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

REPORT NO. 10 - 1997 ACTIVITIES

HADLEY, MASSACHUSETTS
MARCH 2 - 4, 1998

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 2 - 4, 1998.

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 15,203,700 juvenile salmon (fry, parr, and smolts) were stocked. The Connecticut River received the largest percentage (56%); the majority of which was fry. Maine rivers received approximately 27% of the total, followed by the Merrimack River with 13%. The total release was a 13% increase over that of 1996.

In addition to the juveniles stocked, mature adults were stocked by the Maine, Merrimack, and Connecticut programs. In general, these fish are either spent broodstock or broodstock that are excess to hatchery capacity. All these adults are either river specific or domestic progeny of river specific programs. For 1997, a total of 6,629 captive and domestic adults were released into the rivers of New England.

Throughout New England juvenile and adult salmon were marked with a variety of finclips and/or miscellaneous external tags (e.g., PIT tags, VI tags, elastomer tags, Petersen disc tags, etc.). The salmon releases included about 50,000 marked and tagged salmon in 1997. Of the total, 51.4% were released into Maine rivers, 45.6% were released into the Merrimack River drainage, 2.8% were released into the Connecticut River drainage, and 0.2% into the Pawcatuck River. Atlantic salmon of all life stages, except fry, were utilized.

Documented total adult salmon returns to rivers in New England amounted to 1,758 salmon in 1997. The majority of the returns was recorded in the rivers of Maine with the Penobscot River accounting for nearly 77% of the total New England returns. The Connecticut River adult returns accounted for nearly 11% of the New England total and 73% of the adult returns outside of Maine. Overall, 18% of the adult returns to New England were 1SW salmon and 82% were MSW salmon; most (74%) of these fish were of hatchery smolt origin. Of the total returns, approximately 26% were of wild origin (from natural reproduction and from fry plants).

Directed sea-run Atlantic salmon fishing is not allowed in New England, with the exception of a catch and release fishery in Maine. The estimated number of salmon caught and released in 1997 was 333 fish, which was a 39 % decrease from the previous year. The domestic broodstock fishery in the Merrimack River resulted in an estimated 1,705 salmon landed.

Egg sources for the New England Atlantic salmon culture programs included sea-run salmon, captive and domestic brood stock, and reconditioned kelts. A total of 455 sea-run females, 3,849 captive/domestic females, and 208 female kelts contributed to the egg take. The number of females (4,512) contributing was considerably more than in 1996 (3,869). The total egg take, 25,299,700, was nearly the same as that of 1996.

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

It was gratifying for me to see the continued advancement of the committee in working group format. The entire committee was extremely pleased with the work of the presenters and thank each of them for their contribution. The 1998 meeting was productive and set the stage for an excellent meeting in 1999.

The committee agreed to convene the working group meeting in 1999 at the U.S. Fish and Wildlife Service's Regional Office in Hadley, MA. The Working Group meeting will begin on March 1 and continue through March 3, 1999.

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 199 sea-run Atlantic salmon adults was observed returning to the Connecticut River watershed including: 96 at the Holyoke fishway on the Connecticut River; 60 at the Rainbow fishway on the Farmington River; 39 at the Decorative Specialties International (DSI) fishway on the Westfield River; and, three at the Leesville fishway on the Salmon River. One additional salmon was captured by electrofishing and it was released below the Enfield dam. The spring run lasted from May 2 to July 29. Nine salmon returned in the fall, including two at Holyoke, four at Rainbow, one at Leesville and two at DSI. The fall run lasted from September 15 to November 4.

A total of nine salmon was released from the Holyoke fishlift (river km 138) and permitted to continue upstream; of these, two were observed passing the fishway at Turners Falls, MA (river km 198), four were observed passing the fishway at Vernon, VT (river km 228). The fishway at Turners Falls was only monitored part-time explaining why more fish were observed at Vernon. No salmon passed Bellows Falls. A total of thirteen salmon was released above the DSI dam on the Westfield River (12 in support of a radio telemetry study, and 1 by accident). Additionally, one salmon was accidentally released above the Rainbow dam on the Farmington River.

A total of 175 salmon was retained for broodstock: 113 were held at the Richard Cronin National Salmon Station (RCNSS), and 62 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. Sea-age information on released fish was generally determined by size. Of the 199 observed salmon, one (0.5%) was stocked as a smolt, and 198 (99%) were stocked as fry. The smolt origin fish was a repeat spawner. Known sea-age of fry or wild origin fish was comprised of grilse (N=6), 2 sea-winter (N=175), and 3 sea-winter salmon (N=1). Known freshwater ages of wild salmon were 1^{+}(N=15), 2^{+}(N=152) and 3^{+}(N=13). The known sex ratio of the wild salmon was 113 females: 58 males, although this data is incomplete.

2.1.1.b. Hatchery Operations

Over 500 volunteers made a successful stocking season possible in the four state basin. The disease management protocol for control of furunculosis was greatly aided by special Food and Drug Administration approval of oxolinic acid for prophylactic use against the disease this year.

Egg Collection

A grand total of 14,376,226 green eggs was produced at seven state and federal hatcheries within the basin. This is about 628,000 fewer eggs than produced in 1996. The production was reduced in part because of the loss of last year's kelts to furunculosis.

Sea-Run Broodstock

A total of 770,652 eggs (5.4% of the grand total eggs produced) was taken from 110 sea-run females (5.2% of the grand total females spawned) held at the Whittemore Salmon Station (WSS) and the Richard Cronin National Salmon Station (RCNSS). A sample of the fertilized eggs from all sea-run crosses was again egg-banked at the WSS for disease screening and subsequent production of future domestic broodstock.

Domestic Broodstock

A total of 11,602,300 eggs (80.7% of the grand total eggs produced) was taken from 1,809 domestic females (85.8% of the grand total females spawned) held at the RCNSS, White River National Fish Hatchery (WRNFH), Roger Reed State Fish Hatchery (RRSFH), Kensington State Salmon Hatchery (KSSH), and Roxbury Fish Culture Station (RFCS).

Kelts

A total of 2,003,274 eggs (13.9% of the grand total eggs produced) was taken from 188 kelt females (8.9% of the grand total females spawned) held at the WSS, RCNSS, and North Attleboro National Fish Hatchery (NANFH).

2.1.1.c. Stocking

Juvenile Atlantic Salmon Releases. A record total of 8,536,213 Atlantic salmon was stocked into the Connecticut River watershed in 1997. Fish were released into 30 tributary systems throughout the basin. The total consisted of 7,768,596 unfed fry (91%), 757,432 fed fry (8.9%), 8,785 0+ parr (<1%), and 1,400 smolts (<1%). Research utilized 8,700 of the unfed fry. Continued emphasis on fry production has enabled the cooperators to expand the stocking program to include previously unstocked sites in tributaries to the mainstem. The Connecticut River Atlantic Salmon Commission agreed to provide 550,000 fry to the Merrimack River program due to severe fry losses at one of their primary production facilities.

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 in 1997. This was the fifth consecutive year that a study has been conducted by marking smolts at the Cabot Station bypass facility and recapturing them at the bypass facility in the Holyoke Canal. Smolt migration timing was later than past years, probably due to cooler river temperatures. Smolt catches at both Holyoke and Cabot remained fairly low from late April through mid May, before peaking at the end of May. Some smolts were still migrating in early June when sampling terminated. As a result, the population estimate of 29,500 smolts passing Holyoke (95% confidence interval: 20,800-38,100) is likely an underestimate. Travel time for the 54 km distance between mark and recapture averaged 41 h, with half the smolts arriving in less than 28 h. Mean total length of smolts sampled at Cabot was 182 mm. Sensitivity analysis of the population estimate to sampling error, assumption violation, and stratum selection indicates that the model is fairly robust to modest errors and changes.

Based on expanded electrofishing data from index stations and assumed overwinter mortality, it was estimated that 240,000 smolts were produced in tributaries basin wide, of which 179,000 were produced above Holyoke in 1997. Actual overwinter mortality is unknown and the estimate does not include smolt mortality during migration. The differences between the two smolt estimates at Holyoke reflect potential errors in each of the estimates and mortality of smolts between tributary of origin and Holyoke.

Index Station Electrofishing Surveys

Juvenile salmon populations were assessed by electrofishing in late summer and fall at nearly 200 index stations throughout the watershed. Sampling was conducted by CTDEP, MACFWRU, New Hampshire Fish and Game Department (NHFG), USFS, USFWS, and VTFW. Data are used to evaluate fry stocking, estimate survival rates, and estimate smolt production. All of the data has not been analyzed yet. Densities of parr varied widely throughout the watershed. Most smolts produced in 1998 are again expected to be two year olds, with some yearlings and three olds.

2.1.1.e. Fish Passage

Final license applications from the Town of Ashburnham Light Plant/Massachusetts Municipal, Wholesale Electric Company and Holyoke Water Power were filed with the Federal Energy Regulatory Commission (FERC). Review of the applications is ongoing. The opportunity for intervention will follow in December. An expedited settlement was signed in July for the Fifteen Mile Falls Project. Terms of the agreement include flow releases from Moore, Comerford and McIndoes and Lake Francis, requirements for up and downstream passage, and habitat restoration and protection.

Northeast Utilities Service Company deployed and tested a partial barrier net at the Northfield Mountain Pumped Storage intake in 1997. A small number of salmon smolts were entrained in the net. A radio-telemetry study of passage success is planned for 1998. The Turners Falls fish bypass weir with trash rack overlays and corrected lighting provided the best ever efficiency at this site. Results are still under review.

The FERC ruled that International Paper must provide interim downstream fish passage at the Woronoco Dam on the Westfield River immediately.

Interim passage measures will remain in place on the Deerfield River until next summer when bypass designs will be implemented at Projects 2, 3, and 4. A similar agreement concerning bypass and minimum flow has been reached on the Gardners Falls Project.

Smolt passage studies will be repeated in 1998 on the Black River at Cavendish following poor results with landlocked salmon in 1997. Studies will also be completed on the Sugar River.

2.1.1.f. Genetics

In the past, deliberate efforts were made to randomize salmon matings in hopes of minimizing inbreeding. A new initiative was implemented to protect genetic variability and minimize the risk of inbreeding among sea-run broodstock. Each sea-run salmon was tissue sampled upon arrival at the salmon stations. PIT tags were inserted into the fish and tissue samples were correlated to the appropriate PIT tag. Tissues were analyzed by Dr. Tim King (USGS/BRD- Leetown) for microsatellite DNA markers and a "matrix of relatedness" was produced for the population that displayed the familial relatedness among all individual fish. The objective during subsequent spawning was not to mate fish that were closely related to each other and a numerical value of relatedness was established as a threshold to aid egg-takers in determining when a mating should not occur. This activity was coordinated by Dr. Ben Letcher (USGS/BRD-Conte Lab), who established databases and accessed them at each salmon station via computer on the days of egg taking.

Although the sea-run population of broodstock (~180) exceeded the minimum recommended levels for stock conservation (50 pairs), the mating process was complicated by the uneven sex ratio (skewed heavily in favor of females) and the fact that some potential crosses had to be avoided due to the "relatedness guide" described it the previous paragraph. In practice, the program came very close to the minimum recommended level of breeders.

Approximately 2,000 female domestic broodstock were spawned at the WRNFH (USFWS), RRSFH (MA), RFCS (VT), and KSSH (CT) following protocols established in the past. They were spawned with one male each. They are the first group that was selected (from sea-run parents) for the program's egg-bank, located in the Whittemore Salmon Station (CT) in 1993. The fish were screened for fish pathogens.

The genetic initiative described in the first paragraph is part of a larger study that will test the feasibility of using microsatellite DNA markers as a "genetic tag" for stocked fry in order to subsequently identify salmon by their origins. Doctors Letcher and King have worked with the CRASC Genetic Subcommittee to develop this study that will stock into the Farmington River about 450,000 fry of sea-run parentage belonging to as many as nine groups with unique genetic tags. The study will follow these fish through time by tissue sampling Farmington River salmon at the parr, smolt, and adult stages.

Dr. King reported to the Genetic Subcommittee on the results of testing Connecticut River salmon for genetic variability. The population exhibits 75% heterozygosity, which is moderate. However, it possesses one less haplotype than the Maine populations.

2.1.1.g. General Program Information

Mr. Duncan McInnes, New Hampshire Department of Fish and Game, was appointed by the Commission to serve as Chair, and Mr. Ernie Beckwith, Connecticut Department of Environmental Protection, was appointed to serve as Vice Chair of the Connecticut River Atlantic Salmon Commission.

The draft revised *Strategic Plan for the Restoration of Atlantic Salmon to the Connecticut River* was completed and approved for public release by the Connecticut River Atlantic Salmon Commissioners in September 1997. The draft Plan was introduced to the public in January 1998 at Public Information meetings in the four basin states. Comments were accepted, and will be reviewed and addressed before the final document is completed.

A sea-run and domestic broodstock study on the Westfield River Massachusetts, permitted successful, natural, in-stream spawning in that watershed once again this past fall.

The U.S. Fish and Wildlife Service agreed to produce 100,000 two-year smolts at the Pittsford National Fish Hatchery in Vermont. This will enable the program to annually release both smolts and fry, providing a buffer against poor instream smolt production years.

The Connecticut River Atlantic Salmon Commission hosted a scientific forum to bring fisheries managers, fish culturists, researchers, administrators and academics together to hear and discuss research and activities pertaining to the restoration of salmon and shad in the Connecticut River basin. A total of 18 speakers and 85 participants attended the meeting.

2.1.2. MAINE PROGRAM

2.1.2.a. Adult Returns

Partial adult salmon counts were made at weirs operated on the Dennys and Pleasant rivers during 1997, while total salmon counts were obtained at fishway trapping facilities on the St. Croix, Narraguagus, Penobscot, Androscoggin, and Saco rivers. Redd counts in November were also used to estimate adult returns to various Maine rivers.

Returns of adult spawners remain critically low as evidenced by low documented adult returns that include rivers with less than two spawners and extremely low redd counts. While the possibility of undetected wild escapement exists, these developments have further elevated concern for stocks in several rivers. These developments continue a trend of recruitment failure in these rivers and the risk of extirpation of some populations.

Rivers With Native Salmon Runs

Dennys River. A picket-type weir was operated on the Dennys River from early May to early November. Only 2 salmon were captured and both were escapees from aquaculture operations. The weir was very ineffective in capturing fish, as evidenced by the fact that several salmon were observed below the weir on numerous occasions. The possibility exists that fish gained upstream access during periods when the weir was compromised. Therefore, the assessment committee has reservations about the accuracy of the trap count. About 10 salmon were caught and released by anglers fishing the Dennys River in 1997, but information is not available concerning the origin (aquaculture, captive release, or wild) of those fish. A total of 33 redds were counted in the Dennys River in the fall of 1997. Although this represents a slight increase over the previous year when 30 redds were counted, many of the redds constructed in 1997 undoubtedly originated from the 118 adult captive broodstock that were stocked into the river from Craig Brook

NFH.

Narraguagus River. Thirty-one adult salmon were counted at the Cherryfield fishway trapping facility in 1997 with an additional six jumping the spillway as confirmed by video. This number was about 42% less than the number counted in 1996. No farm fish escapees were captured in 1997. Anglers fishing the Narraguagus River were known to have caught and released 13 salmon during 1997, 58% fewer than the previous year. A total of 78 redds were counted in the drainage in 1997.

Pleasant River. A picket-type weir was operated on the Pleasant River throughout 1997 resulted in the capture of only one salmon, which was released downstream of the weir. The possibility exists that fish gained upstream access during periods when the weir was compromised. Therefore, the assessment committee has reservations about the accuracy of the trap count. Only one redd was observed in the fall (compared to 41 in 1996); however, due to the dark, "tea-colored" waters of the Pleasant River it is likely that other redds went undetected. At least one adult salmon was observed above the weir during the fall of the year. There were no reported rod catches of Atlantic salmon in the Pleasant River in 1997.

Sheepscot River. There were no reported rod catches of Atlantic salmon in the Sheepscot River in 1997, and 8 redds were found (vs 12 the previous year) in November.

Machias, East Machias, and Ducktrap Rivers. Anglers caught and released a few salmon on the Machias and East Machias rivers; many of those fish undoubtedly were captive broodstock stocked into those rivers from Craig Brook NFH. There was no reported rod catch in the Ducktrap River. Redd counts in the E. Machias, Machias and Ducktrap rivers in 1997 (vs. 1996 number) were 11 (vs 59), 57 (vs 102) and 2 (vs 44), respectively.

Other Maine Restoration Rivers

Penobscot River. Total adult returns to the Penobscot River fish trapping facility at the Veazie Dam was 1,355 salmon, a 34% decrease from 1996. 1SW returns (247) were 50% lower than the previous year, while MSW returns declined by 29%. Returns of 2SW salmon to the Penobscot River in 1997 were 12% and 33% below the 5- and 10-year averages, respectively. About 300 salmon were estimated to have been caught and released by anglers throughout the angling season, which was closed during the months of July and August in an effort to reduce the potential for mortality of salmon caught and released during the period when water temperatures are highest. About 40% of the Penobscot salmon run (536 fish) was transported to Craig Brook National Fish Hatchery for broodstock purposes in 1997.

St. Croix River. A total of 43 salmon was captured at the Milltown Dam fishway during 1997, and 13 were retained for broodstock purposes. The 1997 trap catch represented a 50% increase in the number of 1SW salmon counted the previous year (33 vs 22); however, MSW salmon numbers declined by 91% (10 vs 110) compared to 1996. The broodstock that were spawned in November at the Mactaquac Hatchery (Fredericton, N.B.) by Department of Fisheries and Oceans personnel, provided about 51,000 eggs for future restocking programs in the St. Croix. An additional 27 farm fish escapees (39% of the total trap catch) were documented in 1997. Three of these fish were sacrificed for fish health/genetics background information.

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

Saco River. A total of 28 adult salmon was enumerated at the Cataract Dam fish passage facilities (one fish lift, one fishway) in 1997. Overall, salmon returns declined by 48% from the previous year.

Union River. Operation of the trapping facility on the Union River at Ellsworth resulted in the capture of 8 salmon, all of which were transported upstream and released. Although the 1997 trap catch was much lower than the previous year (69 salmon), the sporadic releases of fry and parr in recent years undoubtedly contributed to the reduced salmon numbers in the Union River in 1997.

Aroostook River. The trap catch at the Tinker Dam in 1997 was 12 salmon, an 88% decline from the number captured in 1996. Returns to the Aroostook were reflective of the entire Saint John Drainage, which experienced a 50% reduction in salmon returns compared to the previous year. Atlantic salmon returns to the Aroostook River are counted in the returns to the Saint John River in Canada, therefore they are not included in the totals for the USA.

2.1.2.b. Hatchery Operations

Broodstock (all sources) from six Maine rivers produced the following egg takes at Craig Brook NFH in November:

Dennys River	493,650
East Machias River	394,000
Machias River	602,600
Narraguagus River	509,800
Penobscot River	2,223,000
Sheepscot River	375,750
	======
Total	4,598,800

A total of 164 salmon parr was collected from the Pleasant River in 1997. These fish will be reared to maturity at a privately-owned hatchery facility in the drainage (Connors Aquaculture, Inc. hatchery in Deblois), in order to provide river-specific hatchery stocks for future restocking programs in the Pleasant River. No other parr were collected in 1997 for the captive broodstock program at Craig Brook NFH because of the high probability of collecting fish originating from fry which were stocked from Craig Brook in previous years. This approach will be re-evaluated in 1998.

2.1.2.c. Stocking

Most of the 4 million salmon stocked into 10 Maine rivers in 1997 were released as fry that had started feeding prior to release. A complete stocking summary is presented in Table 2.2.1.

Native Atlantic salmon parr have been collected from the Maine native salmon rivers since 1992. These parr were raised to maturity at Craig Brook NFH, and have been producing eggs for the river-specific program since 1994. The increasing number of adult fish, ranging in size from 1.4 to 4.5 kg each, resulted in an increased demand on the water supply at the hatchery. Therefore, as in 1996 a portion of these broodstock (580 salmon) was returned to their rivers of origin in 1997.

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 low and far below average in most rivers, except for the Narraguagus (see below) and at a few sites that had densities commensurate with long term averages due to the recent river-specific fry stocking program. The low juvenile salmon populations throughout many Maine rivers continues to be a direct result of insufficient spawning escapement in recent years, and suboptimal survival of stocked fry.

Based on preliminary data analysis, the drainage-wide population of age 1+ and older parr on the Narraguagus River in 1997 was approximately 26,775 ± 4,016, a 130% increase over the 1996 estimate. Estimates are based upon electrofishing data from up to 45 sites that are sampled annually. Drainage-wide parr population estimates, which have been conducted on this river since 1991, were as follows:

1997	26,775 ±4,016
1996	11,073 ±1,196
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 1997 parr population estimate, which is the highest estimate in the time series of data, reflects the significant influence of the river-specific fry stocking program; in 1996 about 196,000 fry were scatter planted throughout the Narraguagus River Drainage.

The intensive smolt studies in the Narraguagus River, a joint ASA-NOAA effort, continued in the spring of 1997. Four rotary drum, screw-type traps were used to capture about 750 smolts at two sites in the lower river, which produced an estimated smolt run of about 3,000 wild smolts. Ultrasonic pingers were surgically implanted into 109 wild smolts with only 8 mortalities. An additional 29 hatchery-origin smolts (of 2,000 stocked) were also fitted with pingers. There was a high degree of residualism in this group of smolts, indicating that - although silvery and sea-water tolerant - they weren't ready to migrate to sea. These smolts were reared in a private aquaculture hatchery in western Maine (Oquossoc); environmental conditions at the hatchery were very different from the Narraguagus River in eastern Maine, which undoubtedly contributed to the observed residualism. Pingers were also implanted into 10 aquaculture fish which were released from a commercial net-pen in Narraguagus Bay. Data from juvenile and adult salmon tagged with ultrasonic tags is still being analyzed, and detailed results from these studies may be found in other sections of this report.

2.1.2.e. Fish Passage

Kennebec River - Edwards Dam:

In November 1997, the Federal Energy Regulatory Commission denied a new license for the Edwards Dam hydroelectric project and called for the decommissioning and removal of the project facilities. The FERC order requires that the current owners of the project develop a decommissioning plan within one year, which would address removal of the dam from the Kennebec River and related issues. Edwards Dam is the first barrier on the Kennebec River, and its removal will restore 15 miles of riverine habitat. This will benefit a number of migratory species, including Atlantic and shortnose sturgeon, striped bass, rainbow smelt, Atlantic salmon, American shad, river herring (alewife and blueback herring), and American eel. The FERC's decommissioning order is currently under appeal by the owners of the project, which makes the schedule for accomplishing actual removal of the dam unclear.

Lower Penobscot River FEIS:

In October 1997 the FERC staff issued its Final Environmental Impact Statement on the Lower Penobscot River Basin. The FEIS covers the proposed licensing of several hydroelectric projects, including Basin Mills, Milford and Stillwater. In a move that has great significance for salmon and other migratory fishes, the FERC staff recommended against construction of a new 38-MW Basin Mills dam on the Penobscot River (reversing its position in the draft EIS), due to potential impacts to anadromous fish and their future uses by the Penobscot Indian Nation. The FERC staff also recommended expansion of the existing Veazie project (new 8-MW Station C powerhouse), and decommissioning of the 2-MW Orono project (which had already been shut down due to penstock failure), both of which were proposed under the Basin Mills license application. Expansion of the existing Milford project (additional generating unit) and relicensing of the existing Stillwater project were also recommended in the FEIS. The FEIS also adoped all of the improvements in fish passage facilities that had been prescribed by the Department of the Interior for the projects on the lower Penobscot River. The FERC has yet to issue license orders, which would implement the staff's recommendations in the FEIS.

Miscellaneous new licensing orders:

During 1997 the FERC issued new licenses for a number of existing hydroelectric projects, including: Moosehead Lake, Eustis, Wyman, Sandy River, Weston, and Fort Halifax, in the Kennebec River drainage; Marcal, in the Androscoggin River drainage; Swans Falls, in the Saco River drainage; and South Berwick, in the Salmon Falls drainage. All of the newly issued licenses contain provisions for fish passage (immediate or reserved) and instream flows, all of which will directly or indirectly benefit Atlantic salmon and other migratory species.

Saco River. In 1997 Central Maine Power Co. completed construction of new fish passage facilities (fish locks) at the Springs and Bradbury Dams on the lower Saco River. Evaluation of the effectiveness of these facilities is ongoing.

The Saco River Coordinating Committee began the third year of a four year assessment cycle to determine the need for upstream fish passage on mainstem dams. Program activities and accomplishments will be reported in a 1997 annual report.

A comprehensive multi-party instream flow agreement for the Saco River hydro projects was signed in June.

2.1.2.f. Genetics

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

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

During 1997, tissue samples (ventral fins) were collected from 63 Atlantic salmon parr in Kenduskeag Stream, a tributary to the lower Penobscot River, with its confluence below the remains of the Bangor Dam. Additional tributaries to the lower Penobscot River may be sampled in the future.

Four adult salmon (1 Dennys River and 3 St. Croix River), which were identified as escapees from aquaculture facilities, were sampled for DNA analyses. New in 1997 was the collection of Atlantic salmon eggs for genetic analyses. Researchers at the Leetown Science Center are attempting to determine at what time during the egg development stage that the genetic markers become detectable. Egg samples from pre-fertilization to 64 days post-fertilization were collected from the Narraguagus River stock at Craig Brook NFH. In the future, it may be possible to determine the origin (e.g., wild vs aquaculture) of eggs from redds by collecting a sample of eggs and characterizing them genetically.

2.1.2.g. General Program Information

The nine-member Salmon Board, which governs all activities of the Maine Atlantic Salmon Authority, promulgated several new angling regulations in 1997. The general, statewide Atlantic salmon angling season in Maine is from April 1 through June 30, closed during the months of July and August, and open again from September 1 through October 15. All salmon angling continues to be restricted to catch and release. Furthermore, removal of the fish from the water is prohibited (e.g., for photographs), and if a landing net is utilized in releasing the salmon, it must be made of knotless materials and must not exceed ½ inch mesh (stretched). These regulations were designed to further reduce the possibility of salmon mortality associated with the catch and release fishery. Additionally, several known salmon holding pools in the Penobscot River drainage were permanently closed to angling for Atlantic salmon, and to angling for all other species of fish from July 1 through September 30.

On December 15, 1997, the U.S. Fish and Wildlife Service and the National Marine Fisheries Service withdrew the proposal to list the wild salmon populations in seven Maine rivers as "threatened" under the Endangered Species Act. In lieu of listing, the Services accepted the State of Maine's *"Atlantic Salmon Conservation Plan for Seven Maine Rivers"* which had been submitted to the Services in March. In concordance with the withdrawal of the proposed listing under the ESA, Maine Governor Angus King signed a Executive Order directing all state agencies to implement the Conservation Plan. Administration of the Plan was assigned to the Maine Land and Water Resources Council, and the State Planning Office has hired a Coordinator to oversee implementation and reporting requirements associated with the 5-year plan.

