U.S. ATLANTIC SALMON
ASSESSMENT COMMITTEE

ANNUAL REPORT 1992/4

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

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TURNERS FALLS, MASSACHUSETTS
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PREPARED FOR
U.S. SECTION TO NASCO

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1. INTRODUCTION

1.1. EXECUTIVE SUMMARY

The 1992 Annual Meeting of the U.S. Atlantic Assessment Committee was held January 27-31, 1992 at the Silvio Conte Fish Research Center, Turners Falls, Massachusetts. The committee addressed terms of reference established at the 1991 meeting including routine assessments, such as program reviews and database development, and special topics, such as models of fry survival and size-based models of smolt survival. In addition, a portion of the meeting was held in joint cession with researchers from various New England research institutions. Discussions focused on complimentary research goals and implementation of cooperative research initiatives.

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 6.5 million juvenile salmon (fry, parr and smolts) were stocked. Of these 31 thousand parr and 436 thousand smolts carried coded wire tags (CWT) and 50 thousand smolts received Carlin tags. An additional 86 thousand smolts were released with fin-clips only.

A total of 2689 salmon was documented to have returned to U.S. waters in 1991, of which 2149 was counted in Maine rivers. Since many of Maine's rivers do not have counting facilities, and the facilities that do operate are not 100% effective, a system was implemented to estimate total adult returns in Maine and to New England rivers. The estimated returns using this method were 3245 in Maine rivers and 3886 in New England rivers. There were 626 fish with CWT and 27 with Carlin tags which returned to U.S. rivers in 1991.

The angling catch in Maine waters reached 477 fish, which is down from the catch of 1414 for 1990. Exploitation in the sport fishery on the Penobscot River was 11% in 1991.

Due to a 60% reduction in state funding levels, the Atlantic Sea Run Salmon Commission (ASRSC) drastically reduced the scope of the statewide Atlantic salmon restoration program. The Commission will concentrate on restoration and management activities on the seven rivers with wild salmon runs and a scaled-down Penobscot River program.

As a consequence of recent declines in adult salmon abundance in the Dennys, East Machias, Machias, Pleasant, and Narraguagus rivers, the U.S. Fish and Wildlife Service (USFWS) recently listed the salmon populations in these rivers as Category 2 species, under the Endangered Species Act. Further study, including genetic fingerprinting studies, will determine whether these populations warrant protection as distinct populations.

In all of the major river programs fish passage issues, upstream and/or downstream passage, were pursued. Important downstream fish passage agreements between utilities and the agencies were developed for the Connecticut River. Work progessed in this same area for the Merrimack River anadromous fish program.

In both the Connecticut and Merrimack rivers' Atlantic salmon programs additional egg incubation facilities were developed and the use of captive/domestic broodstock provided significant numbers of eggs for these facilities. The stocking of fed and unfed fry increased dramatically. Additionally, plans were initiated to convert Craig Brook National Fish Hatchery (CBNFH) from a broodstock/smolt production facility, to a broodstock/fry production facility. The purpose of this change is to replace the stocking of Penobscot River strain fish in Maine's wild salmon rivers with local (river specific) stocks. As a result, 1992 will be the last year of smolt production at CBNFH. The CBNFH will have the capacity to produce one million fed fry or up to five million non-feeding fry. The facility will also be altered to hold broodstock from Maine's wild rivers.

The committee reviewed a synthesis of fry survival data from the restoration programs in New England. Fry survival was evaluated as a function of the initial fry stocking density. At fry stocking densities below 20 fry/unit, yearling parr production is low. There was some evidence of compensatory mortality mechanisms (reduced survival) at very high stocking densities.

The influence of smolt body size on marine survival was evaluated for smolts from New England rivers. Survival rates were highest for smolts over a range of 15-25 cm in length. These estimates do not separate the effects of mortality and early maturation which may be important for evaluating survival of large smolts.

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 semi-annually to discuss the terms of reference for upcoming meetings of the International Counsel 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, with regard to research proposals and recommendations to the State and Federal fishery agency chiefs through the New England Atlantic Salmon Committee (NEASC).

1.3. RELATIONSHIP OF ICES TO NASCO

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

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

1.4. CHAIRMAN'S COMMENTS

The Working Group is to be congradulated on a job well-done and importantly, nearly the entire U.S. Atlantic Salmon Assessment Committee participated. The latter, in itself, made the Working Group's task a little easier and more enjoyable.

I thank all of you who provided information to me prior to the meeting. This was especially helpful in completing the Status of the Program section of the document in a timely manner. However, I believe that we can do even better in the future which would allow for more meaningful discussion and assessment.

Based on your input during the coming year, all of the standard tables will be reviewed for changes directed at providing more meaningful information for all who use the document. Work started in this area with the changes recommended and incorporated into Table 6.

I believe that the Working Group is evolving in a positive direction. The direction I see the group going will eventually allow for a much stronger program assessment segment of the meeting. The work that Mark Gibson is doing is a good example of that positive direction. In the future, we must allow for sufficient time for much stronger discussion in these kinds of areas.

Relative to the research discussion on Thursday and Friday morning I am pleased with the outcome. To my knowledge this was the first time that this type of interaction occurred at such an informal level. Section 4.1. of the document is testimony to its success. How beneficial the interactive discussion really was will be determined by the research direction taken in the next several years.

I want to thank those who helped with the support and the niceties for the meeting: Ted Meyers, Diane Soucy, and Henry Booke. I also wish to thank Brian Doyle for his assistance in bringing the academic community and the Working Group together. Additionally, thanks are extended to Dave Egan and the Connecticut River Atlantic Salmon Association for lodging/meals support for three members of the Working Group.

Lastly, the U.S. Atlantic Salmon Assessment Committee agreed to hold their fifth Working Group meeting from January 25 - 29, 1993. The location will remain at the Silvio Conte Fish Research Center, Turners Falls, Massachusetts.

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

2. STATUS OF PROGRAM

2.1. STOCKING

2.1.1. Total Releases

In 1991 approximately 6.5 million juvenile Atlantic salmon were released into 15 rivers of New England (Table 1). This total exceeds the number of juveniles released during 1990 (roughly 5.4 million). The Connecticut, Merrimack and Penobscot rivers received the greatest share of the total; 37%, 24%, and 21%, respectively. The stocking of salmon fry constituted over 64% of the releases.

2.1.2. Summary of Tagged and Marked Fish

Nearly 37% of the smolts (approximately 485,000) and 3% of the parr (approximately 30,000) that were released were marked with CWT or Carlin tags in order to address the contribution of salmon of U.S. origin to the ocean commercial fisheries and to carry out various research/management studies (Table 2). In addition, a number of smolts (85,800) were released bearing only fin-clips as marks in order to conduct specific program studies.
It was the concensus of the working group that the information in Table 2 be expanded to include more material relative to the goals and study objectives of the CWT efforts within individual river programs. The river coordinators (Connecticut River, Merrimack

River, and Maine Rivers) are to provide this information to the working group for inclusion into the text for the 1993 (1992 field season) Assessment Report.

A more comprehensive look at the Atlantic salmon marking program for 1991 is presented in Table 3. Information in this table also includes adult salmon releases with Floy tags or Carlin tags as identifying marks.

2.2. ADULT RETURNS

2.2.1. Total Documented Returns

Documented Atlantic salmon returns to rivers in the U.S. totalled 2,689 in 1991 (Table 4). This figure is roughly 40% less than recorded for 1990.

Decreases in documented returns from those recorded in 1990 occurred in the Penobscot, Union, East Machias, Dennys, Kennebec, Androscoggin, Saco, and Connecticut rivers. The decreases for these eight rivers amounted to nearly 2,000 salmon. Increases were observed in the St. Croix and Merrimack rivers: 69% and 34%, respectively. A trapping facility was operated at a fishway on the Narraguagus River during part of the 1991 salmon run. The previous reports were based on rod catch only. Adult returns to most other rivers declined somewhat or remained relatively unchanged when compared to the 1990 numbers.

The information in Table 4 represents **only minimum** documented salmon returns. Salmon returns are obtained utilizing fish counts at traps associated with fish passage facilities and rod catches (fish killed) downstream from the traps. It is difficult to obtain return information for rivers having no trapping facilities. For these rivers rod harvest information is the only return information. Rod catches obviously do not reflect the total run in any of the rivers. Importantly, the reporting of rod catches did not include all of the sport harvest that actually occurred. Salmon counting and capture inefficiencies at salmon traps associated with fish passage facilities are known to occur.

2.2.2. Estimated Total Returns

Many salmon rivers (most of the rivers in Maine) did not have trapping facilities and the existing fish passage and/or trapping facilities were not considered 100% effective in passing Atlantic salmon. As a result, the reported trap and sport fishery catches (Table 4) underestimated salmon returns.

The Assessment Committee made assumptions (regarding the Merrimack, Pawcatuck, and Connecticut rivers' returns) and incorporated biological data collected in Maine to estimate total returns of Atlantic salmon (Table 5). Using the adjustment estimators, approximately 3,886 salmon returned to rivers of New England in 1991.

Assumptions and Adjustment Estimators

On the Penobscot and St. Croix rivers, the re-release of trap caught salmon marked by fin clip and/or radio tags below the lowermost trapping facilities suggest that fish passage facilities at those dams capture approximately 75% of the adult salmon reaching the dam. On the Saco River, salmon were marked and released at a trap at the lowermost dam, but many salmon ascended the spillway and were captured unmarked at the next upstream dam. A Petersen estimate was determined for the Saco River, based upon the captures of marked and unmarked salmon at the second dam. Trap efficiencies of 90% and 50% were used for the Androscoggin and Aroostook, and the Union rivers, respectively.

The ICES Working Group uses sport fishery data to estimate adult returns to rivers without trapping facilities. The ICES method assumes a reporting rate of 80% and an exploitation rate of 20%. This method has limitations, especially on rivers with low sport fishery catches and/or reporting rates, such as the Machias and Pleasant.

Redd count data were collected on several smaller rivers, where accurate counts were possible. There were limited data from rivers in Maine and other areas to indicate that an assumption of two redds per female was reasonable, especially since 2SW females predominated among spawners. Where redd count data were available, they were believed to be a more valid index of run size than the sport fishery. A sex ratio of 1:1 was used among spawners, which approximates that observed at trapping facilities in Maine. For both the redd count and ICES methods, a 10% mortality rate was assumed for salmon caught and released by anglers. For the Kennebec River, a 40% exploitation rate was used, because the sport fishery occurred below a dam without fish passage facilities.

Relative to the Merrimack and Connecticut Rivers it was known that harvests (presently illegal) occurred downstream from the fish passage facilities/traps annually. In years since 1982, documented harvests (legal through 1984 but illegal thereafter) in the Merrimack River have been as high as 25% of the total run size and as low as 0% Additional harvest is believed to occur based on anecdotal reports that fisheries observers receive. The Working Group agreed that it would be reasonable, based on the harvest information for the Merrimack River, to assume that the harvest represented at least 10% of the trap count at the Essex dam. Until additional information becomes available the 10% figure will also be used on the Pawcatuck and

Connecticut rivers. Additionally, it was known that salmon were still downstream from the fish passage facilities/traps on the Connecticut and Merrimack rivers after the fish passage/trapping operations have ceased. Studies in Maine indicated that fish passage/trapping operations could be as high as 90%. The Working Group agreed that, until appropriate data are available, a fish passage/trapping effectiveness rate of 90% is a reasonable assumption for the Merrimack, Pawcatuck, and Connecticut rivers.

2.2.3. Returns of Tagged Salmon

Returns of coded-wire and Carlin-tagged Atlantic salmon to rivers in the U.S. in 1991 are shown in Table 6. The information has been sorted by river of return and sea age.

A total of 568 2SW salmon with CWT returned. Interestingly, the rates of return (number of 2SW salmon with CWT per 1,000 smolts released with CWT two years earlier) varied among the three programs. The rate of return for fish entering the Penobscot River (1.7 2SW salmon/1000 smolts released) was greater than the rate observed for salmon entering the Merrimack (1.2 2SW salmon/1000 smolts released) and the Connecticut (0.7 2SW salmon/1000 smolts released) rivers.

2.2.4. Spawning Escapement, Broodstock Collection, and Egg Take

Egg sources for the New England Atlantic salmon program included sea-run salmon, captive/domestic broodstock, and reconditioned kelts. Sea-run broodstock were collected in Maine at the Veazie dam on the Penobscot River (569 fish) and by electrofishing on the Machias River (14). On the Merrimack River, 310 broodstock were collected at the Essex dam. On the Connecticut River, broodstock were collected at two tributary sites, the Leesville dam on the Salmon River (11) and the Rainbow dam on the Farmington River (33), and one mainstem location, Holyoke dam (137). On the Pawcatuck River, 5 broodstock were taken at the Potter Hill dam. The number of spawners and eggs supporting the hatchery programs are presented in the Table 7.

The total egg take in New England for 1991 reached nearly 15.3 million - a 50% increase over the take that occurred in 1990 (10.9 million). The large increase occurred principally because of the availability of captive/domestic broodstock for the Connecticut and Merrimack rivers.

Salmon entering a counting/trapping facility, yet not captured (allowed to proceed upstream or escaped), included 22 on the Connecticut River (7 not captured on the Salmon River and 15 released on the main stem), 16 (8 escaped at the fish lift in Lawrence, MA and 8 were transported and released into the headwater tributary, the Pemigewasset River) on the Merrimack, 8 on the

Union, and 950 on the Penobscot rivers. The spawning escapement for the Penobscot River represents 974 fish passing the Veazie trap minus 24 known upriver mortalities. In addition, there were 140 adults transferred to the Upper St. John River (above Grand Falls) and 100 released into the Aroostook River from Mactaquac Hatchery by DFO, Canada.

2.2.5. Sport Fishery

The only legal sport fishery for Atlantic salmon in New England occurred in Maine. The documented sport catch of Atlantic salmon in Maine during 1991 was 477 fish (Table 8). This catch represented a decrease of 66% from the 1990 catch. The decrease was different for killed versus released fish at 62% and 70%, respectively. Reductions in catch by age group were: 8% fewer 1SW salmon, 66% fewer 2SW salmon, and 81% fewer 3SW/RS salmon. The sport harvest of Atlantic salmon in Maine in 1991 was the lowest recorded since 1976.

Exploitation rates in Maine rivers continued to be quite variable (0 to ± 25%). On the Penobscot River, the exploitation rate for salmon of wild origin was again higher than for salmon of hatchery-origin (16% vs 9%; total = 11%) because the former appear to enter the river earlier.

Angler effort, as measured by license sales, was slightly (4%) lower in 1991 compared to 1990 (3,157 licenses vs 3,299).

2.3. GENERAL PROGRAM UPDATE

2.3.1. Connecticut River

Hatchery Production and Stocking

Eggs for the Connecticut River program were obtained from the spawning of returning adult salmon at one state and two federal facilities, captive hatchery reared broodstock at two state hatcheries, and reconditioned kelts at both a state and a federal facility. Additional eggs were obtained from sources outside the basin (Maine and the Merrimack River program). Egg incubation occurred at three state and two federal hatcheries.

During 1991, 727,400 fed and 1,007,200 unfed fry were stocked into the Connecticut River basin. These fry were scatter stocked at predetermined densities throughout selected tributary reaches. This was the largest number stocked since the start of the program. The number of fry stocked annually was significantly increased after 1986, and has ranged from 1.1 to 1.7 million during the last five years. Current program planning calls for nearly a 5-fold increase in the number of fry released throughout the basin. Egg incubation space, however, is fully committed under existing release strategies. Plans have been developed to increase salmon egg incubation capacities at three and possibly four hatcheries in the basin by the fall of 1992.

During 1991, 350,200 1Smolts were released into the Connecticut River over the period from March 13 through May 15. With the exception of approximately 25,000 smolts released into the West River and other research and study smolt releases, all smolts produced from the White River National Fish Hatchery (WRNFH) in Vermont and the Kensington State Salmon Hatchery (KSSH) in Connecticut were released downstream of Holyoke, the lowermost mainstem dam. Due to an unusual occurrence of parasites, diseases, and related stress problems with parr at the WRNFH during the summer and fall of 1990, only 115,400 1Smolt and 29,700 1Parr received a CWT.

Major construction activities were undertaken at WRNFH in 1991 to replace the in-river water infiltration system. During this period of uncertainty over the water supply, the target smolt production level for 1992 was lowered to 250,000. Once the performance of the water intake system is satisfactory, smolt production will be maintained at approximately 350,000.

Adult Returns

A total of 203 salmon was recorded returning to the Connecticut River. Returning salmon were counted and trapped at Holyoke Dam on the mainstem, Leesville Dam on the Salmon River, and Rainbow Dam on the Farmington River. The 11 salmon from Leesville and 33 from Rainbow were taken and held at Whittemore Salmon Station in Connecticut. All but 15 of the 152 salmon recorded at Holyoke Dam were retained for fall spawning. In order to accommodate a study of the potential effects of location (hatchery) on spawning success and egg survival, salmon returning to Holyoke were held at both the Richard Cronin National Salmon Station and the Berkshire National Trout Hatchery. Of those 15 salmon released and allowed to proceed upstream from Holyoke, 14 were recorded at Turners Falls, five at Vernon, three at Bellows Falls, and one at Wilder.

