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

REPORT NO. 9 - 1996 ACTIVITIES

HADLEY, MASSACHUSETTS
MARCH 3 - 5, 1997

PREPARED FOR
U.S. SECTION TO NASCO

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1. INTRODUCTION

1.1. EXECUTIVE SUMMARY

The Annual Meeting of the U.S. Atlantic Salmon Assessment Committee was held in Hadley, MA, March 3 - 5, 1997.

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 12,315,600 juvenile salmon (fry, parr, and smolts) were stocked. The Connecticut River received the largest percentage (55%); the majority of which was fry. Maine rivers received approximately 24% of the total, followed by the Merrimack River with 15%.

Within the total juvenile salmon releases were approximately 700,000 marked and tagged salmon. Of the total, 98% were released into Maine rivers, 1.5% were released into the Merrimack River drainage, and 0.5% were released into the Connecticut River drainage. Atlantic salmon of all life stages were utilized. Most (621,000) of the marked salmon released in Maine were fry which bore temperature-induced marks on their otoliths. Throughout New England small numbers of juvenile and adult salmon were marked with a variety of finclips and/or miscellaneous external tags (e.g., PIT tags, VI tags, elastomer tags, Peterson disk tags, etc.). Additionally, Carlin tagged smolts (48,400) were again released in Maine for the first time since 1992.

Documented total adult salmon returns to rivers in New England amounted to 2,827 salmon. The majority of the returns was recorded in the rivers of Maine with the Penobscot River accounting for nearly 73% of the total New England returns. The Connecticut River adult returns accounted for nearly 9% of the New England total and 76% of the adult returns outside of Maine. Overall, 21% of the adult returns to New England were 1SW salmon and 79% were MSW salmon; most (77%) of these fish were of hatchery smolt origin. Of the total returns approximately 23% were of wild origin (from natural reproduction and from fry plants).

Directed sea-run Atlantic salmon fishing is not allowed in New England, with the exception of a catch and released fishery in Maine. The estimated number of salmon caught and released in 1996 was 542 fish, which was a 46 % increase from the previous year. The increased catch may be attributed to increased salmon abundance and excellent angling conditions throughout much of the angling season. In addition, some of the salmon caught in eastern Maine rivers were escapees from aquaculture operations in Maine and New Brunswick and/or captive broodstock from Craig Brook NFH which were released in 3 rivers during the month of June. The domestic broodstock fishery in the Merrimack River resulted in an estimated 1,541 salmon landed.

Egg sources for the New England Atlantic salmon culture programs included sea-run salmon, captive/domestic broodstock, and reconditioned kelts. A total of 538 sea-run females, 3,120 captive/domestic females, and 211 female kelts contributed to the egg take. The number of females (3,869) contributing was considerably more than in 1995 (3,140). The total egg take, a New England record of 25,001,000, was approximately 6 million more than in 1995.

The sub-committee that addressed fish culture outlined six target research areas specific to fish culture and identified 37 research needs. The U.S. Atlantic Salmon Assessment Committee (Working Group) suggested six priorities (fry mark development, emphasis on study design vs. fry mark technology to evaluate hatchery products, handling gametes, smolt conditioning, emphasis on fry vs. smolt research, evaluate value of parr not how parr are stocked or used). The Working Group recommended that the sub-committee be maintained to:

- Provide summaries of research needs
- Provide guidance for active advocacy of program needs
    - Provide a review of options to control furunculosis in Atlantic salmon broodstock, select a plan of action, identify who to contact and what to say to secure the best possible measure of control for program use
- Provide a catalyst to ensure that high priority research is conducted

The sub-committee that addressed the marine area provided two papers for discussion by the Working Group. The first paper addressed sea surface temperatures and post-smolt survival in the northeast Atlantic and the second paper provided preliminary study results that addressed early marine ecology of salmon smolts in the Narraguagus Bay.

The sub-committee addressing smolt emigration success to the ocean provided the Working Group with a detailed look at a modeling concept presently under development. Of the factors in the model, the Working Group identified several in which spatial and temporal variability were considered most likely to have a large impact on salmon growth and survival. These include prey in the streams, predators at dams and in the estuary, temperature, maturation, smolt physiology, and dam passage. These are the areas which were suggested as candidates for management actions or research focus.

The sub-committee that addressed freshwater production provided two papers specific to the topic. The first paper dealt with the "feasibility of assessing overwinter survival and Atlantic salmon smolt production in the Narraguagus River system" while the second addressed the question of "What is the contribution of Atlantic salmon natural reproduction to stock abundance in the Penobscot River". In addition, three papers addressing "Management Considerations related to opportunities to enhance in-river production of Atlantic salmon using virgin sea-run adults, reconditioned kelts, and domestic broodstock" were presented.

The sub-committee that addressed "planning for a Samoset-type meeting" provided the Working Group with survey results collected by the sub-committee. The survey demonstrated that interest in such a meeting is very high. There appears to be two general interests for the purpose of such a workshop:

1) Communication, technical information, networking. This would present opportunities for many workers to keep abreast of current activities addressing Atlantic salmon.

2) Problem solving. The meeting should either have a theme or focus on one or two of the restoration program's most pressing problems/issues and discuss it and try to leave the meeting with some type of solution or ideas to try.

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

The U.S. Atlantic Salmon Assessment Committee continued their evolution based on the re-organization that occurred in June of 1996. I was extremely pleased with the meeting format and results and looks forward to even more productive changes in the future. I and the entire committee commend the work of the sub-committees and their contributions to this year's meeting.

The chairman accepts the new vice-chair, Janice Rowan, with great enthusiasm. Ms. Rowan will be of great assistance to the present chair. In addition, it was proposed that the present chair remain until the year 2000. I was happy to accept the wishes of the committee.

The committee agreed to convene the working group meeting in 1998 at the U.S. Fish and Wildlife Service's Regional Office in Hadley, MA. The Working Group meeting will begin on March 2 and continue through March 6, 1998.

Larry Stolte, Chair

2. STATUS OF PROGRAM

2.1. GENERAL PROGRAM UPDATE

2.1.1. CONNECTICUT RIVER

2.1.1.a. Adult Returns

A total of 260 sea-run Atlantic salmon adults was observed returning to the Connecticut River watershed including: 202 at the Holyoke fishlift on the Connecticut River; 29 at the Rainbow fishway on the Farmington River; 19 at the Decorative Specialties International (DSI) dam on the Westfield River; and 4 at the Leesville dam on the Salmon River. One salmon was captured in a gill net below Holyoke dam, 1 dead salmon was recovered below the DSI dam and 1 salmon was observed on videotape at the DSI dam on the Westfield, 1 was captured by electrofishing below the Enfield dam, 1 was observed below the Leesville dam on the Salmon River, and 1 was illegally angled and retained in Windsor, Connecticut. Three of the above salmon were either captured or observed in October while the remainder returned between April 23 and August 7. Peak return dates were May 31 - June 19, 1996.

Eighteen salmon were released from the Holyoke fishlift (river km 138) and permitted to continue upstream. Three were observed passing the fishway at Turners Falls, MA (river km 198), 9 were observed passing the fishway at Vernon, VT (river km 228), and three were observed passing the fishway at Bellows Falls, VT (river km 349). One salmon was trapped and trucked at the Townshend dam on the West River. Ten salmon were released above the DSI dam on the Westfield River as part of a radio telemetry study. (There are no counts available for fish passing the Wilder dam in 1996. The Wilder fishway was operated but not monitored. Similarly, the Turners Falls fishway counts are incomplete which explains why more salmon passed the Vernon dam than the Turners Falls dam in 1996.)

A total of 226 salmon were retained for broodstock: 193 were held at the Richard Cronin National Salmon Station (RCNSS), and 33 were held at the Whittemore Salmon Station (WSS).

Age and origin information was derived from scales, coded wire tags (CWTs), and physical examination of each fish. Origin information on released salmon was determined by examination for presence or absence of adipose fins. Of the 260 observed salmon, 143 (55%) were stocked as smolts and 117 (45%) were stocked as fry. All smolt origin fish (130), on which scale readings were conducted, were aged 2 sea-winter. Known sea-age of fry or wild origin fish were was comprised of grilse (N=5), 2 sea-winter (N=103), and repeat spawner (N=1). Known freshwater ages of wild salmon were 1+(N=7), 2+(N=95) and 3+(N=7). The known sex ratio of the salmon was 113 females:76 males, although this data is incomplete.

2.1.1.b. Hatchery Operations

Coordination and a strong contingent of volunteers facilitated another successful stocking season. The disease management protocol for control of furunculosis failed this year. However, control of furunculosis through strict management practices helped minimize the spread of furunculosis during the sea-run broodstock spawning period. Post-spawning losses were high among sea-run broodstock at both the WSS and the RCNSS. Since antibiotic resistant strains of furunculosis were isolated from fish at both holding facilities, nearly all of the surviving 1996 year class were euthanized.

Egg Collection

A grand total of 15,004,400 green eggs was produced at seven state and federal hatcheries within the basin which satisfies the program egg production goal. This is about 4.3 million more eggs than produced in 1995. Increased production is primarily the result of a small increase in sea run and kelt egg production and a major increase in domestic egg production. Domestic production increases are the result of attaining full production levels at the White River National Fish Hatchery (WRNFH).

Sea-Run Broodstock

A total of 938,300 eggs (6% of the grand total eggs produced) was taken from 115 sea-run females (6% of the grand total females spawned) held at the WSS and 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 11,844,900 eggs (79% of the grand total eggs produced) was taken from 1,732 domestic females (84% of the grand total females spawned) held at the RCNSS, WRNFH, Roger Reed State Fish Hatchery (RRSH), Kensington State Salmon Hatchery (KSSH), and Roxbury Fish Culture Station (RFCS).

Kelts

A total of 2,221,200 eggs (14% of the grand total eggs produced) was taken from 206 kelt females (10% of the grand total females spawned) held at the WSS, RCNSS, and North Attleboro National Fish Hatchery (NANFH).

2.1.1.c. Stocking

A total of 6,702,800 salmon were stocked into 27 tributaries to the Connecticut River. Of the total number of fish, 5,966,700 (89%) were unfed fry, 708,600 (11%) were fed fry, 12,400 (0.18%) were 0+ parr, 3,600 (0.05%) were 1+ parr, and 11,500 (0.17%) were 1 smolts. Research utilized 10,000 of the unfed fry and 0+ parr. The number stocked in 1996 was slightly lower than 1995's total (6.8 million). All salmon stocked, for the first time in program history, were of Connecticut River origin (i.e., eggs are no longer being brought in from outside sources).

2.1.1.d. Juvenile Population Status

Smolt Monitoring

Northeast Utilities Service Company (NUSCO) and the Sunderland Office of Fisheries Assistance (SOFA) contracted with Greenfield Community College (GCC) to conduct a mark-recapture smolt population estimate again in 1996. This was the fourth consecutive year that an estimate has been attempted by marking smolts at the Cabot

Station bypass facility and recapturing them at the bypass facility in the Holyoke Canal 54 km downstream. No estimate of entrainment at the Northfield Mountain Pumped Storage Facility (NMPSF) was made this year.

Modifications to the methods of this study were made to increase precision of the estimate and allow better determination of travel time from Turners Falls to Holyoke. However, very high river flows throughout most of the smolt run resulted in the collection facility at Cabot Station being inoperable for extended periods and the collection facility at Holyoke had reduced smolt catches because of large volumes of spill over the dam. As a result, a meaningful smolt estimate was not possible this year. A total of 446 smolts was marked at Cabot Station and 662 smolts were captured at Holyoke. Only three of the Holyoke smolts were recaptures. Based on Holyoke smolt catches, the smolt run started in late April, peaked in early-mid May and declined by early June. In 1996, 51 age 2+, and 5 age 3+ smolts were aged . Mean smolt length for the sample is 186 mm.

Based on expanded electrofishing data from index stations and assumed overwinter mortality it was estimated that 287,000 smolts were produced in tributaries basin wide, of which 205,000 were produced above Holyoke in 1996. Actual overwinter mortality is unknown and the estimate does not include smolt losses during migration.

This was the final year of the three-year smolt trapping research project on the West River. Cooperators include the Massachusetts Cooperative Fisheries and Wildlife Research Unit (MCFWRU), the Vermont Cooperative Fisheries 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 in two West River tributaries in 1996. Despite the greater ability to sample high flows that these counting fences afford, repeated severe flooding resulted in washouts and destruction of equipment. No population estimates were possible because of the extended periods when counting fences were inoperable due to high flows. Densities of two year old parr that remained in the habitat after smolt migration had ceased were very low compared to previous years. Smolt migrations commenced in late-April, peaked in early May, and were nearly complete by mid-May. Age two smolts comprised 88% of the smolts sampled in the Rock River, with the remainder three year olds.

Index Station Electrofishing Surveys

Juvenile salmon populations were assessed by electrofishing in late summer at over two hundred stations throughout the watershed. Sampling was conducted by CTDEP, MCFWRU, New Hampshire Fish and Game Department (NHFG), USFS, and VTFW. Data were used to evaluate fry stocking, estimate survival rates, and estimate smolt production. Data analysis is incomplete at this time. Densities of parr varied widely throughout the watershed. Most smolts produced in 1997 are again expected to be two

Brook National Fish Hatchery (CBNFH) (see section 2.1.2.c below) were recaptured. Vandalism impacted weir efficiency July 7, and October 26 through November 5.

About 60 salmon were caught and released by anglers fishing the Dennys River in 1996, but information is not available concerning their origin (aquaculture, captive release, or wild). A total of 30 redds were counted in the Dennys River in the fall of 1996.

Narraguagus River. Sixty-four salmon were counted at the Cherryfield fishway trapping facility. This is slightly higher than the number trapped in 1995 (56). An additional eight farm fish escapees (12% of the run) were also caught in the trap and released downstream. Anglers fishing the Narraguagus River were known to have caught and released 31 salmon during 1996.

Pleasant River. Although no adult trapping facilities were operated in the Pleasant River in 1996, redd counts were conducted in the fall. A total of 41 redds was counted, although it is possible that some may have come from farm fish escapees.

Sheepscot River. In 1996, a weir was installed just above tidewater and operated from May 31 to July 11. The pickets were pulled at this time in preparation for heavy rains associated with tropical storm Bertha. Eight salmon (seven females, and one male) were captured and transported to CBNFH to be used as broodstock. There were no reported rod catches of Atlantic salmon in the Sheepscot River in 1996.

Machias, East Machias, and Ducktrap Rivers. Anglers caught and released a minimum of 10 salmon on the Machias River, and 21 salmon on the East Machias River. There was no reported rod catch in the Ducktrap River. In addition, a total of 102 redds were counted on the Machias River, 41 on the East Machias River, and 44 on the Ducktrap River.

Other Maine Restoration Rivers

Penobscot River. Total known adult returns to the Penobscot River, at the Veazie trapping facility, was 2,045. About 400 salmon were estimated to have been caught and released throughout the angling season. About 28% of the Penobscot salmon run (595 fish) were transported to CBNFH for broodstock purposes in 1996.

St. Croix River. A total of 132 salmon was captured at the Milltown Dam fishway during 1996, and 30 were retained as broodstock. These fish, spawned at the Mactaquack Hatchery by Department of Fisheries and Oceans personnel in November, provided about 158,000 eggs for future restoration programs in the St. Croix. An additional 20 farm fish escapees were documented in 1996 (13% of the total trap catch).

Androscoggin River. Thirty-eight adult salmon were enumerated at the Brunswick Dam fishway.

Saco River. A total of 54 adult salmon was enumerated at the Cataract dam fish passage facilities (one fish lift, one fishway) in 1996.

Union River. Operation of the trapping facility on the Union resulted in the capture of 69 salmon which were transported upstream and released. The exact total number of salmon in the Union River in 1996 is unknown, since some of the 20 salmon released early in the season were probably recaptured and transported upstream later in the season. This catch was the largest return to the river in ten years and most of them originated from the release of 100,000 parr (age 0+) in the fall of 1993.

2.1.2.b. Hatchery Operations

Broodstocks (all sources) from six Maine rivers produced the following egg takes at CBNFH in November: (round numbers)

Dennys River	369,050
East Machias river	221,080
Machias River	526,050
Narraguagus River	434,290
Penobscot River	2,635,000
Sheepscot River	178,950
	=======
	4,185,470

Almost 900 parr were collected from five Maine rivers in 1996. 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: East Machias 132; Machias 238; Pleasant 81; Narraguagus 361; Sheepscot 87. Parr were not collected from the Dennys River for future broodstock use in 1996, because of the high probability of collecting fish originating from fry which were stocked from CBNFH the previous year.

2.1.2.c. Stocking

Most of the approximately 3 million salmon stocked in 10 Maine rivers in 1996 were released as fed-fry. A complete stocking summary is presented in Table 2.2.1.

Native Atlantic salmon parr were collected from the Dennys, Machias and Narraguagus rivers in 1992. These parr were raised to maturity at CBNFH, and have been producing eggs for the river-specific program for up to three years. Holding the adult fish, ranging in size from 1.4 to 4.5 kg each, has put increased pressure on the water supply at the hatchery. Consequently, in 1996 a portion of these broodstock was returned to their rivers of origin. Approximately 100 fish collected in 1992 from each river were retained at the CBNFH as broodstock.

2.1.2.d. Juvenile Salmon Population Status

Juvenile salmon population surveys were conducted at over 100 sites throughout the seven Maine drainages with wild salmon runs. Population surveys ranged from qualitative survival estimates throughout the drainages to quantitative population estimates at well established index sites. Densities of young-of-year and parr (age 1+ and 2+ combined) were far below average in all rivers, except at a few sites that had densities commensurate with long term averages due to recent fry stocking efforts.

Based on preliminary data analysis, the drainage wide population of age 1+ and older parr on the Narraguagus River is approximately 24,000 ± 17%, this is based on electrofishing data from over 30 sites. Drainage wide parr population estimates have been conducted on this river since 1991 and are as follows:

1996	24,400 ±4,031
1995	12,737 ±2,962
1994	9,536 ± 660
1993	22,901 ±6,916
1992	14,915 ±1,815
1991	15,863 ±1,687

The 1996 parr population estimate is the first year to reflect the influence of the river specific fry stocking program. No juvenile stock enhancement occurred on the Narraguagus from 1989 to 1994.

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. In November 1994 the FERC issued a Draft Environmental Impact Statement (DEIS), covering the proposed licensing of the Basin Mills (including Veazie and Orono projects), Milford, and Stillwater hydroelectric facilities. In the spring of 1996, various stakeholders entered into settlement discussions in an attempt to deal with the unresolved issues at the lower Penobscot River projects that are the subject of the FERC DEIS. Parties engaged in these settlement negotiations included Bangor Hydro-Electric Company (BHEC), State of Maine agencies (Maine Atlantic Salmon Authority (MASA), Maine Department of Inland Fisheries and Wildlife (MIFW), Maine Department of Marine Resources (MDMR), State Planning Office, Maine Department of Environmental Protection (MDEP)), Penobscot Indian Nation (PIN), NMFS, USFWS, U.S. Environmental Protection Agency (EPA), and Atlantic Salmon Federation (ASF). The parties requested, and received, from the FERC a series of stays in the licensing process for Basin Mills, Milford, and Stillwater. Under the stay, FERC will not issue a final EIS or new licenses for the projects. The stay expired on January 29, 1997, and settlement talks will not be resumed. It is presumed that the FERC will quickly finalize its EIS and move forward with its licensing decisions for the three projects.

Union. In 1994 the FERC ordered BHEC. To modify its fishway plans for the Ellsworth Project, so that they would be consistent with what the Department of the Interior, Department of Commerce and MDMR had prescribed. BHEC successfully appealed the FERC order in the U.S. Court of Appeals (DC Circuit) in 1996, which concluded that there was no substantial evidence in the record to support the fishway prescription, and reversed the 1994 order. FERC must again consider BHEC's fishway plan and reach a decision.

Saco River. In 1996, Central Maine Power Co. (CMP) completed fishway construction at its Springs and Bradbury dam (Cataract Project). The new facilities (fish locks) complement the fish lift and Denil fishway that were constructed at the Cataract East and West Channel dams in 1993 .

In August 1996, the FERC issued a final EIS on the licensing of the Skelton and Bonny Eagle projects, which also addressed the comprehensive fish passage agreement that was signed in 1994. Under the agreement, CMP is to build a fishway at Skelton by May 1, 1998, or within three years of receipt of its new license for the project. A comprehensive agreement on minimum flows at CMP's Saco River projects and a new license for the Skelton dam are expected in 1997.

2.1.2.f. Genetics

Studies designed to characterize the genetic composition of Maine Atlantic salmon stocks continued in 1996.

Samples consisted of pelvic fin clips, many of which were taken from parr in the hatchery, as opposed to the field, in an effort to reduce the possibility of injury. Exceptions to this were on the Dennys, Ducktrap, Passagassawaukeag, Kennebec, and Penobscot rivers, as these fish were not taken to the CBNFH. In addition, samples were taken from the Dennis and Waweig rivers in Canada. Samples were also obtained from commercially caught salmon in Greenland.

The purpose of this study is to provide a wide geographic dimension to the inter-river comparisons being conducted on Maine rivers. The inter-river comparisons have two important dimensions. The first being the differences between individual rivers, the second being the consistencies between year classes. Tissue samples have now been collected for four year classes, 1993-1996.

2.1.2.g. General Program Information

The nine-member Maine Atlantic Salmon Board, which governs all activities of the

MASA, was appointed by Governor King and approved by the Maine Senate in August. Initial meetings have focused upon program planning and budgetary needs. The MASA will be updating the statewide Atlantic Salmon Restoration and Management Plan which was "inherited" from its predecessor, the Maine Atlantic Sea Run Salmon Commission. Salmon Board members are currently meeting with local stakeholders to obtain input into the future planning process.

In response to the proposed listing of the Atlantic salmon populations of the Dennys, East Machias, Machias, Pleasant, Narraguagus, Ducktrap and Sheepscot rivers as "threatened" under the Endangered Species Act, the Governor of Maine appointed a Task Force on Atlantic Salmon in October of 1995. The Task Force, under the Chairmanship of Ray "Bucky" Owen, recently completed a draft Conservation Plan which the State of Maine would like the two federal agencies to accept as a recovery plan in lieu of formal listing. The Plan addresses the threats listed by federal agencies, and describes the state of Maine's proposed recovery activities.

A delay in passing the Interior appropriations bill delayed federal Endangered Species Act listing and prelisting activities, including those related to the Atlantic salmon. However, in October three public hearings were held in the state of Maine. These hearings were held in Augusta, Ellsworth, and Machias, and were attended by 150 people. Representatives from the USFWS and NMFS were present to respond to questions and comments. The final ruling on this issue is expected to be published during the Spring of 1997.

Salmon returns to Maine rivers in 1996 improved over 1995. Improved runs (through the end of September) were recorded in the Penobscot (2,045), Union (69), and Saco (54) rivers. Salmon returns to other rivers in Maine were equal to or greater than those experienced in 1995. The excellent flows, and accompanying lower water temperatures, were extremely conducive for angling, with an estimated 542 salmon caught and released on a statewide basis. MASA and USFWS biologists nearly completed salmon habitat surveys on the Ducktrap and Pleasant rivers.
Thirty-thousand eggs (10,000 each from the Dennys, Machias and Narraguagus stocks) were transferred to private aquaculture facilities in Maine in February. These fish will be reared to the smolt stage and most will be stocked back into their rivers of origin; however, a small number (500-2,000) will be reared to maturity in sea cages in Eastern Maine. The adult fish will be stocked into their rivers of origin for spawning purposes in future years.

2.1.3. MERRIMACK RIVER

2.1.3.a. Adult Returns

Adult salmon returns to the Merrimack River numbered 76 fish as compared to 34 in 1995. Two of the 76 salmon were taken by anglers downstream from the Essex dam fish-lift with the remainder captured at the fish-lift. The increase can be attributed to: 1) an increase in the number of grilse observed (14 in 1996 versus two in 1995); 2) an increase in the number of smolts stocked (85,000 in 1994 and 59,000 in 1993); 3) an increase in the rate of return for adults of hatchery smolt origin (0.54 adults/1000 smolts released in 1994 versus 0.36 adults/1000 smolts released in 1993); and, 4) the occurrence of repeat spawners in the run. The fry stocking program continued to contribute only small numbers of returning salmon to the river. The composition of the returns relative to stocking origin and sea age is as follows:

Stocking Origin	Sea age Categories			
	Grilse	2SW	3SW	Repeats
Fry Stocking Program	3	13	0	2
Smolt Stocking Program	11	44	0	3

The number of grilse of hatchery smolt stocking origin was a significant increase from the observations of the past three years and was the third largest grilse component recorded within the program. The grilse were produced from Penobscot River parentage.

The five repeat spawners (four females and one male), captured in 1996, had been originally captured at the Essex Dam fish-lift during the salmon run of 1995. They were artificially spawned at the Nashua NFH during the fall of 1995, marked with floy tags and released into the Merrimack River estuary in December. A total of 33 sea-run kelts were released into the estuary. The repeat spawners had regained the weight lost the previous year and scale analysis showed new marine growth for all five fish. Each of the four females provided eggs for a second time.

2.1.3.b. Hatchery Operations

The fish cultural changes initiated in 1994 continued in 1996. As in the past, Atlantic salmon fry produced for stocking purposes were provided by the NANFH and the Warren State Fish Hatchery (WSFH). A very few fed fry were produced by the Nashua NFH (NNFH). Smolts produced for stocking purposes were provided by the Green Lake NFH (GLNFH) and in 1996 were from Penobscot River sea-run parentage.

Egg Collection

Sea-Run Broodstock

Seventy-four adult salmon were captured and transported to the NNFH for fall spawning. Seventy-three survived to maturation, and an estimated 212,500 eggs were taken from 31 females. The majority of the eggs were transported to the NANFH to be hatched and released as fry (some eggs were retained at the NNFH for broodstock developement). Due to the low numbers of available Merrimack River sea-run eggs, 10,000 eyed-eggs of Penobscot River sea-run parentage were imported from CBNFH for future domestic broodstock development.

Following spawning operations, the 73 adult salmon were marked with internal anchor tags and released into the Merrimack River estuary.

Captive/Domestic Broodstock

A total of 912 female broodstock held at the NNFH provided an estimated 5,469,000 eggs. These eggs were transported to the WSFH and NANFH to be held for fry stocking. Approximately 500,000 of the eggs that were transported to the NANFH and incubated for the Pawcatuck River salmon restoration program.

Following spawning operations, 89 broodstock that had not sexually matured (age 3+) and 124 kelts (3+) were marked with internal anchor tags and released into the Merrimack River estuary.

2.1.3.c. Stocking

Approximately 1.8 million juvenile Atlantic salmon were released in the Merrimack River basin during the period April-June 1996. The majority was released as unfed fry, and 50,000 were released as yearling smolts. Although smolts were not marked or tagged, the pattern or signature on the scales of adult returns provides a means to differentiate between fish either stocked as fry or smolts. Seven major watersheds were stocked with fry at densities that ranged from 36 to 96 fry per 100 m^2. The watersheds included the East Branch Pemigewasset, Pemigewasset, Mad, Baker, Smith, South Branch Piscataquog and Souhegan Rivers. Smolts were released in the main stem of the Merrimack River a short distance downstream from Amoskeag Dam in Manchester, N.H.

The number of fry released was less than the proposed target release of 3.1 million. The low number of sea-run returns and the adverse effects of lightning strikes on broodstock at the NNFH contributed to the decrease in the production of fry. Electrical charges from lightning strikes also killed fish and negatively affected egg viability in some broodstock.

2.1.3.d. Juvenile Population Status

Fry/Parr Assessment

A stratified sampling scheme that involved parr collections at 30 sites was conducted in 1996. Sampling was directed at age 1$^+$ parr and involved electrofishing during late summer and early fall. Data collection involved a cooperative effort and included staff from the NHFG, USFS, USFWS, and volunteers.

The 30 sites included a total of 435 units (one unit = 100 m^2) of juvenile habitat. The estimated number of habitat units within the basin is 57,067, and units sampled was about 0.76% of the total available. Of the 64,900 known units, approximately 32,141 were stocked with fry during 1996. Based on the sampling scheme, the estimated number of age 1^+ parr in fall 1996 was 91,602 ± 7,538, indicating survival from the fry stage to age $1^+$of 3.2%. This compares to 10% in 1995 and seven percent in 1994.

Natural reproduction of Atlantic salmon is not known to occur in the Merrimack River basin. In recent years, sexually mature domestic adult salmon have been released in fall in headwater areas, but due to the low numbers released, their contribution to the production of fry is assumed to be negligible. As such, the estimated number of age 1^+ parr in 1996 was derived from a stocking of approximately 2.83 million fry in 1995.