Design, siting and permitting continued in 1997 for the construction of semi-permanent (actually, more stable seasonal) "A-frame" weirs for the Dennys, East Machias , Pleasant rivers. Construction of the weirs is scheduled to begin in 1998.

In 1997, design and planning for the almost $12 million reconstruction of the Craig Brook NFH continued. Construction is scheduled to begin in July, 1998, for a new 6-bay production, incubation and fry rearing isolation facility, a new water supply pipeline from Craig Pond, and expanded office and outreach facilities.

2.1.3. MERRIMACK RIVER

2.1.3.a. Adult Returns

Total Atlantic salmon returns to the Merrimack River in 1997 amounted to 71 fish; five fewer fish than recorded in 1996. Included within the total returns was a single multi-sea-winter salmon angled downstream from the Essex Dam fish-lift in Lawrence, MA and 70 adults lifted at the passage facility (69 captured, one grilse escapee). The returns are broken down as follows:

Fry Stocking Origin Adults

Grilse	2SW	3SW	RS
8	5	0	1

Parr Stocking Origin Adults

Grilse	2SW	3SW	RS
1	0	0	0

Smolt Stocking Origin Adults

Grilse	2SW	3SW	RS
8	43	0	4

Unknowns

Grilse	2SW	3SW	RS
1	0	0	0

The entire grilse component (25% of river returns) was comprised of males. The virgin multi-sea-winter component (68% of river returns) was comprised of 33% males and 67% females. The remaining repeat spawner component (7% of river returns) included two males and three females.

The rate of return (adults produced per 1,000 juveniles stocked) for fry-origin adults continued to be severely low for the sixth consecutive cohort. The rate, 0.0078, for the 1993 fry plant/cohort (ages 2.3, 3.2., and 3.3 not yet accounted for) is now the lowest on record. The dramatic change is illustrated in the following:

Cohort	No. Fry Required to Produce One Adult Return
1978	5,900
1979	1,800
1980	2,900
1981	700
1982	1,000
1983	---------
1984	11,100
1985	2,500
1986	4,800
1987	3,900
1988	18,100
1989	24,000
1990	46,400
1991	85,800
1992	79,800
1993	128,600

The rate of return (adults produced per 1,000 juveniles stocked) for smolt-origin adults increased for the fourth consecutive cohort. The rate for the 1995 cohort (age 1.3 adults not yet accounted for) amounted to 0.76, an increase of 38% above the rate for the 1994 cohort.

2.1.3.b. Hatchery Operations

The fish cultural changes initiated in 1994 continued. As in the past, Atlantic salmon fry produced for stocking purposes were provided by the NANFH and the WSFH and were primarily of domestic brood stock parentage. A very few fed fry were produced by the Nashua NFH (NNFH). Smolts produced for stocking purposes in 1997 were provided by the Green Lake NFH (GLNFH) and were of Penobscot River sea-run parentage.

Egg Collection

Sea-Run Brood Stock

Thirty-four females were captured at the Essex Dam fish-lift and transported to the NNFH, where 31 produced 284,300 eggs. The majority of the eggs (99%) were transported to the NANFH to be hatched and released as fry (some eggs (approximately 1%) were retained at the NNFH for brood stock development). 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 brood stock development.

Post-spawners were not released back into the Merrimack River (as had been done in the past two years) since they had received treatments to prevent the occurrence of furunculosis.

Captive/Domestic Brood Stock

A total of 754 female brood stock held at the NNFH provided an estimated 4,641,700 eggs. Many of the eggs were transported to the WSFH (27%), the Powder Mill SFH (less than 1%), and NANFH (71%) to be held for fry stocking within the Merrimack River basin. Two percent were held at the NNFH for future brood stock development and less than 1% was allocated to research. Approximately 500,000 of the eggs that were transported to the NANFH are being incubated for the Pawcatuck River salmon restoration program.

2.1.3.c. Stocking

Approximately 2 million juvenile Atlantic salmon were released in the Merrimack River basin during the period, March - October of 1997. The release included approximately 1.8 million unfed fry, 189,000 fed fry, 14,900 parr (0^+, yearlings, and 1^+), 52,500 yearling smolts, and 5,300 two-year-old smolts. Although the majority of the smolts were not marked or tagged, it is possible to determine the origin of adult returns by analyzing the pattern or signature on the scales of captured fish. Scale analyses is therefore used to differentiate between fish stocked as fry or smolts.

Eight major watersheds were stocked with fry at densities that ranged from 36 to 72 fry per 100 m^2. The watersheds included the Pemigewasset (includes main stem, East Branch, and a number of small tributaries), Mad, Beebe, Baker, Smith, Contoocook, Piscataquog, and Souhegan rivers. Smolts were released into the main stem of the Merrimack River a short distance downstream from Amoskeag Dam in Manchester, NH.

The number of fry released was less than the proposed target release of 3.1 million. The low number of sea-run returns and a significant loss of fry at the NANFH contributed to the decrease in the production of fry. Melting snow from a major spring storm resulted in water quality perturbations at the hatchery, and significant fry mortality ensued.

2.1.3.d. Juvenile Population Status

Fry/Parr Assessment

Parr were collected at 24 sites throughout the basin in 1997. A stratified sampling scheme was again implemented in 1997 to determine the abundance of parr throughout the basin. Parr estimates were determined for the basin, regions and geostrata. Habitat was stratified into four regions, where each region has different characteristics that include climate, geography, geology, hydrology, and land use. Estimates derived for geostrata involved sampling within regions in very large rivers [drainage area (da) >

200,000 ha, in large rivers (40,289 ≥ da ≤ 200,000 ha), and small rivers and brooks where da < 40,500 ha. Sampling was directed at age 1^+ parr and involved electrofishing during late summer and early fall. Data collection involved a cooperative effort and included staff from the NHFG, USFS, USFWS and volunteers.

The 24 sample sites included a total of 339 units (one unit = 100 m^2) of juvenile habitat. The estimated number of habitat units within the basin is 64,899, and units sampled was about 0.52% of the total available. In contrast, 28 sites representing 366 units were sampled in 1996, 28 sites representing 380 units in 1995, 21 sites representing 265 units were sampled in 1994, and during the period 1984-1993, units sampled ranged from 132 to 153. Of the 64,899 known units, approximately 50,946, 47,029, 32,142, and 38,085 were stocked with fry during the period 1994-1997, respectively.

Based on the geostrata sampling scheme, the preliminary estimate of age 1^+ parr in fall 1997 was 46,187 ±6,468. The basin wide estimate of age 1^+ parr for 1997 represents a fry to age 1^+ parr survival of 2.6%. The estimate for 1996 was 91,602 ± 7,538, and the corresponding estimate of survival from the fry stage to age 1^+ was about 3.2%. The estimated number of age 1^+ parr in fall 1995 was 197,774 ± 9,806 with fry to age 1^+ survival at 7.0%, and in 1994, 77,762 ± 19148, with fry to age 1^+ survival at 6.70%.

Natural reproduction of Atlantic salmon is not known to occur in the Merrimack River basin. In recent years, sexually mature adult salmon have been released in fall in headwater areas, but due to the low numbers released, their contribution to the production of fry is assumed to be negligible. As such, the estimated number of age 1^+ parr in 1997 was derived from a stocking of approximately 1.8 million fry in 1996.

Parr abundance in Region 1 remained similar to year 1996, but the number was nearly half that observed in 1995 when an estimated 33,638 age 1^+ parr were found in this Region. Region 1 represents about 36% of the total juvenile rearing habitat stocked in the basin and key sample sites in the region are located in the East Branch Pemigewasset, Mad, and Beebe Rivers.

In the Smith River, located in Region 2, parr abundance was low (0.9 parr/unit), but at sites in the Pemigewasset River, a very large river in this region, parr abundance (1.7 parr/unit) had increased compared to year 1996. It was significantly lower, however, than in year 1995, when 8.8 parr/unit were observed at the site. Region 2 encompassed 46 % of the juvenile habitat stocked in the basin, and key sample sites include not only the Smith and Pemigewasset Rivers, but also the Baker River.

Parr abundance at sites in Region 4 were comparatively low to that of previous years. Key sample sites in Region 4, which encompasses 18% of the habitat stocked in the basin, include the South Branch Piscataquog and Souhegan Rivers. Few age 1^+ parr were captured in the Souhegan River. A poor year class of age 0^+ parr was observed in the river in 1996. Low numbers of parr have been attributed to high river flows that occurred at the time fry were stocked in spring 1996.

The number of fish observed at sites in recent years 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. Floods occurred in fall 1995 and spring 1996, and these high flow events may have adversely affected the survival of parr. Clearly high flows in some watersheds, notably the Souhegan River, at the time fry were stocked may have been the primary factor that resulted in poor age 1^+ parr abundance this year.

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 the Ayers Island Dam and the Garvins Falls Dam. The studies were directed at assessing the fish bypass and smolt sampler constructed at the Ayers Island project and the effectiveness of the partial louver weir in the power canal at the Garvins Falls hydro project. The results obtained at the Ayers Island hydro project warrant additional work which will be carried out in 1998. The results at the Garvins Falls hydro project were so positive that the partial louver weir was completed to full weir. In addition, a smolt sampler will be tested at the site in 1998.

Upstream Fish Passage

The changes made to the Essex Dam fish-lift in Lawrence, MA are believed to have been totally responsible for the increased passage effectiveness that occurred in 1997 with respect to both salmon and American shad that entered the facility. It is anticipated that the changes at the Lawrence passage facility will be implemented at the Lowell fish passage facility for the spring season in 1998.

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 Brood Stock Releases

In the mid-winter, spring and late fall of 1997, 3,081 surplus brood stock at the NNFH were released to provide angling opportunities in the main stem of the Merrimack River and a small reach of the main stem of the Pemigewasset River. The mid-winter release (January) was comprised of 310 kelts. The spring (April and May) release included 1,423 re-conditioned kelts. The late fall (November and December) release included 1,348 non-spawners and kelts.

An additional 140 adults (pre-spawners) were released into the Pemigewasset River in the spring and early summer. These fish were part of a study to investigate spawning success by domestic brood stock in the wild.

Pre-spawner Releases / Natural Reproduction Study

Domestic Atlantic salmon broodstock were released in a headwater tributary in 1997 as part of a strategy to enhance the production of salmon in the Merrimack River watershed. Broodstock were released at four sites in the Pemigewasset River in June and July. Shore and watercraft based surveys were conducted to visually observe and locate fish and redds. Surveys began in summer and continued into winter.

Radio telemetry was used to assist in evaluating the movement and behavior of fish. Radio transmitters were surgically implanted in the abdominal cavity of 10 salmon. These fish were held at the Nashua National Fish Hatchery four days prior to their release in the river. Digitally encoded transmitters provided unique numerical identification of fish, and three stationary and two mobile receivers were used to determine the locations and movement of tagged fish.

In total, 140 Atlantic salmon broodstock were released in the Pemigewasset River for this study. All fish released in the river, including those with radio transmitters, were tagged with a Petersen disc tag. The tag was color coded as clear, and carried alphanumeric text denoting summer (1997) as the release time and year, and the Pemigewasset River as the release location. Whereas six of the transmitters used in the assessment had a battery duration that exceeded 300 days (long-term), the remaining four transmitters had battery duration expectancies of approximately 90 days (short-term). Riverine habitat at release locations included large, deep (> 3.0 m in depth) pools, and long (≥100 m in length) riffle/run complexes. Substrate in riffle/runs was composed of cobble and gravel, characteristics that denote preferred salmon spawning habitat.

One tagged (short-term) fish died at the time of release, and the carcass of a second tagged (long-term) fish was found 18 days after release approximately 10 rkm downstream. Another tagged (long-term) fish was determined to have passed Ayers Island dam which is located a distance of 39 rkm from the release site. The carcass of this fish was recovered at Eastman Falls dam in late November, approximately 61 rkm downstream from the release site. Three active fish with long-term tags and three with short-term tags remained in the general location of the release site until fall. Transmission of short-term tags ceased in late October, and continued reconnaissance placed the remaining three active fish in deep pools in an area approximately 5 rkm downstream from the release site.

Although recreational angling for salmon in the headwaters is not permitted, incidental catch did occur. The frequency of capture and the impact on the survival and behavior of broodstock is not known. In addition, otters, and sign of their presence, were frequently observed in and around salmon holding pools throughout summer and fall. The impact of this predator on the behavior and survival of broodstock has not been well documented, but it is likely that one of the radio tagged fish was killed by an otter.

Extensive surveys and telemetry reconnaissance were conducted during fall to document spawning and to locate redds. No fish were observed for extended periods in riffles and runs proximal to spawning gravel, and no redds were located. Deep pools provided cover, and fish were often found in pools during daylight surveys. A few broodstock were observed in runs, but quickly sought cover in pools when disturbed. Future evaluations will focus on similar release dates and locations for broodstock, and proposals will be developed to support the release of sea-run salmon at similar locations.

Atlantic Salmon Domestic Brood Stock 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 1996 and spring of 1997, 3470 surplus broodstock were released in support of the 1997 sport fishery. The winter release included 1,424 (age 3+) fish that were spawned prior to release and 623 (age 2+) fish that were surplus to the program. The second release occurred in the early spring and included 1,423 (age 3+) and (age 4+) reconditioned adults that had been spawned in the hatchery the previous fall.

The results of the 1997 fishery are presented in the following table (1993-1995 and 1996 results are included for comparison). The 1997 results show that a total of 1989 Atlantic salmon permits were purchased. Of the total 1,989 potential anglers, 1,352 reported that they fished for broodstock. The majority were NH residents and 8% were from other states. Anglers fished a total of 22, 802 hours during an estimated 8,736 fishing trips. The caught an estimated 1,705, released 1,132, and harvested 573 salmon. Catch per unit of effort was .069 salmon/hour (anglers fished about 14 hours before catching a salmon). The 1,352 anglers spent an average of $110 each which produced a total estimated expenditure of $148,720 for 1997 season.

It was anticipated that the total number of salmon permits and fishing effort for the 1997 season would be substantially lower than in 1996 due to unfavorable angling conditions. The water levels were at flood stage from the season starting date April 1 through late May. However, the total number of permits sold in 1997 (1989) was only 4% lower than in 1996. Total fishing effort, angler trips, and catch data increased from the previous season. The increase in the total estimated catch may be attributed to increased fishing effort and the 15% increase in the total number of broodstock released. Catch per unit effort was the same as in 1996.

RESULTS OF THE DOMESTIC ATLANTIC SALMON BROOD STOCK SPORT FISHERY FOR 1993, 1994, 1995, 1996, and 1997.

Category	1993 - 1995	1996	1997
Total Permits Sold	5,025	2,066	1,989
% Non-residents	7	10	8
Diary Reporting Rate (%)	60	27	22
Estimated No. of Anglers that Fished	3,648	1,355	1,352
% of Anglers Utilizing Fly Fishing	73	76	74
% of Anglers Utilizing Artificial Lures	19	16	16
% of Anglers Utilizing Both Fly Fishing and Artificial Lures	8	8	10
Angler Success in Fly Fishing Area (% catching at least 1 salmon)	30	27	32
Angler Success in Fly Fishing / Artificial Lure Area (% catching at least 1 salmon)	28	30	31
Estimated Total Hours of Fishing Effort	65,710	22,206	24,802
Estimated Catch per Unit of Effort (hours per salmon landed)	17.5	14.4	14.6
Estimated No. of Angler-Trips	20,655	6,958	8,736
Estimated No. of Salmon Caught and Released	2,276	1,080	1,132
Estimated No. of Salmon Caught and Kept	1,482	461	573
Estimated Total Catch (Released and Kept)	3,758	1,541	1,705
Estimated Expenditures Per Angler ($)	108	131	110
Estimated Total Expenditures by Anglers ($)	392,584	177,506	148,720

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 fifth year. In the last year the program has expanded from 50 to 95 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.

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) is preparing to reduce the program (possibly a 50% reduction) during the 1998/1999 school year. This reduction will be necessary because of the inability of the office to administer the program with the present funding and manpower levels. Every attempt will be made to develop a volunteer network such that the program could be maintained at the present level.

Amoskeag Partnership

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

Anadromous Fish Planning

The program cooperators completed the Merrimack River Anadromous Fish Restoration Strategic Plan and Status Review document. The document was extensively reviewed during 1997, modified and finalized in October.

2.1.4. PAWCATUCK RIVER

2.1.4.a. Adult Returns

Three salmon (two males and 1 female) were captured at the Potter Hill Fishway on the Pawcatuck River in May of 1997. By scale analysis, it was determined that all three fish had spent two years at sea after migrating as two year smolts produced from stocked fry.

2.1.4.b. Hatchery Operations

Fish Cultural Changes

The Arcadia Research Hatchery (ARH) was the primary hatchery for the salmon restoration program. Construction of a separate building for isolating returning adults, rejuvenation of kelts, and rearing domestic broodstock was completed in 1997. 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 successfully used to rear parr to the smolt stage. Repairs and improvements to the backup generator system were implemented. Terry Bradley from the University of Rhode Island aided with the smolt release project by monitoring gill Na^+, K^+-ATPase levels, performing salinity stress tests, and evaluating the condition factor of pre-smolts.

Personnel shortages have resulted in an administrative decision in December 1997 to cease smolt culture and broodstock maintenance operations at ARH and reassign the staff to the trout hatcheries. The three sea-run kelts and all domestic broodstock were released. All adipose fin-clipped parr (pre-smolts) were stocked into the Pawcatuck River. Future activities at the hatchery beyond egg incubation, have not been identified by the administration.

Egg Collection

Sea-Run Broodstock

Three adult salmon were captured at Potter Hill Fishway and transported to ARH in 1997. All survived to maturation. An estimated 8200 eggs were taken from the single female. After hatching, fry will either be released or retained for smolt production.

Captive/Domestic Broodstock

The North Attleboro National Fish Hatchery (NANFH) will continue to allocate up to 500,000 eggs per year (including 1997) for the Pawcatuck River. None of the eggs supplied by NANFH in 1997 will be incubated at ARH.

2.1.4.c. Stocking

Fry Stocking

Despite significant losses of fry at NANFH due to the April 1, 1997 snowstorm, fry stocking was continued in 1997. 100,000 fry supplied by White River National Fish Hatchery (WRNFH), were transported directly to central locations within the Pawcatuck watershed for the RI Division of Fish and Wildlife (RIDFW) stocking effort in May of 1997. The volunteer fry stocking effort was cancelled in 1997.

Parr Stocking

An estimated 14,000 age 1 parr produced from domestic broodstock were stocked in the Pawcatuck River in February and March of 1997.

Smolt Stocking

An estimated 11,500 age 1 smolts were stocked in the Pawcatuck River in February and March of 1997. 5,000 were produced from two Pawcatuck River sea-run females and pooled milt from Merrimack River males. The remaining 6,500 smolts were produced from domestic broodstock.

2.1.4.d. Juvenile Population Status

Fry/Parr Assessment

Fry and parr assessments were repeated in 1997. Eleven index stations (52.7 total habitat units) were sampled in March and twelve index stations (61.1 total habitat units) were sampled during September and October in the watersheds of two major tributaries of the Pawcatuck River. Insufficient data was obtained to reliably evaluate the survival of the 100,000 fry stocked in the spring. Fall 1997 1^+ parr density ranged from 0.28 to 13.5/100 m^2 and averaged 3.13/100 m^2 (SE=4.59). Over-winter survival of the 1996 fry cohort at the sample stations ranged from 0% to 80% and averaged 30.8%. The 1996 fry cohort reached a mean length of 82.9 mm by October of 1996, 103.3 mm by March of 1997, and 159.4 mm by October of 1997. 17.9% of the 1997 1^+ parr sampled were precocious males. The 1997 fry cohort attained a mean length of 76.9 mm by October of 1997. Drought conditions and intensive agricultural/golf course water withdrawals were present throughout the Pawcatuck River watershed during the summer of 1997. Over-winter survival percentages of 1996 1^+ parr at the sample stations ranged from 25% to 100% and averaged 54%.

Smolt Abundance

Potential smolt output from stocked fry was estimated by sampling eleven index stations during March of 1997. Mean smolt density ranged from 0.19/100 m^2 to 7.89/100 m^2 and averaged 2.03/100 m^2 (SE=2.25). 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 9115 fish. This smolt run is the third 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 while electrofishing in 1997 was 155.8 mm (SE=28.9). Scale analysis of a sub-sample of captured smolts produced from fry stocking, indicates that all were age 2.

Tagging

7,782 age 1 hatchery smolts stocked in the lower Pawcatuck River were adipose fin clipped to determine recapture rates of a modified fyke net set further downstream. The net was deployed to monitor migrating smolts.

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 RIDFW personnel, was successful in increasing the number of American shad passed in 1997.

Downstream Fish Passage

Migrating smolts were monitored approximately 2.4 km upstream of tidal waters on the mainstem of the Pawcatuck River using a modified fyke net from April 23 through June 3, 1997. The late starting date was due to delivery time of some of the net components. Future monitoring will commence April 1 annually. Smolt origin was determined from scale analysis and observations of adipose fin-clips. 39 smolts were captured during the sample period. 38.5% were adipose fin-clipped hatchery smolts. 15.4% were unmarked hatchery smolts. 25.6% were produced from fry stocking and 20.5% were produced from parr stocking. It is assumed the migration commenced prior to the sample period because of immediate success after only 1 trap night. Applying the 0.193% recapture rate of adipose clipped smolts to the entire sample captured places the 1997 smolt migration at 20,233.

2.1.4.f. Genetics

No work was conducted on this topic during 1997.

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 1997.

Education/Outreach

The educational program developed in 1995 continued in 1997. Westerly Public Schools in cooperation with the RIDFW and the Wood-Pawcatuck Watershed Association conducted a fourth/fifth grade program teaching about the Industrial Revolution, dams, hydropower, mills, and effects on anadromous populations. The students toured the Bradford Dyeing Association Mill, visited the Potter Hill Fishway, observed the tending of a fyke net, 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-August to late 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 NHFG.

No adult Atlantic salmon returned to fishways in the two rivers in 1997.

2.1.5.b. Hatchery Operations

No adult Atlantic salmon from coastal rivers were transported to hatcheries in 1997.

2.1.5.c. Stocking

In April of 1997, approximately 268,500 Atlantic salmon fry were scatter stocked by volunteers into the Lamprey (140,700 fry) and Cocheco (127,800 fry) River systems. Fry were stocked at densities of 37-50 fry/100 yd^2 unit.

Eggs for the 1997 fry stockings were obtained in the fall of 1996 from Connor Brothers Aquaculture of Eastport, Maine. 555,000 St. John strain eggs were fertilized with milt from St. John salmon from Connor Bros. and Merrimack domestics (Mer F1) from the NNFH. All eggs were raised at WSFH. In addition, the Lamprey River was stocked with approximately 52,849 parr donated by the D.E. Salmon Co. of Bristol, N.H. (formerly 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 0.1 - 6.4 fish/unit. The supplemental site surveys had YOY population estimates of 0.9 and 2.1 fish/ unit. Mean length and weight of YOY at index sites ranged from 77-83 mm and 4-5 gms. Estimates of parr abundance at index sites ranged from 0.4 - 4.6 fish/unit. Parr ranged in size from 148-159 mm and 26-37 gms. Population estimates for parr at the supplemental sites were 0.7 and 1.6 fish/unit.

Population estimates at the two index sites in the Cocheco River system contrasted significantly. The population estimate for YOY at the Mad River site was 6.4 fish/unit as compared to 0.8 fish/ unit at the Cocheco River location. Parr population estimates at the two sites were 4.1 and 2.2 fish/unit, respectively. The Mad River index site had below average population estimates for YOY and parr compared to the previous five years. The Cocheco River index site had the lowest population estimate for YOY ever measured while the parr population remained average. Mean length and weight for YOY was average at both locations while parr were larger than the previous five year average.

In the Lamprey River system, the Lamprey River index site had a slightly below average population estimate for YOY while the parr population estimate was next to the highest recorded at this survey location. On the other hand, the North River site had very low population estimates for YOY and parr. At the Lamprey River, mean length and weight was about average for YOY but below average for parr compared to the previous five years.

In 1997, the Isinglass River, a supplemental survey site in the Cocheco River system, showed a population estimate for parr of 1.6 fish/unit. This number represents the highest parr population estimate observed on the Isinglass River. The high estimate may have been influenced by the simultaneous use of a second electrofishing backpack unit at the site for the first time this year.

2.1.5.e. Fish Passage

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

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

2.1.5.f. Genetics

No work was conducted in this area in 1997.

2.1.5.g. General Program Information

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

2.2. STOCKING

2.2.1. TOTAL RELEASES

During 1997 the participating resource agencies released approximately 15,200,000 juvenile Atlantic salmon into 15 rivers (Table 2.2.1.a. in Appendix 10.2.). Included within the table is the Canadian contribution to the release program. The number of fish released was approximately a 13% increase over that of 1996.

In addition to juvenile stocking, mature adults are stocked by the Maine, Merrimack, and Connecticut programs (Table 2.2.1.b. in Appendix 10.2). In general, these fish are either spent broodstock or broodstock that are excess to hatchery capacity. All these adults are either river specific or domestic progeny of river specific programs. The table does not include kelt releases. For 1997, a total of 6,629 captive and domestic adults were released into the rivers of New England.

2.2.2. SUMMARY OF TAGGED AND MARKED FISH

About 50,000 marked and tagged salmon were released in New England rivers in 1997. Of the total, 51.4% were released into Maine rivers, 45.6% were released into the Merrimack River drainage, 2.8% were released into the Connecticut River drainage, and 0.2% into the Pawcatuck River. Atlantic salmon of all life stages were utilized. 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, Petersen disc tags, etc.).

A comprehensive summary of marked and tagged Atlantic salmon released in New England rivers during 1997 is presented in Tables 2.2.2.a. and 2.2.2.b. (Appendix 10.2.).

2.3. ADULT RETURNS

2.3.1. TOTAL DOCUMENTED RETURNS

Documented total adult salmon returns to rivers in New England amounted to 1,758 salmon (Table 2.3.1. in Appendix 10.2.). The majority of the returns was recorded in the rivers of Maine with the Penobscot River accounting for nearly 77% of the total New England returns. The Connecticut River adult returns accounted for nearly 11% of the New England total and 73% of the adult returns outside of Maine. Overall, 18% of the adult returns to New England were 1SW salmon and 82% were MSW salmon; most (74%) of these fish were of hatchery smolt origin. Of the total returns, approximately 26% were of wild origin (from natural reproduction and from fry plants).

Documented returns of 1SW salmon to New England rivers decreased significantly below those observed in 1996 (316 vs. 590). Similarly, MSW returns in 1997 were significantly lower than those observed the previous year (1,442 vs. 2,237).

Decreases in documented salmon runs were observed for nearly all rivers; notably the Connecticut (-23%), Merrimack (-7%), Penobscot (-34%), St. Croix (-67%), Androscoggin (-97%), Saco (-48%), Narraguagus (-42%), and Aroostook (-82%).

