washington, D.C. did not seriously interrupt the spawning schedules since most hatchery employees were designated as "essential" and remained on duty throughout the period. The possibility of transmission of whirling disease from trout at the Kensington State Salmon Hatchery (KSSH) to Atlantic salmon at KSSH and other facilities was investigated at the expense of some broodstock (for disease inspection) at those facilities. All Atlantic salmon sampled at KSSH and receiving hatcheries tested negative for the parasite.

Egg Collection

A grand total of 10,660,200 green eggs was produced at seven hatcheries within the basin. This is about a half million eggs less than in 1994. Decreased production is a result of a decreased sea-run return, domestic production variability, and sampling losses resulting from the need to examine fish for whirling disease.

Sea-Run Broodstock

A total of 945,500 eggs (9% of the grand total) was taken from 101 females held at the WSS and the RCNSS. A sample of the fertilized eggs from all sea-run crosses were again egg-banked at the WSS for disease screening and subsequent production of future domestic broodstock.

Domestic Broodstock

A total of 7,555,400 eggs (71% of the grand total) was taken from 1,258 domestic females held at the Roger Reed SFH, KSSH, Roxbury SFH, RCNSS, and White River National Fish Hatchery (WRNFH).

Kelts

A total of 2,159,300 eggs (20% of the grand total) was taken from 183 kelts held at the WSS, North Attleboro National Fish Hatchery (NANFH), and RCNSS.

2.1.1.c. Stocking

A total of 6,823,900 salmon fry was stocked into 24 tributaries. Of the total number of fish stocked, 6,001,300 (88%) were unfed fry and 816,800 (12%) were fed fry. This year, 823,900 more salmon were stocked than last year which again enabled the cooperators to expand the stocking program to include previously unstocked habitat. The Salmon River received 4,500 0+parr, and the Connecticut and Farmington rivers received a combined total of 1,300 smolts, which were grade-outs from the domestic broodstock program.

2.1.1.d Juvenile Population Status

Smolt Monitoring

Northeast Utilities Service Company (NUSCO) and the Sunderland Office of Fisheries

Assistance (SOFA) of the U.S. Fish and Wildlife Service (USFWS) contracted with Greenfield Community College to conduct a mark-recapture smolt population estimate. This was the third consecutive year that an estimate has been made by marking smolts at the Cabot Station bypass facility and recapturing them at the bypass facility in the Holyoke Canal some 54 km downstream. Thirty of the 2,580 marked smolts were recaptured resulting in wide confidence limits. A strike by NUSCO personnel, smolts migrating from tributaries between the marking and recapture points, and other methodology problems confounds the interpretation of the estimate. The population estimate was 70,244 (± 39,341) smolts passing Turners Falls from May 9-25. Assuming that catch at the sampler is proportional to the number of smolts migrating past it, then the estimate for the entire smolt run can be expanded to 92,308. The smolt run started in late April, peaked in mid-May and declined by early June. Scales sampled from smolts at Cabot Station revealed that most fish were two year-olds (92%) with some three-year olds (8%) present.

An estimate of 186,817 smolts produced in tributaries above Cabot Station was based on expanded electrofishing data from index stations and assumed overwinter mortality. Actual overwinter mortality is unknown and the estimate does not include smolt losses during migration, which may have been particularly high this year due to very low river flows. Large numbers of smolts, that were apparently delayed by the low flows, were observed lingering behind barriers throughout the watershed. Many smolts remained upriver well into June and thus would not have contributed to the smolt run.

This was the second year of a three-year smolt trapping research project on the West River. Cooperators include the Massachusetts Cooperative Fish and Wildlife Research Unit (MACFWRU), the Vermont Cooperative Fish and Wildlife Research Unit (VTCFWRU), the U.S. Forest Service (USFS), Vermont Department of Fish and Wildlife (VTFW), National Marine Fisheries Service (NMFS), and the National Biological Service (NBS). Counting fences made of aluminum conduit were used instead of fyke-net weirs on three West River tributaries in 1995. This resulted in greater ability to sample high flows and as a result trap efficiencies were higher and no washouts occurred. Age two smolts were dominant in all three tributaries, but age three smolts comprised up to 27% of the populations and an age four smolt was captured. Estimated production of two-year old smolts ranged from 0.39 to 1.45/100 m^2 in the three tributaries. Densities of two-year old parr remaining in the streams after smolt migration ceased were similar or higher than smolt densities. Estimated overwinter mortality ranged from 40-71%. Smolt migrations commenced in mid-April, peaked in early-mid May, and ceased by early June. Peak collections did not occur until water temperatures reached 8-10°C. Aggregates of smolts were observed immediately above the fences during the migration. At one of the sites, this persisted into early June. Very low stream flows may have delayed smolts causing reversion to parr and may have resulted in increased mortality from predation while they were concentrated. The smolt trap at the U.S. Army Corps of Engineers Townshend Dam on the West River was also monitored, but only two smolts were captured. The trap needs extensive modifications or relocation in order to operate successfully.

Index Station Electrofishing Surveys

Juvenile salmon populations were assessed by electrofishing in late summer at over 200 stations throughout the watershed by cooperating state and Federal agencies. Data were used to evaluate fry stocking, estimate survival rates, and estimate smolt production. Densities of parr varied widely throughout the watershed. Summer drought conditions dried up some small streams in Connecticut, eliminating production. Smolt production is expected to be slightly higher in 1996 than the record production of 1995. The expanded stocking area resulted in an increased in total production despite generally lower parr densities. Most smolts produced in 1996 are again expected to be two year olds with some yearlings and three year olds. Much of the yearling smolt production is expected from the Eightmile, Salmon, and Farmington River systems.

2.1.1.e Fish Passage

Significant progress was made on implementing downstream fish passage at hydroelectric dams on the mainstem Connecticut and its tributaries. On the mainstem, an angled curtain wall and bypass system was completed and tested at the Bellows Falls Project. Test results indicate the facilities were highly efficient in safely passing smolts. Some success was seen with a deflecting net structure in guiding smolts away from the Northfield Mountain Pumped Storage intake. A complete exclosure net is planned for 1996. The downstream passage facilities at the Holyoke, Turners Falls, and Vernon projects were evaluated in 1995. The results are being analyzed to improve passage at these facilities.

On tributaries to the mainstem, passage facilities were installed and are ready for operation at both the Comtu Falls and Cavendish Projects on the Black River, and new interim passage facilities were installed, for the first time, at 8 projects on the Passumpsic (5), Sugar (2), and Westfield (1) rivers. In addition, plans were developed, or are in development for permanent passage facilities at these 8 projects as well as 2 other Black River facilities. Construction of one of these facilities is almost complete, with the others scheduled for the summer of 1996.

Upstream passage facilities are under construction at the DSI/West Springfield Project on the Westfield River. This project is at the first dam on that river. A Denil ladder and trapping facility will be operable there in the spring of 1996. This will permit cooperators to capture returning salmon in the Westfield sub-basin. It will also facilitate upstream passage of American shad and blueback herring.

2.1.1.f. Genetics

Past practices to protect genetic variability during spawning operations were continued. This involved considerable coordination and cooperation among stations, particularly in the transfer of milt. Tissue samples were taken from all sea-run salmon and 200 domestic broodstock from KSSH for subsequent DNA analysis by the NBS. No tissues were sampled from other domestic broodstock since they all originated from KSSH broodstock.

2.1.1.g. General Program Information

The program emphasis has shifted from hatchery smolt production to natural smolt production from fry releases. The increase in fry stocking is a deliberate strategy whereas the elimination of the smolt production program is the result of budget constraints and fish health concerns. Program cooperators continue to review the role and performance of facilities within the basin and hope to identify a hatchery that can also resume the production and release of smolts. Increased fry production provided the program with the opportunity to stock additional habitat in 1995. The WRNFH has become a domestic broodstock station, with over two million eggs taken from domestic broodstock in 1995. Full production is expected in the fall of 1996.

Strategic Plan and Action Plan updates have not been completed. The Connecticut River Coordinator position has remained vacant although the position has been advertised. The USFWS is expected to fill the vacancy in 1996. Budgetary problems of cooperating States and the USFWS may hamper the ability of the program to meet its future egg production, stocking, and adult return goals.

2.1.2. MAINE PROGRAM

2.1.2.a Adult Returns

Partial adult salmon counts were made at weirs operated on the Dennys and Sheepscot Rivers; while total salmon counts at fishways were made on the St. Croix, Narraguagus, Penobscot, Androscoggin, and Saco rivers. Reports from anglers and redd counts in November were also utilized to estimate adult returns. Unfortunately, high water as a result of heavy rain in November prevented redd counts from being completed on most Maine rivers in 1995. Maine Atlantic salmon rivers are shown in Appendix 11.2.

Rivers With Native Salmon Runs

Dennys River. The Dennys River weir was operated from May 26 to July 6; trapping was discontinued due to high water temperatures and low river flows. The total salmon catch at the Dennys weir was nine fish, with 4 of the 9 (44%) determined to be of aquaculture origin based upon scale analysis and fish appearance. A new type of facility (a resistance board weir) was installed and operated intermittently in late October and early November. No fish were captured in 1995. However, this facility will be operated continuously in 1996.

About 20 salmon were caught and released by anglers fishing the Dennys River in 1995 but anecdotal information indicated that some of these salmon were of aquaculture origin. A total of 48 redds were counted in the Dennys River in the fall of 1995 and it appears that some of these redds may have been produced by aquaculture escapees.

Narraguagus River. Fifty-six salmon were counted at the Cherryfield fishway trapping facility (46 through the trap and 10 which jumped over the spillway), a return well below the spawning escapement target of 270 adults but slightly higher than 1994. All of the adult run were of wild origin in 1995. Anglers fishing the Narraguagus River were known to have caught and released 23 salmon during 1995.

Pleasant River. Although no adult trapping facilities were operated in the Pleasant River in 1995, a partial count of salmon redds was conducted and 8 redds found prior to heavy rains which occurred in November.

Sheepscot River. In 1995, a weir was installed just above tidewater and operated from May 27 to June 30. A total of 23 MSW salmon was enumerated and transported to Craig Brook NFH to be used as broodstock. One additional MSW salmon was observed by Maine Department of Marine Resources personnel above the weir (at the Coopers Mills fishway) in June, therefore the minimum, known salmon run was 24 fish. Scale samples were obtained from all 23 salmon in addition to observations at the trap for missing or deformed fins. Based on this information, 18 salmon used for spawning were determined to be of wild origin (one salmon was of hatchery origin, and four salmon died prior to spawning). Daily water temperatures were recorded during the time of trap operation and the maximum temperature recorded was 25 °C. There were no reported rod catches of Atlantic salmon in the Sheepscot River in 1995.

Machias, East Machias, and Ducktrap Rivers. Anglers caught and released five salmon on the Machias River and 22 salmon on the East Machias River. There was no reported rod catch in the Ducktrap River. A substantial number of the fish caught in the East Machias River (± 50%) were probably aquaculture escapees, based upon discussions with anglers.

Other Maine Restoration Rivers

Penobscot River. Total known adult returns to the Penobscot River were 1,342, an increase of 28% over the previous year. About 300 salmon (primarily MSW fish) were estimated to have been caught and released throughout the angling season. About 44% of the Penobscot salmon run (592 fish) were transported to Craig Brook National Fish Hatchery (CBNFH) for broodstock purposes. The estimated spawning escapement to the Penobscot River in 1995 was 184 MSW females, which represents 5% of the target spawning escapement for the river.

St. Croix River. A total of 60 salmon was captured at the Milltown Dam fishway during 1995, and 14 (23%) were determined to be of aquaculture origin through scale analysis and fish appearance. The St. Croix is the only river in Maine where salmon of aquaculture origin are deliberately allowed to continue upstream above monitoring facilities. Sixteen adult salmon broodstock were transported to Mactaquac Hatchery in Fredericton, N.B., by the Canadian Department of Fisheries and Oceans, and 10 were spawned in November providing about 76,700 eggs for future restoration programs in the St. Croix. An additional female salmon of aquaculture origin was mated with a wild male, producing an additional 10,000 eggs which may be used for research purposes.

Androscoggin River. Sixteen adult salmon were enumerated at the Brunswick Dam fishway.

Of these, two were of wild-origin and 14 were of hatchery origin (apparently strays from other rivers).

Saco River. A total of 34 adult salmon, all of hatchery origin, was enumerated at the new, state-of-the-art fish passage facilities (one fish-lift, one fishway) which were completed in 1993.

2.1.2.b. Hatchery Operations

Broodstocks (all sources) from six Maine rivers produced the following egg takes at Craig Brook National Fish Hatchery (CBNFH) in November:

East Machias River	143,700
Sheepscot River	122,000
Penobscot River	2,635,000
Dennys River	338,000
Machias River	511,800
Narraguagus River	394,400
	4,145,800

More than 1,300 native-origin parr were collected from six Maine rivers in 1995. These fish will be reared to maturity at CBNFH in order to provide river-specific hatchery stocks for future restoration efforts. Numbers of fish collected from individual rivers were: Dennys 207; East Machias 144; Machias 323; Narraguagus 362; Sheepscot 107; Pleasant 166 age 1+ parr and 34 young-of-year.

The new river-specific broodstock "receiving building" at the CBNFH was completed and became operational in November 1995 - in time for the Open House Celebration.

Smolts were reared at the Green Lake National Fish Hatchery (GLNFH) for release into the Merrimack River for the first time in 1995.

2.1.2.c. Stocking

Of the total of 2,189,000 salmon stocked in six Maine rivers in 1995, most (45%) were released at the feeding fry stage. The total number stocked was 18% less than in 1994 (2.7 million). A complete stocking summary is presented in Table 2.2.1.

2.1.2.d. Juvenile Salmon Population Status

Juvenile salmon population surveys were conducted at numerous historic index sites throughout the seven Maine drainages with wild salmon runs. Densities of young-of-year and parr (age 1+ and 2+ combined) were far below average in all rivers except at a few sites that had densities within long-term averages due to recent fry stocking programs. The population of age 1+ and older parr, based upon electrofishing at over 30 sites on the Narraguagus River is approximately

15,600 ± 13%. The low juvenile salmon populations throughout Maine rivers continue to be a direct result of insufficient spawning escapement in recent years.

2.1.2.e. Fish Passage

Penobscot River. The Veazie hydroelectric dam has been running on an annual license since 1986. Bangor Hydro-Electric Co. and the Federal Energy Regulatory Commission (FERC) delayed the relicensing of the Veazie Dam by combining that process with the company's application for a new dam at the Basin Mills site in Orono and Bradley, 6.5 km upstream. The proposal includes a new 7MW "C" plant on the east shore of Veazie, a new 38 MW dam at Basin Mills, and the decommissioning of an older hydro station at Orono. The USFWS, NMFS, and the U.S. Environmental Protection Agency have intervened as being opposed to construction of the Basin Mills Dam, based on the current proposed mitigation measures.

In 1993, the Maine Board of Environmental Protection (BEP) issued a state water quality license for the controversial hydro project. Fishing and environmental groups appealed BEP's decision to the Maine Superior Court but were denied. Next, the FERC, the Army Corps of Engineers, and the Maine Public Utilities Commission must approve the proposal.

The FERC is expected to complete an Environmental Impact Statement for all facilities in the lower Penobscot River, including the three project proposals at Basin Mills, Veazie and Orono.

Studies of fish passage facilities at the West Enfield and Mattaceunk dams have indicated that although upstream passage has been successful, downstream passage efficiency has been poor, with many fish passing through the turbines. Similar studies are being conducted on the Piscatiquis at the Browns Mill Project.

Union River. When the Ellsworth project dams were relicensed by FERC in 1990, one of the requirements was construction of fishways. To date that requirement has not been met. Bangor Hydro-Electric Co.'s position has been that the present trap-and-truck operation for river herring is sufficient and the company has appealed to the Service to modify the fishway prescription. In 1995, the FERC ordered the utility to build fishways at the Leonard and Graham Lake dams, which compose the Ellsworth hydroelectric project. The utility has appealed the decision and oral arguments were recently heard in Washington D.C. with a decision expected in the spring of 1996.

Saco River. In June of 1995, a basin-wide fish passage agreement was developed which will enable fish to migrate freely on the lower river for the first time in one hundred years. More importantly, the plan also sets out a time table for building fish ladders at each of the five up-river dams. With fishway construction completed at the lower two dams of the Cataract Project in 1993, last year's negotiations centered around specific passage proposals for the Springs Island and Bradbury dams, which are also part of the Cataract project. The June 1995 agreement calls for a "lift and lock" system to pass fish around these last lower river obstacles. Additionally, in 1995 a Saco River Restoration Coordinating Committee was formed to assess the anadromous fish restoration program every four years, beginning in 1996.

The Skelton Dam is scheduled for relicensing in 1996 pending the submission of an EIS. The fish passage agreement described above calls for the construction of a new fishway at the facility in 1998. State and federal fishery agencies continue to consult with Central Maine Power on the design of the facility.

2.1.2.f. Genetics

USFWS and Maine Atlantic Salmon Authority (Authority) staff cooperated with the NBS to characterize the genetic composition of Maine Atlantic salmon stocks. In 1994, minimally invasive samples consisting of adipose and anal fin clips were taken from captive parr from the Dennys, East Machias, Machias, Narraguagus, Sheepscot, Kennebec rivers. Analytical procedures were performed utilizing DNA and allozymes. As the anal fin was excised, a small portion of flesh was taken at the base of the fin in order to test the feasibility of using electrophoresis with a non-lethal sample.

In 1995, non-invasive samples consisting of pelvic fin clips were taken from Atlantic salmon captive parr. Genetic samples were taken in the hatchery as opposed to in the field due to adverse conditions which resulted in some mortalities from the Machias River parr.

During 1995, the development of six new genetic screening techniques progressed rapidly. The screening techniques will be used for examination of both nuclear and mitochondrial DNA. In addition, these techniques will be used to characterize salmon in Maine target rivers, several Canadian rivers and two rivers in Spain. The purpose is to provide a wide geographic dimension to the inter-river comparisons being conducted for Maine salmon stocks.

The inter-river comparisons have two important dimensions. The first being the differences among individual rivers, the second being the consistencies among year classes. Tissue samples have been collected for three year classes, 1993-1995. Analyses for one class utilizing several screening techniques will be completed by late summer.

2.1.2.g. General Program Information

Overall, Atlantic salmon runs in Maine improved slightly in 1995 compared to the previous year. The largest increase (28%) was noted in the Penobscot, with smaller incremental increases noted in the Dennys, East Machias, Pleasant, Narraguagus, Sheepscot and Saco rivers. Decreased Atlantic salmon runs in 1995 were noted in the St. Croix, Ducktrap and Androscoggin rivers, while the Aroostook and Machias rivers experienced salmon returns similar to those observed in 1994.

The Maine Atlantic Sea Run Salmon Commission (MASRSC) published a new 5-year (1995-2000) Statewide Atlantic Salmon Restoration and Management Plan in August of 1995. This plan is designed to serve as a basis for river-specific Operational Plans for all Maine rivers, and the preparation of those plans is expected to proceed in 1996.

In one of its final actions as a state agency, the MASRSC promulgated a statewide catch and release fishing rule, which became effective on June 7, 1995. (Note: until that time, one grilse/angler/year was allowed). As a consequence, for the first time in Maine history there was no legal retention of Atlantic salmon allowed on a statewide basis.

As a result of an act of the Maine legislature, on September 29, 1995 the MASRSC was abolished and replaced by the Authority. The Authority will be governed by a 9-member Atlantic Salmon Board which is composed of the Commissioners of Inland Fisheries and Wildlife and Marine Resources, 5 public members and representatives from the Penobscot Indian Nation and the Passamaquoddy Indian Tribe. Gubernatorial appointments are expected in March, with the full Salmon Board expected to be in place sometime in April.

On September 29, 1995 the USFWS and NMFS proposed to list the Atlantic salmon populations in seven Maine rivers as threatened under the Endangered Species Act. Public comment was solicited and the comment period closed on December 28, 1995. A Congressional Moratorium on listing activities has delayed all Federal actions involving formal review and completion of the proposed rule.

In response to the proposed listing of the Atlantic salmon populations in seven Maine rivers as threatened under the Endangered Species Act, Maine Governor Angus King, by executive order on 20 October, 1995, created the Maine Atlantic Salmon Task Force. Inland Fisheries and Wildlife Commissioner Ray Owen is Chairman of the Task Force, which is composed of the following additional representatives: the Commissioner of Marine Resources, the Commissioner of Agriculture, the State Forester, representatives of private recreational fisheries interests and Native American Sustenance fishers, and representatives of the agriculture, aquaculture, paper and forestry sectors.

The Task Force was charged with the following: (1) advising the Governor on the appropriate response to the proposed listing of Atlantic salmon in the Dennys, East Machias, Machias, Pleasant, Narraguagus, Ducktrap and Sheepscot rivers, (2) the development of a Conservation Plan to address preservation of salmon and their habitat on these seven rivers, and (3) advising the Governor on the appropriate response to the federal request for comments on whether any native, naturally- reproducing populations of Atlantic salmon remain in the Penobscot, Kennebec, and St. Croix rivers and Tunk Stream.

Commissioner Owen appointed representatives to six technical working groups which were formed to advise the Task Force in its work. The six Technical Working Groups are: Genetics, Forestry, Agriculture, Recreational Fishing, Aquaculture and Status of the Penobscot, Kennebec, St. Croix and Tunk Stream stocks. Based upon the preliminary reports from the six technical working groups and other information, the Governor responded to the two Federal agencies in a letter with supporting documentation, dated December 27, 1995. In his response the Governor stated that "the State of Maine is strongly opposed to the proposed threatened species listing on the seven rivers on the grounds that the stocks of the seven rivers do not meet the criteria for listing under the Act and that listing would be counter- productive to the superior protection afforded the species under the existing Maine regulatory mechanism, as enhanced by a voluntary public/private partnership to conserve and restore salmon runs."

As an alternative to listing, the Governor requested that the USFWS and NMFS enter into a Cooperative Agreement with the State of Maine in order to implement the Conservation Plan now being developed by the Maine Atlantic Salmon Task Force. The Task Force is expected to have a draft Conservation Plan available for public review and comment by July 1 of this year. The USFWS and NMFS have notified the State of Maine that should the federal government continue to pursue the listing process, the State Conservation Plan could become a major portion of that effort.

2.1.3. MERRIMACK RIVER

2.1.3.a. Adult Returns

Maintenance of the donor stock of salmon used in the Merrimack River restoration program was below the desirable level. Rates of return (adults returning per 1,000 juveniles released) continued to decline for adults of fry stocking origin but rebounded from the previous year for adults of smolt stocking origin.

However, the increase in the rate of return for adults of smolt stocking origin was not great enough to produce an adequate number of the donor stock. Documented adult returns numbered 34 fish in 1995, 91 fish less than the fourteen year average (125 fish) for the period 1982-1995.

The first adult salmon was captured on May 1. Returns continued to enter the trap throughout May, June and early July. The last fish was captured on July 7. Two fish were captured by electro-fishing downstream from the fish-lift at the Essex Dam in Lawrence, MA (first dam on the river at rkm 42), while the remaining 32 fish were captured at the fish-lift. All 34 fish were transported to the Nashua National Fish Hatchery (NNFH) and held as broodstock for egg production.

Fifteen of the adult returns originated from fry releases and 19 from hatchery smolt releases. For those of fry origin, 12 were age 2.2 (1991 cohort), one was age 3.2 (1990 cohort), and two were of unknown age. For those of smolt stocking origin, two were age 1.1 (1994 cohort), 14 were age 1.2 (1993 cohort), and three were of unknown age.

2.1.3.b. Hatchery Operations

The fish cultural changes initiated in 1994 continued in 1995. As in the past, Atlantic salmon fry produced for stocking purposes are provided by the NANFH and the Warren State Fish Hatchery (WSFH), and smolts produced for stocking purposes are provided by the GLNFH.

Egg Collection

Sea-Run Broodstock

Thirty-four adult salmon were captured and transported to the NNFH for fall spawning. Thirty-three survived to maturation, and an estimated 187,600 eggs were taken from 24 females. The majority of the eggs was transported to the NANFH to be hatched and released as fry. A portion of the eggs was transported to the WSFH to be hatched and released as fry. Due to the low numbers of available Merrimack River sea-run eggs, 10,000 eyed-eggs of Penobscot River sea-run stock were imported from CBNFH for future broodstock development.