The first spawning of salmon returning under the current Connecticut River restoration program was documented in the Salmon River in Connecticut in 1991. Three redds were constructed, one of which contained fertilized eggs. Both adult salmon were missing their adipose fin, indicating they were from a hatchery smolt release. The salmon were not captured.

Downstream Fish Passage

Several studies and construction projects related to downstream fish passage occurred in response to the Memorandum of Agreements (MOAs) signed in 1990 with two major utility companies. At Holyoke, phase one of a fish bypass facility was completed in the power canal. Using floating louvers angled across the canal, the system is designed to guide fish to the entrance of a bypass pipe that would transport fish to a point in the tailrace below the generating units. The system will be tested for smolts in the spring of 1992. A study of the movements of radio tagged hatchery smolts through the Holyoke Project showed that 24% of the smolts exited through the bascule gate. Additional tests will be conducted in 1992 with a 10-foot curtain wall installed across the turbine intakes to guide smolts to the bascule gate opening. At the Turners Falls Project, 61% of the radio-tagged smolts were shown to exit the headpond area near Cabot Station via the existing log sluice. A preliminary study of radio tagged smolts in the Northfield Mountain Pumped Storage Project area was completed. Information gained from that effort will be applied in a larger study using radio-tagged stream-reared smolts in 1992. A fish bypass conduit was completed at the Vernon Project. Results of a smolt radio-tagging study indicated that only 14% of tagged smolts used this exit while 66% left the pool through the turbines. In 1992, underwater sound waves will be tested in guiding salmon smolts to the conduit which is located between two generating units. A study of radio-tagged smolts was completed in 1991 at the Bellows Falls Project. This study was designed to assess mortality associated with smolt passage through the bypass system. Results of the study indicate that passage through the system resulted in 4% immediate mortality. Data from a radio-tagging study at Wilder Dam showed that 84% of the tagged smolts passed through the bypass, 10% passed over the spillway, and only 2% entered the turbines. The MOAs call for completion of downstream passage facilities at five mainstem dams by 1994.

Downstream fish passage facilities have also been requested at hydroelectric dams on tributaries identified in the 1982 Strategic Plan as important to restoration. These generating facilities, currently in the licensing or relicensing process, include projects on the Farmington, Westfield, Deerfield, Black, Ottaquechee, White, and Passumpsic rivers.

Genetics

Recommendations of the Connecticut River Atlantic Salmon Commission's Genetics Workgroup concerning spawning procedures and monitoring of genetic indices were continued for the second year in 1991. Techniques were improved over 1990 for packaging and transporting sperm in order to fertilize salmon eggs at other facilities. Analysis of the data indicates there has been an improvement in effective breeding numbers and inbreeding rates within the program.

Management Evaluation and Research

State and Federal agencies continued to monitor index sites throughout the basin and estimate parr production resulting from the release of fry. A method was developed to expand index station data into basin-wide fry-stocked smolt production estimates. An estimated total of 98,000 smolts was produced in the basin's nursery habitat in 1991. The University of Vermont began a study designed to correlate habitat and water chemistry with fry survival. Dartmouth College and the Conte Anadromous Fish Research Center (CAFRC) completed a study of food availability and feeding habits of stocked fry in the West and White Rivers. The Forest

Service continued habitat restoration work started in 1989 on selected Green Mountain National Forest streams. Data suggest juvenile salmon are responding well to the improved habitat. Age 0+ and 1+Parr densities are higher in habitat improvement sites after treatment, while control sites have shown little change.

Emigration of fry-stocked smolts was monitored at three locations in Connecticut: Sandy Brook (as part of the ongoing "Sandy Brook Research Project"), Rainbow fishway (counts at a viewing window), and a headwater tributary of the Salmon River (sampling with a box net underneath a waterfall). Data show a highly variable temperature regime experienced by Connecticut smolts.

The U.S. Forest Service (USFS) completed the second year of a study to enumerate stream reared smolt emigration from two White River locations. This study focused on the performance of two auger-type smolt traps that have been modified following the initial effort in 1990. Trapping efficiency on the 2,100 hatchery smolts used in the study ranged from 0 to 5.2%. A total of seven fry-stocked smolts was captured in the two traps. The first fry-stocked smolt was captured on April 28 and the last on May 2. All smolts were captured when maximum daily temperatures ranged from 7.2 to 11.1°C.

This was the third year of a study initiated in 1989 by CAFRC and University of Rhode Island to examine the smoltification process of hatchery reared salmon and potential lower river impacts on outmigrating smolts. From January through June of each year, smoltification indicators such as Na^+/K^+ ATPase activity, condition factor, and saltwater tolerance have been examined in fish from the 1Smolt program. Also, a comparison will be made between adult salmon returns from smolts released into the main stem and smolts held in a net pen at the same release site then towed 0.6-1.2 km into Long Island Sound prior to release.

Miscellaneous

The bottom and sides of the fish rearing circulars at WRNFH were painted with epoxy paint in the spring of 1991 with the intent of eliminating or reducing parasites problems. The aspirator that de-gases and aerates wellwater for Whittemore Salmon Station was rehabilitated, and one of the two wells was purged and serviced during 1991.

2.3.2. Maine Program

General

Due to a 60% reduction in state funding levels, the ASRSC drastically reduced the scope of the statewide Atlantic salmon restoration program. The Commission will concentrate on restoration and management activities on the seven rivers with wild salmon runs and a scaled-down Penobscot River program. Further reductions in funding and possible layoffs during FY 1993, coupled with many scheduled furlough/government shut-down days, will likely result in further reductions in the Maine Atlantic salmon program.

A bipartisan committee studying restructuring in Maine state government resommended abolishing the ASRSC and transfing staff and functions to the Maine Department of Inland Fisheries and Wildlife. No action has been taken on this plan to date.

During February of 1992, the ASRSC will hold a public hearing to consider options for reducing the harvest of Atlantic salmon by sport fishing. Although the ASRSC has proposed three options ((1) grilse only, (2) no kill of salmon between 26-34 inches, and (3) 1 large salmon after June 30), testimony received at the hearing and in writing during the 10-day comment period may result in modifications to the proposed rules. The ASRSC expects to promulgate rule(s) that will drastically reduce the sport harvest of Maine salmon, beginning in 1992.

Penobscot River

The Veazie hydroelectric project has been operating on an annual license from the Federal Energy Regulatory Commission (FERC) since 1986. In its draft relicensing application Bangor Hydro-Electric Co. originally proposed a 7MW "C" plant on the east shore and combined this proposal with that of a new 38MW dam (Basin Mills) to be built upriver between Veazie and Great Works. Filing date with Maine's Department of Environmental Protection (DEP) for a 401 permit by Bangor Hydro was in July, 1991. DEP has until July, 1992 to reply. The USFWS and the U.S. Environmental Protection Agency have intervened as being opposed to construction of Basin Mills, and are requesting a new fishway if the Veazie "C" plant is built.

Initial negotiations were held this September (1991) between the James River Corporation and the various state and federal resource agencies regarding the reconstruction of Great Works Dam, the second dam on the main stem. The owner wishes to remove the aging structure and rebuild immediately below the original site.

Bangor Hydro-Electric Co. and the resource agencies have been negotiating issues regarding this 85-year old Milford hydroelectric dam for several years now. A FERC ruling, which was expected early this year regarding previous negotiations, has not yet been made. Matters were complicated by state DEP refusal to grant Bangor Hydro a water-quality certificate. Bangor Hydro took the state board to court. The utility won its appeal; however, the state board appealed this decision to the Maine Supreme Court and won. To apply for a new 40-year FERC license, Bangor Hydro must first receive water quality certification from DEP.

Narraguagus River

The ASRSC is continuing a study funded by the National Marine Fisheries Service (NMFS) to evaluate the status of Atlantic salmon stocks in this river. A trapping facility was put into operation in 1991 at an ice control dam near the head of tide in Cherryfield. Other work this year included: habitat surveys, water quality monitoring, parr production estimates, CWT tagging of wild parr, and redd counts.

Wild Salmon Rivers

As a consequence of recent declines in adult salmon abundance in the Dennys, East Machias, Machias, Pleasant, and Narraguagus rivers, the USFWS has recently listed the salmon populations in these rivers as Category 2 species, under the Endangered Species Act. Further study, including genetic fingerprinting studies, will determine whether these populations warrant protection as distinct populations. The ASRSC and USFWS initiated the capture of adult salmon from the Machias River for transfer to CBNFH for use as broodstock. A total of 14 adults were captured with backpack electrofishing gear in 1991. Data collection continues on the Dennys River in an ongoing study of the relationship between redd counts and large parr populations in year N+2. Results to date indicate a close relationship between redds and parr abundance on the Dennys River.

Saco River

A draft outline for an Operational Plan was completed. Central Maine Power Co. made progress in construction towards the 1992 completion of the East Channel fish lift. Construction of the Spring and Bradbury fish passage facilities has been put on hold for one year until the effects of opening the discharge gates can be studied. With the completion of fish passage construction at the 4-dam Cataract Project, the agencies will be able to enumerate and evaluate returning stocks. In addition, a private Atlantic salmon fry hatchery is presently being constructed on the main stem. The Green Lake National Fish Hatchery (GLNFH) will provide domestic Penobscot strain eggs for this facility.

Union River

The Union River broodstock program was terminated this year (1991). Eight adults were captured in the trap in 1991 and trucked above the Ellsworth dam and released.

Smolt Emigration

Completion of the West Enfield smolt pools, a facility designed to allow hatchery smolts to emigrate on their own volition, made it possible to undertake studies which document migration rates, timing, and paths taken in the Penobscot River. Personnel from the ASRSC, the University of Maine and the USFWS have cooperated in a long term radio-telemetry study to investigate these topics. This year's work centered around devising an automated video counting system to log smolt departure from the pools. Two dozen smolts were fitted and released with internal telemetry tags.

Their movements were monitored with fixed and mobile antennae systems. Only about 50% of the fish stocked in the self-release pools left of their own volition. Of these, the vast majority emigrated on the same day. The radio-tagged fish were released in two groups: mid-April and early May. Fish of the first group rapidly moved downstream, whereas fish of the latter group tended to stay near the release site.

Fry Program

Fed fry from CBNFH and GLNFH were stocked in the East Branch of the Penobscot River and its tributaries where spawning and rearing habitat were under-utilized or vacant. This year, the upper drainage received 400,000 fed fry, covering approximately 30 miles of prime habitat. Fry studies continued for the second year on two small tributary streams to the East Branch of the Penobscot River (results are summarized in Setion 3.4.).

Conversion of the CBNFH to a Multiple Broodstock/Fry Facility

Plans were initiated to convert CBNFH from a broodstock/smolt production facility, to a broodstock/fry production facility. The purpose of this change is to replace the stocking of Penobscot River strain fish in Maine's wild salmon rivers with local (river specific) stocks. As a result, 1992 will be the last year of smolt production at CBNFH. The CBNFH will have the capacity to produce one million fed fry or up to five million non-feeding fry. The facility will also be altered to hold broodstock from Maine's wild rivers.

2.3.3. Merrimack River

Efforts to restore Atlantic salmon to the Merrimack River Basin continued at a higher level than those of previous years. The increase is reflected in the number of fry and smolts released into the river system.

Program Status

Background

Atlantic salmon river returns for the period, 1982 - 1991, (trap catches, illegal rod harvest, and all other known sources) totalled 1,436 fish. Annual returns ranged from 23 (fall returns only - 1982) to 332 salmon. Returns were recorded in each month from March through October with the majority recorded in June (52%).

Salmon returns were composed of 1SW, 2SW, and 3SW salmon. The majority of the returns were 2SW fish (85%).

All juvenile salmon stocking components contributed to returns. Of the 1,436 returns recorded, 52% were from fry stocking origin, 3% from parr stocking origin, and 45% from smolt stocking origin. The low contribution from the parr releases suggested that their value to the program was negligible.

The freshwater age distribution of the adults originating from the fry stocking program varied for fry plants. However, based on all known adult returns of fry origin, roughly 5% were contributed by 1Smolts, 83% by 2Smolts, and 12% by 3Smolts.

The fish cultural changes at the Nashua National Fish Hatchery (NNFH) and the North Attleboro National Fish Hatchery (NANFH), as reported in the previous U.S. Atlantic Salmon Assessment Committee's report, are completed. The NNFH is no longer producing salmon smolts for the program. Efforts are directed at raising domestic broodstock for the production of eggs that will allow for major increases in the stocking of salmon fry. The NANFH will be the sole producer of salmon smolts for the program. The fish cultural change occurred because of the desire by the program cooperators to significantly increase the production of fry for release and because smolts originating from the NNFH did not contribute substantially to the number of adults returning to the river. The latter, based on CWT returns to the river for the 1988 and 1989 smolt releases is:

	NANFH	NNFH
1988 Smolt Release	1.62 adults/1000 smolts	0.79 adults/1000 smolts
1989 Smolt Release	1.38 adults/1000 smolts	0.31 adults/1000 smolts

1991 Information and Activities

Juvenile Atlantic Salmon Releases and Adult Returns

The second largest fry plant and the third largest smolt plant recorded in the program occurred in 1991 (Table 1). In addition, the largest adult salmon return recorded in the program was observed (Table 4).

Adult returns consisted of 255 (77%) fish from fry origin, one fish (less than 1%) from parr origin, and 76 (23%) adults from 1Smolt origin. The rate of return to the river for adults from 1Smolt origin was the highest recorded in the program, 1.34 adults/1000 smolts stocked (rate of return not expected to change even though the 3SW salmon component of the smolt release is not due to enter the river until 1992). This rate of return was considerably smaller than the highest rate of return recorded for 2Smolts, 1.77 adults/1000 smolts (1983 2Smolt year-class). The rate of return for the 1987 fry-plant (this fry-plant contributed much of the 1991 returns) was 0.25 adults/1000 fry released but the rate of return for the 1987 fry-plant may increase since three age-classes are still in the marine environment.

Coded Wire Tag Returns

Seventy CWT (all from 2SW salmon of 1Smolt origin) were observed in adult returns. Based on the number of CWT observed, the average rate of return (weighted by release number) was 1.25 adults/1000 tagged smolts (0.31 adults/1000 tagged smolts raised at the NNFH and 1.38 adults/1000 tagged smolts raised at the NANFH). An additional six 2SW salmon that should have possessed a CWT did not. This represented nearly 8% of the 2SW salmon originating from smolt plants (all hatchery smolts are tagged with CWT and marked by removal of the adipose fin prior to release). The total number of salmon not having CWT was one 1SW salmon, 260 2SW salmon, and one repeat spawner.

During the 1991 ocean commercial fishery a total of 15 CWT was recovered from 1SW salmon of Merrimack River origin (13 CWT from the Canadian fishery and two CWT from the Greenland fishery). The recovery rate was 0.111 CWT/1000 tagged smolts (weighted by release number) in the Canadian fishery (0.03 CWT/1000 tagged smolts raised at the NNFH and 0.196 CWT/1000 tagged smolts reared at the NANFH) and 0.017 CWT/1000 tagged smolts (weighted by release number) in the Greenland fishery (no tags recovered from smolts reared at the NNFH and 0.036 CWT/1000 tagged smolts reared at the NANFH). The recovery rate in the Canadian fishery was increased (56%) considerably from the previous year while that observed in the Greenland fishery decreased (941%) from the previous year.

Atlantic Salmon Broodstock Releases

During November the USFWS in cooperation with the New Hampshire Fish and Game Department (NHFG) released 400 domestic broodstock into the Pemigewasset River. These fish, all tagged with CWT and marked by removal of the adipose fin, were mature fish and were a surplus of the domestic broodstock program at the NNFH. It was anticipated that these salmon would spawn in the river, but because they were released late in the season spawning may not have occurred.

Activities and Observations

The USFWS in cooperation with the NHFG and the USFS conducted the annual fall assessment of the fry stocking program. Parr sampling occurred at eight index sites. The sites were representative of the juvenile salmon habitat found within important Merrimack River tributaries.

Juvenile salmon were collected at the sites by electrofishing and population estimates were calculated using mark-recapture and depletion methods. Analyses suggest that there were reasonable numbers of 0+parr at the sites. The densities of 1+Parr were low at most sites when compared to data obtained in past years.

The seasonal abundance of salmon parr originating from fry releases in headwater nursery areas has been documented by annual assessments at index sites. However, knowledge about the production and migration of smolts from these areas is limited. To better understand the factors affecting the production and migration of smolts, the USFWS has conducted assessments to determine the time of migration of smolts and to estimate the number of smolts migrating from Merrimack River headwater areas.