2.3.2. ESTIMATED TOTAL RETURNS

The Assessment Committee recommends that the estimate of total stock size for US rivers provided to the ICES Working Group for the run reconstruction model for North American stocks be reviewed during the 1999 annual meeting.

2.3.3. RETURNS OF TAGGED SALMON

A total of 6 salmon having CWT and four adult salmon having Carlin tags returned to the rivers of New England. All but one of the salmon, a repeat spawner captured in the Connecticut River with a CWT, were captured in the Penobscot River. Five of these fish had CWT (two 2SW and 3 RS) and four (grilse) had Carlin tags.

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

Spawning escapement information, where available, can be found in Section 2.1.

A total of nine salmon was released from the Holyoke fishlift (river km 138) and permitted to continue upstream; of these, two were observed passing the fishway at Turners Falls, MA (river km 198), four were observed passing the fishway at Vernon, VT (river km 228). The fishway at Turners Falls was only monitored part-time explaining why more fish were observed at Vernon. No fish passed the Bellows Falls dam in 1997. A total of thirteen salmon was released above the DSI dam on the Westfield River (12 in support of a radio telemetry study, and 1 by accident). Additionally, one salmon was accidentally released above the Rainbow dam on the Farmington River. Some successful spawning within the Connecticut River basin was documented. Some fish in the Pawcatuck River are likely to have passed upstream from the first dam on the river but no significant natural reproduction was likely. 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 brood stock, and reconditioned kelts. A total of 455 sea-run females, 3,849 captive/domestic females, and 208 female kelts contributed to the egg take. The number of females (4,512) contributing was considerably more than in 1996 (3,869). The total egg take, 25,299,700, was nearly the same as that of 1996. A more detailed description of the egg production program is contained within Table 2.3.4. (Appendix 10.2.).

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 1997 was 333 fish (Table 2.3.5 in Appendix 10.2), which was a

Broodstock Management Practices

We attempt to collect only MSW, early-run salmon for broodstock purposes. Salmon with scale loss, abrasions, wounds or physical abnormalities are not selected. There may also be an unintentional effort to select larger MSW salmon. Although about 70% of the run is of hatchery origin, we attempt to select primarily wild salmon for broodstock purposes (target of 50%+ wild). Date of capture in the Collection Facility is indicative of run timing. Run timing is influenced to some extent by discharge, generation pattern and by the concentrations of alewives and blueback herring in and at the entrance to the Collection Facility. Ideally, we attempt to collect equal numbers of male and female salmon so we can carry out individual matings (one female x one male). However, this is rarely accomplished as there is a shortage of MSW male salmon returning to the Collection Facility. About 85% of the Saint John MSW salmon are females. Broodstock are also collected in tributaries to the Saint John River and in other Outer Fundy rivers. Early-run MSW salmon are preferred in these collections but selection for these characteristics is not always possible.

The broodstock are tagged, injected with Baytril and then transferred to the broodstock ponds where they are held on groundwater. Two of the ponds measure 43m x 4.3m x 1.2 m and the other pond 15m x 2.5m x 1.2m. We have used Flumiquil and Baytril on different occasions to eliminate the carrier state of furunculosis, *Aeromonas salmonicida*. Although controlled experiments have not been carried out, furunculosis has not been detected since Flumiquil and Baytril have been administered to the broodstock. This year we had some mortalities attributable to the gill copepod, *Salmincola salmoneus*. There is no treatment for this except to maintain low densities in the broodstock ponds while providing as much water flow as possible. Scales are used to age the male salmon in some groups so that repeat spawning 1SW salmon are not used for spawning. Spawning is carried out during the last week of October and the first week of November.

1997 Spawning Program

Following is a summary of the groups of salmon spawned at the Mactaquac Hatchery this year (M=male; F=female; H=hatchery; W=wild; FL=fork length; WT=weight):

<u>Serpentine (tributary located above Mactaquac Dam)</u>

N=26; 9M&17F; 62%W; mean FL=71.0 cm; FL range=63.0-77.0 cm; mean WT=3.7 kg; WT range=2.6-4.6 kg; Run Timing=June 18-July 2; # Eggs/F=5,330; Total # Eggs=82,250; Spawning=October 30-November 4.

<u>Saint John Earliest-Run</u>

N=74; 17M&57F; 77%W; mean FL=79.7 cm; FL range=72.0-92.0 cm; mean WT=5.7 kg; WT range=3.4-8.3 kg; Run Timing=June 18-August 15; # Eggs/F=9,420; Total #

39 % decrease from the previous year.

The domestic brood stock fishery in the Merrimack River resulted in an estimated 1,705 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 10.2. and in Section 5. (sub-sections 5.1. and 5.2.) of this document.

3.3. ATLANTIC SALMON BROOD STOCK MANAGEMENT

a. Overview of Brood Stock Management Practices at the Mactaquac Hatchery

Gil Farmer / Department of Fisheries and Oceans / Canada

Background

The hatchery is located on the Saint John River 2.5 km below the Mactaquac Dam. Most juvenile Atlantic salmon produced at the hatchery are released as compensation for habitat losses attributable to construction of the Mactaquac Dam. Annual production at the hatchery is 450,000 0+parr and 320,000 1+smolts. Staff are also responsible for collecting all the migratory fish which return to the Collection Facility incorporated in the dam and for transporting them to release locations located above the dam. Most numerous species collected are Atlantic salmon, alewives and blueback herring. All of the salmon collected at the dam are transported to the hatchery where they are sorted before they are transported above the dam. Broodstock are selected during the sorting process.

Eggs=537,000; Spawning=October 28-November 3.

Saint John Early-Run

N=134; 33M&101F; 61%W; mean FL=79.5 cm; FL range=68.0-87.0 cm; mean WT=5.6 kg; WT range=3.2-7.5 kg; Run Timing=June 26-September 17; # Eggs/F=10,120; Total # Eggs=1,032,640; Spawning=October 21-November 4.

Saint John Early-Run (100% lethal sample; for Aroostook River)

N=34; 12M&22F; 62%W; mean FL=75.4 cm; FL range=54.0-94.0 cm; mean WT=5.0 kg; WT range=1.6-8.5 kg; Run Timing=July 7-September 17; # Eggs/F=10,120; Total # Eggs=222,700; Spawning=November 3.

Hammond (tributary located below Mactaquac Dam)

N=13; 6M&7F; 54%W; mean FL=70.2 cm; FL range=56.0-94.0 cm; Seining on August 22; # Eggs/F=6,460; Total # Eggs=45,200; Spawning=November 3-November 6.

St. Croix River

N=13; 6M&7F; 46%W; mean FL=69.5 cm; FL range=52.0-95.0 cm; Collected throughout the run; # Eggs/F=7,330; Total # Eggs=51,300; Spawning=October 30.

b. Brood Stock Management at Craig Brook NFH

Dan Tozier, U.S. Fish and Wildlife Service

The Craig Brook National Fish Hatchery (CBNFH), East Orland, Maine, has been involved with the propagation of sea run Atlantic salmon since 1871. From 1957 to 1990, the production program consisted of the holding and spawning of sea run adults from the Penobscot River. As part of the Pre-listing Recovery Plan, the smolt production facilities at CBNFH were renovated to hold populations of broodstock from five Maine rivers. The scarcity of wild adult Atlantic salmon for use as river-specific broodstock created the need to collect wild parr from the individual rivers for rearing through sexual maturity in captivity.

Sea run adults are taken from the Penobscot River as broodstock to support smolt and fry stocking on the Penobscot River and other rivers in Maine. Penobscot River broodstock support smolt production at Green Lake National Fish Hatchery (GLNFH) and fry production at CBNFH. Approximately 600,000 smolts and 1.5 million fry are produced annually. We propose to continue the collection of 400 females and 200 males, for a total of 600 brood fish, which is the capacity of the Swedish pools at CBNFH dedicated to holding Penobscot broodstock. In 1996, program staff began collecting 1SW salmon (grilse) as broodstock from the Penobscot River, in order to avoid the selection inherent in excluding them from spawning and to increase the age diversity within the spawning population. We have set a collection goal of forty 1 SW broodstock, which will be approximately 20% of the male broodstock collected, and the balance will be MSW males.

The captive broodstocks being held at CBNFH for the Dennys, East Machias, Machias, Narraguagus, and Sheepscot rivers are sufficient to meet short-term program stocking targets (3-5 years), but additional egg sources need to be developed to meet production objectives for the year 2000 and beyond. It may be possible to extend egg availability from some fish for a year or two beyond current projections, but we are uncertain about the viability of eggs spawned from older brood fish.

Although fixed in number, the current inventory of captive wild broodstocks continue to increase in biomass. That biomass needs to be reduced periodically as the fish grow, in order to remain within the carrying capacity of the CBNFH. Each of the river-specific broodstock populations consists of multiple year-classes. When biomass reductions within a river-specific stock are required, the oldest fish will be removed first for the following reasons:

1. They have contributed to the gene pool disproportionately relative to the younger fish.
2. They are larger than younger fish, so that fewer individuals are lost for a give biomass reduction.
3. Cumulative hatchery selection (via attrition) is greatest on older year-classes.
4. Viability of eggs tends to decline with subsequent spawnings for older brood fish.

In small broodstocks, it is desirable to adopt a matrix approach to mating spawners. This ensures that each fertile brood fish in the mating scheme has an equal probability of contributing to a cohort. A matrix spawning approach is also needed when the sex ratio is unbalanced in the group to fish to be mated, in order to assure that all individuals are spawned. To ensure that no fertile female is lost due to a sterile mate, it is desirable to use that more than one male to fertilize aliquots of that individual's eggs. For males, it is desirable to have each male fertilize an aliquot of eggs from more than one female. Multiple paternity for a female's offspring can increase effective population size.

c. Merrimack River Brood Stock Management

Vic Segarich / U.S. Fish and Wildlife Service

The paper describes the management practices and spawning protocols used in the Merrimack River program at the Nashua National Fish Hatchery . The station rears and maintains both sea run and domestic Atlantic salmon brood stock to provide eggs for the restoration program.

Introduction

The Nashua National Fish Hatchery rears and maintains both sea run and domestic Atlantic salmon to provide eggs for the Merrimack River restoration program. The station began its involvement with brood stock management in the fall of 1982 when it held the first sea run salmon captured at the Essex Dam in Lawrence Massachusetts. In 1989 a domestic brood stock was started to produce eggs for an increased fry stocking program proposed for the Merrimack River. Basic protocols for spawning and handling of both brood stocks are similar although the relative success of producing viable eggs from a feral brood has yet to be matched by their domestic counterparts. The philosophy for the management of all stocks maintained is again similar and encompasses three tenets. Do no harm. Maintain the greatest genetic diversity possible. Do not panic in the face of genetic adversity.

The do no harm concept was foremost in our minds while developing spawning protocols. To achieve this goal three strategies were developed. Use mature fish from all available year classes for spawning in any brood year. If possible, use one on one paired matings. Ask enough to questions to get to answers needed for a successful program.

Sea run Brood Stock Management

Handling Protocols

Sea run fish generally begin returning to the Merrimack in May and continue to run up river until July and resume again late August and September. The prolonged time span of the run requires trapping and transporting of fish in water temperatures from 9°to 24°c . To keep temperature related stress to a minimum, captured fish are held in water midway between river and Nashua's ambient temperature of 11°c. They are then transported for 35 minutes in 11°c water to the station. Once received, the fish are identified with a double T bar Floy tag, measured for length and weight, checked for tags and fin clips, have scale samples removed , and are given a protective intraperitoneal inoculation. The inoculation consists of an antibiotic for short term protection against stress induced pathogens and an attenuated vaccine thought to promote longer term protection against furunculosis and enteric red mouth disease. Oxolinic acid and Liquamycin (LA200) are the antibiotics permitted for use, and Furogen and Ermogen are vaccines for the prevention furunculosis and enteric red mouth disease. Throughout the trapping and receiving process fish are only moved using a smooth PVC bag instead of nets . Nets tend to abrade both the skin and eyes creating entry sites for fungal and pathogen invasion.

Up to 75 fish are then placed in a 6.6 m diameter Ewos style holding tank , .6m deep, with a water flow of 210 L/min and are not handled again until spawned. The holding building has translucent panels covering 45% of roof's surface and 60% of the eastern wall of the building. The natural lighting is subdued but emulates normal photoperiod. Electrical lighting is not needed to supplement sunlight.

Disease Prevention, Detection, and Treatment

The three primary fish health concerns for sea run brood stock at the station are fungal infections, furunculosis, and high bacterial concentrations on the skin leading to extensive scale and skin loss. To help determine the level of bacteria and fungus the fish are exposed to, filtered water samples are analyzed semiweekly. The resultant cultures can pick up low levels of A. salmonicida before it reaches epizootic proportions and track sudden increases in bacterial and fungal levels indicating therapeutic treatments maybe required .

Formaldehyde, administered as a 1:4000 concentration bath for three successive days, has proven to prevent the formation of fungus and will remove it from infected fish. The treatment is given every three days after fish arrive on station and at five to seven day intervals in late summer and early fall.

Scale and skin loss, sometimes affecting up to 50% of the lateral surface of the fish, have been a problem since 1992. The condition has not been associated with a particular organism but generally occurs when bacterial levels in tanks rise from 1-3 CFU/ml (Colony Forming Units) of water to over 100 CFU/ml. Chloromine -T , at a 9 ppm concentration, has been effective in stopping the infection. The fish tend to regenerate new skin two to three weeks following treatment.

Spawning Protocols

Spawning generally occurs from October 18 to November 15. All year classes of fish represented in the sea run population are randomly spawned each year. If adequate numbers of the sexes permit, fish are spawned at a one to one ratio. Unfortunately the number of sea run fish have been low and in only two years has the ideal ratio been achieved. To get the lowest ratio possible, all males and unspawned females are checked prior to each egg take and virgin males are given first preference for fertilizing eggs.

Gamete collection occurs separately. Sperm is taken from each male, 10 to 80 ml, contained in a 5cm vial and kept cool. An effort is made to use the sperm within one hour of collection. Eggs are taken from each female and are hand spawned into a dry 20cm diameter pan. The pan is marked with the female's ID number and is fertilized. The eggs are allowed to sit for a few minutes, are rinsed, and placed into a 50 ppm Argentine bath for 30 minutes to disinfect. They are removed from the disinfectant and placed in running water for up to two hours to water harden. Each female's eggs are then enumerated and prepared for shipping. Approximately seven thousand eggs are shipped in a one gallon thermos jug filled to the brim with water. An appropriate quantity of ice is added to the eggs to temper them in transit to the receiving station's water temperature if required.

Egg survivals are generally high, ranging from 88 to 95 % eye ups.

Depending upon the FDA restrictions of the antibiotic used on the fish, the kelts are either released back into the Merrimack River, sacrificed for bioassay, or are reconditioned at North Attleboro NFH.

Domestic Brood Stock Management

Handling Protocols

Domestic brood are taken from the progeny of sea run brood stock. If over 50 pairs of sea run parents are available to provide eggs, a sample is taken from each female to provide ten thousand eggs for a year class of fish. If adequate parental pairs are not available, sea run origin eggs from outside the Merrimack basin are brought in to augment existing supplies. The Penobscot River salmon have supplied for program needs for the past four years.

Once the eggs have hatched they are distributed randomly into 2m diameter Ewos style rearing units for their first year, and are then transferred into 2.4 x 30 m raceways, supplied with 1890 - 2260 L/min flow, were they are kept until sexually mature. The fry are started on brine shrimp, and converted to BioDiet semi-moist crumbles and then fed ASD2 standard Service diet once they reach 5 cm in length. The fish are not graded for the duration of their life on station. When lots of fish are reduced in numbers, randomly selected rearing units are stocked out to keep selection by phenotype to a minimum.

Disease Prevention, Detection, and Treatment

Domestic brood lots have classified as disease free since the program has begun. Mortalities from all lots are sampled according to the New England Disease Protocol annually. No other monitoring program is used. Formaldehyde is used to control fungus on eggs and is used in a 1:600 drip treatment on an every other day schedule from the time eggs are taken until they are eyed.

Spawning Protocols

Spawning generally begins November 1 and continues for an extremely variable period of time, sometimes into mid January. There has been no continuity or trend in the spawning period. Most females mature as four-year-olds with fewer than 8% maturing in their third year. The percentage of females reaching maturity in their fourth year is about as unpredictable as their spawning period. The range varies from 74 to 95%. All year classes are treated in the same manner and are reared in similar holding tanks.

Males used for spawning are taken from sexually mature two, three, and four- year-old fish with a majority taken from the two oldest groups. Four year-old fish always ripen during the beginning November followed by the three and two year-olds who do not mature until the middle of the month. There are generally adequate numbers of domestic males and females to achieve a one to one spawning ratio.

Spawning procedures are essentially the same for domestic as sea run fish, except that all sperm is checked for motility prior to being used. Significant numbers of males produce non-motile or not highly active sperm. This finding is probably a function of their extended spawning period and our inability to select males at the peak of sperm production. The eggs are also fertilized and disinfected in the same manner as the sea run brood.

Domestic egg survivals have not been as high as their sea run counterparts. Some of reasons have been identified while others are still waiting for answers. A significant number of broodstock have been injured by lightening strikes during the summer prior to spawning. The electrical charge was not strong enough to kill the fish but caused most of the eggs to not fully mature. Brood years with many summer storms have produced low egg survivals. As previously mentioned, checking sperm motility increased eye ups. Studies are currently being conducted with the Northeast Fisheries Center and the USGS Wellsboro Lab dealing with diet formulations and egg handling procedures. Early analysis suggests that dietary changes can increase the quantity of sperm produced and that green eggs may be more fragile during certain periods the first 24 hours following fertilization than previously thought.

Kelts and unspawned fish, surplus to the program, are used in the New Hampshire Atlantic salmon interim brood stock sport fishery initiative.

d. Connecticut River Brood Stock Management

Ken Gillette / U.S. Fish and Wildlife Service

Six broodstock facilities consisting of both State and Federal stations are the primary egg producers for the Atlantic salmon restoration in the Connecticut River basin. The table below lists broodstock facilities and their 1997 egg production.

	STATION	**1997 EGG PRODUCTION**
SEA-RUN STATIONS :	Cronin SS	552,800
	Whittemore SS	217,900
KELT STATIONS:	North Attleboro NFH	1,466,500
	Whittemore SS	432,800
CAPTIVE-DOMESTIC:	White River NFH	6,757,500
	Kensington SFH	2,510,800
	Roger Reed SFH	2,259,000

Sea-run and kelt broodstock facilities deal exclusively with the adult life stages of the salmon as opposed to a captive domestic broodstock facility that is involved with all life stages of the broodstock. Cronin SS and Whittemore SS retrieve sea-run salmon from trapping sites within the Connecticut river, pit tag them, record weight and length, take mucus and scale samples, give an antibiotic injection, vaccinate and maintain these fish until spawning season.

North Attleboro NFH and Whittemore SS kelt operations involve rejuvenation of spent female sea-run fish to be utilized over the next 4 or 5 years. Every fish brought into these stations is placed into a 6 foot rejuvenation pool, vital information recorded, tagged, treated with salt initially then treated prophylactically for several days with 250ppm. formaldehyde. Fish are gradually brought back on feed and restored as productive broodstock.

White River NFH assists restoration goals through its mission to: 1) produce sufficient F-1 Atlantic Salmon broodstock to produce 6.7 million green eggs; 2) incubate 9 million or more green eggs and; 3) produce 6 million or more Atlantic Salmon fry for stocking in the basin.

EGG PRODUCTION HISTORY

	1994	1995	1996	1997
NO. EGGS	**618,000**	**2,072,800**	**7,115,100**	**6,757,500**

Current production levels at White River (typical)

- **0+ FISH 32000 (98'S)**
- **1+ FISH 15000 (97'S)**
- **2+ FISH 4500 (96'S)**
- **3+ FISH 2600 (95's)**
- **4+ FISH 658 (94'S)**

Broodstock at White River originate from a representative sample of eggs taken from all sea-run crosses at Cronin SS and Whittemore SS. These eggs are banked at Whittemore SS totaling 72,000. After eye up, White River NFH receives 32,000 eyed eggs with remaining eggs sent to Kensington SFH and Roger Reed SFH for their future broodstock. Fish are kept here for three or four years where they are spawned once and are offered to the States for release as a recreation broodstock fishery.

Spawning procedures are standard and consistent with the other captive broodstock facilities. White River NFH uses single paired and cross year mating procedures. Ovarian fluids are collected and sent to Lamar Fish Health Lab. After fertilization, eggs are rinsed and placed in 50 p.m. idophor solution for 30 minutes, transported to a holding and isolation area in the garage section of the main building for two hours, then topically disinfected in a 100 p.m. idophor solution for ten minutes and laid up at 10,000 green eggs per tray. The same isolation area is also used for all incoming eggs from other broodstock facilities which are topically disinfected before being placed in incubation trays.

Egg incubation. In the fall 1997, White River NFH incubated 9.8 million green eggs utilizing all its incubation space and later incubated 7.5 million eyed eggs. These 65 double stack heath type incubators (975 trays) are arranged in 11 banks, each with two water supplies used to manipulate water temperatures. Water temperature manipulation is critical to accelerate or decrease egg or fry development to correspond with a 6 week fry stocking schedule. Fry stay in incubator trays until they are stocked out. Six million fry were stocked from White River NFH in 1997.

Tributary Marking Pilot Project. Whittemore SS, Cronin SS, White River NFH and others are working with Dr. Ben Letcher in a pilot project using genetic markers to identify fish stocked into specific tributaries of the Farmington river. All sea-run salmon at Cronin SS and Whittemore SFH were pit tagged and an anal fin snip collected for genetic analysis. This information was placed in a data base developed by Dr. Ben Letcher. During spawning, a computer was used to determine the most distantly related male and female using a relatedness value developed by Dr. Tim King. A total of 160 distinct families were used in this project and shipped to White River NFH for incubation. To help conserve incubation space, a number of families were mixed together or, "mini-batched" and bar-codes identifying each family were placed in incubator trays with the eggs. This spring, Connecticut will determined the exact stocking numbers for specific tributaries within the Farmington and the mini-batches will be combined to match those tributary specific numbers.

Genetic Based Broodstock Management Pilot Project. White River NFH is also involved with another pilot project developed by Dr. Ben Letcher intended to increase genetic diversity and marking fry on a larger scale for specific tributaries throughout the Connecticut River Basin. Sixty of the 160 distinct sea-run families sent up to White River NFH from Cronin SS and Whittemore SS had a small sample of eggs (600) taken from each family and placed on a small hatching tray inside a 2 ft circular tank where eggs eventually hatched out. Each circular, containing one family, will be pared down to fifty fish and will receive a distinct family mark (visible or coded wiretag). When broodstock are sexually mature, crosses will be made between the most distantly related families similar to the **tributary marking** project.

e. Genetic Brood Stock Management and Fry Marking Studies

Ben Letcher and Tim King / USGS-BRD

In this abstract, we report the use of unique multilocus microsatellite DNA genotypes of individual adult sea-run salmon returns in a novel, integrated way to accomplish three goals; *i*) evaluation of the baseline genetic diversity of this highly-managed population, *ii*) maximization of available genetic variability with selected broodstock, and *iii*) development of a fry marking system to identify tributary of stocking and other ecological and evolutionary attributes. Compared to traditional random mating (eggs from each female fertilized by four males), allowing only matings of distantly-related fish (based on proportion of shared alleles) increased heterozygosities by 6.2 % in one generation (0.76 to 0.81), increased overall genetic distances by 19%, and suggested no gene drift occurred as no alleles were lost in the population. Gene drift was also zero with the traditional method of mating four males per female, but several alleles would be lost if single males were mated randomly with single females. Matings based on genotypes of individual broodstock allow matings of single males and females resulting in increases in genetic diversity without allele loss.

In addition to maximizing genetic variability, we can use the paired matings of individuals with known genotypes as the basis for a mark or tag to identify characteristics of the fish (stocking date, density and size and family differences in growth, survival, run timing, and disease exposure, etc.) and of specific rearing tributaries (latitude, aquatic community, temperature profiles, barriers to migration, etc.) that successfully produce smolts and adult returns. Fish leaving the river (smolts) and adults returning to the river can be trapped and assayed for family membership and therefore for any of the characteristics above. To understand factors responsible for smolt production it is critical to identify which specific tributaries are supporting relatively more smolts. The 'family membership tag' allows such an analysis. This approach uses inherent genetic differences among families to discriminate among them. We know of no other marking technique that provides simultaneously permanent, non-lethal, non-destructive, batch marking for groups of small fish.

Offspring of parents with known genotypes can be assigned to the correct parents with as few as four loci (with 8 or more alleles/locus) and to the correct set of four grandparents with 10 loci containing 12 or more alleles/locus. In the Connecticut River, it is important to be able to identify grandparents because 80% of the fry for stocking typically come from domestic broodstock. Computer simulations indicated that the genetic variability of adult Connecticut River Atlantic salmon used for broodstock in 1996 and 1997 was sufficient to assign all F1 and F2 offspring to the correct set of two parents or four grandparents using 11 loci. This means that the family of stocked fish in the program could be unequivocally identified and any of the many factors (treatments) associated with the smolt or adult return (stocking tributary, stock date, etc.) could be correlated with migration timing and counts per tributary, among other factors. This approach could also be used to discriminate between hatchery and wild fish. The microsatellite markers contain such a wealth of information that it is possible to identify family membership of hatchery fish with parents with known genotypes even against a background of tens of thousands of fish with unknown parentage.

f. Discussion

Much of the discussion focused on the work by Ben Letcher. There was discussion about the timetable of this work and some of the potential benefits Do possibilities exist to select beneficial traits such as early migration, large size, etc. from other populations, and inject them into a restoration population, thus accelerating the stock selection process? There are currently limitations on what can be done, but it is thought that some of these actions may be possible at some point in the future. There is also the potential of conducting performance evaluations of different families. This technology also provides the opportunity to breed a few individuals within a subgroup (such as adult returns to a tributary) and avoid breeding closely-related individuals. It is hard to anticipate all of the potential benefits that could come from this work, particularly as our knowledge of Atlantic salmon genetics increases. Comments were made that this was a major undertaking for the Connecticut River program and that it represents a major inconvenience for the standard hatchery operations, however, it was felt that the genetic management of the restoration population was one of the most important things that can be done in the program. The hard work and cooperation of the hatchery staff were acknowledged. There was discussion about the funding of this effort and Dr. Letcher commented that long-term funding is not yet secured but work for the next year should be assured. The Committee agreed that this line of investigation holds great promise, not just for the Connecticut River program but the entire region and all programs should consider how they could use and contribute to this approach. There was some talk about establishing salmon genetics as a standing Term of Reference for future meetings as well as possibly holding a workshop on this research and genetics, in general.