Sample sites in rivers and streams located in the headwaters upstream from Ayers Island Dam, Bristol, NH, had significantly reduced numbers of both age 0^+ and 1^+ parr compared to those observed in 1995. Sites in rivers and streams in the middle and lower portion of the basin had greater numbers of age 1^+ parr, but significantly reduced numbers of age 0^+ parr. The number of fry released or stocked per unit is similar for specific watersheds or sites each year, and the number of fish observed at sites may have been influenced by environmental variables. Precipitation for year 1995 was above average, and for year 1996 it exceeded that observed for any year of record. Three floods in fall 1995 either equaled or exceeded the 50 year flood event, and similar floods occurred in fall 1996. These events may have adversely affected the survival of parr. In addition, high flow in some watersheds, notably the Souhegan River, at the time fry were stocked may have been a key factor that resulted in the low number of age 0^+ parr subsequently observed in 1996.

2.1.3.e. Fish Passage

Downstream Fish Passage

Public Service of New Hampshire (PSNH) continued to conduct downstream fish passage studies utilizing Atlantic salmon smolts at several of their mainstem hydropower projects. In addition, PSNH constructed a partial louver weir in the power canal at the Garvins Falls hydro project and also completed the fish bypass and smolt sampler at their Ayers Island hydro project. Studies will be undertaken in 1997 to test the effectiveness of these structures.

Upstream Fish Passage

Work continued at the Essex dam in Lawrence, MA, to improve the effectiveness of the fish passage entrances to the fishlift for American shad. Based on the studies conducted during 1994, 1995, and 1996, fish passage entrance structural changes are expected to be in place for the passage season of 1997. The changes being made will likely enhance passage for Atlantic salmon and the river herrings.

2.1.3.f. Genetics

No work, other than the maintenance of the existing Atlantic salmon spawning protocols, was conducted in this area with regard to the salmon program in 1996.

2.1.3.g. General Program Information

Domestic Atlantic Salmon Broodstock Releases

In mid-winter, spring and late fall of 1996, 3,848 surplus broodstock were released to provide angling opportunities in the mainstem of the Merrimack River. The mid-winter release (January) was comprised of 534 kelts. The spring (May and June) release included 1,577 re-conditioned kelts. The late fall (October, November, December) release included 1,737 non-spawners and kelts.

An additional 729 adults (pre-spawners) were released into the Pemigewasset River in the spring (300 fish) and the fall (429). These fish were part of a study to investigate spawning success by domestic broodstock in the wild.

Pre-spawner Releases / Natural Reproduction Study

Domestic Atlantic salmon broodstock were released in years 1994 and 1995, and their continued release in 1996 in the Pemigewasset River watershed was part of a strategy to enhance the production of salmon and aid in the restoration of the species.

The 300 fish released in the spring were stocked at various locations within the mainstem of the Pemigewasset River. The 429 salmon released in the fall were stocked into two sites in the Pemigewasset River watershed. Sites included the mainstem of the Pemigewasset River, and Hubbard and Stinson Brooks, tributaries to the Pemigewasset and Baker Rivers, respectively. A radio telemetry system was used to evaluate the movement and behavior of salmon, and shore and watercraft based surveys were conducted to visually observe and locate fish and redds. Picket weirs were deployed on the two brooks to contain fish near spawning habitat, and 23 salmon were affixed with radio transmitters to monitor movement.

Fish were released in late October and surveys continued through January. Fish confined by weirs and those with radio transmitters generally exhibited passive or active downstream movement. Fish released in the brooks initially established positions immediately upstream from weirs. Two fish were killed by otters, and these predators caused most fish to move away from the weirs and into deep pools.

Similar to environmental events in year 1995, floods hampered surveys to document spawning and to locate viable redds. Only fish released in brooks were observed to dig redds. This involved two pairs, occurred one day prior to flood flows, and three days post release. These fish did not carry transmitters. Movement of fish with transmitters suggested that high flows adversely affected behavior and survival. Seven carcasses with transmitters were found after the floods, and the stationary position of an additional 13 transmitters following floods on the 9th of November and the 1st of December suggests that these fish may have expired. One transmitter was never located after the first flood, but two fish continued to move subsequent to the second flood. One was located proximal to spawning gravel in the tailwater of a tributary dam about 15.5 km downstream from the release site, and the other downstream from Ayers Island dam on the Pemigewasset River, about 20.5 km from the release site.

Based on the results the practice of releasing broodstock will continue, but consideration will be given to altering methods. Evaluations in 1997 may focus on earlier release dates and alternative release sites; the use of intraperitoneal radio transmitters; and the release of both domestic broodstock and sea-run salmon.

Atlantic Salmon Domestic Broodstock Sport Fishery

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

In the early winter of 1995 and spring of 1996, 3003 surplus broodstock were released in support of the 1996 sport fishery. The winter release included 1,426 (age 3+) fish that were spawned prior to release. The second release occurred in the early spring and included 1,577 (age3+) and (age 4+) reconditioned adults that had been spawned in the hatchery the previous fall.

The results of the 1996 fishery are presented in the following table (1995 results included for comparison). The 1996 results show that a total of 2,066 Atlantic salmon permits were purchased. Of the total 2,066 potential anglers, 1,355 reported that they fished for broodstock. The majority were NH residents and 10% were from other states. Anglers fished a total of 22,206 hours during an estimated 6,958 fishing trips. They caught an estimated 1,541, released 1,080, and harvested 461 salmon. Catch per unit of effort was .069 salmon/hour (anglers fished about 14 hours before catching a salmon). The 1,355 anglers spent an average of $131 each which produced a total estimated expenditure of $177,505 for 1996 season.

It was anticipated that the total number of salmon permits and fishing effort for the 1996 season would be substantially lower than in 1995 due to unfavorable angling conditions.

The water levels were at flood stage for the early part of the spring season and did not improve until the first of June. However, the total number of permits sold in 1996 (2066) was only 14 % lower than in 1995. Total fishing effort, angler trips, and catch data were down only slightly from the previous season. Catch per unit effort was the highest recorded for the program.

Category	1995	1996
Total Permits Sold	2,387	2,066
% Non-residents	7	10
Diary Reporting Rate (%)	60	27
Estimated No. of Anglers that Fished	1,683	1,355
% of Anglers Utilizing Fly Fishing	69	76
% of Anglers Utilizing Artificial Lures	20	16
% of Anglers Utilizing Both Fly Fishing and Artificial Lures	11	8
Angler Success in Fly Fishing Area (% catching at least 1 salmon)	30	27
Angler Success in Fly Fishing/Artificial Lure Area (% catching at least 1 salmon)	31	30
Estimated Total Hours of Fishing Effort	29,205	22,206
Estimated Catch per Unit of Effort (hours per salmon landed)	15.9	14.4
Estimated No. of Angler-Trips	9,746	6,958
Estimated No. of Salmon Caught and Released	1,105	1,080
Estimated No. of Salmon Caught and Kept	737	461
Estimated Total Catch (Released and Kept)	1,841	1,541
Estimated Expenditures Per Angler ($)	132	131
Estimated Total Expenditures by Anglers ($)	221,584	177,505

Education/Outreach

Adopt-A-Salmon Family

The Adopt-A-Salmon Family (AASF) program, an interdisciplinary watershed education program for elementary and middle school students, is now in its fourth year. In the last year the program has expanded from twenty to fifty schools in five of the six New England states. AASF is an on-the-ground opportunity for working partnerships - both within and outside the USFWS. The list of partners is diverse and growing: USFS, Lake Champlain Basin Program, Merrimack River Watershed Council, two tribal nations (Passamaquoddy and Penobscot), New England Salmon Association, UNH Sea Grant, National Park Service, and the National Wildlife Federation.

Students participating in AASF explore the interactions of human culture with the environment and ultimately come to understand their connection to the local watershed. The realization of this connection better positions them to develop an environmental stewardship ethic. AASF brings the USFWS closer to a variety of partner organizations 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.

<u>Amoskeag Partnership</u>

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

Anadromous Fish Planning

The Strategic Plan for Atlantic salmon restoration was revised and expanded to include American shad and the river herrings. The document also included a comprehensive status review of the salmon and clupeids within the restoration program. The entire package was distributed to various publics for review and comment. The comment period ended on February 20, 1997.

2.1.4. PAWCATUCK RIVER

2.1.4.a. Adult Returns

One female salmon was captured at the Potter Hill Fishway on the Pawcatuck River in May of 1996. By scale analysis, it was determined that the fish had spent two years at sea after migrating as a two year smolt and was stocked as an age one parr. An unconfirmed number of escapees jumping over the Potter Hill Dam were reported by fishermen. Electrofishing attempts to capture the escapees upstream of the trap were unsuccessful. A fisherman harvested a male salmon in October of 1996 upstream of the Potter Hill trap. By scale analysis, it was determined that the fish had spent two years at sea after migrating as a two year smolt and was stocked as an age one parr.

2.1.4.b. Hatchery Operations

Fish Cultural Changes/Improvements

The Arcadia Research Hatchery (ARH) remains the primary hatchery for the salmon restoration program. The hatchery discharges into Roaring Brook, which flows out of Browning Mill Pond. Roaring Brook is a tributary located in Pawcatuck River Watershed. The ultra viloet water purification system, installed in 1995, allowed the use of water from Browning Mill Pond. The resulting manipulation of water temperatures in hatchery operations aided in egg incubation and smolt development of retained parr. A separate building for isolating returning adults, rejuvenation of kelts, and rearing of parr to smolts was under construction by the end of 1996. To increase production and improve the condition factor of smolts, circular tanks were added to the hatchery in 1996. The drainage system for hatchery effluent was replaced in conjunction with the new building construction. One of the existing ponds on site which receives the cold water hatchery effluent was used to rear parr that were graded from the circular tanks. The suitability of pond rearing is being evaluated. Repairs and improvements to the backup generator system were implemented. Compressed oxygen cylinders with regulators and diffusers are kept at the hatchery as an additional precaution. Terry Bradley from the University of Rhode Island is aiding with the smolt release project by monitoring gill Na^+, K^+-ATPase levels, performing salinity stress tests, and evaluating the condition factor of pre-smolts. The Carolina Hatchery, which received a small percentage of retained parr, was unsuccessful as a smolt production facility and will no longer be used for salmon production.

Egg Collection

A total of 16,950 eggs was collected from the single female captured in the spring of 1996. The eggs were fertilized with pooled milt obtained from Merrimack fish and supplied by the NANFH in the fall of 1996. Approximately 141,984 fertilized Merrimack River strain domestic eggs were supplied by NNFH in the fall of 1996. These eggs and those obtained from the captured female will be incubated at ARH. All of the eggs from the captured female and the bulk of the eggs supplied by NANFH taken in fall of 1996 and incubated at ARH will be retained for subsequent release as 0+ parr, 1+ parr and 1+ smolts.

NANFH will continue to allocate up to 500,000 eggs per year (including 1996) for the Pawcatuck River.

2.1.4.c. Stocking

Fry stocking was continued in 1996. Eggs taken in the fall of 1995 were incubated until spring of 1996 and released as unfed fry or retained for subsequent parr/smolt release. NANFH supplied 273,998 fry in May of 1996, and ARH supplied 14,906 fry for a total of 288,904 with a resulting density of 64/unit. Stocking of fry throughout the Pawcatuck River Watershed was performed by RI Division of Fish and Wildlife (RIFW) personnel and volunteers from Trout Unlimited, the Wood-Pawcatuck Watershed Association and the public. The number of volunteers was at a record level resulting in better fry distribution.

Approximately 136,132 St. John River strain 0+ domestic parr were donated by Kennebec Aquaculture of Solon, Maine in September and October of 1996. RIFW personnel stocked 107,500 in the Pawcatuck watershed. Due to a surplus of available parr, 28,630 were introduced into the Hunt/Potowomut watershed.

In addition, 5,000 smolts were stocked in the lower Pawcatuck River in April of 1996.

The fish were produced from two Pawcatuck River sea-run females and pooled milt from Merrimack River males, and reared at the ARH.

Swim-up fry from eggs taken in the fall of 1996 by NANFH, will be distributed in the Pawcatuck River watershed in the spring of 1997.

Stocking/Transport Improvements

The 200 gallon transport tank utilizing compressed oxygen and microbubble diffusers developed in 1995 was used successfully in fry and smolt stocking. The perforated aluminum boxes in the tank significantly reduced handling of transported fish. Smolts suffered no observed scale loss or mortality from transport and stocking. Fry were transported directly from NANFH to central locations within the Pawcatuck watershed for the two day volunteer stocking effort in May of 1996. Each container of fish distributed to the volunteers was equipped with a battery powered aerator. No significant fry stress or mortality was observed.

The RIFW has purchased an eight compartment fish transport tank equipped with a microbubble diffuser/liquid oxygen based aeration system. The tank is also equipped with side discharges and a flexible piping system to reduce handling mortality. While the primary use of the tank will be for the trout stocking program, the tank will also be used for the transport of smolts.

2.1.4.d. Juvenile Population Status

Fry/Parr Assessment

Fry and parr assessments were repeated in 1996. Ten index stations were sampled in March and thirteen index stations were sampled during September and October in the watersheds of the two major tributaries which form the Pawcatuck River. Fall 1996 fry density ranged from 0.41 to 24.95/100 m^2 and averaged 10.07/100 m^2 (SE=6.58). Fall 1996 1+parr density ranged from 0.18 to 9.23/100 m^2 and averaged 4.49/100 m^2 (SE=2.87). Mean total density was 14.64/100 m^2 (SE=8.64). Over-winter fry survival ranged from 0.63% to 38.78% and averaged 15.65%. Unrealistic (>100%) over-winter survival percentages of 1995 1+parr are attributed to emigration of fish during low flows in the fall of 1995. The 1995 fry cohort reached a mean length of 79.3mm by October of 1995, 96.0mm by March of 1996, and 142.51 mm by October of 1996. Precocious males made up 20.5% of the 1996 1+ Parr sampled. Fry stocked in spring of 1996 attained a mean length of 82.9 mm by October of 1996. Relatively cool temperatures and consistent rainfall were present throughout the Pawcatuck River watershed during the summer of 1996.

Smolt Abundance

Potential smolt output from stocked fry was estimated by sampling ten index stations during March of 1996. Mean smolt density was 1.14/unit (SE=0.81), which was an improvement over the mean density for the previous three years ($0.89/m^2$). The estimated amount of juvenile habitat units in the Pawcatuck River watershed is 4,490 units. Total smolt output based upon expansion of sample density over area stocked was 5,119 fish. This smolt run is the second produced predominantly from fry plants. High water at all index stations during the sampling period prevented sampling at some of the larger stations. Mean length of smolts captured in 1996 was 154.8 mm, 12.3 mm smaller than the mean smolt size for the previous three years of smolts captured (167.1 mm).

Tagging

Approximately 7,782 parr were adipose fin clipped in October of 1996 as a prerequisite to 1997 smolt release. This will insure differentiation between hatchery smolts and smolts produced from fry stocking.

1997 Smolt Monitoring

A smolt trap was under development in 1996 to capture migrating smolts in the spring of 1997. The efficiency of the trap will be evaluated by stocking a known number of marked hatchery smolts upstream of the trap. The trap efficiency for the marked smolts can be used to estimate total smolt production utilizing the number of unmarked smolts produced from fry that are captured in the trap.

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 the owners 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 the ability of the State of RI to deal with the problem is necessary. The redistribution of stones downstream of the Potter Hill Fishway, by RIFW personnel, was somewhat successful in increasing the number of American shad passed in 1996.

Downstream Fish Passage

No work was conducted on this topic during 1996.

2.1.4.f. Genetics

No work was conducted on this topic during 1996.

2.1.4.g. General Program Information

Domestic Atlantic Salmon Domestic Broodstock Releases

Surplus captive broodstock, when available from the USFWS, are stocked outside the Pawcatuck River watershed for a popular sportfishery. No salmon were available in 1996.

Education/Outreach

The educational program developed in 1995 continued in 1996. Westerly Public Schools in cooperation with the RIFW and the Wood-Pawcatuck Watershed Association conducted a fourth/fifth grade program teaching about the Industrial Revolution, dams, hydropower, mills, and effects on anadromous populations. The students toured the Bradford Dyeing Association Mill, visited the Bradford Fishway, toured the ARH, and stocked Atlantic salmon fry as part of the restoration efforts.

2.1.5. NEW HAMPSHIRE COASTAL RIVERS

2.1.5.a. Adult Returns

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

Two male Atlantic salmon returned to the Cocheco River in June and one male salmon returned to the Lamprey River in October. They ranged in size from 76 cm to 80 cm and all were age 2.2.

2.1.5.b. Hatchery Operations

The male Atlantic salmon that returned to the Lamprey River in October was transported to the Milford State Fish Hatchery (MSFH) in anticipation of taking milt during fall spawning. Milt was taken from this fish in late November and used to fertilize landlocked salmon eggs for the 1997 stockings. This fish was then released back to the Lamprey River.

2.1.5.c. Stocking

In April of 1996, approximately 241,000 Atlantic salmon fry were scatter stocked by volunteers into the Lamprey (115,000 fry) and Cocheco (126,000 fry) River systems. Fry were stocked at densities of 40-50 fry/unit.

Fry stocked in 1996 were from two egg sources in the fall of 1995, landlocked salmon from Squam and Winnipesaukee Lakes in New Hampshire (205,000 eggs), and domestic Atlantic salmon of Merrimack River origin raised at the NNFH (263,000 eggs). All eggs obtained were fertilized with milt from domestic Atlantic salmon raised at the NNFH. All eggs were raised at the WSFH. In addition, the Lamprey River was stocked with approximately 46,300 parr that were donated by New England Fish Farming Enterprises.

2.1.5.d. Juvenile Population Status

Electrofishing surveys for juvenile salmon at four index sites on the rivers produced population estimates for young-of-the-year (YOY) fry ranging from 0.2 - 3.7 fish/ unit. The supplemental site surveys had YOY population estimates that ranged from 0.8 - 1 fish/unit. Mean length and weight of YOY at index sites ranged from 85-92 mm and 6-8 g. Estimates of parr abundance ranged from 1.3 - 6.4 fish/unit. Parr ranged in size from 140-145 mm and 24-26 g. Parr were encountered at only one supplemental site, the Ela River. The parr population estimate at this location was 1.6 fish/unit.

Population estimates at index sites in the Cocheco River system varied drastically between sites. The Mad River index site had the highest population estimates for parr ever measured at this site, however the Cocheco River index site had the lowest population estimates for both YOY and parr. Mean length and weights for both YOY and parr were well above the average compared to the last three years.

The Lamprey River index sites had average or above average population estimates for both YOY and parr. Once exception to this was the North River site which had an extremely low population estimate for YOY. Mean lengths and weights were above average for YOY and slightly under average for parr compared to the last three years.

The high variability in the change in juvenile salmon abundance between years at each sampling site suggest that the index sites may be monitoring the movement of juvenile salmon (parr in particular) within the watershed between years rather than changes in survivorship between years. As one example of possible migration between years, consider the 1996 population estimate of parr at the Mad River index site. The 1996 estimate of 6.3 parr/unit is considerably higher than the 1995 YOY population estimate at this same site (3.1 YOY/unit). Since calculated estimates of the probability of capture were higher for YOY than for parr in both 1995 and 1996, the increase in parr is likely due to migration. Further examination of this hypothesis is needed.

2.1.5.e. Fish Passage

The NHFG has petitioned the FERC to reopen the operating license of Southern New Hampshire Hydroelectric Development Corporation's (SNHHDC) hydroelectric facility at Cocheco Falls on the Cocheco River. The petition requested three changes to the license: 1) provide for summer and fall operation of the NHFG fish ladder at the Cocheco Falls with sufficient attraction water, 2) increase the required operation time of the SNHHDC's downstream fish passage facility into the spring to allow for downstream migration of Atlantic salmon smolts, and 3) modify the downstream passage facility to increase the passage efficiency.

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

2.1.5.f. Genetics

No work was conducted in this area in 1996.

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. The NFHG draws from a database of more than 200 individuals that have expressed an interest in assisting us and generally 50 to 100 individuals show up per day of stocking during the spring.

2.2. STOCKING

2.2.1. TOTAL RELEASES

During 1996 the participating resource agencies released approximately 12,300,000 juvenile Atlantic salmon into 15 rivers (Table 2.2.1. in Appendix 10.1.). Included within the table is the Canadian contribution to the release program. The number of fish released was nearly identical to that of 1995.

2.2.2. SUMMARY OF TAGGED AND MARKED FISH

About 700,000 marked and tagged salmon were released in New England rivers in 1996. Of the total, 98% were released into Maine rivers, 1.5% were released into the Merrimack River drainage, and 0.5% were released into the Connecticut River drainage.

Atlantic salmon of all life stages were utilized. Most (621,000) of the marked salmon released in Maine were fry which bore temperature-induced marks on their otoliths. Throughout New England small numbers of juvenile and adult salmon were marked with a variety of finclips and/or miscellaneous external tags (e.g., PIT tags, VI tags, elastomer tags, Peterson disk tags, etc.). Additionally, Carlin tagged smolts (48,400) were again released in Maine for the first time since 1992.

A comprehensive summary of marked and tagged Atlantic salmon released in New England rivers during 1996 is presented in Tables 2.2.2.a. and 2.2.2.b. (Appendix 10.1.).

2.3. ADULT RETURNS

2.3.1. TOTAL DOCUMENTED RETURNS

Documented total adult salmon returns to rivers in New England amounted to 2,827 salmon (Table 2.3.1. in Appendix 10.1.). The majority of the returns was recorded in the rivers of Maine with the Penobscot River accounting for nearly 73% of the total New England returns. The Connecticut River adult returns accounted for nearly 9% of the New England total and 76% of the adult returns outside of Maine. Overall, 21% of the adult returns to New England were 1SW salmon and 79% were MSW salmon; most (77%) of these fish were of hatchery smolt origin. Of the total returns, approximately 23% were of wild origin (from natural reproduction and from fry plants).

Documented returns of 1SW salmon to New England rivers increased significantly over those observed in 1995 (590 vs. 189). Similarly, MSW returns in 1996 were significantly higher than those observed the previous year (2,237 vs. 1,584).

Increases in documented salmon runs were noted for the Connecticut (+38%), Merrimack (123%), Penobscot (52%), St. Croix (187%), Androscoggin (138%), Saco (59%), and Narraguagus (14%). An unexpected return of 69 salmon was documented in the Union River. Additionally, redd counts in the lower Kennebec River, which normally is not censused, indicated that at least 50 adult salmonids (Atlantic salmon and brown trout) spawned there in 1996.

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) under-estimates the total salmon returns to New England.

In order to estimate total adult returns the Working Group used the same general assumptions as in past annual reports.

Estimated total returns to New England rivers in 1996 were 4,022 fish (Table 2.3.2. in Appendix 10.1). The total estimated return represents a 62% increase (1,533 salmon) from the total estimate of 2,489 in 1995.

2.3.3. RETURNS OF TAGGED SALMON

Returns of CWT and Carlin-tagged Atlantic salmon to rivers in New England in 1996 are shown in Table 2.3.3. (Appendix 10.1.). The information has been sorted by river of return and sea-age. A total of 601 salmon having CWT returned to the rivers of New England. No adult salmon having Carlin tags returned to the rivers of New England.

2.3.4. SPAWNING ESCAPEMENT, BROODSTOCK COLLECTION, AND EGG TAKE

Spawning escapement information, where available, can be found in Section 2.1. Twenty-eight adult salmon utilizing fish passage facilities in the Connecticut River basin were allowed to proceed upstream (not trapped for broodstock). Of the 28, 10 were closely monitored for spawning behavior on the Westfield River. Some successful spawning was documented. 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 538 sea-run females, 3,120 captive/domestic females, and 211 female kelts (206 reconditioned from Connecticut River sea-run salmon and 12 obtained from the Dennys River (3), the Machias River (2), and the Sheepscot River (7)) contributed to the egg take. The number of females (3,869) contributing was considerably more than in 1995 (3,140). The total egg take, 25,001,000, was approximately six million more than in 1995. A more detailed description of the egg production program is contained within Table 2.3.4. (Appendix 10.1.).

2.3.5. SPORT FISHERY

Directed sea-run Atlantic salmon fishing is not allowed in New England, with the exception of a catch and release fishery in Maine. The estimated number of salmon caught and released in Maine in 1996 was 542 fish (Table 2.3.5 in Appendix 10.1), which was a 46 % increase from the previous year. The increased catch may be attributed to increased salmon abundance and excellent angling conditions throughout much of the angling season. In addition, some of the salmon caught in eastern Maine rivers were escapees from aquaculture operations in Maine and New Brunswick and/or captive broodstock from CBNFH which were released in three rivers during the month of June.

The domestic broodstock fishery in the Merrimack River resulted in an estimated 1,541 salmon landed. This fishery is described in more detail in section 2.1.3.f.

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

The historical data were validated by the Assessment Committee and the information can be found in Tables 3.2.a. and 3.2.b. in Appendix 10.1. and in Section 5. (sub-sections 5.1. and 5.2.) of this document. In a departure from past practices the 1996 data were added to the tables.

3.3. REPORT OF THE FISH CULTURAL SUB-COMMITTEE

3.3.1. Sub-committee Members

Sub-Committee Members include Paul Gaston, USFWS - GLNFH, Mike Hendrix (chair), USFWS - Northeast Fishery Center, Steve McCormick, USGS - Biological Resources Division, Vic Segarich, USFWS - NNFH, Steve Swartz, Atlantic Salmon of Maine, and Rick VanNostrand, CTDEP - Burlington State Fish Hatchery.

3.3.2. Focus of Sub-committee

The Sub-Committee focused effort on identifying fish cultural research issues covering all sectors of aquaculture that were not being adequately addressed. Private, state, federal, and Canadian fish cultural and research professionals were surveyed to obtain a list of the most pressing research issues needing attention.

It should be noted that genetics research was identified in the survey but the Sub-

Committee considered it to be outside of the specific fish cultural realm since culturists are not involved in basic genetics work. While guidance in developing spawning protocols and broodstock is important, the Sub-Committee recommended that a Genetics Sub-Committee be formed to address this issue.

Six target research areas specific to fish culture were identified: fish health; marking, fry to adult; time and method of smolt release; sterilization methods; broodstock management and reproductive protocols; and survival enhancement, egg to smolt.

3.3.3. Results

1. FISH HEALTH

Fish health is a primary concern in the restoration of Atlantic salmon (ATS). Egg production for the various restoration programs comes from three sources: sea-run, kelt, and domestic broodstock. Since all of these sources originate from sea-run broodstock, degree of survival in all life stages directly impacts numbers of returning adults and hence, egg production critical to recovery efforts. Without adequate fish health information on all life stages, we do not know if, or to what degree, fish pathogens might be negatively affecting overall survival to spawning adult. In addition, though comprehensive fish health work is done on incoming, captive, and domestic broodfish, there is a general failure to monitor the outmigrating and resident ATS populations while in the freshwater phase. It would benefit the various recovery programs to evaluate the pathogen exposure of juvenile ATS in order to better evaluate the need for pre-release vaccines and to anticipate and prepare for potentially problematic pathogens that might occur during capture and spawning of immigrating adults.

Hatchery held broodfish may also require treatment for identified pathogens, but few Food and Drug Administration (FDA) approved therapeutants/bacterins are available and strains of furunculosis resistant to approved antibiotics have recently been detected. Research involving therapeutant/vaccine registration should be paramount, especially with regard to antibacterials.

Much of the work involved in sampling for primary pathogens requires fish to be sacrificed. Additional work is needed in the area of non-lethal sampling to minimize fish losses to commercial growers and protect valuable wild stocks used in restoration programs.

Research Needs

- Using a combination of lethal and non-lethal techniques, perform a comprehensive, statistically valid fish health examination of juvenile ATS during the freshwater phase of their life cycle at key river locations.

- Expand current research on development of non-lethal sampling techniques for furunculosis to include other primary bacterial, viral, and parasitic pathogens of concern. Expand water sampling and pathogen detection to include other primary pathogens of concern.

- Expand comprehensive fish health monitoring to include fish species other than ATS that may harbor pathogens detrimental to salmon.

- Continue research on the development of a furunculosis vaccine, including investigation into oral or immersible administration.

- Pursue registration of additional antibacterials such as amoxicillin or florfenicol by performing required pivotal studies.

- Conduct research on the use of cypermethrin for external control of sea lice and *Argulus sp.* and develop protocols for oral sea lice treatments.

- Conduct research on the use of hydrogen peroxide as an antifungal for ATS adults and eggs.