Captive/Domestic Broodstock

A total of 694 female broodstock held at the NNFH provided an estimated 4,353,200 eggs. These eggs were transported to the WSFH and NANFH to be held for fry stocking. Approximately 1,000,000 of the eggs that were transported to the NANFH are being incubated for the Pawcatuck River salmon restoration program (500,000 eggs) and the Saco River Atlantic salmon restoration program (500,000 eggs).

2.1.3.c. Stocking

Approximately 2.9 million juvenile Atlantic salmon were released into the Merrimack River during the period March-June of 1994. Although the majority was released as unfed fry, 70,800 were released as yearling smolts. None of the smolts were marked.

The number of fry released was the largest stocking in the history of the program, but was less than the target release of 3,100,000 fry. Six major tributary systems were stocked with fry at densities that ranged from 25 fry to 50 fry per 100 m^2. Major tributary systems stocked included the Souhegan, Piscataquog, Suncook, Soucook, Contoocook, and Pemigewasset rivers.

2.1.3.d. Juvenile Population Status

Fry/Parr Assessment

A stratified sampling scheme that involved parr collections at 28 sites was conducted in the Merrimack River basin in 1995. A similar scheme involving a reduced number of sites had been initiated in 1994, and positive results supported an alternative strategy to increase sampling effort in 1995. In each year, sampling was directed at age 1+parr and involved electrofishing during late summer and early fall. Data collection was a cooperative effort and included staff from the NHFG, USFS, USFWS and volunteers.

The 28 sites included a total of 376 metric units (one unit = 100 m^2) of juvenile habitat. The estimated amount of juvenile habitat units within the basin is 57,067, thus habitat sampled was about 0.66% of the total available. In contrast, 21 sites representing 265 habitat units were sampled in 1994, and during the period 1983-1993 typically eight sites representing 129 habitat units were sampled. Of the 57,067 habitat units available, approximately 51,225 were stocked with fry in 1995.

The estimated number of age 0+ and age 1+parr at sites was greater than in previous years, a trend that likely reflects the increase in density at which fry were stocked in years 1994 and 1995. For age 1+parr the number found at most sites was generally three fold greater than what had been observed at these sites during the last five years.

Natural reproduction of Atlantic salmon is not known to occur in the Merrimack River basin. In recent years, sexually mature adult salmon have been released in fall in headwater areas, but due to the low numbers released their contribution to the production of fry, if any, is assumed to be insignificant. Accordingly, the estimated number of age 1+parr in 1995 was derived from a stocking that approached 2,186,000 fry in 1994. Based on a stratified sampling scheme, the estimated number of age 1+parr was 209,122 ± 11,870, and the corresponding estimate of survival from the fry stage to age 1+parr approached 10.0%.

The increase in the number of sites sampled in 1995 mitigated data gaps that were prevalent in calculations to estimate parr abundance in 1994. Assumptions were required in 1994 analyses due to a paucity of units sampled in some strata. For 1994, the estimated number of age 1+parr was 77,752 ± 19,148, and the corresponding estimate of survival from the fry stage (1,157,000 fry stocked) to age 1+parr approached 7.0%.

Although parr abundance was robust in fall 1995, extreme flooding ensued shortly after sampling ceased. Ground-water levels and surface-water runoff had remained low during summer and early fall, but flood flows in October and November at key salmon nursery areas equalled or exceeded 50 year flood events. The impacts of these events on the survival of parr has not been determined.

2.1.3.e. Fish Passage

Downstream Fish Passage

After several years of discussion the cooperating agencies (Merrimack River Anadromous Fish Program cooperative) and Public Service of NH reached an agreement relative to providing downstream fish passage at all mainstem dams owned by Public Service of NH. The hydro dams included within the plan are as follows: Amoskeag, Hooksett, Garvins Falls (all on the main stem of the Merrimack River), Eastman Falls and Ayers Island (both on the main stem of the Pemigewasset River). The agreement (plan) was endorsed by all parties in October. The document initially addresses a five-year period but will be updated (revised) on a regular basis. Revisions will occur until satisfactory downstream fish passage becomes operational at all facilities. Included within the plan are studies directed at determining the degree of effective passage. A basin map is included in Appendix 11.2.

Upstream Fish Passage

Work continued at the Essex Dam in Lawrence, MA to improve the effectiveness of the fish passage entrances to the fish-lift. Utilizing data obtained in 1993 and 1994, Consolidated Hydro, Inc. introduced fish passage entrance changes that appeared to improve the effectiveness of the facility in passing American shad. Further refinements are planned for the passage season of 1996. The changes being proposed will likely enhance passage for Atlantic salmon and the river herrings also.

2.1.3.f. Genetics

No work was conducted in this area with regard to the salmon program in 1995.

2.1.3.g. General Program Information

Domestic Atlantic Salmon Broodstock Releases

In spring and late fall of 1995, 3,031 surplus broodstock were released to provide angling opportunities. The spring release included 1,605 re-conditioned adults that had been spawned in the hatchery the previous fall. The second release occurred in the fall and included 1,426 fish that were spawned prior to release.

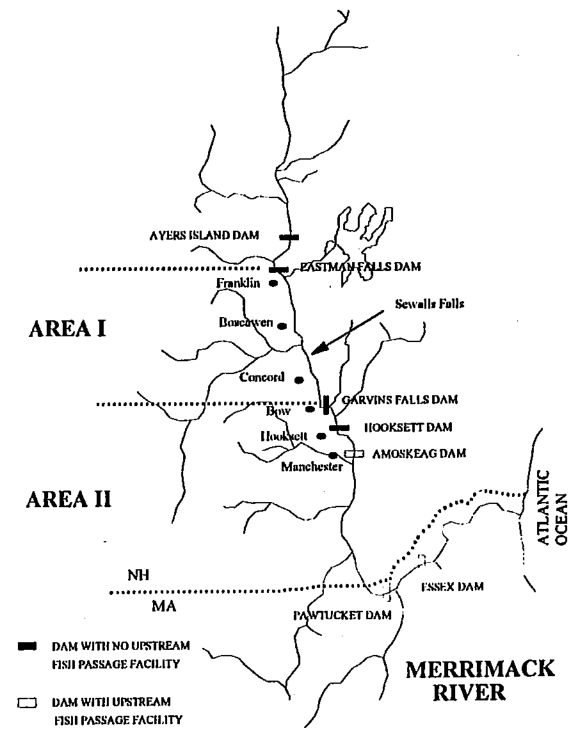
An additional 554 sexually mature adults (pre-spawners) were released into the Pemigewasset River in the fall. These fish were part of a study to investigate spawning success by domestic broodstock in the wild.

Pre-spawner Releases / Natural Reproduction Study

The prospect of releasing salmon into habitat that once supported adult salmon offered numerous benefits to the program. It was anticipated that the pre-spawners would provide information about the quality and quantity of suitable spawning and juvenile rearing habitat in the watershed; provide information about the effects of environmental variables and human activities on the survival of large salmon in the watershed; decrease the dependence on hatchery produced and distributed juvenile salmon; and set the stage for releasing 2,000 sexually mature fish on the spawning grounds by 1998.

In 1995, a formal study was initiated when domestic broodstock pre-spawners were released in October at sites in the Pemigewasset River watershed proximal to spawning habitat, from Woodstock to Bristol N.H. Approximately 530 salmon were released at two sites in the Pemigewasset River and 24 were released in the Baker River. Of those released in the Pemigewasset River, 28 were fitted with radio transmitters. A single fish released in the Baker River was also fitted with a radio transmitter. The radio transmitters were expected to provide a signal for approximately 100 days before an internal battery expired.

MANAGEMENT AREAS FOR BROODSTOCK SPORT FISHERY



Extreme weather events, including floods and early snow and ice, hampered the efforts to locate the salmon. All fish located utilizing the radio tracking equipment exhibited a downstream movement and seven were known to have passed over the spillway of Ayers Island Dam. Passages over the Ayers Island Dam appeared to coincide with high flow events. Broodstock without radio tags were observed throughout the study area in October, but due to high flows and poor water clarity, fish were not observed again until mid-December when field reconnaissance ended. Although no spawning was documented or redds located, the results proved instructive for similar work that is expected to occur in 1996.

Atlantic Salmon Domestic Broodstock Sport Fishery

The sport fishery, managed by the NHFG, occurs primarily in the mainstem of the Merrimack River from the Eastman Falls Dam (Franklin, NH) to the NH/MA state line. The principal areas of importance are shown on the associated map. The river reach denoted by Area I, encompassing Eastman Falls, Boscawen, and Sewalls Falls, is regulated such that salmon can only be taken by fly-fishing methods. Area II, encompassing the Garvins Falls Dam to the NH/MA state line, is regulated such that salmon can be taken by utilizing any terminal gear having only a single point and being artificial.

Some fishing does occur in Massachusetts near the Pawtucket dam in Lowell but this fishery is not directly managed nor formally documented.

Results for the period, 1993 - 1995, are presented in the table on the following page.

Education/Outreach

Adopt-A-Salmon Family

The "Adopt A Salmon Family" program, a multi-disciplinary watershed education program for elementary and middle school students, is now in its third year. Presently offered in twenty schools across the New England region, the program is an on-the-ground opportunity for real, working partnerships - both within and outside the USFWS. The list of partners is diverse and growing: USFS, Lake Champlain Basin Program, two tribal nations (Passamaquoddy, and

RESULTS OF THE DOMESTIC ATLANTIC SALMON BROODSTOCK SPORT FISHERY FOR 1993, 1994, AND 1995.

Category	1993	1994	1995
Total Permits Sold	930	1,708	2,635
% Non-residents	3	9	7
Diary Reporting Rate (%)	61	61	58
Estimated No. of Anglers that Fished	715	1,250	1,685
% of Anglers Utilizing Fly Fishing	76	77	75
% of Anglers Utilizing Artificial Lures	24	14	25
% of Anglers Utilizing Both Fly Fishing and Artificial Lures	0	9	0
Angler Success in Fly Fishing Area (% catching at least 1 salmon)	35	26	30
Angler Success in Fly Fishing / Artificial Lure Area (% catching at least 1 salmon)	28	24	30
Estimated Total Hours of Fishing Effort	14,779	21,726	26,165
Estimated Catch per Unit of Effort (hours per salmon landed)	14.9	23.5	13.9
Estimated No. of Angler-Trips	4,651	6,258	8,790
Estimated No. of Salmon Caught and Released	594	577	817
Estimated No. of Salmon Caught and Kept	400	345	573
Estimated Total Catch (Released and Kept)	994	922	1,390
Estimated Expenditures Per Angler ($)	92	84	129
Estimated Total Expenditures by Anglers ($)	66,000	105,000	217,000

Penobscot), UNH Sea Grant, UNH Cooperative Extension, New England Salmon Association, Atlantic Salmon Federation, and a number of school districts. A productive dialogue with the National Park Service is presently moving forward.

Adopt-A-Salmon Family examines the interactions of human culture and the environment; seeks to engender an environmental stewardship ethic among participating students and adults; and builds constructive bridges between the USFWS/partners and local communities. The office of the Central New England Anadromous Fish Coordinator (USFWS) plans to expand the program in subsequent years, involving additional school districts and new partners.

Amoskeag Partnership

The USFWS through the Central New England Anadromous Fish Coordinator's office in cooperation with the New England Field Office (Ecological Services) has joined in a very unique partnership with Public Service of NH, NHFG, and the Audubon Society of NH to create a broad-based educational outreach program to be based at the Amoskeag Fishways facility in

Manchester, NH. With the Merrimack River as a general focus, the partnership will offer educational outreach programming to school groups, teachers, the general public and other targeted audiences.

Outreach Products

The USFWS through the office of the Central New England Anadromous Fish Coordinator has been involved in developing an Adopt-A-Salmon Family curriculum package (teacher's guide and related support materials). In addition, the office has developed a Merrimack River anadromous fish program static display, and slide and video library, an anadromous fish program fact sheet, and environmental education resource materials.

Anadromous Fish Planning

A "Status Review" report addressing Atlantic salmon, American shad, and the river herrings was prepared by the Merrimack River Technical Committee and is presently in review. This document, when finalized, will become the foundation for developing the anadromous fish strategic plan for the Merrimack River.

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 1995 respectively. Both of the fish were female. By scale analysis, it was determined that both fish had spent two years at sea after migrating as two year smolts. Two escapees were documented jumping over the Potter Hill Dam. Electrofishing attempts to capture the escapees upstream of the trap were unsuccessful. Reports of other salmon escapees were unconfirmed.

2.1.4.b. Hatchery Operations

Fish Cultural Changes/Improvements

The Arcadia Research Hatchery was designated as the primary hatchery for the salmon restoration program. The hatchery discharges into Roaring Brook, a tributary located in Pawcatuck River Watershed. New incubators were obtained and improvements to existing incubators were implemented. A UV water purification system was installed to allow use of water from Browning Mill Pond. This will allow better manipulation of water temperatures in hatchery operations, with reduced risk of disease. A separate building for isolating returning adults should be completed by the end of 1995.

Egg Collection

A total of 12,400 eggs was taken from the two females captured in the spring of 1995 and were fertilized with milt obtained from domestic broodstock supplied by the NANFH in the fall of 1995. Approximately 153,800 fertilized Merrimack River strain eggs were supplied to the Rhode Island Division of Fisheries and Wildlife (RIDFW) by NNFH in the fall of 1995. These eggs and those obtained from the two captured females were incubated at the Arcadia Research Hatchery. Fry obtained from eggs taken in fall of 1995 and incubated at Arcadia will be retained for subsequent release as 0+ parr or 1+ parr. Some of the parr will be reared at the recently acquired Carolina Hatchery (formerly American Fish Culture). The Carolina Hatchery is the headwater for White Brook, also a tributary in the Pawcatuck River Watershed.

NANFH has allocated 500,000 eggs per year (including 1995) for the Pawcatuck River Watershed.

2.1.4.c. Stocking

Fry stocking was continued in 1995. Eggs taken in the fall of 1994 were incubated until spring of 1995 and released as unfed fry. NANFH supplied 276,700 fry, and Arcadia Hatchery supplied 89,900 fry for a total of 366,600. Stocking of fry throughout the Pawcatuck River Watershed was performed by RIDFW personnel, and volunteers fromTrout Unlimited, the Wood-Pawcatuck Watershed Association and the general public.

Approximately 60,100 Saint John River strain 0+ parr were donated by New England Fish Farming Enterprises of Bristol, NH in the fall of 1995. Approximately 7,900 were retained for spring release as 1+ parr and the remainder were distributed in the Pawcatuck River Watershed by RIDFW personnel.

Swim-up fry from eggs taken in the fall of 1995 by NANFH, will be distributed in the Pawcatuck River Watershed in the spring of 1996.

Stocking/Transport Improvements

A 200 gallon fry/parr transport tank utilizing compressed oxygen and microbubble diffusers was developed. The tank is divided into four separate chambers and each chamber is outfitted with two perforated aluminum boxes for a total of eight. Fry were successfully transported from NANFH to the Pawcatuck River Watershed. Some fry remained in the tank for up to 10 hours with no observed mortality.

2.1.4.d. Juvenile Population Status

Fry/Parr Assessment

Fry assessments were continued in 1995. Nine index stations were sampled during September and October in the watersheds of the two major tributaries which form the Pawcatuck River. Fry survival ranged from 0.84 to 24.7% and averaged 6.3%. Survival of the 1994 fry cohort from age 0+ parr to age 1parr averaged 50.4%. Survival of age 1parr to age 1+ parr averaged 100%, but is probably attributed to parr movement into some of the sample stations during drought conditions. The 1994 fry cohort reached a mean length of 78mm by October of 1994, 89.3mm by April of 1995, and 154.2mm by October of 1995. Approximately 20.7% of the 1+ parr sampled were precocious males. Fry stocked in spring of 1995 attained a mean length of 79.3 mm by October of 1995. Drought conditions were present throughout the Pawcatuck River Watershed during the summer of 1995.

Smolt Abundance

Potential smolt output was estimated by sampling nine index stations during March of 1995. Mean smolt density was 0.84 per habitat unit (SE=0.47). Total smolt output based upon expansion of sample density over area stocked was 4511 fish. This smolt run is the first produced predominantly from fry plants. While the mean density is very low, the winter survival rate for large parr was 47.5%, (higher than the projected 36%). High water at all index stations during the sampling period prevented sampling at some of the larger stations. Mean length of smolts captured in 1995 was 176.9 mm.

Tagging

A program employing "fluorescent elastomer visual implant tagging" is being used in a mark and recapture effort for all parr and pre-smolts/smolts captured while electrofishing. The elastomer is injected into the adipose tissue surrounding the eye. Eighteen smolts and 589 parr were tagged. Of 122 age 1parr tagged in the spring of 1995, 7 were recaptured during the fall sampling effort. Fish recaptured were remarked in a different location. Tagging options include varying location of tag adjacent to the eye (left front, right front, left rear, right rear), multiple tags, and alternating colors. Tags placed in adult hatchery trout were clearly visible to the naked eye or when observed under ultraviolet light. To better evaluate tag retention, all fish tagged in the future will be adipose fin clipped. The tagging mortality according to the manufacturer should be minimal with excellent tag retention through adulthood. All returning adult salmon will be inspected for tags.

2.1.4.e. Fish Passage

Upstream Fish Passage

Problems with upstream fish passage have been documented 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 have refused to do so. The dam is not a hydropower dam so regulatory authority to force the owners to repair the dam is severely limited. It is clear that new legislation increasing State of RI authority to deal with the problem is necessary. Some boulders downstream of the dam/fishway were redistributed by RIDFW personnel in attempt to guide fish away from the broken gates and toward attraction flow coming from the fishway entrance.

Downstream Fish Passage

No work was conducted on this topic during 1995.

2.1.4.f. Genetics

No work was conducted on this topic during 1995.

2.1.4.g. General Program Information

Domestic Atlantic Salmon Domestic Broodstock Releases

Surplus domestic broodstock, when available from NANFH are stocked outside the Pawcatuck River Watershed for a popular sportfishery. Fifty salmon were distributed in four separate ponds for ice fishing and some were caught during the regular trout season in 1995.

Education/Outreach

Westerly Public Schools in cooperation with the RIDFW and the Wood-Pawcatuck Watershed Association developed a fourth/fifth grade program teaching about the Industrial Revolution, dams, waterpower, mills, and effects on anadromous populations. The students toured the Bradford Dyeing Association Mill, observed the Bradford Fishway, observed the Arcadia Hatchery, and stocked Atlantic salmon fry as part of the restoration efforts.

2.1.5. NEW HAMPSHIRE COASTAL RIVERS

2.1.5.a. Adult Returns

The Lamprey and Cocheco Rivers fish ladders were monitored from the middle of April until the end of June for returning adult Atlantic salmon. The Lamprey River ladder was also operated during the fall but on an abbreviated basis (Oct. 6 - Nov. 15) due to drought conditions that persisted until the beginning of October. The Cocheco River fishway has not been operated during the fall since 1993 due to a dispute between the owner of the hydroelectric facility at Cocheco Falls and the NHFG.

Two adult Atlantic salmon returned to coastal New Hampshire fish ladders in 1995. One male returned to the Cocheco River in June and a female returned to the Lamprey River in October. The salmon ranged in size from 79.0 - 82.0 cm and were both age 2.2.

2.1.5.b. Hatchery Operations

The female Atlantic salmon that returned to the Lamprey River in October was transported to Milford State Fish Hatchery (MSFH)in anticipation of egg taking during fall spawning. This fish succumbed to disease prior to spawning despite regular formalin bath treatments and inoculation with Enteric Redmouth and Aeromonas Salmonicida Bacterins.

2.1.5.c. Stocking

In 1995, 114,000 Atlantic salmon fry were stocked into the Cocheco River system and 91,000 fry were stocked into the Lamprey River system. The fry were from several sources including 116,000 landlocked salmon X Merrimack River domestic crosses, 17,000 Lamprey F_1, and 72,000 Merrimack domestic from the NNFH. The fry were reared at the MSFH and the WSFH and released into the two rivers at a rate of 48 to 60/100 m^2 during the month of April.

The Lamprey River was also stocked with 4,800 Saint John River strain smolts in May and 57,100 Saint John River strain 0+parr in December. These fish were donations from New England Fish Farming Enterprises.

2.1.5.d. Juvenile Population Status

During the fall, two index sites on each river system were sampled for juvenile Atlantic salmon via electrofishing. Seines were used to prevent emigration and immigration of fish from a 91 meter section of the index site and a three pass removal method was used. All Atlantic salmon captured were enumerated, measured (total length to the nearest millimeter), weighed (grams), and classified via length measurements as young-of-the-year (generally $\leq$ 100mm) or parr (generally > 100mm). Population estimates were calculated using the micro-computer program REMOVE.BAS which uses a maximum weighted likelihood estimation to calculate population size and variance formulas of Zippen to determine standard errors and 95 percent confidence intervals.

In addition, five other sites were sampled on the two river systems to supplement the information gained at the index sites. Two of these supplemental sites were in areas that had been previously sampled on an irregular basis while the other three locations were in sections of the North River (tributary to the Lamprey River) that were fry stocked for the first time this year.

Electrofishing surveys for juvenile salmon at four index sites on the rivers produced population estimates for young-of-the-year (YOY) ranging from 2.4 - 5.4 fish/100 m^2 unit while estimates for parr ranged from 0.5 - 6.0 fish/100 m^2 unit. Mean length and weight of YOY at index sites ranged from 60-78 mm and 2-4 gms while parr ranged from 125-151 mm and 18-27 gms. The supplemental site surveys had YOY population estimates that ranged from 0-2.2/100 m^2. Parr were encountered at only one of the supplemental sites, the Ela River. The parr population estimate at this location was 3.2 fish/100 m^2. (Note: The three supplemental survey sites on the North River were in areas that had not been fry stocked prior to 1995, so no parr were expected to be encountered.)

The drought conditions that persisted during the summer or 1995 appeared to have an affect on juvenile salmon growth and survival or distribution within each watershed. Mean length and weight for both YOY and parr at all index sites were some of the smallest observed since inception of this program.

Population estimates at index sites in the Cocheco River system were the lowest ever recorded. This was most evident at the Mad River index site which typically has the highest population estimates for juvenile salmon in coastal rivers but in 1995 has some of the lowest values ever observed. Conversely, the Lamprey River index sites had average or above average population estimates for both YOY and parr.

Also of note was the Ela River supplemental site which had the highest population estimates of any site electrofished on the Cocheco River system this year. Past sampling on the Ela River in 1989 and 1990 have captured far fewer juvenile salmon. This high variability in the change in juvenile salmon abundance between years at each sampling site suggests that these index sites may be monitoring more of the movement of juvenile salmon (parr in particular) within the watershed between years than changes in survivorship between years.

2.1.5.e. Fish Passage

The NHFG has petitioned the FERC to reopen the operating license of Southern New Hampshire Hydroelectric Development Corporations (SNHHDC) hydroelectric facility at Cocheco Falls on the Cocheco River. The petition requested changes to the license to provide for summer and fall operation of the NHFG fish ladder at Cocheco Falls with sufficient attraction water, increase the required operation time of SNHHDC downstream fish passage facility into the spring to allow for downstream migration of Atlantic salmon smolts, and modification of the downstream passage facility to increase the passage efficiency.

In addition, the NHFG along with USFWS, are working with the owners of the Wyandotte Hydro on the Cocheco River to facilitate the installation of downstream passage at that facility.

2.1.5.f. Genetics

There is nothing to report on this topic.

2.1.5.g. General Program Information

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

2.2. STOCKING

2.2.1. TOTAL RELEASES

During 1995 the participating resource agencies released approximately 12,700,000 juvenile Atlantic salmon into 13 rivers (Table 2.2.1. in Appendix 11.1.). Included within the table is the contribution of Canada to the release program. The number of fish released was nearly identical to that of 1994.