Greater than 60% of all fry released annually in the basin were distributed upstream from Ayers Island dam, the first of seven mainstem dams that smolts encountered during their seaward migration. Although not usually distributed into headwater areas, approximately 6,000 1Smolts with tags were released at sites upstream from the dam in the spring of 1991. The tagged smolts were used to determine the capture efficiency of portable auger smolt traps located in the Mad, Baker, and East Branch of the Pemigewasset rivers. They were also used to determine the capture efficiency of traps integrated with downstream fish passage facilities.

The auger smolt traps and the traps at the dams were operating by the first or second week in May. The assessment revealed problems associated with fish passage due to low flows and in-river obstructions. Capture efficiency of the auger traps was determined to be about 3%, similar to the efficiency of the trap located at the Ayers Island dam. Operation of a trap at Garvins Falls dam was experimental, and although it operated intermittently, its success ensured a commitment of funds by Public Service Company of NH for the construction and installation of enhanced fish passage and capture facilities at the site in 1992.

A total of 247 wild smolts (originating from fry plants) was captured at the Ayers Island trap from May 6 through June 11. Most captures occurred when water temperature was at or above 16°C and when river discharge was below station generating capacity (1,650 cfs) with no spill over the dam. The onset of migration appeared to occur when water temperature reached 10°C and during a spill condition at the dam. When river discharge was less than 1650 cfs, conditions at the dam may have impeded or delayed the passage of smolts.

2.3.4. Pawcatuck River

For the third consecutive year, parr stockings exceeded 100,000 fish. This should result in increased adult returns beginning in 1992.

Program Status

Adult Returns - A total of five 2SW salmon returned to the Pawcatuck river in May and June of 1991. Two fish were females and were spawned in October yielding a total of 14,500 eggs. The five returns in 1991 represent a 0.044% return from the estimated 11,363 smolts in 1989. This very low rate of return has occurred since the 1984 smolt class and is associated with the use of domestic broodstock as an egg source.

Parr Stocking - A total of 104,500 0+Parr were released into the watershed in 1991. These parr were supplied by three sources: the NANFH, adult returns to the Pawcatuck River in 1990, and from 0+Parr donated by Kennebec Aquaculture in ME. Since 1989, parr stockings have risen dramatically to an average of 224,233 fish per year. This was three times greater than the 1986-88 average of 62,567. These increased numbers of parr should lead to greater adult returns beginning in 1992.

Research Update - Recent research has focused on the effect of high parr stocking densities on smolt production. An experiment began in 1989 was concluded in spring 1991 when smolt abundance estimates were made for four experimental areas stocked with high densities of 0+Parr in 1989. Initial densities exceeded 100 parr/100 m^2 in the fall. The densities had declined to between 0.5 and 3.0/unit by 2Smolt, 17 months later. No increase in smolt production was achieved by stocking in excess of the 50/unit optimum suggested by earlier work. An environmentally modified Ricker function was fit to the complete Pawcatuck data base. Temperature was used as the auxiliary variable. This model is being used in optimization studies using Monte Carlo techniques to estimate stocking regimes in different mixes of habitat which will maximize adult returns.

Physiology studies are continuing at the University of Rhode Island Department of Zoology. The thrust of these studies are to examine differences between wild and hatchery smolts.

2.3.5. General Program Information

No information was provided for this category.

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. Data needs for NASCO

a. summary of status of stocks for NASCO
b. summary of research for ANACAT

The information necessary to summarize the status of the New

England Atlantic salmon stocks for NASCO can be found in Sections 2.1., 2.2., and their sub-sections of this document.

Research activities necessary for ANACAT are summarized and presented in Section 5.1.

3.3. Historical data - validate 1990 stocking and return data and add to historic database

The historical data were validated by the Assessment Committee and the information can be found in Tables 9 and 10, Section 6. (sub-sections 6.1. and 6.2.) of this document.

3.4. Synthesize available data and model fry survival rates

At previous Assessment Committee meetings, investigators had presented survival data for fry stocked in various New England rivers. A synthesis of available data was needed to make all investigators and managers fully aware of the results and implications of work undertaken in other river systems. In addition, a compilation of data from each program made available a larger data set for analysis and model development than was available within any one river program. Nearly 300 records were available for a modeling exercise. Each record included stocking date and density, survival to age 0+ and/or age 1+, and variable amounts of data on environmental parameters.

All suitable available data from fry stocking evaluation in New England were assembled for analysis. It was recognized that environmental conditions, feeding status, strain,etc. varied widely between systems but it was felt that density dependent effects would override the differences. Survival to 1Parr was examined because this was the latest stage with sufficient data available. Data were standardized to a common 16 month window to account for differences in survival due to different stocking and sampling times. A Ricker curve was fitted to the standardized data. Separate analyses were done on various subsets of data, in addition to the pooled data.

Although there was considerable scatter in the data, several points are clear. At fry stocking densities below 20/unit, yearling parr production is low. At fry stocking densities between 20 and 140/unit parr densities are more variable but higher. At fry stocking densities above 160/unit parr production is low. A broad shallow dome is evident (Figure 1). The pooled model explains only 6.4% of the variation but the parameter estimates were highly significant. The density independent survival rate from stocked fry to yearling parr was 11.7%. Maximum yearling parr densities (4.78/unit) were predicted to occur at a stocking density of 111 fry/unit but there was little change in estimated production over wide stocking densities (90 - 143 fry/unit). Region specific estimates of density independent survival ranged widely from 4.0% in the Merrimack River to 20.5% in the West River. The density dependent coefficient was significant only for the Rhode

Island/Connecticut and the West River data sets. Maximum parr production in the West River (3.77/unit) was predicted to occur at a density of 50/unit; the maximum parr in Rhode Island/Connecticut (6.31/unit) was predicted to occur at stocking densities of 135/unit.

Model results suggest managers should stock fry at low densities over a wide area of habitat when numbers of fry are limited. Although this would reduce per unit production slightly, it would ensure maximum total production. If fry are unlimited, high stocking densities (50-135/unit) should be used to maximize per unit parr populations. The goal of fry stocking programs is to maximize adult returns. Maximum parr densities do not neccessarily result in maximum smolt and adult production due to density dependent and size effects. Fry stocking density studies need to be followed up with studies of the effects of stocking densities upon abundance.

The Assessment Committee found merit in continuing the development and refinement of a fry stocking survival model. Inclusion of environmental data in the model will be investigated. A task group was appointed to investigate the model, its assumptions, and the database.

Two similar tributary streams to the East Branch of the Penobscot River were stocked with high and low densities of fed Atlantic salmon fry to assess the effect of stocking density on growth and survival of parr. Lunksoos Stream was stocked with 145 fry/100 m^2 and Little Spring Brook with 45 fry/100 m^2. There were no significant differences in instantaneous growth rate of parr between test streams (2%/week). Survival estimates for 0+Parr were 22% in the high density treatment stream and 29% in the low density treatment stream. Initial mortality was 23.5%/week in the high density treatment and 5.1% in the low treatment stream, suggesting that the mortality in the high density stream was excessive. Overall mortality 69 weeks after stocking was comparable, 9.3%/week and 8%/week, in the high and low density treatments, respectively. Overwinter mortality of 0+Parr was found to be twice as high in the low density treatment stream (7.8%/week) compared to the high density treatment stream (3.5%/week). Overall survival from initial stocking to 1+Parr was 11.5% in the high density stocked stream and 3.2% in the low density stocked stream. Escapement from the low density stocked stream of 1+Parr may account for the lower survival estimates in the low density treatment stream. The 1993 stocking density will be transposed at each test stream.

3.5. Develop a methodology to identify stocked hatchery smolts based upon minimum length criteria; e.g. compute an annual index of smolt survival probability based upon the length frequency distribution and associated survival rates

A mathematical model for analyzing the influence of body size on survival (tag returns) for several New England rivers was presented. The model divided survival into two components: initial survival or "smoltification rates" (p), which included all potential mortality factors in the river, estuary and coastal environment and long-term survival (open-ocean survival) (Z). The number of returning salmon at time t (Nt) can be expressed as a function of the number released Nr as follows:

$$Nt=p\ Nr\ \exp(-Z\ t)$$

The parameters p and Z occur as a product and simplifying assumptions are required to allow estimation. First, evidence on size-specific mortality was used to express mortality as a decreasing linear function of length with a constant slope derived from the literature. Second, the probability of successful smoltification was modeled as a logistic function of length. Again, literature values were used to reduce the number of parameters to a feasible number. The more general form of the model becomes:

$$Nt(L) = p(L)\ Nr\ \exp(-Z(L)\ t)$$

where p(L) and Z(L) are functions of length at release.

Analysis of survival data indicates that hatchery fish less than 15 cm and greater than 25 cm total length survive at lower rates than 15-25 cm fish. Within this range of lengths the minimum size for successful smoltification varied among the systems tested. Notably, the minimum critical size for the Penobscot River was about 17 cm whereas, the minimum size for the southern rivers (Merrimack, Pawcatuck, and Connecticut) was 20 - 24 cm. Tthe function p(L) for the southern rivers suggests that substantial increases in returns would occur if smolt size at release were at least 22 cm. This conclusion may serve as a guideline for the hatchery production of smolts.

Limitations in the original data include possible exclusion of grilse returns in Nt, and a difference in the size of tagged fish versus the entire population. The findings underscore a lack of information on the factors involved in mortality in the river and estuary. Additional information is necessary to distinguish potential interactive effects of river age and size. Moreover, it was noted that the scope of inference for these analyses is confined to hatchery fish. Wild smolts or those arising from fry releases may have smaller threshold sizes associated with better adaptation to river and marine environments during smoltification.

A task group was appointed to investigate the model and its assumptions.

3.6. Develop methodology to estimate homewater returns to U.S. rivers

No new information was presented regarding the Atlantic salmon returns to the rivers of Maine. However, the Assessment Committee agreed on several assumptions that were used in developing total run sizes for the Merrimack, Pawcatuck, and Connecticut Rivers (Section 2.2.2.). The assumptions were in line with the information utilized in Maine with one major exception. The known sport harvest of salmon in the three rivers was considered to represent 10% of what the trap catch. Because of the fact that any sport harvest (fish killed and taken) that occurs in these rivers is illegal, it is believed that the reporting is extremely low - for obvious reasons.

4. DISCUSSION TOPIC

4.1. <u>Atlantic salmon research - what's important?</u>

One entire day of the working group meeting was devoted to a discussion of ongoing "research" and needed research for the Atlantic salmon restoration program of New England. A number of researchers throughout New England (all participants listed in Appendix 3) joined with the Assessment Committee during this discussion. The principal theme of the discussion centered around activities underway or required to address (juvenile) Atlantic salmon mortality rates prior to the marine phase of their life-cycle (freshwater and the estuary).

Summary of Past Research

Summary reports of salmon management activities and information needs for New England rivers identified areas where further research may complement restoration and enhancement efforts. Activities that have occurred within all programs include: surveys to quantify habitat for various life history stages of salmon, assessments to document the success of stocking programs, studies to define the time and routes of in-river migration, and studies to determine the effectiveness and efficiency of fish passage facilities at dams. These studies are likely to continue.

There are also dissimilar activities occurring between programs. Emphasis has recently been placed on the need to determine whether discrete stocks of salmon exist in select Maine rivers. A continued decline in the return of salmon to these rivers, and the implementation of an enhancement strategy that included the introduction of non-native juvenile salmon into the rivers, prompted a study to better understand the genetic integrity of wild salmon found in the rivers. Changes in hatchery operations in the Merrimack program have increased the number of unfed fry that will be released in the Basin. Adult return rates from fry releases have been nearly as high as those from hatchery smolt releases and these results have encouraged increasing the numbers of fry in other rivers. The Connecticut and Pawcatuck rivers are generally thought to represent the southern extreme of the range of salmon, and thus present unique problems for salmon migrating to and from these rivers.

Approach to Future Research

Research with direct applicability to increasing returns of adult salmon should be given highest priority. Research which addresses the underlying causes of poor adult returns is recognized as important to the advancement to our basic understanding of Atlantic salmon and can play an important role in the development of management strategies to improve returns. Research on the underlying mechanisms should be oriented toward the development of specific changes in stocking procedures that could be tested in large scale field programs. Research and management can aid each other, in this time of limited funding, by collaborating and sharing information/resources whenever possible. The following categories and their sub-categories are not necessarily listed in order of priority.

Fry

1. **Food Availability** - Food availability is an important component of habitat. The relationship between food quantity/quality and fry survival/growth needs to be investigated.

2. **Habitat Structure** - Habitat structure is important in providing quality territories for salmon. The relationship between physical habitat and density-dependent survival needs to be examined. The conditions that contribute to variation in fry growth and time of residence of resultant smolts in the river and estuary also need to be examined.

3. **Optimal Stocking Strategies** - In the future, fry stocking will be expanded and information on strategies that maximize returns are needed. Further retrospective assessments of the relationship between past stocking regimes and subsequent fry survival/growth are needed. Examining density-dependent relationship between fry stocking and subsequent survival can provide information on optimal stocking strategies such as preferred stocking density and feeding modes.

Parr

1. **Interactions With Conspecifics** - Density dependent factors may affect parr survival and smolt production. Alternative stocking strategies that could include adjustments in the density of fry stocked, differential stocking of cohorts (alternate year stocking), and point or scatter stocking should be explored.

2. **Interactions with Other Species** - Predator-prey interactions involving juvenile salmon are not well understood. Interactions with predators and concomitant learning experiences affect behavior and survival. A better understanding of the mechanisms involved in these interactions would be beneficial. Interaction with other, non-predatory species may be important and should be investigated.

Smolt

Many factors at the hatchery and in the river can inhibit or alter parr-smolt transformation. Topics requiring additional investigation to produce better smolts and increase adult returns included:

1. **Functional smolts** - Hatchery production of functional smolts that are capable of migrating and surviving in the marine environment is critical for restoration. Research is needed to determine which factors inhibit or alter smoltification and what remedial or preventative measures can be taken to correct them.

2. **Abundance** - Distribution and numbers of smolts must be measured to determine potential number of adult returns and to calculate adult return rates. Presently there is limited or no information on the number of individuals successfully migrating to estuaries and coastal waters.

3. **Smolt Quality** - Indicators are needed to assess the quality of smolts produced by hatcheries. Fin condition data have been collected but in most cases have not yet been related to return rate. Additional and more sensitive methods of assessment are necessary to monitor the effect of hatchery practices on fish health and quality.

4. **Precociousness/Residualization** - A certain percentage of individuals released from any hatchery are destined to become sexually precocious or residualize in freshwater. Although these fish may be an important component of the population structure they do not contribute to adult returns. Efforts should be made to determine the environmental factors or hatchery practices which might induce precociousness/residualization and how to alleviate this problem.

5. **Behavioral Studies** - Limited information is available on the behavioral aspects of parr-smolt transformation. Investigations are required to assess behavior patterns of smolts and how they relate to migration, dam passage and imprinting.

6. **Age of Smolts** - The merits of producing hatchery 1Smolts vs. 2Smolts were discussed. It was suggested that both groups be evaluated to determine which rearing regimen produces the best smolts and adult returns. Additionally, the potential differences in the window of smoltification were mentioned.

7. **Behavioral Physiology** - Studies to correlate the physiology and behavior of smolts were suggested. This information would be of greater value if both laboratory and field studies were conducted.

8. **Timing of Smoltification** - Comparative studies to examine spatial and temporal differences in smoltification in fry stocked and hatchery reared smolts would be of value. Additional areas that should be investigated are: optimizing dates of release to produce

the greatest numbers of returning adults and examining date of release and actual time of outmigration.

Mortality Factors

1. Predation - Predation by fish, birds, and mammals in river and estuary could be an important cause of mortality. The magnitude of this factor needs to be studied. Coincident with field studies on predation, experiments should be conducted on hatchery fish to develop techniques which will increase the ability of smolts to avoid predators, capture prey, and endure variable flow conditions in the wild. Large scale field trials should be initiated to evaluate the efficacy of these hatchery-culture modifications. Such studies could lead to remedial measures that might alter stocking time and place. Control and manipulation of predator populations should also be considered.

2. Passage - Smolts suffer mortality during downstream migration over dams. Impediments to downstream migration may (1) kill fish, (2) prolong migration time, and (3) increase susceptibility to other sources of mortality. The relative importance of these and ways to mitigate this mortality need to be examined.

3. Residency - The effect of length of river, delays, and changes in behavior during river/estuary residence need to be examined.

Post-Smolt

1. Growth and Survival - The logistical difficulties to sample salmon in the ocean during the post smolt phase complicates study of this important life stage. Until estimates of total smolt output become available, survival must be inferred from patterns of growth and the rates of return of 1SW, 2SW, and 3SW salmon. Retrospective studies of post smolt scales, using image analysis techniques, has shown promise as a means of relating growth to oceanic conditions. Broad scale evaluations of sea surface temperatures have been shown to be related to variations in salmon growth in the North Atlantic. Such analyses have a high probability of explaining cyclical changes in salmon abundance coincident with changes in temperature.