Staff from the Maine programs expressed their concern about collection of wild parr in streams for future broodstock. They are now fry stocking most stream reaches and there is a possibility that captured parr would originate as hatchery fry. There was discussion about the advisability of this practice but the consensus was that this practice was preferable to not having broodstock or simply retaining fry in the hatchery and raising them to maturity.

There was discussion about the "C1 Kelt Diet," particularly the use of fresh beef liver. At this time, there does not appear to have been problems with liver breaking down in the diet.

3.4. ATLANTIC SALMON GENETICS OVERVIEW

Tim King / USGS-BRD

In October 1993, all anadromous U.S. Atlantic salmon were included in a petition to the U.S. Fish and Wildlife Service and the National Marine Fisheries Service for a Rule to List the species under the ESA. To provide the most informed response to this petition and for planning and implementing biologically sound management programs, knowledge of the amount of genetic diversity present and a thorough understanding of the evolutionary relationships among geographic populations of Atlantic salmon are essential. This report summarizes an extensive range-wide (Maine to Spain) population genetics survey of mitochondrial and nuclear DNA variation in Atlantic salmon with emphasis on selected rivers of Maine.

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

Brook of the lower Penobscot River, the Ducktrap River, and Bond Brook, a tributary of the Kennebec River. The collections from the Narraguagus, East Machias, and Sheepscot Rivers as well as from Togus Stream, a tributary of the Kennebec River, exhibited higher than average h values.

Genotypes at 12 microsatellite loci were determined for 910 Atlantic salmon sampled from 37 collections. Considerable variation was observed at 11 of 12 loci with 230 alleles recorded. Study wide, 38 alleles were found to be unique; of those, 26 were recorded in Europe and 12 were only observed in NA collections. Of the 12 unique alleles found among NA populations, four were observed at low frequencies among three collections in Maine (lower Penobscot, lower East Machias, and Dennys Rivers). NA and European localities possessed largely different allelic distributions at five loci. European populations were found to have slightly more alleles and higher heterozygosities than NA populations.

Heterogeneity of both mitochondrial and nuclear markers was observed at all classification (i.e., continent, country, and river) levels. Within NA, highly significant differences in haplotype and allele frequencies were observed between pooled (within country) Maine and Canadian collections. Frequency comparisons also indicated haplotypes and microsatellite genotypes were heterogeneous among and within several rivers.

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

Gene flow estimates for both mitochondrial and nuclear DNA at the inter-continental scale were <1 migrant per generation (Nem), strongly indicating that a major discontinuity exists between NA and European populations. Within each continent, Nem estimates of >1 suggested that gene flow (in the absence of selection pressure) was sufficient to minimize the loss of polymorphism and prevent populations from becoming fixed for alternate alleles.

The pair-wise comparison tests of microsatellite genotypes revealed evidence of some significant population subdivisions. Four of the six European collections, seven of seven wild Canadian collections, and fourteen of eighteen wild Maine collections indicated significant population subdivisions. Correct assignment of individuals to the river from which they were sampled was mostly higher than the number expected by chance. Every NA fish was most similar to another NA fish and every European fish was most similar to another European fish. Canadian and Maine fish were correctly assigned 68.4% and

94.6% of the time, respectively. Of the Canadian fish correctly assigned to Canada, 90.8% were correctly assigned to their original river. In contrast, 64% of Maine fish were assigned to their original collection.

Numerous glacial advances and retreats characterized the Pleistocene Epoch, apparently leaving biogeographic imprints of varying degrees of depth on the population structure of Atlantic salmon. Analyses of mitochondrial and nuclear microsatellite DNA variation in Atlantic salmon confirmed the existence of a deep phylogeographic discontinuity in genetic structure between NA and European populations. Knowledge concerning these deeper phylogenetic structures is important for conservation biology because if the discontinuity has resulted in the absence of gene exchange and populations collectively encompass a substantial fraction of a species' genetic diversity, they should be considered as evolutionarily significant units or ESUs. Based on the overwhelming evidence presented in this study, we believe the Atlantic salmon inhabiting North America and Europe are sufficiently divergent and reproductively isolated to warrant ESU status. Although no such rich phylogenetic disjunctions were readily observed within North America or Europe, shallower genetic subdivisions worthy of management consideration have been identified.

Our data do not support the hypothesis that Atlantic salmon have been totally "homogenized" by migration (introgression), stocking, and aquaculture operations. The discovery of highly divergent populations (Cove Brook of the lower Penboscot River, Togus Stream of the Kennebec River) existing in an apparent sympatric manner with relatively nondivergent populations of the Penobscot and Kennebec is remarkable, particularly so in light of the apparent temporal stability (persistence) of the Cove Brook collections. Restoration efforts should take into account inter- and intra-river diversity and utilize supplementation if needed to boost effective population sizes.

Discussion

1. The take home message from the genetics discussion was that sample size is extremely critical to this work. This was highlighted in the data presented on the difference between Penebscot hatchery and the Penobscot aquaculture populations. The difference can be explained by the larger effective population size in the aquaculture animals. The aquaculture fish are representative of Maine wild stocks except some aquaculture stocks have European alleles. The greatest potential threat to Maine salmon is probably escapees from "Landcatch", which is a European stock, rather than from escapees from sea cages with the St. John River aquaculture stock.

2. There was also discussion related to the difference between Penobscot River and Cove Brook salmon. Genetic information indicates that Cove Brook salmon may likely be the most genetically distinct Atlantic salmon population in North America that were sampled. The Cove Brook salmon population has three unique alleles suggesting this is a divergent naturally reproducing population. It also appears these fish have not contributed to the Penobscot hatchery population and that this population has not been managed. Salmon

from Bond Brook also exhibit similar characteristic to Cove Brook, an unmanaged population exchanging lots of genes. A point was raised that interest groups in the Bond Brook and the Kennebec River area may want to use this unique Bond Brook stock as donor stock for Kennebec restoration. It was recommended that small populations such as the Bond Brook population be left alone, in line with a conservation biology approach.

3. Several Maine rivers have very low numbers of brood stock which presents challenges for maximizing genetic diversity. The Pleasant and Dennys Rivers were specifically mentioned as being in this situation. In the case of the Pleasant River, only 350 broodstock are currently available. Broodstock availability in the Dennys River is also very low. In light of these situations, managers are faced with sampling stream habitat to collect fry for future broodstock. The desirable outcome is to increase the effective population size and get as many fry from multiple locations (e.g. sample three sites in one day not one site for three days). There was a sense that stocking fry and collecting them from the stream two years later provided a selective advantage over retaining all fish in the hatchery.

4. Current genetic research has provided New England salmon biologists with salmon stock identification and resolution down to the individual level. Future work should include monitoring salmon populations and looking at genetic variability through time. It may also be that allele frequency is temporally stable. Monitoring for missing alleles is also a valuable qualitative monitoring effort that should be pursued.

3.5. INVENTORY OF FRY STOCKING TECHNIQUES

a. Connecticut River Program

James McMenemy / VT Dept. of Fish and Wildlife

Fry stocking is a key strategy in the program to restore Atlantic salmon to the Connecticut River. Fry stocking has increased from less than 200,000 fry in 1986 to 8.5 million in 1997. The current program fry stocking target is at least 10 million fry stocked in all available habitat. Each of the four basin state fishery agencies and the U.S. Forest Service lead stocking and evaluation activities in areas under their jurisdiction.

Fry are produced at five state and two federal facilities with the majority of fry being produced at the White River National Fish Hatchery. Fry from state facilities are stocked by the home state and fry from the federal hatcheries are allocated cooperatively to all states. Most fry stocked in the basin are unfed, but some hatcheries produce fed fry due to incubation temperature constraints. Unfed fry are targeted for stocking just prior to initiation of first feeding at a developmental index of 92. Most fry stocking in the basin occurs from mid April to late May. Stocking is planned to occur when stream temperatures are above 7 C but logistical constraints sometimes require stocking at cooler temperatures.

Most fry are bulk transported in large tanks. Transport water is oxygenated and/or aerated. Up to 175,000 fry are transported in a trip. Some fry are transported in coolers and cubitainers. Fry are enumerated at streamside by weight or volume. Fry stocking density varies from 20 to 100/ 100 m^2 of habitat with most fry stocked at densities from 30-75/100 m^2. Area of habitat is quantified by detailed habitat surveys which have been completed on most of the stocked areas. Stocking density is determined by past performance of the stream. Fry are stocked from buckets into appropriate habitat by a mixture of agency crews and volunteers. Volunteers have become increasingly important as fry stocking has expanded. Fry are scatter planted over the entire length of stream.

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

Evaluations have shown that survival declines with increasing stocking density. Fed and unfed fry have similar survival. No difference has been found in survival between different strains and broodstock types. Fry stocked into flooded streams have poor survival, but flooding hours or days after stocking apparently does not greatly impact survival.

b. Pawcatuck River Program

Dennis Erkan / RI Div. Fish and Wildlife

Fry stocking using volunteers has been the major focus for Atlantic salmon restoration in Rhode Island since 1993. Over the course of the stocking effort, improvements have been phased in to maximize fry survival. Initially fry were transported to the Arcadia Research Hatchery (ARH) in a tank with mechanical aeration. The fry were then placed in troughs, and ultimately distributed to the volunteers in pails for stocking. The handling mortality was significant. To improve survival during transport, a 4 compartment 400 gallon tank was outfitted with a compressed oxygen cylinder, regulator, flowmeters, and microbubble diffusers. Additionally each tank compartment has 2 perforated aluminum boxes to contain the fry and further reduce handling mortality. The fry are poured directly from the incubator trays into tubs and subsequently from the tubs into the perforated boxes. The fry are transported directly from North Attleboro National Fish Hatchery (NANFH) to central watershed locations for the two day stocking effort. The fry are in noticeably better condition after being transported with oxygen. Additionally mortality is significantly diminished from the reduction in handling. The volunteers are given a stocking location map and a lesson on handling of fry. The approximate volume of fry for an entire tributary is determined and then divided among assigned volunteers. Fry are then transported in pails and coolers equipped with battery operated aerators. Most of the stocking is done from shore or by wading. Certain relatively inaccessible sections of stream are stocked from canoes. Fry produced from sea-run returns are stocked in the most productive tributaries. The goal is as uniform a distribution over the 4490 100 m^2 habitat units in the watershed as is possible given the number of volunteers. The number of volunteers is maximized through press releases, newsletters, coordinators, and mailings.

Smolt Production from Stocked Fry

Year	Number of fry stocked	Stocking density	Estimated smolt migration (age 2)	Adult returns from fry stocking
1993	382,800	85/100 m^2	-	-
1994	557,165	124/100 m^2	-	-
1995	**366,618**	82/100 m^2	4242 (1993 origin 1.11% survival)	-
1996	**288,904**	64/100 m^2	5119 (1994 origin 0.92% survival)	-
1997	**100,000**	22/100 m^2	**9115** (1995 origin 2.49% survival)	2♂ 1♀ (1993 origin)

Bold indicates fry transport with new tank (compressed oxygen, microbubble diffusers, perforated boxes).

c. Merrimack River Program

Jon Greenwood / NH Fish and Game

New Hampshire Fish and Game (NHFG) has been stocking the Merrimack River watershed with Atlantic Salmon fry since 1984 according to a fry stocking plan developed by the Merrimack River Technical Committee. The watershed is divided into three sections or basin zones that differ in topography and delineate regional differences in climatic conditions. The lower and middle zones have streams with moderate gradients and higher annual water temperatures. The upper basin zone is characterized by steep gradient headwater streams, which have cooler annual stream temperatures.

Streams within the basin and have been surveyed and habitat units have been inventoried. The agencies have identified approximately 70,000 100yd^2 units of habitat that represent 215 miles of stream for fry stocking. The stocking plan calls for 3.1 million fry to be stocked annually. The lower basin receives 20% of this total, the middle 10% and the headwater reach and historical nursery area receives 70% of all the fry stocked. Three hatchery facilities Nashua NFH, NANFH and the WSFH provide the eggs and incubation facilities for the stocking target of 3.1 million non-feeding fry.

A fry distribution schedule has been developed and is provided to the hatcheries, resource agencies, and volunteer groups and shows the date stocking will occur, the number of fry required for the day, the location to meet, the number of volunteers needed and the hatchery that is providing the fish for that day. Fry stocking begins in the lower basin in late April when water temperatures are at 47°F. North Attleboro National Fish Hatchery provides the fry that are scatter stocked in the lower and middle basin. The Warren State Fish Hatchery provides fry for the upper basin. Nearly half of the fish in the upper basin are stocked from a drift boat into the Pemigewasset River Mainstream a river reach of eighteen miles. Upper Basin Rivers including the Smith, Baker, Mad, Beebe, Pemigewasset east branch and an additional fourteen small tributaries are also scatter stocked with major assistance from the U. S. Forest Service volunteers. Fry stocking for the Merrimack River normally ends the first week of June and is accomplished in approximately twenty-four days.

The stream surveys have been transferred onto USGS Maps. Rivers and streams have been partitioned into sections that identify the number of habitat units and physical features that delineate a stream section. The number of fry to be stocked in each section is identified on the USGS map. Field data sheets are filled out prior to stocking and provide field personnel with the stocking plan for the day.

d. Maine Program

Denise Buckley / U.S. Fish and Wildlife Service

Fry stocking is done in Maine rivers for a variety of reasons. While smolt stocking produces more adult returns per green eggs, the less time spent in a hatchery environment encourages a more "wild" product. In addition, stocking fry allows for a wider distribution of returning adults throughout the river due to the specific stocking sites used. In the case of the river-specific program, the production of six separate smolt stocks at Craig Brook NFH is unfeasible. Fry stocking on the Penobscot River is supplemental to the current smolt stocking program. Current fry stocking efforts require the use of feeding fry (a fish from the end of yolk sac dependence to June 30 of the hatching year). All fry, as well as broodstock, for each river in the river-specific program are kept in separate bays or raceways at Craig Brook NFH to reduce the spread or introduction of disease from one stock to another.

The first broodstock for the river-specific fry stocking program were collected from the Machias River in 1991. From 1992 through 1997, 1.98 million river-specific fry have been stocked into the Dennys (469,817), East Machias (227,480), Machias (682,569), Narraguagus (502,127), and Sheepscot (166,284) rivers. These fry are the progeny of river-specific sea-run adults (captured at seasonal weirs) and parr broodstock raised to sexual maturity at Craig Brook NFH (captured using electrofishing equipment). During the same time period 6.5 million fry have been stocked into the Penobscot River. An estimated 1.4 million fry will by stocked in these five rivers in 1998. An estimated 961,359 fry will be stocked in the Penobscot River in 1998.

The current recommended number of fry per unit of habitat (100 square meters) is 100. To date the amount of available habitat has exceeded the number of available fry, which has resulted in stocking levles at an average of 25 - 75 fry per unit. Several studies were done during 1997 and are proposed for 1998 to estimate the carrying capacity for certain sites. Study sites in 1997 were stocked at an estimated 500 fry per unit. Sites proposed in 1998 for carrying capacity studies are scheduled to be stocked at 200 - 300 fry per unit. The availability of GIS habitat maps and standardized reach designations has assisted fry stocking crews in locating rearing habitat during high spring flows.

Areas of natural reproduction, either by sea-run adults or released captive broodstock, are noted during redd counts the previous fall. These areas are located on GIS habitat maps prior to stocking and stocking fry over these areas are avoided.

Fry stocking in Maine typically occurs during a two to three week period in May. This window is often interrupted by high water conditions caused by spring rains and melting. Stocking fry during high water conditions is both impractical and hazardous to personnel. There is a need to determine the feasibility of expanding this two week window, for logistical and hatchery capacity reasons.

Logistical information pertaining to the date a certain trip is to occur, the number of personnel and level of canoeing expertise needed, the number of fry, and equipment needed are decided jointly by staff from the USFWS and ASA. Stocking logistics are complex and are subject to change on a daily basis due to weather, availability of personnel, and condition of the fry. Ninety percent of all stocking in Maine is performed from canoes in remote locations. Some stocking sites, especially on the tributaries to the Penobscot River, are up to 150 miles from Craig Brook NFH. A typical day of fry stocking can begin as early as 5:30 am and end later than 8:00 pm to allow for loading out vehicles for different rivers, several hours travel time to the site, set up of canoes, the stocking trip, travel back to Craig Brook NFH, and the disinfection of each truck used.

Fry capacity at Craig Brook NFH is 200,000 per river in each bay. Often this number is exceeded which can require earlier than desired stocking. Early May stocking was done on the Narraguagus River during 1997, however, evaluation of this effort was relatively unsuccessful due to unusually cold temperature and high water levels through the spring. The logistics of dealing with five separate river stocks creates many other obstacles. Often several stocks become available for stocking in close proximity to one another, which causes a general scramble for equipment, vehicles, and personnel. An additional factor to consider in dealing with five separate stocks is the necessity of disinfecting all equipment used for the stocking of one river-strain to the next.

Personnel responsible for stocking fry on the Downeast rivers include staff from the Office of the Maine Fishery Program Coordinator, Craig Brook NFH, and the Maine Atlantic Salmon Authority. Fry stocking on the Penobscot River is conducted by the above staff and additional staff from Green Lake NFH and the Penobscot Indian Nation. The number of personnel available for stocking is limited by individual familiarity with the target river and the level of canoeing experience required for each trip.

Fry are sample counted at Craig Brook NFH prior to being loaded into fry stocking vehicles. Fry are transported to each river via 4X4 pick-up trucks fitted with specially designed cooler set-ups. Each set-up consists of four 178 quart coolers fitted with oxygen supply systems and aerators. The coolers are strapped onto a frame constructed of 3/4 inch plywood with aluminum brackets, drain hoses, and electrical wiring to run the aerators. Control boxes for each set of four aerators are located in the cab of the truck. Each cooler contains three perforated plastic cubes which allow for specific numbers of fry to be allocated to specific sites. Each truck unit is able to carry between 100,000 to 125,000 fry per trip. There are typically four truck units available per stocking season. During 1997 a truck was fitted with a 224 gallon fish transport tank fitted with an oxygen supply system and aerator. This tank was modified by hatchery personnel to hold eleven individual cubes. This tank is able to carry up to 150,000 fry per trip.

Once fry arrive at the site they are transferred into similarly equipped canoes. Several canoes of varying sizes have been fitted with welded aluminum frames which attach to the gunwales. Each frame is specifically designed for each canoe. Each canoe, with the exception of the 20 foot canoe, holds two 35 quart coolers fitted with oxygen supply systems. The 20 foot canoe has been fitted with two separate frames and carries four 35 quart coolers. Each canoe cooler can carry up to 25,000 fry. Over 90 percent of all river-specific fry stocking is completed using this type of canoe set-up.

Foot stocking accounts for less than 10 percent of the total river-specific fry stocking program. This is often done in areas where the use of canoes is impractical or for outreach purposes. Foot stocking is often accomplished using volunteers under the supervision of a USFWS or ASA staff member. No special equipment is required for foot stocking once the fish have been transported to the site.

Considerable maintenance is required for fry stocking equipment throughout the year. This is includes repair of damage incurred during the fry stocking season, replacement of lost or damaged equipment, and the development of more efficient technologies. Personnel involved in fry stocking must have a working knowledge of the oxygen systems, aerators, and valve systems used on the stocking vehicles and canoes in order to ensure safe delivery of fry to the target river. Emergency tool kits are placed in each canoe and truck at the onset the fry stocking season and contain an assortment of equipment to fix almost any mishap. Such equipment ranges from adjustable wrenches, spare oxygen fittings and regulators, rubber bands, shoe goo, Teflon tape, wire ties and the inevitable duct tape.

Two private hatcheries are also involved in the raising and stocking of fry in Maine rivers. The Saco River Hatchery, operated by the Saco River Salmon Club receives eggs of Penobscot River origin each year. These fry are stocked by volunteers, primarily by foot, with assistance from Craig Brook NFH. The Pleasant River Hatchery, which is operated by the Downeast Salmon Federation, receives Machias and Narraguagus river eggs from Craig Brook NFH. These fry are stocked using the canoe method described above, in addition to foot stocking by volunteers. Once eggs are available from Pleasant River broodstock, a percentage of these will be raised at the Pleasant River Hatchery.

Many schools throughout Maine participate in programs which provide salmon eggs and incubators as part of a ecology-based curriculum. These programs include the Atlantic Salmon Federation Fish Friends, Craig Brook NFH Salmon-in-the-Schools, and Nashua NFH Adopt-a-Salmon. These schools receive up to 300 eggs of either Penobscot or river-specific origin (dependent on location) and stock the resulting fry in the appropriate rivers.

e. Discussion

Questions were raised relative to stocking densities, such as: Are they a function of ease of stocking? Are some areas being missed? Consensus was that most programs were happy with present densities. More fry would be helpful to saturate all available habitat.

Merrimack is in the process of reviewing the whole fry stocking program and will have better information next year.

Discussion over the Norway stocking technique of using fewer fish but planting them individually behind every rock. Most felt that this might work better, however, it is not at all practical for the large systems or the number of fry being released in the Northeast.

There was a feeling that many fry are being stocked in areas where flows were much too high. The over-all question was: are we getting the fish into the habitat with the techniques that we are presently using. Most felt present techniques are OK however, more studies are being done to evaluate post stocking mortalities and look at fry stocking densities.

The committee recognized that the use of volunteers was essential but posed challenges.

3.6. FRY STOCKING ASSESSMENT

Merrimack River Watershed: Atlantic Salmon Fry Stocking Evaluation 1982 - 1997

Joseph F. McKeon and Everett A. McLaughlin / U.S. Fish and Wildlife Service
John F. Kocik / National Marine Fisheries Service
Jonathon C. Greenwood / NH Fish and Game

We examined the impacts of two stocking densities of Atlantic salmon (*Salmo salar*) fry in the Merrimack River watershed by analyzing estimates of abundance of yearling parr at sample sites, and by analyzing morphometric measurements of parr captured at sites. In addition, we estimated yearling parr abundance in geographic regions of the watershed, and also developed estimates of total abundance and survival of yearling parr for the watershed. The survival of parr from the fry to yearling parr stage was determined for years 1994-1997, and was reported as percent survival of yearling parr for the total watershed.

The impact of changes in fry stocking density at six river sites was evaluated where fry were stocked at low (x) density and at high (2x) density. Comparisons were made between the mean estimates of yearling parr/unit (one unit = 100 m^2 habitat) for each stocking level at each site, and between mean total lengths of yearling parr captured at each site and in regions for both stocking levels. Mean yearling parr density/unit at river sites and in regions where fry were stocked at a low density did not change significantly when fry were stocked at a high density. The mean total lengths of yearling parr at each river site and in regions was significantly different ($P < 0.001$), however, where the mean total length of parr from low density fry stocking was greater than the mean total length of parr from high density fry stocking. The mean total length of yearling parr at low and high density fry stocking was 11.2 cm and 10.7 cm, respectively in Region 1 and 15.1 cm and 13.4 cm in Region 4.

In four of six rivers (Baker, Smith, South Branch Piscataquog, and Souhegan Rivers), fry were stocked at a low density in years 1991-1993, and at a high density in years 1994-1996. In the Pemigewasset River, fry were stocked at a low density in years 1987-1990, and at a high density in years 1991-1996. However, in the Mad River, fry were stocked at a low density in years 1985-1990, and at a high density in years 1991-1996. Fry stocking density was different for some rivers, with low density stocking at 30 fry/unit in the Pemigewasset, Baker, and Souhegan rivers; 18 fry/unit in the Mad River; 36 fry/unit in the Smith River; and 48 fry/unit in the South Branch Piscataquog River.

Estimates of yearling parr abundance for geographic regions and the watershed reveal a decreasing trend in survival. Based on the regional sampling scheme, survival for yearling parr in the watershed was 10%, 7.0%, 3.9%, and 3.3% for years 1994-1997, respectively. A more rigorous geostrata sampling scheme provided total watershed survival estimates of 6.7%, 7.0%, 3.2% and 2.6% for yearling parr in these years.

Our evaluation and analyses were based on a number of assumed constants. Unfed fry at similar stages of development were released in all years. Sampling of yearling parr at each river site occurred at or on a similar date in every year. The coefficient of variation for yearling parr estimates at sites was typically 10%. Abiotic and biotic factors affecting parr survival and growth did not vary significantly in the watershed during years of low and high density fry stocking, or similar environmental or biological perturbations occurred during both low and high density stocking years. Therefore, our grand assumption stated that the level at which fry were stocked was the key variable that changed.

Atlantic salmon fry were first released at sites in headwater tributaries of the watershed in 1975, and by 1984 a large scale stocking program was well established. In years prior to 1984, the number of fry stocked throughout the watershed ranged from a low of 8,370 to a high of 125,500, and the average number stocked was 66,108. For years 1984-1996, the number of fry stocked ranged from 148,350 to 2.8 million, with an annual average of 1,320,652 fry stocked.

In 1982, six tributaries were identified where index sites were established to estimate abundance of parr within river reaches (sites). A generalized regional sampling effort was also established, where at least one site was located in one of four regions. Each region has different characteristics that include climate, geography, geology, hydrology and land use.

The transition from the northern mountains and foothills (Regions 1 and 2) to the southern seaboard plateau and lowlands (Regions 3 and 4), depicts the change in characteristics of parr habitat in the watershed. In all years of sampling, parr were captured by electrofishing, and although sampling was directed at yearling parr, estimates for underyearling and overyearling (age 2) parr were also calculated. Estimates for these age classes were less reliable, as smaller underyearling parr may elude capture by seeking refuge in boulder and rubble substrate, and few overyearling parr are observed at sites. Estimates of abundance at sites was determined using a mark-recapture method in years prior to 1990, but an equal-effort, catch-removal method was used in subsequent years.

In 1994, a sampling scheme was implemented that identified three habitat strata within regions, including very large rivers with drainage areas (da) >200,000 ha; large rivers, where 40,500 ha ≥ da ≤ 200,000 ha; and small rivers where da < 40,500 ha. This sampling scheme provided opportunities to calculate estimates of parr abundance for regions, geostrata, and the watershed. Using an optimization matrix, we identified optimal sample allocation necessary to achieve a desired 10% coefficient of variation in our watershed estimate. In addition, we documented the effort involved in sampling based on the number of personnel needed at a sample site, and kilometers traveled to and from sites. We have begun to contrast sampling effort with the desired level of precision in the parr estimate, and suspect that sampling effort will not differ significantly in future years.

There may be bias in our stated grand assumption. The number of fish observed at sites in recent years may have been influenced by environmental factors. Precipitation for year 1995 was above average, and for year 1996, it exceeded that observed for any year of record. Floods occurred in fall 1995 and spring 1996, and these high flow events may have adversely affected the survival of parr. High flows in some watersheds, notably the Souhegan River, at the time fry were stocked may have been an additional factor that resulted in poor yearling parr abundance at this site, and therefore in Region 4.

Discussion

The assessment committee considered research on the effect of fry stocking density on the occurrence of precocious male parr in salmon populations. Early maturation is perceived to be an undesirable trait in salmon populations in New England and elsewhere. Specifically, can stocking density and conditions be manipulated to control maturity rate in juveniles? It was pointed out that parr tend to mature during fall outside the sampling period.