2.2.2. SUMMARY OF TAGGED AND MARKED FISH

Approximately 3,265 juvenile Atlantic salmon were marked with VI tags (Table 2.2.2.a. in Appendix 11.1.). The marked fish were parr and smolts produced from the fry stocking program and some wild parr. A more comprehensive look at the Atlantic salmon marking program is presented in Table 2.2.2.b. (Appendix 11.1.).

2.3. ADULT RETURNS

2.3.1. TOTAL DOCUMENTED RETURNS

Documented total adult salmon returns to rivers in New England amounted to 1,773 salmon (Table 2.3.1. in Appendix 11.1.). The majority of the returns was recorded in the rivers of Maine with the Penobscot River accounting for nearly 76% of the total New England returns. The Connecticut River adult returns accounted for nearly 11% of the New England total and 82% of the adult returns outside of Maine. Overall, 11% of the adult returns to New England were 1SW salmon and 89% were MSW salmon; most (87%) of these fish were of hatchery smolt origin. Of the total returns approximately 14% were of wild origin (from natural reproduction and from fry plants).

2.3.2. ESTIMATED TOTAL RETURNS

Many salmon rivers in New England do not have trapping facilities and the existing fish passage and/or trapping facilities are not 100% effective. As a result, the information contained in Table 2.3.1. (documented adult salmon returns) underestimate the total salmon returns to New England.

In order to estimate total adult returns the Assessment Committee used the same general assumptions which were described in the 1994 Annual Report, with the following additional adjustment:

1) aquaculture escapees, to the extent which they could be identified, were excluded.

Estimated total returns to New England rivers in 1995 were 2,489 fish (Table 2.3.2. in Appendix 11.1.). The total estimated return represents a 7% increase from the total estimate of 2,318 in 1994.

2.3.3. RETURNS OF TAGGED SALMON

Returns of CWT and Carlin-tagged Atlantic salmon to rivers in New England in 1995 are shown in Table 2.3.3. (Appendix 11.1.). The information has been sorted by river of return and sea-age. A total of 502 salmon (47 1SW, 453 2SW, and 2 RS) having CWT returned to the rivers of New England. Adult salmon having Carlin tags totalled one, a repeat spawner.

2.3.4. SPAWNING ESCAPEMENT, BROODSTOCK COLLECTION, AND EGG TAKE

Spawning escapement information, where available, can be found in Section 2.1. Although 14 adult salmon utilizing fish passage facilities in the Connecticut River basin were allowed to proceed upstream (not trapped for broodstock), no significant natural reproduction was expected. Some fish in the Pawcatuck River were not trapped and passed upstream from the first dam on the river. Significant natural reproduction was unlikely. Adult salmon returning to various rivers in Maine will contribute to natural reproduction but the adult female numbers are far less than required for optimum seeding.

Egg sources for the New England Atlantic salmon culture programs included sea-run salmon, captive/domestic broodstock, and reconditioned kelts. A total of 518 sea-run females, 2,430 captive/domestic females, and 192 female kelts (183 reconditioned from Connecticut River sea-run salmon and nine obtained from the Dennys River (5) and the Machias River (4)) contributed to the egg take. The number of females (3,140) contributing was less than in 1994 (3,575). This decrease is attributed to a decline in the number of domestic broodstock females available. The total egg take was approximately 1.5 million less than in 1994. A more detailed description of the egg production program is contained within Table 2.3.4. (Appendix 11.1.).

2.3.5. SPORT FISHERY

Prior to June 9, 1995, the sport fishery for Atlantic salmon in Maine was restricted to one salmon per angler per year, and no salmon longer than 64 cm could be retained. Beginning on June 9 only a catch-and-release sport fishery was allowed throughout the state. The estimated number of salmon caught and released was 370 fish (Table 2.3.5. in Appendix 11.1.).

3. TERMS OF REFERENCE

3.1. PROGRAM SUMMARIES FOR CURRENT YEAR

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

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

3.2. HISTORICAL DATA - VALIDATE 1994 STOCKING AND RETURN DATA AND ADD TO HISTORICAL DATABASE

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 11.2. and in Section 6. (sub-sections 6.1. and 6.2.) of this document.

3.3. CONTINUE TO SYNTHESIZE AVAILABLE DATA AND MODEL JUVENILE SURVIVAL AND GROWTH RATES

3.4. CONTINUE TO CONFIRM SMOLT STATUS UTILIZING EXISTING SMOLT WORK, STRESS EVALUATION, AND EXAMINATION OF SELECTED CHARACTERISTICS IN POTENTIAL SMOLTS AND RETURNING ADULTS

3.5. RETROSPECTIVELY EXAMINE RIVER AND NEAR COASTAL ENVIRONMENTAL INTERACTIONS IN RESPECT TO MOVEMENT OF SMOLTS AND ADULTS

3.6. COMPARE MARINE SURVIVAL RATES OF U.S. ATLANTIC SALMON STOCKS AND IDENTIFY FACTORS AFFECTING THESE RATES

3.7. DEVELOP METHODOLOGIES TO ESTIMATE SMOLT PRODUCTION AND PARR TO SMOLT OVER-WINTERING MORTALITY FOR U.S. ATLANTIC SALMON STOCKS

4. DISCUSSION TOPICS

4.1. Loss of Smolt Characteristics in Hatchery-and Stream-Reared Atlantic Salmon in the Connecticut River.

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Abstract

Changes in physiological smolt characteristics of Atlantic salmon were examined in hatchery-reared fish under controlled conditions, and in fish reared in the wild during normal smolt migration. Hatchery fish reared at ambient river temperatures (2 °C in winter, 16 °C in mid-May) had more rapid decreases in gill Na^+,K^+-ATPase activity and salinity tolerance than fish maintained at a constant 10 °C. This finding corroborates previous studies in Atlantic and Pacific salmon in which loss of smolt characteristics is more rapid with increasing temperature. To examine changes in fish reared in the wild, Atlantic salmon that had previously been released as

fry in tributaries of the Connecticut River were captured during their smolt migration at a dam 198 km from the mouth of the river. In 1993 and 1994 gill Na^+,K^+-ATPase activity and salinity tolerance were high at the beginning of migration in early May. In 1993 decreases in salinity tolerance were observed by May 14 and decreases in gill Na^+,K^+-ATPase activity were observed by May 21. In 1994 temperatures increased more slowly and decreases in salinity tolerance and gill Na^+,K^+-ATPase activity were not observed until May 27 and June 3, respectively. Plasma chloride and thyroid hormones of migrating smolts in fresh water varied but did not show a consistent pattern of change during the migratory period. In early May, salinity tolerance and gill Na^+,K^+-ATPase activity of hatchery- and stream-reared fish were not different. The results indicate that late migrants have lower physiological smolt characteristics than early migrants, and we suggest these differences represent a loss of smolt characteristics due to the higher temperatures and longer migratory period experienced by these fish.

Introduction

Loss of migratory urge and the capacity to survive in seawater occurs in hatchery-reared smolts (McCormick and Saunders, 1987; Hoar, 1988), but it is not currently known whether they occur in the wild. Loss of these characteristics may be particularly important when migration is delayed, as might occur at dams and impoundments. Salmon inhabiting rivers with higher spring temperatures, such as those in the southern portion of their natural distribution, may have a greater risk of losing smolt characteristics because higher temperatures can result in rapid loss of salinity tolerance and gill Na^+,K^+-ATPase activity in smolting salmonids (Zaugg and McLain, 1976; Zaugg, 1981; Adams et al. 1973; Duston and Saunders, 1990).

The Connecticut River is near the historical southern limit of Atlantic salmon in North America. The Atlantic salmon population of this river was lost in the early 1800's following dam construction (Moffitt et al. 1982). A restoration effort begun in 1967 originally involved release of smolts from a variety of North American stocks (Rideout and Stolte, 1988). A more recent strategy for restoration of Atlantic salmon to rivers of New England involves hatchery spawning of returning adults and planting of progeny into tributaries as recently hatched fry (Orciari et al. 1994; McMenemy, 1995). Progeny of Connecticut River returns comprise the bulk of current releases, but introductions from outside stocks (primarily Penobscot River, Maine) continued until 1995 due to an insufficient supply of Connecticut River eggs. The present study was undertaken to determine whether loss of salinity tolerance occurs in Atlantic salmon in nature and to examine the potential environmental factors and mechanisms involved. McCormick and Bjornsson (1994) made physiological comparisons between wild- and hatchery-reared fish in the Connecticut River, they examined migrating fish at only a single time point and therefore could not resolve any differences that might occur over the migratory period. In the present study, migrating smolts that had previously been released 2-3 years earlier as fry (stream-reared fish) were examined for changes in physiological smolt characteristics during their normal downstream migration. In addition, one-year-old hatchery smolts, also the progeny of fish returning to the Connecticut River, were reared under two thermal regimes and examined for changes in smolt physiology in spring.

Materials and Methods

Hatchery fish were reared from eggs at the White River National Fish Hatchery in Bethel, VT (USA) using standard hatchery practices and then transferred to the Anadromous Fish Research Center, Turners Falls, MA (USA) on December 3, 1992 . These 9-month old fish (15-19 cm, 35-80 g) were randomly divided into four 1-m diameter tanks containing approximately 80 fish each. In the 10 °C group (2 tanks) water was maintained at a constant temperature of 9-10 °C and a flow rate of 4 $L \cdot min^{-1}$ by mixing two sources of well water (both infiltrated Connecticut River water) in an aerated header tank with supplemental chilling in May and early June. The ambient temperature group was maintained on Connecticut River water with a flow rate of 4 $L \cdot min^{-1}$. Both groups were fed to satiation twice daily. Lighting was supplied by overhead fluorescent lights and a simulated natural photoperiod maintained by adjusting the on-off cycle twice a week.

Stream-reared smolts were released into tributaries of the Connecticut River as fry. These fish reside in the streams for 2-3 years prior to smolt migration. Smolts were captured at a by-pass facility at Cabot Station (a dam on the Connecticut River at Turners Falls, MA, 198 km from the river mouth) designed to facilitate movement of fish around the dam. Ten fish selected at random were sampled immediately after capture as described above beginning on May 5 (in 1993) or May 11 (in 1994) and every 7-10 days thereafter during the migratory period (these fish are referred to as migrants). Ten additional fish were brought back to the laboratory and held overnight in 1.8 m diameter tanks with flow-through river water, then subjected to a seawater challenge the next morning. A second group of 80 additional fish were returned to the lab on May 6 1993 and May 11 1994 and reared in a 1.8 m diameter tank supplied with 15 $L \cdot min^{-1}$ river water and aeration. The intake for river water is 100 m upstream of the capture site and tank temperatures were always within 0.5 °C of river temperatures and within 10% of full oxygen saturation. These fish were fed commercial salmon feed (Zeigler Bros., Gardners, PA, USA) and are referred to as the captive group.

For seawater challenges fish were transferred to 1 m diameter tanks containing 40 ppt seawater (artificial sea salt added to dechlorinated tap water) maintained at 10 °C. Paper and charcoal filtration and continual aeration maintained low ammonia and high oxygen levels. After 24 hours the surviving fish were anesthetized and sampled as described above. Plasma chloride and osmolality were used as indicators of the capacity to regulate ions following seawater exposure. In an effort to reduce mortality found in seawater challenges of migrant and captive fish in 1993, 35 ppt was used for seawater challenges of stream-reared fish in 1994. Gill Na^+,K^+-ATPase activity was measured by the method outlined in McCormick (1993). Plasma osmolality was measured using a vapor pressure osmometer and plasma chloride was measured by coulometric titration.

Results

Hatchery-reared Fish

In each of the two temperature groups gill Na^+,K^+-ATPase activity began to increase in late

February and reached peak levels on April 21 (Figure 1). Although the pattern and timing of increase was similar in the two groups, gill Na^+,K^+-ATPase activity in the 10 °C group was higher than in the ambient group throughout the period of increase, significantly so in late March. In May gill Na^+,K^+-ATPase activity began to decline in both groups. This decrease was most precipitous in the ambient group which experienced higher temperatures than the 10 °C group in May (Figure 1). Gill Na^+,K^+-ATPase activity in the ambient group had near-peak levels on May 7 but two weeks later had levels similar to those seen in January.

Salinity tolerance was high in each group from March through early May (Figure 1). In late May, mortality of the ambient group was 80% after seawater challenge and plasma chloride of the survivors was 63% higher than in previous challenges. At this time, mortality and plasma chloride were still low in the 10 °C group. Two weeks later the 10 °C group showed a substantial loss of salinity tolerance (significant increases in mortality and plasma chloride of surviving relative to earlier challenges). In early June when temperatures reached 20 °C, all fish died in the ambient temperature group in fresh water, precluding examination of salinity tolerance.

Stream-reared Fish

In 1993 smolt migration began on May 1 and reached peak levels between May 5 and 16 (Figure 2). Thereafter migration continued at a slower rate until the trap was shut down in early June. Temperatures increased rapidly from below 10 °C on May 1 to above 17 °C on May 11, and remained near this temperature for several weeks (Figure 2). There was more evening and night migration early in the run than later, but daytime migrations occurred throughout the migratory period. There is no evidence that Atlantic salmon juveniles are in the mainstem of the river before May 1, and migration from tributaries of the Connecticut River does not begin until late April (Orciari et al. 1994).

Gill Na^+,K^+-ATPase activity was at high levels at the first and second sampling periods on May 5 and May 14 (Figure 2). Values were also high for captive fish (those captured at Cabot May 5 and maintained in the laboratory on river water) sampled on May 14. One week later both groups had significantly lower gill Na^+,K^+-ATPase activity. Fish sampled at Cabot had 25% lower activity on May 20 than those sampled at the beginning of the migratory period. The captive group had lost 60% of initial gill Na^+,K^+-ATPase activity by May 22.

Salinity tolerance also showed a significant decline during the migration period in 1993. Fish collected at Cabot Station on May 5 and subjected to a seawater challenge had no mortality and low plasma osmolality (Figure 2). Mortality after seawater challenge increased significantly in fish sampled at Cabot by May 14 and remained high. Although mortality after seawater challenge remained low in the captive group (Figure 2), plasma osmolality increased (Figure 2). Plasma chloride showed an identical pattern to that of plasma osmolality in each group (data not shown).

Migration began and peaked later in 1994 than in 1993, and migrants were more numerous in late May and early June of 1994 than in the previous year (Figure 3). In 1994 temperatures in early

May were lower than in 1993 but eventually reached temperatures of 17 °C in late May. Gill Na^+,K^+-ATPase activity was high on the first sampling date (May 10) and remained unchanged throughout May until a significant 40% decrease occurred on June 3. Gill Na^+,K^+-ATPase activity of captive fish decreased more rapidly; a 40% decrease occurred by May 27 and decreased further by June 3. Salinity tolerance was greatest at the beginning of migration when survival was 100% and plasma osmolality after 24 hours in seawater was 302 $mmol \cdot kg^{-1}$ (Figure 3). Significant increases in plasma osmolality occurred on May 27 in the migrant group and June 3 in the captive group. Mortality was significantly higher than initial levels in the captive group on May 27.

In both years smolts captured at the beginning of the migratory period were slightly smaller than those later in the run (data not shown). Condition factor remained constant throughout the migration in both years. In 1993, plasma chloride of migrants was highest in early May and was slightly but significantly lower on May 10 and May 28. In 1994 there was no significant difference in plasma chloride over the course of the migration, nor was there a difference in captive fish from the initial sampling in early May in either year.

Smolt characteristics of hatchery- and stream-reared Atlantic salmon smolts were similar. Peak levels of gill Na^+,K^+-ATPase activity in hatchery-reared fish in 1993 held at ambient (river) temperatures were 10.6 ± 0.8 in early April and 9.8 ± 0.8 in early May (Figure 1), while in stream-reared fish in 1993 peak activity was 9.4 ± 0.5 in early May (Figure 2). Similarly, salinity tolerance was nearly identical in the two groups. Mean plasma chloride after exposure to 40 ppt seawater was 161-163 in April and May in hatchery-reared fish and 159-166 in stream-reared fish in the first 2 weeks of May.

Discussion

Previous research has demonstrated that for several species of smolting salmonids the loss of salinity tolerance and other smolt characteristics in hatchery or laboratory reared fish occurs more rapidly at higher temperatures (Zaugg and McLain, 1976; Zaugg, 1981; Adams et al. 1973; Duston et al. 1991). Loss of smolt characters in Atlantic salmon occurs quickly at high temperatures under conditions of both constant and seasonally increasing temperature (Johnston and Saunders, 1981; Duston et al. 1991). That temperature is the primary determinant is demonstrated by the clear and direct relationship between the degree days (cumulative daily temperature) and loss of smolt characters under both constant and changing temperature (Figure 4). Figure 4 indicates that Atlantic salmon have a period of 100-200 degree days in which to migrate without loss of gill Na^+,K^+-ATPase activity; a 2 °C increase in average river temperature would decrease this period by 10-20%. This relationship between temperature and loss of smolt characteristics can explain the more rapid loss of salinity tolerance and gill Na^+,K^+-ATPase activity in the hatchery-reared ambient temperature group that experienced significantly higher temperatures than the 10 °C group after the peak of smolting in May.

There is an apparent correspondence between annual differences in spring temperatures and the rate of loss gill Na^+,K^+-ATPase activity in migrants. In 1993 river temperatures reached 17 °C on

May 10, 12 days earlier than in 1994. Decreased gill Na^+,K^+-ATPase activity was detected earlier (both as a absolute date and time since the beginning of the migratory period) in 1993 than in 1994. The present study lends credence to the idea of a physiological 'smolt window' in which there is a limited time for successful migration of wild migrating smolts. This smolt window is controlled by the environmental and biotic factors that regulate the onset, development and subsequent loss of salinity tolerance and other smolt characteristics. There may also be genetic factors that affect the interaction of temperature and loss of smolt characteristics, and some of the results observed for this restored population of Atlantic salmon in the Connecticut River may reflect their more northern origins.

The present findings strongly suggest that loss of smolt characteristics occurs in some portion of the population during the migration of Atlantic salmon in the Connecticut River. The loss of smolt characteristics in 1993 and 1994 occurred after the peak of migration indicating that a majority of the population is not affected by this phenomenon. Nonetheless, in some years a significant portion of the population will be affected by loss of smolt characteristics. In 1993, significant decreases in gill Na^+,K^+-ATPase activity were detected on May 20, and an estimated 18% of the run occurred after this date (based on smolt capture data at Cabot Station, Figure 2). The fact that these changes were detected 198 km from the mouth of the Connecticut River indicates that the additional time necessary to reach the ocean will result in even greater loss of smolt characteristics and a larger portion of the population being affected. The proportion of the population affected by loss of smolt characteristics will depend on the timing of migration of the population and the temperature experienced throughout the migratory period. Since migration times of individual fish are likely to vary (Fangstam, 1993) and will be affected by temperature (Jonsson and Ruud-Hansen, 1985), it may be difficult to predict the overall population effect. Dams and their impoundments may increase the problem of lost smolt characteristics by slowing migration rates and increasing water temperatures. In such regulated river systems, loss of smolt characteristics can be reduced by ensuring that smolts have the opportunity to maximize migratory rate, such as by allowing maximum passage of fish over or through dams. To increase effectiveness of population management, information on loss of smolt characteristics and reduced smolt survival could be combined with adaptive management strategies. Such management actions may be particularly important in years with unusually rapid rising or high spring temperatures, or in mitigating the effects of global climate change.

The present study addressed only physiological changes that are part of the parr-smolt transformation; other characteristics such as migratory behavior are also important. There is little information on how migratory behavior is lost or how it might be affected by high temperature. Greenstreet (1992) found that movement rates of individually tagged Atlantic salmon smolts migrating through a fish ladder increased with increasing temperature up to 16 °C, but decreased slightly at 16-18 °C. Studies of Pacific salmon show a close correspondence between physiological smolt development and migratory behavior (Zaugg et al., 1985; Zaugg, 1989; Ewing et al. 1994). If a similar link between migratory behavior and gill Na^+,K^+-ATPase activity exists for Atlantic salmon, loss of migratory behavior will decrease in late spring and will be lost more rapidly at high temperatures.

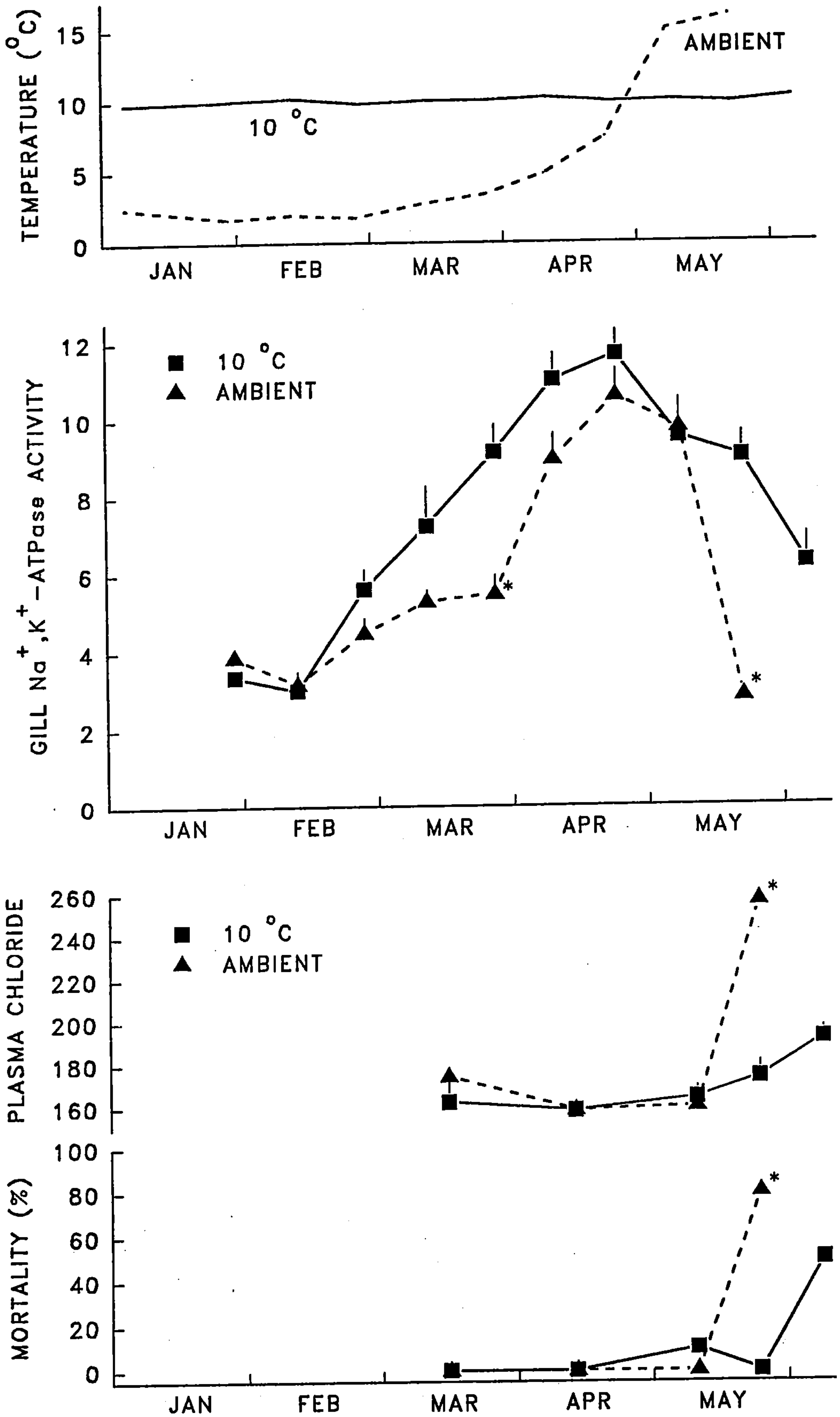

Figure 1. Rearing temperature, gill Na^+,K^+-ATPase activity and salinity tolerance of hatchery-reared juvenile Atlantic salmon. Gill Na^+,K^+-ATPase (μmol ADP·mg protein·h^{-1}) is the mean of 10 fish per group. Salinity tolerance was measured by transferring 10 fish in each group to 40 ppt (10 °C) for 24 hours. Values are mean ± standard error (n = 10 per group). Plasma chloride (mM) is that of all the surviving fish. Asterisk indicates significant difference of the ambient group from the 10 °C group.