2. Environmental Influences - Relationships between environmental conditions and survival of smolts upon initial entry into seawater are poorly understood. Temperature regimes in the near-shore region are thought to be critical for successful and rapid movement of post-smolts to feeding grounds. The duration of acceptable times for migration may be short. Temperatures in the river are also important determinants of successful smoltification. Unfortunately, little information has been assembled on either river or nearshore temperatures. A compilation of existing data from USGS monitoring stations, fixed buoys, and satellite data would be useful for identifying periods in which successful migrations could occur.

Adults

1. **Passage at Dams** - Determining the efficiency of passage at dams is problematic because of the low and unknown numbers of returning fish. Mark-recapture methodologies may provide conditional estimates of passage efficiency because of potential problems: capturing, tagging and releasing fish that were initially captured at the same location where they will be recaptured (i.e. they have prior experience of the migratory path). Alternative tagging methods and techniques to include the use of PIT tags may be employed to overcome this bias. The limitations of tagging methods and the inherent bias should not preclude the initiation of studies if the assumptions are made.

Broodstock Collection - Genetics

1. **Hatchery Protocols** - Broodstock selection at capture facilities and hatchery environment selection may affect genetic variability. Proper hatchery protocols at spawning may mitigate some of the unwanted problems resultant from the mixing of genetic material. Although some programs are developing methods that are thought to be useful in separating stocks or isolating genetic material, straying of salmon returning in New England rivers may have implications for maintaining river specific stocks.

2. **Genetic Background** - Retrospective and continuing examination of hatchery records should be undertaken to assess pedigrees, effective breeding numbers, inbreeding, and loss of alleles.

3. **Precocious Parr** - Use of precocious parr in the fish culture programs may ensure genetic variation within the fry, parr and smolt components. The use of parr in the programs may pose problems, particularly those related to disease because of introductions into the hatcheries, but their use in propagation should continue.

General

1. **Modeling** - Population modeling could provide a context for the evaluation of research efforts designed to improve return rates and meet restoration objectives. Sensitivity analyses of such models could assist in quantifying the relative magnitude of various mortality factors, and in identifying alternative managment strategies.

2. **Historical Assessments** - Another important category of investigation is an evaluation of historical data from each of the restoration programs and existing environmental databases. While such studies are often not strictly comparable, they provide a strong basis for the identification, and the preliminary testing of alternative hypotheses and design of experiments.

Technological Advances

1. Tags - Recent technological advances offer the promise of substantially improving field assessment and research programs. In particular, new types of tags could be used for non-lethal recovery and tracking of salmon movements and estimation of survival rates. Smaller PIT tags, less than half the size of today's models, would afford the opportunity to uniquely mark large numbers of smolts and adults without the drawbacks of external tags or the limited information content of CWT. Continued development of this type of tag should be a high priority.

2. Telemetry - Radiotelemetry studies are expensive, require specialized equipment, and cannot be used to simultaneously track large numbers of fish. A new type of data-logging tag, now under development at the Lowestoft Fisheries Laboratory, U.K., allows scientists to record information on temperature, depth and direction of fish. These tags could become a substitute for radiotelemetry in situations where a high recovery probability of tags was possible. Additional information, reductions in costs and increased samples sizes are among the substantial benefits of such tags.

3. Marking - Mechanical marking is not feasible for very small fish. Mass marking of batches with biological stains may provide a means of evaluating fry stocking programs. Research on this type of marking should continue. With this technique, site-specific survival can be compared.

4. Video - Advances in video technology may allow scientists to improve estimates of smolt emigration and numbers of returning adults. When interfaced with appropriate image analysis software, video records could be used to both enumerate the run and estimate its size structure. Pilot studies now underway should continue and be expanded to other river systems once the feasibility of video technology has been demonstrated. Video technology may also improve studies of fish passage and behavioral.

5. RESEARCH

5.1. Current Research Activities

The following information depicts known research activities (studies) and/or publications dealing with the Atlantic salmon. The first entry in each case is the contact person (name, address, etc.) for the specific research or publication(s) followed by the publication title and/or description of the activity or study.

CONTACT:

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PUBLICATION:

Proceedings of the Atlantic Salmon Workshop, Rockport, Maine, March 6-7, 1991.

Studies Completed in 1991:

1. EGG STUDIES AT CRONIN NATIONAL SALMON STATION

Survival to the eyed stage of eggs taken from Connecticut River sea-run ATS declined from 73 percent in 1986 to 58 percent in 1988, at the Cronin National Salmon Station. Two studies were initiated in 1990 to 1) determine if calcium enrichment of ambient water would improve egg survival, and; 2) to compare survival among ATS eggs fertilized with milt from sea-run, domesticated, and precocious males. The studies were completed in 1991.

1) Ambient water at Cronin was used as the control. Calcium chloride was used to enrich ambient water to the calcium concentrations of 25, 50, 75, 100, and 125 ppm Ca^{++}. The results of this study did not show that calcium enrichment through the water hardening stage had a positive effect on egg survival at Cronin NSS.

2) Sperm was taken from nine precocious parr, nine domesticated ATS broodfish from Roger Reed SFH, and nine Connecticut River sea-run males. The eggs used in the study were taken from three Connecticut River sea-run females. The eggs from each female were split into nine sublots. Each sublot was fertilized with sperm from a different male, using three different males from each group. The results from the experiment were inconclusive. There was no significant difference in mean survival of eggs fertilized with the sperm from the three groups of males. We believe the experimental design used in this study did not answer the question as to whether or not poor sperm is the cause of the decline in eye-ups at Cronin, therefore, we proposed further studies in 1991.

Studies Begun in 1991:

1. EVALUATION OF THE TOXICITY OF IODOPHOR TO EGGS AND FRY OF ATLANTIC SALMON

The 1988 Federal Fish Health Policy required that all eggs at Fish and Wildlife Service facilities be water hardened in polyvinylpyrrolidone iodine compound. The recommended rate for Atlantic salmon is 100 mg/L of active iodine for 30-60 minutes at pH 7.0 or above. Prior to 1988, egg disinfection was done at the rate of 100 mg/L active iodine for 10 minutes after water hardening in ambient water. Many salmon hatcheries felt this recommendation was not based on adequate information; that the toxicity of water hardening eggs in 100 mg/L iodophor to Atlantic salmon eggs had not been adequately tested. The objective of this study is to determine if Atlantic salmon eggs water hardened in 50, 75, 100, 125, and 150 mg/L of active iodine for 30, 60, and 120 minutes will have the same survival to the eyed and fry stages as eggs water hardened in ambient water for one hour, followed by disinfection with 100 mg/L of active iodine for 10 minutes.

The study was initiated at Nashua NFH, October 22, 1991, and will be completed in 1992.

2. THE EFFECT OF HATCHERY LOCATION ON ATS EGG VIABILITY

Percent survival of ATS eggs taken from Connecticut River sea-run salmon at Cronin National Salmon Station has declined from 73 percent in 1986 to 58 percent in 1990. Prior studies involving calcium enrichment of egg-hardening water and the use of milt from precocious parr and domesticated broodstock did not significantly improve egg survival. Prior to construction of Cronin NSS, Connecticut River sea-run salmon were transported to Berkshire NFH and held until spawning. Egg survival at Berkshire exceeded 73 percent then. The objective of this study is to compare egg survival between Cronin NSS and Berkshire NFH, and determine if hatchery location has a significant effect.

The study was initiated at Berkshire and Cronin from October 17-31, 1991, spawning 9 pair of sea-run ATS at each station. A core spawning team oversaw all spawning and egg transport procedures. The eggs were transported to White River NFH for incubation. The study will be completed in 1992.

3. EVALUATION OF THE USE OF LHRH HORMONE ON MALE ATLANTIC SALMON TO INCREASE SPERM COUNT AND IMPROVE EGG FERTILIZATION RATE.

The percent survival of eggs taken from Connecticut River sea-run ATS at Cronin NSS has declined from 73 percent in 1986 to 58 percent in 1990. Fish culturists at Cronin believe that lower egg survival is due to a decline in the quality of milt extracted from the male. They occasionally observe watery milt or milt that has a yellowish-green color. The objectives of this study were 1) to determine the sperm count in a group of ten untreated males, and in two groups of ten males implanted with LHRH hormone 7 and 14 days, respectively, prior to spawning; 2) to compare survival between like groups of eggs fertilized with the milt from the hormone-treated and untreated males, and; 3) to determine the optimum sperm to egg ratio in ATS. The study was initiated at Cronin NSS October 17-31, in cooperation with the National Research and Development Lab at Wellsboro. The eggs were transported to Wellsboro for incubation. The study will be completed in 1992.

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RESEARCH STUDIES:

1. NARRAGUAGUS RIVER RESEARCH PROGRAM

Principal Investigator: Kenneth F. Beland
Maine Atlantic Sea Run Salmon Commission

In 1990, the ASRSC received a grant from NMFS to conduct a comprehensive investigation of the Atlantic salmon resource and habitats of the Narraguagus River and its tributaries. The goals of the study are to determine the magnitude of the adult and juvenile components of the Narraguagus River salmon population, inventory the available habitats for Atlantic salmon production, determine whether those habitats are fully utilized, and determine whether degradation has adversely affected the carrying capacity of those habitats.

An adult trapping facility was operated continuously between 6/6/91 and 10/31/91, with the exception of a total of 20 days in July. A total of 74 salmon was counted through the facility. This does not represent a complete count of adult salmon entering the system due to incomplete counts prior to June 6 and during the 20 day interval in July when adult migrants were not trapped but were allowed to pass the trapping facility. A majority of the salmon captured were of wild origin (73%), based upon scale samples or external characteristics. A small salmon run, low water levels and high temperatures in the Narraguagus River resulted in low angler catches for the 1991 angling season. A total of 28 salmon was reported caught by anglers, of which 22 were retained by anglers and six released. One trap-caught salmon was subsequently caught in the sport fishery. Wild salmon were caught in a similar proportion (69% wild) to that observed in the trap catch. As a result of unfavorable angling conditions, angling pressure is believed to be less than usual during 1991.

Redd counts were conducted on the main stem and most tributaries in 1991. A total of 186 redds was counted in 1991, which indicates that the salmon run was probably of a similar magnitude to 1988 and 1989, and was smaller than most salmon runs since the late 1970's. Using an assumption of 2-3 redds per female salmon, the trap catch accounts for only about 50-60% of the salmon that returned to the Narraguagus River.

One segment of the research project examined the relationship between the redd count for a river reach and parr density two years later on three eastern Maine rivers. The data set for the Cathance Stream (Dennys) index site showed a significant correlation between parr density and redd counts ($r^2=0.904$, $p\leq0.0001$), based upon nine years' data. The correlation approached significance for eight years' data from Old Stream (Machias) ($r^2=0.408$, $p=0.088$). The were no sites with more than five years of concurrent parr population estimates and redd count data for the Narraguagus River, so this relationship could not be shown.

The juvenile salmon population monitoring on the Narraguagus River is needed to accurately estimate the year class strength within the Narraguagus River. A total of 57 stations on the Narraguagus River was sampled utilizing standard electrofishing techniques in 1991. Parr populations were generally low throughout the lower and middle reaches of the Narraguagus River. Parr populations of less than 2 parr/100m^2 were commonplace. These data will be used to assess the utility of sampling a limited number of index sites to determine salmon parr year class strength for the smaller salmon rivers of eastern Maine. Large parr (ages 1+ and 2+) were marked with CWT to assess their contribution to interception fisheries. A goal of tagging approximately 5,000 parr was established in order to achieve a reasonable probability of recovering tags in the interception fisheries. If tags can be recovered from the local sport fishery then data can be obtained regarding the contribution of specific river reaches to the adult run. As a result of low parr densities, only 824 parr were marked with CWT in 1991. The ratio of marked to unmarked adults in the 1994 trap catch may provide an alternative estimator of the drainage-wide juvenile salmon population.

Water chemistry data (pH, conductivity, and aluminum) were collected at two sampling stations during the spring of 1990. Continuous pH data were collected at up to four sampling stations between October 1990 and June 1991. The water chemistry monitoring in the spring of 1990 indicated that pH on the upper main stem varied between 5.29 and 6.66. For most of the spring sampling period, the pH varied between 5.6 and 6.1. The 1990-1991 (autumn through spring) sampling data indicated that pH at the two main stem Narraguagus stations remained above 5.5 throughout the sampling period. The West Branch Narraguagus and Sinclair Brook experienced multiple pH excursions below 5.0 throughout the sampling period. Population effects upon juvenile salmon are likely under the observed conditions in the West Branch. Examination of aluminum concentrations in water samples revealed low levels of exchangeable aluminum (<14 ug/L) and represent little threat to juvenile salmon.

The first stage of the physical habitat survey and inventory is virtually complete. All potential spawning and nursery habitats in the main stem and West Branch of the Narraguagus have been measured and classified. The habitat information will be integrated into a Geographic Information System (GIS).

A total of 25 water samples was collected between May and October 1991 at sites along the Narraguagus for chemical contaminant analysis. Seven samples were analyzed for a wide array of potential contaminants (pesticides, herbicides, and a fungicide). The only chemical detected in the May/June sampling was Hexazinone (Velpar), a herbicide in widespread use in the blueberry industry. It was detected at the two sites sampled in the vicinity of blueberry production areas, at concentrations of 0.33 and 0.26 ppb. The laboratory analysis of samples collected in 1991 was incomplete.

Invertebrate sampling studies were conducted in 1991. A total of eight sites was sampled for benthic invertebrates, six of which are located in the Narraguagus watershed. Two sites on Old Stream (Machias River watershed) were selected as controls. Sampling was scheduled monthly between June and November.

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<u>PUBLICATIONS:</u>

Lo, Y.H., T.M. Bradley and D.E. Rhoads. 1991. L-alanine binding sites and Na , K -ATPase in cilia and other membrane fractions of olfactory rosettes of Atlantic salmon <u>(Salmo salar).</u> Comp. Biochem. Phsysiol. 98B(1):121-126.

Robertson, J.C. and T.M. Bradley. 1991. Hepatic ultrastructure changes associated with parr-smolt transformation of Atlantic salmon <u>(Salmo salar).</u> J. Exp. Zool. (In press).

Roberston, J.C. and T.M. Bradley, 1991. Liver ultrastructure of juvenile Atlantic <u>salmon(Salmo salar).</u> J. Morphol. 210:1-14.

Tremblay, G.C. and T.M. Bradley. 1991. L-carnitine protects fish against ammonia toxicity. Comp. Biochem. Physiol. (In press).

RESEARCH STUDIES:

1. **Bodammer, J.E. and Bradley, T.M.**
USE OF THE PASSIVE HEMOLYTIC PLAQUE ASSAY TO MEASURE THE IMMUNE RESPONSE OF ATLANTIC SALMON DURING SMOLTIFICATION AND OF WINTER FLOUNDER FROM CONTAMINATED ENVIRONMENTS.

Despite increased efforts at both the federal and state levels, the numbers of Atlantic salmon adults returning to southern New England rivers remain low. Multiple factors probably contribute to the poor status of these runs. One potential factor that has not been well investigated is the immune system of Atlantic salmon migrating to seawater. Numerous hormone changes occur during parr-smolt transformation, including an increase in cortisol, a hormone known to decrease immune response in other vertebrates. These scientists are attempting to measure the immune status of Atlantic salmon to determine whether the fish are more susceptible to infection and disease during parr-smolt transformation. Additionally, they are examining the effects of environmental contaminants on the immune system in another important local species, the winter flounder. Specific knowledge of susceptibility to infection and disease creates opportunities for corrective measures. This work is presently supported by the National Marine Fisheries Service.

2. **Bradley, T.M. and Tremblay, G.C.**
HEAT SHOCK PROTEINS AND SMOLTIFICATION IN ATLANTIC SALMON

This project is a collaborative venture between a fish physiologist (Bradley) and a biochemist (Tremblay). the objective of this research is to obtain a reliable indicator of the stage of smoltification, and of the potential for growth in seawater. Cell production of heat shock proteins is a common response to a wide variety of stressful conditions. Activation of genes that control production of these proteins is well understood in microbes and some animals, but little studied in fish. The work in progress should establish whether the pattern of appearance of heat shock exposure to seawater, will provide the long-sought indicator of smoltification status and growth potential in seawater.

3. **Bradley, T.M.**
AN ULTRASTRUCUTRAL INVESTIGATION OF THE ENDOCRINE PANCREAS OF ATLANTIC SALMON DURING PARR-SMOLT TRANSFORMATION

Unlike humans, fish lack a discrete organ comparable to the pancreas (which produces insulin and other hormones). However, pancreatic cells are found dispersed throughout the gut area in fish. The role of these cells, and their hormone products, is not well understood in fish. Professor Bradley is seeking to determine whether pancreatic cells function in regulating parr-smolt transformation of Atlantic salmon. The effects of hatchery conditions and practices on the function of these cells are also being investigated. This work is currently supported by the U.S. Department of Agriculture, Rhode Island Agricultural Experiment Station.