The size of stream parr was related to the density at which those fish were stocked as fry. It was suggested that it might be more productive to measure growth rates of parr instead of relying on the length frequency data. These rates could be calculated by comparing fry to parr sizes. It was also pointed out that the relationship between stocking rates and resultant parr densities appear to show significant variability and it may be useful to examine them as continuous variables instead of post-stratifying the data into the two stocking regimes, the early low density period versus the later high density period.

This variability in the Merrimack River program coincides with perceived variability in predation conditions affecting migration smolts. The committee agreed that the interaction of stocking density and the resultant predation rate for migrating smolts be investigated.

3.7. EFFECTS OF DEVELOPMENTAL STAGE AND MATERNAL EGG SOURCE ON FRY STOCKING SUCCESS

Timothy D. Terrick and Benjamin H. Letcher / USGS-BRD

In this abstract, we report on the growth and survival rates for Atlantic salmon fry stocked 1) at different developmental stages and different times and 2) from different maternal egg sources. We examined growth and survival in three study rivers, the West Branch of the North River, Mill Brook and Sawmill River, within different drainages, Deerfield River, Westfield River and the main stem of the Connecticut River respectively, in Massachusetts during 1996 and 1997.

In 1996, we examined the effect of developmental stage and stocking time on stocking success using four treatment groups each based in a fixed stocking Developmental Index (DI) of 92. A delayed group (DI=85), held in cold water during rearing and, at stocking, was developmentally delayed a nominal group (DI=95), held under ambient water conditions and stocked at a typical developmental stage, and two accelerated groups (DI=115), each held in warm water during rearing to be developmentally advanced, one which was fed beginning at a DI of 100 the other unfed. Within each river three sites were established each separated by at least 1 km. Each site was divided into two sections, an upper and lower section, each approximately 10 units (1000 m^2). Each section was randomly assigned a stocking treatment. The early treatment was stocked three weeks prior to the late treatment, each receiving the same four developmental stage treatment groups. Each section received 500 fish, equally represented by the four treatment groups for a stocking density of 50 fish/100 m^2. Hatchery fish were stocked between all sites. Sampling was conducted in the fall using three-pass removal electrofishing with rivers with sites chosen randomly. Fork length and wet weight were measured for all trout and salmon and all 0^+ salmon were retained for group identification. Groups were identified by distinct thermal otolith banding patterns created during rearing. River and treatment effects were analyzed from population estimates and growth rates. We found significant differences in mean population estimates between treatment groups ($p=0.002$, $df=3,48$) with the difference resulting from the accelerated-unfed group ($p>0.05$ for three treatments). There was no difference in mean population estimates between early and late stock times ($p=0.50$, $df= 1,48$).

In 1997, we repeated the developmental study, only this time eliminating the accelerated-unfed treatment because accelerated-unfed fish were captured in such low numbers (3 total). We also limiting stocking to a single time because there were no significant differences in stock time in 1996. Additionally, we added the maternal source component to the study to examine growth and survival of fry stocked from different mothers.

Currently, in the Connecticut River, salmon eggs are derived from three types of broodstock. Our maternal treatment groups consisted of eggs from sea-run, domestic and kelt broodstock. Typically sea-run eggs make up approximately 20% of the restoration programs' stocking with domestic making up 70% and kelts 10%.

We stocked the developmental treatment groups into the lower section and the maternal treatment groups into the upper section of each site at the same densities as 1996. Again rivers and sites were randomly sampled as in 1996 and the results for both developmental and maternal treatments were analyzed separately for differences in growth and survival.

The results of the developmental study showed no significant difference in mean population estimates between the three treatment groups ($p=0.066$, df= 2,18).We did see significant differences in mean length between treatment groups at the time of stocking ($p<0.001$, df= 2,57; delayed were smallest, accelerated-fed were largest) but this difference was not apparent at the time of sampling ($p=0.657$, df= 2,257). These results, along with those from 1996, suggest that it is not necessary to target a specific DI, and that stocking times can be more flexible to suit specific environmental conditions.

The results from the maternal study show a significant difference in mean population estimates among maternal treatment group ($p=0.026$, df= 2,18) with sea-runs having the greatest survival and kelts the lowest. We found, as with the developmental treatments, differences in mean length at the time of stocking ($p<0.001$, df= 2,57; sea-runs were smallest, kelts were largest) but this difference was not apparent at the time of sampling ($p=0.896$, df= 2,217). These results indicate that there are differences in survival among treatment groups with sea-run offspring having a 39.6% greater chance of survival than kelts and domestic offspring having a 22.2% greater chance of survival.

Discussion

All fish came from White River National Salmon Hatchery and all had a DI of 94. The presenter said that dispersal data had yet to be analyzed for 1997, but that about 80% of the parr captured in the site were fish from the study. The committee wondered what effect various flood regimes may have had on the effects. The presenter indicated that these data were not collected and that there were no gauging station on the study rivers, but that a massive spate had resulted in the lowest study densities in the Sawmill in 1996. The Sawmill had the highest study densities in 1997. The committee also inquired about the likelihood of starvation for the fish in different treatments and a member of the committee indicated that previous laboratory starvation studies suggested that starvation was likely in about 45 days for the fish in all treatments except for the accelerated-unfed treatment. Those fish starved in about 4 days.

4. RESEARCH

4.1. CURRENT RESEARCH ACTIVITIES

The following is a list of Atlantic salmon related research which was conducted during 1997. The capital letters (codes) following the authors names refers to the address of their research facility. These addresses are listed at the end of the Section. The information presented is by no means complete, as it is unknown whether every Atlantic salmon researcher was contacted and some of the researchers that were contacted did not respond to the information request. A list of people and agencies contacted is presented following the address list.

STOCK IDENTIFICATION

Tracing the tributary origins of anadromous Atlantic salmon (*Salmo salar*) through the use of stable isotopes

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

Efforts to restore Atlantic salmon and to conserve juvenile salmon habitat are greatly assisted by identifying the natal habitats which produce the most successful individuals. To address this issue we have been continuing our research on the use of stable isotopes to trace the rearing habitats of migrating salmon. Our goal is to develop an isotopic map of Vermont streams using elements (e.g. strontium (Sr) and nitrogen (N)) to distinguish fish from among different tributaries. On the basis of d87Sr values in salmon backbones and water, we have separated ten rearing tributaries into eight distinct groups. Nitrogen isotopes also differed significantly among sites with a strong positive relationship between the percent of agricultural area within a watershed and the 15N enrichment of stream water nitrate and salmon tissue. Work that is currently underway will expand the number of sites studied and explore additional isotopic systems in areas where finer scale resolution is necessary.

SMOLTIFICATION AND SMOLT ECOLOGY

Growth Patterns in Atlantic Salmon Post-smolts and the Nature of the Marine Juvenile Nursery

Kevin D. Friedland / NMFS (L)

See pages 79-81

Factors influencing smolt production, overwinter mortality, and downstream migration of Atlantic salmon in the Connecticut River

Donna L. Parrish and Kevin Whalen (B)
Cooperators: NMFS, VT Dept. FW, US Forest Service, BRD

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. Because little is known about smolt production from fry stocking, including numbers produced, cross-tributary variation, and factors affecting downstream migration, 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 with net weirs and counting fences installed on the Rock River, Wardsboro Branch, and Utley Brook, three large tributaries of the West River, Vermont. 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. The smolt migration was typically initiated in late April and was completed by late May, although smolts were at times collected through early June. Between 70 and 95% of the smolts spent two winters instream before migrating. Of the 3282 smolts collected, 2654 were marked for efficiency tests and 863 (33%) were recaptured. Percent age 1+ parr smolting and out-migrating as age 2+ smolts ranged from 10 to 31% and overwinter mortality ranged from 40 to 75%. Most smolts were between 120 and 190 mm TL and typically, age 3+ smolts were larger than age 2+ smolts. Smolts also differed in mean length among tributaries with abundances essentially equal to those of immature parr. Generally, percent maturity increased with parr age. Results from fall marking and spring recapture studies suggests that mature parr are recruited to smolt at is lower frequency than immature parr.

Loss of smolt characteristics in Atlantic salmon in the wild

S.D. McCormick (A)

Atlantic salmon smolts undergo preparatory physiological changes that allow them to make a rapid transition from fresh water to seawater. This process is reversible, and loss of migratory urge and the capacity to survive in seawater occurs in hatchery-reared smolts. It is not currently known whether such reversal occurs in the wild. Loss of these characteristics may be particularly important when migration is delayed, as might occur at dams and impoundments. Atlantic salmon that had previously been released as fry in tributaries of the Connecticut River were captured during their normal spring smolt migration from 1993-1997 at a dam 198 km from the mouth of the river. Significant decreases in gill Na^+,K^+-ATPase activity and salinity tolerance were seen in smolts at the end of the migratory period in all years sampled. Loss of smolt characteristics was earlier and more severe when temperatures were high during the migratory period. The reduction in gill Na^+,K^+-ATPase activity was directly related to the degree days of river temperature during the migratory period (r^2=0.75). 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). Hatchery fish from the Connecticut River 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 is a constant 10 °C. Similarly, migrating smolts from the Connecticut River that were brought into the laboratory and held under controlled conditions lost physiological smolt characteristics more rapidly at warmer temperatures. The results indicate that late migrants in warm, southern rivers have lost physiological smolt characteristics as is a result of high temperatures experienced by these fish during migration.

Do Atlantic salmon "re-smolt"?

M.J. Shrimpton and S.D. McCormick (A)

Increases in salinity tolerance that occur during smolting are known to be reversible. Fish that are maintained in fresh water beyond the period of normal spring migration lose their elevated capacity to osmoregulate in seawater. Research on Atlantic salmon reared in the wild indicates that loss of smolt characteristics also occurs under some conditions in naturally migrating smolts. These fish may cease migration and continue to reside in the river. Fish that physically appear to be smolts have been captured behind dams in the Connecticut River with low levels of gill Na^+K^+ATPase activity. It is not known whether or not these fish that have undergone the parr-smolt transformation will repeat the morphological and physiological changes associated with smolting the following spring. To evaluate the ability of Atlantic salmon to smolt twice, we held a group of salmon at the White River National Fish Hatchery in Bethel, VT for two years. At monthly intervals, we examined the growth, physical appearance, physiological changes and hormone levels of the fish. Bimodal growth distribution was evident by the first October post-hatch. LM fish were 9.9 ± 0.5 g and 9.7 ± 0.2 cm and the UM fish were 19.9 ± 1.7 g and 12.0 ± 0.4 cm fork length. The UM and LM fish showed significant increases in gill Na^+K^+ATPase activity in the first spring. The increase in enzyme activity, however, was three-fold greater in the UM fish than LM fish. Gill Na^+K^+ATPase activity was highest in May, declined and then remained low in both groups until the next spring. Both UM and LM fish showed significant increases in gill Na^+K^+ATPase activity in the second spring. Although the levels of Na^+K^+ATPase in the UM fish were approximately 70% of LM fish, they were clearly higher than the small increase in Na^+K^+ATPase observed in the LM fish the previous spring. Gill Na^+K^+ATPase activity in LM fish during the second spring were similar to those of the UM during the first spring. Endocrine changes in GH and cortisol showed similar seasonal rhythms that paralleled the changes observed in gill $Na^{+}K^{+}$ATPase activity. Our findings indicate that Atlantic salmon are capable of undergoing the physiological changes associated with smolting during two subsequent years.

Physiological changes in mature Atlantic salmon parr; does maturation preclude smolting?

M.J. Shrimpton and S.D. McCormick (A)

In many species of salmon, a proportion of males mature in fresh water without migrating to the sea. Maturation can compromise smolt development. In Pacific salmonids, maturing male parr exhibit decreased ability to adapt to seawater compared with immature fish. The mechanism for impaired smolting in previously mature males could be linked to sex steroids as plasma androgens are known to affect osmoregulatory ability. It is also possible, however, that energetic constraints limit smolting in parr that mature. Mesenteric fat stores are depleted during the maturation process of salmonids, and the winter decrease in energy content has been shown to be greatest in previously mature fish. To evaluate the ability of Atlantic salmon to smolt following maturation, we held is a group of salmon at the White River National Fish Hatchery in Bethel, VT for two years. At monthly intervals, we examined the growth, physical appearance, physiological changes and endocrine levels of the fish. In spring, previously mature parr could be split into two groups based on appearance. Some of the fish were silver and looked like smolts. Others remained dark with highly visible parr marks. There was no correlation, however, between physical appearance and gill $Na^{+}K^{+}$ATPase activity. Some of the fish with high levels of gill $Na^{+}K^{+}$ATPase activity were silver and others were dark. The same was true for fish with low enzyme activities. There was a slight increase in plasma testosterone levels (three-fold) in some of the previously mature fish which inversely correlated with $Na^{+}K^{+}$ATPase activity, but was not related to physical appearance. A similar increase in 11-ketotestosterone levels was not seen, and there was no corresponding correlation between this hormone and gill Na^{+},K^{+}-ATPase activity. Condition factor, however, was also highly inversely correlated with gill $Na^{+}K^{+}$ATPase activity. Our findings indicate that Atlantic salmon that previously mature are capable of smolting the subsequent spring. Some of the fish, however, do not smolt. As plasma testosterone levels were higher in the fish that did not smolt, this hormone may inhibit smolting. Whether or not these fish will remature the following fall is unknown.

Environmental regulation of downstream migratory behavior of hatchery and wild Atlantic salmon smolts

G. Barbin and S.D. McCormick (A)

Effective restoration of Atlantic salmon necessitates an understanding of survival through critical periods of the life cycle. A major assumption of fry stocking, a management practice that has expanded considerably, is that smolts reared in the wild can successfully migrate from the freshwater to seawater environment. However, we know little about the behavioral aspects associated with successful movement downstream while we have a fairly good understanding of the physiology associated with transition between these two environments. Continuous monitoring was accomplished by using a passive integrated transponder (PIT) system. PIT tags, with individual codes, were implanted in all fish before they were placed in experimental tanks. We used five and eight foot diameter annular tanks to continuously monitor downstream migratory behavior from 12 April - 24 July 1997. Changes in daily activity rhythms were evident and parr (control fish) demonstrated significantly less movement than smolts under the same conditions. An advanced temperature regime (1°C increase every 3 d) induced increased activity earlier in the season than the ambient (control, 1°C increase every 4 d) temperature regime. The delayed regime (1°C increase every 9 d) delayed behavioral and physiological activity relative to the ambient regime, indicating that cooler temperatures extends the period of downstream migration. Field analyses of downstream migratory behavior have been initiated in Masschusetts and Vermont.

Investigation of heat shock proteins and the role they play in adaptation of salmon to seawater

Terry Bradley (K)

The objective of this research is to determine if specific protein are necessary for successful adaptation of salmon to the marine environment. If proteins specific to osmotic adaptation can be identified they would provide us with a better understanding of smoltification and might be used as sensitive markers of this process.

FRESHWATER SURVIVAL

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

Donna L. Parrish and Matthew Raffenberg (B)
Cooperators: US Forest Service, Vermont Dept. Of Fish and Wildlife.

During the past few years, as part of the Atlantic salmon restoration program, juvenile salmon have been reintroduced into the West and White rivers, Vermont, where native brook trout (*Salvelinus fontinalis*) and rainbow trout (*Onchorhynchus mykiss*) reside. In addition to changes in the salmonid community, decreased habitat complexity in riparian areas and within the streambed have led to changes in flow regimes, water temperatures, and sedimentation rates and have thus affected feeding, growth and survival of salmonid fish species. Competition for space among salmonids has been studied extensively, however, partitioning of food in relation to occupied microhabitats has not. This study will determine how food partitioning can affect Atlantic salmon performance based on the occupation of sites by two trout species that predominate in Vermont streams. Results of this study will assist fisheries managers in making stocking decisions regarding the optimal salmonid species composition in tributaries of the Connecticut River.

During Summer 1995, stomach contents and other relevant data were obtained from a total of 976 Atlantic salmon, brook trout, and rainbow trout collect 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 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.

Factors influencing age-0 salmon survival in the first month after stocking

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

Previous research has indicated that stream conditions during the first month after stocking may be key to age-0 salmon survival. To address this hypothesis, we stocked age-0 salmon at prescribed densities in study sections of six rearing streams, censused age-0 salmon and all other fish species 5-6 weeks later, and measured habitat and food availability during this period. Preliminary results indicate that, as predicted, early-season survival was positively correlated with the availability of microhabitats predicted to yield positive growth. Early season survival was also greater in streams which historically have had high total spring-summer survival. Analysis of the influence of other biotic and abiotic factors on early-season is currently underway.

Effect of overwintering and maturation on energetics of Atlantic salmon parr

M.J. Shrimpton and S.D. McCormick (A)

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, survival and development of salmon reared naturally in rivers. Previous research has suggested that winter is a time of high mortality in stream fishes and that greater energetic reserves can increase winter survival. It has also been suggested that parr maturation may decrease energy reserves in the fall and thus compromise overwinter survival. In order to understand the possible impact of energetics on winter survival, we have been examining growth and energetics of juvenile Atlantic salmon in tributaries of the Connecticut River, and comparing fish that mature as parr to immature fish. In the fall, immature and mature Atlantic salmon parr did not differ significantly in size, although the mature fish had significantly greater condition factor. Testes of mature males comprised up to 10% of body weight in October. Testes reabsorption over the winter was gradual, and was still approximately 2% by the end of March. Plasma androgens were significantly greater in mature male parr than immature parr in October, but had declined by January and did not differ from immature fish for the duration of the study. In the mature fish gonadal regression was linear with time over the winter, however, condition factor declined significantly in early winter. In contrast immature fish showed a small and insignificant reduction in condition factor over the winter. Utilization of both proteins and lipids over the winter was higher in fish that had matured in the fall compared to their immature counterparts. The reduced lipid and protein content may lead to greater overwinter mortality and result in fewer males smolting the following spring.

Physiological impact of stress on Atlantic salmon

S.D. McCormick and J. Carey (A)

Atlantic salmon parr and smolts reared under a natural temperature and photoperiod regime were subjected to an acute handling and confinement stress in early May. Smolts had a mean plasma cortisol concentration of 10 ng/ml before stress and 242 ng/ml 3 hours (h) after initiation of stress which returned to pre-stress levels within 8 h. Parr had a plasma cortisol concentration of 4 ng/ml prior to stress which increased to 11 ng/ml 3 h after initiation of stress and returned to pre-stress levels within 8 h. Plasma glucose was significantly higher in parr and smolts 3 h after initiation of stress; in parr plasma glucose returned to pre-stress levels within 8 h, but not until 48 h in smolts. Plasma chloride concentration in smolts decreased from 139 to 124 mM 3 h after initiation of stress but returned to pre-stress levels within 24 h; plasma chloride in parr was not altered by stress. The results demonstrate that Atlantic salmon smolts are more responsive to stress than parr and that developmental differences are more important than seasonal changes. In order to examine the impact of repeated handling stress on growth, 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 and over a 30 day period it was 50% lower than controls. In fish stressed once daily, growth rate was 18% lower than controls after 10 days and over is a 30 day period it was 34% lower than controls. In fish stressed once daily, food consumption was reduced by 62% after 17 days and 37% after 37 days. At the end of 40 days of acute stress once daily, control and stressed fish were sampled 1 h prior to, 3 and 7 h after a stress event. The results indicate that acute stressors decrease growth of Atlantic salmon parr, with increasing frequency of stress having a more rapid and larger effect.

Atlantic salmon overwinter survival and smolt production in the Narraguagus River

John F. Kocik (NMFS)and Kenneth F. Beland (MASA) (L)

See pages 76-79

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

John F. Kocik (NMFS)and Kenneth F. Beland (MASA) (L)

See pages 76-79

Growth, movement and maturity of individual Atlantic salmon parr in West Brook, MA

Ben Letcher, Gabe Gries, and Tim Terrick (A)

By tagging and resampling Atlantic salmon parr in a small stream (1 km study section of West Brook, Whately, MA), we are developing a record of the growth, movement and maturity of individual fish. From 14 May 1997 to 9 October 1997 we tagged 556 age-one and age-two parr during seven sampling sessions. We used electroshocking to sample the study stream the first and seventh session and used kick seines at night during the other sessions. By the seventh sample, 96.7 percent of the parr were recaptures. Twenty percent of the fish (111 fish) were tagged and captured three times, 17 percent once and three percent all seven times. Fish grew rapidly during the early summer (0.28 d-1) but most fish lost mass (-0.03 d-1) during the summer and early fall. The first mature fish were observed on 6 August and by 29 September 50.8 percent of the fish in the stream were mature (expressing milt). In spring, fish that eventually matured were 13 percent heavier (25.6 g vs. 22.6 g) than fish that did not mature, but by fall maturing fish grew slower and were 5% lighter than non-maturing fish. Movement of individual fish was minimal over the course of the summer; over 95 percent of the fish were recaptured each time in the same 20-m stream section.

Effects of developmental stage and maternal source on Atlantic salmon fry growth and survival

Ben Letcher and Tim Terrick (A)

See pages 58-59.

Predation on stocked Atlantic salmon fry

Nate Henderson and Ben Letcher (A)

We sampled trout gut contents following stocking of Atlantic salmon fry to determine the extent of trout predation on fry. Preliminary results indicate that 13 percent of trout in the Four-mile Brook and 14 percent of trout in the Manhan Brook had consumed salmon fry during the stocking day. No predation on fry was observed beyond two days after stocking. In the Manhan, one brown trout had consumed six fry and another three. Combining gut evacuation rates with gut contents data, future analyses will estimate the percentage of stocked fry consumed by trout.

MARKING

Effect of water temperature and hardness on uptake of calcein marks in larval Atlantic salmon caudal fin tissue

NE Fishery Center (D)

Previous studies at NE Fishery Center-Lamar have shown that immersion of larval Atlantic salmon in a solution of calcein produces is a non-lethally detectable mark in caudal fin tissue for up to 234 days. To further refine mark quality and technique, this study was performed to: (1) compare effects of two temperatures and two water hardness levels on calcein mark readability in larval ATS immersed in calcein (green) solution for 24 and 48 hours. (2) compare 30-day mortality and growth on one set of treatments and controls. Immersion trials consisted of calcein static baths. Each treatment had 3 replicates in the form of 6½-liter acrylic jars containing 200 non-feeding ATS fry of Connecticut River domestic parental origin. Calcein immersions were prepared at concentrations of 125 and 250 mg/L. Immersions were performed in both NEFC spring water and water from a local aquifer which has low hardness. In addition to immersion replicates, three control replicates received the same treatment as immersed fish but without an added chemical. Appropriate temperature (13° or 5° C) of replicates was maintained. At the end of 24 or 48-hour immersion, 50 fish from each calcein replicate were scored for mark readability. Results showed that mark readability was effected by:

a. interaction of calcein concentration and immersion time
b. interaction of calcein concentration and temperature
c. interaction of hardness, temperature, and immersion time

In general, more readable marks were obtained using 250mg/L calcein in soft water at 13° C for 48 hours. There was no significant difference in 30-day growth between calcein and control fish ($P > 0.05$). There was no difference in mortality between controls and fish immersed at 125 mg/L calcein ($P > 0.05$). Thirty-day mortality was significantly greater in fish immersed in 250 mg/L calcein (13.5%) vs. controls (3.5%) ($P \leq 0.05$).

Development of immunological fry marking methods for stock identification of Atlantic salmon

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

Two phases of this project are near completion. We marked several groups of Atlantic salmon fry (1996 and 1997), lake trout fry (1997), and are evaluating the long-term retention of the biochemical markers applied. Also, we have, or are, completing several short-term studies to confirm uptake and retention of antigen markers. We have demonstrated the ability to reliably detect markers such as bovine serum albumin (BSA) in 14-month parr marked with a single immunization at swim-up. We have determined a minimum effective bath concentration for BSA of 3.1 mg/L. We are analyzing samples from fish marked before and at swim-up to determine optimum marking time. Fish immunized as fry are being held for future evaluation (at least 2 years post-immunization). Present tests confirm that the marker antigens are taken up, processed, and retained by the fish over the short-term (40 days). Some antigens form chemical complexes *in situ* and are found in both blood and serum samples. Results demonstrate that antigens given high dosages are not retained in high serum concentrations because fish have an efficient mechanism to clear antigen when triggered by high concentrations. In a test comparing salmon injected with 10 to 100 ug of BSA versus those receiving bath concentrations from 5 to 20 mg/L, we are finding that lower bath and injection concentrations provide higher antigen retention in fish, and that the fish had their highest antigen concentrations when exposed to 10 mg/L baths, higher than for any of the injections used. We are testing the efficacy of dimethyl sulfoxide (DMSO) as an agent to increase antigen uptake and retention. Early results indicate a more rapid antigen level is acquired in fish receiving 1% DMSO in bath treatments. Further aspects of this study now in progress include retrieval of marks from stocked Atlantic salmon, development of monoclonal antibodies for use in evaluation of antibody response to antigens, continued evaluation of DMSO used in bath treatments, evaluation of fry marked in 1996-1997, and final development of the field identification method. We are satisfied that the biochemical marking method works and will proceed to refine the method.

POPULATION ESTIMATES/TRACKING

Westfield River adult salmon radio-tag study

Donald Pugh and Boyd Kynard (A)

The object of this study is to determine movement and habitat use of sea-run and broodstock Atlantic salmon in the Westfield River, Massachusetts. Eleven sea-run salmon were trapped at the lowermost dam (DSI, Inc.

dam, West Springfield) radio-tagged, and released above Knightville dam on the East Branch. Fish were tracked from early summer 1997 until January 1998. Six fish moved downriver to the hydroelectric dam in Huntington, remaining in the pond upstream of the dam throughout the summer. Five fish moved upriver and also remained in pools throughout the summer. Two fish were poached or lost during the summer. Eight of the remaining nine fish moved upriver prior to spawning, which occurred in November (temperature range: 3-7°). Post-spawning movement was downriver. Radio-tagged broodstock salmon were released in the East Branch (n=8) and West Branch (n=8) in mid-October. Sea-run fish were present in the East Branch above the release point, but no sea-run fish were upstream of the broodstock fish in the West Branch. No redd construction or spawning was observed in the West Branch but some broodstock spawning (n=3) occurred in the East Branch. Although all broodstock did not spawn, 15 of 16 fish moved downriver. Fish movements varied greatly in timing and distance. All fish remaining in the river (sea-run=5, broodsstock=8) will be monitored during their residence in the river. Spawning success will be evaluated spring 1998.

Merrimack River Domestic Salmon : Pre-Spawn Release Results

McKeon, Joseph F. (N)

Domestic Atlantic salmon broodstock were released at four sites in the Pemigewasset River in June and July of 1997. Shore and watercraft based surveys were conducted to visually observe and locate fish and redds. Surveys began in summer and continued into winter. Radio telemetry was used to assist in evaluating the movement and behavior of fish and transmitters were surgically implanted in the abdominal cavity of 10 salmon. Three stationary and two mobile receivers were used to determine the locations and movement of tagged fish. In total, 140 Atlantic salmon broodstock were released in the Pemigewasset River for this study. Riverine habitat at release locations included large, deep (> 3.0 m in depth) pools, and long (≥100 m in length) riffle/run complexes. Substrate in riffle/runs was composed of cobble and gravel, characteristics that denote preferred salmon spawning habitat.