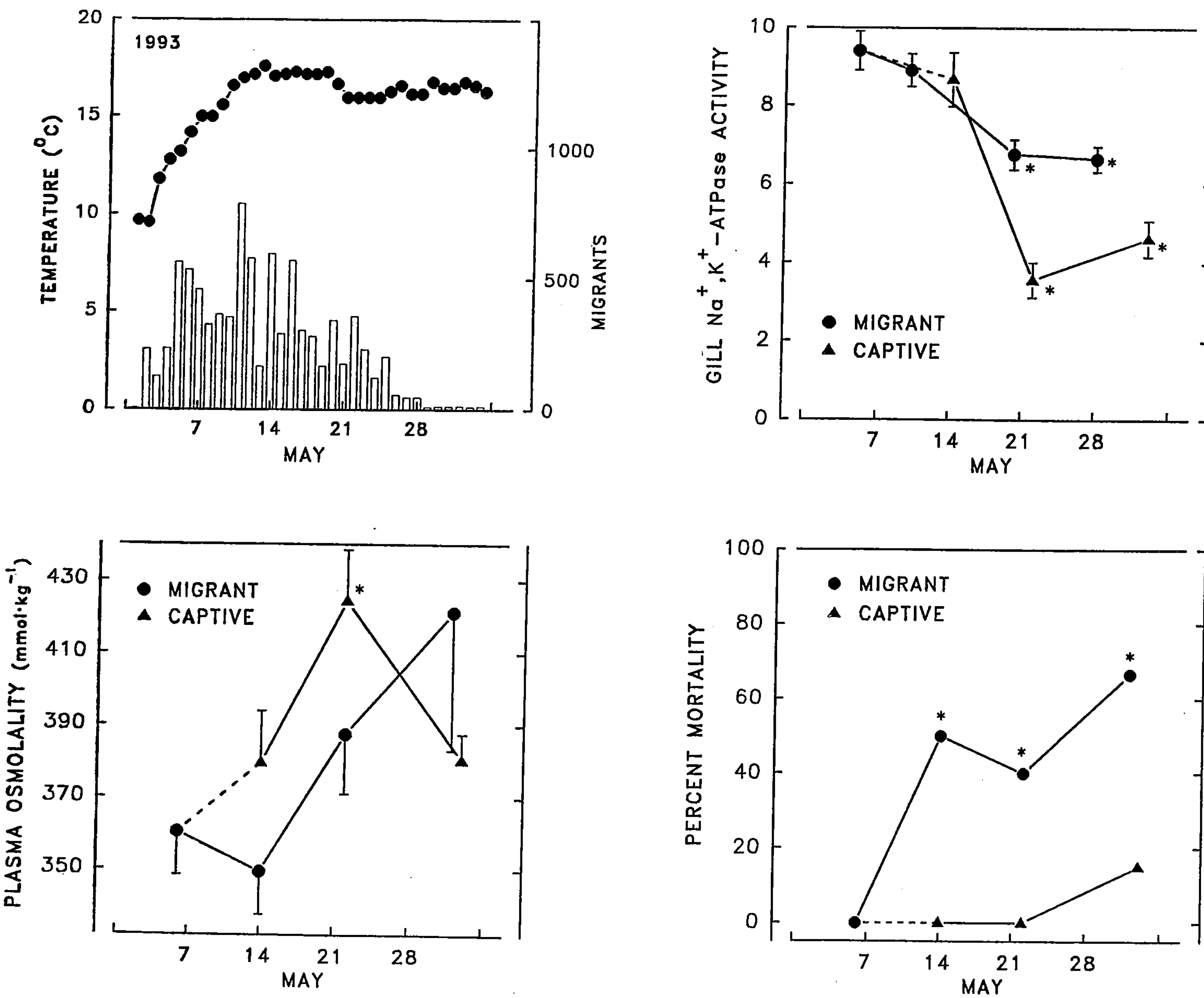

Figure 2. River temperature, number of migrants, gill Na^+,K^+-ATPase activity (μmol ADP·mg protein·h^{-1}) and salinity tolerance of migrant and captive stream-reared Atlantic salmon in 1993. Fish were captured at a bypass of Cabot dam, Turners Falls, MA on the Connecticut River during normal migration. Captive fish were those initially captured on May 5 and maintained in flowing river water in 1.6 m diameter tanks. Values are mean $\pm$ standard error (n=10-15 per group). Asterisk indicates significant difference from the May 5 migrants ($P < 0.01$, Kruskal-Wallis test). Number of migrants are daily counts of smolts through the bypass structure at Cabot dam and represent a subsample of the total population of migrants on the Connecticut River (data from Northeast Utilities Service Company, 1995, Downstream Passage of Atlantic Salmon Smolts.). Non-migratory parr in late May and early June have gill Na^+,K^+-ATPase activity of 1-2 μmol ADP·mg protein·h^{-1} (McCormick and Bjornsson (1994), McCormick, unpublished data).

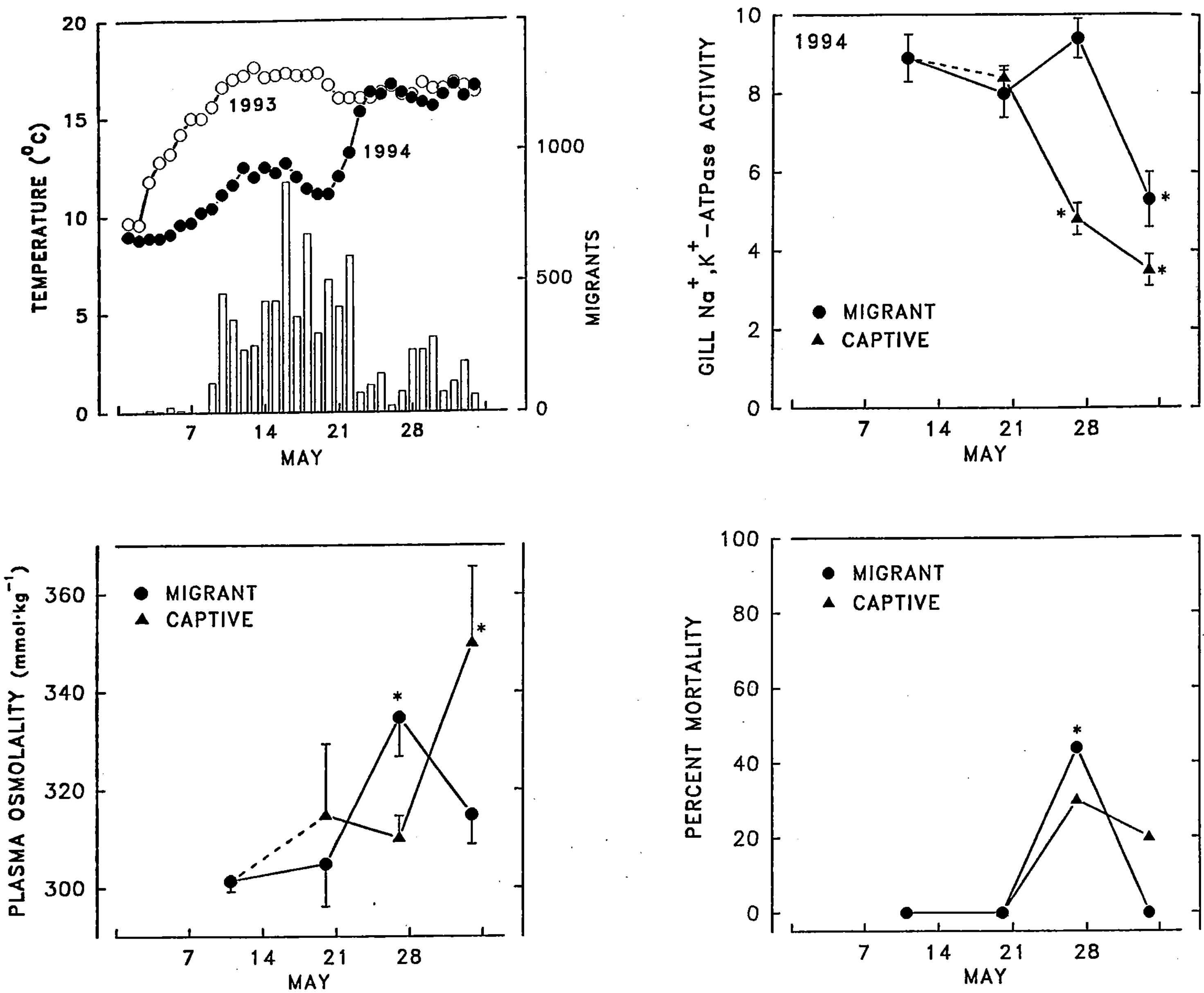

Figure 3. River temperature, number of migrants, gill Na^{+},K^{+}-ATPase activity (μmol ADP·mg protein·h^{-1}) and salinity tolerance of migrant and captive stream-reared Atlantic salmon. Fish were captured at a bypass of Cabot dam, Turners Falls, MA on the Connecticut River during normal migration in 1994. Captive fish were those initially captured on May 11 and maintained in flowing river water in 1.6 m diameter tanks. Values are mean $\pm$ standard error (n = 10 per group). Asterisk indicates significant difference from the May 11 migrants ($P < 0.01$, Kruskal-Wallis test). Number of migrants are daily counts of smolts through the bypass structure at Cabot dam and represent a subsample of the total population of migrants on the Connecticut River (data from Northeast Utilities Service Company, 1995, Downstream Passage of Atlantic Salmon Smolts.).

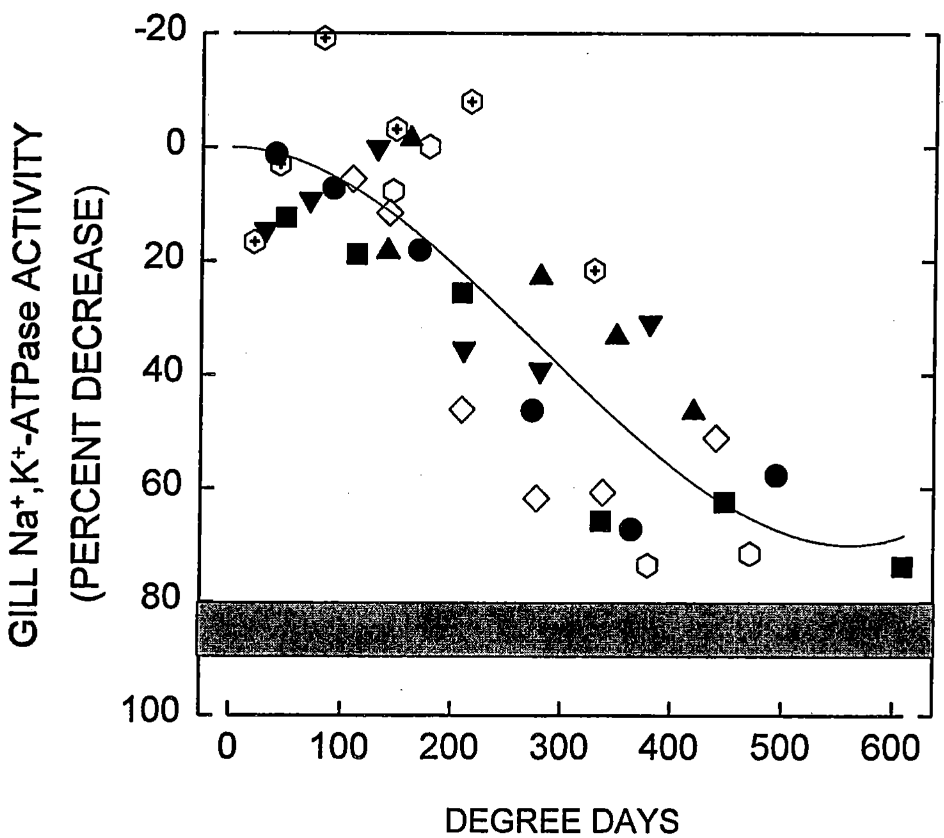

Figure 4. Effect of degree days experienced on loss of gill Na^+,K^+-ATPase activity in Atlantic salmon smolts. Percent loss of gill Na^+,K^+-ATPase activity is calculated as percent change from peak levels between April 20 and May 3. Degree days are calculated as the additive daily temperature experienced since peak gill Na^+,K^+-ATPase levels. Symbols represent the following conditions: laboratory-reared Atlantic salmon (Duston et al., 1991) at 16 °C (filled square), 13 °C (filled circle), 10 °C (filled downward pointing triangle), and ambient (increasing) temperature (open hexagon with cross); laboratory-reared Atlantic salmon (Duston et al., 1991), McCormick, unpublished results) at 10 °C (filled upward pointing triangle) and ambient temperature (open hexagon), and Atlantic salmon reared in the wild, captured early in migration and maintained at ambient temperature (open diamond) (McCormick et al., 1995). Gray bar represents levels of gill Na^+,K^+-ATPase typical of parr with low salinity tolerance. Line is a third-order regression forced to go through the origin, r^2=0.70.

The present study demonstrates that migrating Atlantic salmon smolts have initially high salinity tolerance and gill Na^+,K^+-ATPase activity and that reductions in these physiological smolt characteristics occur at the end of the normal migratory period. The applicability of the present results to all smolting salmonids or even to all Atlantic salmon populations is unclear. It is not currently known whether loss of smolt characteristics in wild and fry-released Atlantic salmon is widespread or geographically limited. If temperature is indeed the driving force for loss of smolt characteristics in nature, this process may be of greater importance in the southern portion of the range of Atlantic salmon. Factors other than latitude, such as local hydrographic and climactic conditions, may also be important. The results also suggest that any significant delays in migration will have negative impacts on the capacity of smolts to survive in seawater and return as adults.

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4.2 Smolt Production and Overwinter Mortality of Atlantic salmon (Salmo salar) Stocked as Fry

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Introduction and Study Objectives

Fry stocking is an important component of the management strategy to restore Atlantic salmon (Salmo salar) to New England rivers. Little is known about smolts produced from fry stocking, specifically, how production varies among tributaries and what factors affect the recruitment process. This information is critical to the restoration effort, as information on smolt production and recruitment processes will enable managers to direct fry resources to maximize smolt production. We initiated a study in 1994 with the following objectives: (1) to determine the number of smolts produced in selected tributaries of the West River, Vermont; (2) to determine the magnitude of overwinter mortality, an important factor for smolt production; and (3) to evaluate the processes that affect smolt recruitment, such as precocial maturation and overwinter habitat selection. Research is ongoing and will be completed in the fall of 1996. Following is a summary of the results to date.

Study Location

This study is being conducted on the Rock River, Wardsboro Branch, and Utley Brook, three large tributaries of the West River, a southern Vermont tributary of the Connecticut River. Fry are stocked annually by state and federal biologists in these tributaries at target densities of 30 to 50 x 100 m^{-2}.

Methods

Smolt trapping was completed with fyke-net weirs in 1994 and with counting fences in 1995. Mark-recapture was used to estimate smolt population size, with releases of marked smolts stratified throughout the smolt migration season. Densities of parr not migrating were estimated in June at multiple locations on the study streams using a removal method and electrofishing. Densities of parr in the fall were estimated by state and federal biologists at several locations on the study streams. Scale samples were collected during all surveys for cohort recruitment analysis.

Results

Estimates of trap efficiency have ranged from 10 to 46% over the two study years. Smolt migrations in the study tributaries have typically been initiated in mid-April and have been completed by early June. Peak migrations have generally been associated with rising water temperatures from 8 to 10 C, which occur early and mid-May. Peaks in flow generally result in increased smolt movement. Differences in smolt out-migration timing have been observed between the southern-most (Rock River) and northern-most (Utley Brook) study tributaries. The date of 50% catch for the Rock River was 6 May in 1994 and 4 May in 1995 and 11 May for Utley Brook in both 1994 and 1995. Differences in mean total length for both age-2+ and age-3+

smolts have been observed among tributaries within each year and among years within each tributary. Mean total smolt length has typically been near 150 to 160 mm. The age composition of the smolt run has been consistent among years within each tributary and the dominant smolt age in all tributaries is age-2+. Utley Brook has produced the largest proportion of age-3+ smolts (26%) over the two study years.

Density estimates have ranged from 0.40 to 1.45 x 100 m^{-2} for age-2+ smolts and from 0.03 to 0.22 x 100 m^{-2} for age-3+ smolts. Thus, for both age-classes combined, annual smolt production has generally approached 1 x 100 m^{-2}. Over all tributaries, the percent recruitment of fall age-1+ parr to age-2+ spring smolt has ranged from 10 to 31% with a mean (± SE) of 15% (± 3). Generally, age-2+ parr have been recruited with a higher frequency (21% ± 3) to smolt than age-1+ parr. Estimates of overwinter mortality for the two study years have ranged from 40 to 74% with a mean (± SE) of 64% (± 5). Smolt recruitment frequency and percent overwinter mortality, at present, appear to differ little among tributaries, with smolt production dependent primarily on fall parr densities.

Percent maturity among age-1+ fall parr is approximately 45% and increases to near 63% for age-2+ parr. Tagging experiments have revealed that mature parr (males only) are recruited to smolt at a reduced frequency compared with immature parr (males and females). In the fall, immature and mature parr differ in mean total length (immature > mature) and condition factor (mature > immature). Preliminary results suggest that precocial maturation of male parr is important to smolt recruitment.

Overwinter snorkeling surveys, with the objective of defining habitat selection and movement patterns of presmolt parr, were completed in 1994-1995 and are currently ongoing. Parr have been found to be active nocturnally at low water (0 to 2 C) temperatures, showing preferences for the stream margin and areas of low flow. Measurements of ice formation and flow and parr habitat relations have shown that ice affects a significant change in the physical stream environment and ice accumulation results in periods of constraint in parr habitat. Through marking studies parr have been found to exhibit both strong site fidelity, as well as extended movements (>100 m) during the winter period.

5. RESEARCH

5.1. CURRENT RESEARCH ACTIVITIES

The following is a list of Atlantic salmon related research that was conducted during 1995. The capital letters (codes) following the listing of the authors refers to the address of the research facility (listed at the end of the Section). The information presented is by no means complete, since many of the agencies/research labs did not respond to the Working Group's request for information.

STOCK IDENTIFICATION

King, Tim, Bane Schill, Barbara Lubinski, Mary Smith and Ed Pendleton (J)
GENETIC STOCK IDENTIFICATION OF ATLANTIC SALMON INHABITING NORTH AMERICA AND EUROPE WITH EMPHASIS ON THE DOWNEAST RIVERS OF MAINE

This study is designed to develop and evaluate techniques to identify and assess genetic variability in Atlantic salmon nuclear and mitochondrial DNA at the population level.

Schill, Bane, Bob Walker and Roger Herman (J)
ASSESSMENT OF SPATIAL AND TEMPORAL DISTRIBUTION OF GENETIC DIVERSITY IN ATLANTIC SALMON

The purpose of this study is to extend the preliminary genetic studies previously conducted by a host of laboratories to examine spatial and temporal components of genetic diversity in Atlantic salmon populations.

King, Tim, Bane Schill, Barbara Lubinski, Mary Smith, Bob Walker, Roger Herman and Ed Pendleton (J)
GENE MARKING: A TOOL TO ASSIST WITH HATCHERY PRODUCT EVALUATION (HPE) IN SUPPLEMENTAL AND RESTORATION STOCKING PROGRAMS

This study is designed to identify a gene marker(s) to assess stocking success of the Federal Atlantic salmon stocking program. This research has included investigations into: 1) development of primers to amplify selected regions of the mitochondrial DNA molecule, internal spacer regions of ribosomal DNA, and randomly amplified polymorphic DNA markers; 2) development of microsatellite DNA markers; 3) use of multi-locus and single-locus probes for DNA fingerprinting; and 4) the determination of inheritance patterns for all new genetic markers using progeny and progenitors from multiple paired matings.

Krise, Bill and Jim Meade (A, J)
DEVELOPMENT OF IMMUNOLOGICAL LYMPHOCYTE CELL SURFACE MARKERS FOR STOCK IDENTIFICATION

Study will determine the efficacy of biochemical/immune markers on Atlantic salmon lymphocytes. Immune markers would be regenerated from immune system memory of exposure to an antigen not normally encountered in natural systems.

Kincaid, Harold and Jim Meade (J)
NATIONAL FISH BROODSTOCK DATABASE AND REGISTRY OF GENETIC PERFORMANCE CHARACTERIZATION FOR MANAGED SPECIES

Designed to establish and maintain a single centralized database for fish broodstock information including descriptive characteristics that can be used by managers as a basis for management decisions.

Northeast Fishery Center Biologists (G)
MASS MARKING TRIALS WITH NON-FEEDING ATLANTIC SALMON FRY

The efficacy of marking calcified tissues of Atlantic salmon sac-fry is tested using two treatments: 1) tetracycline immersion bath 2) calcine immersion bath. Additionally, fluorescent pigment and micro-taggant will be mechanically pressure sprayed into the epidermis of a number of sac-fry for additional treatments. Short and long term mark retention and effects on health and growth will be tracked over a five year period.

Neither oxytetracycline-treated or control fish received a detectable mark when examined under 100x using long wave UV light. Fish from both calcine treatments received a mark detectable as brilliant green fluorescence in all fin ray structures when viewed as above. The mark was non-lethally detected in 35 out of 40 parr sampled at 5 months post-immersion and 58 out of 61 sampled at 8 months post-immersion.

Krise, William, John Sternick, John W. Fletcher and Michael Hendrix (A, L, G)
DEVELOPMENT OF IMMUNOLOGICAL MARKING METHODS FOR TAGGING OF ATLANTIC SALMON FRY

This project is an investigation into development of methods for marking swim-up Atlantic salmon fry using immunological tags (or immunological memory). To date, ATS parr have been exposed to one of four antigens (BSA, avidin, TNP and DNP) used for marking and blood sampled at 20, 30 and 40 days after exposure. We have developed an enzyme-linked immunospecific assay (ELISA) and are currently evaluating results of these exposure treatments. We have also sampled unexposed parr and have 100 samples from sea-run fish from the Connecticut, Merrimack and Maine rivers courtesy of Dr. Rocco Cipriano, NBS, Fish Health Laboratory, Leetown, WV. We will test these samples for the presence or absence of antigenic doses of the previously mentioned potential markers. Preliminary studies include more work testing dosage rates of markers, secondary immune response, IgM production, and retention time of marks. Our intentions are to make specific antibodies for analysis of mark retention and to develop a field kit for simple analysis of mark retention in returning adult ATS. Tests with fry will begin in the spring of 1996.

Folt, Carol, Brian Kennedy, Joel Blum, Page Chamberlain, and Keith Nislow (E)
THE USE OF ISOTOPES TO TRACE THE ORIGINS OF MIGRATION FOR ATLANTIC SALMON SMOLTS IN THE CONNECTICUT RIVER

Traditional techniques for marking and recapturing fish over large geographical areas are difficult and impractical because they require intensive field sampling, entail high mortality, and usually result in poor sample sizes. We propose the use of stable isotope techniques to identify the natal tributaries of Atlantic salmon smolts. By analyzing isotope ratios in water, algae, invertebrates and fish tissue in individual stocking steams, a stream-specific isotope signature can be derived. This information can then be used to assess the contribution of individual streams to overall smolt production.

Northeast Fishery Center Biologists (G)
REPRODUCTION AND ALEVIN MARKING TECHNIQUES FOR ATLANTIC SALMON

Marks applied to bone, skin, or similar tissue become hidden in tissue, or lost as tissue regenerates over time. These marks could require lethal sampling. The objective of this study is to establish an alevin blood marker which can be identified in returning adult ATS. Immune markers would be regenerated from immune system memory of exposure to an antigen not normal encountered in natural systems. Sea-run ATS will be sampled to ascertain that wild fish do not encounter the antigen naturally. Seven hundred (1+) Penobscot smolts were used as controls or exposed to one of four antigens. Efforts are underway to determine optimum dose and time exposure rates, blood sampling frequency, and purification of antibodies. Blood serum from 1995 searun ATS were collected in December for screening against cross reactive antibodies.