4. Chang, P.W. and Bradley, T.M.
IMMUNOLOGICAL-BASED ASSAYS FOR VIRAL DETECTION IN FISH

Federal and state regulations require hatcheries to be tested for the presence of disease causing organisms (viruses and bacteria) before fish can be transferred from one facility to another. Available technology requires 60 individuals be killed and examined from each group of fish at the facility. In the case of large brood fish the loss of revenue to the aquaculturist is significant; the value of a single brood female often exceeds $300. This study is a collaborative effort between a virologist (Chang) and a fish physiologist (Bradley). Present efforts center on measurement of antibodies in the blood as indicators of exposure to specific bacterial and viral pathogens, similar to the test for exposure to the AIDS virus. This work is currently supported by the U.S. Department of Agriculture.

5. Nelson, D.R., Kjelleberg, S., and Bradley, T.M.
DIFFERENTIATION OF VIBRIO ANQUILLARUM, A MARINE FISH PATHOGEN, TO A STARVATION-STRESS RESISTANT FORM

Rearing fish at the high population densities characteristic of aquaculture in seawater netpens greatly increases the risk of transmission of disease. Infection with the pathogenic bacterium Vibrio anquillarum is a major health problem in raising Atlantic salmon and other seawater species. It is known that some bacteria exist in more than one form, and that the various forms are not equally infectious. Professor Nelson believes infection by Vibrio anquillarum is caused by a particular (stress-resistant) form of the bacterium. He also believes the reason vaccines against vibrio anquillarum are largely ineffective is because they have not been made against this form. Professor Nelson just returned from a month of research with Professor Kjelleberg at the University of Goteborg in Sweden, where the study of infection and disease in fish is a primary research focus to aid the Scandinavian aquaculture industry. Professors Nelson and Kjelleberg will continue their collaborative research on this important problem to the industry, and Professor Bradley at URI will become involved at the stage of testing corrective measures or vaccines against this disease. The work is currently supported by the College of Arts and Sciences, the College of Resource Development, and the Rhode Island Sea Grant Program.

6. Rhoads, D.E.
THE ROLE OF CALCIUM ION IN OLFACTORY TRANSDUCTION

The mechanisms by which salmon navigate from the open ocean to the freshwater stream of their origin are poorly understood. Many believe they are able to detect the unique chemical composition of their natal stream, by the sense of smell. Professor Rhoads is attempting to define this process in Atlantic salmon. He is able to measure responses in the brain to the addition of minute quantities of chemicals that trigger sensory perception. This line of research will not only provide insight into the nature of the homing mechanism, but also allow subsequent study of impairment of this mechanism by specific environmental pollutants. The work is currently supported by the U.S. Office of Naval Research.

7. Tremblay, G.C. and Bradley, T. M.
EFFECT OF CARNITINE ON GROWTH AND AMMONIA TOXICITY IN ATLANTIC SALMON

The body produces ammonia when it uses dietary protein for energy. Normally the liver quickly converts this ammonia to non-toxic urea, but failure to do so quickly causes death, through ammonia-induced impairment of the nervous system. Fish lack this ability to convert ammonia to urea; they simply excrete ammonia into their aquatic environment. However, under conditions where the water supply is limited, such as hatchery or static pond culture, ammonia accumulation is second only to depleted oxygen as a cause of disease and death.

Recent biomedical research has provided evidence that carnitine, a normal constiturent in the diet, can protect mice and rats against the toxicity of what would otherwise be a lethal dose of ammonia, by a mechanism as yet unknown. Professors Tremblay and Bradley joined forces to examine this problem in fish, and found similar protection in salmon. Their current research is partly directed toward establishing the biochemical mechanism of protection. They are also seeking to determine whether addition of carnitine to the diet, much as a vitamin supplement, will permit substitution of fat for protein in Atlantic salmon feed. Carnitine promotes use of fat for energy, and substitution of fat for protein would reduce ammonia output, and might also lower the fat content in salmon and accelerate growth to market size. Dietary modifications that protect against ammonia toxicity, reduce ammonia output, reduce body fat, and accelerate growth to market size would have broad application for improved economic return across the aquaculture industry.

8. Bradley, T.M.
SMOLTIFICATION AND SEAWATER SURVIVAL OF ATLANTIC SALMON REARED AT WHITE RIVER NFH AND KENSINGTON SSH

A major problem faced by hatcheries involved in Atlantic salmon restoration is assessing the timing and occurrence of smoltification. Fish released prematurely are susceptible to predation and diseases in the river. Individuals released after parr-smolt transformation do not migrate to the ocean and residualize in freshwater. Traditional and novel indicators of smoltification were measured in juveniles to determine if fish actually did undergo smoltification at the hatchery and to assess the best dates for release. Parameters were monitored from January through June. In May, fish from both hatcheries were transferred to a netpen in Narragansett Bay to assess growth, survival, incidence of disease and the efficacy of a bivalent vaccine against Vibrio species.

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PUBLICATIONS:

Siemien, M.J. and R.F. Carlin. 1991. EFFECT OF TEMPERATURE ON THE GROWTH OF FEEDING ATLANTIC SALMON FRY. The Prog. Fish-Cult., 53:11-14.

A 3-week test was performed to determine the optimal temperature for growth of first-feeding fry of Atlantic salmon (Salmon salar). The fish were fed three times the recommended daily ration and held at water temperatures of 10, 14, 18 and 22°C. Growth was significantly greater at 18°C than at any other temperature.

Also, the effect of temperature cycling on growth was studied and a manuscript is in preparation.

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RESEARCH STUDIES:

1. CURRENT VELOCITIES AND THEIR EFFECTS ON THE FEEDING BEHAVIOR OF ATLANTIC SALMON, SALMO SALAR L., JUVENILES.

Principal Investigators: Joe Bachman and Carol L. Folt, Dartmouth College

This project had three objectives: (i) to extensively survey the current flow conditions and water depth over a 19 km stretch of the West branch of the White River, (ii) to intensively survey specific USFS habitat-remediated sites on the river with respect to current velocity and water depth on several dates during the summer season; and (iii) to experimentally measure the effects of current velocity on the feeding behavior of salmon fry.

The extensive survey demonstrated that there was roughly equivalent habitat heterogeneity over small (across stream transects) and large (along the 19 km stretch) scales. It also provided valuable estimates of the range in current flows and water depths in that region of the river system. The intensive survey showed that the remediated portions of the river tended on average to have slower water velocities, deeper depths and greater coefficients of variation in flow (i.e., be more spatially heterogeneous) than did adjacent unremediated sections. In the laboratory, fish were found to feed most efficiently at medium and low flows (<.05 m/sec) and in the absence of complex substrate.

2. ANALYSIS OF FOOD AVAILABILITY FOR ATLANTIC SALMON FRY

Principal Investigators: Carol L. Folt, Dartmouth College, and Donna L. Parrish, Vermont Cooperative Fish and Wildlife Research Unit

This project is a companion to "Prey selection of age 0 Atlantic salmon in the West and White Rivers, VT." The primary objective of this aspect of our cooperative research effort is to evaluate food availability for Atlantic salmon fry introduced into the West and White Rivers, VT, during the period from May through August. Sites include both high and low survival areas. The field sampling program began in May 1991, concomitant with the first fry stocking in the West and White Rivers. We collected invertebrate drift and measured a number of physical habitat variables (cover, substrate, current flow, etc.) on a bi-weekly basis in each of six sites. We also conducted a diurnal analysis of drift at several locations. In total, we have collected approximately 400 invertebrate drift samples. The invertebrates in these samples will be identified and measured to estimate seasonal changes in available drift biomass and diversity. They will also be used to make site-to-site comparisons (between the West and White Rivers).

Our results will be valuable because they will provide the first quantitative assessment of seasonal and spatial variation in food availability in these two important river systems. These data will also provide an essential component for the feeding and preference estimates collected as part of the companion project.

3. INFLUENCE OF HABITAT COMPLEXITY ON FOOD AVAILABILITY FOR AGE 0 ATLANTIC SALMON IN THE WHITE AND WEST RIVERS, VT.

Principal Investigator: Keith H. Nislow, Dartmouth College

This project evaluates the effect of habitat complexity, particularly spatial heterogeneity in depth, flow, and substrate, on the abundance and distribution of potential prey for age 0 Atlantic salmon in the West and White Rivers of Vermont throughout the spring and summer of 1991. My approach is to use both natural variation in and among sites along the two rivers, and variation produced by stream remediation projects via the introduction of large instream structure. Steve Roy and Dan McKinley of the U.S. Forest Service provided background information and assisted in site selection. Potential prey availability will be assessed via drift samples, and comparisons with information on fish diets obtained in a concurrent study. By evaluating the interaction between habitat complexity and food availability, results of this study will be valuable in evaluating habitat suitability and mechanisms responsible for differential survival of juvenile salmon in the West and White Rivers.

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RESEARCH STUDY:

1. SURVIVAL AND MATURATION OF ATLANTIC SALMON IN THE SEA

The factors affecting post-smolt survival and maturation of Atlantic salmon have been investigated by a retrospective analysis of growth and an exploratory analysis of sea surface temperature. The post-smolt period of marine survival and development has been variously described as critical to stock production and genetics in Atlantic salmon and anadromous salmonids worldwide. The mechanisms controlling these events reflect the interaction of the life history of the species or stock and the ecosystem dynamics governing the critical nursery habitat. With Atlantic salmon, there is limited information on the post-smolt stage and the information that has been developed suggests post-smolts migrate nearly as far as adults during their first summer at sea. With such expansive use of the marine environment, investigations must directed at many oceanic provinces and during a minimum of three seasons of the year.

The retrospective analysis of growth was based on the extraction of circuli spacing measurements from the marine first summer and winter zones of scales. Scale samples were from a stock of known survivorship, thus inference about survival and growth can be made. Circuli spacing patterns for fish that returned as 1SW salmon were not correlated with the return rate of 1SW salmon. Circuli spacing patterns for fish that returned as 2SW salmon contained information related to grilse and salmon return rate trends. Growth during summer appears to be critical in determining the maturation rate. Growth during winter appears to affect the survivorship of the non-maturing (2SW) component of the stock.

The exploratory analysis of trends of sea surface temperature was developed for eastern and western portions of the North Atlantic. Temperature anomalies for continental regions, subcontinental regions and stock specific locations were developed. In addition to trends in temperature, habitat, as defined by the temperature parameter, was quantified for each continent and related to life history stages. Limited findings for Europe (due to latitudinal limitations of the data) suggest post-smolt habitat has been constricted in recent years by North Sea cooling and warming along the southern extent of the nursery habitat. Findings for North America suggest redistribution of warm water has constricted critical winter habitat. Analyses are continuing.

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RESEARCH STUDIES:

1. EFFECT OF ADVANCED PHOTOPERIOD ON THE TIMING OF SMOLTIFICATION OF HATCHERY SMOLTS.

Investigators:	Steve Gephard	CT DEP/DMF
	Al Sonski	CT DEP/DIF
	Terry Bradley	URI/Aquacul.

A flood light and timer were used to illuminate a single rearing pond at the Kensington State Salmon Hatchery containing ATS pre-smolts, December to April. The timing of the lighting resulted in a graduated advanced photoperiod that was one month advanced at time of stock-out in April. Gill ATPase was measured from sacrificed samples at bi-weekly intervals to monitor the stage of smoltification. Unpublished results show that the peak of smoltification was advanced. Expanded work and a study of the effect of advanced smoltification on the adult return rate of smolts sea-ranched from the Connecticut River are planned to begin in 1992.

2. COMPARISON OF RELEASE TECHNIQUES, ATS HATCHERY SMOLTS

Investigator: Steve Gephard, CT DEP/DMF

Hatchery ATS smolts have been traditionally released into the Salmon River (Connecticut River Basin) either directly or after a month-long holding period in concrete imprint ponds three miles above the head-of-tide. Adult return rates have been disappointing and there are many reasons to believe the use of the ponds is counterproductive. The use of a net enclosure to hold smolts in a protected mainstem location at the head-of-tide prior to release was initiated in 1990 and continued in 1991. Adult return rates from these fish will be compared to groups released in the traditional manners (all fish carry CWTs) beginning in 1992. No results to date.

3. THE USE OF STREAMSIDE GRAVEL INCUBATORS LOCATED IN A POWERHOUSE TO INCUBATE AND HATCH GREEN EGGS

Investigators: Steve Gephard, CT DEP/DMF
Joe Ravita, CT DEP/DMF

Streamside gravel incubators have been used extensively to incubate salmon eggs for fry stocking and other purposes. It is not known whether any such incubators have been located in a hydroelectric powerhouse previously. A series of four wooden incubators were built and installed by the CT DEP into a powerhouse, owned by the Hartford MDC, on the Farmington River (Connecticut River Basin) to accept 300,000 - 400,000 salmon eggs. The eggs will be used to produce fry for stocking as part of the Connecticut River Restoration Program, but the pilot project will be evaluated to determine its usefulness for such management programs. Details of the study (e.g., type and density of eggs, type of incubation substrate, etc.) are being developed as of this writing and eggs are expected to be received for loading very soon.

4. EMIGRATION OF ATLANTIC SALMON SMOLTS IN WEST BRANCH FAWN BROOK (CONNECTICUT RIVER).

Investigator: Steve Gephard, CT DEP/DMF

The smolt run in West Branch Fawn Brook, a small headwater tributary of the Salmon River, was sampled with a box net placed under a waterfall in 1991. A total of 48 smolts was captured from April 5 to 18. The total catch approximated a smolt production estimate calculated from fall electrofishing data, but was greater than spring electrofishing data indicated. All smolts were two years old and ranged from 195-243 mm (mean = 221 mm).

Water temperatures fluctuated dramatically on a daily basis with a peak of 20 C as early as April 9. Based on temperature data collected and the immediate capture of smolts when sampling commenced, smolt runs may start as early as March in southern Connecticut streams. Peak daily temperatures of 20 C may be reached in small streams before the mainstem Connecticut River warms to 10 C. Although this technique requires an suitable site, it is an effective, low maintenance means of sampling the smolt run in small tributaries.

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RESEARCH STUDIES:

1. RESTORATION OF ATLANTIC SALMON TO THE PAWCATUCK RIVER

Restoration of Atlantic salmon to the Pawcatuck river in Rhode Island is being undertaken using parr stocking as a strategy. Releases of age 0+Parr into all suitable tributaries have been made since 1979. Adult returns have occurred since 1982. Research studies have focused on the population dynamics of parr and smolts in the freshwater habitat. Field experiments have shown that growth rates of parr are independent of density but positively correlated to environmental factors such as alkalinity and temperature. The relationship between parr stocking density and smolt density has been determined to follow a Ricker function. The stocking rate for parr which yields the highest smolt density was 56.8/100 m^2. Smolt production at this stocking rate was 2.51/unit. At low stocking densities, the survival rate from parr to smolt was 12%. Limited fry stocking evaluations have been conducted and these resulted in fewer smolts. It is believed that predation rates on stocked fry are much higher than on 0+Parr.
Current research is involved with developing optimization techniques to estimate the most efficient parr stocking regimes which will maximize adult return. Studies are also ongoing to evaluate the effect of smolt size on adult return in relation to predation in the estuary.

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RESEARCH STUDY:

1. PHYSIOLOGICAL AND ENDOCRINE CHANGES DURING HATCHERY REARING AND RELEASE OF ATLANTIC SALMON.

The parr-smolt transformation is a complex series of developmental events which prepares fish for downstream migration and entry into seawater. Failure to complete this developmental process can result in poor seawater survival, growth and return rates. Knowledge of the timing of the physiological, biochemical and endocrine changes during the parr-smolt transformation can provide two related and important advances: 1) they can be used as 'markers' of developmental change to determine whether changes in timing and extent of development are related to migratory rates, downstream passage and return rates, and 2) they can be used to track the development of the parr-smolt transformation so as to optimize time of release. Although a variety of diagnostic features have been proposed, there is no single feature (or combination of features) that is currently accepted for anadromous salmonids. Sampling of this nature at hatcheries involved in the Atlantic Salmon Restoration Program is currently limited to two or three parameters.

The objectives of this research are to:

1. Define the physiological and endocrine changes that occur during the parr-smolt transformation of Atlantic salmon in hatcheries and in rivers in order to develop diagnostic criteria for normal rearing.

2. To determine the physiological and endocrine changes that are correlated with migratory rates, downstream passage and return rates to determine their value as predictors of return rates and as a means to alter husbandry and release practices to maximize returns.

2. PHOTOPERIOD CONTROL OF THE PARR-SMOLT TRANSFORMATION IN ATLANTIC SALMON.

Previous research has indicated that the timing of release of anadromous salmonids must coincide with full development of the parr-smolt transformation in order to achieve maximum migratory rates and return rates. In the Atlantic Salmon Restoration Program, however, current management techniques and limitations in stocking procedures can result in a protracted (2 month) stocking period for smolts which precludes precise timing of release with developmental events. One possible means of circumventing this limitation is to alter the timing of the parr-smolt transformation so that some lots of fish are available for stocking earlier than others. Although environmental manipulations are known to delay, advance or inhibit the parr-smolt transformation, a simple, well-accepted method for altering the timing of the parr-smolt transformation does not currently exist.