One tagged fish died at the time of release, and the carcass of a second tagged fish was found 18 days after release approximately 10 rkm downstream. This fish had been eviscerated given the reported condition of the carcass. One tagged fish was determined to have passed Ayers Island dam, located a distance of 39 rkm from the release site. The carcass was recovered at Eastman Falls dam in late November, approximately 61rkm downstream from the release site. Six tagged fish remained in the general location of the release site until mid fall when three tags ceased transmission. Continued reconnaissance in early winter placed three fish in deep pools in a area approximately five rkm downstream from the release site. No fish were observed for extended periods in riffles and runs proximal to spawning gravel, and no redds were located. Deep pools provided cover, and fish were often found in pools during daylight surveys. A few broodstock were observed in runs, but quickly sought cover in pools when disturbed. Future evaluations will focus on similar release dates and locations for broodstock, and proposals will be developed to support the release of sea-run salmon at similar locations.

CULTURE/LIFE HISTORY

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

NE Fishery Center/USGS-BRD-Wellsboro Lab (D, E)

The NEFC, other Service facilities, and Wellsboro-BRD have conducted a number of studies which have resulted in limited success in improving reproductive performance of Atlantic salmon. To expand our efforts to improve Atlantic salmon production efficiency, a study was performed to determine the effect of diet on reproductive performance of Atlantic salmon broodstock fed the current standard pelleted diet (ASD2-30) or a nutritionally updated extruded diet (ATS-5). The experimental ATS-5 diet was prepared using modern extrusion technology which has been shown to improve nutrient availability. Feeding experimental diets was conducted at Nashua NFH and egg incubation at North Attleboro NFH. Experimental diets were fed for 6 months (April - September 1997) using two raceways each with 150 randomly selected 4-year-old Atlantic salmon. Individual fish lengths and weights were recorded at start of trial and at the time of spawning. Reproductive success will be measured by evaluating 15 spawns for each diet on three spawning days. Percent eye-up will be determined from the first take of eggs from each female and total number of second take eggs will be recorded. Each spawn was conducted as 1:1 mating. Eggs were transported to North Attleboro NFH and no initial pick of green eggs was conducted. Milt motility/viability via flow cytometry will be performed at Penn State Univ. In addition, egg shock sensitivity, quantification of egg color differences, and egg analyses for selected nutrients will be examined. The study is ongoing and scheduled for completion in Spring 1998.

Effect of density on mortality of green and eyed Atlantic salmon eggs in vertical Heath-style incubator trays

NE Fishery Center (D)

In 1996/97 White River National Fish Hatchery (WRNFH) incubated over 9 million eggs and incubation space became scarce. Therefore, it is necessary to optimize existing space by determining maximum egg densities per Heath tray while maintaining mortality acceptable to Region 5 managers. Normally, egg densities are maintained at 6000-8000 eggs per tray at WRNFH but no studies have been performed to compare densities. We propose to test the effect of density on mortality of both green and eyed eggs at WRNFH. Green egg densities to be tested are: 8,000, 10,000, and 12,000 per tray and eyed egg densities will be 6,500, 8,500, and 10,500 per tray during the 1997/98 incubation period. Through analysis of egg mortality data, we will recommend a maximum egg density for future incubation of green and eyed ATS eggs in Heath trays at White River NFH. There will be five replicates of each egg density. Throughout the incubation period, formalin will be administered to experimental eggs using the same treatments given production eggs. Experimental egg trays will be subject to similar treatment concerning periodic examination, shocking, and removal of dead eggs. Once eggs have eyed, at least 127,500 will be composited, mixed, enumerated and placed into Heath trays as before but with densities of 6,500, 8,500, and 10,500 per tray (± 5%). The study will conclude after performing final larval counts/tray. The study is ongoing with results expected in Spring 1998.

Atlantic salmon fertility studies, 1996, effect of Billard's diluent upon fertilization success

NE Fishery Center/USGS-BRD-Wellsboro Lab (D, E)

Since 1989, the Northeast Fishery Center, other Service facilities and Wellsboro-BRD have conducted a number of studies concerning water quality, fertilization procedures, and Atlantic salmon physiology with the aim of improving egg quality. North Attleboro NFH and R.S. Cronin NSS both maintain Connecticut River kelt salmon for egg production. Typically, milt from Connecticut River sea-run salmon collected at Cronin NSS is transported to North Attleboro NFH in chilled oxygenated zip-lock bags or in chilled loosely capped test tubes. Time from milt collection to use may vary from 4 to 24 hours. Billard's diluent, a physiological saline, was employed in 1995 at Tunison Lab., USGS-BRD, to significantly extend ATS milt viability over a six hour period (Bill Krise). The objective of this study was to test the null hypothesis that use of a physiological saline such as Billard's diluent, along with appropriate sperm activators, would not effect sperm viability when compared to traditional milt transport methods. Milt was collected from RS Cronin NSS sea-run Atlantic salmon. The milt from each male was split into 2 aliquots. One half of the milt was held in an oxygenated ziplock bag. The second half was suspended 1: 100 in is a solution of Billard's diluent and then oxygenated. Approximately 11,250 eggs from each of four female kelts at N. Attleboro NFH were used in the study. Fertilization was conducted 24 hours following collection of milt. Three bowls of eggs were fertilized with 3 ml each of milt stored in zip-lock bags. The other three bowls of eggs were fertilized with the equivalent quantity of milt suspended in Billard's diluent. The study concluded when eyed eggs were enumerated. Results showed that Billard's diluent-stored milt had a negative impact on egg eye-up. No eye-up was obtained for eggs fertilized with milt stored in Billard's diluent. Average eye-up for three Heath trays of eggs fertilized with milt stored in chilled oxygenated plastic bags was 84 %.

Atlantic salmon fertilization trials, 1996 Merrimack domestic eggs, evaluation of Billard's diluent, pooling of milt and effects of time upon fertilization success

NE Fishery Center/USGS-BRD-Wellsboro Lab (D, E)

In 1993 a pilot scale study showed significantly better domestic egg eye-up by delaying fertilization until the eggs had arrived at the incubating facility (87% vs 41% shipping fertilized eggs in insulated jugs). Based on these observations, trials were conducted to evaluate delayed fertilization shipping protocol on a production scale basis in the fall of 1994 (Study L-95-02). Although study egg lots showed improved eye-up with delayed fertilization, results of statistical evaluations were not strongly conclusive. In the study L-95-02, pooled milt was employed; however, the unfertilized eggs were not pooled. A large degree of variability in egg quality within treatment groups was observed. It is also believed that milt handling techniques can effect egg survival. Billard's diluent, a saline solution, was employed in 1995 at Tunison Lab., USGS-BRD, to extend ATS milt viability over 6-hours (B. Krise). The objective of this study was to test the following null hypotheses: 1) no differences in milt viability exists between individual male salmon; 2) the effect of pooling milt prior to fertilization will not impact overall eyeup for a series of replicates when compared to utilizing milt from individual males; 3) there are no differences in eye-up between eggs fertilized prior to transport vs. delayed fertilization at the receiving station and 4) Billard's diluent along with sperm activating solutions does not effect milt viability vs. milt stored in oxygenated bags. Atlantic salmon (45,000 eggs) from Nashua NFH were employed in the study to conduct nine fertility trials designed to test the above hypotheses. The study was concluded when eyed eggs were enumerated by NEFC staff. Results showed: (1) Viability of individual males varied more than pooled milt fertilizations. 2) trials which employed Billard's diluent showed poor eye-up and is a positive correlation between length of time suspended in diluent and reduced viability. (3) No difference was found between eggs fertilized immediately at Nashua NFH vs. those fertilized at North Attleboro NFH employing chilled oxygenated transport of gametes. (4) Eye-up was better for eggs fertilized with milt used 2 hrs. after collection vs. eggs fertilized with milt collected immediately.

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

NE Fishery Center (D)

The eggs of Atlantic salmon (*Salmo salar*) and various other salmonids have routinely been administered prophylactic treatments with iodine compounds as a means to prevent or limit the transmission of certain egg-associated viral and bacterial pathogens. Due to their toxicity to numerous fish pathogens, iodophores are particularly desirable as broad-spectrum egg disinfectants. However, studies have shown that at certain concentrations, iodophor can adversely impact egg survival. The 1995 Fish Health protocol called for all salmonid eggs shipped from or received at Service facilities to be water-hardened in active iodine at a concentration of 50mg/L for 30 minutes. In addition, any water-hardened eggs being received at Service facilities are to undergo is a 10 minute disinfection in 100mg/L active iodine. Under this scenario, salmonid eggs could potentially be subjected to two iodophor treatments in a relatively short time frame. Therefore, the primary objective of this investigation is to assess the affects various immersion times and concentrations of iodophor have on the survival of Atlantic salmon eggs. Eggs and milt from Connecticut River F1 broodstock held at the Northeast Fishery Center were used. Iodophor was administered at 0, 50,100 and 150mg/L iodine at various time combinations of 30, 60, and 90 minutes with is a follow-up immersion for 10 minutes at 100mg/L iodine or in control water. Individual lots of 300 eggs representing the various treatments (in triplicate) were placed in partitioned Heath trays for incubation. The study is on-going and results are expected in the spring of 1998.

Studies to improve Atlantic salmon captive broodstock gamete quality and gamete handling techniques

Dale C. Honeyfield, William F. Krise, John W. Fletcher, andVictor J. Segarich (E, E, D, G)

Current Atlantic salmon reproductive biology research discussed in this overview has two inter-related components. The object of the work is to improve reproduction by improving the quality of the gametes and secondly, enhance gamete and zygote (fertilized egg) handling procedures. Broodfish diets for Atlantic salmon have not changed in the last 15-20 years yet our understanding of nutrient requirements of fish and feed manufacturing techniques have made significant changes during this time. A group of broodfish at Nashua National Fish Hatchery are being fed an experimental feed (ATS-5) prepared with modern feed technology and reformulated to more closely meet known nutrient requirements. At spawning, fish fed ATS-5 produced more eggs per female and higher sperm cells per ml in the males than fish fed ASD2 standard feed formula. The percentage of live sperm cells was similar between the two groups. Egg pigmentation appeared more like wild-run fish from those fish fed the ATS-5 diet. Data for percentage eye-up, fry hatch and general condition of fry will be collected.

We are also investigating sperm storage, sperm diluents for storage, sperm quality measurements and egg tolerance to shock. Dilution of sperm into Billard (1977) or Erdahl (1987) media resulted in higher cell survival after 24 hours of storage than when cells were kept in one of three other storage media, or held in bags filled with oxygen. Percentage of live sperm cells was only minimally affected when mixed with less than 50% urine in this study. Above 50% urine concentration, percent live cells after 24 hours were lower. Fertilized eggs were subjected to four levels of shock force by dropping eggs in is a mechanical shock device (J. O. T. Jensen, Department of Fisheries and Oceans, Nanaimo, BC, Canada) at one of four heights, 0, 10, 40, or 90 cm. As shock intensity increased, percentage live eggs measured 24 hours post shock were, 86.3%, 75.6%, 52.8%, and 23.6%, respectively. Sensitivity to shock is also being collected at the eyed egg stage.

GENETICS

Cloning of major heat shock proteins of salmon

Terry Bradley (K)

Heat shock proteins are a family of highly conserved proteins that are found in all organisms from bacteria to humans. These proteins are induced in response to elevated temperatures and confer protection against subsequent exposure to lethal temperatures. In addition to heat shock, other environmental stressors such as hypoxia, exposure to heavy metals and pollutants, have been shown to induce synthesis of these proteins. We are in the process of cloning the genes of the major heat shock proteins of salmon to assess their use as sensitive indicators of stress.

Construction of cDNA libraries from tissues of Atlantic salmon

Terry Bradley (K)

We have already produced cDNA libraries to gill and liver tissue of Atlantic salmon, for cloning genes involved in smoltification and seawater tolerance. These libraries will be used for a variety of studies in the coming year and we anticipate construction of additional libraries to other tissues of Atlantic salmon.

Tools for restoration: Atlantic salmon genetics, broodstock management and fry marking

Ben Letcher and Tim King (A, M)

Use of genetics is providing tools which address several critical research needs: development of a fry mark, genetically-based broodstock management and assessing the genetic variability of the Connecticut River population. By using the inherent genetic variability within the Connecticut River population, we have developed protocols that allow the identification of family membership (family-level DNA fingerprint using microsatellites) of fish produced in a hatchery. Fish from the different families will be stocked into selected tributaries. By determining the family membership of smolts and returning adult fish, we will also be able to determine the tributary of stocking. We are using this fry mark in a pilot study in the Farmington River in Connecticut, into which we will be stocking almost 500,000 fry from 160 known families in the spring of 1998. We are using genetic information on individual Connecticut River broodstock to limit matings of closely related fish. This approach maximizes available genetic variability and virtually eliminates the possibility of inbreeding in this small population. Using it in 1997, we decreased the relatedness among the sea-run progeny by about 20% compared to previous random mating protocols.

FISH HEALTH/NUTRITION

Influence of experimental and commercially manufactured diets on effluent discharges of waste phosphorus by Atlantic salmon

H. George Ketola (H)

A 14 week study was conducted with Atlantic salmon, *Salmo salar*, (initial mean weight 44 g) to measure the effect of four commercially manufactured feeds and four experimental formulas on discharges of waste phosphorus (P) in effluents. Triplicate lots of Atlantic salmon were fed four experimental diets (1-4) and four commercially manufactured feeds- namely, the federal Atlantic salmon diet ASD2-30 diets, the New York State open formula feed #3, BioDry 1000 Low-Phosphorus Life Stage Diets by BioProducts, and a low-phosphorus Trout Food by Martin Mills of Canada. The ASD diet was high in phosphorus (1.7%P) and discharged 72% of dietary P in the effluent, equating to 12-13 grams of P discharged per kg weight gain or feed fed. The other commercially manufactured diets contained lower levels of P (0.89-0.97%) and discharged 51 to 58% of dietary P in effluents (4-6 g P/kg gain or feed). Four experimental diets were formulated to contain lower levels of P (0.70-0.88%) and discharged 29-56% of dietary P in effluents, equating to about 2-5 g P discharged/kg gain or feed. The experimental diet that reduced wastes most discharged only 29 % of dietary P (equating to 2 g P/kg weight gain or feed fed).

Thiamine injections in gravid females prevents early mortality in fry of Atlantic salmon from Cayuga Lake

H. George Ketola, Paul R. Bowser, Greg A. Wooster, Leslie R. Wedge, and Steven S. Hurst (H, I, I, J, J)

Atlantic salmon, *Salmo salar*, once naturally abundant in the Finger Lakes of New York State, must now be stocked to sustain a limited fishery. Salmon stocked in Cayuga Lake readily grow to adults and spawn, but their fry do not survive. Previous workers demonstrated that mortality in Cayuga Lake salmon fry (called Cayuga Syndrome) was associated with low levels of thiamine in eggs. They reduced mortality of fry by bathing or injecting fry with thiamine. In this study, we injected physiological saline (PS) + thiamine (7 mg/kg weight) into six pre-spawning gravid female Atlantic salmon from Cayuga Lake. Four control females were injected with PS. After 14-23 days, eggs were stripped, fertilized, and incubated in individual lots. Chemical analyses showed that eggs from control salmon contained 1.1 nanomoles thiamine/gram while thiamine-enhanced eggs contained 1.6 nanomoles/gram. There was no significant effect of thiamine injections on hatchability. By approximately 700 Celsius degree-days post-fertilization, control fry showed signs of Cayuga Syndrome and increased mortality. By 1,000 degree-days post-fertilization, survival of control fry was only 12%, while that for thiamine-injected salmon was 97%.

Development of diets to limit the depletion of liver glycogen and low blood sugar associated with smoltification

George Tremblay (K)

When salmon undergo smoltification there is a significant decline in the stored energy levels in the liver. It is unclear whether this is a phenomenon related to hatchery feeds and if the decrease in energy stores places the fish at a disadvantage. The effects of supplementing salmon diets with metabolic compounds on energy utilization and storage are being examined. This research could lead to development of diets capable of producing better smolts.

Development of cDNA vaccines for specific pathogens of salmon and trout

Marta Gomez-Chiarri (K)

The use of cDNA vaccines in fish is being investigated. cDNA vaccines have been proven effective against several human pathogens and are generally more stable and less expensive than traditional protein or organism-based vaccines.

Development of mutant strains of *Vibrio sp.* for potential use as vaccines

David Nelson and Terry Bradley (K)

The invesitgation of the use of mutant *Vibrio* bacteria for the production of vaccines is being investigated. The approach used might enable production of highly effective and inexpensive vaccines.

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4.2. OVERVIEW OF NARRAGUAGUS RIVER SMOLT STUDIES: 1997

John F. Kocik / National Marine Fisheries Service
Kenneth F. Beland / Maine Atlantic Salmon Authority
Timothy F. Sheehand / Maine Atlantic Salmon Authority

Our primary study objectives were 1) to estimate total smolt production in the Narraguagus River and 2) to evaluate the ecology of emigrating smolts using ultrasonic telemetry. The following extended abstract details progress on these two objectives for the 1997 smolt run and should be considered preliminary as it represents initial analyses and the second year of a 4-year study.

We monitored outmigration of Atlantic salmon smolts in the Narraguagus River from 24 April to 17 June 1997 using four rotary screw fish traps. Two traps were located at river km 14 (Crane Camp) and two were located at river km 17 (Little Falls). We marked smolts with fin clips at Little Falls, changing marks every four days, and recaptured them at Crane Camp to perform a stratified population estimate. These sites are downstream of approximately 85% of juvenile rearing habitat in the basin. We captured a total of 772 smolts. Most smolts were in excellent condition upon removal from the traps but three trap mortalities (0.38%) occurred when excessive debris impeded proper trap function. Smolts averaged 181 $\pm$ 17 mm total length and 46 $\pm$ 15 g wet weight (n = 276). Smolt length (P=0.77) and weight (P=0.11) did not vary significantly between 1996 and 1997. We also compared the total length of our 1997 samples to smolts collected in the Narraguagus River 1960-1968 (E. Baum, Maine Atlantic Salmon Authority). Smolts during that period averaged 178 mm (n=3,920), significantly ($P < 0.01$) smaller than the smolts that we collected in 1997. Further analyses of these data will be conducted to compare individual years as well as weight data. Scale samples were taken from a sub-sample of 97 smolts and will be image processed in summer 1998.

The timing of outmigration for wild smolts was normally distributed with 23 May being the date of 50% outmigration; this was 11 days later than observed in 1996. The median migration date for the 1960-1968 was 17 May (E. Baum, Maine Atlantic Salmon Authority). Utilizing a Darroch maximum likelihood model, we estimated the emigrant smolt population to be 2,871 ($\pm$ 539) in the watershed area above the traps. Trap efficiency averaged 14% at Little Falls and 9% at Crane Camp. Analysis of length data suggests differential efficiency between sites may be due to lower capture efficiency of larger individuals at the downstream traps. We are examining ways to increase capture efficiency at this site. We used simulation modeling of the error bounds on this estimate and BGEST estimates of parr abundance (fall 1996) to calculate an average overwinter survival of 24.4 % (range 11% - 41%). There is a 90% probability that overwinter survival was below 30%, a minimum value frequently reported in the literature for this species until recently.

We also collected data on river-specific hatchery smolts (683) that we marked and released in the Narraguagus River on May 8 and 11, 1997. Only 15 of these were recovered in smolt traps. Assuming equal recapture efficiency to wild fish, this represents a hatchery migration of approximately 75 smolts past Crane Camp. This smolt estimate suggests that 89% of hatchery smolts either regressed to parr, migrated after June 17, or died. The mean migration date for hatchery smolts was 5 June, 13 days later than wild fish. These data suggest that further study is needed to determine the movements, migration, and survival of hatchery smolts stocked in these rivers.

We met all primary objectives for smolt trapping in 1997; we substantially increased sampling effort yielding more accurate population estimates of outmigrating smolts without adversely affecting this threatened population. The study also suggests that overwinter mortality of pre-smolts in this river may be relatively high. However, data from additional years with different overwinter conditions is needed to better understand the magnitude of overwinter mortality in this river system. This information initiates a database that will allow testing of environmental correlates to overwinter survival. If suspect relationships are found, we can investigate probable causes of mortality and work to identify possible habitat rehabilitation or enhancement that could increase survival to the smolt stage.

To evaluate smolt ecology, we prepared and tested automated ultrasonic detection units (VR-20s) from 13-19 April 1997 in Narraguagus Bay to determine adequate positioning and bottom types. On 28-30 April, we deployed 16 VR-20s in Narraguagus River (4) and Bay (12) to evaluate the number of smolts passing ecological transition zones. The positioning of all units was checked on 30 April and 15 May by NOAA divers. We surgically implanted pingers in 109 wild Atlantic salmon smolts from 9 May to 1 June (22 days); this represents 3.6% of the total smolt population. We also implanted 29 pingers in hatchery smolts and released them with approximately 325 additional smolts on both 8 May (n = 15) and 11 May (n=14). We documented a total initial surgical mortality in the first 6 hours of 8 fish; this represents 5% of attempted surgeries. Pingers from these 8 fish were reinserted in other fish later in the study. We retrieved all VR-20 units by 30 June. Data from these 138 Atlantic salmon and 16 detection units were analyzed and audited to filter out false detections that occur when acoustic noise levels are high or when a fish swims very close to a detection unit causing multiple signals. Additional searches conducted by boat, trapping study results, and follow-up electrofishing through summer and autumn were used to augment data from stationary units. Surgical recovery appeared to delay the initial departure of the smolts with pingers from the release site at Crane Camp (river-km 14). As such, we report migration timing from the VR-20 unit located at the headpond of the Cherryfield dam. The median transit time for wild smolts from the Cherryfield Dam (river-km 10) to the marine array (21 km) was 16 hours. Transit speeds for this 18-km trek varied between ecological transition zones. Median speed in the riverine sections was 2.1 km/h. In the riverine estuary, the median travel speed was 1.5 km/h. Upon exiting the estuary and entering the Bay, median travel times slowed to 0.9 km/hour. In riverine and estuarine habitats, wild smolts appeared to move primarily during low light periods, with 73% of movements occurring at dusk, night, or dawn. In

Narraguagus Bay, smolt movements were more common (49%) during daylight hours. Narraguagus Bay has two major corridors to the ocean, a 4-km wide west channel and a 2-km wide eastern channel. Dyer Island delineates these channels and smaller islands bisect each one. Of the smolts detected in the marine array, 93% exited in the western channel and most were detected near Dyer Island.

Only five (17%) of the hatchery smolts were detected moving downstream and only one (3%) was detected at the marine array. Telemetry data further confirm our trapping observations that suggest a significant portion of hatchery smolts did not emigrate by 30 June. Low-light movements were less pronounced in hatchery smolts as 48% of riverine-estuarine movement occurred during the day.

To simultaneously estimate survival and detection rates, we used the maximum likelihood models in the program MARK to evaluate our telemetry data. Our preliminary results suggest that observed survival (including natural mortality and experimental effects) through each transition zone ranges between 71% and 95%. Using these preliminary estimates, 51% of smolts with pingers reached the marine array. These values are dependent upon estimated detection rates; the 95% confidence limits on these detection rates ranges from 82% to 100%. We are currently evaluating additional models to determine the most accurate and representative fit of our data. Additional data to be collected in 1998 will improve information on initial mortality and tag-loss events; these data will further improve the accuracy and precision of our estimates.

The incorporation of an automated detection system greatly enhanced our night-sampling efficiency and greatly improved monitoring capabilities. Our preliminary analyses suggest that we have made rigorous assessments of outmigration movement and mortality. The addition of seven VR-20s in 1998 will increase sampling precision and allow us to better describe the ecological zones where smolt mortality is occurring.

Discussion

A number of questions were posed to the speaker following the presentation. One member of the audience inquired if there was any attempt to determine the difference in migration between hatchery or wild smolts. Approximately 44 smolts affixed with pingers were recorded at the marine array of receivers, but only one was of hatchery origin. Sample sizes were to small to thoroughly analyze differences in movement, migration or behavior between hatchery and wild smolts.

The speaker was asked whether there was any attempt to differentiate between active and passive movement of smolts. The relationship between river discharge and movement has not yet been examined. In future years, point estimates of river discharge and water velocity may be obtained to better understand the relationship between river hydrology and downstream movement of smolts. Qualitative observations suggested that there was a reduction in activity, and a delay in movement of smolts immediately following their release to the river. There was a clear indication that smolts were more stationary in river during daylight hours, and movement tended to increase during evening hours. Observations further indicated that the downstream movement of smolts slowed considerably when they approached or entered the estuary.

The predators that prey on smolts throughout the watershed were identified in response to a question about the extent of mortality associated with predation. Striped bass, commorants, osprey, and mergansers were common predators found in the watershed, however it was noted that the spatial distribution of these species varied. Mergansers were often observed in river, stripers were found in the estuary, and commorant abundance was high in a specific area where loss or disappearance of tagged fish was known to occur. It was not clear whether commorants were the primary predator in this area. Predation by striped bass was often apparent when downstream smolt movement was interrupted or ceased, but subsequently resumed, with movement upstream against an outgoing tide. The fact that smolt movement may have decreased or ceased at times in the estuary was explored in a discussion. It was stated that these observations may be associated with smolt staging behavior when in the estuary. It was noted that such behavior had been observed in other anadromous fish, where changes in the rate and direction of movement was related to fish encountering salinity and temperature gradients. This aspect may be given further consideration in the Narraguagus River smolt study.

4.3. Growth Patterns in Atlantic Salmon Post-Smolts and the Nature of the Marine Juvenile Nursery

Kevin Friedland / National Marine Fisheries Service

The assessment committee considered a report on growth patterns in Atlantic salmon post-smolts. Scale samples from historical collections of post-smolts made in the Gulf of St. Lawrence were analyzed with the aim of understanding the role of estuarine habitat as juvenile nursery for Atlantic salmon. Circuli spacing patterns were extracted from the scales of 580 post-smolts collected in the Gulf of St. Lawrence during three seasons, 1982-1984. Post-stratification of the samples by collection date within year suggests that in some years post-smolts remain in the Gulf throughout the entire summer growth season whereas in other years only slower growing fish are retained in these areas (Figure 1). Comparing the growth patterns for Gulf of St. Lawrence post-smolts to returns for three southern Atlantic stocks believed to utilize oceanic post-smolt habitat suggests that the Gulf may serve as an important part of the post-smolt nursery range in some years (Figure 2).