IMPACTS OF PEN AQUACULTURE

McKenna, Jim and Jim Johnson (J)
POTENTIAL IMPACTS OF CULTURED ATLANTIC SALMON ON AQUATIC RESOURCES IN THE GULF OF MAINE: A SYNTHESIS OF THE LITERATURE

An extensive synthesis of the literature focusing on the potential impacts of aquaculture on the natural resources of the Gulf of Maine.

FISH HEALTH/NUTRITION

Cipriano, Rocco, Cliff Starliper and Roger Herman (J)
FISH HEALTH PARAMETERS ASSOCIATED WITH ECOLOGICAL SURVIVAL OF ATLANTIC SALMON AND THEIR SUBSEQUENT RESTORATION IN NEW ENGLAND RIVERS

This study is designed to aid in the development of disease resistant strains of Atlantic salmon that would enhance survival and thereby be of direct benefit to the Connecticut River restoration effort.

Elston, Ralph, Ann S. Drum and Paul R. Bunnell
FURUNCULOSIS INJECTION MODEL FOR DRUG EFFICACY TESTING OF SEAWATER-ADAPTED ATLANTIC SALMON

J. Aquat. Anim. Health 7(1):16-21. 1995. FR 40(2) (Battelle Mar. Sci. Lab., 1529 West Sequim Bay Road., Sequim WA 98382)

Elston, Ralph, Ann S. Drum and Paul R. Bunnell
EFFICACY OF ORALLY ADMINISTERED DIFLOXACIN FOR THE TREATMENT OF FURUNCULOSIS IN ATLANTIC SALMON HELD IN SEAWATER

J. Aquat. Anim. Health 7(1):22-28. 1995. FR 40(2) (Battelle Mar. Sci. Lab., 1529 West Sequim Bay Road., Sequim WA 98382)

Ford, Larisa and Roger Herman (J)
SYNERGISTIC ASSOCIATION BETWEEN CYTOPHAGA (FLEXIBACTER) COLUMNARIS AND CHRONIC FUNGAL INFECTIONS THAT DEHABILITATE SEXUALLY MATURE, SEA-RUN BROODSTOCK USED TO RESTORE ATLANTIC SALMON IN NEW ENGLAND RIVERS

This study is designed to provide basis information on the significance of *Cytophaga columnaris* associated with Atlantic salmon broodstock held at federal and state fish hatcheries.

McAllister, Phil (J)
CHARACTERIZATION OF AN ATLANTIC SALMON VIRUS ISOLATE

This study is designed to determine the biochemical and biophysical characteristics of a virus recovered from kidney, spleen, and gill homogenates of landlocked (Sebago Lake, Maine) Atlantic salmon.

Cipriano, Rocco and Roger Herman (J)
RELATION BETWEEN CARRIER RATES OF FISH ASYMPTOMATICALLY AFFECTED WITH FURUNCULOSIS AS DETERMINED BY LETHAL VERSUS NON-LETHAL ASSAY FOR AEROMONAS SALMONICIDA

This study is comparing rates of recovering *A. salmonicida* from mucus of asymptomatic salmonids with results of pre-incubation assays and corticosteroid/heat stress treatment described by other researchers.

Ford, Larisa and Roger Herman (J)
ENHANCEMENT OF SALMONID IMMUNE RESPONSES TO FUNGAL INFECTION USING A YEAST GLUCAN

The study will provide basic information of the effects of an immunostimulator (e.g. glucans) on various immune parameters of salmonids.

Cipriano, Rocco, Jeff Teska and Roger Herman (J)
EFFECTS OF SEAWATER ON THE SURVIVAL OF ATLANTIC SALMON INFECTED

WITH LOW LEVELS OF RENIBACTERIUM SALMONINARUM

Seawater challenges were used to assess BKD mortality in Atlantic salmon infected with *R. salmoninarum*. Results indicated that the LD_{50} is at least one log lower for fish held in seawater, indicating that the stress of smoltification and acclimation to seawater may induce BKD mortality in fish infected with low levels of *R. salmoninarum*.

Abernathy Salmon Culture Technology Center
IMMUNOMODULATORS AS A FISH HEALTH MANAGEMENT TOOL

Furunculosis is a pathogenic disease in salmonids is caused by the bacterium *Aeromonas salmonicida*. The disease has a negative impact on the Atlantic salmon program from holding returning sea-run fish for spawning to maintaining and producing domestic broodstock and smolts. The study will test the efficacy of three different diets (VST, Tetraselmis and Levucell) containing additives for immune system enhancement in prevention of furunculosis in domestic Atlantic salmon parr.

During the first attempt in 1994 immersion baths did not elicit a furunculosis response in challenged fish. Fish broke out with furunculosis prior to the challenges during the second 1994 attempt. There was 98% mortality of ATS smolts which were bath challenged with 10^7 cells/ml of *A. salmonicida*. Mortality occurred both in control and test diet groups. Of interest, mortality was delayed for 24 hours in the Tetraselmis treatment.

Ketola, George (B)
PROTEIN NUTRITION OF ATLANTIC SALMON COMPARISON OF AMINO ACID RESPONSES WHEN FED PLANT PROTEINS OR FISH MEAL

Three plant meals (corn gluten meal, soybean meal, and peanut meal) are investigated as substitutes for fish meal in diets for fingerling Atlantic salmon. Herring meal served as the fish meal control. Amino acids were supplemented to meet either the 1993 National Academy of Science --National Research Council's requirements of rainbow trout or the amino acid content of rainbow trout eggs.

Amino acid supplementation improved the growth of salmon regardless of protein source. Supplementation of plant meal diets to the egg standard supported better growth than supplementation to the NRC standard. Supplementation of the herring meal diet to the egg standard significantly improved growth. Growth of the salmon fed all the plant meal diets supplemented to the egg standard was not significantly different from that of the salmon fed the herring meal diet without supplement. Digestibilities were determined for protein and amino acids and were generally highest for corn gluten meal, followed in decreasing order by soybean meal, fish meal and peanut meal.

This study shows that Atlantic salmon may have a higher requirement for essential amino acids than the rainbow trout. Herring meal may be slightly deficient in one or more amino acids and plant protein even more. However, these protein are highly effective for rearing Atlantic salmon when the deficiencies are supplemented. Results further suggest that it is possible to economically replace most of the fish meal with a plant meal as the major protein source in salmon diets, and provide a way to reduce the levels of excess dietary phosphorus in salmon diets, thereby reducing the amount of phosphorus discharged from hatcheries.

SMOLTIFICATION AND SMOLT ECOLOGY

Mather, Martha, Donna Parrish and Henry Booke (D, E)
FACTORS INFLUENCING SMOLT PRODUCTION, OVERWINTER MORTALITY, AND DOWNSTREAM MIGRATION OF THE ATLANTIC SALMON IN THE WEST RIVER SYSTEM, VERMONT

Smolts stocked as fry were sampled in April and May 1994 at eight locations on five tributaries of the West River, using vertical-slot net weirs. Qualitatively, smolt production differs between tributaries, mediated by differential overwinter mortality and population factors.

Bitman, Eric and Henry Booke (J)
JUVENILE ATLANTIC SALMON AND CLUPEID SMOLTIFICATION PHYSIOLOGY

Examine and compare physiological and endocrine differences in laboratory, hatchery and wild Atlantic salmon, and determine if similar conditions exist in clupeid fishes.

Johnson, Jim and David Dropkin (J)
COMPARATIVE DIETS OF HATCHERY AND WILD ATLANTIC SALMON SMOLTS IN THE MERRIMACK RIVER

This study examined the diet of 224 wild Atlantic salmon smolts (released as fry two years prior) and 150 hatchery salmon released as smolt 3 to 15 days prior to collection. Diet overlap between hatchery and wild smolts was observed to be high during all years.

Shrimpton, Mark and Henry Booke (J)
IMPORTANCE OF CORTISOL RECEPTORS IN PARR-SMOLT TRANSFORMATION

Examination of cortisol receptors (CR) in the gills of juvenile Atlantic salmon to detect changes in tissue responsiveness to cortisol. At completion, the results should indicate the role rearing environment will play in the parr-smolt transformation and development of saltwater tolerance.

Parrish, Donna L. and Kevin Whalen (D)
FACTORS INFLUENCING SMOLT PRODUCTION, OVERWINTER MORTALITY, AND DOWNSTREAM MIGRATION OF ATLANTIC SALMON IN THE CONNECTICUT RIVER

Four states (Connecticut, Massachusetts, New Hampshire, and Vermont) and two federal agencies (U.S. Fish and Wildlife Service and National Marine Fisheries Service), have been working together to reestablish Atlantic salmon populations in the Connecticut river basin. Much progress has been made regarding restoration of Atlantic salmon, e.g. closure of high seas fisheries, increased fry stocking, and upstream and downstream fish passage. Yet, on average, only two to four hundred adult salmon return to the river each year. The Connecticut River program seeks to improve the number of returning adults. Recent findings indicate the salmon program benefits most from fry stocked into tributaries, rather than hatchery smolts stocked into the mainstem river. The move toward increasing fry stocking focuses attention on addressing critical questions of what determines smolt production in tributaries. By examining factors that influence smolt production, this proposal seeks to facilitate research that will provide answers to several critical questions.

McCormick, Stephen D., B. Thrandur Bjornsson, Shusuke Moriyama, Judith B. Carey and Michael O'Dea (C)

PLASMA GROWTH HORMONE (GH), INSULIN-LIKE GROWTH FACTOR I (IGF-I), CORTISOL AND THYROID HORMONES DURING ENVIRONMENTAL MANIPULATION OF THE PARR-SMOLT TRANSFORMATION OF ATLANTIC SALMON

Atlantic salmon juveniles were reared at a constant temperature of 10°C or ambient temperature (AMB: 1-3 °C from January to April followed by seasonal increase). At 10 °C an increase in daylength (LD 16:8) in February resulted in advanced increases in gill Na+,K+-ATPase activity, whereas fish at AMB did not respond to increased daylength. Increases in gill Na+,K+-ATPase activity under normal photoperiod occurred later at AMB than at 10 °C. Plasma GH and IGF-I increased within 7 days and remained elevated after LD 16:8 at 10 °C but did not respond at AMB. Plasma cortisol increased transiently following LD 16:8 at both temperatures. Plasma thyroxine was consistently higher at AMB but increased transiently following LD 16:8 at 10 °C. Plasma triiodothyronine was initially higher in the 10 °C group than at AMB, but there was no response to LD 16:8 in either group. The results provide evidence that GH and IGF-I are involved in the response of the parr-smolt transformation to changes in temperature and photoperiod.

McCormick, Stephen D., Judith B. Carey and Michael O'Dea (C)

LOSS OF SMOLT CHARACTERISTICS IN HATCHERY- AND STREAM-REARED ATLANTIC SALMON

Changes in physiological smolt characteristics of Atlantic salmon were examined in hatchery-reared fish under controlled conditions, and in fish reared in the wild during normal smolt migration. Hatchery fish reared at ambient river temperatures (2°C in winter, 16 °C in mid-May) had more rapid decreases in gill Na+,K+-ATPase activity and salinity tolerance than fish maintained at a constant 10 °C. This finding corroborates previous studies in Atlantic and Pacific salmon in which loss of smolt characteristics is more rapid with increasing temperature. To examine changes in fish reared in the wild, Atlantic salmon that had previously been released as fry in tributaries of the Connecticut River were captured during their smolt migration at a dam

198 km from the mouth of the river. In 1993 and 1994 gill Na+,K+-ATPase activity and salinity tolerance were high at the beginning of migration in early May. In 1993 decreases in salinity tolerance were observed by May 14 and decreases in gill Na+,K+-ATPase activity were observed by May 21. In 1994 temperatures increased more slowly and decreases in salinity tolerance and gill Na+,K+-ATPase activity were not observed until May 27 and June 3, respectively. Plasma chloride and thyroid hormones of migrating smolts in fresh water varied but did not show a consistent pattern of change during the migratory period. In early May, salinity tolerance and gill Na+,K+-ATPase activity of hatchery and stream-reared fish were not different. The results indicate that late migrants have lower physiological smolt characteristics than early migrants, and we suggest these differences represent a loss of smolt characteristics due to the higher temperatures and long migratory period experienced by these fish.

Carey, Judith B., and Stephen D. McCormick (C)
AN ENZYME IMMUNOASSAY FOR CORTISOL IN FISH

Plasma cortisol levels in fish are known to rise in response to environmental stressors and during the parr-smolt transformation in salmonids. Measurement of this hormone is therefore important in understanding the stress response of fish and may be helpful in determining optimal release times for migratory salmonids. Plasma cortisol in fish has traditionally been measured by RIA (radioimmunoassay), which has increasing costs associated with licensing and disposal of radioactive material. Based on published methods for measuring sex steroids, a competitive solid-phase microtiter enzyme immunoassay (EIA) for measuring plasma cortisol in fish was developed. Sensitivity, as defined by the dose-response curve, was measurable from 1 ng/ml to 400 ng/ml. The lower detection limit was 0.30 ng/ml. There was a strong correlation of cortisol values obtained by EIA and RIA ($r = 0.986$, $n = 36$). Using a pooled plasma sample, the average intra-assay variation was 5.5% ($n = 10$) and the average inter-assay variation was 8.8% ($n = 10$). Testosterone and estradiol showed negligible (less than 1%) cross-reactivity. Cortisone had 1.6%, 7.7%, and 4.2 % cross-reactivity at 10 ng/ml, 100 ng/ml, and 400 ng/ml, respectively. (Cortisone is a breakdown product of cortisol with little biological activity but which can interfere with measurement of cortisol). Heat denaturation and ethanol extraction of plasma samples gave mean calculated values of 98% and 87% ($n=9$), respectively, compared to untreated plasma. We examined the differences in plasma cortisol between parr and smolt following a 3 hour handling and confinement stress. Parr had a plasma cortisol concentration of 4 ng/ml at time 0, rising to 11 ng/ml 3 hours after initiation of stress and dropping to 3 ng/ml by 8 hours after stress initiation. Smolts had plasma cortisol concentrations of 10 ng/ml at time 0, peaking at 243 ng/ml after 3 hours and dropping to 18 ng/ml within 8 hours after stress initiation. The results indicate a greater sensitivity of the interrenal axis to stress in smolts than in parr.

Shrimpton, J. Mark, and Stephen D. McCormick (C)
IMPACT OF STREAM HABITAT IMPROVEMENT ON SMOLTING, MATURATION AND SURVIVAL OF ATLANTIC SALMON

The changes in restoration strategy for Atlantic salmon in the Connecticut River from smolt production to a colonization program has placed increased importance on stream habitat.

Atlantic salmon have a very flexible life history pattern and rate of development, which is controlled by environmental variables. Consequently, rearing environment will regulate important changes in developmental physiology of the animals. In a combination of field and laboratory experiments, we are examining how environmental variables affect energy reserves for maturation, overwinter survival and smolt development. Mature and immature parr from tributaries of the Connecticut River from Connecticut, southern Massachusetts, southern Vermont and northern New Hampshire have been sampled to determine energy stores in relation to severity of winter conditions. Ongoing are laboratory studies to assess the effect of temperature on rate of gonadal regression and the effect of feed ration on lipid reserves at ambient temperatures.

Shrimpton, J. Mark, and Stephen D. McCormick (C)

FACTORS AFFECTING CORTISOL DYNAMICS AND SMOLTING

Many hormonal and biochemical changes occur with the development of saltwater tolerance during the parr-smolt transformation. One avenue of our investigations has been to examine how hormone receptors for cortisol change during the spring as salmon smolt. We have previously shown that cortisol receptor concentration increases and affinity decreases in fish that smolt during the spring. These changes in the cortisol receptor can be influenced by photoperiod and temperature, and correlate with the increase in Na+K+ATPase activity. Other hormones, most notably growth hormone (GH), also play an important role in stimulating physiological changes associated with smolting. We have also found that GH can increase the concentrations and decrease the affinity of cortisol receptors, similar to the seasonal changes in cortisol receptors that are seen during smolting. The studies examining seasonal changes and hormonal regulation of cortisol receptors have been conducted on potential smolts or fish that were smolting. Little is known, however, regarding the endocrine changes that occur in juvenile salmon that do not smolt during the spring. In a study comparing upper mode (potential smolts) and lower mode (fish that will smolt the following year) we found that seasonal changes in cortisol receptor concentrations and affinity do not differ significantly between the two groups. Other endocrine factors must account, therefore, for the differences in development of saltwater tolerance that exist between upper and lower mode juvenile Atlantic salmon. Circulating plasma cortisol levels can partly account for the differences that were observed. Plasma cortisol levels were significantly greater in the upper mode group and correlate with the peak in gill Na+K+ATPase activity. We do not know what other endocrine differences exist between the upper and lower mode fish, or what factors are controlling the changes in cortisol receptors observed in the lower mode group.

HABITAT

Johnson, Jim and Cara Campbell (J)

QUALIFICATION AND QUANTIFICATION OF ATLANTIC SALMON HABITAT IN THE CONNECTICUT RIVER BASIN USING A GEOGRAPHIC INFORMATION SYSTEM

This study is designed to identify (map) the available Atlantic salmon habitat throughout the

Connecticut River watershed.

Parrish, Donna L., Carol L. Folt and Kathleen L. Newbrough (D, E)
AN EVALUATION OF HABITAT QUALITY FOR AGE-0 ATLANTIC SALMON IN THE WEST AND WHITE RIVERS, VERMONT

Tributaries to the West and White rivers in Vermont have been stocked every spring with Atlantic salmon fry, as a part of the Connecticut River Atlantic salmon restoration program. Survival of age-0 salmon in the streams has been quite variable, although the general pattern indicated higher survival in the West River than in the White River. All accessible physical habitat measurements collected at sites on the West and White rivers was summarized and analyzed. Because selected nose velocities did not differ among tributaries with differing survival rates, we concluded that salmon nose velocity is not a good predictor of age-0 salmon survival in the six tributaries we sampled. There was a positive correlation between fish total length and free stream velocity in all tributaries except one, indicating that fish moved into faster water as they grew. None of the physical habitat variables we measured varied consistently among high and low salmon survival sites and lack of suitable physical habitat does not appear to be driving patterns of salmon survivorship. We can conclude that interactions between water velocities at different depths may influence net energy gains available to salmon.

Nislow, K.H., C.L. Folt and D. Parrish (E, D)
EFFECTS OF FOOD AVAILABILITY AND HABITAT STRUCTURE ON MICROHABITAT SELECTION, GROWTH AND SURVIVORSHIP OF YOY ATLANTIC SALMON

A general model was developed and testing begun on the relationship between food availability, microhabitat conditions, and YOY salmon performance. The influence of microhabitat velocity on prey availability and prey capture success was used to predict microhabitat preferences in early season (May-early June) and late season (late July - August) fish. We then estimated growth potential of individual fish over a range of microhabitat velocities, and at different levels of food concentrations. These predictions were tested against previously-collected data on foraging rates, habitat use, individual growth and first-year survivorship in 6 rearing streams. Estimates were also used to assess the availability of preferred microhabitats and growth potential of YOY salmon in USFS habitat manipulation project reaches vs. non-manipulated reference reaches. Preliminary results indicate 1) good fit between predicted and observed habitat preferences and growth rates of YOY salmon, 2) potentially strong effects of both food and habitat on YOY growth potential, particularly for early-season fish, 3) habitat changes associated with manipulation projects may increase the percentage of preferred microhabitats for early season YOY salmon.

Perlroth, N., K.H. Nislow, and C.L. Folt (E)
FEEDING BEHAVIOR AND HABITAT SELECTION IN OVERYEARLING SALMON PARR

We extended our previous work on feeding and habitat selection in YOY salmon to overyearling parr in three Vermont Department of Fish and Wildlife index sites in the Connecticut River drainage. Behavior of individual fish was observed via snorkeling, and physical conditions (depth, velocity, substrate) at salmon-occupied positions were compared to measurements along random transects. These data will be used to 1) determine habitat requirements of overyearling parr and 2) compare with YOY habitat use and behavior in these systems.

Gries Gabe, and Francis Juanes (F)
EFFECTS OF STREAM HABITAT MANIPULATIONS ON SIZE-STRUCTURED, INTRA-SPECIFIC INTERACTIONS OF JUVENILE ATLANTIC SALMON

The objectives of this project are to 1) determine the influence of overyearling salmon on the behavior and microhabitat selection of underyearling salmon; and 2) determine the influence of United States Forest Service stream habitat manipulations on these size-structured, intra-specific interaction. Enclosure experiments were conducted during the summer of 1995 in manipulated and non-manipulated areas of Greendale Brook, a tributary of the West River, Vermont. Snorkeling observations and microhabitat measurements were performed in these 100 m^2 enclosures to assess the behavior and microhabitat selection of underyearling salmon in the presence and absence of overyearling salmon. Juvenile salmon were also individually marked and observed on a day to day basis for short periods of time to assess the temporal variability of microhabitats occupied. Similar experiments will continue during the summer of 1996 and will be expanded to include an evaluation of the use of large woody debris as cover by juvenile salmon.

Parrish, Donna L. and Matthew Raffenberg (D)
A COLLABORATIVE APPROACH TO THE RESTORATION ECOLOGY AND MANAGEMENT OF JUVENILE ATLANTIC SALMON, (SALMO SALAR) IN FORESTED ECOSYSTEMS. PART III. INTERACTIONS BETWEEN ATLANTIC SALMON AND TROUT

As a part of the Atlantic salmon restoration program, juvenile salmon have been reintroduced into the West and White rivers, Vermont, where native brook trout (Salvelinus fontinalis), naturalized brown trout (Salmo trutta) and rainbow trout (Oncorhynchus mykiss) reside. In addition to changes in the salmonid community, decreased habitat complexity in riparian areas and within the streambed have led to changes in flow regimes, water temperatures, and sedimentation rates and have affected feeding, growth and survival of salmonid fish species. Competition for space among salmonids has been studied extensively, however, partitioning of food in relation to occupied microhabitats has not. This study will determine how food and feeding station can affect individual growth rates and survival among Atlantic salmon and the three trout species found in Vermont streams.

CULTURE/LIFE HISTORY

Krise, Bill and Jim Meade (A)

EVALUATION OF EMBRYOLOGICAL DYSFUNCTION IN ATLANTIC SALMON EGGS TRANSPORTED TO HATCHERIES FOR INCUBATION

Designed to determine fertilization success in eggs which fail to develop after transport to egg incubation facilities.

Honeyfield, Dale, Bill Krise and Jim Meade (A)
EVALUATION OF CRYO-PRESERVED AND FRESH MILT USING FLOW CYTOMETRY

Designed to develop and evaluate new methods from assessing the viability of cryo-preserved sperm in threatened and endangered fish (e.g. Atlantic salmon). Findings suggest flow cytometry allows the evaluation of a wider number of cryo-preserved media.

Fletcher, Bill, Mike Hendrix and Jerre Mohler (G)
COMPARISON OF EYE-UP BETWEEN GREEN ATLANTIC SALMON (SALMO SALAR) EGGS TRANSPORTED TO INCUBATION FACILITIES UNFERTILIZED WITH THOSE FERTILIZED PRIOR TO TRANSPORT

Many of the Atlantic salmon production eggs are spawned at one station and transported for incubation to another. Eye-ups for fertilized ATS eggs transported in gallon jugs, have reached levels over 90%; however, in recent years eye-ups have been as low as 60%. Since 1989, the NEFC and other Service facilities have conducted studies on improving egg quality. For example, when testing a small lot of Kensington SFH (CT) domestic eggs in FY 94 NEFC biologists found greater ($P \leq 0.001$) egg eye-up by delaying fertilization until eggs arrived at the incubating facility rather than shipping fertilized eggs (87 vs 41% resp.). Overall, the eye-up for green Atlantic salmon eggs fertilized after transport to incubation facilities (61.0%) was higher than for eggs fertilized at spawning sites prior to transport (49.2%). Results of statistical evaluations demonstrated significant improvement for delayed egg fertilization at $P \leq 0.10$ for Connecticut River searuns (80.7% vs 72.2%) and at $P \leq 0.05$ for Merrimack River domestics (56.6% vs 41.6%). No significant differences were found for egg groups from Penobscot domestics (50.1% vs 42.6%), or Connecticut River domestics (82.3% vs 80.1%).