While not considered basic research needs, two other areas of work did surface that should be mentioned: 1) the need to take advantage of tracking projects (such as on the Westfield River) to monitor the health and survival of sea-runs in the natural environment as well as the incidence of disease; and 2) the need to enhance the database on hatchery held returning sea-runs for better fish health evaluation such as the relationship of injuries, sea lice, water temperature at capture, fish origin (hatchery or wild), etc. to incidence of disease.

2. MARKING, FRY TO ADULT

Tagging and marking of Atlantic salmon (*Salmo salar*) are important techniques used by fishery managers to study individual fish or fish populations. Evaluation of on-going restoration efforts for this species is not possible without the ability to obtain information through use of marked fish for: (1) migration patterns (2) behavior, including habitat use and interactions between wild and hatchery fish (3) age and growth (4) mortality rates (5) abundance, using mark/recapture techniques and (6) contribution of stocked fish to numbers of returning spawners. The size and type of tag necessary for the desired evaluation varies depending upon the life stage of the fish to be marked, i.e., (fry, parr, smolt, adult) and the desired evaluation as listed in numbers 1 through 6 above. Therefore, the types of tags in use and further research needs identified herein will be broken down into life stage of the fish.

Fry marking

Fry stocking by the U.S. Fish and Wildlife Service has become an increasingly important part of the Atlantic salmon restoration program in the Northeastern U.S. Paramount to the success of fry stocking in achieving management goals is the ability to assess the effectiveness of such a management strategy. Therefore, a need exists within Region 5 of the U.S. Fish and Wildlife Service for a technique of marking non-feeding Atlantic salmon fry (sac-fry) with a readily recognizable tag or mark capable of being non-lethally detected in returning adult fish. In some cases, only a single mark is needed (to distinguish between hatchery and naturally produced fry, for example), while in others, numerous marks are needed (for example, to determine which river tributary is contributing most to adult returns). Currently, there is no technique completely developed to induce such a mark but progress is being made on the problem.

Calcein mark - In 1995 and 1996, Northeast Fishery Center-Lamar (NEFC) biologists tested batch-marking larval ATS by immersion in calcein solutions for various time intervals for effects on short and long term mark retention, health, and growth *(Studies L-95-04 and L-96-08)*. Calcein-treated fish received a mark detectable as brilliant green fluorescence in all fin ray structures when viewed under long wave fluorescent microscopy. Marks have been non-lethally detected at 22 months post-immersion in experimental fish.

Research Needs

- Long-term evaluation of marked fish through adulthood (5 years post-immersion).

- Reduce exposure time of fish in the chemical while inducing more consistent, brighter marks.

- Get FDA approval for experimental use of the compound.

- Conduct pilot scale stocking of calcein-marked fry with a follow-up evaluation.

- Explore alternative mark detection techniques.

Immunogenic mark - Work is currently underway on another fry marking technique which uses the fry's own immune system (B lymphocyte cells) to produce antibodies in response to immersion in a foreign antigen solution. If the immune system of the fish retains its "memory" of the antigen until the fish reaches adult stage (approximately 5 years), an assay could be designed for a blood test to identify returning spawners as marked or unmarked. This work is being pioneered by the USGS-BRD, Research and Development Lab-Wellsboro, PA and Mansfield University with cooperation by NEFC-Lamar, PA. Progress has been made on the technique which shows that non-feeding fry do have an active immune system and that parr immersed as fry in Bovine Serum Albumin (BSA) solution retain the immunologic memory of the substance as long as 14 months. This technique, once developed, could theoretically utilize a variety of antigen solutions to induce different immunologic marks depending on which river was targeted to receive fry stocking.

Research Needs

- Immersion of non-feeding fry in selected antigen baths with annual evaluation of immune system memory to adult stage.

- Determine best dosage rates for antigen bath.

- Determine the number of times the antigen bath can be used to mark fry.

- Confirm that the mark stays on the proper blood protein.

- Develop a suite of markers so managers can select the one that best suits their needs.

Strontium mark - Dartmouth University researchers are investigating relationships between natural strontium isotope ratios in streams to strontium isotope ratios in skeletal components of Atlantic salmon. They have found that natural strontium levels and isotopic ratios are constant and reflect for each tributary and stream fixed levels of strontium in the underlying geologic strata. As a result, these strontium signatures are able to be detected in bone tissue of the Atlantic salmon inhabiting the particular stream. As salmon migrate into different areas of a stream , or perhaps a different stream or the ocean, they will be subjected to different strontium signatures and correspondingly, their new skeletal growth will reflect the new strontium levels. Therefore, to determine the origin of migrating salmon, the older skeletal layers, such as the early layers of otolith growth or perhaps the center annuli of a scale, would have to undergo strontium analyses. Additional elemental analysis, for example nitrogen, may provide the ability to discern between overlapping strontium regions should they occur. Disadvantages are to this technique are: (1) the analytical equipment is expensive and few universities have it (2) currently, lethal samples must be taken (3) special training is necessary to run the analytical equipment (4) sample analysis is time consuming.

Research Needs

- Measuring the strontium signatures of all salmon waters is necessary to obtain baseline information.

- Developing ways to obtain non-lethal samples for analysis (perhaps scale sampling).

- Experimenting with incubation of hatchery-reared fry under known strontium levels with subsequent release and analysis for the original strontium signature in all life stages up to mature adult (5 years).

Microsatellite markers - Development and subsequent screening of a class of variable number tandem repeat loci with simple sequence repeat loci in Connecticut River ATS has been conducted at Leetown BRD-USGS. These loci, termed microsatellite markers, exhibit a high degree of polymorphism in many taxa and provide considerable information on parentage, population structure, and genome mapping. The Leetown Laboratory has successfully identified twelve microsatellite markers and computer simulations using 1996 sea-run return microsatellite data showed that offspring from individual Connecticut River parents can be identified with as few as four loci without the need for a selective breeding program.

Research Need

- Research is needed to work out hatchery logistics for tracking families of fish.

Smolt marking

Though not currently performed "program-wide" on hatchery-reared Atlantic salmon released for restoration efforts, smolt stocking is performed in Maine using fish produced at Green Lake NFH. In general, fishery managers working in the hatcheries and in the field are not satisfied with currently available marking techniques related to smolt releases. The major problem is that two or more groups of smolts released at the same time cannot be compared for survival or percent return of adults when using current marking methods. Reasons for this are discussed in each of the following categories of current smolt marking techniques:

Coded Wire Tag - This 1mm long piece of stainless steel is equipped with a binary code and injected into the snout tissue of the smolt. Each fish must be handled individually in this process. Retention is generally considered good for this tag in returning adult salmon, but tag recovery is lethal in order to read the code. For some purposes, just detecting the tag with a wand is adequate, but when a comparison between two or more groups of fish is desired, lethal tag recovery becomes necessary. This is time consuming and undesirable from a fishery manager's point of view because of the high biological value of returning adult fish. As a result, small sample sizes are evaluated in returning CWT fish leading to the possibility of biased return information. In field conditions when returning adult salmon are captured in a trapping device, there could be hundreds of salmon in need of assessment as quickly as possible due to warm temperatures and stress of capture. At times, CWT go undetected due to increased fish growth resulting in more deeply imbedded tags. Therefore, searching for CWT with a wand in all returning spawners can be inefficient, time consuming, and threatening to the health of the fish. Sometimes an adipose fin clip is used in conjunction with CWT to eliminate the need for scanning unmarked fish, but this limits managers to only one mark and eliminates comparisons between two or more groups of fish. An additional concern of CWT detection is unwanted interference with metal objects associated with the trapping device and other field equipment. Additional work needed to improve CWT as a tagging method has not been identified.

Adipose Fin Clip - Smolts released in the Maine program receive adipose fin removal as well as CWT with the adipose clip serving as a visual cue that the fish may have a CWT. It is considered to be a fairly acceptable external mark but the clip can only identify one group of fish and each fish must be individually marked.

Elastomer Tags - Application of this mark involves injection of a colored liquid polymer under a translucent layer of tissue on the fish such as the adipose eye tissue, fin tissue, or subcutaneous jaw tissue. Each fish must be individually tagged with this method. Detection of the mark is simply a visual one. Grilse returning this summer (1997) in the Penobscot River are expected to include some fish marked as smolts with colored elastomer in the adipose eye tissue. The method shows some promise but evaluations have not yet been performed. If the mark is readily detectable, it may prove useful when comparison of two or more groups of fish released as smolts is desired through use of a variety of colors of elastomer. It may also be possible to use fluorescent fabric paint between anal fin rays, which has been used successfully in short-term (up to 1 year) studies in the Connecticut River.

<u>Research Need</u>

- Evaluation of long-term mark identification on returning adults released as marked smolts.

Pit Tags - This tag allows electronic identification of various groups of fish, if desired, and is easy to apply to individual fish. However, use of this tag for large numbers of smolts is not practical due to price. Current quotes are approximately $3.85/ea if a 10,000 tag quantity is purchased ($38,500). PIT tags are currently not used for mass mark/release stocking in the ATS program.

Carlin Tags - This externally applied tag is not generally used for application to large numbers of smolts due to the time consuming nature of tag preparation and application. There is an increased probability of predation on fish marked with this type tag since it resembles a "spinner bait" lure commonly used by fishermen to attract large fish to strike. Additional work needed to improve Carlin tagging techniques has not been identified.

Adults

The need exists to develop a cheap, easily readable external tag for adult fish that will last two or more years. External tags are used to mark hatchery held sea-run adults and can be used to develop information such as the relationship of time of capture to incidence of disease or to egg fecundity or egg size. In both sea-run and domestic stocks, external tags are needed to identify individuals in a selective breeding program and/or to ensure that established spawning protocol is followed (such as paired matings only). The ability to readily identify commercially produced escapees entering coastal rivers would be of considerable assistance to fisheries managers intent on preventing these fish from interacting with wild populations.

Internal Anchor Tags - Sea-run kelts were marked with this type tag prior to release in the Merrimack River in 1996. An incision is made in the body wall of the fish into which the plastic anchor mechanism portion of the tag is placed. The external portion of the tag consists of a streamer for visual identification. In general, limited numbers of sea-run kelts are released annually, but if the tag shows good retention, it's use may be expanded to domestic broodstock release programs. Even though no tag retention studies for this type tag have been performed yet on Atlantic salmon kelts, the tag has shown good performance in the Striped Bass restoration program.

Research Need

- Tag retention studies in domestic and sea-run kelts or other broodstock released into the Merrimack River.

Petersen Disc Tag - Currently, all broodstock released annually (N= 3,000 in 1996) into the Merrimack river for the sport fishery or sea-run restoration efforts receive this tag type placed at the base of the dorsal fin. With this tag, two plastic discs sandwich the base of the dorsal fin and are connected through the fin base by a stainless steel pin or wire. This tag is easily readable with the naked eye for tag information recovery but abrasion occurs as the disc rubs against the fish body during normal fish activity. This could lead to disease problems and be unattractive to sport fisherman who catch a tagged fish. Additional work needed on this tagging technique have not been identified.

Radio Tags - Radio transmitter tags are either fastened to the exterior of the fish or surgically placed in the body cavity. In the Merrimack River broodfish stocking program, both methods have been used to identify fish movements related to spawning activity or migration. Two types of radio tags are in use: low tech and high tech. Low tech tags have a transmission life of about 100 days and are less expensive than higher tech transmitters which can last about 1 year. Internal implantation has been reported to give good results with little mortality. There is some problem with abrasion and skin degradation with the external attachment of these tags. In the hatchery, fish have been observed rolling in attempt to knock the tag off. If ripe female broodfish are released relatively close to spawning, workers are limited to external tag placement so that oocytes are not disturbed. Surgical implantation early in the year prior to completion of oogenesis, may be a way to circumvent tag abrasion and/or loss in these fish.

Research Needs

- Retention studies on released kelts.

- Study effects on ovulation subsequent to radio tag implantation early in the oogenesis cycle.

Floy Tags (T-bar) - This type tag is easily applied in the field and is used on all adult spawners which return to the Connecticut River and its tributaries prior to transport to Cronin NSS and eventual spawning. It is becoming more critical to have superior tag retention on these fish with the increased emphasis being placed on proper genetically paired matings. Current success with T-bar Floy tags is less than desirable according to fishery managers due to tag loss.

Research Need

- Retention study comparing use of a different anchor mechanism on the Floy tag vs. the currently used T-Bar. (such as modified dart tag which has a conical anchor).

Visual Implant Tag (VI) - VI tags are celluloid chips with printed information and are generally applied in the adipose eye tissue. Application time is similar to that of Floy tags. Ideally, a transparent layer of fish tissue keeps the tag in place and permits readability without tag removal. In the Connecticut River broodstock program, all returning adults receive these implants as well as a T-bar Floy tag. Managers have noted that the VI tags can become obscured by an opaque tissue layer and therefore become difficult to read over time.

Research Need

- Research is needed to determine the long term readability of these tags.

3. TIME AND METHOD OF SMOLT RELEASE

It has been shown that timing of smolt release is an important determinant of adult return rates. Adult returns can vary by as much as an order of magnitude as a function of timing of release. This effect of timing may be caused by the physiological preparedness of fish as there is a limited period of time during which fish have the urge and capacity for seawater entry. Salinity tolerance and other measures of physiological preparedness are positively correlated with seasonally optimal release times. Ecological factors, such as food resources and predators, and physical conditions, such as temperature and flow, which will vary from year to year, are also likely to be important. It is probable that there are interactions between physiological preparedness and ecological conditions.

Site of smolt release has also been shown to be important to adult return rates. In general, increasing returns are seen from fish planted further downstream or in estuaries, whereas ocean releases generally have poorer returns. The reason(s) for this pattern of returns is unclear, and this pattern has not been found in all studies. In addition, methods of handling of fish at the time of release has also been shown to affect returns.

Smolts are known to be more sensitive to handling stress than other stages, and this may negatively affect their subsequent migratory behavior, disease resistance, seawater acclimation and predator avoidance.

Research Needs

- Determine how timing of release affects adult return rates. It is possible that optimum release times will be river-, hatchery-, or stock-specific and thus evaluation will be necessary in several rivers. Time of release studies should include measures of physiological preparedness.

- Determine how site of release affects adult return rates. As with time of release, site of release may be river-, hatchery-, or stock-specific and thus evaluation may be necessary in several rivers. This evaluation may include up-river (above dams), down-river (below dams) and estuarine releases.

- Evaluation of how prior treatment and transport of fish affects adult returns and would include effect of food withdrawal period prior to transport; how handling and loading procedures affect stress and subsequent returns; and whether a period of recovery from transport stress improves adult returns.

4. STERILIZATION METHODS

Sterilization of commercially grown Atlantic salmon could reduce or minimize any possible hybridization between feral and escaped cultured Atlantic salmon. A major concern of many fishery biologists/managers is that hybridization may potentially decrease the wild gene pool and in turn reduce genetic fitness. There are currently 4 known methods of sterilization for fish:

* Gonad irradiation - not approved for fish
* Hormone treatments - not approved for food fish
* Surgically removing of gonads - not practical on a large scale
* Chromosome (3n) triploid manipulation - currently only reasonable approach to explore

Although producing triploids in rainbow trout has been commercially successful by applying a chemical, temperature or pressure shocking of newly fertilized gametes, similar methods using Atlantic salmon have been unacceptable mainly due to increased production costs, deformities (especially lower mandible), and various other less than desirable performance characteristics.

To date, numerous studies have been conducted in Tasmania, France, Norway, Scotland, Canada, the United States, and most recently in Maine using the local Penobscot strain. Also, new large scale triploid studies have been started in several

European countries. If perfected, sterilization could lessen potential threats from the majority of escaped commercially grown salmon, but broodstock (mature 2n) salmon will still be necessary in significant numbers to produce future generations of fish. Research in the use of triploids is at least two decades old. It should continue to be addressed as a high priority.

Research Need

- Expand research efforts to produce triploid fish acceptable to the commercial aquaculture industry.

5. BROODSTOCK MANAGEMENT AND REPRODUCTIVE PROTOCOLS

Current broodstock management techniques for both restoration programs and commercial aquaculture ventures have been reasonably successful in providing viable gametes for operational needs. Refinements in handling procedures could increase survival rates and permit more efficient use of both genetically important stocks and the limited funding and rearing resources dedicated to brood maintenance. Areas for research encompass improving established protocols for physically handling sperm and eggs, preservation of gametes, and determining factors that influence female fecundity and egg quality.

Research Needs

- Develop short and long term techniques to handle eggs and preserve sperm. Restoration and aquaculture operations often maintain brood at a considerable distance from facilities used to incubate eggs. Delaying the fertilization of eggs until they arrive at the incubation area has proven to increase survival. Methods of handling and storing sperm to keep them viable during transport need to be developed. Work in this area is currently ongoing at the Northeast Fishery Center and the USGS-BRD Research and Development Laboratory-Wellsboro, but production scale methods have yet to be defined. Long term preservation of sperm, up to a year or longer, is needed to maintain genetically important salmon stocks and to insure adequate supplies are available throughout a spawning season. The ability to cryopreserve Atlantic salmon sperm has been reported in European literature but thus far American researchers have not been able to duplicate their success. Limited work in this area is in progress at the Wellsboro FRDC, but significantly more research is needed.

- Determine the causes of variation in fecundity and egg quality among and within stocks. Wide fluctuations have been noted in female fecundity and egg quality within and among stocks each year. These variations have made it difficult to maintain stable production programs and allocate adequate rearing and funding resources. Questions also arise about whether these changes influence the subsequent survival of the resulting fish. A number of factors is known to contribute to variability among broodstock, including diet, photoperiod, rearing regime, temperature, and genetic history, but little is known about how these influences interact and affect fish. A possible avenue to pursue would be to form an interdisciplinary panel to develop a plan to investigate the issue and to recommend which group or facility would be best suited to study the problem.

6. SURVIVAL ENHANCEMENT, EGG TO SMOLT

During the past decade, efforts to increase production of smolts and fry have resulted in repeated large stockings of these life stages in many of our New England restoration rivers. In spite of these hatchery successes, resultant marine survival and in the case of fry, post release fresh water survival are highly variable.

Undoubtedly there are natural changes in both the freshwater and marine environment which greatly affect post stocking survival and over which we have no control, however, it may be that in "our rush to numbers" we have overlooked other more effective means of increasing survival.

Research Needs

- Evaluate effectiveness of various exercise (fitness) and predator avoidance conditioning regimes in increasing post stocking survival of hatchery smolts.

- Evaluate egg planting or streamside incubation as a cost effective method for saturating juvenile habitat.

- Evaluate the effects of hatchery production densities and feeding on post stocking performance of fry and/or smolts.

- Evaluate the use of naturally spawning, seapen or hatchery reared adults, as a method for seeding juvenile habitat.

- Evaluate how time of fry release and river conditions during release (e.g. temperature and flow) affect fry survival. Although these are only secondarily related to fish culture, altering time of release will directly impact culture activities.

3.3.4. Discussion

- Develop a Genetics Sub-Committee
- Maintain the Fish Culture Sub-Committee to:
    - Provide summaries of research needs
    - Provide guidance for active advocacy of program needs
        - Provide a review of options to control furunculosis in ATS broodstock, select a plan of action, identify who to contact and what to say to secure

the best possible measure of control for program use
- Provide a catalyst to ensure that high priority research is conducted

- Suggested priorities for research among those identified by the Sub-Committee

  - Fry mark development
  - Emphasis on study design vs. fry mark technology to evaluate hatchery products
  - Handling gametes
  - Smolt conditioning
  - Emphasis on fry vs. smolt research
  - Evaluate value of parr not how we stock parr or use the fish

3.4. REPORT OF THE MARINE SUB-COMMITTEE

3.4.1. Sub-committee Members

Members of the sub-committee included Kevin Friedland (Chair) and John Kocik, both of the NMFS.

3.4.2. Focus

Two papers were presented for discussion. One dealt with "Sea Surface Temperatures and Post-smolt Survival in the Northeast Atlantic" and the second addressed "Preliminary Studies of the Early Marine Ecology of Atlantic Salmon Smolt in the Narraguagus Bay Using Gillnets and Ultrasonic Telemetry".

3.4.2.a. Sea Surface Temperatures and Post-smolt Survival in the Northeast Atlantic

The first year of ocean life of Atlantic salmon is shaped by natural mortality and sexual maturation, which in combination dictate reproductive success and fishery yields of salmon populations. Maturation rate is a function of both stock genetics and environment. The relative influences of these effects on the fraction of a cohort to mature after one year at sea is still being actively researched (Thorpe, 1994; Friedland and Hass, 1996; Friedland et al. 1996). However, it is clear that stocks have differing maturity schedules and that stocks can show dramatic variation in maturity rate (Power 1981, Saunders 1981, Shearer 1990, Summers 1995). Marine natural mortality in salmonids is believed to be most severe on populations during the first weeks to months at sea (Fisher and Pearcy 1988; Holtby *et al.*, 1990, Eriksson 1994, Salminen et al., 1995). It is also believed that mortality effects are growth mediated during this period due to either variation in ocean productivity, interspecific competition, or intraspecific interactions (Ricker 1962; Neilson and Geen, 1986; L'Abee-Lund et al., 1993; Friedland et al. 1996). Therefore, broad scale processes that may affect salmon growth are of keen interest.

Ocean climate appears to be intimately linked to mortality and maturation mechanisms in salmon. Maturation, as evidenced by returns and survival of various aged salmon, has been shown to vary in correlation to a number of environmental signals such as temperature (Saunders *et al.* 1983, Scarnecchia 1983, Martin and Mitchell 1985, Scarnecchia *et al.* 1991, Friedland *et al.* 1993). However, some signals are not clearly distinguished from purely survival effects since they are related to ocean temperatures affecting smolts during the first weeks at sea (Scarnecchia *et al.* 1989). Survival of Pacific salmon species have been shown to vary with fluctuations in broadscale circulation patterns like ENSO events (Johnson 1988, Beamish and Bouillon 1992, Francis and Hare 1994) and more localized upwelling circulation that would be expected to impact local productivity and juvenile salmon growth (Fisher and Pearcy, 1988, Kope and Botsford 1990). Even in confined systems like the Baltic Sea, temperature and circulation effects have been implicated as a determinate of growth and survival (Salminen et al., 1995). However, there is limited knowledge of the factors influencing the growth and survival of post-smolts from the stocks comprising North American and European Atlantic salmon.

The survival of two Atlantic salmon stocks that inhabit rivers confluent with the North Sea was examined in respect to historical distributions of sea surface temperatures. The rivers Figgjo and North Esk are relatively small salmon rivers in southern Norway and eastern Scotland, respectively (Figure 1). Wild salmon smolts have been tagged in these rivers since 1965. The return of tags for one and two seawinter salmon were used to evaluate survival conditions for salmon in this region. Survival rates were correlated among rivers and sea ages (Figure 2). Survival rates were compared to the areal extent of thermal habitat in the Northeast Atlantic Ocean. A positive correlation was found between the area of 8-10°C water in May and the survival of salmon. A reciprocal negative correlation was also found between survival and 5-7°C water in the same month (Figure 3). An analysis of sea surface temperature distributions for periods of good versus poor salmon survival showed that when cool surface waters dominate the Norwegian coast and North Sea during May, salmon survival has been poor (Figure 4). Conversely, when the 8°C isotherm extended northward along the Norwegian coast during May, survival was good.

The distribution of spring water temperatures in the Northeast Atlantic ocean emerged from our study as an important factor influencing the survival of salmon stocks from the North Sea area. Survival fluctuated similarly for both 1SW and 2SW salmon for both index stocks, thus the contribution of maturation mechanisms to the observed return rates can be discounted. Survival for 1SW fish is recorded as the rate of return of tags versus the number released. The tagged fish were at liberty for the post-smolt year before being recovered, therefore, there is no way to ascertain when during the post-smolt year the highest mortalities occurred. Eriksson (1994) reported on a tagging experiments in the Baltic Sea in which post-smolt recoveries allowed for the estimation of weekly mortality rates for post-smolts. These results generally confirm the suspicions held by most salmon researchers that the highest mortality rates occur during the first weeks at sea. The rates for the balance of the year are elevated as compared to those observed for adults, but they were none-the-less lower than the spring mortalities. This draws our focus to the time period that Figgjo and North Esk salmon would first be entering the marine environment, which is also accomplished by the results of the sea surface temperature correlation analysis.

The strongest correlations between survival rate and areal extent of thermal habitat occurred during the month of May. In both stocks, correlation to warm water habitat (8-10°C) was restricted to May whereas correlations to cold water habitat were also observed for June data. The distribution of sea surface temperature, which in essence is driving these correlations, were found to be ecologically significant. Sea surface temperature distributions for periods of good versus poor salmon survival showed that when cool surface waters dominate the Norwegian coast and North Sea during May, salmon survival has been poor. Conversely, when the 8°C isotherm extended northward along the Norwegian coast during May, survival was good. Thus, it is the variation in temperature conditions for this segment of the Norwegian coast which is most critical to the post-smolts. This section of the Norwegian coast is dominated by a coastal current that travels to the northeast at mean seasonal rates of 15-20 cm/sec^{-1} (Hopkins 1991). Jonsson *et al.* (1993) reported on the migration of post-smolt in this current and found migratory speeds averaged 7.45 km/day^{-1} and post-smolt were rarely able to transport themselves southward against the prevailing currents. Thus, salmon post-smolts from the Figgjo and North Esk would be expected to occupy this thermally dynamic segment of the coast. Variation in the distribution of sea surface temperature could act on salmon post-smolts in a number of different ways.

Growth mediated effects would respond directly to variation in temperature. Mortality rates of pelagic fishes are inversely related to body size (Peterson and Wroblewski 1984). Variation in growth and survival of early life history stages are broadly identified as critical to the recruitment process (Anderson 1988, Pepin 1991). In salmonids, growth related mechanisms have also been associated with survival patterns (Furnell and Brett 1986, Mathews and Ishida 1989, Holtby *et al.* 1990, L'Abee-Lund *et al.* 1993 Friedland *et al.* 1996). Growth increases linearly with water temperature up to an optimum rate (Brett 1979), thus making post-smolt growth-survival mechanisms temperature dependent. Post-smolts from the Figgjo and North Esk advected into the Norwegian coastal current would be subjected passively to prevailing temperature trends in a given year. In years where water temperatures were high enough to support rapid growth, the juvenile fish would be expected to attain body sizes to avoid predation and survival for the cohort would be enhanced. Conversely, lower temperatures would depress growth and survival. This represents the most direct effect sea surface temperature distributions could have on post-smolts. Other factors, that co-vary with sea surface temperature trends, may be impacting growth and survival through indirect mechanisms.

Variation in temperature conditions may be indicative of change in ecosystem productivity and feeding opportunities for post-smolts. Recent studies with Pacific salmonids point to the importance of variation in diet in the recruitment process (Healey 1991, Brodeur *et al.* 1992, Perry *et al.* 1996). Prey availability is often related to oceanographic processes and structural features in the water column (Levings 1994). Juvenile salmonids have been shown to modify their diet in response to restrictions imposed by thermal structure (Reddin 1985, Pearcy *et al.* 1988) or opportunities created by the concentration of food along fronts (Brodeur 1989, St. John 1992). Variation in ocean productivity has also been hypothesize to act on post-smolts by shifting predation pressure from other species onto the post-smolts (Fisher and Pearcy 1988).

Salmon are highly migratory and depend upon a number of cues to successfully pilot during the marine phase. The conditions first encountered by post-smolts may force additional swimming as the fish respond to migration cues (Salminen *et al.* 1994), thus creating energetic deficits for the fish as they swim harder to avoid undesirable thermal conditions. Post-smolts also may face potentially lethal or stressful conditions when they attempt to transition between river and ocean environments (Narayanan *et al.* 1995).

The divergence in maturity stage may be decided early in the life history of Atlantic salmon. Little difference is seen in the time series pattern of 1SW and 2SW return rate for the North Esk stock suggesting maturation is mostly influence by stock genetics. However, the return of 2SW Figgjo fish was not as well correlated to the 1SW data, thus the correlation between 2SW return rate and thermal habitat were markedly different than for the 1SW data. The only significant correlations for the 2SW Figgjo fish were with 7-9°C thermal habitat. This could be interpreted as divergence between the two maturity groups, thus indicating that fish destined to mature at 2SW are set on a migrational trajectory differing from the balance of the cohort. Temperature may be a good indicator of this divergence because it likely an important migrational cue for post-smolts.

Correlation between the survival time series for the two stocks, or coherence in recruitment patterns, argues against survival being mainly influenced by riverine or estuarine effects. Their are a multitude of survival effects that are associated with conditions local to the natal river of a salmon population (Wood 1987, Hvidsten and Johnsen 1993, Farmer 1994, Lundqvist *et al.* 1994). Correlation in survival, especially for non-neighboring stocks, argues for survival effects which act on the populations when they are mixed and that operate on broad spatial scales. From cursory inspection of the population data outside the North Sea area, it appears that survivorship differs regionally for European stocks (Crozier and Kennedy 1993). Further elucidation of the boundaries between stock groups within the European stock complex is encouraged.