The objectives of this research are to:

1. Determine the role of increasing daylength in the timing of the parr-smolt transformation.

2. Induce advanced onset of the parr-smolt transformation using altered photoperiod(s).

3. Determine if an endogenous rhythm of physiological changes occurs in the absence of changes in daylength.

4. Define the hormones involved in timing of the parr-smolt transformation.

5. Determine the effect of return to normal photoperiod on phase-advanced smolts.

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RESEARCH STUDY:

1. A PILOT STUDY TO ESTIMATE THE NUMBER OF ATLANTIC SALMON SMOLTS MIGRATING FROM MERRIMACK RIVER HEADWATER AREAS

The purpose of this study was to develop estimates of the numbers of wild smolts migrating past the Ayers Island dam on the Merrimack River. Smolts were captured in a trap in a downstream passage facility. Three techniques were used to provide independent estimates:

1) the re-capture of hatchery smolts from a known-quantity upriver release to generate an efficiency rating for the smolt trap;

2) use of mark-and-recapture calculations of wild smolts that were trapped, marked, and released upstream of the Ayers Island trap;

3) the use of pre-smolt density data (from index sites sampled the previous fall) for upstream nursery habitat and overwinter mortality estimates to generate a smolt population estimate for all habitat upstream of the trap.

Population estimates derived from these three techniques were 8,153, 7,907, and 28,449 smolts, respectively. Approximately two-thirds of all smolts may have passed over the dam spillway (thus avoiding the trap) during periods of spill. Some of the problems with these estimates include: (1) the efficiency rating technique could have been more accurate if more hatchery smolts were released and recaptured, (2) some smolts estimated by the index site technique may have failed to emigrate, (3) and some fish tagged for the mark-and-recapture technique may have lost their tags.

Discussion of this research during the annual meeting centered around the use of a overwinter survival rate of 65% from parr to smolt. Participants agreed that overwinter survival rates could be affected by fish density, and fish size and quality of habitat. The need to conduct corraborative field studies for each system was emphasized. There was considerable discussion concerning the occurrence and value of late season migrants.

The Working Group recommended that a 1993 Term of Reference include a survey of the literature and salmon researchers elsewhere to determine whether the occurrence of late migrants is widespread or is an artifact of hatchery practices.

CONTACT:

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Orono, Maine 04469
Phone: 207-581-2582

PUBLICATIONS:

Vanderpool, A.M. 1991. Migratory patterns and behavior of Atlantic salmon smolts in the Penobscot River, Maine. M.S. thesis, Univ. of Maine, Orono.

Gustafson-Greenwood, K.I., and J.R. Moring. 1991. Gravel compaction and permeabilities in redds of Atlantic salmon, Salmo salar L. Aquaculture and Fisheries Management 22: 165-168.

Gustafson-Greenwood, K.I., and J.R. Moring. 1990. Territory size and distribution of newly-emerged Atlantic salmon (Salmo salar). Hydrobiologia 206: 125-131.

Boyle, K.J., T.F. Teisl, J.R. Moring, and S.D. Reiling. 1991. Economic benefits accruing to sport fisheries on the lower Kennebec River from the provision of fish passage at Edwards Dam or from the removal of Edwards Dam. Maine Agricult. Exper. Station, Univ. of Maine, staff paper 429. 45 p. plus 47 p. of appendices.

Perry, C.M. 1990. Effect of different methods of killing Atlantic Salmon on whole-body concentrations of selected electrolytes. J. Aquatic Animal Health 2: 154-156.

Smith, T.R. 1991. Response of brook trout (Salvelinus fontinalis) and Atlantic salmon (Salmo salar) exposed to low Ph with and without aluminum. M.S. thesis, Univ. of Maine, Orono.

RESEARCH STUDIES:

1. DOWNSTREAM MIGRATION OF ATLANTIC SALMON SMOLTS IN THE PENOBSCOT RIVER, MAINE.

The study examines the timing and routes of smolt migration in two ways. A video camera system was installed at the self release ponds near the Enfield Hydroelectric Project, and smolts were filmed as they left to enter the Penobscot River. In addition, radio tags were placed on 30 smolts during the migration period. Fish were tracked by airplane approximately 40 miles downstream.

The final data are being analyzed.

2. REFINEMENT OF THE HABITAT SUITABILITY INDEX MODEL FOR ATLANTIC SALMON.

One shortcoming of the existing HSI model for Atlantic salmon is the assessment of adult holding pools. After measurements in the Dennys River in 1990, detailed studies were made of holding pools in several streams in New Brunswick from June to October, 1991, as well as evaluations of the Deerfield River, Massachusetts. An assessment model is being prepared.

3. PREDATION ON ATLANTIC SALMON SMOLTS BY DOUBLE-CRESTED CORMORANTS.

Mortality of smolts is thought to be high in the Penobscot River, partly due to predation by cormorants. This study examines the numbers, movements, and behavior of cormorants, the availability of smolts to birds, and the importance of smolts in the diet of cormorants.

4. FOOD HABITS OF SMALLMOUTH BASS, CHAIN PICKEREL, AND FALLFISH, AND THE ROLE OF JUVENILE ATLANTIC SALMON IN THE DIET.

Predation of smolts by fish predators will be assessed during spring migration, and summer and fall residence of juvenile salmon. In addition, predation during irregular events, such as hatchery stocking will be monitored using various types of sampling gear and stomach tubes.

CONTACT:

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RESEARCH STUDIES:

1. PREY SELECTION OF AGE 0 ATLANTIC SALMON IN THE WEST AND WHITE RIVERS, VT

Principal Investigators: Donna L. Parrish, Vermont Cooperative Fish and Wildlife Research Unit, and Carol L. Folt, Dartmouth College

This project is a companion to the study plan titled, "Analysis of food availability for Atlantic salmon fry". Our focus here is to determine prey selection of age 0 salmon in the West and White Rivers of Vermont throughout the summer of 1991. Prey selectivities will be calculated from fish gut analyses in relation to prey availability, which is based on organisms present in invertebrate drift samples. Prey selection not only includes types of organisms eaten, but also, biomass of each prey type consumed. our results will be valuable in evaluating mechanisms responsible for differential survival of juvenile salmon in the West and White Rivers.

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RESEARCH STUDY:

1. PRELIMINARY EVALUATION OF A NON-LETHAL METHOD FOR RECOVERING CODED WIRE TAGS FROM ADULT ATLANTIC SALMON BROODSTOCK

The clear tissue posterior to the eye, known as the adipose eye, was evaluated as a CWT implant site for Atlantic salmon. Earlier research by Northwest Marine Technology, the manufacturer of the tag, found this tissue to be stable and not readily traumatized by manipulation or foreign substances. This tissue remains clear in Atlantic salmon at least until the post-smolt stage and generally up to sexual maturation. The evolving information requirements for salmon management makes non-lethal recovery of marking information highly desirable. The characteristics of the proposed adipose eye implant site and the established effectiveness of the coded wire tagging system suggests this approach to mass tagging could be accomplished with non-lethal recovery and effectively address standing and proposed research problems.

Preliminary trials of the approach were carried out at the NNFH. A group of 200 parr, ranging in size from 11 to 24 cm, were tagged with CWT in the adipose eye and fin-clipped. Tag detection and recovery were evaluated after a 18 month residence in the tissue. Despite some difficulty in identifying fin-clipped fish, tags were successfully located in a minimum of 85% of fish examined. Tags were reliably removed from anesthetized fish and remained readable and displayed no signs of deterioration. The investigators felt the approach could be applied to bright and sexually mature sea run salmon without significant technical or logistical problems.

RECOMMENDATION:

The Working Group recommended that each restoration program investigate application and retention of CWT in the adipose eye implant site and concurrently develop protocols to recover tags in manners compatible with present tagging and handling procedures.

CONTACT:

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RESEARCH STUDY:

1. QUALITY ASSESSMENT OF CONNECTICUT RIVER ATLANTIC SALMON SMOLTS.

This is a five year study to assess the quality of Connecticut River hatchery smolts. Objectives are: 1) to determine, using salinity tolerance, NA^+/K^+ ATPase activity levels, and condition factor if the smolts being produced by the Connecticut River program undergo the parr/smolt transformation process; 2) to determine if there is significant differential mortality occurring between release sites in-river and in Long Island Sound; and 3) to determine if Connecticut River smolts can live and adapt to seawater. The last objective was addressed by stocking several thousand salmon smolts directly into a seawater net pen in Narragansett Bay, RI. Information from this study will provide insight to managers considering problems of when and where to stock their fish and the ability of these smolts to adapt to seawater. The draft report, "Mortality of Connecticut River Atlantic Salmon - Is It Occurring In The Ocean", provided preliminary data and results for the 1991 adult returns from the 1989 net pen smolt release and on the 1989, 1990 and 1991 salinity tolerance testing. A concern was expressed that the sample size used in the net pen study was to small to provide statistically valid results. To date, four returning adults have been identified from the net pen release and eight from the control group.

CONTACT:

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PUBLICATIONS:

Sower, S.A. and R.S. Fawcett. 1991. Changes in gill Na+,K+-ATPase, thyroxine and triiodothyronine of coho salmon held in two different rearing densities during smoltification. Comp. Biochem. Physiol. 99A:85-89.

Lewis, K.M. and S.A. Sower. 1991. Effects of dietary testosteroneon growth and sex ratio of juvenile Atlantic salmon (Salmo salar). Fish Physiol. Biochem. (In press).

Diets to which testosterone (1 or 10 ng/g diet) had been added were fed to juvenile Atlantic salmon (Salmon salar) for nine months beginning for months after hatching (Experiment 1) and upon completion of yolk absorption (Experiment 2) to determine the effects on growth, gonadal development, and sex ratio. Dietary testosterone at 10 ng/g fed to juvenile salmon at four months after hatching (Experiment 1) induced significant changes in condition factor (0.69±0.01) compared to controls (0.79±0.01) at the end of the test period. In both experiments, salmon treated with 10 ng/g diet induced a significantly higher percentage of male fish compared to controls. Dietary testosterone at 1 ng/g fed to juvenile salmon beginning four months after hatching induced significant increases in weight (18.95±0.99) and length (13.58±0.23) compared to controls (14.55+1.50 and 11.94±0.43, respectively). In Experiment 1 or 2, there was no apparent influence of dietary testosterone on precocious male sexual development. Dietary testosterone at 1 or 10 ng/g fed to juvenile salmon upon completion of yolk absorption (Experiment 2) induced no consistent changes in growth in juvenile Atlantic salmon. These studies indicate that low levels of dietary testosterone may influence physiological responses in juvenile Atlantic salmon dependent upon timing of treatment.

Sower, S.A., K.H. Karlson, and R.S. Fawcett. 1992. Changes in plasma thyroxine, estradiol-17B, and 17a,20B-dihydroxy-4-pregnen-3-one during smoltification of coho salmon. Gen.Comp. Endocrinol. (In press).

CONTACT:

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RESEARCH STUDY:

PROJECT TYPE: Cooperative Research Programs: Atlantic Salmon Studies

Job Number and Title: I-1 Performance of Atlantic Salmon Stocked as Parr or Smolts in Rhode Island Streams

The goal of this research is to aid in the Atlantic salmon re-establishment efforts in New England. the overall objective is to determine the relative potential contribution of Atlantic salmon stocked in streams as parr in the fall or as smolts in the spring. To this end, we monitor the physiology and behavior of Atlantic salmon during the parr-smolt transformation. We compare the performance, morphology, and physiology of salmon at the North Attleboro National Fish Hatchery (NFH) with their counterparts stocked as parr or as presumptive smolts in Beaver River, a tributary of the Pawcatuck River.

Atlantic salmon smolt production has been studied for three consecutive years at North Attleboro National Fish Hatchery. An effort has been made to monitor salmon subjected to normal procedures such as grading and grow out with the exception that only one grading occurred during each study season (September to June).

Salmon form this study group in the hatchery were fin-clipped and stocked into Beaver River, Washington county, Rhode Island. Salmon were released either as parr in October or as presumptive smolts in late March or April. Both groups were then captured by electroshocking or caught in a trap placed about 10 km downstream. Sampling of the salmon form the stream occurred monthly in the fall and winter and as often as weekly in the spring. The trap is in place from late march to early june. During this period it is checked daily.

PUBLICATIONS:

Specker, J.L., Whitesel, T.A., Parker, S.J. and Saunders, R.L., 1989. Thyroidal response of Atlantic salmon to seawater challenge: predictor of growth in seawater. Aquaculture, (1989) 82: 307-318.

The aim of these investigations was to apply current ideas about the relationships among salmon development, thyroid endocrinology, and seawater adaptation to the problems of delayed growth and stunting that occur unpredictably when commercial growers move salmon "smolts" to sea cages. A test was designed that is analogous in many respects to the seawater challenge test. Whereas the seawater challenge test predicts survival in seawater, the seawater challenge-thyroxine (T_4) response test is being developed to predict growth in seawater. Atlantic salmon at North Attleboro National Fish Hatchery (NAFH) were tested at two developmental stages: as parr in March and as smolts in May. Two groups of Atlantic salmon at St. Andrews Biological Station (STABS) were also tested in May. At this time, one group had been reared under simulated natural photoperiod (SNP) while the other had been exposed to constant light (L24) since August. Those under SNP are characterized as smolts, whereas those under L24 served as "smolt controls" in that they did not survive or grow as well in seawater. In these tests, the salmon were injected with either 0.2 IU bovine thyrotropin (TSH) or the saline vehicle and transferred to seawater or returned to fresh water. Changes in plasma concentrations of thyroid hormones were measured at 8, 24, and 48 or 8 and 27 h after injection, depending on location. The response to seawater and to bovine TSH occurred within 8 h. At this time, seawater suppressed thyroid activity in parr (NAFH) and in the "smolt controls"

(STABS). In contrast, seawater did not suppress, but tended to stimulate thyroid activity in smolts. These findings suggest the potential usefulness of the seawater challenge-T_4 response test for predicting growth of Atlantic salmon in sea cages

Bisbal, G.A., and J.L. Specker, 1991. CORTISOL STIMULATES HYPO-OSMOREGULATORY ABILITY IN ATLANTIC SALMON, SALMO SALAR L. Journal of Fish Biology (1991) 39, 421-432.

Hypo-osmoregulatory ability in juvenile Atlantic salmon, *Salmo salar L*., was improved by cortisol treatment. Implantation of a vegetable shortening pellet containing cortisol (50 mg kg_{-1}) resulted in elevated plasma cortisol titres. Maximum cortisol levels (160-170 ng ml_{-1}) were observed at days 6 and 12 after the implantation and dropped significantly by day 55. Cortisol-implanted fish in fresh water developed a twofold increase in gill NA_+/K^+-ATPase activity at days 6 and 12 , and a threefold increase by day 55. Intestinal mucosa NA_+/K^+-ATPase activity was not affected by cortisol. Cortisol-implanted fish exposed to 28 ppt sea water for 48 h tended to show an improved ability to regulate their plasma osmolarity and reduce their ionic load. The osmo-regulatory ability attained at days 12 and 55 was further evaluated by exposing fish to 37 ppt sea water for 96 h. While all the control fish died relatively early in these tests, cortisom-implanted fish showed a clear reduction in their mortality rate. These results indicate that cortisol can induce biochemical and organismal changes during winter month that typify preadaptive events normally occurring in the spring.

5.2. Research Needs and Data Deficiencies

The reader is referred to Section 4. (Discussion Topic) of this document.

5.3. New Research Proposals

No new research proposals were presented to the Working Group. However, the Working Group did recommend that each restoration program investigate application and retention of CWT in the adipose eye implant site and concurrently develop protocols to recover tags in manners compatible with present tagging and handling procedures.

6. HISTORICAL DATA (1980 - 1990)

6.1. Stocking

As shown in Table 9, nearly 38 million juvenile Atlantic salmon were released into New England rivers during the 11-year period. Nearly 50% of the releases was contributed by the stocking of salmon fry (unfed and fed). The remainder is fairly evenly split between smolt releases and parr releases.

6.2. Adult Returns

The documented returns of adult salmon to New England rivers for the 11-year period of 1980 - 1990 are presented in Table 10. Of the nearly 44000 adult salmon that have returned to New England during the period, the majority of returns (76%) has been contributed by the Penobscot River.

7. TERMS OF REFERENCE FOR 1993 MEETING

The U.S. Atlantic Salmon Assessment Committee agreed to address eight Terms of Reference for the 1993 meeting.

1. Program summaries for current year 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. Data needs for NASCO
   a. summary of status of stocks for NASCO
   b. summary of research for ANACAT

3. Historical data - validate 1991 stocking and return data and add to historic database.

4. Continue to synthesize available data and model fry survival rates.

5. Develop a methodology to confirm smolt status based on examination of selected characteristics in potential smolts and returning adults.