Johnson, Catharine (G)
COMPARISON OF USE OF LHRHa AND CCP FOR SYNCHRONIZATION OF GONADAL DEVELOPMENT IN ATLANTIC SALMON (SALMO SALAR)

A management tool was necessary to synchronize the gonadal development ensuring that sufficient male gametes were available at the appropriate time to permit paired matings. Time of spermiation, milt volume, and sperm counts were determined in three groups of fish receiving either Luteinizing Hormone Releasing Hormone analogue (LHRHa), Common Carp Pituitary Hormone (CCP), or injections of saline solution (control).

At 7 days post-injection, percentages of fish which produced milt were 95% of LHRHa, 91% of

CCP, and 43% of controls. Statistically, LHRH and CCP-injected fish gave significantly greater average milt volumes than controls. The average number of cells per unit of milt was significantly greater between all three treatments with LHRH having the greatest number followed by CCP, then controls ($P \leq 0.05$). Motility appeared to be comparable between the three treatments. At 14 days post-injection, there was no significant difference between milt volumes for the treatments. However, controls increased average milt production as compared to the 7 day examination while both LHRH and CCP gave significantly less milt. There was no significant difference ($P \leq 0.05$) in mean percent hatch between eggs fertilized with milt from any treatment group at 7 or 14 days post-injection. Average hatch rates ranged from 53 to 60% in the study.

Krise, William (A)
MECHANICAL SHOCK SENSITIVITY OF ACTIVATED ATLANTIC SALMON EGGS DURING EARLY EMBRYONIC DEVELOPMENT

Losses of Atlantic salmon eggs due to handling measures during fertilization and transportation to egg incubation stations have resulted in variable fertilization rates with higher than acceptable egg mortality. This project was designed to determine the effects of mechanical shock (which occur when eggs are handled, packed and poured in water) independently of transport shock. This study also allows for quantification of shock sensitivity of eggs. The objective of this study is to measure egg sensitivity to breakage and apply differences in shock sensitivity to the handling and transport needed to complete present FWS egg incubation programs. We are looking for the least sensitive egg stages in order to plan egg movements when eggs are most tolerant of handling. We tested Atlantic salmon eggs from domestic broodstock (Cronin) and kelts (N. Attleboro) for shock sensitivity at 0.5, 1, 2, 4 and 6 hours after fertilization to determine differences in egg sensitivity over a range of transport times. Preliminary results from the test with kelt eggs indicates that the estimates of force (in ergs) causing 10% breakage was lowest in eggs one half hour after fertilization (110 ergs), than for eggs 6 hours after (200 ergs). Sensitivity was intermediate from 1-4 hours post fertilization. These results indicate that eggs are most sensitive to handling shocks within an hour after fertilization.

Mather, Martha and Henry Booke (F)
ESTIMATE THE IMPACT OF FISH PREDATORS ON ATLANTIC SALMON

Designed to determine the population effects of predators on Atlantic salmon.

POPULATION ESTIMATES/TRACKING

Kocik, John F., Kenneth F. Beland and Norman R. Dube (H, K)
IMPROVING BASINWIDE JUVENILE SALMONINE POPULATION ESTIMATES USING GIS AND FISH ECOLOGY

Estimating basinwide salmonine abundance is important to understanding presmolt production dynamics and overwinter survival. Biologists frequently use a representative reach estimation technique (RRET) - extrapolating index sites to an entire basin. However, index site selection is subject to investigator bias. To limit bias, we have combined habitat databases developed using GIS with sample theory to refine fish sampling plans and optimize efficiency. We present a framework, Basinwide Geographic and Ecologic Stratification Technique (BGEST), for defining strata and improving estimates. The foundation of BGEST is that fish production in discrete stream sections is based on egg deposition rates, habitat quality and quantity, the juxtaposition of spawning-rearing habitat, and juvenile dispersal. We compared estimates of Atlantic salmon abundance using RRET and BGEST in the Narraguagus River, Maine, from 1991 to 1995. Annual variances were lower using BGEST and results were consistent across years. We found significant differences in the density of fish between strata. RRET estimates were significantly different from observed values in 36% of strata. We also found that similar levels of variance could be obtained with less sampling effort using BGEST. BGEST provides an adaptable approach to determine production while providing useful insight into ecosystem structure.

Friedland, Kevin D., Ruth E. Haas, and Tim F. Sheehan (H)
COMPARATIVE POST-SMOLT GROWTH, MATURATION, AND SURVIVAL IN TWO STOCKS OF ATLANTIC SALMON

The marine survival and sea-age of maturation for two hatchery dependent stocks of Atlantic salmon were compared in respect to differences in post-smolt growth as evidenced by circuli spacing patterns. The two stocks, the Penobscot and Connecticut, are located at the southern extent of the range of Atlantic salmon in North America. Return rates for 1SW (seawinter) and 2SW salmon and the fraction of the smolt year class or cohort that matured as 1SW fish were found to be significantly higher in the Penobscot stock. Using image processing techniques, we extracted inter-circuli distances from scales of 2,302 2SW fish. Circuli spacing data were expressed as seasonal growth indices for the spring period, when post-smolts first enter the ocean; the summer, when growth appear maximal; and winter, when growth appears to be at a minimum. Circuli spacings of the Penobscot fish were wider during the summer season than for their Connecticut counterparts of the same smolt year. The results suggest post-smolt growth may play a significant role in deciding the age-at-maturity and survival patterns for Atlantic salmon stocks.

Kocik, John F., Kevin D. Friedland, Amy E. Lesen, Kenneth F. Beland and Norman R. Dube (H, K)
PRELIMINARY EVALUATION OF THE EARLY MARINE LIFE OF POSTSMOLT ATLANTIC SALMON IN NARRAGUAGUS BAY

Sampling of Atlantic salmon postsmolts would provide information on their early marine migration, behavior, and diet. Preliminary sampling was conducted in Narraguagus Bay to evaluate the feasibility of collecting wild postsmolt Atlantic salmon in nearshore marine environments and the sampling intensities required. Methods used were similar to those used by researchers to collect postsmolt Atlantic salmon in Canada. Biweekly sampling started on 24 April 1995 and ended 23 June 1995. Five-panel experimental monofilament gillnets (12.2 m x 4.9 m) were set along three transects at 1 nautical mile increments from the mouth of the

Narraguagus River. Thirty nets were set at the surface in fixed locations covering 3.6%, 3.1%, and 1.5% of the total transect length. No Atlantic salmon were captured. A total of 381 fish was collected with the catch dominated by pelagic species. Results suggest that gear types were adequate but effort was not intense enough to sample the low numbers of Atlantic salmon present in Narraguagus Bay. Future sampling will focus on increasing sampling intensity in concert with in-river evaluation of smolt outmigration timing.

Kocik, John F., Joseph F. McKeon and Kevin D. Friedland (H, I)
ULTRASONIC TRACKING OF EARLY MOVEMENTS OF ATLANTIC SALMON SMOLTS IN THE MERRIMACK RIVER ESTUARY

The goal of this study was to gain a better understanding of early postsmolt migration in estuary of the Merrimack River. Specific objectives were to evaluate 1) the feasibility of ultrasonic tracking of wild Atlantic salmon smolts and the sampling effort required and 2) the timing and spatial dispersal of postsmolts as they enter marine ecosystems. Migrating Atlantic salmon smolts were collected from the diversion canal below the Essex Dam by angling. Smolts were held in holding cages in the river and transported downstream by truck to the head of tide. Seven smolts were fitted with an external ultrasonic pinger then released on an outgoing tide. Movement out of the system was slightly faster than a passive drift on outgoing tides. Depending on location of the fish at shift to flood tide, movement was negligible or upriver. This preliminary study indicates that tracking in the lower estuary is feasible but smaller/lighter pingers may be needed to reduce potential effects on movement and survival.

FISH PASSAGE

Odeh, Mufeed, and Henry Booke (J)
FISH PASSAGE AND HYDRAULICS OF STEEP PASSES

Designed to evaluate a standard denil fish passage design and determine the applicability to east coast anadromous fish species.

Haro, Alexander, and Henry Booke (J)
BEHAVIOR OF DOWNSTREAM MIGRANT JUVENILE ALOSA SP. AND ATLANTIC SALMON IN RESPONSE TO LIGHT, SOUND AND FLOW NEAR OVERFLOW WEIR

This study attempts to define hydraulic characteristics that attract shad, herring, and Atlantic salmon to modified surface onfaces on fish passage devices for downstream migration.

CONTAMINANTS

Haines, Terry and Ed Pendleton (J)
INFLUENCE OF FLUORIDE ON ALUMINUM TOXICITY TO ATLANTIC SALMON

Fluoride, aluminum, and pH were found to be related in overall toxicity to Atlantic salmon.

High concentrations of fluoride increased the solubility of aluminum, and therefore aluminum toxicity increased at higher pH and fluoride concentrations.

Ketola, George and Jim Johnson (B, J)
RESTORATION OF ATLANTIC SALMON IN LAKE ONTARIO: AN ASSESSMENT OF IMPEDIMENTS TO REPRODUCTION IN TRIBUTARIES

This study will determine levels of heavy metals in the tributaries of Lake Ontario to examine potential linkages to reproductive failure in Atlantic salmon.

GREAT LAKE ATLANTIC SALMON ECOLOGY

Ketola, George and Jim Johnson (B, J)
CHANGES IN FORAGE FISH POPULATIONS AND THEIR IMPACTS ON RESTORING LAKE TROUT AND ATLANTIC SALMON IN LAKE ONTARIO

This study is examining the role of non-native forage fishes in the restoration process of native salmonids and examining the feasibility of restoring native forage fishes in Lake Ontario.

Fynn-Aikins, Kofi and Jim Johnson (J)
IDENTIFICATION OF FACTORS AFFECTING FISH COMMUNITY STRUCTURE IN THE GREAT LAKES ECOSYSTEM: "EARLY MORTALITY SYNDROME"

Study examines the potential influence of nutritional factors on Early Mortality Syndrome which has severely impacted reproduction of several salmonid species (including Atlantic salmon) inhabiting the Great Lakes since 1985.

LIST OF CONTRIBUTING INSTITUTIONS

Code	Address
A	National Biological Service National Fishery Research & Develop. Lab. R.D. #4, Box 63 Wellsboro, PA 16901 Phone: 717-724-3322 Fax: 717-724-2525
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I	U.S. Fish & Wildlife Service Laconia Office of Fishery Assistance Federal Bldg., Room 124 Laconia, NH 03246 Phone: 603-528-8750 Fax: 603-528-8729
J	National Biological Service Leetown Science Center Box 700, C.R. 1 Kearneysville Road Kearneysville, WV 25430
K	Maine Atlantic Salmon Authority 650 State Street Bangor, ME 04401-5654 (207) 941-4486
L	Mansfield University Biology Department Mansfield, PA

5.2. RESEARCH NEEDS AND DATA DEFICIENCIES

The reader is referred to Annual Report 1992/4 for a detailed description of the research needs and data deficiencies regarding Atlantic salmon in New England.

6. HISTORICAL DATA (1970 - 1994)

6.1. STOCKING

The historical stocking information is presented in Table 3.2.a. in Appendix 11.1. The information is also displayed graphically by major program and by lifestage at stocking in figures 6.1.a. and 6.1.b. (Appendix 11.1.).

6.2. ADULT RETURNS

The historical return information is presented in Table 3.2.b. in Appendix 11.1. The information is also displayed graphically by major program and by sea-age in figures 6.2.a. and 6.2.b. (Appendix 11.1.).

7. TERMS OF REFERENCE FOR 1997 MEETING

The U.S. Atlantic Salmon Assessment Committee agreed to address the following Terms of

Reference for the 1997 meeting.

1. Program summaries for current year (1996) 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. Historical data - validate 1995 stocking and return data and add to historic database.

3. Continue to synthesize available data and model juvenile survival and growth rates.

4. Continue to confirm smolt status utilizing existing smolt work, stress evaluation, and examination of selected characteristics in potential smolts and returning adults.

5. Retrospectively examine river and near coastal environmental interactions in respect to movement of smolts and adults.

6. Compare marine survival rate of U.S. Atlantic salmon stocks and identify factors affecting these rates.

7. Develop methodologies to estimate smolt production and parr to smolt over-wintering mortality for U.S. Atlantic salmon stocks.

8. U.S. ATLANTIC SALMON ASSESSMENT COMMITTEE MEMBERS

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Larry Stolte	U.S. Fish & Wildlife Service 151 Broad Street Nashua, NH 03063	 Fax	603-598-4393 603-595-3478

9. PAPERS SUBMITTED

Because the regularly scheduled meeting was canceled, no papers were submitted.

10. LITERATURE CITED

Any literature cited is included within the body of the report.

11. APPENDICES

11.1. TABLES AND FIGURES SUPPORTING THE DOCUMENT

TABLE 2.2.1. ATLANTIC SALMON STOCKING SUMMARY FOR NEW ENGLAND IN 1995 BY RIVER SYSTEM AND BY PROGRAM. 1)

RIVER SYSTEM	NUMBER OF FISH 2)						TOTAL
	FRY	0+PARR	1PARR	1+PARR	1SMOLT	2SMOLT	
UNITED STATES							
St. John	0	0	0	0	0	0	0
Aroostook	4,300	0	0	0	0	0	4,300
St. Croix	1,000	0	0	0	0	0	1,000
Dennys	84,000	0	0	0	0	0	84,000
Pleasant	0	0	0	0	0	0	0
East Machias	0	0	0	0	0	0	0
Machias	150,000	0	0	0	0	0	150,000
Narraguagus	105,000	0	0	0	0	0	105,000
Union	0	54,800	0	0	0	0	54,800
Penobscot	501,000	325,000	5,553	0	568,400	0	1,399,953
Ducktrap	0	0	0	0	0	0	0
Sheepscot	0	0	0	0	0	0	0
Saco	376,000	0	0	0	19,700	0	395,700
Cocheco	114,000	0	0	0	0	0	114,000
Lamprey	91,000	57,100	0	0	4,800	0	152,900
Merrimack	2,827,000	0	12,700	0	70,800	0	2,910,500
Pawcatuck	367,000	52,200	0	0	0	0	419,200
Connecticut	6,818,000	4,500	0	0	1,300	0	6,823,800
TOTAL	11,438,300	493,600	18,253	0	665,000	0	12,615,153
CANADA							
Upper St. John	0	0	0	0	0	0	0
Aroostook	0	0	0	0	0	0	0
St. Croix	0	21,000	0	0	17,000	0	38,000
TOTAL	0	21,000	0	0	17,000	0	38,000
PROGRAM							
Maine							
United States	1,221,300	379,800	5,553	0	588,100	0	2,194,753
Canada	0	21,000	0	0	17,000	0	38,000
Cocheco	114,000	0	0	0	0	0	114,000
Lamprey	91,000	57,100	0	0	4,800	0	152,900
Merrimack River	2,827,000	0	12,700	0	70,800	0	2,910,500
Pawcatuck River	367,000	52,200	0	0	0	0	419,200
Connecticut River	6,818,000	4,500	0	0	1,300	0	6,823,800
TOTAL	11,438,300	514,600	18,253	0	682,000	0	12,653,153

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 2.2.2.a. SUMMARY OF JUVENILE ATLANTIC SALMON MARKING PROGRAMS NEW ENGLAND IN 1995. 1)

PROGRAM	NO. CODED WIRE TAGS		NO. CARLIN TAGS		NO. FIN CLIPS ONLY		NO. VI TAGS	
	PARR	SMOLTS	PARR	SMOLTS	PARR	SMOLTS	PARR	SMOLTS
Maine Program	0	0	0	0	0	0	301	0
Merrimack River	0	0	0	0	0	0	0	0
Pawcatuck River	0	0	0	0	0	0	589	18
Connecticut River 2)	0	0	0	0	0	0	251	2,106
TOTAL	0	0	0	0	0	0	1,141	2,124

1) All numbers rounded to nearest 100 fish.
2) An additional 301 wild parr were tagged with PIT tags.

TABLE 2.2.2.b. ATLANTIC SALMON MARKING DATABASE FOR NEW ENGLAND - 1995.

MARKING AGENCY	AGE	LIFE STAGE	H/W	STOCK ORIGIN	TAG TYPE	NUMBER MARKED	CODE OR SERIAL	AUX CLIP	REL DATE	PLACE OF RELEASE	COMMENT
MACFWRU *	1,2	parr	W	Connecticut	PIT	301			10-11/95	Connecticut R.	
TOTAL PIT, CONNECTICUT RIVER						301					
MACFWRU *	2,3	parr	W	Connecticut	VI	251	D64		6/95	Connecticut R.	Green
							DA0-DE9		6/95	Connecticut R.	Green
							E47-E81		6/95	Connecticut R.	Green
							P00-P94		6/95	Connecticut R.	Green
							PM0-PZ9		6/95	Connecticut R.	Green
							NA7-ND9		6/95	Connecticut R.	Green
							H93		6/95	Connecticut R.	Yellow
MACFWRU *	2,3	smolt	W	Connecticut	VI	2,106	D00-D99		4-5/95	Connecticut R.	Green
							DF0-DL8		4-5/95	Connecticut R.	Green
							E00-E99		4-5/95	Connecticut R.	Green
							EA1-EZ9		4-5/95	Connecticut R.	Green
							N00-N99		4-5/95	Connecticut R.	Green
							NA0-NZ9		4-5/95	Connecticut R.	Green
							BA0-BZ9		4-5/95	Connecticut R.	Yellow
							CA0-CZ9		4-5/95	Connecticut R.	Yellow
							D00-D99		4-5/95	Connecticut R.	Yellow
							DA2-DZ9		4-5/95	Connecticut R.	Yellow
							EA6-ES0		4-5/95	Connecticut R.	Yellow
							F22-F99		4-5/95	Connecticut R.	Yellow
							FA0-FL9		4-5/95	Connecticut R.	Yellow
							H21-H49		4-5/95	Connecticut R.	Yellow
							HA0-H49		4-5/95	Connecticut R.	Yellow
							J00-J99		4-5/95	Connecticut R.	Yellow
							JA0-JL0		4-5/95	Connecticut R.	Yellow
							K34-K45		4-5/95	Connecticut R.	Yellow
							KA0-KW9		4-5/95	Connecticut R.	Yellow
							L25-L99		4-5/95	Connecticut R.	Yellow
							LA0-LL9		4-5/95	Connecticut R.	Yellow
							MA0-ML9		4-5/95	Connecticut R.	Yellow
							N94-N99		4-5/95	Connecticut R.	Yellow
							P44-P49		4-5/95	Connecticut R.	Yellow
TOTAL VI, CONNECTICUT RIVER						2357					
USFWS		adult	H/W	Merrimack	FLOY	33	1287 - 1290		11/95	Merrimack R.	
							1292				
							1294 - 1304				
							1306 - 1308				
							1310 - 1316				
							1318 - 1324				
TOTAL FLOY, MERRIMACK RIVER						33					
NHFG	3+/4+	adult	H	Merrimack	Disk	375	95-S		4/95	Merrimack R.	Green
NHFG	3+/4+	(domestic)	H	Merrimack	Disk	357	95-S		4/95	Merrimack R.	Red
NHFG	3+		H	Merrimack	Disk	171	95-S		4/95	Merrimack R.	Dark Blue
NHFG	3+		H	Merrimack	Disk	170	95-S		4/95	Merrimack R.	Orange
NHFG	3+		H	Merrimack	Disk	172	95-S		4/95	Merrimack R.	White
NHFG	3+/4+		H	Merrimack	Disk	360	95-S		4-5/95	Merrimack R.	Yellow
NHFG	3+		H	Merrimack	Disk	189	A/5-2		10/95	Merrimack R.	Clear
NHFG	3+		H	Merrimack	Disk	123	F/5-2		10/95	Merrimack R.	Clear
NHFG	3+		H	Merrimack	Disk	109	H/5-2		10/95	Merrimack R.	Clear
NHFG	3+		H	Merrimack	Disk	109	G/5-2		10/95	Merrimack R.	Clear
NHFG	3+		H	Merrimack	Disk	24	S/5-2		10/95	Merrimack R.	Clear
NHFG	3+		H	Merrimack	Disk	538	B/5-2		12/95	Merrimack R.	Dark Blue
NHFG	3+		H	Merrimack	Disk	531	S/5-2		12/95	Merrimack R.	Dark Blue
NHFG	3+		H	Merrimack	Disk	357	F/5-2		12/95	Merrimack R.	Dark Blue
TOTAL DISK, MERRIMACK RIVER						3585					

TABLE 2.2.2.b. ATLANTIC SALMON MARKING DATABASE FOR NEW ENGLAND - 1995.

MARKING AGENCY	AGE	LIFE STAGE	H/W	STOCK ORIGIN	TAG TYPE	NUMBER MARKED	CODE OR SERIAL	AUX CLIP	REL DATE	PLACE OF RELEASE	COMMENT
RIDFW	1	parr	W	Pawcatuck	VI	589			3/95	Pawcatuck R.	Flourescent Orange
RIDFW	2	smolt	W	Pawcatuck	VI	18			3/95	Pawcatuck R.	Flourescent Orange
TOTAL VI, PAWCATUCK RIVER						607					
MASA	0+	parr	W	Narraguagus	VI	131			10/95	Narraguagus R.	Red, Right Jaw
MASA	0+	parr	W	Narraguagus	VI	25			10/95	Narraguagus R.	Green, Left Jaw
MASA	0+	parr	W	Narraguagus	VI	68			10/95	Narraguagus R.	Blue, Left Jaw
MASA	0+	parr	W	Narraguagus	VI	77			10/95	Narraguagus R.	Yellow, Left Jaw
TOTAL VI, NARRAGUAGUS RIVER						301					

* MACFRWRU = Massachusetts Cooperative Fish and Wildlife Research Unit

TABLE 2.3.1. DOCUMENTED ATLANTIC SALMON RETURNS TO NEW ENGLAND RIVERS IN 1995. 1)

RIVER	NUMBER OF ATLANTIC SALMON BY SEA AGE								TOTAL FOR 1995	
	1SW		2SW		3SW		RS			
	Hat	Wild	Hat	Wild	Hat	Wild	Hat	Wild		
Penobscot River	158	6	1,077	84	7	0	9	1	1,342	
Aroostook River	19	0	3	0	0	0	0	0	22	2)
Union River										
Narraguagus River	0	0	0	51	0	0	0	5	56	
Pleasant River										
Machias River										
East Machias River										
Dennys River	0	0	0	5	0	0	0	0	5	3)
St. Croix River	7	8	15	16	0	0	0	0	46	3)
Kennebec River										
Androscoggin River	2	0	12	2	0	0	0	0	16	
Sheepscot River	0	0	2	22	0	0	0	0	24	
Ducktrap River										
Saco River	0	0	34	0	0	0	0	0	34	
Cocheco River	0	0	1	0	0	0	0	0	1	4)
Lamprey River	0	0	1	0	0	0	0	0	1	5)
Merrimack River	2	0	17	15	0	0	0	0	34	
Pawcatuck River	0	0	4	0	0	0	0	0	4	
Connecticut River	1	0	158	29	0	0	0	0	188	
TOTAL	189	14	1,324	224	7	0	9	6	1,773	

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) It is unknown whether the adults were of hatchery origin or wild orgin.
3) The totals exclude adults of aquaculture origin.
4) Fish ladder not operated in fall.
5) Fish ladder operated as swim through in April and May.

TABLE 2.3.2. INDICIES AND ESTIMATED ABUNDANCE OF ATLANTIC SALMON RETURNS TO NEW ENGLAND RIVERS IN 1995.