Retrospective growth analyses offers a relatively easy means of testing a number of the explanatory hypotheses concerning the effect of growth on survival of salmon stocks in the North Sea area. Friedland *et al.* (1996) demonstrated a relationship between post-smolt growth and survivorship in hatchery stocks from North America. The post-smolt growth histories for North Sea index stocks would reveal any seasonal growth effects would could be related to the environmental record. It would be essential for such an exercise to include 1970's data, when survivorship was at high levels and the area of post-smolt habitat was relatively warm.

Discussion

The assessment committee discussed the mechanisms that may contribute to the observed correlations of return rates and sea surface temperature (SST) in the eastern Atlantic. Possible hypotheses suggested were 1) direct effect of temperature on growth related to physiology, 2) a temperature derived energy deficit of increased migration costs, 3) food availability, or 4) predator fields. The point was made that while all these scenarios were possible and all likely contribute to the observed relationship, that better growth itself was probably the key factor integrating each of these. The group also discussed the important consequences of the relationship between postsmolt growth and survival. It was suggested that it might be beneficial to look at the sizes of returning adults to further confirm this relationship. K. Friedland noted that this data was available but this aspect was not yet assessed Future work to examine the relationship between return rates and SST on a more refined scale in the western Atlantic is underway and is showing promising results.

3.4.2.b. Preliminary Studies of the Early Marine Ecology of Atlantic Salmon Smolt in the Narraguagus Bay Using Gillnets and Ultrasonic Telemetry

Gillnetting and ultrasonic telemetry were used to study the outmigration and early marine ecology of Atlantic salmon smolts in Narraguagus Bay, Maine. In 1995, five-panel 12.2 m x 4.9 m experimental gillnets were fished on alternating weeks (538 sets). In 1996, effort was intensified using 36.6 m x 4.9 m three-panel experimental gillnets fished continuously throughout smolt outmigration (608 sets). A total of 386 fish were collected in 1995 and 650 fish in 1996 (Table 1). Increased effort in 1996 also resulted in extensive seal predation on gilled fish and subsequent damage to nets. In both years, the catch was dominated by Atlantic herring and alewife; Atlantic mackerel and pollock were also relatively common. A single Atlantic salmon smolt was collected on 13 May 1996. The investigators believe that smolts were susceptible to this gear but that low abundance in a relatively large area precluded higher catch rates. The investigators also tracked 5 outmigrating Atlantic salmon smolts by boat from 13-24 May 1996 using ultrasonic pingers. Wild smolts were captured in a rotary-screw fish trap and an ultrasonic tag was attached externally. No mortalities of tagged fish were observed after a 24-h recovery period. These studies suggest that smolts moved to deep pools upon release and began migrating approximately ½ h before dark. Extensive searches indicated that they exited the Narraguagus River and Estuary system within one evening. One smolt was eaten by a striped bass, documenting predation by striped bass in northern rivers. Wild smolts appeared to move less during daylight hours than has been

Table 1. Fish Species Composition of Gillnet Sampling in Narraguagus Bay - 1995 and 1996.

			1996 Sampling		1995 Sampling	
Families/Codes	Common Name	*Scientific Name*	Number	% Total	Number	% Total
Salmonidae						
	Atlantic salmon	*Salmo salar*	1	0.15%	0	0.00%
Clupeidae						
	Clupeidae sp	*unidentified*	14	2.15%		
	blueback herring	*Alosa aestivalis*	4	0.61%	10	2.58%
	alewife	*Alosa pseudoharengus*	75	11.50%	133	34.28%
	American shad	*Alosa sapidissima*			4	1.03%
	Atlantic menhaden	*Brevoortia tyrannus*			1	0.26%
	Atlantic herring	*Clupea harengus*	402	61.66%	126	32.47%
Scombridae	- mackerels					
	Atlantic mackerel	*Scomber scombrus*	1	0.15%	81	20.88%
Gadidae	- cods					
	silver hake	*Merluccius bilinearis*			3	0.77%
	pollock	*Pollachius virens*	23	3.53%	2	0.52%
	Atlantic tomcod	*Microgadus tomcod*	1	0.15%	5	1.29%
	white hake	*Urophysis tenius*	1	0.15%		
Cottidae	- sculpins					
	longhorn sculpin	*Myoxocephalus octodecemspinosus*	96	14.72%	6	1.55%
Cyclopteridae						
	lumpfish	*Cyclopterus lumpus*	16	2.45%	3	0.77%
Others						
	spiny dogfish	*Squalus acanthias*			1	0.26%
	butterfish	*Peprilus tricanthus*	6	0.92%	11	2.84%
	sea raven	*Hemitripterus americanus*	1	0.15%		
	rainbow smelt	*Osmerus mordax*	1	0.15%		
	striped bass	*Morone saxatilis*	5	0.77%		
	Unidentified Fish Sp.		3	0.46%		
	harbor seal	*Phoca vitulina*	1	0.15%	2	0.52%
	red throated grebe		1	0.15%		
Grand Total			652	100.00%	388	100.00%

reported for hatchery smolts in other U.S. studies. Gillnetting trials helped to better understand the benefits and constraints of using gillnets in these waters. Gillnetting provided a useful data set on the relative abundance of other pelagic species in the bay that can be used for modeling competition or predation. However, until seal interactions can be minimized and Atlantic salmon numbers increase, researchers decided that gillnet studies will be discontinued. Conversely, ultrasonic telemetry has great potential in this system. Our sampling showed that tracking was possible and accurate assessments of outmigration movements and mortality could be made using automated equipment and less vessel time.

3.4.3. Discussion

Acoustic tag tracking in fast water was achieved by taking the gear over land and using the gear from shore. In these experiments, external tags were used to meet weight requirements of the fish. From experience of Canadian researchers and preliminary experiments on the Narraguagus, larger internal tags were found not to pose an undue stress on the fish. It was also felt that external tags are more visible and thus increase the visibility of the fish predators. Internal tags would not increase smolt visibility and are thus preferable.

3.4.4. References

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3.4.5. List of Figures

Map of Northeast Atlantic area with rivers Figgjo and North Esk marked and general area of post-smolt habitat marked with hatching.

1. Tag recovery rate for 1SW salmon to the rivers Figgjo and North Esk versus year (A); tag recovery rate for 1SW salmon to the river Figgjo versus recovery rate for the North Esk (B); tag recovery rate for 2SW salmon to the rivers Figgjo and North Esk versus year (C); tag recovery rate for 2SW salmon to the river Figgjo versus recovery rate for the North Esk (D).
2. Correlation between thermal habitat and recovery rate of 1SW salmon versus the center longitude used to calculate the thermal habitat time series. Each habitat index is for a 22° range at the center longitude. Data for the Figgjo stock and thermal habitat ranges of 5-7°C (A); 6-8°C (B); 7-9°C (C); 8-10°C (D). Data for the North Esk stock and thermal habitat ranges of 5-7°C (E); 6-8°C (F); 7-9°C (G); 8-10°C (H).
3. Sea surface temperature maps of the Northeast Atlantic area with 2°C isotherms and the SST area of 8-10°C marked with hatching for the period 1971-74, months March

(A); April (B); May (C); June (D). Data for period 1985-88 , months March (E); April (F); May (G); June (H).

Figure XX. Length distribution comparison of Atlantic salmon smolts from Cherryfield trap compared to pollack, Atlantic herring, and alewife collected in gillnetting in 1996.

3.5. REPORT OF THE SUB-COMMITTEE ADDRESSING SMOLT EMIGRATION SUCCESS TO THE OCEAN (freshwater → estuary)

3.5.1. Sub-committee Members

Sub-committee members included Ben Letcher (chair), USGS - Biological Resources Division, Jay McMenemy (VTFW), John Kocik (NMFS), Joe McKeon (USFWS), and Steve McCormick (USGS - Biological Resources Division).

3.5.2. Focus

The goal of this report is to introduce the framework for a mathematical model describing the growth and survival of Atlantic salmon from the fry stage to emigration. The model will be used to organize current available information on Atlantic salmon and as an organizational tool will identify data gaps.

3.5.3. Procedures

By their structured nature, models force compiling available information in an ordered fashion and help identify areas with strong data and areas with weaker data. This in itself is a useful exercise, but, once configured, we will also use the model as a tool to identify how the various processes in the model impact growth and survival and which are likely to have the largest effects. For example, we can ask how do losses from the population due to precocious maturity compare to losses from predation or from passing dams. Identifying critical processes will teach us about how the system works and will indicate, where possible, where management actions may have the largest impact. Quantifying the relative importance of processes will also help focus future research efforts.

Few models are actually predictive due to the uncertainty in model structure, uncertainty in data sources, lack of appropriate data, and variability in time and space. Rather, most models that are not used solely for management are a guide in some way to understanding the system. Although our model may eventually be used specifically as a management tool, our initial intent is to use it to help understand the system better. This understanding should aid management decisions. Specific model output will provide bounds on growth and survival under various conditions. For example, we might find that the limits to emigration under certain combinations of environmental conditions.

The first step in developing a model is to outline goals clearly. The goals of our model are discussed briefly above. Following goal identification, the next step is to evaluate previous models to determine what has been accomplished already; someone else may have done the work for you. Previous Atlantic salmon models have been developed with goals different than ours, e.g. to evaluate specifically the impact of precocious maturation on salmon populations, determine the sensitivity of a very simple salmon age-structured model, to determine smolt production, and to evaluate the effects of acid rain on salmon populations. While parts of these models will be useful to incorporate into our model, none of the previous models can completely satisfy our goals.

The next step in model development is identifying data sources. Data for our model will be gleaned from the literature, from reports, from personal communication, from previous models, and from current studies including index sites and research.

After data sources have been identified, we need to select the appropriate level of aggregation for the model. Decisions about levels of aggregation center mainly around how divided spatially and temporally the model will be and whether we model groups of fish or individual fish. For example, questions include what order of stream should we consider, should we use an actual landscape, how do we describe the habitat, do we define the actual location of individual fish within a tributary? Decisions on level of aggregation depend to a large extent on data availability; we cannot create a model that is more complex than the data will allow. We are delaying final decisions on aggregation level until we establish data sources.

Once the previous steps have been completed, it is possible to create a model flow chart that indicates interactions among model components. We included biotic and abiotic factors in preparing a conceptual model. The biotic factors were predators, prey and disease and the abiotic factors included physical habitat, temperature, flow, and dam bypass. Fish were described by age, size, maturity state, wild/hatchery origin, smolt physiology, migration timing and migration behavior.

Of the factors in the model, committee members identified several in which spatial and temporal variability were considered most likely to have a large impact on salmon growth and survival. These include prey in the streams, predators at dams and in the estuary, temperature, maturation, smolt physiology, and dam passage. These are the areas which we suggest *a priori* may be candidates for management actions or research focus. We will use the model to test our intuition of these principal focus areas and will make further recommendations once the model analysis is complete.

3.5.4. Discussion Points

1. Provide additional life stages as inputs to the model, including "egg" and "adult" (characteristics include egg source such as wild or hatchery).

2. For fry, parr, smolt stages; add density to biotic factors, and condition factor to fish characteristics. Fish health and condition factors should be added as modifiers to number stocked.

3. Interjected discussion: Kevin Friedland: "The model should focus on "smoking gun", i.e. smolt survival at time of entry into the marine environment. Steve Gephard: Disagrees ... "our smolt estimates are just that...estimates. We truly don't know how many smolts are being produced. Overwinter fry survival could be a big factor, we don't know!"

4. Interjected discussion: Joe McKeon: "proposed we sample the survivors from stocking 100,000 fry and use them to determine overwinter mortality in one tributary, even if we have to resort to lethal methods. We need to answer the key question of how many smolts are actually being produced."

5. Ben Lechter and John Kocik recognize the enormity of this task (designing the model) and reiterate they will need substantial support from Committee members, for data, and technical support. They will outline process they will follow to develop model, and let Committee members know what dates they will be requesting participation.

6. Larry Stolte reminded Ben that Paul Rago and others had developed the ASAL model in the 1980's, and that this could serve as a useful starting place.

7. Considerable discussion took place on how to address issues such stream characteristics as size (stream order), distance from the sea, etc..

3.6. REPORT OF THE FRESHWATER PRODUCTION (natural reproduction, fry stocking, assessments → smolt production) SUB-COMMITTEE

3.6.1. Sub-committee Members

Sub-committee members included Joe McKeon (chair), USFS, Ed Baum (MASA), Norm Dube (MASA), Randy Spencer (MASA), Jerry Marancik (USFWS), and Larry Stolte (USFWS). Assistance was also provided by Don Pugh (MCFWRU).

3.6.2. Focus

The Freshwater Production Subcommittee addressed both freshwater production and management of adult salmon in freshwater. A total of five papers was presented and discussed. The first two primarily addressed freshwater production, while the latter three addressed the topic "Management Considerations: Opportunities to Enhance In-River Production of Atlantic Salmon Using Virgin Sea-Run Adults, Reconditioned Kelts, and Domestic Broodstock".

3.6.3. Results and Discussion

3.6.3.a. Feasibility of Assessing Overwinter Survival and Atlantic Salmon Smolt Production in the Narraguagus River System.

Outmigration of Atlantic salmon smolts in the Narraguagus River was monitored in spring, 1996, using a rotary-screw fish trap. Trapping was successful despite the high flows experienced this spring. Captured smolts suffered no mortality and no apparent injury. Smolts averaged 176 mm and 46 g. Age two smolts dominated the sample (93%), with the remainder three year olds. The timing of smolt migration was normally distributed with 11 May being the date of 50% outmigration. The total smolt population was estimated to be 2,800 based on mark-recapture but confidence limits were very wide because of low trap efficiency. If the estimate is accurate, overwinter mortality may be as high as 70-80%. Sampling this spring will utilize a total of four traps-two for marking and two for recapture. This should allow more accurate estimation of the outmigrating population and overwinter mortality.

3.6.3.b. Penobscot River: What is the Contribution of Atlantic Salmon Natural Reproduction to Stock Abundance.

Available data from the Penobscot River was analyzed with respect to the contribution of natural reproduction to stock abundance for the cohorts from 1982 to 1991. While the data has many limitations and many assumptions involved, it is apparent that adult escapement above Veazie is not replacing itself under current conditions and is far short of escapement goals. Among the assumptions in the analysis is the need to use fry to adult survival estimates from the Merrimack River to estimate the contribution of fry stocking to "wild" adult returns. This again emphasizes the need for a non-lethal mark to separate adult returns of fry origin from those of natural reproduction. However, even if fry stocking did not contribute to "wild" adult returns, there still would not be adequate numbers of "wild" adults for replacement.

Discussion on this topic indicated a need to estimate stock/recruitment ratios over the entire period from 1969 to the present. Despite the limitations of the data, this would allow estimates of stock/recruitment during periods when marine survival was much higher than experienced in recent years. In addition, it is important to examine the reasons for recruitment falling below replacement levels. If, for example, upstream or downstream fish passage problems are resulting in significant mortalities, it is necessary to address these problems rather than assuming replacement can not be achieved.

3.6.3.c. Movement and Habitat of Sea-Run Atlantic Salmon in the Westfield River.

Sea-run adults originating from fry stocking were monitored by radio telemetry in the Westfield River in 1996. Radio tags were surgically implanted in nine salmon captured at the DSI fishway, then the fish were trucked above Knightville Dam and released.

Salmon were subsequently located on a daily basis until late fall at which point monitoring was reduced to once or twice per week. Three fixed location data-logging receivers were also used to monitor critical locations.

Of the nine tagged fish, five survived until spawning and one died soon after tagging. Of the remaining tags, two were recovered and one disappeared. Based on the five fish that survived until spawning, fish initially moved upriver 6-20 km after leaving the release location. Subsequently, they resided in summer holding areas for 37 to 103 days. Two primary and two secondary pools were utilized. Prior to spawning, salmon again moved upstream, although one fish eventually spawned downstream of its summer holding pool. Spawning occurred from October 9-23 . Four of the five salmon dug redds and eggs were recovered from three of them. Precocious parr were observed spawning with the sea-run females; none of the remaining sea-run fish were males. After spawning, salmon moved downstream 5-45 km. Dams proved to be significant obstacles to downstream migration of the kelts. This study will continue in 1997.

3.6.3.d. Using Captive Broodstock in Maine Rivers.

The success of the captive broodstock program at CBNFH has resulted in the need to remove fish from the hatchery to avoid exceeding the carrying capacity of the hatchery. The oldest fish, initially captured as parr in 1992, have spawned at least once and were available for stocking. The status of wild salmon populations in the affected rivers necessitates that these surplus broodstock be utilized to potentially augment natural reproduction in their rivers of origin. Broodstock were released in the Narraguagus, Machias, and Dennys River in June and October of 1996. All kelts released in June were marked with a fin punch or a Peterson disc tag. Kelts released in October were marked with a color coded streamer tag.

Captive kelts dispersed widely, mostly in a downstream direction, immediately after release. Kelts were reported caught in the sport fishery in limited numbers. Spawning by stocked kelts was observed in the Narraguagus River and spent kelts were captured in the Dennys. Redd counts on all three rivers indicated a surplus of redds relative to known escapement, suggesting that kelts spawned successfully. Qualitative observations suggested that kelts utilized similar spawning locations as wild sea-runs and dug similar sized redds. Spawning by kelts in an isolated river reach with no wild spawners will allow electrofishing evaluation in 1997 of the survival from kelt spawning. Additional captive kelts will be released in 1997. Plans are being developed to implant some of the kelts with ultrasonic tags to allow tracking of their movements in the Narraguagus River with both active and passive telemetry gear.

3.6.3.e. Atlantic Salmon Domestic Broodstock Release- 1996. Pemigewasset River, Hubbard and Stinson Brooks.

Pre-spawned domestic broodstock were released in the upper portions of the Merrimack

River watershed in 1996. Experimental releases in 1994 resulted in the documentation of redd construction but repeated severe flooding in 1995 seemed to displace most of that year's stocking downstream and no spawning was documented. Releases in 1996 were monitored by radio-tagging 23 of the 550 salmon released and by containing salmon near spawning habitat in two small streams by weir construction.

Salmon were released in late October and monitoring continued through January. Fish confined by weirs and those with radio transmitters generally exhibited downstream movement. Similar to 1995, floods hampered surveys to document spawning and locate redds. Redd construction was documented by two pairs in the small streams and occurred prior to the floods. Movement of fish with transmitters suggested that high flows adversely affected behavior and survival. The stocking and monitoring of pre-spawn domestics has resulted in a great deal of public interest, cooperation, and support. Overwinter survival of stocked pre-spawn domestics was demonstrated by their capture in the sport fishery.

Pre-spawn domestic releases will continue in 1997, but methods will be modified based on findings of evaluations of the 1994-1996 releases. Among the modifications to be considered include earlier release dates and alternative release locations to attempt to minimize downstream dispersal; use of surgically implanted transmitters; and release of both domestic and sea-run salmon if sufficient numbers of sea-runs are available.

3.7. REPORT OF THE SUB-COMMITTEE ADDRESSING PLANNING FOR A SAMOSET TYPE MEETING (how, when, structure, etc.)

3.7.1. Sub-committee Members

Members of the sub-committee were Steve Gephard (CTDEP) and Kathryn Staley (USFS) (co-chairs).

3.7.2. Background and Focus

The USFWS sponsored an annual workshop devoted to Atlantic salmon for a number of years. It gradually expanded into an annual meeting of all salmon workers and adopted a relatively formal format that included paper presentations and printing of proceedings similar to many meetings of professional societies. The workshops were discontinued after the 1993 meeting. The U.S. Atlantic Salmon Assessment Committee (USASAC) heard from enough salmon workers who missed the meeting that it charged a sub-committee with exploring the matter. The sub-committee was asked to determine the level of interest and provide recommendations for the future.

The sub-committee designed a questionaire (questionaire and results available from authors) to assess the opinions and desires of salmon workers regarding the workshop. Copies were sent to key personnel within government agencies and selected universities for further distribution.

3.7.3. Results

There were 53 respondees to the questionaire (87% government workers, 11% academics). Of the respondees, 68% had attended previous meetings and 98% said they would be interested in attending future meetings. It was clear that interest in such a meeting is very high.

There appears to be two general interests for the purpose of such a workshop:
1) Communication, technical information, networking. This would present opportunities for many workers to keep abreast of current activities addressing Atlantic salmon.

2) Problem solving. The meeting should either have a theme or focus on one or two of the restoration program's most pressing problems/issues and discuss it and try to leave the meeting with some type of solution or ideas to try.

Recommendations presented to the USASAC for discussion were as follows:

- The USASAC should endorse the resumption of Northeast Atlantic Salmon Workshops, to be held biannually in February or March. The first one should be scheduled for 1998.

- The USASAC should solicit offers of sponsorship from an interested party, such as USFWS, NMFS, a specific lab, or some other government agency. Such sponsorship shall consist of the designation of a staff person(s) to act as a coordinator for location arrangements and cooresponence as well as minor financial support for overhead and costs not covered by charges to attendees. The USASAC felt that the workshop may not be feasible if a financial and administrative sponsor could not be found.

- The USASAC should maintain and expand the current subcommittee for the purposes of serving as an advisory committee to the coordinator on matters of agenda content and format.

- The workshop should be two days/one night long. The first day should consist of presentations by invited speakers, discussing work of interest to the attendees. The advisory committee shall make decisions on who gets invited to speak.
- The second day will include discussion/working sessions to address problems or issues facing the regionwide restoration program. Management recommendations and suggestions for future research might be a product of these exercises. Topics will be announced in advanced so that attendees may compile data to bring, even though they will not be asked to make a presentation.

- Attendance should be by invitation only, at least for the first workshop, to facilitate the second day and to ensure that the mood stays "small" and informal. The USASAC felt strongly that the workshop should be open to everyone.

- In order to lessen the organizational burden, there should be only abbreviated proceedings subsequently printed and distributed.

- Questionaires should be distributed at the end of the workshop to allow evaluation by the attendees.

3.7.4. Discussion

The USASAC felt that the workshop may possibly coincide with the annual meeting of the Assessment Committee but did not want the two meetings to detract from each other.

There was a discussion on format such as only allowing pre-approved general topics; invited speakers regarding a specific topic; "hot issues" and brief program updates. The USASAC felt that important issues should be dealt with and not be put off for several years, that the number of people attending is not as important as the formality of the workshop and the theme, and that it should be open to everyone.

A steering committee was appointed to address the recommendations of the USASAC and address a format for a possible workshop in 1998. The steering committee consists of:

Steve Gephard (Chairperson)
Kathryn Staley (Chairperson)
Kevin Friedland
Ben Letcher
Dennis Erkin
Jay McMenemy
Jerry Marancik
Melissa Evers

4. RESEARCH

4.1. CURRENT RESEARCH ACTIVITIES

The following is a list of Atlantic salmon related research that was conducted during 1996. 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.

FISH PASSAGE

Haro, Alex (C)

EFFECT OF WATER ACCELERATION ON DOWNSTREAM MIGRATORY BEHAVIOR AND PASSAGE OF ATLANTIC SALMON SMOLTS AND JUVENILE AMERICAN SHAD AT SURFACE BYPASSES

Behavior and passage rate of Atlantic salmon smolts (Salmo salar) and juvenile American shad (Alosa sapidissima) were compared between a standard (sharp-crested) and modified surface bypass weir that employs uniform flow acceleration (1 m • sec $^{-1}$ • m $^{-1}$ of linear distance). Significantly more smolts passed the modified weir than the standard weir, but no differences in passage rate between weir types were noted for juvenile American shad. More smolts and juvenile American shad were passed by the modified weir in groups of two or more than were passed by the standard weir. The observed reduction of delay time before passage and maintenance of school integrity may facilitate appropriate timing of emigration and enhance passage survival.

SMOLTIFICATION AND SMOLT ECOLOGY

Carey, Judith B., and Stephen McCormick (C)

ATLANTIC SALMON SMOLTS ARE MORE RESPONSIVE TO HANDLING AND CONFINEMENT STRESS THAN PARR

Atlantic salmon parr and smolts reared under a natural temperature and photoperiod regime were subjected to a handling and confinement stress in early May. Plasma cortisol was measured using a fully validated enzyme immunoassay. Smolts had a mean plasma cortisol concentration of 10 ng/ml prior to stress, 242 ng/ml 3 hours (h) after initiation of stress, and returned to pre-stress levels within 8 h. Parr had a plasma cortisol concentration of 4 ng/ml prior to stress, only 11 ng/ml 3 h after initiation of stress, and returned to pre-stress levels with 8 h. Plasma glucose was significantly higher in parr and smolt 3 h after initiation of stress; in parr plasma glucose returned to pre-stress levels with 8 h, but not until 48 h in smolts. Plasma chloride concentration in smolts decreased from 139 mM to 124 mM 3 h after stress and returned to pre-stress levels within 24 h; plasma chloride in parr was not altered by stress. Plasma thyroxine of parr and smolt peaked at 3 h after initiation of stress and returned to pre-stress levels within 8 h, but smolts had 72% higher levels at 3 h. Plasma triiodothyronine of parr and smolt were unaffected by stress. Pre-smolts (February) and smolts (May) reared under constant temperature (8-10 °C) were also subjected to a handling and confinement stress. Although peak levels of plasma cortisol 3 h after initiation of stress were twice as high as smolts, other physiological and endocrine responses were not substantially different between pre-smolts and smolts. The results demonstrate that smolts are more responsive to stress than parr and that developmental differences are more important that seasonal changes. Rearing and transport conditions should account for the heightened stress response of Atlantic salmon smolts to minimize these effects.

Friedland, Kevin D. (H)
MARINE TEMPERATURES EXPERIENCED BY POST-SMOLTS AND THE SURVIVAL OF ATLANTIC SALMON (*SALMO SALAR* L.) FROM NORWAY TO SCOTLAND

The survival of two Atlantic salmon stocks that inhabit rivers confluent with the North Sea was examined in respect to historical distributions of sea surface temperatures. The rivers Figgjo and North Esk are relatively small salmon rivers in southern Norway and eastern Scotland, respectively. Wild salmon smolts have been tagged in these rivers since 1965. The return of tags for one and two seawinter salmon were used to evaluate survival conditions for salmon in this region. Survival rates were compared to the areal extent of thermal habitat in the Northeast Atlantic Ocean. A positive correlation was found between the area of 8-10 °C water in May and the survival of salmon. A reciprocal negative correlation was also found between survival and 5-7 °C water in the same month. An analysis of sea surface temperature distributions for periods of good versus poor salmon survival showed that when cool surface water dominate the Norwegian coast and North Sea during May, salmon survival has been poor. Conversely, when the 8°C isotherm extended northward along the Norwegian coast during May, survival was good. The effect of water temperature distributions on the growth of post-smolts and other survival factors are discussed.

Kocik, John F. (H)
ATLANTIC SALMON OVERWINTER SURVIVAL AND SMOLT PRODUCTION IN THE NARRAGUAGUS RIVER

Outmigration of Atlantic salmon smolts in the Narraguagus River was monitored from 24 April to 4 June 1996 using a rotary screw fish trap. Trapping was conducted successfully despite high water throughout sampling, including a 50-year flood event. All fish captured were in excellent condition upon removal from the trap. No injuries or mortalities were observed. Smolts averaged 176 ± 3 mm total length and 46 ± 2 g wet weight (n=97) and were age 2. The timing of outmigration was normally distributed with 11 May being the date of 50% outmigration. The total emigrant smolt population was estimated to be 2,800 utilizing mark-recapture data. This estimate suggests that overwinter mortality of Atlantic salmon pre-smolts exceeded 75%. All primary objectives of year-1 were met: the rotary screw trap was effective in East Coast streams and Atlantic salmon smolts were not harmed by sampling. Preliminary sampling showed that, with increased sampling effort, more accurate population estimates of outmigrating Atlantic salmon smolts can be conducted without adversely affecting this threatened population. The study also suggests that overwinter mortality of pre-smolts in this river is higher than observed in other studies and may be negatively affecting this population.

McCormick, Stephen D., Judith B. Carey and Michael O'Dea (C)
TEMPERATURE-RELATED 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 migrations. 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. There is a strong and direct relationship between degree days and loss of smolt characteristics. 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 but both significantly decreased at the end of migration. Loss of smolt characteristics was earlier and more sever when temperatures were high during the migratory period. Migrating smolts were also compared in several rivers along the east coast of North America. Reduced gill Na^+, K^+-ATPase activity was found at the end of migration in warmer, southern rivers (Connecticut River and Penobscot River, Maine), but not in northern rivers (Catamaran Brook, New Brunswick and Conne River, Newfoundland). The results indicate that there is a temperature-related loss of smolt characteristics that may affect smolt migration and survival in warm, southern rivers. Delays in migration in southern rivers will decrease smolt survival.