6. Continue to develop methodology to estimate homewater returns to U.S. rivers.

7. Retrospectfully examine river and near coastal environmental interactions in respect to movement of smolts and adults.

8. Conduct a survey of the literature and salmon researchers to determine whether the occurrence of late migrants (smolts) is widespread or is an artifact of hatchery practices.

8. U.S. ATLANTIC SALMON ASSESSMENT COMMITTEE PARTICIPANTS

Fred Trasko	Maine Atl. Sea-Run Sal.Comm.	Bangor, ME
Ken Beland	Maine Atl. Sea-Run Sal.Comm.	Bangor, ME
Henry Booke	U.S. Fish & Wildlife Ser.	Turners Falls, MA
Kevin Friedland	National Marine Fish. Ser.	Woods Hole, MA
Steve Gephard	Conn. Dep/Marine Fish.	Waterford, CT
Mark Gibson	RI Div. of Fish & Wildlife	W.Kingston, RI
Jon Greenwood	NH Fish and Game Department	Concord, NH
Rusty Iwanowicz	MA Div. of Marine Fisheries	Salem, MA
Jerry Marancik	U.S. Fish & Wildlife Ser.	E. Orland, ME
Joe McKeon	U.S. Fish & Wildlife Ser.	Laconia, NH
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Ted Meyers	U.S. Fish & Wildlife Ser.	Turners Falls, MA
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Paul Rago	U.S. Fish & Wildlife Ser.	Kearneysville, WV
Steve Roy	Green Mt. Nat. Forest	Rutland, VT
Larry Stolte, Chairman	U.S. Fish and Wildlife Ser.	Concord, NH

9. PAPERS SUBMITTED

Baum, E.T. General Program Update - Maine.

Baum, E.T. Atlantic Salmon Returns to Maine Rivers in 1991.

Beland, K. Narraguagus River Research Program.

Booke, H.E. Research On Atlantic Salmon in New England--1991.

Gephard, S. Emigration of Atlantic Salmon Smolts in West Branch Fawn Brook, Connecticut.

Gibson, M. Analysis of Fry Stocking Results in New England Salmon Restoration: Effect of Stocking Density and Environment on Survival.

Gibson, M. The Influence of Body Size on Smoltification Rates and Marine Survival in New England Salmon Rivers.

McKeon, Joseph. A Pilot Study to Estimate the Number of Atlantic Salmon Smolts Migrating from Merrimack River Headwater Areas.

Segarich, Victor. Preliminary Evaluation of a Non-Lethal Method for Recovering Coded Wire Tags from Adult Atlantic Salmon Broodstock.

Sousa, Robert. An Interim Report, Mortality of Connecticut River Atlantic Salmon - Is it Occurring in the Ocean?

Stolte, L. Evidence that the Atlantic Salmon Runs to the Merrimack River have been Larger than the Documented Records.

Trasko, F. Assessment of Feeding Fry Stocking Densities as they Relate to Survival and Growth in two Maine Streams.

10. LITERATURE CITED

There were no literature citations within Sections 1,2,3, or 4.

11. APPENDICES

11.1. Terms of Reference for 1992 Meeting

1. Program summaries for current year 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. Data needs for NASCO
   a. summary of status of stocks for NASCO

   b. summary of research for ANACAT

3. Historical data - validate 1990 stocking and return data and add to historic database.

4. Synthesize available data and model fry survival rates.

5. Develop a methodology to identify stocked hatchery smolts based upon minimum length criteria; e.g. compute an annual index of smolt survival probability based upon the length frequency distribution and associated survival rates.

6. Develop methodology to estimate homewater returns to U.S. rivers.

11.2. Tables and Figures Supporting the Document

TABLE 1. ATLANTIC SALMON STOCKING SUMMARY FOR NEW ENGLAND IN 1991 BY RIVER SYSTEM AND BY PROGRAM. 1)

RIVER SYSTEM	NUMBER OF FISH 2)						TOTAL
	FRY	0+PARR	1PARR	1+PARR	1SMOLT	2SMOLT	
St. John (USA)							
Aroostook	74000	46600	0	0	0	0	120600
St. Croix	51000	40000	0	0	60200	0	151200
Dennys	25000	0	400	0	11700	0	37100
Pleasant	23000	0	0	0	0	0	23000
East Machias	27000	0	8300	0	15300	0	50600
Machias	13000	30000	21400	0	21100	0	85500
Narraguagus	0	0	0	0	15200	0	15200
Union	0	0	0	0	0	0	0
Penobscot	398000	202600	104100	0	657800	15000	1377500
Ducktrap	0	0	0	0	0	0	0
Sheepscot	18000	15000	600	0	14400	0	48000
Saco	111000	0	0	0	10300	0	121300
Merrimack	1475000	0	0	0	65200	58100	1598300
Pawcatuck	0	101000	1000	0	2000	500	104500
Connecticut	1735000	294200	33100	0	350200	800	2413300
TOTAL	3950000	729400	168900	0	1223400	74400	6146100
St. John (CANADA)							
Upper St. John	227500	139300	0	0	5100	5100	377000
Aroostook	0	0	0	0	0	9600	9600
TOTAL	227500	139300	0	0	5100	14700	386600
PROGRAM							
Maine							
USA	740000	334200	134800	0	806000	15000	2030000
CANADA	227500	139300	0	0	5100	14700	386600
Merrimack River	1475000	0	0	0	65200	58100	1598300
Pawcatuck River	0	101000	1000	0	2000	500	104500
Connecticut River	1735000	294200	33100	0	350200	800	2413300
TOTAL	4177500	868700	168900	0	1228500	89100	6532700

1) The distinction between USA and Canadian stocking of the St. John River Basin is based on the sources of the fish. Fish received from hatcheries located in Canada are reported as Canada and hatcheries located in the U.S. are reported as USA.

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

TABLE 2. SUMMARY OF JUVENILE ATLANTIC SALMON MARKING PROGRAMS FOR NEW ENGLAND IN 1991. 1)

PROGRAM	NO. CODED WIRE TAGS 2)		NO. CARLIN TAGS		NO. FIN CLIPS ONLY	
	PARR	SMOLTS	PARR	SMOLTS	PARR	SMOLTS
Maine Program	800	197400	0	49800	0	85800
Merrimack River	0	123300	0	0	0	0
Pawcatuck River	0	0	0	0	0	0
Connecticut River	29700	115400	0	0	0	0
TOTAL	30500	436100	0	49800	0	85800

1) All numbers rounded to nearest 100 fish.

2) All fish marked with coded wire tags were also given adipose fin clips and some parr were given adipose and ventral fin clips.

TABLE 3. ATLANTIC SALMON MARKING DATABASE FOR NEW ENGLAND – 1991.

MARKING AGENCY	AGE	LIFE STAG	H/W	STOCK ORIGIN	TAG TYPE	NUMBER MARKED	CODE OR SERIAL	AUX CLIP	REL DATE	PLACE OF RELEASE	COMMENT
USFWS	1	smolt	H	Connecticut	CWT	9000	7/18/58	AD	4/91	Connecticut R.	
USFWS	1	smolt	H	Connecticut	CWT	5100	7/18/59	AD	4/91	Connecticut R.	
USFWS	1	smolt	H	Connecticut	CWT	9200	7/18/45	AD	4/91	Connecticut R.	
USFWS	1	smolt	H	Connecticut	CWT	12500	7/18/46	AD	4/91	Connecticut R.	
USFWS	1	smolt	H	Connecticut	CWT	14500	7/18/31	AD	4/91	Connecticut R.	
USFWS	1	smolt	H	Connecticut	CWT	12500	7/18/32	AD	4/91	Connecticut R.	
USFWS	1	smolt	H	Connecticut	CWT	19100	7/18/55	AD	4/91	Connecticut R.	
USFWS	1	smolt	H	Connecticut	CWT	2600	7/18/56	AD	4/91	Connecticut R.	
USFWS	1	smolt	H	Connecticut	CWT	20800	7/18/56	AD	5/91	Connecticut R.	
USFWS	1	smolt	H	Connecticut	CWT	7000	7/18/28	AD	5/91	Connecticut R.	
USFWS	1	smolt	H	Connecticut	CWT	1800	7/18/45	AD	5/91	Narragansett Bay	
USFWS	1	smolt	H	Connecticut	CWT	1300	7/18/46	AD	5/91	Narragansett Bay	
SUBTOTAL (SMOLT)						115400					
USFWS	1	parr	H	Connecticut	CWT	10200	7/18/58	AD	4/91	Connecticut R.	
USFWS	1	parr	H	Connecticut	CWT	13800	7/18/59	AD	4/91	Connecticut R.	
USFWS	1	parr	H	Connecticut	CWT	100	7/18/45	AD	4/91	Connecticut R.	
USFWS	1	parr	H	Connecticut	CWT	200	7/18/46	AD	4/91	Connecticut R.	
USFWS	1	parr	H	Connecticut	CWT	300	7/18/31	AD	4/91	Connecticut R.	
USFWS	1	parr	H	Connecticut	CWT	200	7/18/32	AD	4/91	Connecticut R.	
USFWS	1	parr	H	Connecticut	CWT	4300	7/18/55	AD	4/91	Connecticut R.	
USFWS	1	parr	H	Connecticut	CWT	500	7/18/56	AD	4/91	Connecticut R.	
USFWS	1	parr	H	Connecticut	CWT	100	7/18/56	AD	5/91	Connecticut R.	
SUBTOTAL (PARR)						29700					
TOTAL – CWT'S, CONNECTICUT RIVER						145100					
CT DEP	4	adult	H	Connecticut	Floy	299	3100		11/90	Connecticut R.	Color=Pink
							3500				
TOTAL – FLOY TAGS CONNECTICUT RIVER						299					
USFWS	1	smolt	H	Merrimack	CWT	11000	7/18/57	AD	4/91	Merrimack R.	
USFWS	1	smolt	H	Merrimack	CWT	6200	7/18/60	AD	4/91	Merrimack R.	
USFWS	1	smolt	H	Merrimack	CWT	9000	7/18/61	AD	4/91	Merrimack R.	
USFWS	1	smolt	H	Merrimack	CWT	2000	7/18/57	AD	4/91	Merrimack R.	
							7/18/60				
USFWS	1	smolt	H	Merrimack	CWT	33000	7/18/57	AD	4/91	Merrimack R.	
							7/18/60				
							7/18/61				
USFWS	1	smolt	H	Merrimack	CWT	4000	7/18/61	AD	5/91	Merrimack R.	
USFWS	2	smolt	H	Merrimack	CWT	400	7/18/1	AD	4/91	Merrimack R.	
USFWS	2	smolt	H	Merrimack	CWT	6100	7/18/2	AD	4/91	Merrimack R.	
USFWS	2	smolt	H	Merrimack	CWT	12900	7/18/3	AD	4/91	Merrimack R.	
USFWS	2	smolt	H	Merrimack	CWT	5400	7/18/4	AD	4/91	Merrimack R.	
USFWS	2	smolt	H	Merrimack	CWT	5500	7/18/1	AD	4/91	Merrimack R.	
							7/18/2				
							7/18/3				
USFWS	2	smolt	H	Merrimack	CWT	5500	7/18/4	AD	4/91	Merrimack R.	
							7/18/5				

TABLE 3. ATLANTIC SALMON MARKING DATABASE FOR NEW ENGLAND - 1991.

MARKING AGENCY	AGE	LIFE STAG	H/W	STOCK ORIGIN	TAG TYPE	NUMBER MARKED	CODE OR SERIAL	AUX CLIP	REL DATE	PLACE OF RELEASE	COMMENT
USFWS	2	smolt	H	Merrimack	CWT	5600	7/18/4	AD	4/91	Merrimack R.	
							7/18/5				
							7/18/6				
USFWS	2	smolt	H	Merrimack	CWT	5400	7/18/3	AD	4/91	Merrimack R.	
							7/18/5				
							7/18/6				
USFWS	2	smolt	H	Merrimack	CWT	1000	7/18/6	AD	4/91	Merrimack R.	
							7/18/7				
USFWS	2	smolt	H	Merrimack	CWT	10300	7/18/5	AD	4/91	Merrimack R.	
							7/18/6				
SUBTOTAL (SMOLT)						123300					
TOTAL - CWT'S, MERRIMACK RIVER						123300					
USFWS	1	smolt	H	Penobscot	CWT	25234	7/18/47	AD	4/91	Penobscot R.	
USFWS	1	smolt	H	Penobscot	CWT	24369	7/18/48	AD	4/91	Penobscot R.	
USFWS	1	smolt	H	Penobscot	CWT	25190	7/18/49	AD	4/91	Penobscot R.	
USFWS	1	smolt	H	Penobscot	CWT	16625	7/18/50	AD	4/91	Penobscot R.	
USFWS	1	smolt	H	Penobscot	CWT	23600	7/18/51	AD	4/91	Penobscot R.	
USFWS	1	smolt	H	Penobscot	CWT	24900	7/18/53	AD	4/91	Penobscot R.	
USFWS	1	smolt	H	Penobscot	CWT	23618	7/18/54	AD	4/91	Penobscot R.	
USFWS	1	smolt	H	Penobscot	CWT	8500	7/18/50	AD	5/91	Penobscot R.	
USFWS	1	smolt	H	Penobscot	CWT	25345	7/18/52	AD	5/91	Penobscot R.	
TOTAL - CWT'S, PENOBSCOT RIVER						197381					
ASRSC	1	parr	W	Narraguagus	CWT	not	not	AD	not	Narraguagus R.	
ASRSC	2	parr	W	Narraguagus	CWT	avail.	avail.	AD	avail.	Narraguagus R.	
TOTAL - CWT'S, NARRAGUAGUS RIVER						800					
DFO	2	smolt	H	St. John	CWT	5110	62/1/31	AD	4/91	Upper St. John R.	
DFO	1	smolt	H	St. John	CWT	5068	62/1/42	AD	4/91	Upper St. John R.	
DFO	2	smolt	H	St. John	CWT	5061	62/1/35	AD	4/91	Aroostook R.	
DFO	2	smolt	H	St. John	CWT	4525	62/1/37	AD	4/91	Aroostook R.	
TOTAL - CWT'S, ST. JOHN RIVER						19764					
USFWS	1	smolt	H	Penobscot	Carlin	24774	800001		4/91	Penobscot R.	
							824999				
USFWS	1	smolt	H	Penobscot	Carlin	24980	825000		4/91	Penobscot R.	
							849999				
TOTAL - CARLIN TAGS PENOBSCOT RIVER						49754					

TABLE 3. ATLANTIC SALMON MARKING DATABASE FOR NEW ENGLAND - 1991.

MARKING AGENCY	AGE	LIFE STAG	H/W	STOCK ORIGIN	TAG TYPE	NUMBER MARKED	CODE OR SERIAL	AUX CLIP	REL DATE	PLACE OF RELEASE	COMMENT
ASRSC	All	adult		Penobscot	Floy	371	1784-2278		6/91	Penobscot R.	Yellow
ASRSC	All	adult	W	Narraguagus	Streamer	39	2001-2063		6/91	Narraguagus R.	Orange
ASRSC	All	adult	W	Narraguagus	Streamer	2	1-4		10/91	Narraguagus R.	Green
ASRSC	All	adult	H	Penobscot	Streamer	21	2001-3951		6/91	Narraguagus R.	Blue
TOTAL - FLOY & STREAMERS						433					
USFWS	1	smolt	H	Penobscot		10320		RV	4/91	Saco R.	
USFWS	1	smolt	H	Penobscot		60215		RV	5/91	St. Croix R.	
USFWS	1	smolt	H	Penobscot		15225		RV	5/91	Narraguagus R.	
TOTAL - FIN CLIPS						85760					

TABLE 4. DOCUMENTED ATLANTIC SALMON RETURNS TO NEW ENGLAND RIVERS IN 1991. 1)

RIVER	NUMBER OF ATLANTIC SALMON BY SEA AGE 1SW	2SW	3SW	RS	TOTAL FOR 1991	TOTAL FOR 1990
Penobscot River	216	1512	4	25	1757	3341
Aroostook River	37	2	0	0	39	
Union River	2	6	0	0	8	21
Narraguagus River 2)	11	72	0	12	95	51
Pleasant River 3)						
Machias River 4)	4	12	0	0	16	2
East Machias River	2	3	0	0	5	48
Dennys River	1	6	0	0	7	33
St. Croix River	57	128	0	4	189	112
Kennebec River	0	4	0	0	4	46
Androscoggin River	0	21	0	0	21	185
Sheepscot River	0	4	0	0	4	9
Ducktrap River 3)					0	2
Saco River	0	4	0	0	4	73
Merrimack River	1	330	0	1	332	248
Pawcatuck River	0	5	0	0	5	8
Connecticut River	0	202	1	0	203	263
TOTAL	331	2311	5	42	2689	4442

1) These are considered minimum numbers; reflecting only trap counts and rod catches.