(EXPLANATIONS OF INDICIES AND EXTRAPOLATION METHODS ARE INCLUDED IN TEXT BODY)

RIVER	RECREATIONAL FISHERY				TRAP CATCH			REDD COUNTS		ESTIMATED ABUNDANCE
	Creel / Reporting		Estimator	Est.	100%	90%	75%	Total	Partial	
	Release	Harvest	(10% * Released)	Total						
Aroostook 1)	0	0	0	0	22					162
St. Croix	0	0	0	0			80			80
Dennys 2)	20	0	2	2				48		48
East Machias 2)	22	0	2	2						(22+) Unknown
Machias	5		1	1					19	(20+) Unknown
Pleasant	0								8	(8+) Unknown
Narraguagus	23	0	2	2	56			61		56
Union	0	0	0	0						0
Penobscot	300	0	30	30			1789			1819
Ducktrap	0	0	0	0				15		16
Sheepscot	0	0	0	0						(24+) Unknown
Kennebec	0	0	0	0						Unknown
Androscoggin	0	0	0	0		18				18
Saco	0	0	0	0	34					34
Cocheco	0	0	0	0		1			0	1
Lamprey	0	0	0	0		1			0	1
Merrimack	0	0	0	0		32				35
	0	0	0	0						
Pawcatuck	0	0	0	0		4				4
	0	0	0	0						
Connecticut 3)	0	0	0	6		209				215
TOTALS	370	0	37	43	112	265	1869	124	27	2489

1) Includes trap catch of 22 adults and 140 adults trucked into the system (162 total).
2) Some of these were probably of aquaculture origin.
3) Estimate based on 3% of trap catch.

TABLE 2.3.3. SUMMARY OF 1995 CODED WIRE TAGGED (CWT) AND CARLIN TAGGED ADULT ATLANTIC SALMON RETURNS TO USA RIVERS.

RIVER	TAG TYPE	AGE GROUP 1SW	2SW	3SW	RS	TOTAL
Connecticut River						
Trap	CWT	1	156	0	0	157
Merrimack River						
Trap	CWT	2	17	0	0	19
Rod	CWT	0	0	0	0	0
Penobscot River 1)						
Trap	CWT	44	280	0	2	326
Rod	CWT	0	0	0	0	0
Trap	Carlin	0	0	0	1	1
Rod	Carlin	0	0	0	0	0
Other Rivers in Maine 1)						
Trap	CWT	0	0	0	0	0
Rod	CWT	0	0	0	0	0
TOTAL	CWT	47	453	0	2	502
	Carlin	0	0	0	1	1

1) It is assumed that any Atlantic salmon in Maine with an adipose finclip also carried a CWT.

TABLE 2.3.4. SUMMARY OF ATLANTIC SALMON EGG PRODUCTION IN NEW ENGLAND FACILITIES IN 1995 1).

SOURCE RIVER	ORIGIN	FEMALES SPAWNED	TOTAL EGG TAKE	NO. OF EGGS PER FEMALE
Sheepscot River	Sea-run	11	78,500	7,136
Penobscot River	Sea-run	380	2,635,000	6,934
Lamprey River	Sea-run	0	0	0
Merrimack River	Sea-run	24	187,600	7,817
Pawcatuck River	Sea-run	2	14,400	7,200
Connecticut River	Sea-run	101	945,500	9,361
TOTAL SEA-RUN		518	3,861,000	7,454
Penobscot River	Domestic	0	0	0
Merrimack River	Domestic	694	4,353,200	6,273
Connecticut River	Domestic	1,258	7,555,400	6,006
Dennys River	Captive 2)	105	303,900	2,894
East Machias River	Captive	65	143,700	2,211
Sheepscot River	Captive	22	44,400	2,018
Machias River	Captive	171	484,200	2,832
Narraguagus River	Captive	115	394,400	3,430
TOTAL CAPTIVE/DOMESTIC		2,430	13,279,200	5,465
Dennys River	Kelts	5	34,200	6,840
Connecticut River	Kelts	183	2,159,300	11,799
Machias River	Kelts	4	27,600	6,900
TOTAL SEA-RUN KELTS		192	2,221,100	11,568
GRAND TOTAL		**3,140**	**19,361,300**	**6,166**

1) Egg takes 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 1995 SPORT CATCH OF ATLANTIC SALMON IN MAINE.								
	NO. SALMON HARVESTED				TOTAL	EST. NO.	TOTAL	TOTAL
RIVER	1SW	2SW	3SW	RS	HARVEST	RELEASED	ANGLED 1995	ANGLED 1994
St. Croix	0	0	0	0	0	0	0	3
Dennys	0	0	0	0	0	20	20	33
East Machias	0	0	0	0	0	22	22	12
Machias	0	0	0	0	0	5	5	5
Pleasant	0	0	0	0	0	0	0	2
Narraguagus	0	0	0	0	0	23	23	20
Union	0	0	0	0	0	0	0	0
Penobscot	0	0	0	0	0	300	300	182
Ducktrap	0	0	0	0	0	0	0	0
Sheepscot	0	0	0	0	0	0	0	1
Kennebec	0	0	0	0	0	0	0	0
Saco	0	0	0	0	0	0	0	1
Aroostook	0	0	0	0	0	0	0	3
TOTAL	0	0	0	0	0	370	370	262

TABLE 3.2.a. ATLANTIC SALMON STOCKING SUMMARY FOR NEW ENGLAND BY RIVER
1970 THROUGH 1994

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
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
1976	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
TOTAL	624000	317100	36800	1800	32600	29800	1042100

TABLE 3.3.a. Continued

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
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	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
TOTAL	1259000	303400	158100	0	731600	20100	2472200
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
TOTAL	184000	8300	3400	0	143100	28300	367100

TABLE 3.3.a. Continued

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
TOTAL	187000	2500	1800	0	54700	18100	264100
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
TOTAL	140000	6500	42600	0	97600	30400	317100

TABLE 3.3.a. Continued

RIVER / YEAR	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
TOTAL	**239000**	**86900**	**117800**	**0**	**180500**	**42200**	**666400**
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
TOTAL	**74000**	**30300**	**12600**	**0**	**106100**	**84000**	**307000**

TABLE 3.3.a. Continued

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
TOTAL	**81000**	**111700**	**0**	**0**	**379700**	**251000**	**823400**
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	35100	9100	34300	65900	144400
1975	0	0	12300	0	15800	94800	122900
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
TOTAL	**5927000**	**1232700**	**1348700**	**9100**	**7099100**	**2508200**	**18124800**

TABLE 3.3.a. Continued

RIVER / YEAR	FRY	0+PARR	1PARR	1+PARR	1SMOLT	2SMOLT	TOTAL
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
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
TOTAL	159000	70800	20600	0	92200	7100	349700

TABLE 3.3.a. Continued

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
TOTAL	**669000**	**165200**	**201200**	**0**	**203500**	**9500**	**1248400**
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
TOTAL	**682000**	**50000**	**9500**	**1000**	**5300**	**0**	**747800**

TABLE 3.3.a. Continued

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
TOTAL	**599000**	**280700**	**48000**	**1100**	**133300**	**32800**	**1094900**

RIVER / YEAR	FRY	0+PARR	1PARR	1+PARR	1SMOLT	2SMOLT	TOTAL
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	36000	0	0	0	0	0	36000
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
TOTAL	**13148000**	**222500**	**398800**	**157300**	**935800**	**630500**	**15492900**

TABLE 3.3.a. Continued

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
TOTAL	**1103000**	**1020900**	**234500**	**0**	**30500**	**500**	**2389400**
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
TOTAL	**21348500**	**2794900**	**1565500**	**222300**	**3726200**	**855300**	**30512700**

TABLE 3.3.a. Continued

GRAND TOTAL BY RIVER (1970-1993)

RIVER	NUMBER OF FISH						
	FRY	0+PARR	1PARR	1+PARR	1SMOLT	2SMOLT	TOTAL
Upper St. John	2165000	1456700	14700	0	5100	27700	3669200
Aroostook	624000	317100	36800	1800	32600	29800	1042100
St. Croix	1259000	303400	158100	0	731600	20100	2472200
Dennys	184000	8300	3400	0	143100	28300	367100
Pleasant	187000	2500	1800	0	54700	18100	264100
East Machias	140000	6500	42600	0	97600	30400	317100
Machias	239000	86900	117800	0	180500	42200	666400
Narraguagus	74000	30300	12600	0	106100	84000	307000
Union	81000	111700	0	0	379700	251000	823400
Penobscot	5927000	1232700	1348700	9100	7099100	2508200	18124800
Ducktrap	83000	0	0	0	0	0	83000
Sheepscot	159000	70800	20600	0	92200	7100	349700
Saco	669000	165200	201200	0	203500	9500	1248400
Cocheco	682000	50000	9500	1000	5300	0	747800
Lamprey	599000	280700	48000	1100	133300	32800	1094900
Merrimack	13148000	222500	398800	157300	935800	630500	15492900
Pawcatuck	1103000	1020900	234500	0	30500	500	2389400
Connecticut	21348500	2794900	1565500	222300	3726200	855300	30512700
TOTAL	48671500	8161100	4214600	392600	13956900	4575500	79972200

TABLE 3.2.b. HISTORICAL ATLANTIC SALMON RETURNS TO NEW ENGLAND RIVERS
1970 THROUGH 1994
INCLUDES TRAP AND / OR 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 SYSTEM	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	3401
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
TOTAL	**7945**	**35262**	**198**	**462**	**415**	**2325**	**23**	**65**	**46695**
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									
TOTAL	**290**	**1734**	**9**	**24**	**1**	**11**	**0**	**0**	**2069**

TABLE 3.3.b. Continued

RIVER SYSTEM YEAR	HATCHERY ORIGIN 1-S-W	2-S-W	3-S-W	REPEAT	WILD ORIGIN 1-S-W	2-S-W	3-S-W	REPEAT	TOTAL
NARRAGUAGUS									
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
TOTAL	29	408	11	15	43	1744	40	93	2383
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
TOTAL	4	12	0	0	10	204	2	2	234

TABLE 3.3.b. Continued

RIVER SYSTEM YEAR	HATCHERY ORIGIN 1-S-W	2-S-W	3-S-W	REPEAT	WILD ORIGIN 1-S-W	2-S-W	3-S-W	REPEAT	TOTAL
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									
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									
TOTAL	21	244	1	2	12	307	1	10	598

TABLE 3.3.b. Continued

RIVER SYSTEM YEAR	HATCHERY ORIGIN 1-S-W	2-S-W	3-S-W	REPEAT	WILD ORIGIN 1-S-W	2-S-W	3-S-W	REPEAT	TOTAL
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	1	0	0	0	0	40	0	0	41
1974	0	0	0	0	3	43	0	3	49
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
TOTAL	21	294	0	1	19	641	3	10	989
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
TOTAL	605	987	38	12	403	613	39	17	2714

TABLE 3.3.b. Continued

RIVER SYSTEM YEAR	HATCHERY ORIGIN 1-S-W	HATCHERY ORIGIN 2-S-W	HATCHERY ORIGIN 3-S-W	HATCHERY ORIGIN REPEAT	WILD ORIGIN 1-S-W	WILD ORIGIN 2-S-W	WILD ORIGIN 3-S-W	WILD ORIGIN REPEAT	TOTAL
KENNEBEC									
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									
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
TOTAL	**22**	**468**	**5**	**2**	**4**	**61**	**0**	**1**	**563**

TABLE 3.3.b. Continued

RIVER SYSTEM YEAR	HATCHERY ORIGIN 1-S-W	HATCHERY ORIGIN 2-S-W	HATCHERY ORIGIN 3-S-W	HATCHERY ORIGIN REPEAT	WILD ORIGIN 1-S-W	WILD ORIGIN 2-S-W	WILD ORIGIN 3-S-W	WILD ORIGIN REPEAT	TOTAL
SHEEPSCOT									
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
TOTAL	6	36	0	0	27	287	9	0	365
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									
TOTAL	0	0	0	0	3	30	0	0	33

TABLE 3.3.b. Continued

RIVER SYSTEM	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
TOTAL	23	324	2	2	0	2	0	0	353
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
TOTAL	0	0	1	1	1	3	0	0	6

TABLE 3.3.b. Continued

RIVER SYSTEM 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
TOTAL	**10**	**17**	**1**	**0**	**1**	**12**	**0**	**0**	**41**
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
TOTAL	**137**	**653**	**17**	**1**	**77**	**809**	**23**	**0**	**1717**

TABLE 3.3.b. Continued

RIVER SYSTEM YEAR	HATCHERY ORIGIN 1-S-W	2-S-W	3-S-W	REPEAT	WILD ORIGIN 1-S-W	2-S-W	3-S-W	REPEAT	TOTAL
PAWCATUCK									
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
TOTAL	1	137	1	0	0	1	0	0	140
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
TOTAL	34	3199	28	1	8	456	8	0	3734
GRAND TOTAL	9171	44185	322	523	1042	8551	164	238	64243

TABLE 3.3.b. Continued
GRAND TOTAL BY RIVER (1970-1993)

RIVER SYSTEM	HATCHERY ORIGIN				WILD ORIGIN				
	1-S-W	2-S-W	3-S-W	REPEAT	1-S-W	2-S-W	3-S-W	REPEAT	TOTAL
PENOBSCOT	7945	35262	198	462	415	2325	23	65	46695
UNION	290	1734	9	24	1	11	0	0	2069
NARRAGUAGUS	29	408	11	15	43	1744	40	93	2383
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	19	641	3	10	989
ST. CROIX	605	987	38	12	403	613	39	17	2714
KENNEBEC	12	189	5	1	0	9	0	0	216
ANDROSCOGGIN	22	468	5	2	4	61	0	1	563
SHEEPSCOT	6	36	0	0	27	287	9	0	365
DUCKTRAP	0	0	0	0	3	30	0	0	33
SACO	23	324	2	2	0	2	0	0	353
COCHECO	0	0	1	1	1	3	0	0	6
LAMPREY	10	17	1	0	1	12	0	0	41
MERRIMACK	137	653	17	1	77	809	23	0	1717
PAWCATUCK	1	137	1	0	0	1	0	0	140
CONNECTICUT	34	3199	28	1	8	456	8	0	3734
TOTAL	9181	44202	324	524	1044	8566	164	238	64243

FIGURE 6.1.a.

NEW ENGLAND ATLANTIC SALMON STOCKING PROGRAM
1970 - 1994 (79,972,200 FISH)

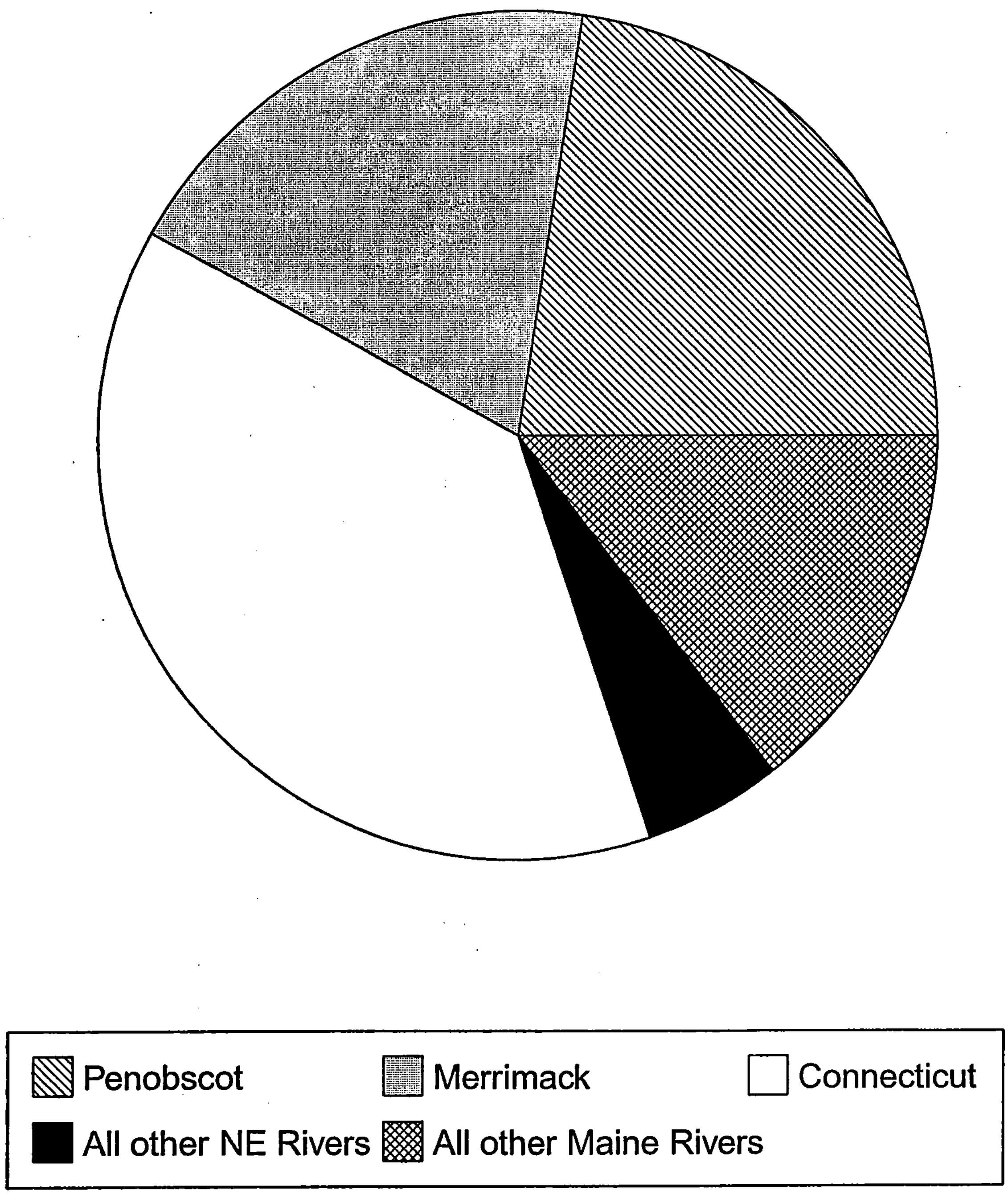


FIGURE 6.1.b.
NEW ENGLAND ATLANTIC SALMON STOCKING PROGRAM
1970 - 1994 (79,972,200 FISH)

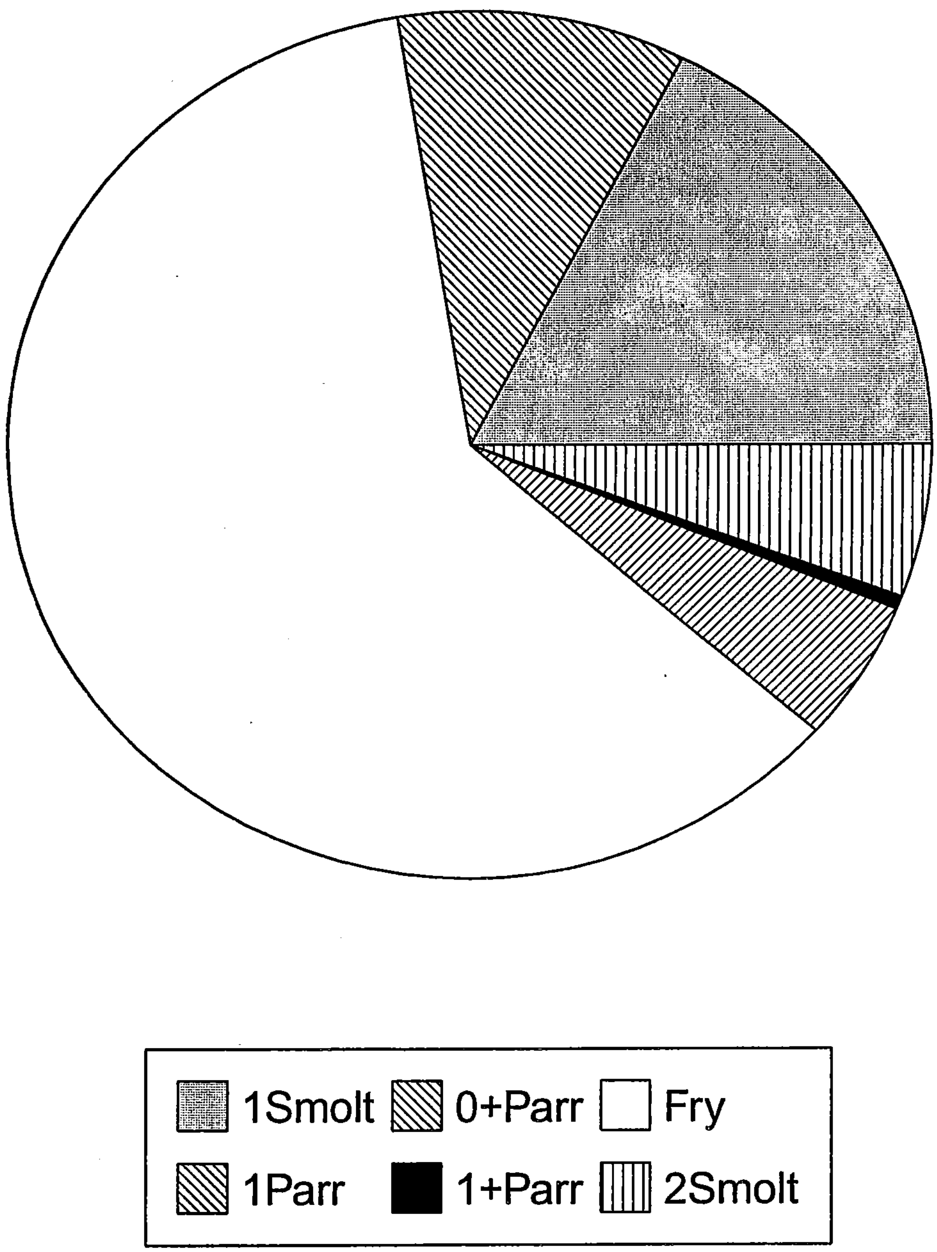


FIGURE 6.2.a.