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

SEASONAL DIFFERENCES IN PLASMA CORTISOL AND GILL CORTICOSTEROID RECEPTORS IN UPPER AND LOWER MODE JUVENILE ATLANTIC SALMON

Circulating plasma cortisol and gill corticosteroid receptors (CR) have been observed to change seasonally in conjunction with smolting in Atlantic salmon. To differentiate whether these changers are seasonal or ontogenic, juvenile Atlantic salmon parr were separated by size into upper (UM) and lower mode (LM) in September. At monthly intervals, the fish were sampled for plasma cortisol, gill Na^+K^+-ATPase activity and CR abundance (B_{max}) and dissociation constant (k_D). UM were significantly larger than LM, and showed the silver appearance characteristics of smolts in April and May. Gill Na^+K^+-ATPase activity of UM fish increased 6-fold during spring; LM fish increased 1.5-fold. Plasma cortisol levels increased significantly (10-fold) in UM fish in May, but not in LM fish. Gill CR B_{max} increased 5-fold over the duration of the study in both groups. CR k_D was lowest in October and highest in May; a 1.8- and 2-fold increase in LM and UM, respectively. There were no significant differences in gill CR B_{max} and k_D between the two groups during the study, except in May, when k_D was significantly greater and B_{max} lower in UM than LM. Peak levels of gill Na^+K^+-ATPase activity occur coincident with an increase in plasma cortisol concentration. Seasonal increases in

CR B_{max} and k_D are similar in UM and LM fish and occur independent of smolting in juvenile Atlantic salmon. In UM fish, plasma cortisol increases in spring are concurrent with increased smolt characteristics.

Whalen, Kevin and Donna Parrish (D)

FACTORS INFLUENCING SMOLT PRODUCTIONS, OVERWINTER MORTALITY, AND DOWNSTREAM MIGRATION OF ATLANTIC SALMON IN THE CONNECTICUT RIVER.

An important aspect of the restoration of Atlantic salmon (*Salmo salar*) to the Connecticut River involves the production of smolts through fry stocking in Vermont tributaries. Due to the limited knowledge of smolt production from fry stocking, a three-year study of fry stocked smolt production in Vermont tributaries was initiated. Smolt trapping was completed in April and May 1994 and 1995 on the Rock River, Wardsboro Branch and Utley Brook, three large tributaries of the West River. Peak smolt catches in the three tributaries occurred in May of each year and the date of 50% catch ranged between 5 and 16 May. Between 70 and 95% of the smolts spent two winters instream before migrating. Percents age 1+ parr smolting and out-migrating as age 2+ smolts ranged from 10 to 31% and overwinter mortality ranged from 40 to 75%. Results from fall marking and spring recapture studies suggests that mature parr are recruited to smolt at a lower frequency than immature parr.

Orciari, Robert D., and Gerald H. Leonard

LENGTH CHARACTERISTICS OF SMOLTS AND TIMING OF DOWNSTREAM MIGRATION AMONG THREE STRAINS OF ATLANTIC SALMON IN A SOUTHERN NEW ENGLAND STREAM

North Am. J. Fish. Mgmt. 1996. pp. 851-860. Vol. 16.

HABITAT

Gries, Gabe and Dr. Francis Juanes (F)

MICROHABITAT USE BY DAYTIME SHELTERING JUVENILE ATLANTIC SALMON DURING SUMMER

Daytime snorkeling surveys were completed on the Wardsboro Branch, a tributary of the West River, Vermont, in July and August 1996. Microhabitat use was documented of 245 sheltering salmon (i.e. salmon which were concealed beneath the stream substrate) at water temperatures ranging from 17 to 23 °C; well above the maximum temperature at which these fish are thought to shelter. The majority (92%) of sheltering salmon were YOY (young-of-the-year). Of the YOY salmon seen during the surveys, 45% were sheltering while 55% were observed in the water column. In comparison, only 10% of PYOY (post-young-of-the-year; age one or older) salmon were sheltering while 90% were observed in the water column. Sheltering salmon (YOY and PYOY) were found in pools 43% of the time. Sheltering PYOY occupied greater water depths and were found under larger substrate than were YOY. Sheltering salmon were not distributed in proportion to the microhabitat available to them. Salmon only sheltered beneath unembedded cobble or boulder substrate. The availability of suitable sheltering habitats may be a factor affecting juvenile salmon growth and survival during the growing season with streams containing smaller substrate likely being more limiting for PYOY.

McKeon, Joe (I)

MERRIMACK RIVER DOMESTIC SALMON: PRE-SPAWN RELEASES AND POST-SPAWN RELEASE RESULTS

Domestic Atlantic salmon broodstock were released on the spawning grounds in the Merrimack River watershed in years 1994-1996 as part of a strategy to enhance the production of salmon and aid in the restoration of the species. These releases placed sexually mature salmon on the spawning grounds in river reaches where adult salmon have been absent for over 150 years. Although spawning habitat throughout the watershed has been qualified, the absence of fish on the spawning grounds has resulted in a lack of understanding about its quality and production potential. Also, the behavior of broodstock salmon and their potential to enhance production in the wild has not been well documented. A radio telemetry system was used to evaluate the movement and behavior of salmon and public support was enlisted through posters explaining the study. During the 3 years of evaluation, a total 868 salmon was released with radio transmitters affixed to 52 fish. Passive and active downstream movement was observed for most salmon in all years, and redd construction was documented in years 1994 and 1996. Future studies will focus on earlier release dates and alternative release sites, the use of intraperitoneal radio transmitters, and the release of both domestic broodstock and sea-run salmon.

Nislow, Keith H. and Carol Folt (E)

BIOENERGETICS AND SPECIES RESTORATION: IDENTIFYING CRITICAL HABITAT FOR JUVENILE ATLANTIC SALMON RESTORED TO NEW ENGLAND STREAM

A spatially-explicit bioenergetic model was constructed to predict growth rate potential for age-0 Atlantic salmon (*Salmo salar*) re-introduced to New England streams, and tested some of the predictions against growth and survival observed in 10 rearing streams. Growth rate potential was predicted to be lowest during the first month after stocking (May-June), as <15% of the available habitat was predicted to support positive growth. Growth rate potential was predicted to be highest from mid-June - August, as >60% of available habitat area was predicted to yield positive growth rates at that time. It was found that streams with a higher predicted growth rate potential during the early season also had higher total spring-summer survival, while predicted growth rate potential in the later season was uncorrelated with total spring-summer survival. Identification of stream reaches with a higher proportion of energetically-profitable early-season habitat, and creation of such habitat in poorer reaches, should facilitate the restoration of Atlantic salmon to the New England region.

Raffenburg, Matthew and Donna Parrish (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

During the past few years, as a part of the Atlantic salmon restoration program, juvenile Atlantic salmon have been reintroduced into the West and White rivers, Vermont, where populations of brook trout (*Salvelinus fontinalis*) and rainbow trout (*Oncorhynchus mykiss*) reside. Competition for space among salmonids has been studied extensively, however, partitioning of good in relation to occupied microhabitats has not. During Summer 1995, stomach contents and other relevant data were obtained from a total of 976 Atlantic salmon, brook trout and rainbow trout collected by electrofishing at 17 sites in tributaries of the West and White rivers. In summer 1996, 1182 salmonid stomachs were collected at 25 sites. In addition to drift, surber samples were taken to target the benthic macroinvertebrates in 1996. Preliminary results from 1995 data indicate the following: 1) age 1 and older salmonids are not as dependent on drifting macroinvertebrates as age 0 fish, 2) benthic macroinvertebrates (Trichoptera sp.) appear to be a large component of Atlantic salmon diets, and 3) the presence of terrestrial insects in salmonid diets is related to the amount of stream canopy.

Campbell, Cara, and Martha Mather (F)

ASSESSING LARGE SCALE PATTERNS IN THE DISTRIBUTION AND ABUNDANCE OF JUVENILE ATLANTIC SALMON IN THE CONNECTICUT RIVER WATERSHED

Research incorporating larger spatial and temporal scales is necessary for a comprehensive understanding of species-habitat relationships. Density, survival, size, and growth data for 0, 0+, 1+, and 2+ Atlantic salmon, Salmo salar, from the Connecticut River watershed were incorporated into a geographic information system (GIS). Data was obtained from four state agencies, and the U.S. Forest Service, and encompasses over 200 index sites, 125 tributaries, and 23 basins, for over seven years. Index sites were isolated in ArcInfo, linked to the juvenile data in ArcView, and displayed. Temperature loggers were placed at a total of 51 index sites in the West, Westfield, and Farmington River basins and the collection of physical data (gradient, land use, stream order, stream length, stream width, and basin area) commenced. In 1997, pattern identification in salmon abundance and size will continue to be examined for variation; (1) within basins, (2) across basins, and (3) across years. Differences in salmon size and abundance have already been found both within and across basins. Temperature data will be examined in relation to the juvenile population data from 1996. Physical data collection will be completed, incorporated into the GIS, and examined for possible relationships to the juvenile salmon patterns.

STOCK IDENTIFICATION

Kennedy, Brian, Carol Folt, Joel Blum and Page Chamberlain (E)
DETERMINING NATAL TRIBUTARY ORIGINS OF ATLANTIC SALMON USING STABLE ISOTOPES

Stable isotopes including strontium and nitrogen, derived from geological structures under rivers and tributaries, can be isolated from age 0-Atlantic salmon backbone, otolith and muscle tissue and used to distinguish natal tributaries of these migrating fish. Preliminary results showed that salmon picked up the tributary signal within the first three months after stocking, and stable isotopes of strontium alone successfully distinguished salmon from 10 of 12 sites. Non-lethal sampling methods, isotopic mapping of salmon streams, minimum residence time for mark-uptake and identification of additional isotopes are needed. These marks can then be used to monitor habitat quality, measure tributary-specific productivity, and determine causes for behavior and mortality. Isotope ratios in approximately 10% of the fish indicated that they had moved from the reach where they were stocked.

Krise, Bill (A)
DEVELOPMENT OF AN IMMUNOLOGICAL MARKER METHOD TO TAG ATLANTIC SALMON FRY; SHORT-TERM SPERM STORAGE METHODS TO IMPROVE ATLANTIC SALMON EGG FERTILIZATION; & MECHANICAL SHOCK SENSITIVITY OF ATLANTIC SALMON EGGS

Atlantic salmon eggs poured from a height of 10" suffer losses of about 10%, which should be considered in designed egg handling protocols.

Bath immersion of Atlantic salmon fry (before swim-up) and immersion of parr in bovine serum albumin is effective in marking the B-lymphocytes. Marks can be used to determine differences between naturally-produced, or stocked fry, and stream of origin. Longevity of mark retention, antigen dose response, monoclonal antibodies and other methods of field assay kits are being developed.

Fertilization of Atlantic salmon eggs using cold-stored sperm works best using diluted deactivated sperm. Sperm is diluted at least 1:100 in potassium and Tris buffer solution to immobilize it, then stored. The sperm can be re-activated with ovarian fluid or a buffer salt solution. Oxygenated sperm is nearly as effective and both techniques result in higher fertilization rates than plain cold storage. However, results using any technique are clearly dependent on the initial quality of the sperm.

Letcher, Ben and Tim King (C, J)
GENETIC VARIABILITY OF CONNECTICUT RIVER ATLANTIC SALMON

BROODSTOCK

Genetic variability of Connecticut River sea-run and domestic Atlantic salmon broodstock was evaluated against variability observed in Penobscot and Narraguagus river stocks. Mitochondrial DNA tests demonstrate a dramatic reduction in the number of individuals exhibiting the second haplotype in the Connecticut stocks when compared to Maine stocks which exhibit higher percentages of two and even three haplotypes. DNA microsatellites indicate that Connecticut stocks also exhibit a qualitative reduction in the number of alleles yet sufficient variation exists to identify individuals. Some of the observed reduction may be due to natural selection but it may also reflect a genetic bottleneck (e.g. genetic drift). While the results do not indicate that the population is unhealthy, it could be healthier because lack of variation limits adaptability.

Mohler, Jerry (G)

IMMERSION OF LARVAL ATLANTIC SALMON IN CALCEIN SOLUTION TO INDUCE A NON-LETHALLY DETECTABLE MARK

Chemical immersion of Atlantic salmon sac-fry in calcein (flourexon) for 48 hours results in uptake of calcein by skeletal structure. Calcein fluoresces green under light wavelengths of 490 nm. Samples of caudal fin rays can be taken non-lethally with good results up to 22 months post-treatment. Calcein has not been approved for use by FDA and detection sampling through adult life stages must be completed.

POPULATION ESTIMATES/TRACKING

Kocik, John F. (H)

TRACKING OF ATLANTIC SALMON SMOLTS TO DETERMINE EARLY MARINE MOVEMENTS AND SURVIVAL IN NARRAGUAGUS BAY

Outmigrating Atlantic salmon smolts from the Narraguagus River were tracked by boat from 13 -24 May 1996 using ultrasonic pingers. Actively migrating smolts were captured in a rotary screw fish trap and nine Atlantic salmon smolts were tagged with an external ultrasonic tag. Only five smolts could be tracked due to defective ultrasonic pingers on four fish. No mortalities of tagged fish were observed after a 24-hour recovery period. Smolts moved to deep pools upon release and began migrating approximately 1/2 hour before dark. They exited the Narraguagus River and Estuary system within one evening. One smolt was eaten by a striped bass that was caught by an angler while it was being tracked, documenting predation by striped bass in northern rivers. Compared with hatchery smolts, these wild fish exhibited lower tagging mortality (0%) and moved less during daylight hours. All primary objectives of year-1 were met: pingers were suitable for wild Atlantic salmon smolts and tracking was accomplished in fresh and salt water. Because smolts migrated through waters that are unnavigable at night, an automated pinger detection system would improve night-sampling efficiency and improved monitoring capabilities. Sampling showed that with modifications to the preliminary sampling design, accurate assessments of outmigration mortality and movements could be made using automated equipment and less vessel time.

Pugh, Don (F)

WESTFIELD RIVER SEA-RUN SALMON ADULT RADIO-TAG STUDY RESULTS

Movement and habitat use of sea-run Atlantic salmon in the Westfield River was documented. Nine salmon were trapped at the DSI dam, PIT tagged, and released above the Knightville dam on the East Branch. Their behavior, residence time and movement was tracked from early summer until late fall. The fish held where release for a short time, moved upstream, held in pools for the summer, dug redds and spawned in October, moved downstream post-spawning, and are still under observation at various points in the basin.. Outmigration will be monitored, spawning success will be evaluated and additional studies will be initiated with new sea runs in the spring.

CULTURE/LIFE HISTORY

Friedland, Kevin D. (H)

A MECHANISM TO EXPLAIN THE VARIATION IN SEXUAL MATURATION IN ATLANTIC SALMON SUGGESTED BY STRONTIUM:CALCIUM RATIOS OF OTOLITHS AND GONADOSOMATIC INDICES

The maturity of salmon caught in Newfoundland-Labrador fisheries during the period 1985-1988 was examined and it was found that many fish believed to be on feeding migrations were in an advanced state of sexual development. To attempt to clarify the meaning of these data, chronological transects of strontium:calcium ratios from the otoliths of maturing and immature one seawinter fish were examined. Patterns of Sr:Ca ratio were not correlated with thermal or somatic growth histories of sampled fish. Sr:Ca ratio in the freshwater portion of the otolith varied by stock as influenced by the environmental availability of strontium. Ratios in the marine region of the otolith reflected sexual development. The ratios for immature fish suggested that an advanced state of sexual development was achieved during feeding migrations and that maturation regression occurred by late summer. Maturing fish were found to have Sr:Ca ratios similar to the immature fish of the same stock. The relative abundance of North American salmon that mature after two seawinters is correlated to the areal extent of over-wintering habitat in the Northwest Atlantic. A hypotheses is developed that relates this over-wintering area and the migration of post-smolts to sexual development of salmon in the Northwest Atlantic area.

Letcher, Ben, and Tim Terrick (C)

EFFECTS OF FRY DEVELOPMENT STAGE ON STOCKING SUCCESS

Developmental stage and stocking time are not critical to survival (unless fish are accelerated without feed). There was no difference in survival between fed and unfed fry. The conditions in the river are of far more importance to survival than developmental stage. 82.9% of the fish stayed where they were stocked, at least through the fall sampling.

McCormick, S.D., J.M. Shrimpton, J.B. Crew, M.F. O'Dea, K.E. Sloan, S. Moriyama and B.Th. Björnsson (C)

REPEATED ACUTE STRESS REDUCED GROWTH RATE OF ATLANTIC SALMON PARR AND ALTERS PLASMA LEVELS OF GROWTH HORMONE, INSULIN-LIKE GROWTH FACTOR I AND CORTISOL.

Atlantic salmon parr were subjected to acute handling stresses and growth was monitored for at least 30 days. In fish stressed twice daily, growth rate in weight was 61% lower than controls after 11 days (1.00 vs 2.57% · day $^{-1}$) and over a 30 day period it was 50% lower than controls (1.53 vs 3.07% · day $^{-1}$). In fish stressed once daily, weight growth rate was 18% lower than controls after 10 days (2.17 vs 2.63% · day $^{-1}$) and over a 30 day period is was 34 % lower than controls (1.71 vs 2.59% · day $^{-1}$). In fish stressed once daily, food consumption was reduced by 62% and 37% after 17 and 37 days, respectively. At the end of 40 days of once daily acute stress, controlled and stressed fish were sampled 1 hour (h) prior to, 3 and 7 h after a stress event. Plasma growth hormone levels were significantly higher in the stressed group prior to and 7 h after stress. Plasma insulin-like growth factor I levels were lower in the stressed group prior to and 3 h after stress. Plasma cortisol levels were lower in the stressed group prior to and 3 h after stress. The results indicate that acute stressors decrease growth of Atlantic salmon parr, with increasing frequency of stress having a more rapid and larger effect. The observed endocrine responses to repeated acute stress may be part of a compensatory response to stress.

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

ENERGETICS OF OVER-WINTERING IN MATURE AND IMMATURE 1+ ATLANTIC SALMON IN THE CONNECTICUT RIVER

The change in management strategy for Atlantic salmon in the Connecticut River from smolt production to fry stocking has placed greater importance on understanding growth and development of salmon reared naturally in rivers. We have been examining growth and energetics of Atlantic salmon in tributaries of the Connecticut River and comparing fish that mature as parr to immature fish. In the fall, immature and mature parr did not differ significantly in size, although mature fish had significantly greater condition factor. Testes of mature males comprised up 10% of body weight in October. Testes reabsorption over the winter was gradual, and was still approximately 2% by the end of March. Plasma androgens were significantly greater in mature male parr than their immature cohorts in October, but had declined by January and did not differ from immature fish for the duration of the study. In October all mature males were "running" (milt easily expressed) and some males were still running in January and February. Gonadal regression of mature fish was linear with time, whereas condition factor declined significantly in early winter. In contrast, immature fish showed a small and insignificant reduction in condition factor over the winter. Utilization of both proteins and lipids in the winter was higher in mature parr than in immature parr. Immature fish in March were significantly larger than mature fish, suggesting better growth in immature fish or emigration of the larger mature males. Immature fish also had significantly greater gill Na+K+ATPase activity than their previously mature parr. Our findings suggest that the energetic cost of maturation reduced the available energy reserved for precociously mature parr over the winter. The reduced lipid and protein content may lead to greater overwinter mortality and result in a lower number of males smolting the next spring.

Whalen Kevin, and Donna Parrish (D)
OVER-WINTER SURVIVAL OF ATLANTIC SALMON

Ice formation and overwinter parr movements and changes in spatial distribution were evaluated in a 200-m reach of the Rock River, Vermont. Ice formation resulted in significant changes in the abundance and distribution of habitats that were commonly used by salmon parr. With ice formation, the proportion of habitats used by the majority of parr decreased, while the proportion of habitats used by few parr increased. Habitats used by the majority of parr represented <15% of the total available habitat measured on all survey dates. Salmon parr moved up to 150 m upstream and downstream, while others were observed during and after winter in the 22 to 30 m stream reach where they were marked in November. The spatial distribution of parr changed overwinter and they were unequally distributed throughout the study reach. Movements and redistributions of parr may reflect the dynamic nature of winter carrying capacity. Because ice is a significant factor affecting the amount and distribution of suitable habitats, movements may be important for overwinter survival of presmolt Atlantic salmon in ice affected streams.

FISH HEALTH/NUTRITION

Cipriano, Rocco (J)
FISH DISEASE PARAMETERS ASSOCIATED WITH ECOLOGICAL SURVIVAL OF ATLANTIC SALMON (*SALMO SALAR*) AND THEIR SUBSEQUENT RESTORATION IN THE CONNECTICUT RIVER

Detection of the *Aeromonas salmonicida* bacterium in fish mucus and water effluent samples is non-lethal, more reliable than single point/lethal inspections, and provides and opportunity for alleviating effects of the disease before it results in loss of fish. Sample site reliability and correlation between systemic infections and mucus colonizations must be completed. Used in inspection procedures as part of a non-lethal stress induced furunculosis challenge, it can reduce labor cost, result in reduced sampling loss, and work with wild fish samples.

An improved *Aeromonas salmonicida* vaccine has shown a dose dependent response in Atlantic salmon with 9% loss of vaccinated fish versus 91% loss of control fish. This may improve the efficacy of treatment protocols in the future given that the existing antibiotic/vaccine protocol was ineffective in 1996.

Vertical transmission of *Aeromonas salmonicida* and cold-water disease and bacterial pathogen resistance in domestic and sea-run Atlantic salmon to bacterial pathogens including *Aeromonas salmonicida, Renibacterium salmoninarum, Yersinia ruckeri,* and *Vibrio sp.* is under investigation to see if there is any fish health basis for selective breeding.

Immunological surveillance of sea-run Atlantic salmon is under investigation to determine what pathogens the fish are exposed to in the marine environment and to determine if sea lice are important disease vectors.

Cipriano, R.C., L.A. Ford, and J.D. Teska
ASSOCIATION OF CYTOPHAGA PSYCHROPHILA WITH MORTALITY AMONG EYED EGGS OF ATLANTIC SALMON (SALMO SALAR)

J. of Wildl. Diseases. 1995. pp. 166-171. Vol. 31, No. 2.

Buckler, D.R., L. Cleveland, E.E. Little, and W.G. Brumbaugh
SURVIVAL, SUBLETHAL RESPONSES, AND TISSUE RESIDUES OF ATLANTIC SALMON EXPOSED TO ACIDIC PH AND ALUMINUM

Aquatic Toxicol. 1995. pp. 203-216. Vol. 31.

MISCELLANEOUS

Teisl, Mario F., Kevin J. Boyle, and Brian Roe
CONJOINT ANALYSIS OF ANGLER EVALUATIONS OF ATLANTIC SALMON RESTORATION ON THE PENOBSCOT RIVER, MAINE

North Am. J. Fish. Mgmt. 1996. pp. 861-871. Vol. 16.

Orciari, R.D., and G.H. Leonard
INLAND FISHERIES RESEARCH AND MANAGEMENT. COLDWATER FISHERY RESEARCH AND MANAGEMENT; EVALUATION OF ALTERNATE-YEAR ATLANTIC SALMON FRY STOCKING IN SANDY BROOK, COLEBROOK, CONNECTICUT

CT DEP. Final Rpt. 1995. 42 pp.

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4.2. RESEARCH NEEDS AND DATA DEFICIENCIES

The reader is referred to the Terms of Reference (Section 3).

5. HISTORICAL DATA (1970 - 1996)

5.1. STOCKING

The historical stocking information is presented in Table 3.2.a. in Appendix 10.1. Over 104 million juvenile salmon have been released into the rivers of New England during the period, 1970 - 1996. Nearly 68% of the total have been fry. The majority of the juvenile releases have occurred in the Connecticut River (over 44 million), the Penobscot River (over 21 million), and the Merrimack River (over 20 million).

5.2. ADULT RETURNS

The historical return information is presented in Table 3.2.b. in Appendix 10.1. Total returns to New England rivers from 1970 through 1996 now equals 68,754. The majority of the returns have occurred in Maine rivers (91%) followed by the returns to the Connecticut River (6%), and the Merrimack River (3%). The Penobscot River alone accounts for 72% of the total.

6. TERMS OF REFERENCE FOR 1998 MEETING

The U.S. Atlantic Salmon Assessment Committee agreed to address the following standard Terms of Reference for the 1998 meeting (additional terms of reference will be developed later):

1. Program summaries for current year (1997) to include:
   a. current year's stocking program with breakdowns by time, location, marks and lifestage.
   b. current year's returns by sea age, marked vs. unmarked, and wild vs. hatchery.
   c. general summary of program activities including regulation changes, angling catch, and program direction.

2. Update historical databases.

7. U.S. ATLANTIC SALMON ASSESSMENT COMMITTEE MEMBERS

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8. PAPERS SUBMITTED

The papers submitted have been identified in Section 3.

9. LITERATURE CITED

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

10. APPENDICES

10.1. TABLES AND FIGURES SUPPORTING THE DOCUMENT

TABLE 2.2.1. ATLANTIC SALMON STOCKING SUMMARY FOR NEW ENGLAND IN 1996 BY RIVER SYSTEM AND BY PROGRAM. 1)

RIVER SYSTEM	NUMBER OF FISH 2)						TOTAL
	FRY	0+PARR	1PARR	1+PARR	1SMOLT	2SMOLT	
UNITED STATES							
Aroostook	28,000	0	0	0	0	0	28,000
St. Croix	3,000	0	0	0	0	0	3,000
Dennys	142,000	0	0	0	0	900	142,900
Pleasant	0	0	0	0	0	0	0
East Machias	115,000	0	0	0	0	0	115,000
Machias	233,000	0	0	0	0	1,900	234,900
Narraguagus	196,000	0	0	0	0	0	196,000
Union	0	53,500	0	0	0	0	53,500
Penobscot	1,242,000	226,000	17,500	0	552,200	0	2,037,700
Ducktrap	0	0	0	0	0	0	0
Sheepscot	102,000	0	0	0	0	0	102,000
Saco	0	45,000	0	0	20,000	0	65,000
Cocheco	126,000	0	0	0	0	0	126,000
Lamprey	115,000	37,000	8,400	1,000	0	0	161,400
Merrimack	1,795,000	0	0	4,900	50,000	0	1,849,900
Pawcatuck	289,000	136,100	0	0	5,000	0	430,100
Connecticut	6,675,000	12,400	0	3,600	11,500	0	6,702,500
TOTAL	**11,061,000**	**510,000**	**25,900**	**9,500**	**638,700**	**2,800**	**12,247,900**
CANADA							
Aroostook	0	0	0	0	0	0	0
St. Croix	0	52,100	0	0	15,600	0	67,700
TOTAL	**0**	**52,100**	**0**	**0**	**15,600**	**0**	**67,700**
PROGRAM							
Maine							
United States	2,061,000	324,500	17,500	0	572,200	2,800	2,978,000
Canada	0	52,100	0	0	15,600	0	67,700
Cocheco	126,000	0	0	0	0	0	126,000
Lamprey	115,000	37,000	8,400	1,000	0	0	161,400
Merrimack River	1,795,000	0	0	4,900	50,000	0	1,849,900
Pawcatuck River	289,000	136,100	0	0	5,000	0	430,100
Connecticut River	6,675,000	12,400	0	3,600	11,500	0	6,702,500
TOTAL	**11,061,000**	**562,100**	**25,900**	**9,500**	**654,300**	**2,800**	**12,315,600**

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 1996.

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	48,400	0	20,000	0	0
Merrimack River	0	0	0	0	4,900	0	0	0
Connecticut River	0	0	0	0	0	0	141	270
TOTAL	**0**	**0**	**0**	**48,400**	**4,900**	**20,000**	**141**	**270**

TABLE 2.2.2.b. ATLANTIC SALMON MARKING DATABASE FOR NEW ENGLAND - 1996.