2) Rod and trap catches in 1991 (rod only in 1990).

3) Unknown (no trapping facilities or no trap catch and no reported sport catch).

4) Includes 1SW (2) and 2SW (12) broodstock taken from redds in October.

TABLE 5. ESTIMATED TOTAL NUMBER OF ATLANTIC SALMON RETURNS TO THE RIVERS OF NEW ENGLAND IN 1991.

RIVERS WITH TRAPPING FACILTIES

RIVER	ROD CATCH REL.	ROD CATCH HARVEST 1)	ROD CATCH EST. TOTAL 2)	TRAP CATCH TOTAL	TRAP CATCH ADJ. TOTAL 3)	GRAND TOTAL
Aroostook	0	0	0	39	44	44
St. Croix	1	2	2	187	249	251
Union	0	0	0	8	16	16
Narraguagus	6	21	27	74	148	175
Penobscot	230	181	249	1576	2101	2350
Androscoggin	0	0	0	21	23	23
Saco	0	0	0	4	8	8
Merrimack	0	3	33	327	363	396
Pawcatuck	0	0	1	5	6	7
Connecticut	0	0	20	196	218	238
SUB-TOTAL	237	207	332	1909	2589	3508

RIVERS WITHOUT COUNTING FACILITIES

RIVER	ROD CATCH REL.	ROD CATCH HARVEST 1)	ROD CATCH EST. TOTAL 2)	REDD COUNT	NO. OF SPAWNERS		
Dennys	2	7	9	81	82	91	
East Machias	0	5	6			38	4)
Machias	0	2	2	118	118	120	
Pleasant				44	44	44	
Ducktrap				37	38	38	
Sheepscot	0	4	5			31	4)
Kennebec	0	4	5			16	5)
SUB-TOTAL	2	22	27			378	
GRAND TOTAL	239	229	359			3886	

1) Rod kill below lowest trapping facility.

2) Assume 100% reporting rate for sport fish and 10% delayed mortality for released fish except in the case of the Merrimack, Pawcatuck, and Connecticut rivers where the estimated harvest represents 10% of trap counts.

3) Assumed fish passage efficiencies of: 90% for Androscoggin, Aroostook, Merrimack, Pawcatuck, and Connecticut Rivers, 75% for Penobscot and St. Croix Rivers, and 50% for Narraguagus, Union, and Saco.

4) Estimated run size computed using ICES method from rod catch (80% reporting rate and 20% exploitation rate).

5) Estimated run size computed using ICES method from rod catch (80% reporting rate and 40% exploitation rate).

TABLE 6. SUMMARY OF 1991 CODED WIRE TAGGED (CWT) AND CARLIN TAGGED ADULT ATLANTIC SALMON RETURNS TO USA RIVERS.

RIVER	TAG TYPE	AGE GROUP 1SW	2SW	3SW	RS	TOTAL
Connecticut River						
Trap	CWT	0	153	1	0	154
Merrimack River						
Trap	CWT	0	69	0	0	69
Rod	CWT	0	1	0	0	1
Penobscot River 1)						
Trap	CWT	55	334	1	1	391
Rod	CWT	0	6	0	0	6
Trap	Carlin	3	21	0	0	24
Rod	Carlin	0	3	0	0	3
Other Rivers in Maine 1)						
Trap	CWT	0	3	0	0	3
Rod	CWT	0	2	0	0	2
TOTAL	CWT	55	568	2	1	626
	Carlin	3	24	0	0	27

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

TABLE 7. 1991 SUMMARY OF ATLANTIC SALMON EGG PRODUCTION IN NEW ENGLAND FACILITIES.

SOURCE RIVER	ORIGIN	NO. OF FEMALES	TOTAL EGG TAKE	NO. OF EGGS PER FEMALE
Penobscot River	Sea-run	340	2448000	7200
Machias River 1)	Sea-run	4	15900	3975
Penobscot Female X Machias Male	Sea-run	16	113800	7113
Merrimack River	Sea-run	168	1244000	7405
Pawcatuck River	Sea-run	2	14500	7250
Connecticut River	Sea-run	79	651000	8241
TOTAL SEA-RUN		609	4487200	7368
Penobscot River	Domestic	705	1648200	2338
Merrimack River	Domestic	1297	5170000	3986
Connecticut River	Domestic	637	3455500	5425
TOTAL DOMESTIC		3248	10273700	3163
Connecticut River	Kelts	52	486100	9348
TOTAL KELTS		52	486100	9348
GRAND TOTAL		3909	15247000	3900

1) Machias River females – 2 partially spawned (plus or minus 1,000 eggs/female)
2 produced plus or minus 14,000 eggs (plus or minus 7,000 eggs/female)

TABLE 8. DOCUMENTED 1991 SPORT CATCH OF ATLANTIC SALMON IN MAINE.

RIVER	NO. SALMON HARVESTED 1SW	2SW	3SW	RS	TOTAL HARVEST	EST. NO. RELEASED	TOTAL ANGLED	TOTAL ANGLED 1990
St. Croix	2	0	0	0	2	1	3	6
Dennys	1	6	0	0	7	2	9	34
East Machias	2	3	0	0	5	0	5	83
Machias	2	0	0	0	2	0	2	2
Pleasant	Catch and Release				0	0	0	0
Narraguagus 1)	1	20	0	1	22	6	28	61
Union	0	0	0	0	0	0	0	0
Penobscot 1)	40	148	1	3	192	230	422	1091
Ducktrap	0	0	0	0	0	0	0	2
Sheepscot	0	4	0	0	4	0	4	9
Kennebec	0	4	0	0	4	0	4	106
Saco	0	0	0	0	0	0	0	19
Misc (Marine)	0	0	0	0	0	0	0	1
TOTAL	48	185	1	4	238	239	477	1414

1) The Penobscot (11 fish) and Narraguagus (1 fish) sport catches include salmon previously captured in fishway trapping facilities.

TABLE 9. ATLANTIC SALMON STOCKING SUMMARY FOR NEW ENGLAND BY PROGRAM 1980 THROUGH 1990

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

	NUMBER OF FISH						
YEAR / PROGRAM	FRY	0+PARR	1PARR	1+PARR	1SMOLT	2SMOLT	TOTAL
1980							
Maine	0	0	0	0	399900	282000	681900
Merrimack	126000	0	0	0	2300	30100	158400
Pawcatuck	0	1000	0	0	0	0	1000
Connecticut	286000	0	0	11500	0	51800	349300
TOTAL	412000	1000	0	11500	402200	363900	1190600
1981							
Maine	252000	0	70700	0	24700	232700	580100
Merrimack	57000	0	0	0	2600	97400	157000
Pawcatuck	0	2000	108000	0	800	0	110800
Connecticut	168000	182000	1900	3600	5300	73300	434100
TOTAL	477000	184000	180600	3600	33400	403400	1282000
1982							
Maine	349000	118900	256500	0	135000	259700	1119100
Merrimack	50000	57600	0	124200	0	67300	299100
Pawcatuck	2000	1000	0	0	0	0	3000
Connecticut	292000	9400	25100	9600	28100	180800	545000
TOTAL	693000	186900	281600	133800	163100	507800	1966200
1983							
Maine	20000	20300	57400	0	368000	170300	636000
Merrimack	8000	5000	0	20000	47000	61600	141600
Pawcatuck	0	700	0	0	0	0	700
Connecticut	226000	104400	293800	400	89100	8900	722600
TOTAL	254000	130400	351200	20400	504100	240800	1500900
1984							
Maine	134000	34400	22500	0	657700	137200	985800
Merrimack	519000	0	5300	24000	24000	44100	616400
Pawcatuck	0	23000	0	0	0	0	23000
Connecticut	625000	178600	241200	11400	312300	0	1368500
TOTAL	1278000	236000	269000	35400	994000	181300	2993700
1985							
Maine	472000	105900	61700	0	663200	108700	1411500
Merrimack	148000	0	0	5800	62500	111000	327300
Pawcatuck	8000	51000	1400	0	0	0	60400
Connecticut	422000	130500	110700	0	255000	0	918200
TOTAL	1050000	287400	173800	5800	980700	219700	2717400

YEAR / PROGRAM	NUMBER OF FISH						
	FRY	0+PARR	1PARR	1+PARR	1SMOLT	2SMOLT	TOTAL
1986							
Maine	576000	53500	70700	0	710700	69500	1480400
Merrimack	524000	0	31500	0	40100	64100	659700
Pawcatuck	0	50700	15000	0	0	0	65700
Connecticut	162000	188400	267100	0	290500	0	908000
TOTAL	1262000	292600	384300	0	1041300	133600	3113800
1987							
Maine	969000	117900	190900	0	637500	82800	1998100
Merrimack	1078000	0	111700	0	141100	0	1330800
Pawcatuck	3000	46200	4700	0	1000	0	54900
Connecticut	1101000	383200	345300	0	205800	0	2035300
TOTAL	3151000	547300	652600	0	985400	82800	5419100
1988							
Maine	858000	863700	102800	0	850900	87100	2762500
Merrimack	1718000	0	129300	0	90500	0	1937800
Pawcatuck	150000	59600	7100	0	5400	0	222100
Connecticut	1310000	72200	75200	0	395300	0	1852700
TOTAL	4036000	995500	314400	0	1342100	87100	6775100
1989							
Maine	580000	430500	282200	0	524300	80200	1897200
Merrimack	1033000	60000	88600	0	58200	0	1239800
Pawcatuck	0	379900	35800	0	6500	0	422200
Connecticut	1243000	282100	76800	0	217700	0	1819600
TOTAL	2856000	1152500	483400	0	806700	80200	5378800
1990							
Maine	910000	237800	250700	0	644100	33100	2075700
Merrimack	979000	0	5600	29700	117000	0	1131300
Pawcatuck	0	83500	55000	0	7500	0	146000
Connecticut	1271000	341600	25400	0	475900	0	2113900
TOTAL	3160000	662900	336700	29700	1244500	33100	5466900
GRAND TOTAL	18629000	4676500	3427600	240200	8497500	2333700	37804500

TABLE 10. HISTORICAL ATLANTIC SALMON RETURNS TO NEW ENGLAND RIVERS 1980 THROUGH 1990 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

STREAM 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									
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	2531	14	27	93	255	3	3	3356
TOTAL	5653	25496	119	321	278	1367	21	46	33301
UNION									
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
TOTAL	144	1023	5	11	0	6	0	0	1189
NARRAGUAGUS									
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
TOTAL	8	130	0	2	5	524	0	23	692

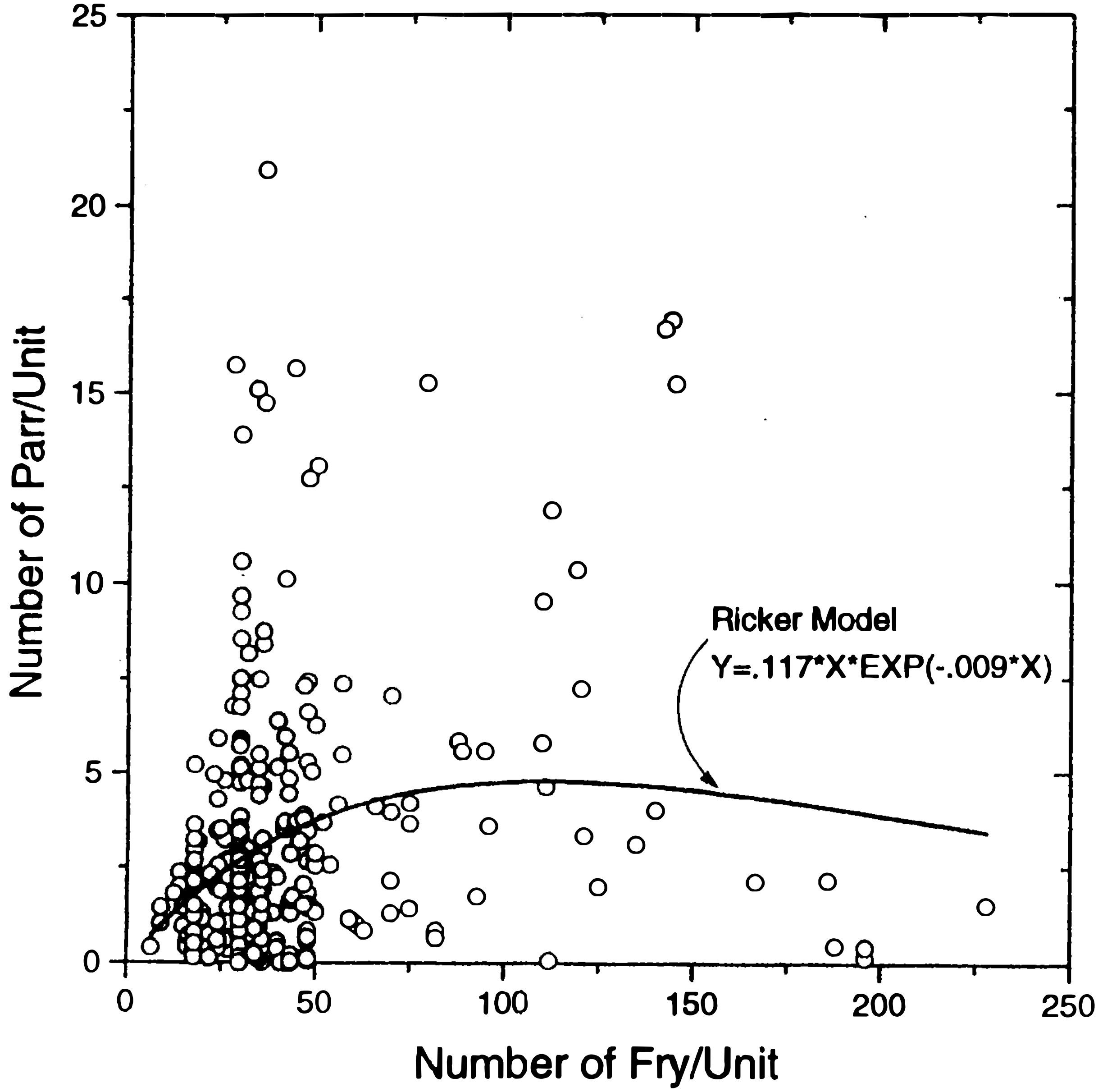
STREAM SYSTEM / YEAR	HATCHERY ORIGIN				WILD ORIGIN				TOTAL
	1-S-W	2-S-W	3-S-W	REPEAT	1-S-W	2-S-W	3-S-W	REPEAT	TOTAL
PLEASANT									
1980	0	0	0	0	0	5	0	0	5
1981	0	0	0	0	0	23	0	0	23
1982	4	8	0	0	0	6	0	1	19
1983	0	0	0	0	2	35	0	1	38
1984	0	0	0	0	1	16	0	0	17
1985	0	0	0	0	3	28	0	0	31
1986	0	0	0	0	0	19	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
TOTAL	4	12	0	0	6	137	0	2	161
MACHIAS									
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
TOTAL	5	66	1	0	9	243	0	21	345
EAST MACHIAS									
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
TOTAL	18	179	0	0	11	188	1	7	404
DENNYS									
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
TOTAL	11	252	0	1	13	260	3	0	540

STREAM 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
ST. CROIX									
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
TOTAL	535	804	38	11	359	538	39	11	2335
KENNEBEC									
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
TOTAL	10	129	3	1	0	6	0	0	149
ANDROSCOGGIN									
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
TOTAL	17	401	5	1	2	31	0	1	458
SHEEPSCOT									
1980	0	0	0	0	2	27	1	0	30
1981	0	0	0	0	1	14	0	0	15
1982	0	0	0	0	1	14	0	0	15
1983	0	0	0	0	1	11	0	0	12
1984	0	0	0	0	1	20	1	0	22
1985	0	0	0	0	1	5	0	0	6
1986	0	0	0	0	1	10	0	0	11
1987	2	7	0	0	1	5	0	0	15
1988	1	0	0	0	0	0	0	0	1
1989	1	1	0	0	2	1	0	0	5
1990	1	8	0	0	0	0	0	0	9
TOTAL	5	16	0	0	11	107	2	0	141

STREAM 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
DUCKTRAP									
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	1	0	0	1
TOTAL	0	0	0	0	3	28	0	0	31
SACO									
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
TOTAL	13	249	2	1	0	2	0	0	267
MERRIMACK									
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
TOTAL	119	482	14	0	60	407	22	0	1104
PAWCATUCK									
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
TOTAL	1	122	1	0	0	0	0	0	124

STREAM 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
CONNECTICUT									
1980	0	175	0	0	0	0	0	0	175
1981	0	529	0	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
TOTAL	13	2153	5	0	3	173	6	0	2353
GRAND TOTAL	6556	31514	193	349	760	4017	94	111	43594

Figure 1. Age 1+ Parr Density in Fall versus Fry Stocking Density in New England



11.3. List of all Participants

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