NEW ENGLAND ATLANTIC SALMON RETURNS
1970 - 1994 (64243 ADULT SALMON)

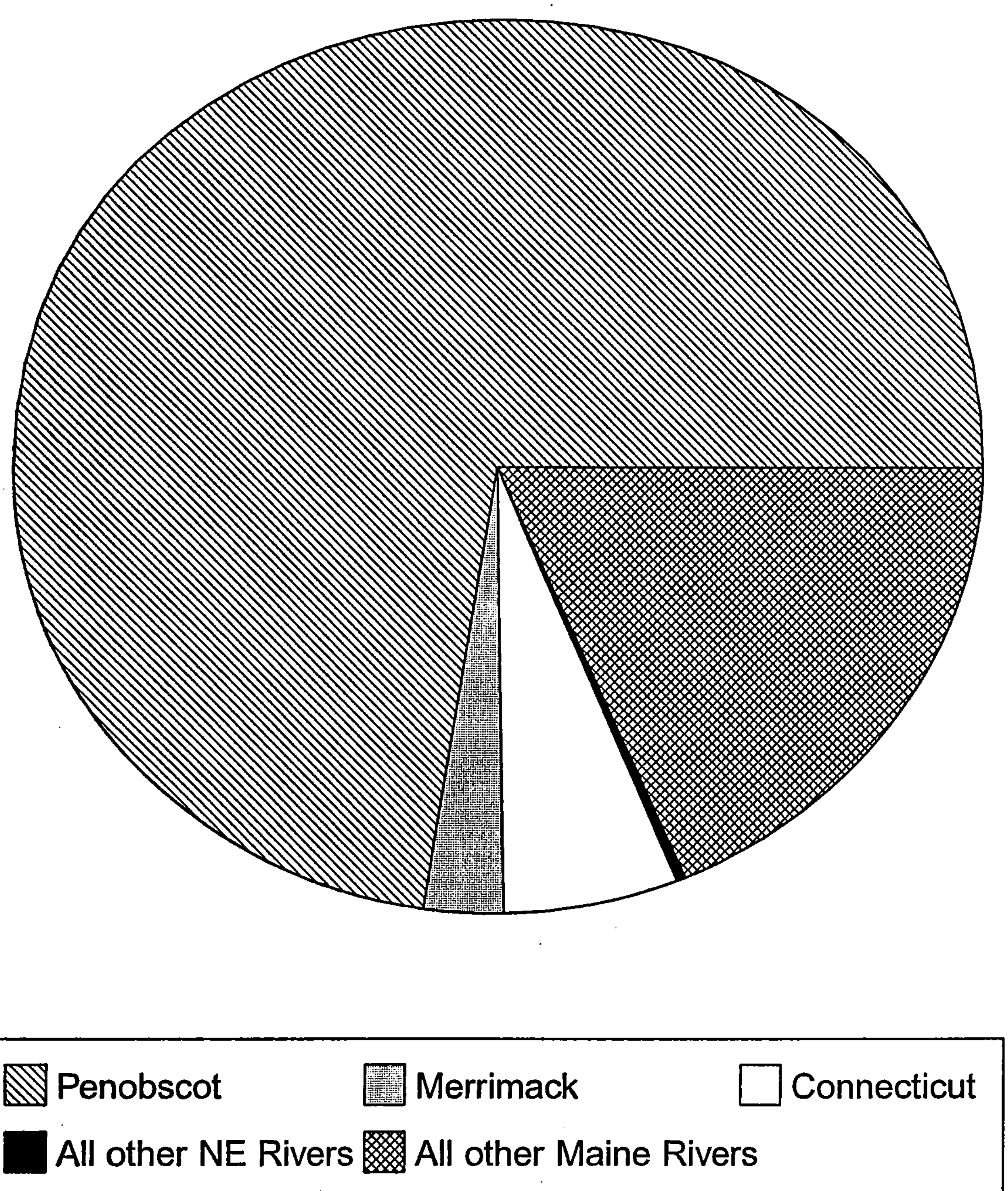
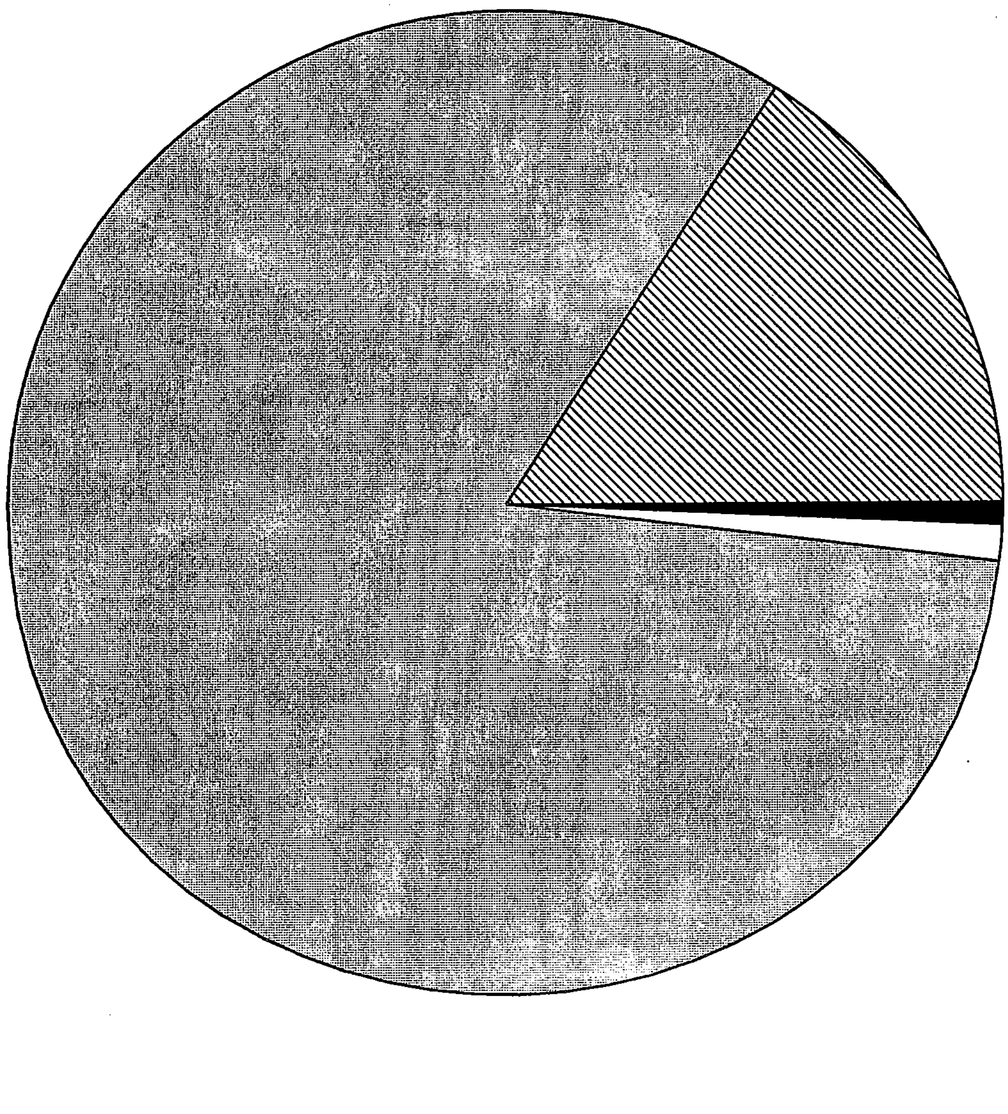
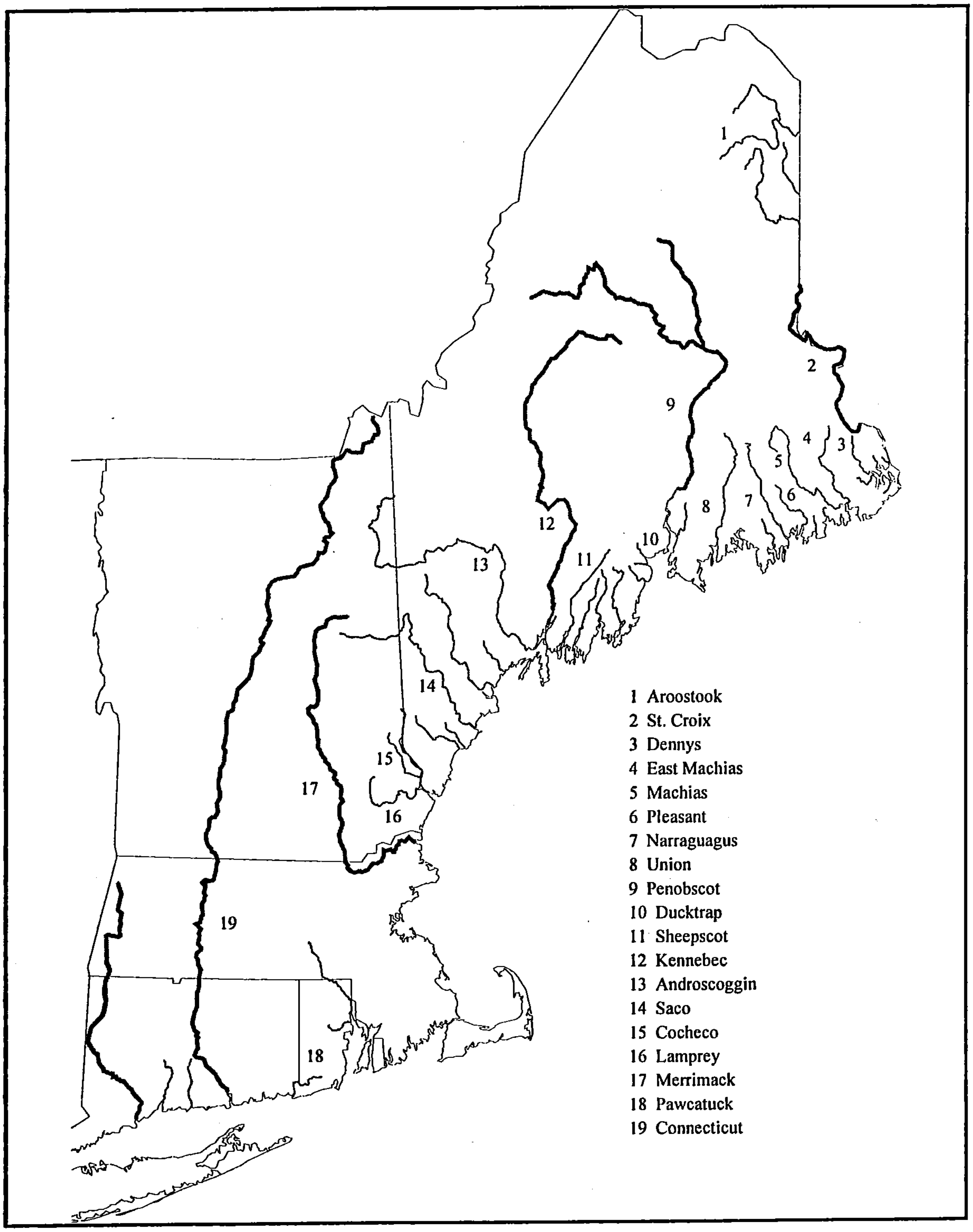


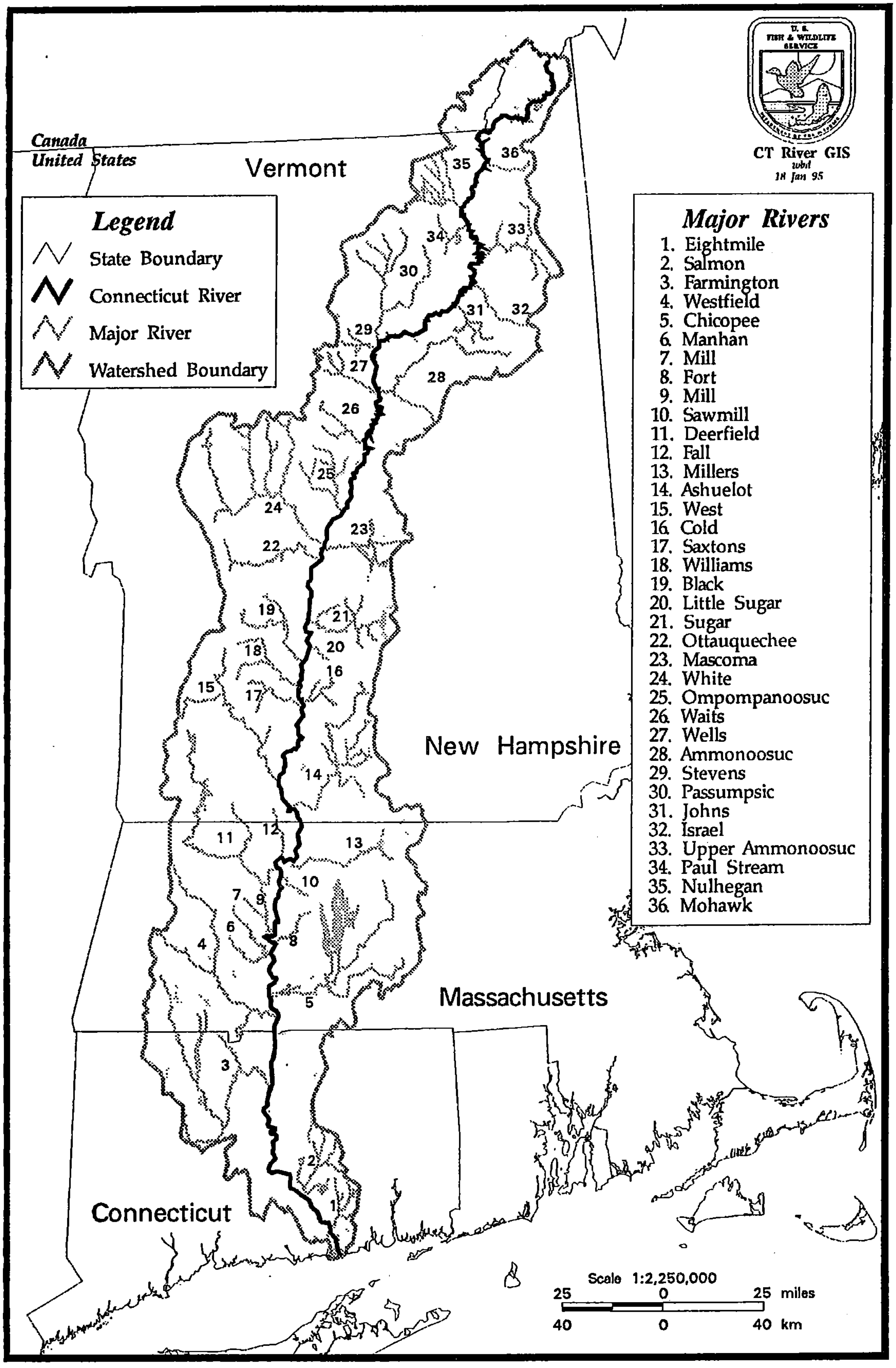
FIGURE 6.2.b.
NEW ENGLAND ATLANTIC SALMON RETURNS
1970 - 1994 (64243 ADULT SALMON)

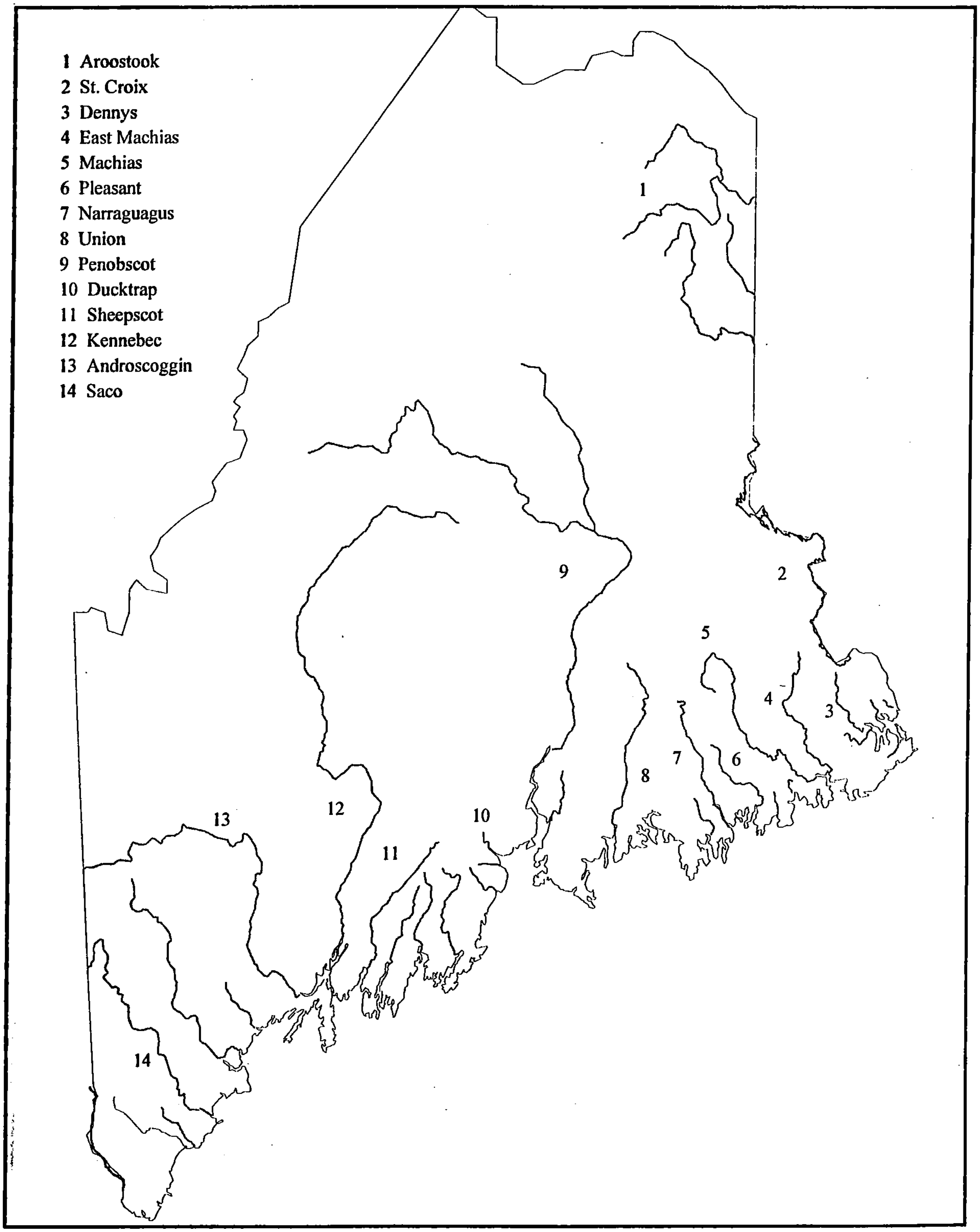


11.2. LOCATION MAPS

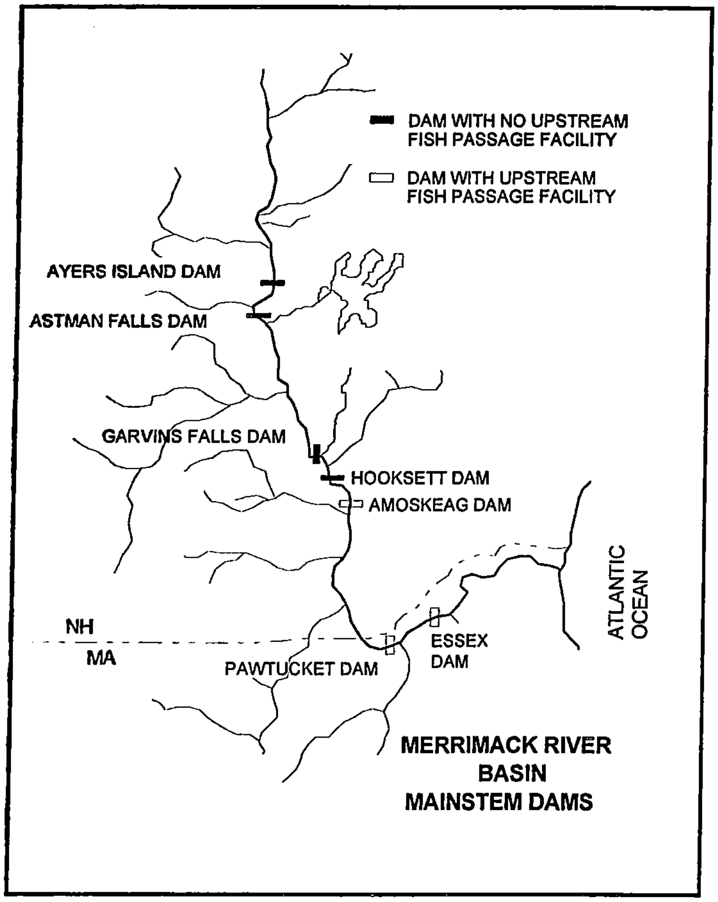


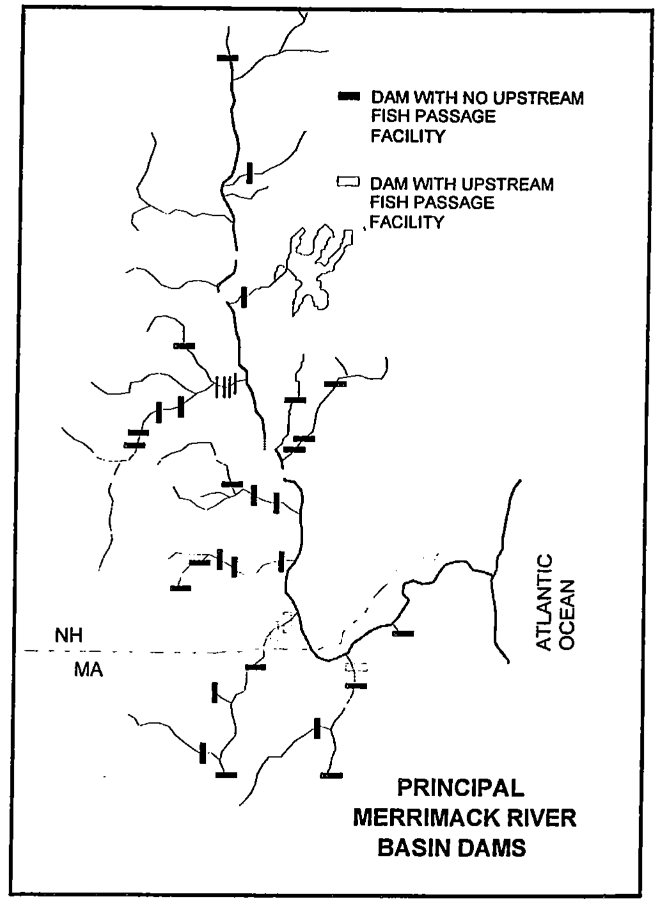
Important Atlantic Salmon Rivers of New England

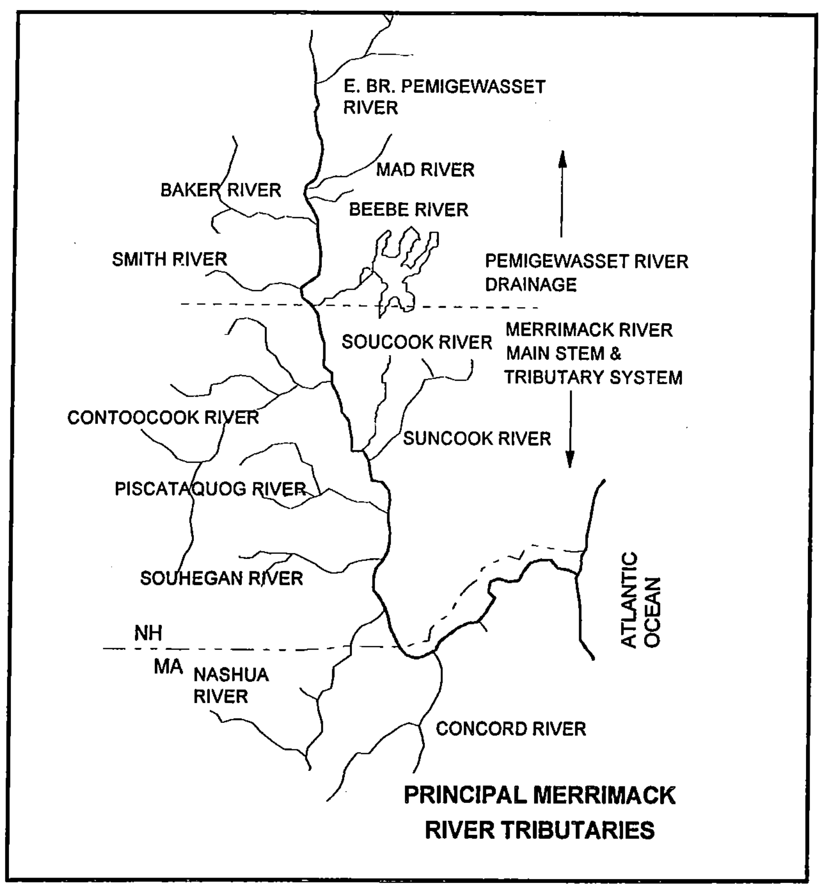

Canada
United States
Vermont
New Hampshire
Massachusetts
Connecticut
CT River GIS
wbd
18 Jan 95
Legend
State Boundary
Connecticut River
Major River
Watershed Boundary
Major Rivers
1. Eightmile
2. Salmon
3. Farmington
4. Westfield
5. Chicopee
6. Manhan
7. Mill
8. Fort
9. Mill
10. Sawmill
11. Deerfield
12. Fall
13. Millers
14. Ashuelot
15. West
16. Cold
17. Saxtons
18. Williams
19. Black
20. Little Sugar
21. Sugar
22. Ottauquechee
23. Mascoma
24. White
25. Ompompanoosuc
26. Waits
27. Wells
28. Ammonoosuc
29. Stevens
30. Passumpsic
31. Johns
32. Israel
33. Upper Ammonoosuc
34. Paul Stream
35. Nulhegan
36. Mohawk
Scale 1:2,250,000
25 0 25 miles
40 0 40 km



Important Atlantic Salmon Rivers of Maine


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


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


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

11.3. LIST OF ALL PARTICIPANTS

The individuals who attended the March 19, 1996 meeting were as follows:

Ed Baum, Maine Atlantic Salmon Authority
John Kocik, National Marine Fisheries Service
Dan Kuzmeskus, U. S. Fish and Wildlife Service
Jerry Marancik, U.S. Fish and Wildlife Service
Joe McKeon, U.S. Fish and Wildlife Service
Jay McMenemy, Vermont Fish and Wildlife Department
Kathryn Staley, U.S. Forest Service
Larry Stolte, U.S. Fish and Wildlife Service