The analysis suggests that the role of the Gulf of St. Lawrence as salmon post-smolt nursery habitat varies annually. In some years it appears that the growth of post-smolts retained in the Gulf is as robust as observed for post-smolts assumed to use open ocean habitats. This correlation suggests that either post-smolts from other areas invade the Gulf and use it as a nursery area, or, the Gulf region is continuous with a larger area of similar growth conditions where the nursery is formed. In other years it appears only the smaller, and assumed less robust, post-smolts remain in the Gulf area suggesting that the nursery was formed elsewhere.

The salmon post-smolt nursery habitat can be viewed as a dynamic that shifts distribution annually to regions where the production will support growth. Many marine fishes utilize staged distribution separations between estuarine, coastal, and offshore habitat (Blabber, Brewer, and Salini 1995). North American origin salmon are generally concentrated in the Labrador Sea as feeding adults or on various migration routes back to their natal rivers as maturing fish (Reddin and Shearer 1987). However, post-smolt distributions are constrained by passive displacement mechanisms and the swimming potential of the fish (Reddin and Friedland 1993; Jonsson, Hansen, and Jonsson 1993) and migrations are unlikely to be equivalent between years (Caron 1983). At some point during the post-smolt spring into summer season, swimming ability begins to exceed current velocity and post-smolts can more effectively modify their distribution according to orientation preferences driven by migration mechanisms or foraging behavior. These factors may concentrate post-smolt in specific habitats that best suit their feeding requirements and afford them some measure of predation release. However, the process of habitat selection may result in a nursery, which utilizes different habitats each year and thus not linked to a specific area (Friedland, Ahrenholz, and Guthrie 1996). Thus, years of poor feeding and growth conditions in the Gulf of St. Lawrence does not preclude the use of other neritic areas as post-smolt nursery. For example, in some years the nursery may set up along the south coast of Newfoundland or make use of few neritic habitats at all.

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Discussion

The committee inquired about the relationship between the growth patterns observed in the Gulf of St. Lawrence and ambient sea surface temperatures (SST). The presenter indicated that these analyses were currently underway and would be available for review next year. The continued close correlation between favorable growth as indicated by wider cirucli spacing and higher return rates was notable. This observation is particularly evident in the slower growth rates of the Connecticut River compared to the Penobscot and St. John river stocks. It was suggested that it would be interesting to look at the freshwater origin of the stocks examined in this analysis to account for potential differences between the wild and hatchery as well as different smolt ages to determine if any of these parameters explain part of the observed variance and provide additional information. The question was raised regarding the impact of these results upon the thermal index value and its relationship to adult returns. It was pointed out that present analyses focused upon both grilse and salmon while the thermal index is related primarily to the non-maturing 2SW component, and as such, may be more related to maturity effects then survival effects .

5. HISTORICAL DATA (1970 - 1997)

5.1. STOCKING

The historical stocking information is presented in Table 3.2.a. in Appendix 10.2. Nearly 119 million juvenile salmon have been released into the rivers of New England during the period, 1970 - 1997. Nearly 71% of the total have been fry. The majority of the juvenile releases have occurred in the Connecticut River (over 52 million), the Penobscot River (over 23 million), and the Merrimack River (over 22 million).

5.2. ADULT RETURNS

The historical return information is presented in Table 3.2.b. in Appendix 10.2. Total returns to New England rivers from 1970 through 1997 now equals 70,484. 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 73% of the total.

6. TERMS OF REFERENCE FOR 1999 MEETING

The U.S. Atlantic Salmon Assessment Committee agreed to address the following Terms of Reference for the 1999 meeting:

1. **Program summaries for current year (1998) to include:**
   a. **current year's stocking program with breakdowns by time, location, marks and lifestage.**

b. current year's returns by sea age, marked vs. unmarked, and wild vs. hatchery.
c. general summary of program activities including regulation changes, angling catch, and program direction.

2. Update historical databases.

3. The Assessment Committee recommends that the estimate of total stock size for US rivers provided to the ICES Working Group for the run reconstruction model for North American stocks be reviewed during the 1999 annual meeting.

4. Video footage on fry stocking technique and related studies with respect to instream survival.

The Assessment Committee agreed to develop a detailed video of the fry stocking techniques utilized throughout the New England programs for the 1999 meeting. Raw video footage should be sent to the committee chairman for editing.

5. The Assessment Committee agreed to update the previous work of Mark Gibson (RI Div. of Fish and Wildlife) relative to optimum fry stocking levels throughout New England. The update will include the following:

a. stocking densities
b. size of stocked fry
c. stocking dates
d. survival and size of 0^+ and 1^+ parr
e. assessment sampling date

John Kocik, Ben Letcher, and Dennis Erkan will be working with the data and preparing a report for the Assessment Committee.

6. Program summary of historical smolt runs to include:

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

7. Historical data on returns by age structure related back to fry stocking programs for use in development of comparative river specific life tables

7. U.S. ATLANTIC SALMON ASSESSMENT COMMITTEE MEMBERS

Ed Baum	Maine Atlantic Salmon Authority
Dr. Ben Letcher	USGS - Biological Resources Division
Mary Colligan	National Marine Fisheries Service
Dennis Erkan	RI Div. of Fisheries and Wildlife
Dr. Kevin Friedland	National Marine Fisheries Service
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Joe McKeon	U.S. Fish and Wildlife Service
Jay McMenemy	VT Fish and Wildlife Dept.
Janice Rowan	U.S. Fish and Wildlife Service
Steve Roy	U.S. Forest Service
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8. PAPERS SUBMITTED

The papers submitted have been identified in Sections 3 and 4.

9. LITERATURE CITED

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

10. APPENDICES

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10.2. TABLES AND FIGURES SUPPORTING THE DOCUMENT

TABLE 2.2.1.a. JUVENILE ATLANTIC SALMON STOCKING SUMMARY FOR NEW ENGLAND IN 1997 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	578,000	0	0	0	0	0	578,000
St. Croix	1,000	400	0	0	0	0	1,400
Dennys	213,000	0	0	0	0	0	213,000
Pleasant	0	0	0	0	0	0	0
East Machias	111,000	0	0	0	0	0	111,000
Machias	237,000	0	0	0	0	0	237,000
Narraguagus	209,000	0	2,000	0	700	0	211,700
Union	12,000	69,300	0	0	0	0	81,300
Penobscot	1,472,000	310,900	4,200	0	580,200	0	2,367,300
Ducktrap	0	0	0	0	0	0	0
Sheepscot	64,000	0	0	0	0	0	64,000
Saco	97,000	63,300	0	0	20,200	0	180,500
Cocheco	128,000	0	0	0	0	0	128,000
Lamprey	141,000	52,900	0	0	0	0	193,900
Merrimack	1,977,000	5,000	4,700	5,300	52,500	5,400	2,049,900
Pawcatuck	100,000	0	14,000	0	11,500	0	125,500
Connecticut	8,526,000	8,800	0	0	1,400	0	8,536,200
TOTAL	**13,866,000**	**510,600**	**24,900**	**5,300**	**666,500**	**5,400**	**15,078,700**
CANADA							
Aroostook	0	0	0	0	0	0	0
St. Croix	1,000	100,000	0	24,000	0	0	125,000
TOTAL	**1,000**	**100,000**	**0**	**24,000**	**0**	**0**	**125,000**
PROGRAM							
Maine							
United States	2,994,000	443,900	6,200	0	601,100	0	4,045,200
Canada	1,000	100,000	0	24,000	0	0	125,000
Cocheco	128,000	0	0	0	0	0	128,000
Lamprey	141,000	52,900	0	0	0	0	193,900
Merrimack River	1,977,000	5,000	4,700	5,300	52,500	5,400	2,049,900
Pawcatuck River	100,000	0	14,000	0	11,500	0	125,500
Connecticut River	8,526,000	8,800	0	0	1,400	0	8,536,200
TOTAL	**13,867,000**	**610,600**	**24,900**	**29,300**	**666,500**	**5,400**	**15,203,700**

[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.

ABLE 2.2.1.b. CAPTIVE AND DOMESTIC ADULT ATLANTIC SALMON STOCKING SUMMARY FO NEW ENGLAND IN 1997 BY RIVER SYSTEM AND BY YEAR CLASS. *

RIVER SYSTEM	SEASON RELEASED AND YEAR CLASS							
	Spring			Autumn				
UNITED STATES	1992	1993	1994	1992	1993	1994	1995	TOTAL
Aroostook								0
St. Croix								0
Dennys	31	27		19	39			116
Pleasant								0
East Machias		35			56			91
Machias		159		18	54			231
Narraguagus	28	35		20	44			127
Union								0
Penobscot						2,811		2,811
Ducktrap								0
Sheepscot					16			16
Saco								0
Cocheco								0
Lamprey								0
Merrimack		949	614		948	400	310	3,221
Pawcatuck								0
Connecticut					16			16
TOTAL								6,629
CANADA								
Aroostook								0
St. Croix								0
TOTAL								0
PROGRAM								
Maine								
United States	59	256	0	57	209	2,811	0	3,392
Canada	0	0	0	0	0	0	0	0
Cocheco	0	0	0	0	0	0	0	0
Lamprey	0	0	0	0	0	0	0	0
Merrimack River	0	949	614	0	948	400	310	3,221
Pawcatuck River	0	0	0	0	0	0	0	0
Connecticut River	0	0	0	0	16	0	0	16
TOTAL								6,629

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

TABLE 2.2.2.a. SUMMARY OF JUVENILE AND ADULT ATLANTIC SALMON MARKING PROGRAMS NEW ENGLAND IN 1997

Mark	Stage	Connecticut	Dennys	Machias	Merrimack	Narraguagus	Pawcatuck	Saco	Total
Clip	adult					63			63
	parr				14450	2025		15078	31553
	smolt				5100	654	7782		13636
	Total				19550	2742	7782	15078	45252
Disc	adult								24
Elastomer	adult		19	18		20			57
Floy	adult				3221				3221
Ping	smolt					138			138
PIT	parr	1365							1365
Radio	smolt							150	150
Carlin	adult					43			43
VI	adult	27							27
All	adult	51	19	18	3221	126			3435
	parr	1365			14450	2025		15078	32918
	smolt				5100	792	7782	150	13924
	Total	1416	19	18	22771	2943	7782	15228	50234

TABLE 2.2.2.b. ATLANTIC SALMON MARKING DATABASE FOR NEW ENGLAND - 1997.

MARKING AGENCY	AGE	LIFE STAGE	H/W	STOCK ORIGIN	TAG TYPE	NUMBER MARKED	CODE OR SERIAL	AUX CLIP	REL DATE	PLACE OF RELEASE	COMMENT
USGS	4	adult	W	Connecticut	VI	1	RB2		5/97	Connecticut R.	Radio freq. 30.240
USGS	4	adult	W	Connecticut	VI	1	RB3		5/97	Connecticut R.	Radio freq. 30.030
USGS	4	adult	W	Connecticut	VI	1	RB4		5/97	Connecticut R.	Radio freq. 30.070
USGS	4	adult	W	Connecticut	VI	1	RB5		6/97	Connecticut R.	Radio freq. 30.170
USGS	4	adult	W	Connecticut	VI	1	RB6		6/97	Connecticut R.	Radio freq. 30.200
USGS	4	adult	W	Connecticut	VI	1	RB7		6/97	Connecticut R.	Radio freq. 30.250
USGS	4	adult	W	Connecticut	VI	1	RB8		6/97	Connecticut R.	Radio freq. 30.230
USGS	4	adult	W	Connecticut	VI	1	RB9		6/97	Connecticut R.	Radio freq. 30.181
USGS	4	adult	W	Connecticut	VI	1	RC1		6/97	Connecticut R.	Radio freq. 30.190
USGS	4	adult	W	Connecticut	VI	1	RC2		6/97	Connecticut R.	Radio freq. 30.030
USGS	4	adult	W	Connecticut	VI	1	RC3		6/97	Connecticut R.	Radio freq. 30.240
USGS	4	adult	H	Connecticut	VI	1	RC4		10/97	Connecticut R.	Radio freq. 30.050
USGS	4	adult	H	Connecticut	VI	1	PK7		10/97	Connecticut R.	Radio freq. 30.060
USGS	4	adult	H	Connecticut	VI	1			10/97	Connecticut R.	Radio freq. 30.170
USGS	4	adult	H	Connecticut	VI	1	RD2		10/97	Connecticut R.	Radio freq. 30.180
USGS	4	adult	H	Connecticut	VI	1	RC8		10/97	Connecticut R.	Radio freq. 30.190
USGS	4	adult	H	Connecticut	VI	1	RC6		10/97	Connecticut R.	Radio freq. 30.020
USGS	4	adult	H	Connecticut	VI	1	PK1		10/97	Connecticut R.	Radio freq. 30.230
USGS	4	adult	H	Connecticut	VI	1	PK4		10/97	Connecticut R.	Radio freq. 30.250
USGS	4	adult	H	Connecticut	VI	1	PK9		10/97	Connecticut R.	Radio freq. 30.050
USGS	4	adult	H	Connecticut	VI	1	RD0		10/97	Connecticut R.	Radio freq. 30.060
USGS	4	adult	H	Connecticut	VI	1	RC5		10/97	Connecticut R.	Radio freq. 30.070
USGS	4	adult	H	Connecticut	VI	1	RD3		10/97	Connecticut R.	Radio freq. 30.170
USGS	4	adult	H	Connecticut	VI	1	RC9		10/97	Connecticut R.	Radio freq. 30.180
USGS	4	adult	H	Connecticut	VI	1	PK3		10/97	Connecticut R.	Radio freq. 30.190
USGS	4	adult	H	Connecticut	VI	1	PK2		10/97	Connecticut R.	Radio freq. 30.230
USGS	4	adult	H	Connecticut	VI	1	PK6		10/97	Connecticut R.	Radio freq. 30.240
TOTAL VI, CONNECTICUT RIVER						**27**					
USGS	0	parr	W	Connecticut	PIT	473			9-12/97	Connecticut R.	
USGS	1,2	parr	W	Connecticut	PIT	892			5 -12/97	Connecticut R.	
TOTAL PIT TAGS, CONNECTICUT RIVER						**1,365**					
USFWS	4	adult	W	Connecticut	Disc	24	#62		2/97	Connecticut R.	RCNSS Kelts
TOTAL PETERSEN DISC, CONNECTICUT RIVER						**24**					
RIDFW	1	smolt	H	Merrimack		7782		AD	10/97	Pawcatuck R.	
TOTAL MARKS, PAWCATUCK RIVER						**7782**					
NHFG	2+	adult	H	Merrimack	Floy	310	S/6-2		1,5/97	Merrimack R.	Dark Blue
NHFG	3+,4+	adult	H	Merrimack	Floy	345	F/7-1		4,5/97	Merrimack R.	Dark Blue
NHFG	3+,4+	adult	H	Merrimack	Floy	341	B/7-1		4,5/97	Merrimack R.	Dark Blue
NHFG	3+,4+	adult	H	Merrimack	Floy	267	S/7-1		4,5/97	Merrimack R.	Dark Blue
NHFG	3+,4+	adult	H	Merrimack	Floy	170	H/7-1		5/97	Merrimack R.	Dark Blue
NHFG	3+,4+	adult	H	Merrimack	Floy	150	G/7-1		5/97	Merrimack R.	Dark Blue
NHFG	3+,4+	adult	H	Merrimack	Floy	150	M/7-1		5/97	Merrimack R.	Dark Blue
NHFG	4+	adult	H	Merrimack	Floy	140	7-1		6,7/97	Merrimack R.	Clear
NHFG	3+,4+	adult	H	Merrimack	Floy	1348	97/F		11,12/97	Merrimack R.	Purple
TOTAL FLOY, MERRIMACK RIVER						**3221**					
NHFG	2	smolt	H	Merrimack		3850		LV	3/97	Merrimack R.	
NHFG	2	smolt	H	Merrimack		1250		LV	4/97	Merrimack R.	
NHFG	1	parr	H	Merrimack		4600		LV	6/97	Merrimack R.	
TOTAL LV CLIP, MERRIMACK RIVER						**9700**					

TABLE 2.2.2.b. ATLANTIC SALMON MARKING DATABASE FOR NEW ENGLAND - 1997.

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	2	parr	H	Merrimack		4890		AD	5/97	Merrimack R.	
USFWS	0+	parr	H	Merrimack		4960		AD	10/97	Merrimack R.	
TOTAL AD CLIP, MERRIMACK RIVER						9850					
USFWS	5	adult	H	Machias	elast.	18		AD	12/97	Machias R.	yellow, right eye
TOTAL MARKS, MACHIAS RIVER						18					
USFWS	5	adult	H	Dennys	elast	19		AD	12/97	Dennys R.	orange, right eye
TOTAL MARKS, DENNYS RIVER						19					
USFWS	5	adult	W	Narraguagus	elast.	20		AD	12/97	Narraguagus R.	green, right eye
USFWS	1	parr	H	Narraguagus		2025		LV	5/97	Narraguagus R.	
USFWS	2	smolt	W	Narraguagus	Ping	109			5-6/97	Narraguagus R.	
USFWS	1	smolt	H	Narraguagus		654		AD	5/97	Narraguagus R.	
USFWS	1	smolt	H	Narraguagus	Ping	29		AD	5/97	Narraguagus R.	
USFWS	5	adult	W	Narraguagus		31		LCP	6/97	Narraguagus R.	
USFWS	5	adult	W	Narraguagus		9		LCC	6/97	Narraguagus R.	
USFWS	5	adult	W	Narraguagus		9		UCC	6/97	Narraguagus R.	
USFWS	5	adult	W	Narraguagus		14		UCP	6/97	Narraguagus R.	
USGS/NMFS	3+,4+	adult	H	Narraguagus	Carlin	43		CP	10/97	Narraguagus R.	Yellow, Orange, White
TOTAL MARKS, NARRAGUAGUS RIVER						2943					
USFWS	1	smolt	H	Penobscot	radio	150			5/97	Saco R.	149 mhz
USFWS	0	parr	H	Penobscot		15078		RV	5/97	Saco R.	
TOTAL MARKS, SACO RIVER						15078					

** UCP = upper caudal punch

*** LCP = lower caudal punch

**** AP = adipose punch

***** CP = caudal punch

****** AD = adipose clip

TABLE 2.3.1. DOCUMENTED ATLANTIC SALMON RETURNS TO NEW ENGLAND RIVERS IN 1997.[1]

RIVER	NUMBER OF ATLANTIC SALMON BY SEA AGE								TOTAL FOR 1997
	1SW		2SW		3SW		RS		
	Hatchery	Wild	Hatchery	Wild	Hatchery	Wild	Hatchery	Wild	
Penobscot River	241	6	914	174	4	2	13	1	1,355
Aroostook River	3	3	3	3	0	0	0	0	12
Union River	0	0	8	0	0	0	0	0	8
Narraguagus River	0	1	2	30	0	0	0	4	37
Pleasant River	0	0	0	1	0	0	0	0	1
Machias River									unknown
East Machias River									unknown
Dennys River	0	0	0	0	0	0	0	0	0
St. Croix River	26	7	2	8	0	0	0	0	43
Kennebec River									unknown
Androscoggin River	0	0	0	1	0	0	0	0	1
Sheepscot River									unknown
Ducktrap River									unknown
Saco River	5	0	23	0	0	0	0	0	28
Cocheco River	0	0	0	0	0	0	0	0	0
Lamprey River	0	0	0	0	0	0	0	0	0
Merrimack River	9	9	43	5	0	0	4	1	71
Pawcatuck River	0	0	0	3	0	0	0	0	3
Connecticut River	0	6	0	191	0	1	1	0	199
TOTAL	284	32	995	416	4	3	18	6	1,758

[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 2.3.4. SUMMARY OF ATLANTIC SALMON EGG PRODUCTION IN NEW ENGLAND FACILITIES IN 1997 [1]

SOURCE RIVER	ORIGIN	FEMALES SPAWNED	TOTAL EGG PRODUCTION	NO. OF EGGS PER FEMALE
Sheepscot River	Sea-run	0	0	0
Penobscot River	Sea-run	313	2,224,900	7,108
Dennys River	Sea-run	0	0	0
Merrimack River	Sea-run	31	284,300	9,171
Pawcatuck River	Sea-run	1	8,200	8,200
Connecticut River	Sea-run	110	770,700	7,006
TOTAL SEA-RUN		**455**	**3,288,100**	**7,227**
Penobscot River	Domestic	639	1,381,100	1,832
Merrimack River	Domestic	754	4,641,700	6,156
Connecticut River	Domestic	1,809	11,602,300	6,414
Dennys River	Captive [2]	113	429,500	3,801
East Machias River	Captive	111	394,000	3,550
Sheepscot River	Captive	75	257,300	3,431
Machias River	Captive	176	602,600	3,424
Narraguagus River	Captive	172	516,800	3,005
TOTAL CAPTIVE/DOMESTIC		**3,849**	**19,825,300**	**5,151**
Dennys River	Kelts	7	64,500	9,214
Connecticut River	Kelts	188	2,003,300	10,656
Sheepscot River	Kelts	13	118,500	9,115
Machias River	Kelts	0	0	0
TOTAL SEA-RUN KELTS		**208**	**2,186,300**	**10,511**
GRAND TOTAL		**4,512**	**25,299,700**	**5,607**

[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 1997 SPORT CATCH OF ATLANTIC SALMON IN MAINE.				
RIVER	TOTAL HARVEST	EST. NO. RELEASED	TOTAL ANGLED 1997	TOTAL ANGLED 1996
St. Croix	0	0	0	0
Dennys	0	10	10	60
East Machias	0	0	0	21
Machias	0	10	10	10
Pleasant	0	0	0	0
Narraguagus	0	13	13	31
Union	0	0	0	15
Penobscot	0	300	300	400
Ducktrap	0	0	0	0
Sheepscot	0	0	0	0
Kennebec	0	0	0	2
Saco	0	0	0	0
Aroostook	0	0	0	0
Misc.	0	0	0	3
TOTAL	**0**	**333**	**333**	**542**

* Information on age and origin is not available.

TABLE 3.2.a. ATLANTIC SALMON STOCKING SUMMARY FOR NEW ENGLAND BY RIVER
1970 THROUGH 1997

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
1997	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
1997	578,000	0	0	0	0	0	578000
TOTAL	**1206300**	**317100**	**36800**	**1800**	**32600**	**29800**	**1624400**

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
1997	1000	400	0	0	0	0	1400
TOTAL	**1261000**	**355900**	**158100**	**0**	**747200**	**20100**	**2542300**
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
1997	213,000	0	0	0	0	0	213000
TOTAL	**623000**	**8300**	**3400**	**0**	**143100**	**29200**	**807000**

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
1997	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
1997	111000	0	0	0	0	0	111000
TOTAL	**366000**	**6500**	**42600**	**0**	**97600**	**28400**	**541100**

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
1997	237000	0	0	0	0	0	237000
TOTAL	**859000**	**86900**	**117800**	**0**	**166900**	**13000**	**1243600**
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
1997	209000	0	2025	0	683	0	211708
TOTAL	**584000**	**30300**	**14625**	**0**	**106783**	**48000**	**783708**

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
1997	12000	69300	0	0	0	0	81300
TOTAL	**93000**	**289300**	**0**	**0**	**361700**	**203300**	**947300**
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
1997	1472000	310900	4200	0	580200	0	2367300
TOTAL	**9014000**	**2069600**	**1325100**	**0**	**8700600**	**2244200**	**23353500**

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
1997	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
1997	64000	0	0	0	0	0	64000
TOTAL	**325000**	**70800**	**20600**	**0**	**91200**	**6100**	**513700**

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
1997	97000	63300	0	0	20200	0	180500
TOTAL	**1142000**	**273500**	**201200**	**0**	**263400**	**9500**	**1889600**
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
1997	128000	0	0	0	0	0	128000
TOTAL	**1050000**	**50000**	**9500**	**1000**	**5300**	**0**	**1115800**

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
1997	141000	52900	0	0	0	0	193900
TOTAL	**946000**	**427700**	**56400**	**2100**	**138100**	**32800**	**1603100**
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
1997	1977000	5000	4700	5300	52500	5400	2049900
TOTAL	**19747000**	**227500**	**416200**	**167500**	**1109100**	**635900**	**22303200**

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
1997	100000	0	14000	0	11500	0	125500
TOTAL	**1859000**	**1209200**	**248500**	**0**	**47000**	**500**	**3364200**
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
1997	8526000	8800	0	0	1400	0	8536200
TOTAL	**43291500**	**2790600**	**1544600**	**184000**	**3718400**	**753900**	**52283000**

TABLE 3.2.a. Continued

GRAND TOTAL BY RIVER (1970-1997)

RIVER	NUMBER OF FISH						
	FRY	0+PARR	1PARR	1+PARR	1SMOLT	2SMOLT	TOTAL
Upper St. John	2165000	1456700	14700	0	5100	27700	3669200
Aroostook	1206300	317100	36800	1800	32600	29800	1624400
St. Croix	1261000	355900	158100	0	747200	20100	2542300
Dennys	623000	8300	3400	0	143100	29200	807000
Pleasant	187000	2500	1800	0	54700	18100	264100
East Machias	366000	6500	42600	0	97600	28400	541100
Machias	859000	86900	117800	0	166900	13000	1243600
Narraguagus	584000	30300	14625	0	106783	48000	783708
Union	93000	289300	0	0	361700	203300	947300
Penobscot	9014000	2069600	1325100	0	8700600	2244200	23353500
Ducktrap	83000	0	0	0	0	0	83000
Sheepscot	325000	70800	20600	0	91200	6100	513700
Saco	1142000	273500	201200	0	263400	9500	1889600
Cocheco	1050000	50000	9500	1000	5300	0	1115800
Lamprey	946000	427700	56400	2100	138100	32800	1603100
Merrimack	19747000	227500	416200	167500	1109100	635900	22303200
Pawcatuck	1859000	1209200	248500	0	47000	500	3364200
Connecticut	43291500	2790600	1544600	184000	3718400	753900	52283000
TOTAL	**84801800**	**9672400**	**4211925**	**356400**	**15788783**	**4100500**	**118931808**

TABLE 3.2.b. HISTORICAL ATLANTIC SALMON RETURNS TO NEW ENGLAND RIVERS
1970 THROUGH 1997
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
1997	241	914	4	13	6	174	2	1	1355
TOTAL	**8826**	**38440**	**215**	**498**	**440**	**2918**	**28**	**72**	**51437**
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
1997	0	8	0	0	0	0	0	0	8
TOTAL	**296**	**1804**	**9**	**24**	**1**	**12**	**0**	**0**	**2146**

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
1997	0	2	0	0	1	30	0	4	37
TOTAL	**30**	**417**	**11**	**15**	**53**	**1867**	**40**	**107**	**2540**
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									
1997	0	0	0	0	0	1	0	0	1
TOTAL	**4**	**12**	**0**	**0**	**10**	**204**	**2**	**2**	**234**

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
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									
1997									
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									
1997									
TOTAL	**21**	**244**	**1**	**2**	**12**	**307**	**1**	**10**	**598**