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 *	2,3	parr	W	Connecticut	PIT	220			6/96	Connecticut R.	Pink latex anal fin
MACFWRU	1,2	parr	W	Connecticut	PIT	76			10-11/9	Connecticut R.	Blue latex anal fin
MACFWRU	1,2	parr	W	Connecticut	PIT	182			10-11/9	Connecticut R.	Yellow latex anal fin
MACFWRU	4	adult	W	Connecticut	PIT	1			5/96	Connecticut R.	Radio freq. 30.24
MACFWRU	4	adult	W	Connecticut	PIT	1			6/96	Connecticut R.	Radio freq. 30.25
TOTAL PIT, CONNECTICUT RIVER						480					
MACFWRU	2,3	smolt	W	Connecticut	VI	270	SF0-SL9 PA0-PL9 DM0-DZ9 S00-S99		4-5/96	Connecticut R.	Green
MACFWRU	1,2	parr	W	Connecticut	VI	73	BN0-BT9		10-11/9	Connecticut R.	Blue latex anal fin
MACFWRU	1,2	parr	W	Connecticut	VI	68	SU0-SZ9		10-11/9	Connecticut R.	Yellow latex anal fin
MACFWRU	4	adult	W	Connecticut	VI	1	RE2		6/96	Connecticut R.	Radio freq. 30.39
MACFWRU	4	adult	W	Connecticut	VI	1	RE1		6/96	Connecticut R.	Radio freq. 30.25
MACFWRU	4	adult	W	Connecticut	VI	1	RE0		6/96	Connecticut R.	Radio freq. 30.20
MACFWRU	4	adult	W	Connecticut	VI	1	RD8		6/96	Connecticut R.	Radio freq. 30.19
MACFWRU	4	adult	W	Connecticut	VI	1	RD6		6/96	Connecticut R.	Radio freq. 30.07
MACFWRU	4	adult	W	Connecticut	VI	1	RD4		6/96	Connecticut R.	Radio freq. 30.04
MACFWRU	4	adult	W	Connecticut	VI	1	RE3		6/96	Connecticut R.	Radio freq. 30.07
TOTAL VI, CONNECTICUT RIVER						418					
USFWS		adult	H/W	Merrimack	FLOY	73			12/96	Merrimack R.	Searun Kelts (various ages)
NHFG	3+	adult	H	Merrimack	FLOY	89			12/96	Merrimack R.	Domestic Kelts
NHFG	3+	adult	H	Merrimack	FLOY	124			12/96	Merrimack R.	Domestic Barren Adults
TOTAL FLOY, MERRIMACK RIVER						286					
NHFG	3+	adult	H	Merrimack	Disc	357	F/5-2		1/96	Merrimack R.	Dark Blue
NHFG	3+	adult	H	Merrimack	Disc	177	S/5-2		1/96	Merrimack R.	Dark Blue
NHFG	4+	adult	H	Merrimack	Disc	215	F/6-1		4/96	Merrimack R.	Dark Blue
NHFG	4+	adult	H	Merrimack	Disc	94	B/6-1		4/96	Merrimack R.	Dark Blue
NHFG	4+	adult	H	Merrimack	Disc	110	S/6-1		4/96	Merrimack R.	Dark Blue
NHFG	3+	adult	H	Merrimack	Disc	233	F/6-1		5/96	Merrimack R.	Dark Blue
NHFG	3+	adult	H	Merrimack	Disc	200	B/6-1		5/96	Merrimack R.	Dark Blue
NHFG	3+	adult	H	Merrimack	Disc	205	S/6-1		5/96	Merrimack R.	Dark Blue
NHFG	3+	adult	H	Merrimack	Disc	175	G/6-1		5/96	Merrimack R.	Dark Blue
NHFG	3+	adult	H	Merrimack	Disc	176	H/6-1		5/96	Merrimack R.	Dark Blue
NHFG	3+	adult	H	Merrimack	Disc	169	M/6-1		5/96	Merrimack R.	Dark Blue
NHFG	3+	adult	H	Merrimack	Disc	100	A/6-1		5/96	Pemigewasset R.	Clear
NHFG	3+	adult	H	Merrimack	Disc	100	B/6-1		5/96	Pemigewasset R.	Clear
NHFG	3+	adult	H	Merrimack	Disc	100	G/6-1		5/96	Pemigewasset R.	Clear
NHFG	3+	adult	H	Merrimack	Disc	128	F/6-2		10/96	Merrimack R.	Dark Blue
NHFG	3+	adult	H	Merrimack	Disc	117	B/6-2		10/96	Merrimack R.	Dark Blue
NHFG	3+	adult	H	Merrimack	Disc	126	S/6-2		10/96	Merrimack R.	Dark Blue
NHFG	3+	adult	H	Merrimack	Disc	49	A/6-2		10/96	Pemigewasset R.	Clear
NHFG	3+	adult	H	Merrimack	Disc	50	B/6-2		10/96	Pemigewasset R.	Clear
NHFG	3+	adult	H	Merrimack	Disc	183	F/6-2		11/96	Merrimack R.	Dark Blue
NHFG	3+	adult	H	Merrimack	Disc	210	B/6-2		11/96	Merrimack R.	Dark Blue
NHFG	3+	adult	H	Merrimack	Disc	75	G/6-2		11/96	Pemigewasset R.	Clear
NHFG	3+	adult	H	Merrimack	Disc	41	B/6-2		11/96	Pemigewasset R.	Clear
NHFG	2+	adult	H	Merrimack	Disc	10	B/6-2		11/96	Pemigewasset R.	Clear
NHFG	3+	adult	H	Merrimack	Disc	240	F/6-2		12/96	Merrimack R.	Dark Blue
NHFG	2+	adult	H	Merrimack	Disc	313	B/6-2		12/96	Merrimack R.	Dark Blue
NHFG	3+	adult	H	Merrimack	Disc	171	B/6-2		12/96	Merrimack R.	Dark Blue
NHFG	3+	adult	H	Merrimack	Disc	249	S/6-2		12/96	Merrimack R.	Dark Blue
NHFG	3+	adult	H	Merrimack	Disc	214	H/6-2		12/96	Pemigewasset R.	Clear
TOTAL DISC, MERRIMACK RIVER						4587					
USFWS	1+	parr	H	Merrimack		4900		LV	3/96	Souhegan R.	
TOTAL LV CLIP, MERRIMACK RIVER						4900					

TABLE 2.2.2.b. ATLANTIC SALMON MARKING DATABASE FOR NEW ENGLAND - 1996.											
MARKING AGENCY	AGE	LIFE STAGE	H/W	STOCK ORIGIN	TAG TYPE	NUMBER MARKED	CODE OR SERIAL	AUX CLIP	REL DATE	PLACE OF RELEASE	COMMENT
USFWS	5	adult	W	Machias		65		UCP **	6/96	Machias R.	
USFWS	5	adult	W	Machias		65		LCP ***	6/96	Machias R.	
USFWS	5	adult	W	Machias		35		AP ****	6/96	Machias R.	
USFWS	2	adult	W	Machias		1935		AD	6/96	Machias R.	
TOTAL CLIPS, MACHIAS RIVER						**2100**					
USFWS	5	adult	W	Dennys	Disc	130			6/96	Dennys R.	45 Yellow, 45 Green, 40 Pink
USFWS	2	smolt	W	Dennys		912		AD	6/96	Dennys R.	
TOTAL MARKS, DENNYS RIVER						**1042**					
USFWS	5	adult	W	Narraguagus	Disc	18			6/96	Narraguagus R.	Orange
USFWS	5	adult	W	Narraguagus		40		CP *****	6/96	Narraguagus R.	
USFWS	5	adult	W	Narraguagus	Streamer	50			6/96	Narraguagus R.	25 Orange, 25 Blue
TOTAL MARKS, NARRAGUAGUS RIVER						**108**					
USFWS	1	smolt	H	Penobscot		20000		RV	4/96	Saco R.	
TOTAL RV CLIP, SACO RIVER						**20000**					
USFWS	1	smolt	H	Penobscot	Elastomer	25016			5/96	Penobscot R.	Orange
USFWS	0+	fry	H	Penobscot	Otolith	621124			5/96	Penobscot R.	
USFWS	1	smolt	H	Penobscot	Carlin	48400	900300-950000		5/96	Penobscot R.	
TOTAL MARKS, PENOBSCOT RIVER						**694540**					

* MACFRWRU = Massachusetts Cooperative Fish and Wildlife Research Unit
** UCP = upper caudal punch
*** LCP = lower caudal punch
**** AP = adipose punch
***** CP = caudal punch

TABLE 2.3.1. DOCUMENTED ATLANTIC SALMON RETURNS TO NEW ENGLAND RIVERS IN 1996. 1)

RIVER	NUMBER OF ATLANTIC SALMON BY SEA AGE								TOTAL FOR 1996
	1SW		2SW		3SW		RS		
	Hat	Wild	Hat	Wild	Hat	Wild	Hat	Wild	
Penobscot River	482	13	1,187	335	6	3	14	5	2,045
Aroostook River	10	10	22	23	0	0	0	0	65
Union River	6	0	62	1	0	0	0	0	69
Narraguagus River	1	9	7	42	0	0	0	5	64
Pleasant River									unknown
Machias River									unknown
East Machias River									unknown
Dennys River	0	3	0	7	0	0	0	0	10
St. Croix River	13	10	77	32	0	0	0	0	132
Kennebec River									unknown
Androscoggin River	2	1	19	16	1	0	0	0	39
Sheepscot River	0	0	0	8	0	0	0	0	8
Ducktrap River									unknown
Saco River	11	0	39	0	1	0	3	0	54
Cocheco River	0	0	0	2	0	0	0	0	2
Lamprey River	0	0	0	1	0	0	0	0	1
Merrimack River	11	3	44	13	0	0	3	2	76
Pawcatuck River	0	0	2	0	0	0	0	0	2
Connecticut River	0	5	143	111	0	0	0	1	260
TOTAL	**536**	**54**	**1,602**	**591**	**8**	**3**	**20**	**13**	**2,827**

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.

TABLE 2.3.2. INDICIES AND ESTIMATED ABUNDANCE OF ATLANTIC SALMON RETURNS TO NEW ENGLAND RIVERS IN 1996.

(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	65					205
St. Croix	0	0		0			176			176
Dennys 2)	60	0	0	0	10			30		10
East Machias 3)	21	0	2	2				41		20+ unknown
Machias	10	0	1	1				102		50+ unknown
Pleasant	0	0	0	0				41		41
Narraguagus	31	0	3	3	64			161		67
Union	15	0	1	1			92			93
Penobscot	400	0	40	40			2,727			2767
Ducktrap	0	0	0	0				44		44
Sheepscot	0	0	0	0			8+	12		20
Kennebec	2	0	0	0					50	50
Androscoggin	0	0	0	0		42				42
Saco	0	0	0	0	54					54
Misc. (ME)	3	0	0	0						3
Cocheco	0	0	0	0		2				2
Lamprey	0	0	0	0		1				1
Merrimack	0	2	0	2		82				84
Pawcatuck	0	1	0	1		1				2
Connecticut	0	0	0	8		283				291
TOTALS	**542**	**3**	**47**	**58**	**193**	**411**	**3,003**	**431**	**50**	**4,022**

1) Includes trap catch of 65 adults and 140 adults trucked into the system (205 total).

2) Minimum estimate - weir catch only. Cannot use redd counts.

3) Some of the Dennys and E. Machias salmon caught and released were of aquaculture origin.

* Redd counts in Narraguagus, Machias, Dennys compromised by release of captive brood stock from CBNFH.

TABLE 2.3.3.. SUMMARY OF 1996 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	0	140	0	0	140
Merrimack River						
Trap	CWT	0	33	0	3	36
Rod	CWT					0
Penobscot River 1)						
Trap	CWT	3	402	3	1	409
Trap	Carlin	0	0	0	0	0
Other Rivers in Maine 1)						
Trap	CWT	0	13	3	0	16
TOTAL	**CWT**	**3**	**588**	**6**	**4**	**601**
	Carlin	**0**	**0**	**0**	**0**	**0**

1) It is assumed that any Atlantic salmon with an adipose finclip in the Penobscot and any wild salmon in the Narraguagus, Saco, Androscoggin, Kennebec, and Union also carried a CWT.

TABLE 2.3.4. SUMMARY OF ATLANTIC SALMON EGG PRODUCTION IN NEW ENGLAND FACILITIES IN 1996 1).

SOURCE RIVER	ORIGIN	FEMALES SPAWNED	TOTAL EGG PRODUCTION	NO. OF EGGS PER FEMALE
Sheepscot River	Sea-run	7	46,800	6,686
Penobscot River	Sea-run	380	2,635,000	6,934
Dennys River	Sea-run	4	28,800	7,200
Merrimack River	Sea-run	31	212,500	6,855
Pawcatuck River	Sea-run	1	16,900	16,900
Connecticut River	Sea-run	115	938,300	8,159
TOTAL SEA-RUN		**538**	**3,878,300**	**7,209**
Penobscot River	Domestic	0	0	0
Merrimack River	Domestic	912	5,469,000	5,997
Connecticut River	Domestic	1,732	11,844,900	6,839
Dennys River	Captive 2)	86	311,000	3,616
East Machias River	Captive	96	221,100	2,303
Sheepscot River	Captive	36	66,000	1,833
Machias River	Captive	141	513,200	3,640
Narraguagus River	Captive	117	434,300	3,712
TOTAL CAPTIVE/DOMESTIC		**3,120**	**18,859,500**	**6,045**
Dennys River	Kelts	3	29,200	9,733
Connecticut River	Kelts	206	2,221,200	10,783
Sheepscot River	Kelts	7	66,100	9,443
Machias River	Kelts	2	12,800	6,400
TOTAL SEA-RUN KELTS		**211**	**2,263,200**	**10,726**
GRAND TOTAL		**3,869**	**25,001,000**	**6,462**

1) Egg production rounded to nearest 100 eggs.
2) Captive refers to adults produced from wild parr that were captured and reared to maturity in the hatchery.

TABLE 2.3.5. ESTIMATED 1996 SPORT CATCH OF ATLANTIC SALMON IN MAINE.

RIVER	NO. SALMON HARVESTED 1SW	2SW	3SW	RS	TOTAL HARVEST	EST. NO. RELEASED	TOTAL ANGLED 1996	TOTAL ANGLED 1995
St. Croix	0	0	0	0	0	0	0	0
Dennys	0	0	0	0	0	60	60	20
East Machias	0	0	0	0	0	21	21	22
Machias	0	0	0	0	0	10	10	5
Pleasant	0	0	0	0	0	0	0	0
Narraguagus	0	0	0	0	0	31	31	23
Union	0	0	0	0	0	15	15	0
Penobscot	0	0	0	0	0	400	400	300
Ducktrap	0	0	0	0	0	0	0	0
Sheepscot	0	0	0	0	0	0	0	0
Kennebec	0	0	0	0	0	2	2	0
Saco	0	0	0	0	0	0	0	0
Aroostook	0	0	0	0	0	0	0	0
Misc.	0	0	0	0	0	3	3	0
TOTAL	**0**	**0**	**0**	**0**	**0**	**542**	**542**	**370**

TABLE 3.2.a. ATLANTIC SALMON STOCKING SUMMARY FOR NEW ENGLAND BY RIVER
1970 THROUGH 1996

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							
1970-1974	0	0	0	0	0	0	0
1975	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0
1979	0	2100	0	0	0	0	2100
1980	0	0	0	0	0	2700	2700
1981	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0
1987	306000	60000	0	0	0	0	366000
1988	128000	779400	4800	0	0	0	912200
1989	66000	0	0	0	0	10300	76300
1990	110000	21000	9900	0	0	9600	150500
1991	228000	139300	0	0	5100	5100	377500
1992	400000	136100	0	0	0	0	536100
1993	361000	102800	0	0	0	0	463800
1994	566000	216000	0	0	0	0	782000
1995	0	0	0	0	0	0	0
1996	0	0	0	0	0	0	0
TOTAL	**2165000**	**1456700**	**14700**	**0**	**5100**	**27700**	**3669200**
AROOSTOOK							
1970-1974	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
1995	4300	0	0	0	0	0	4300
1996	0	0	0	0	0	0	0
TOTAL	**628300**	**317100**	**36800**	**1800**	**32600**	**29800**	**1046400**

TABLE 3.2.a. Continued

RIVER / YEAR	FRY	0+PARR	1PARR	1+PARR	1SMOLT	2SMOLT	TOTAL
ST. CROIX							
1970-1974	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
1995	1000	0	0	0	0	0	1000
1996	0	52100	0	0	15600	0	67700
TOTAL	**1260000**	**355500**	**158100**	**0**	**747200**	**20100**	**2540900**
DENNYS							
1970-1974	0	0	0	0	0	0	0
1975	0	0	3000	0	0	4200	7200
1976	0	0	0	0	0	8900	8900
1977	0	0	0	0	0	0	0
1978	0	0	0	0	30200	0	30200
1979	0	0	0	0	10200	0	10200
1980	0	0	0	0	0	15200	15200
1981	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0
1983	20000	0	0	0	5200	0	25200
1984	0	0	0	0	3300	0	3300
1985	0	0	0	0	4500	0	4500
1986	0	8300	0	0	5400	0	13700
1987	24000	0	0	0	9000	0	33000
1988	30000	0	0	0	25700	0	55700
1989	12000	0	0	0	12100	0	24100
1990	20000	0	0	0	25800	0	45800
1991	25000	0	400	0	11700	0	37100
1992	0	0	0	0	0	0	0
1993	33000	0	0	0	0	0	33000
1994	20000	0	0	0	0	0	20000
1995	84000	0	0	0	0	0	84000
1996	142000	0	0	0	0	900	142900
TOTAL	**410000**	**8300**	**3400**	**0**	**143100**	**29200**	**594000**

TABLE 3.2.a. Continued

RIVER / YEAR	FRY	0+PARR	1PARR	1+PARR	1SMOLT	2SMOLT	TOTAL
PLEASANT							
1970-1974	0	0	0	0	0	0	0
1975	0	0	0	0	0	3000	3000
1976	0	0	0	0	0	1000	1000
1977	0	0	0	0	0	0	0
1978	0	0	0	0	3100	0	3100
1979	0	0	0	0	0	0	0
1980	0	0	0	0	200	10000	10200
1981	0	0	0	0	0	4100	4100
1982	0	0	0	0	5000	0	5000
1983	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0
1985	33000	0	0	0	4100	0	37100
1986	25000	0	0	0	6500	0	31500
1987	25000	0	0	0	7500	0	32500
1988	25000	0	1800	0	10500	0	37300
1989	26000	2500	0	0	7300	0	35800
1990	30000	0	0	0	10500	0	40500
1991	23000	0	0	0	0	0	23000
1992	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0
1995	0	0	0	0	0	0	0
1996	0	0	0	0	0	0	0
TOTAL	**187000**	**2500**	**1800**	**0**	**54700**	**18100**	**264100**
EAST MACHIAS							
1970-1974	0	0	0	0	0	2000	2000
1975	0	0	0	0	0	3000	3000
1976	0	0	0	0	0	3900	3900
1977	0	0	0	0	0	0	0
1978	0	0	0	0	12200	0	12200
1979	0	0	0	0	5200	0	5200
1980	0	0	0	0	0	15900	15900
1981	0	0	0	0	0	0	0
1982	0	0	0	0	0	5600	5600
1983	0	0	0	0	0	0	0
1984	0	0	8700	0	0	0	8700
1985	13000	0	0	0	4500	0	17500
1986	8000	0	0	0	5300	0	13300
1987	10000	0	0	0	9000	0	19000
1988	10000	0	7500	0	20700	0	38200
1989	30000	6500	8000	0	15300	0	59800
1990	42000	0	10100	0	10100	0	62200
1991	27000	0	8300	0	15300	0	50600
1992	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0
1995	0	0	0	0	0	0	0
1996	115000	0	0	0	0	0	115000
TOTAL	**255000**	**6500**	**42600**	**0**	**97600**	**30400**	**432100**

TABLE 3.2.a. Continued

RIVER / YEAR	FRY	0+PARR	1PARR	1+PARR	1SMOLT	2SMOLT	TOTAL
MACHIAS							
1970-1974	0	0	0	0	13600	31100	44700
1975	0	0	0	0	0	0	0
1976	0	0	0	0	5300	11100	16400
1977	0	0	0	0	0	0	0
1978	0	0	0	0	10200	0	10200
1979	0	0	0	0	10200	0	10200
1980	0	0	0	0	0	0	0
1981	0	0	0	0	0	0	0
1982	0	0	0	0	5500	0	5500
1983	0	12500	0	0	0	0	12500
1984	0	0	0	0	15800	0	15800
1985	0	0	7000	0	5100	0	12100
1986	8000	8000	0	0	0	0	16000
1987	0	12500	12300	0	13600	0	38400
1988	30000	0	31500	0	30900	0	92400
1989	49000	13800	28000	0	23100	0	113900
1990	75000	10100	17600	0	26100	0	128800
1991	13000	30000	21400	0	21100	0	85500
1992	14000	0	0	0	0	0	14000
1993	0	0	0	0	0	0	0
1994	50000	0	0	0	0	0	50000
1995	150000	0	0	0	0	0	150000
1996	233000	0	0	0	0	1900	234900
TOTAL	**622000**	**86900**	**117800**	**0**	**180500**	**44100**	**1051300**
NARRAGUAGUS							
1970-1974	0	0	0	0	0	36000	36000
1975	0	0	0	0	0	5000	5000
1976	0	0	0	0	0	8400	8400
1977	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0
1979	0	0	0	0	10100	0	10100
1980	0	0	0	0	0	20400	20400
1981	0	0	0	0	0	4100	4100
1982	0	0	0	0	0	5200	5200
1983	0	7800	0	0	0	0	7800
1984	0	0	0	0	5200	0	5200
1985	10000	0	0	0	4500	0	14500
1986	0	0	0	0	7500	0	7500
1987	15000	0	0	0	9000	0	24000
1988	20000	13000	5600	0	15700	0	54300
1989	29000	9500	7000	0	22100	4900	72500
1990	0	0	0	0	16800	0	16800
1991	0	0	0	0	15200	0	15200
1992	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0
1995	105000	0	0	0	0	0	105000
1996	196000	0	0	0	0	0	196000
TOTAL	**375000**	**30300**	**12600**	**0**	**106100**	**84000**	**608000**

TABLE 3.2.a. Continued

RIVER / YEAR	FRY	0+PARR	1PARR	1+PARR	1SMOLT	2SMOLT	TOTAL
UNION							
1970-1974	0	0	0	0	18000	47700	65700
1975	0	0	0	0	0	31300	31300
1976	0	0	0	0	1800	31800	33600
1977	0	0	0	0	13000	22500	35500
1978	0	0	0	0	0	31900	31900
1979	0	0	0	0	12900	29900	42800
1980	0	0	0	0	30600	0	30600
1981	0	0	0	0	0	29400	29400
1982	0	0	0	0	5900	26500	32400
1983	0	0	0	0	41600	0	41600
1984	0	0	0	0	50200	0	50200
1985	7000	0	0	0	45800	0	52800
1986	7000	0	0	0	48400	0	55400
1987	7000	0	0	0	40100	0	47100
1988	0	0	0	0	30600	0	30600
1989	0	0	0	0	20400	0	20400
1990	0	0	0	0	20400	0	20400
1991	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0
1993	60000	111700	0	0	0	0	171700
1994	0	0	0	0	0	0	0
1995	0	54800	0	0	0	0	54800
1996	0	53500	0	0	0	0	53500
TOTAL	**81000**	**220000**	**0**	**0**	**379700**	**251000**	**931700**
PENOBSCOT							
1970-1974	129000	25000	50900	9100	99300	264000	577300
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
1995	502000	325000	5600	0	568400	0	1401000
1996	1242000	226000	17500	0	552200	0	2037700
TOTAL	**7671000**	**1783700**	**1371800**	**9100**	**8219700**	**2508200**	**21563500**

TABLE 3.2.a. Continued

RIVER / YEAR	FRY	0+PARR	1PARR	1+PARR	1SMOLT	2SMOLT	TOTAL
DUCKTRAP							
1970-1974	0	0	0	0	0	0	0
1975	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0
1979	0	0	0	0	0	0	0
1980	0	0	0	0	0	0	0
1981	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0
1985	15000	0	0	0	0	0	15000
1986	8000	0	0	0	0	0	8000
1987	15000	0	0	0	0	0	15000
1988	10000	0	0	0	0	0	10000
1989	17000	0	0	0	0	0	17000
1990	18000	0	0	0	0	0	18000
1991	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0
1995	0	0	0	0	0	0	0
1996	0	0	0	0	0	0	0
TOTAL	**83000**	**0**	**0**	**0**	**0**	**0**	**83000**
SHEEPSCOT							
1970-1974	0	0	0	0	1000	1000	2000
1975	0	0	0	0	0	2500	2500
1976	0	0	0	0	3000	0	3000
1977	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0
1979	0	0	0	0	0	0	0
1980	0	0	0	0	0	0	0
1981	0	0	0	0	0	0	0
1982	0	0	0	0	5300	0	5300
1983	0	0	0	0	5200	0	5200
1984	0	0	0	0	5000	0	5000
1985	20000	0	0	0	3900	3600	27500
1986	10000	11600	0	0	7500	0	29100
1987	15000	8200	0	0	9000	0	32200
1988	40000	12300	0	0	10200	0	62500
1989	29000	13600	10000	0	10200	0	62800
1990	27000	10100	10000	0	17500	0	64600
1991	18000	15000	600	0	14400	0	48000
1992	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0
1995	0	0	0	0	0	0	0
1996	102000	0	0	0	0	0	102000
TOTAL	**261000**	**70800**	**20600**	**0**	**92200**	**7100**	**451700**

TABLE 3.2.a. Continued

RIVER / YEAR	FRY	0+PARR	1PARR	1+PARR	1SMOLT	2SMOLT	TOTAL
SACO							
1970-1974	0	0	0	0	0	0	0
1975	0	0	0	0	0	9500	9500
1976	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0
1979	0	0	0	0	0	0	0
1980	0	0	0	0	0	0	0
1981	0	0	0	0	0	0	0
1982	0	47100	0	0	0	0	47100
1983	0	0	0	0	20300	0	20300
1984	0	0	0	0	5100	0	5100
1985	0	0	23600	0	5100	0	28700
1986	0	0	10000	0	35200	0	45200
1987	0	0	69800	0	22000	0	91800
1988	47000	0	0	0	25100	0	72100
1989	0	37800	49600	0	9900	0	97300
1990	0	30100	47800	0	10600	0	88500
1991	111000	0	0	0	10300	0	121300
1992	154000	50200	400	0	19800	0	224400
1993	167000	0	0	0	20100	0	187100
1994	190000	0	0	0	20000	0	210000
1995	376000	0	0	0	19700	0	395700
1996	0	45000	0	0	20000	0	65000
TOTAL	**1045000**	**210200**	**201200**	**0**	**243200**	**9500**	**1709100**
COCHECO							
1970-1974	0	0	0	0	0	0	0
1975	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0
1979	0	0	0	0	0	0	0
1980	0	0	0	0	0	0	0
1981	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0
1988	2000	0	0	0	0	0	2000
1989	106000	0	0	0	0	0	106000
1990	32000	50000	9500	0	0	0	91500
1991	138000	0	0	0	0	0	138000
1992	128000	0	0	0	0	0	128000
1993	127000	0	0	1000	0	0	128000
1994	149000	0	0	0	5300	0	154300
1995	114000	0	0	0	0	0	114000
1996	126000	0	0	0	0	0	126000
TOTAL	**922000**	**50000**	**9500**	**1000**	**5300**	**0**	**987800**

TABLE 3.2.a. Continued

RIVER / YEAR	FRY	0+PARR	1PARR	1+PARR	1SMOLT	2SMOLT	TOTAL
LAMPREY							
1970-1974	0	0	0	0	0	0	0
1975	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0
1978	0	0	0	0	19600	0	19600
1979	0	0	0	0	8600	5800	14400
1980	0	0	0	0	39900	8400	48300
1981	0	0	0	0	19500	12200	31700
1982	0	0	0	0	30700	6400	37100
1983	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0
1989	146000	0	0	0	0	0	146000
1990	50000	87000	11400	0	0	0	148400
1991	110000	68200	0	0	0	0	178200
1992	127000	12700	0	0	0	0	139700
1993	68000	56500	28800	1100	15000	0	169400
1994	98000	56300	7800	0	0	0	162100
1995	91000	57100	0	0	4800	0	152900
1996	115000	37000	8400	1000	0	0	161400
TOTAL	**805000**	**374800**	**56400**	**2100**	**138100**	**32800**	**1409200**
MERRIMACK							
1970-1974	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
1995	2827000	0	12700	0	70800	0	2910500
1996	1795000	0	0	4900	50000	0	1849900
TOTAL	**17770000**	**222500**	**411500**	**162200**	**1056600**	**630500**	**20253300**