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
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
1997	0	0	0	0	0	0	0	0	0
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
1997	26	2	0	0	0	0	0	0	28
TOTAL	**651**	**1081**	**38**	**12**	**421**	**661**	**39**	**17**	**2920**

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									
1997									
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
1997	0	0	0	0	0	1	0	0	1
TOTAL	**26**	**499**	**6**	**2**	**5**	**80**	**0**	**1**	**619**

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	
SHEEPSCOT										
1970-1974	0	0	0	0	6	86	4	0	96	
1975	0	0	0	0	1	10	0	0	1	1
1976	0	0	0	0	1	9	0	0	1	0
1977	0	0	0	0	1	22	1	0	2	4
1978	0	0	0	0	2	32	1	0	3	5
1979	0	0	0	0	1	7	0	0		8
1980	0	0	0	0	2	27	1	0	3	0
1981	0	0	0	0	1	14	0	0	15	
1982	0	0	0	0	1	14	0	0	15	
1983	0	0	0	0	1	11	0	0	12	
1984	0	0	0	0	1	20	1	0	22	
1985	0	0	0	0	1	5	0	0	6	
1986	0	0	0	0	1	10	0	0	11	
1987	2	7	0	0	1	5	0	0	15	
1988	1	0	0	0	0	0	0	0	1	
1989	1	1	0	0	2	1	0	0	5	
1990	1	8	0	0	0	0	0	0	9	
1991	0	4	0	0	0	0	0	0	4	
1992	1	2	0	0	1	2	1	0	7	
1993	0	9	0	0	0	0	0	0	9	
1994	0	5	0	0	3	12	0	0	20	
1995	0	2	0	0	0	22	0	0	24	
1996	0	0	0	0		8	0	0	8	
1997	0	0	0	0	0	0	0	0	0	
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										
1997										
TOTAL	**0**	**0**	**0**	**0**	**3**	**30**	**0**	**0**	**33**	

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
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
1997	5	23	0	0	0	0	0	0	28
TOTAL	**39**	**420**	**3**	**5**	**0**	**2**	**0**	**0**	**469**
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
1997	0	0	0	0	0	0	0	0	0
TOTAL	**0**	**0**	**1**	**1**	**3**	**4**	**0**	**0**	**9**

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
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
1997	0	0	0	0	0	0	0	0	0
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
1997	9	43	0	4	9	5	0	1	71
TOTAL	**159**	**758**	**17**	**8**	**89**	**841**	**23**	**3**	**1898**

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
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
1997	0	0	0	0	0	3	0	0	3
TOTAL	**1**	**141**	**1**	**0**	**0**	**4**	**0**	**0**	**147**
CONNECTICUT									
1970-1974	0	1	0	0	0	0	0	0	1
1975	0	3	0	0	0	0	0	[illegible]	3
1976	0	2	0	0	0	0	0	0	2
1977	0	7	0	0	0	0	0	0	7
1978	3	90	0	0	0	0	0	0	93
1979	4	50	4	0	0	0	0	0	58
1980	4	164	7	0	0	0	0	0	175
1981	6	513	10	0	0	0	0	0	529
1982	3	57	0	0	0	10	0	0	70
1983	0	39	0	0	0	0	0	0	39
1984	7	65	0	0	2	18	0	0	92
1985	0	293	0	0	0	17	0	0	310
1986	0	275	0	0	0	43	0	0	318
1987	0	343	5	0	0	0	5	0	353
1988	1	93	0	0	0	1	0	0	95
1989	1	58	0	0	1	48	1	0	109
1990	1	226	0	0	0	36	0	0	263
1991	0	168	1	0	0	34	0	0	203
1992	3	353	1	0	5	127	1	0	490
1993	0	136	0	0	0	61	1	0	198
1994	1	263	0	1	0	61	0	0	326
1995	1	158	0	0	0	29	0	0	188
1996	0	143	0	0	5	111	0	1	260
1997	0	0	0	1	6	191	1	0	199
TOTAL	**35**	**3500**	**28**	**2**	**19**	**787**	**9**	[illegible]	**4381**
GRAND TOTAL	**10148**	**48075**	**341**	**570**	**1122**	**9743**	**170**	**263**	**70484**

TABLE 3.2.b. Continued

GRAND TOTAL BY RIVER (1970-1997)

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	8826	38440	215	498	440	2918	28	72	51437
UNION	296	1804	9	24	1	12	0	0	2146
NARRAGUAGUS	30	417	11	15	53	1867	40	107	2540
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	651	1081	38	12	421	661	39	17	2920
KENNEBEC	12	189	5	1	0	9	0	0	216
ANDROSCOGGIN	26	499	6	2	5	80	0	1	619
SHEEPSCOT	6	38	0	0	27	317	9	0	397
DUCKTRAP	0	0	0	0	3	30	0	0	33
SACO	39	420	3	5	0	2	0	0	469
COCHECO	0	0	1	1	3	4	0	0	9
LAMPREY	10	17	1	0	1	14	0	0	43
MERRIMACK	159	758	17	8	89	841	23	3	1898
PAWCATUCK	1	141	1	0	0	4	0	0	147
CONNECTICUT	35	3500	28	2	19	787	9	1	4381
TOTAL	**10158**	**48092**	**343**	**571**	**1126**	**9761**	**170**	**263**	**70484**

Figure 1. Circuli spacing versus circuli pair for Gulf of St. Lawrence post-smolts for two smolt year classes, 1982 (A) and 1983 (B). Samples post-stratified by date of capture. Error bars mark 95% confidence intervals. The 1982 data suggest post-smolts were retained in the Gulf, whereas, 1983 suggest fish emigrated as the season progressed.

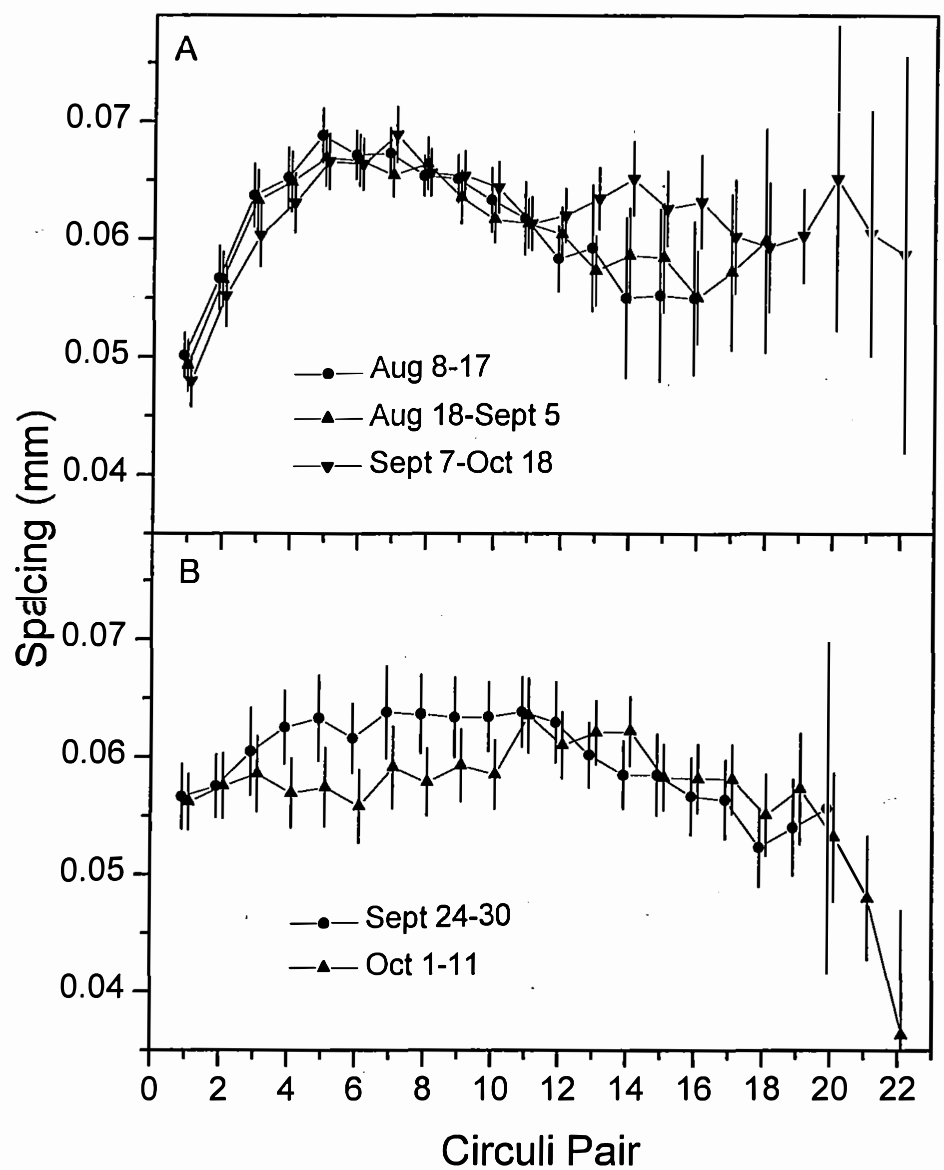
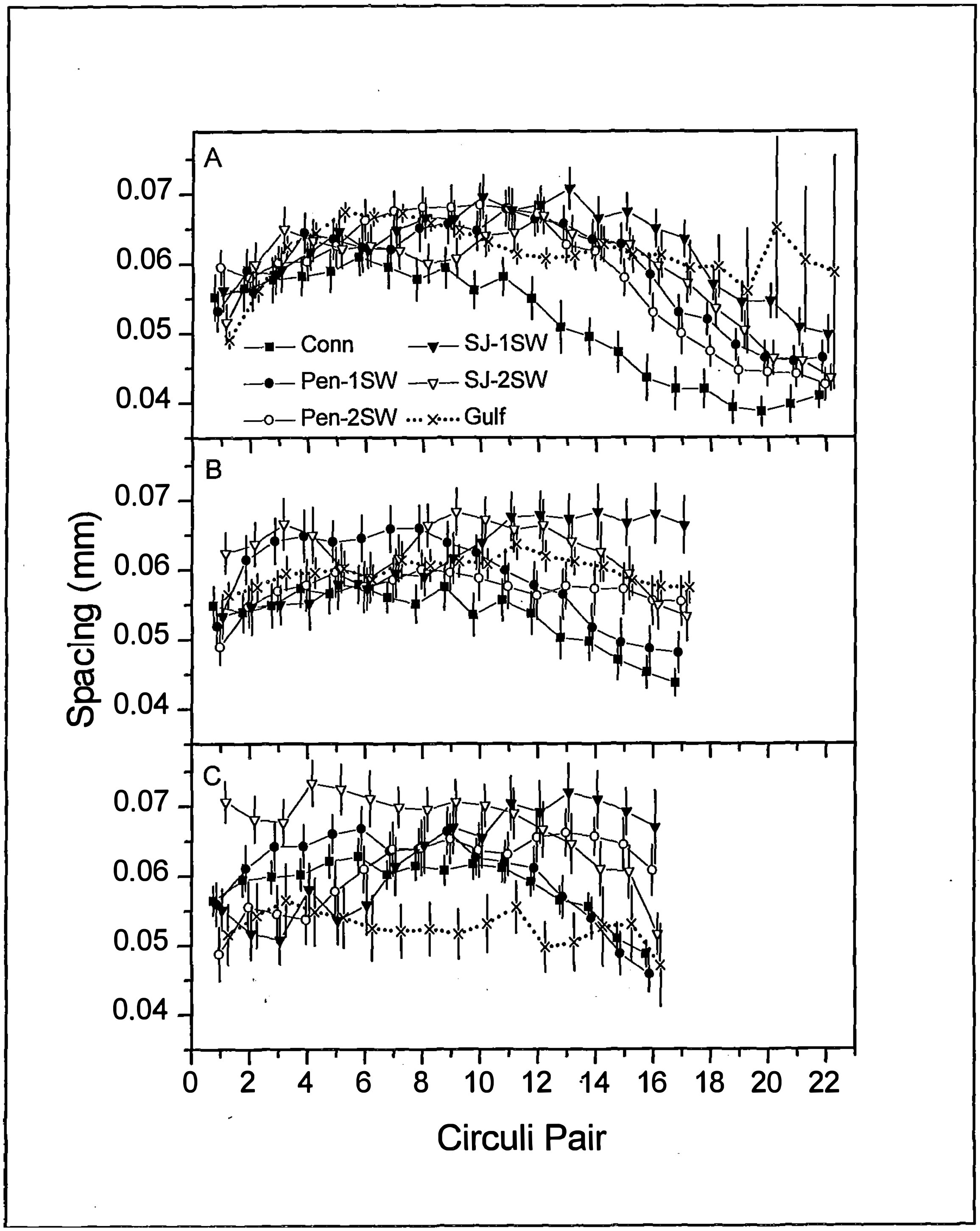
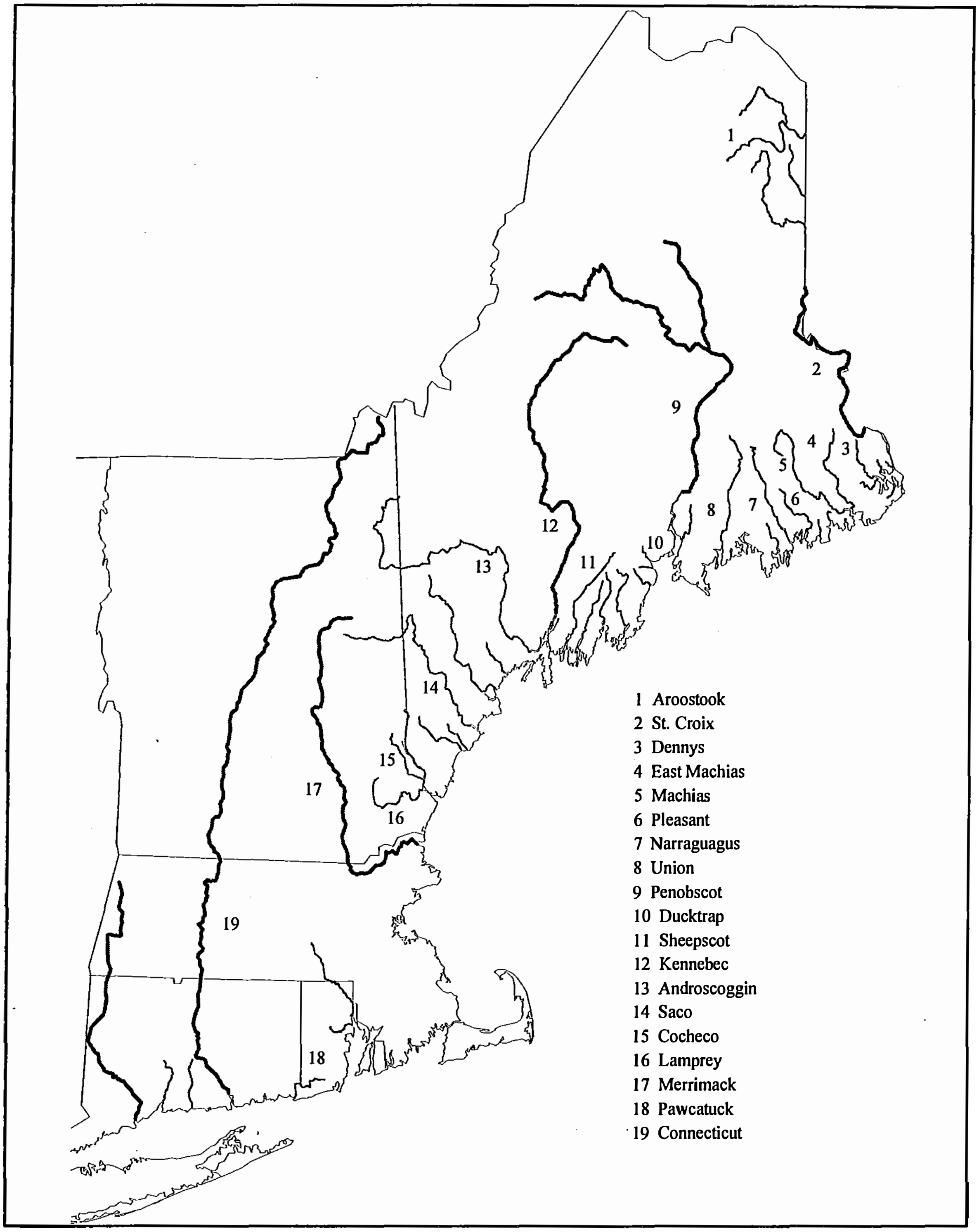


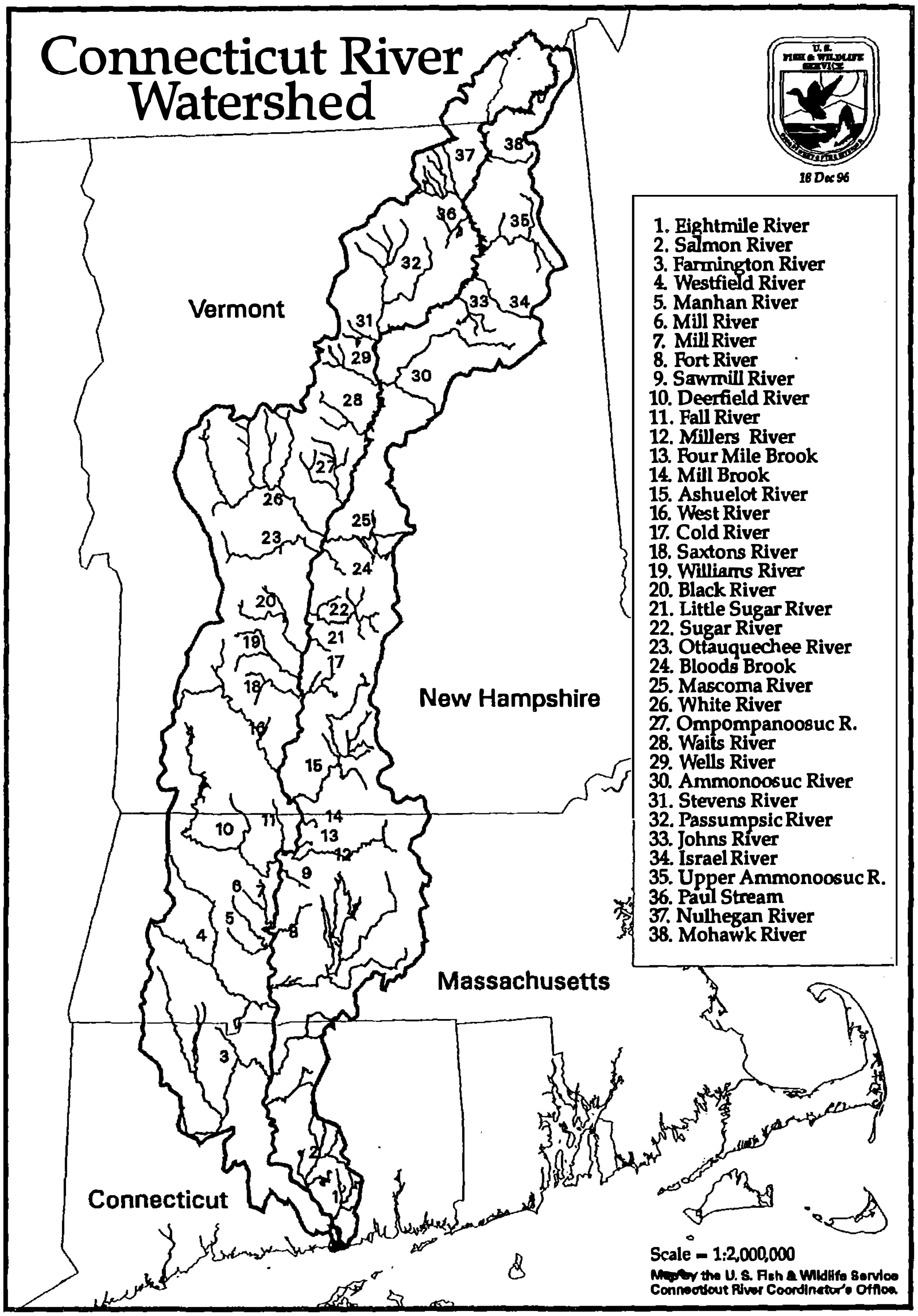
Figure 2. Circuli spacing versus circuli pair for Connecticut 2SW (Conn), Penobscot 1SW and 2SW (Pen), Saint John 1SW annd 2SW (SJ), and Gulf of St. Lawrence post-smolts (Gulf) for three smolt year classes, 1982 (A), 1983 (B), and 1984 (C). Error bars mark 95% confidence intervals.

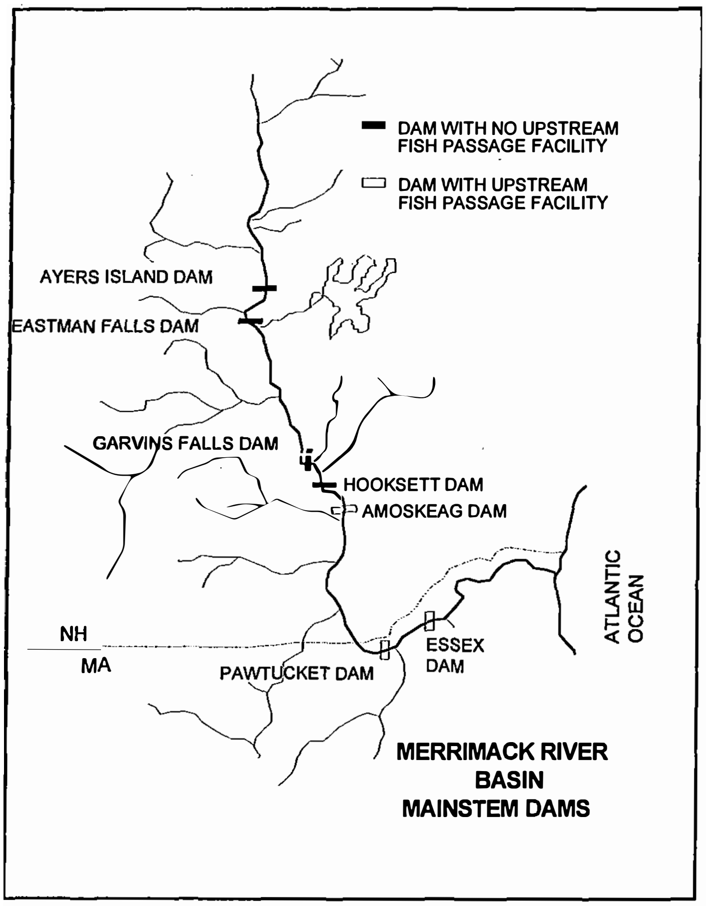


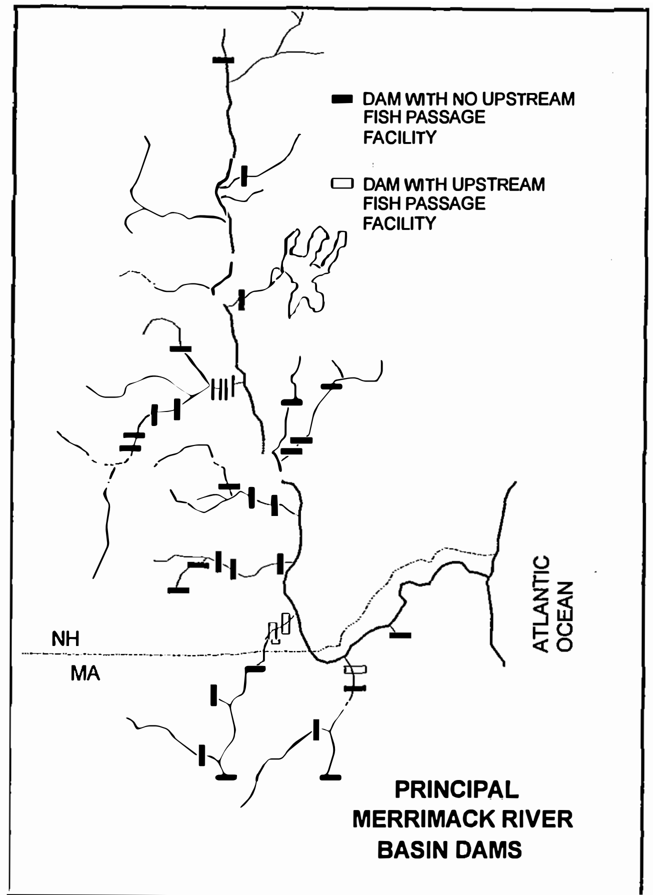
10.3. LOCATION MAPS

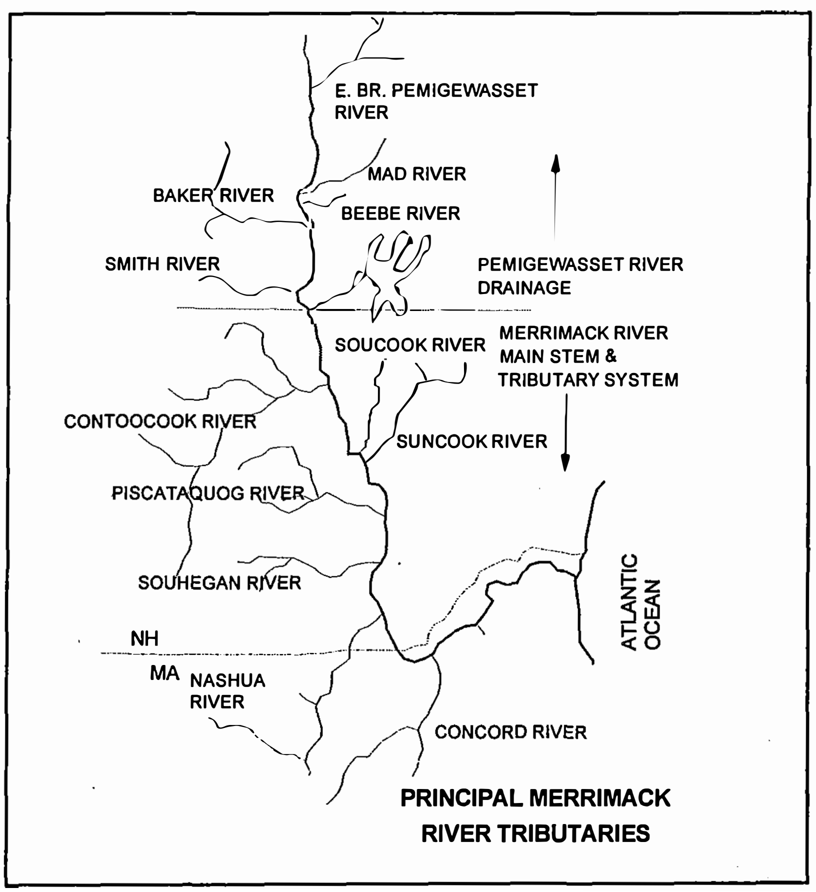


Important Atlantic Salmon Rivers of New England


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


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

Important Atlantic Salmon Rivers of Maine