TABLE 3.2.a. Continued

RIVER / YEAR	FRY	0+PARR	1PARR	1+PARR	1SMOLT	2SMOLT	TOTAL
PAWCATUCK							
1970-1974	0	0	0	0	0	0	0
1975	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0
1979	0	136000	0	0	0	0	136000
1980	0	1000	0	0	0	0	1000
1981	0	2000	108000	0	800	0	110800
1982	2000	1000	0	0	0	0	3000
1983	0	700	0	0	0	0	700
1984	0	23000	0	0	0	0	23000
1985	8000	51000	1400	0	0	0	60400
1986	0	50700	15000	0	0	0	65700
1987	3000	46200	4700	0	1000	0	54900
1988	150000	59600	7100	0	5400	0	222100
1989	0	379900	35800	0	6500	0	422200
1990	0	83500	55000	0	7500	0	146000
1991	0	101000	1000	0	2000	500	104500
1992	0	70800	2500	0	5000	0	78300
1993	383000	14500	4000	0	2300	0	403800
1994	557000	0	0	0	0	0	557000
1995	367000	52200	0	0	0	0	419200
1996	289000	136100	0	0	5000	0	430100
TOTAL	**1759000**	**1209200**	**234500**	**0**	**35500**	**500**	**3238700**
CONNECTICUT							
1970-1974	76000	30000	20900	41900	22000	101400	292200
1975	31900	0	1700	16400	2800	70000	122800
1976	26600	0	5000	24200	4000	30500	90300
1977	49500	0	0	15400	0	99200	164100
1978	50000	0	0	36600	0	94300	180900
1979	53500	0	0	38400	0	145100	237000
1980	286000	0	0	11500	0	51800	349300
1981	168000	182700	1900	3600	5300	73300	434800
1982	294000	9400	25100	9600	28100	180800	547000
1983	226000	115400	293800	400	89100	8900	733600
1984	625000	178600	241200	11400	312300	0	1368500
1985	422000	130500	110700	0	255000	0	918200
1986	176000	188400	267100	0	290500	0	922000
1987	1180000	383200	345100	0	206000	0	2114300
1988	1310000	72200	75200	0	395300	0	1852700
1989	1243000	268700	76800	0	217700	0	1806200
1990	1271000	341600	25400	0	475900	0	2113900
1991	1725000	306200	33100	0	351000	0	2415300
1992	2009000	313900	11500	0	313300	0	2647700
1993	4147000	237100	28700	0	382800	0	4795600
1994	5979000	37000	2300	12900	375100	0	6406300
1995	6818000	4500	0	0	1300	0	6823800
1996	6675000	12400	0	3600	11500	0	6702500
TOTAL	**34841500**	**2811800**	**1565500**	**225900**	**3739000**	**855300**	**44039000**

TABLE 3.2.a. Continued

GRAND TOTAL BY RIVER (1970-1996)

RIVER	NUMBER OF FISH						
	FRY	0+PARR	1PARR	1+PARR	1SMOLT	2SMOLT	TOTAL
Upper St. John	2165000	1456700	14700	0	5100	27700	3669200
Aroostook	628300	317100	36800	1800	32600	29800	1046400
St. Croix	1260000	355500	158100	0	747200	20100	2540900
Dennys	410000	8300	3400	0	143100	29200	594000
Pleasant	187000	2500	1800	0	54700	18100	264100
East Machias	255000	6500	42600	0	97600	30400	432100
Machias	622000	86900	117800	0	180500	44100	1051300
Narraguagus	375000	30300	12600	0	106100	84000	608000
Union	81000	220000	0	0	379700	251000	931700
Penobscot	7671000	1783700	1371800	9100	8219700	2508200	21563500
Ducktrap	83000	0	0	0	0	0	83000
Sheepscot	261000	70800	20600	0	92200	7100	451700
Saco	1045000	210200	201200	0	243200	9500	1709100
Cocheco	922000	50000	9500	1000	5300	0	987800
Lamprey	805000	374800	56400	2100	138100	32800	1409200
Merrimack	17770000	222500	411500	162200	1056600	630500	20253300
Pawcatuck	1759000	1209200	234500	0	35500	500	3238700
Connecticut	34841500	2811800	1565500	225900	3739000	855300	44039000
TOTAL	**71140800**	**9216800**	**4258800**	**402100**	**15276200**	**4578300**	**104873000**

375,100

85,000

TABLE 3.2.b. HISTORICAL ATLANTIC SALMON RETURNS TO NEW ENGLAND RIVERS
1970 THROUGH 1996
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									
1970-1974	80	1330	32	20	0	17	0	0	1479
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
1995	158	1077	7	9	6	84	0	1	1342
1996	482	1187	6	14	13	335	3	5	2045
TOTAL	**8585**	**37526**	**211**	**485**	**434**	**2744**	**26**	**71**	**50082**
UNION									
1970-1974	9	85	1	0	0	0	0	0	95
1975	23	56	0	0	0	0	0	0	79
1976	90	158	0	0	0	0	0	0	248
1977	13	222	1	8	0	0	0	0	244
1978	4	147	2	4	0	0	0	0	157
1979	6	38	0	1	0	0	0	0	45
1980	42	197	0	1	0	0	0	0	240
1981	10	284	1	0	0	0	0	0	295
1982	30	118	1	7	0	0	0	0	156
1983	25	116	1	2	0	4	0	0	148
1984	3	37	0	0	0	0	0	0	40
1985	3	79	0	0	0	0	0	0	82
1986	7	59	1	0	0	0	0	0	67
1987	19	43	0	1	0	0	0	0	63
1988	0	45	0	0	0	2	0	0	47
1989	4	25	1	0	0	0	0	0	30
1990	1	20	0	0	0	0	0	0	21
1991	1	1	0	0	1	5	0	0	8
1992	0	4	0	0	0	0	0	0	4
1993	0	0	0	0	0	0	0	0	0
1994									
1995									
1996	6	62	0	0	0	1	0	0	69
TOTAL	**296**	**1796**	**9**	**24**	**1**	**12**	**0**	**0**	**2138**

TABLE 3.2.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									
1970-1974	9	169	11	3	8	651	36	33	920
1975	0	2	0	0	0	103	2	4	111
1976	0	4	0	0	0	25	0	3	32
1977	2	5	0	0	1	105	0	11	124
1978	0	35	0	0	0	94	2	2	133
1979	0	9	0	0	0	49	0	0	58
1980	0	0	0	0	0	112	0	3	115
1981	1	20	0	1	0	49	0	2	73
1982	0	11	0	1	0	57	0	10	79
1983	2	17	0	0	0	69	0	2	90
1984	0	10	0	0	0	57	0	1	68
1985	0	0	0	0	0	56	0	1	57
1986	0	20	0	0	2	23	0	0	45
1987	0	11	0	0	0	24	0	2	37
1988	1	10	0	0	2	24	0	1	38
1989	3	9	0	0	1	26	0	0	39
1990	1	22	0	0	0	27	0	1	51
1991	3	19	0	5	8	53	0	7	95
1992	6	19	0	1	11	32	0	4	73
1993	0	16	0	4	6	66	0	2	94
1994	1	0	0	0	4	42	0	4	51
1995	0	0	0	0	0	51	0	5	56
1996	1	7	0	0	9	42	0	5	64
TOTAL	**30**	**415**	**11**	**15**	**52**	**1837**	**40**	**103**	**2503**
PLEASANT									
1970-1974	0	0	0	0	2	32	1	0	35
1975	0	0	0	0	1	6	1	0	8
1976	0	0	0	0	0	1	0	0	1
1977	0	0	0	0	0	3	0	0	3
1978	0	0	0	0	0	16	0	0	16
1979	0	0	0	0	0	8	0	0	8
1980	0	0	0	0	0	5	0	0	5
1981	0	0	0	0	0	23	0	0	23
1982	4	8	0	0	0	6	0	1	19
1983	0	0	0	0	2	35	0	1	38
1984	0	0	0	0	1	16	0	0	17
1985	0	0	0	0	3	28	0	0	31
1986	0	0	0	0	0	19	0	0	19
1987	0	4	0	0	0	5	0	0	9
1988									
1989	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0	0	0
1994	0	0	0	0	1	1	0	0	2
1995									
1996									
TOTAL	**4**	**12**	**0**	**0**	**10**	**204**	**2**	**2**	**234**

TABLE 3.2.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									
1970-1974	11	121	6	0	4	582	16	16	756
1975	0	10	0	0	5	36	0	0	51
1976	2	5	0	0	0	18	0	0	25
1977	2	8	0	0	0	15	0	0	25
1978	0	15	0	0	0	87	0	3	105
1979	0	8	0	0	0	58	0	0	66
1980	0	13	0	0	0	58	0	7	78
1981	0	19	0	0	0	31	0	3	53
1982	0	0	1	0	1	52	0	2	56
1983	0	0	0	0	0	16	0	1	17
1984	0	8	0	0	2	21	0	2	33
1985	0	5	0	0	0	25	0	2	32
1986	2	16	0	0	2	24	0	2	46
1987	0	0	0	0	0	4	0	0	4
1988	0	0	0	0	0	6	0	2	8
1989	3	4	0	0	4	5	0	0	16
1990	0	1	0	0	0	1	0	0	2
1991	1	0	0	0	1	0	0	0	2
1992	0	3	0	0	0	0	0	0	3
1993	0	2	0	0	1	12	0	0	15
1994									
1995									
1996									
TOTAL	**21**	**238**	**7**	**0**	**20**	**1051**	**16**	**40**	**1393**
EAST MACHIAS									
1970-1974	0	4	0	0	0	15	0	0	19
1975	0	8	0	0	0	20	0	2	30
1976	2	16	0	2	0	0	0	0	20
1977	0	9	1	0	0	19	0	1	30
1978	0	13	0	0	0	46	0	0	59
1979	0	7	0	0	0	18	0	0	25
1980	0	24	0	0	2	34	0	2	62
1981	4	67	0	0	4	24	0	1	100
1982	0	15	0	0	0	22	0	0	37
1983	0	3	0	0	0	5	0	0	8
1984	0	9	0	0	3	33	0	2	47
1985	0	0	0	0	0	30	0	0	30
1986	0	5	0	0	0	8	0	0	13
1987	0	8	0	0	0	5	1	0	14
1988	1	8	0	0	0	5	0	0	14
1989	12	10	0	0	2	6	0	1	31
1990	1	30	0	0	0	16	0	1	48
1991	1	2	0	0	1	1	0	0	5
1992	0	6	0	0	0	0	0	0	6
1993	0	0	0	0	0	0	0	0	0
1994									
1995									
1996									
TOTAL	**21**	**244**	**1**	**2**	**12**	**307**	**1**	**10**	**598**

TABLE 3.2.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									
1970-1974	1	0	0	0	3	212	0	3	219
1975	0	0	0	0	0	40	0	0	40
1976	0	0	0	0	2	13	0	5	20
1977	0	0	0	0	0	26	0	0	26
1978	0	37	0	0	0	38	0	0	75
1979	0	0	0	0	0	36	0	2	38
1980	0	117	0	0	0	73	0	0	190
1981	6	74	0	0	0	43	3	0	126
1982	3	15	0	0	6	14	0	0	38
1983	0	0	0	0	0	28	0	0	28
1984	0	0	0	0	7	61	0	0	68
1985	0	6	0	0	0	14	0	0	20
1986	0	7	0	0	0	8	0	0	15
1987	0	0	0	0	0	1	0	0	1
1988	0	3	0	0	0	6	0	0	9
1989	1	10	0	0	0	1	0	0	12
1990	1	20	0	1	0	11	0	0	33
1991	1	0	0	0	0	6	0	0	7
1992	1	3	0	0	0	1	0	0	5
1993	7	2	0	0	0	4	0	0	13
1994	0	0	0	0	1	5	0	0	6
1995	0	0	0	0	0	5	0	0	5
1996	0	0	0	0	3	7	0	0	10
TOTAL	**21**	**294**	**0**	**1**	**22**	**653**	**3**	**10**	**1004**
ST. CROIX									
1970-1974									
1975									
1976									
1977									
1978									
1979									
1980									
1981	25	14	1	0	24	14	1	0	79
1982	28	1	0	0	56	13	1	0	99
1983	14	62	4	0	11	28	3	0	122
1984	138	50	5	0	39	11	1	0	244
1985	28	144	14	0	28	122	14	0	350
1986	34	116	13	0	33	116	13	0	325
1987	108	63	1	0	94	103	6	0	375
1988	76	229	0	3	18	61	0	1	388
1989	78	66	0	1	44	44	0	8	241
1990	6	59	0	7	12	26	0	2	112
1991	41	90	0	0	16	38	0	4	189
1992	1	0	0	0	0	0	0	0	1
1993	5	76	0	0	4	18	0	2	105
1994	23	17	0	1	24	19	0	0	84
1995	7	15	0	0	8	16	0	0	46
1996	13	77	0	0	10	32	0	0	132
TOTAL	**625**	**1079**	**38**	**12**	**421**	**661**	**39**	**17**	**2892**

TABLE 3.2.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									
1970-1974									
1975	2	30	0	0	0	1	0	0	33
1976	0	2	2	0	0	0	0	0	4
1977	0	2	0	0	0	0	0	0	2
1978	0	2	0	0	0	0	0	0	2
1979	0	18	0	0	0	2	0	0	20
1980	1	3	0	0	0	0	0	0	4
1981	1	13	0	0	0	0	0	0	14
1982	1	22	1	0	0	0	0	0	24
1983	1	16	1	0	0	0	0	0	18
1984	0	1	0	0	0	0	0	0	1
1985	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0
1987	0	2	1	0	0	2	0	0	5
1988	4	15	0	1	0	0	0	0	20
1989	1	16	0	0	0	0	0	0	17
1990	1	41	0	0	0	4	0	0	46
1991	0	4	0	0	0	0	0	0	4
1992	0	0	0	0	0	0	0	0	0
1993	0	2	0	0	0	0	0	0	2
1994									
1995									
1996									
TOTAL	**12**	**189**	**5**	**1**	**0**	**9**	**0**	**0**	**216**
ANDROSCOGGIN									
1970-1974									
1975									
1976									
1977									
1978									
1979									
1980									
1981									
1982									
1983	1	16	0	0	0	3	0	1	21
1984	4	79	1	0	0	7	0	0	91
1985	1	18	0	0	0	2	0	0	21
1986	0	72	1	0	0	8	0	0	81
1987	2	20	3	0	0	1	0	0	26
1988	2	11	0	0	1	0	0	0	14
1989	1	17	0	0	0	1	0	0	19
1990	6	168	0	1	1	9	0	0	185
1991	0	9	0	0	0	12	0	0	21
1992	2	9	0	0	1	3	0	0	15
1993	1	33	0	0	1	9	0	0	44
1994	2	16	0	1	0	6	0	0	25
1995	2	12	0	0	0	2	0	0	16
1996	2	19	1	0	1	16	0	0	39
TOTAL	**26**	**499**	**6**	**2**	**5**	**79**	**0**	**1**	**618**

TABLE 3.2.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
SHEEPSCOT									
1970-1974	0	0	0	0	6	86	4	0	96
1975	0	0	0	0	1	10	0	0	11
1976	0	0	0	0	1	9	0	0	10
1977	0	0	0	0	1	22	1	0	24
1978	0	0	0	0	2	32	1	0	35
1979	0	0	0	0	1	7	0	0	8
1980	0	0	0	0	2	27	1	0	30
1981	0	0	0	0	1	14	0	0	15
1982	0	0	0	0	1	14	0	0	15
1983	0	0	0	0	1	11	0	0	12
1984	0	0	0	0	1	20	1	0	22
1985	0	0	0	0	1	5	0	0	6
1986	0	0	0	0	1	10	0	0	11
1987	2	7	0	0	1	5	0	0	15
1988	1	0	0	0	0	0	0	0	1
1989	1	1	0	0	2	1	0	0	5
1990	1	8	0	0	0	0	0	0	9
1991	0	4	0	0	0	0	0	0	4
1992	1	2	0	0	1	2	1	0	7
1993	0	9	0	0	0	0	0	0	9
1994	0	5	0	0	3	12	0	0	20
1995	0	2	0	0	0	22	0	0	24
1996	0	0	0	0	0	8	0	0	8
TOTAL	**6**	**38**	**0**	**0**	**27**	**317**	**9**	**0**	**397**
DUCKTRAP									
1970-1974									
1975									
1976									
1977									
1978									
1979									
1980									
1981									
1982									
1983									
1984									
1985	0	0	0	0	0	15	0	0	15
1986	0	0	0	0	3	12	0	0	15
1987	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	3	0	0	3
1991	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0	0	0
1994									
1995									
1996									
TOTAL	**0**	**0**	**0**	**0**	**3**	**30**	**0**	**0**	**33**

TABLE 3.2.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									
1970-1974									
1975									
1976									
1977									
1978									
1979									
1980									
1981									
1982									
1983									
1984									
1985	2	58	0	0	0	0	0	0	60
1986	0	36	1	0	0	0	0	0	37
1987	4	34	1	0	0	1	0	0	40
1988	1	37	0	0	0	0	0	0	38
1989	2	16	0	1	0	0	0	0	19
1990	4	68	0	0	0	1	0	0	73
1991	0	4	0	0	0	0	0	0	4
1992	0	0	0	0	0	0	0	0	0
1993	4	54	0	1	0	0	0	0	59
1994	6	17	0	0	0	0	0	0	23
1995	0	34	0	0	0	0	0	0	34
1996	11	39	1	3	0	0	0	0	54
TOTAL	**34**	**397**	**3**	**5**	**0**	**2**	**0**	**0**	**441**
COCHECO									
1970-1974									
1975									
1976									
1977									
1978									
1979									
1980									
1981									
1982									
1983									
1984									
1985									
1986									
1987									
1988									
1989									
1990									
1991									
1992	0	0	0	0	0	1	0	0	1
1993	0	0	1	1	1	2	0	0	5
1994	0	0	0	0	0	0	0	0	0
1995	0	0	0	0	0	1	0	0	1
1996	0	0	0	0	2	0	0	0	2
TOTAL	**0**	**0**	**1**	**1**	**3**	**4**	**0**	**0**	**9**

TABLE 3.2.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
LAMPREY									
1970-1974									
1975									
1976									
1977									
1978									
1979	2	0	0	0	0	0	0	0	2
1980	2	5	0	0	0	0	0	0	7
1981	2	0	0	0	0	0	0	0	2
1982	2	9	0	0	0	0	0	0	11
1983	2	0	1	0	0	0	0	0	3
1984	0	3	0	0	0	0	0	0	3
1985	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	2	0	0	2
1993	0	0	0	0	1	7	0	0	8
1994	0	0	0	0	0	3	0	0	3
1995	0	0	0	0	0	1	0	0	1
1996	0	0	0	0	0	1	0	0	1
TOTAL	**10**	**17**	**1**	**0**	**1**	**14**	**0**	**0**	**43**
MERRIMACK									
1970-1974									
1975									
1976									
1977									
1978									
1979									
1980									
1981									
1982	3	14	0	0	4	2	0	0	23
1983	7	54	5	0	1	41	6	0	114
1984	64	20	0	0	16	12	3	0	115
1985	8	112	1	0	5	85	2	0	213
1986	19	33	0	0	4	44	3	0	103
1987	8	94	4	0	2	26	5	0	139
1988	4	16	2	0	4	38	1	0	65
1989	3	24	1	0	0	55	1	0	84
1990	3	115	1	0	24	104	1	0	248
1991	1	76	0	0	0	254	1	0	332
1992	17	66	2	0	14	100	0	0	199
1993	0	27	1	1	2	30	0	0	61
1994	0	2	0	0	1	18	0	0	21
1995	2	18	0	0	0	14	0	0	34
1996	11	44	0	3	3	13	0	2	76
TOTAL	**150**	**715**	**17**	**4**	**80**	**836**	**23**	**2**	**1827**

TABLE 3.2.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
PAWCATUCK									
1970-1974									
1975									
1976									
1977									
1978									
1979									
1980									
1981									
1982	0	38	0	0	0	0	0	0	38
1983	1	37	0	0	0	0	0	0	38
1984	0	26	0	0	0	0	0	0	26
1985	0	1	0	0	0	0	0	0	1
1986	0	0	0	0	0	0	0	0	0
1987	0	1	0	0	0	0	0	0	1
1988	0	5	1	0	0	0	0	0	6
1989	0	6	0	0	0	0	0	0	6
1990	0	8	0	0	0	0	0	0	8
1991	0	5	0	0	0	0	0	0	5
1992	0	6	0	0	0	0	0	0	6
1993	0	2	0	0	0	1	0	0	3
1994	0	2	0	0	0	0	0	0	2
1995	0	2	0	0	0	0	0	0	2
1996	0	2	0	0	0	0	0	0	2
TOTAL	**1**	**141**	**1**	**0**	**0**	**1**	**0**	**0**	**144**
CONNECTICUT									
1970-1974	0	1	0	0	0	0	0	0	1
1975	0	3	0	0	0	0	0	0	3
1976	0	2	0	0	0	0	0	0	2
1977	0	7	0	0	0	0	0	0	7
1978	3	90	0	0	0	0	0	0	93
1979	4	50	4	0	0	0	0	0	58
1980	4	164	7	0	0	0	0	0	175
1981	6	513	10	0	0	0	0	0	529
1982	3	57	0	0	0	10	0	0	70
1983	0	39	0	0	0	0	0	0	39
1984	7	65	0	0	2	18	0	0	92
1985	0	293	0	0	0	17	0	0	310
1986	0	275	0	0	0	43	0	0	318
1987	0	343	5	0	0	0	5	0	353
1988	1	93	0	0	0	1	0	0	95
1989	1	58	0	0	1	48	1	0	109
1990	1	226	0	0	0	36	0	0	263
1991	0	168	1	0	0	34	0	0	203
1992	3	353	1	0	5	127	1	0	490
1993	0	136	0	0	0	61	1	0	198
1994	1	263	0	1	0	61	0	0	326
1995	1	158	0	0	0	29	0	0	188
1996	0	143	0	0	5	111	0	1	260
TOTAL	**35**	**3500**	**28**	**1**	**13**	**596**	**8**	**1**	**4182**
GRAND TOTAL	**9867**	**47083**	**337**	**552**	**1100**	**9339**	**167**	**257**	**68754**

TABLE 3.2.b. Continued
GRAND TOTAL BY RIVER (1970-1996)

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	8585	37526	211	485	434	2744	26	71	50082
UNION	296	1796	9	24	1	12	0	0	2138
NARRAGUAGUS	30	415	11	15	52	1837	40	103	2503
PLEASANT	4	12	0	0	10	204	2	2	234
MACHIAS	21	238	7	0	20	1051	16	40	1393
E. MACHIAS	21	244	1	2	12	307	1	10	598
DENNYS	21	294	0	1	22	653	3	10	1004
ST. CROIX	625	1079	38	12	421	661	39	17	2892
KENNEBEC	12	189	5	1	0	9	0	0	216
ANDROSCOGGIN	26	499	6	2	5	79	0	1	618
SHEEPSCOT	6	38	0	0	27	317	9	0	397
DUCKTRAP	0	0	0	0	3	30	0	0	33
SACO	34	397	3	5	0	2	0	0	441
COCHECO	0	0	1	1	3	4	0	0	9
LAMPREY	10	17	1	0	1	14	0	0	43
MERRIMACK	150	715	17	4	80	836	23	2	1827
PAWCATUCK	1	141	1	0	0	1	0	0	144
CONNECTICUT	35	3500	28	1	13	596	8	1	4182
TOTAL	**9877**	**47100**	**339**	**553**	**1104**	**9357**	**167**	**257**	**68754**

Figure 1

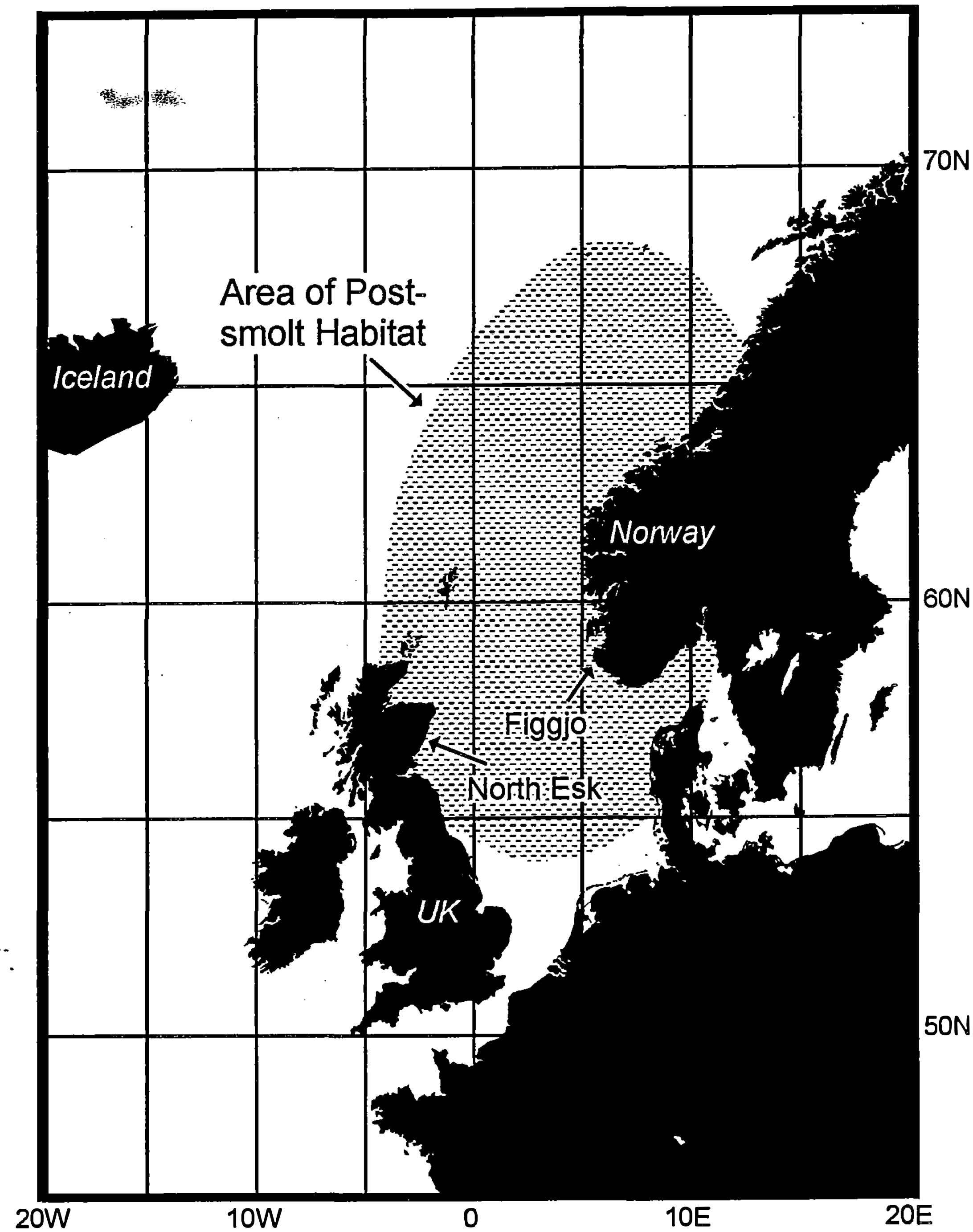
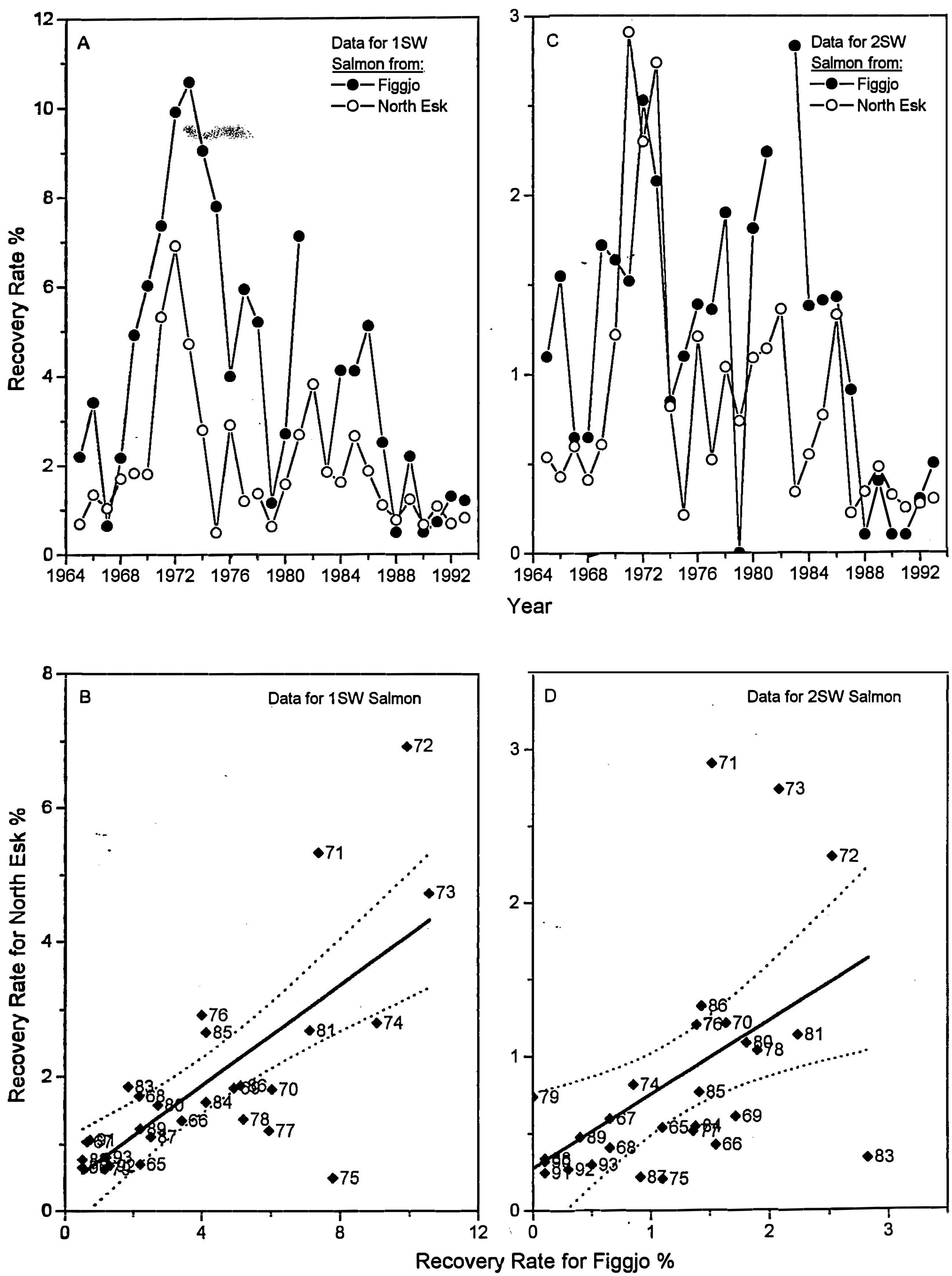
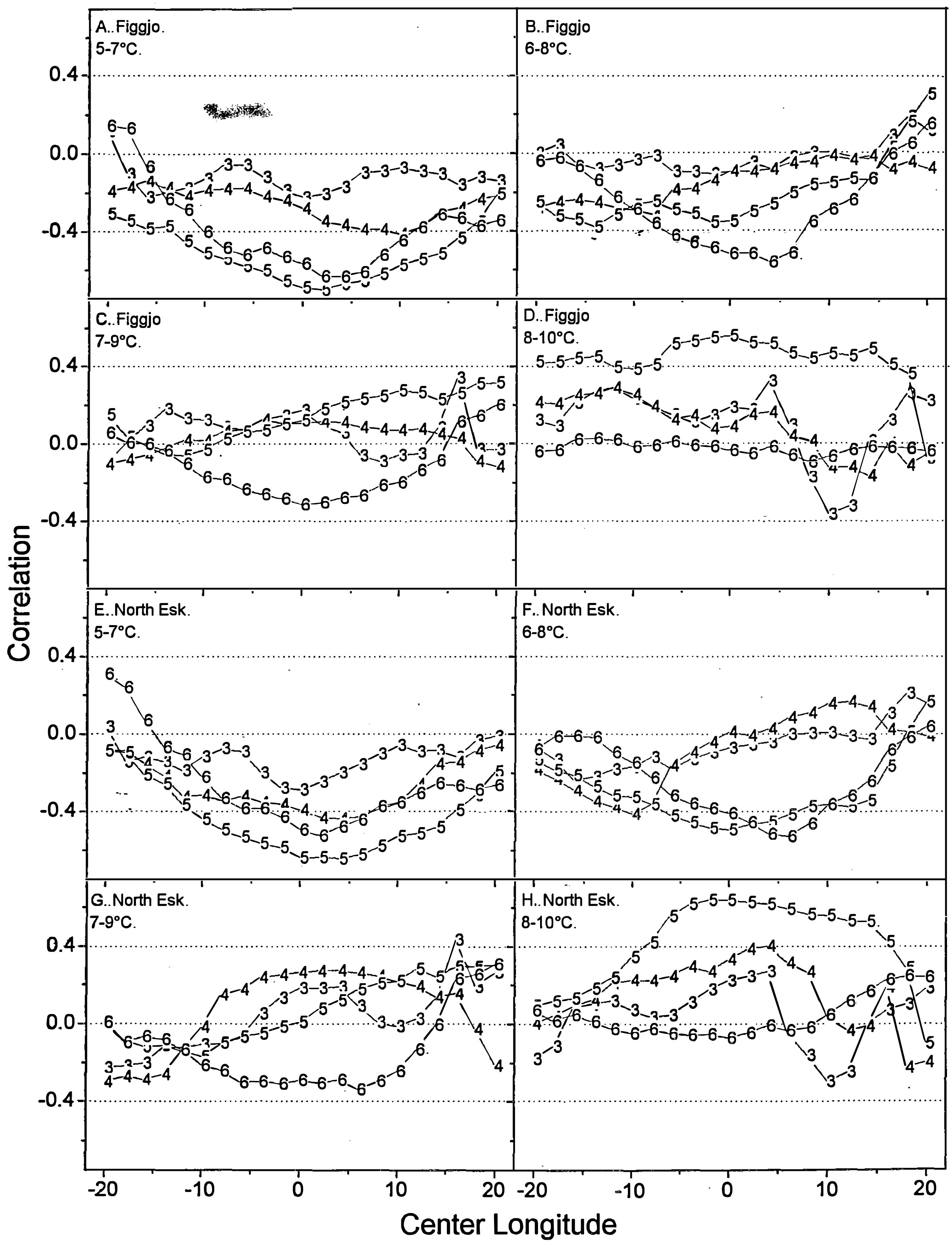

Area of Post-smolt Habitat
Iceland
Norway
Figgjo
North Esk
UK
70N
60N
50N
20W
10W
0
10E
20E

Figure 2



A
Data for 1SW
Salmon from:
Figgjo
North Esk
Recovery Rate %
C
Data for 2SW
Salmon from:
Figgjo
North Esk
Year
B
Data for 1SW Salmon
Recovery Rate for North Esk %
D
Data for 2SW Salmon
Recovery Rate for Figgjo %

Figure 3



A..Figgjo
5-7°C.
B..Figgjo
6-8°C.
C..Figgjo
7-9°C.
D..Figgjo
8-10°C.
E..North Esk.
5-7°C.
F..North Esk.
6-8°C.
G..North Esk.
7-9°C.
H..North Esk.
8-10°C.
Correlation
0.4
0.0
-0.4
-20
-10
0
10
20
Center Longitude

Figure 4

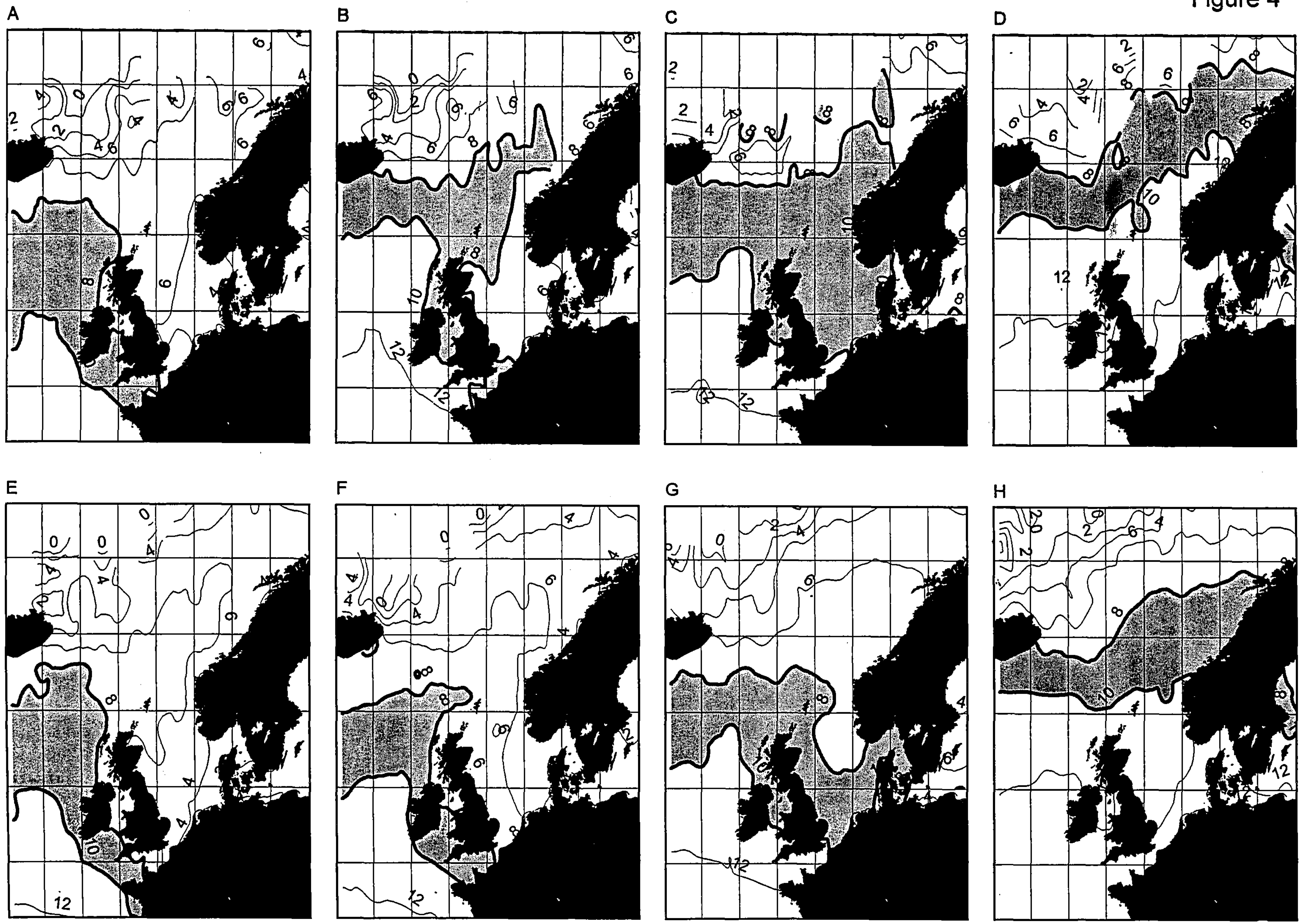
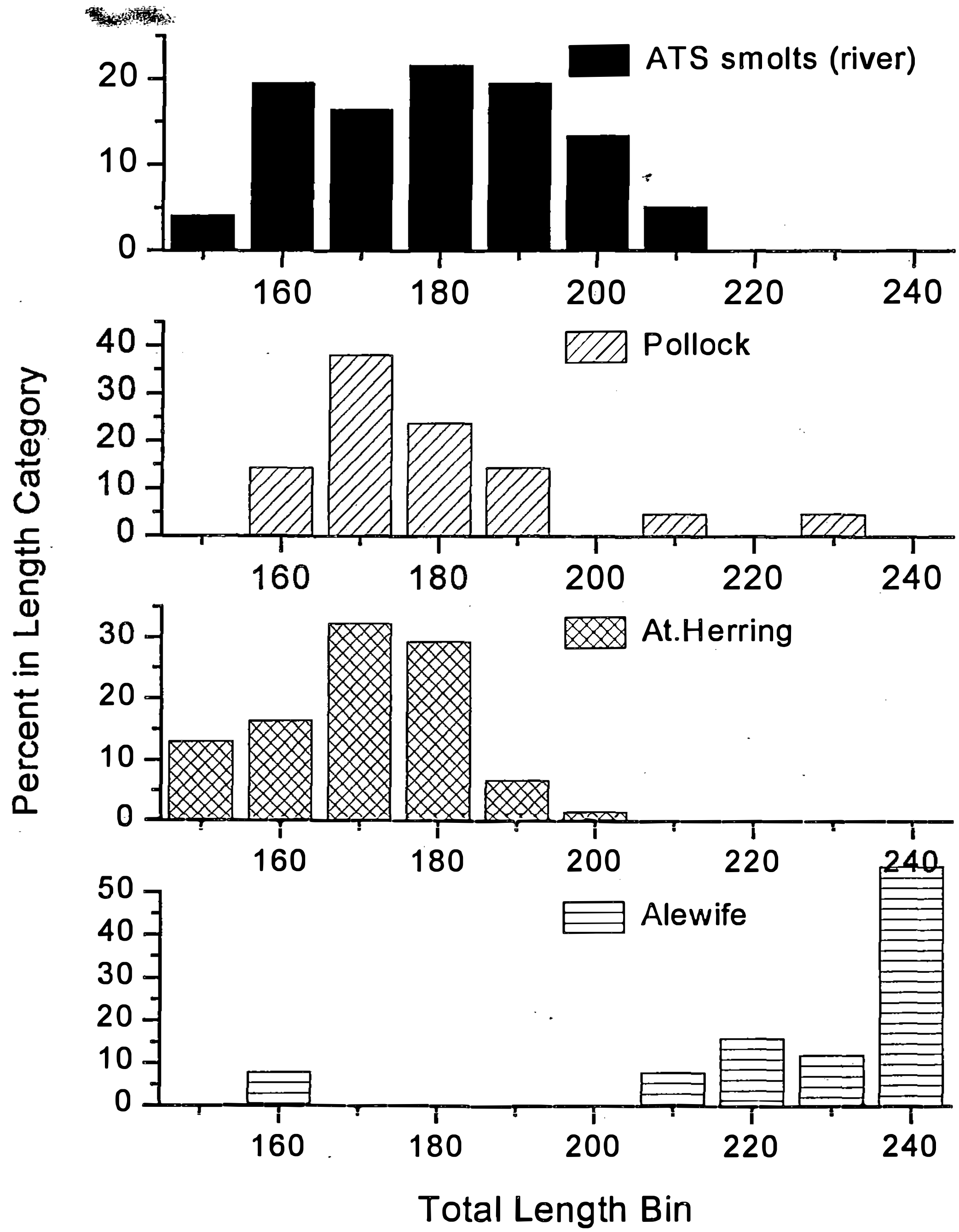
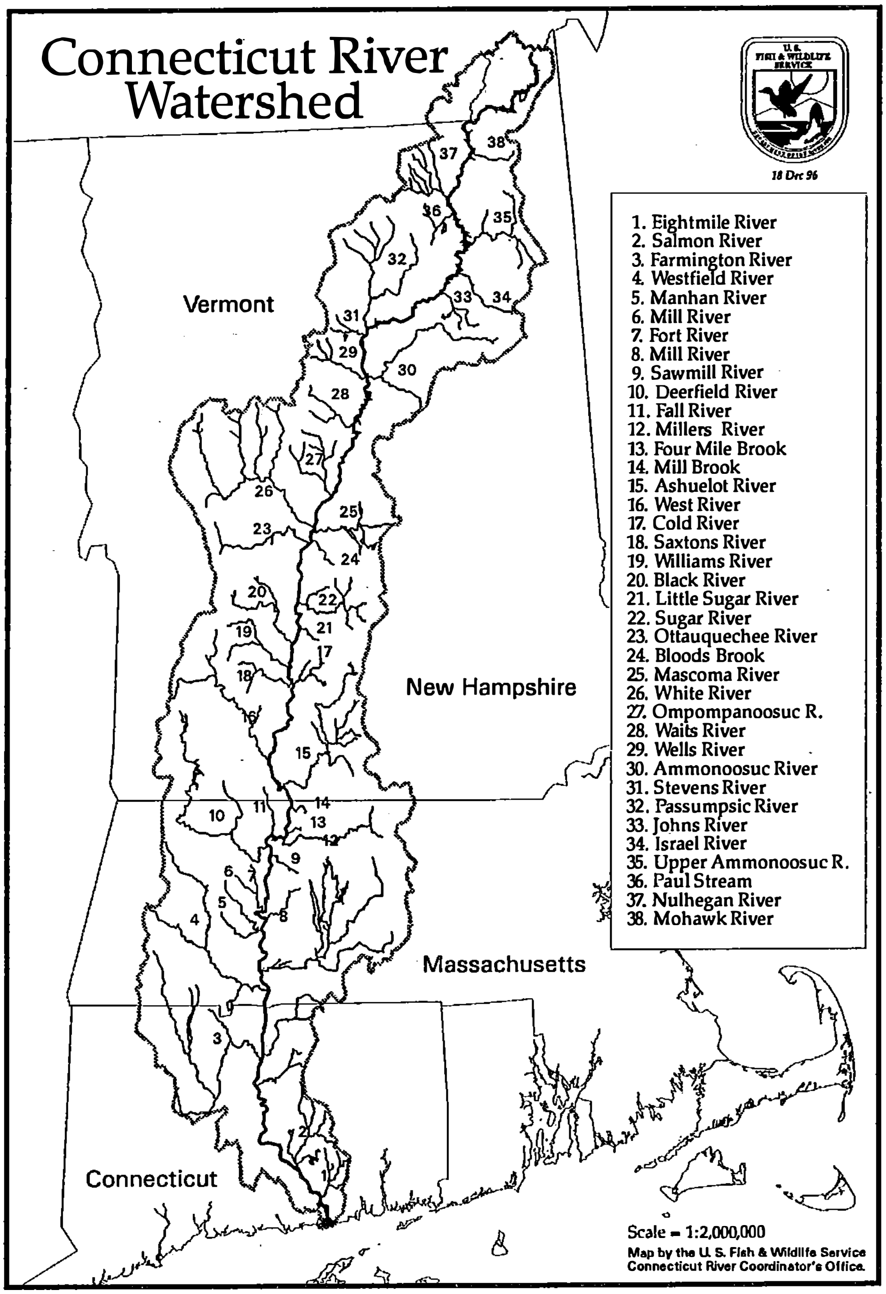


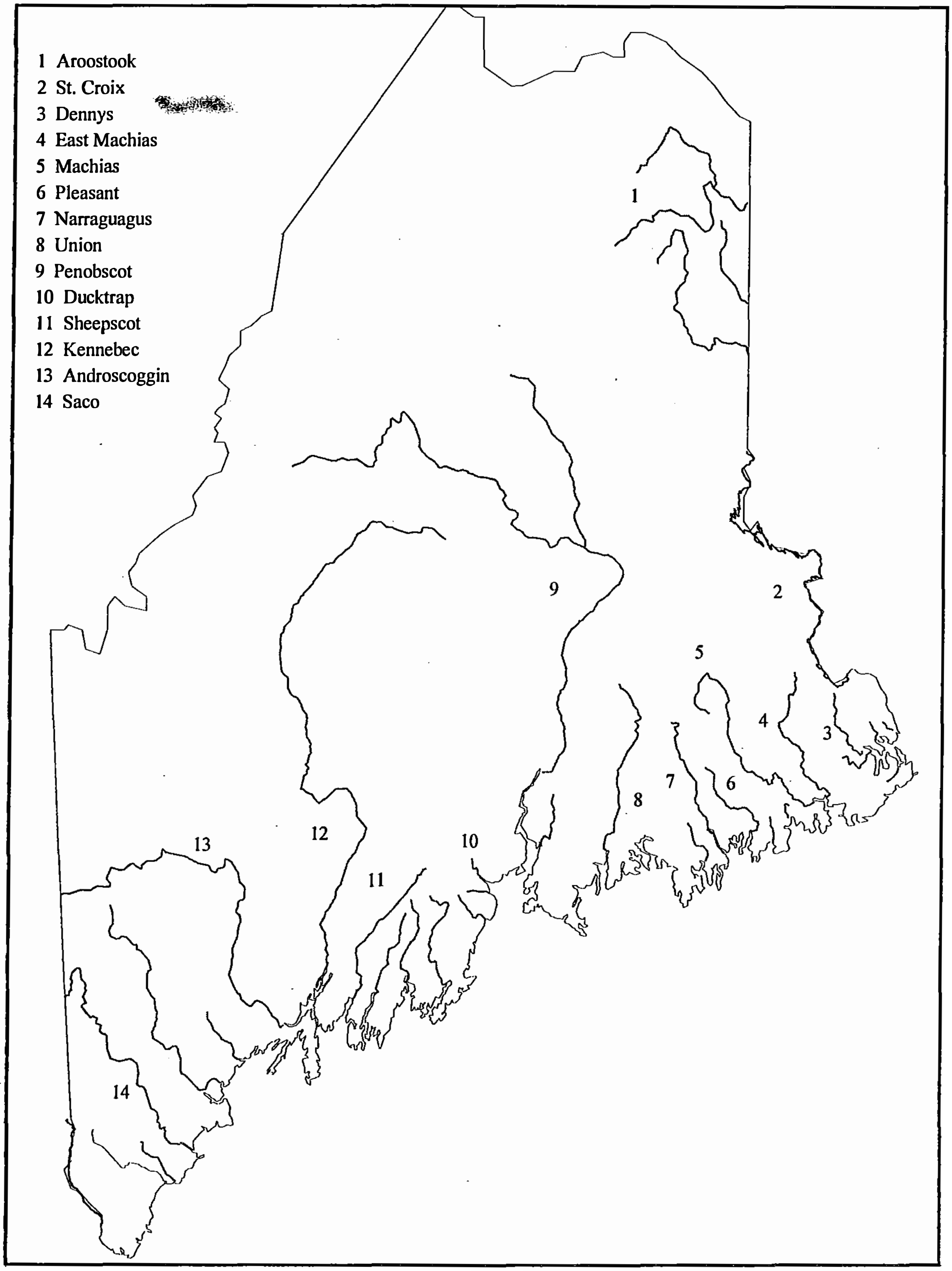
Figure XX. Length distribution comparison of Atlantic salmon smolts from Cherryfield trap compared to pollack, Atlantic herring, and alewife collected in gillnetting in 1996.



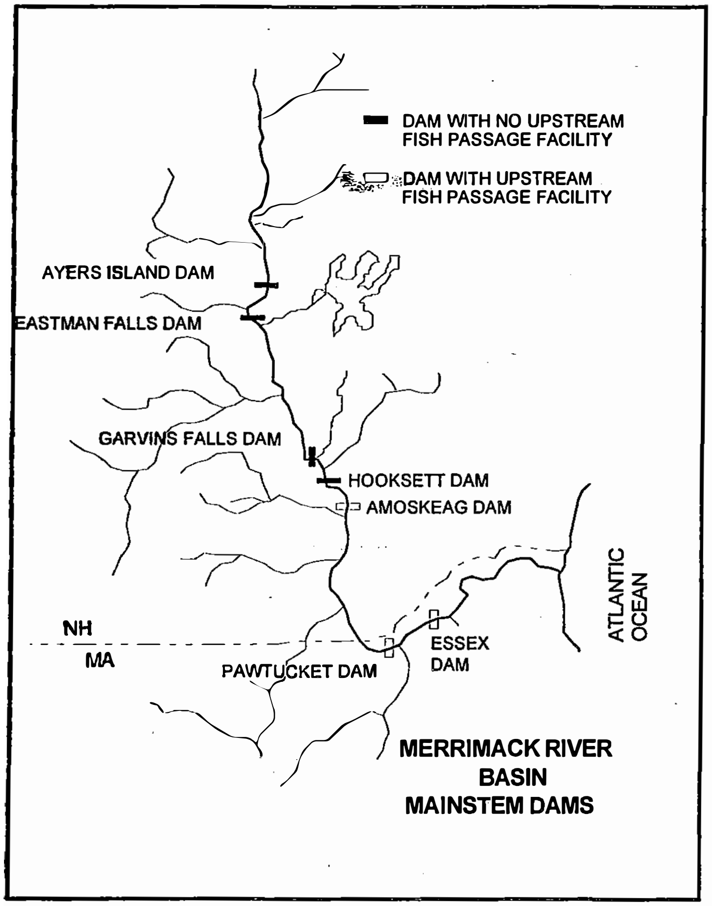
10.3. LOCATION MAPS

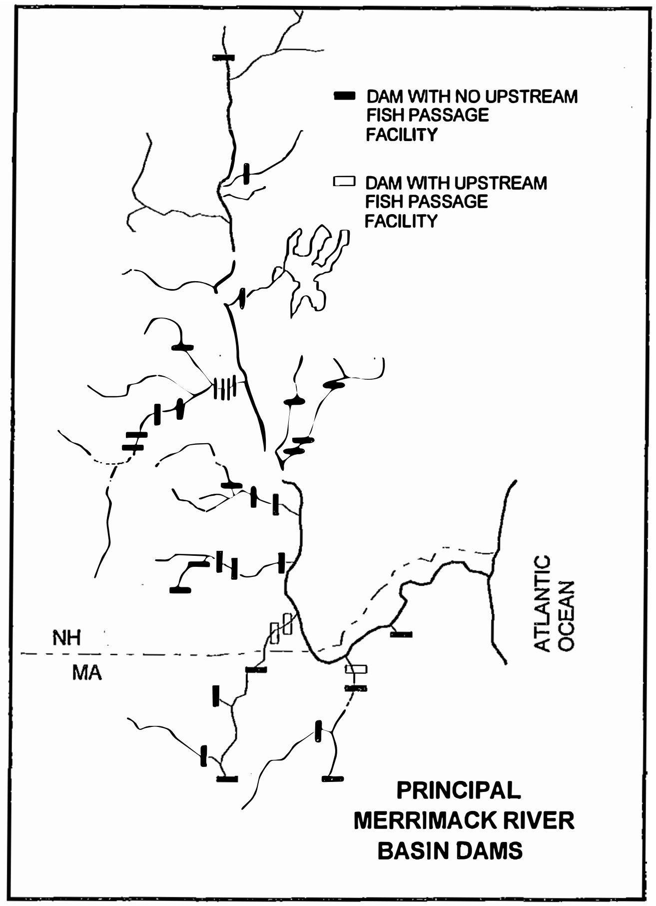
Important Atlantic Salmon Rivers of New England

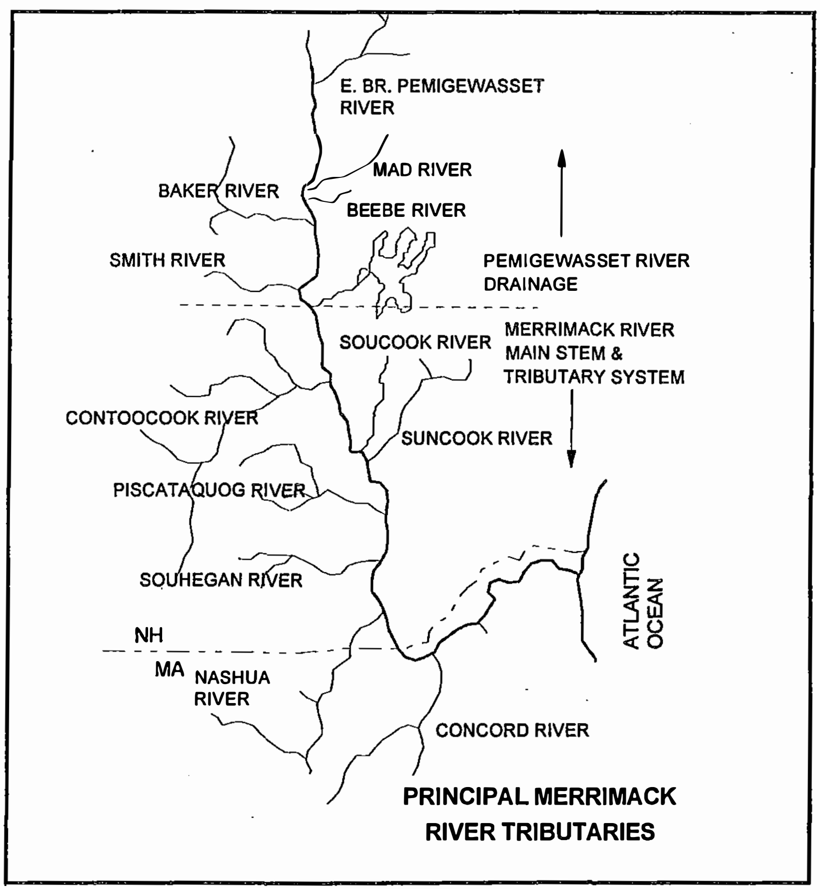

Connecticut River Watershed
18 Dec 96
1. Eightmile River
2. Salmon River
3. Farmington River
4. Westfield River
5. Manhan River
6. Mill River
7. Fort River
8. Mill River
9. Sawmill River
10. Deerfield River
11. Fall River
12. Millers River
13. Four Mile Brook
14. Mill Brook
15. Ashuelot River
16. West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



Important Atlantic Salmon Rivers of Maine


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


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


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
NH
MA
NASHUA RIVER
ATLANTIC OCEAN
CONCORD RIVER
PRINCIPAL MERRIMACK RIVER TRIBUTARIES