U.S. ATLANTIC SALMON
ASSESSMENT COMMITTEE

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1. INTRODUCTION

1.1. EXECUTIVE SUMMARY

The 1994 Annual Meeting of the U.S. Atlantic Salmon Assessment Committee was held during January 24-28, 1994 at the Silvio Conte Anadromous Fish Research Center, Turners Falls, Massachusetts. The committee addressed terms of reference established at the 1993 meeting including routine assessments, such as program reviews and database development, and special topics.

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 9.8 million juvenile salmon (fry, parr, and smolts) were stocked. Of these, five (5) thousand parr and 682 thousand smolts carried coded-wire-tags (CWT) and 186 received Carlin tags. An additional 60 thousand smolts were released with fin-clips only.

A total of 2,602 salmon was documented to have returned to U.S. waters in 1993, of which nearly 90% (2,329) was counted in Maine rivers. Since many of Maine's rivers do not have counting facilities, and facilities that do operate throughout New England are not 100% effective, a system was implemented to estimate total adult returns in Maine and to New England rivers. The estimated returns using this method were 3,123 in Maine rivers and 3,433 in New England rivers. There were 421 fish with CWT (366 two-sea-winter (2SW) salmon) and 33 with Carlin tags (31 2SW salmon) which returned to U.S. rivers in 1992.

The angling catch in Maine waters reached 659 fish, which is an increase from the catch of 600 in 1992. Exploitation in the sport fishery on the Penobscot River was 7.0% in 1993.

Atlantic salmon egg production for the New England program was a record, approaching 21 million (3.4 million sea-run, nearly 16 million captive/domestic, and 1.7 million reconditioned kelts). The egg production was still less than the desired number.

During the meeting three tables (2.2.1.a., 2.2.1.b., and 2.2.3.a.) were restructured in order to provide more useful information. A reordering of Section 2 of the document was recommended for future reports. The reordering will provide a more logical sequence of the sub-sections and will allow for easier program comparisons.

An overview of downstream fish passage as related to the Atlantic salmon was provided to the working group by John Warner (U.S. Fish and Wildlife Service (USFWS), Ecological Services, Concord, NH). Mr. Warner indicated that a great deal of work remains to be done on the mainstems of the major rivers. Significant progress has been made on a number of important tributaries.

As a special topic, Paul Nickerson (USFWS) and Doug Beach of the National Marine Fisheries Service (NMFS) led a discussion related to the potential listing of the Atlantic salmon as an endangered species. A great deal of feedback was provided to Mr. Nickerson and Mr. Beach by the committee and the biologists from the Pacific Northwest. Following the discussion the U.S. Atlantic Salmon Assessment Committee recommended that the reviewing agencies seek the following information to assist with their decision:

1. Determination of genetic uniqueness of populations.

2. River-specific salmon stock information, including historic spawning run disruptions, stock origin, and current management regimes.

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

Although the meeting was somewhat smoother than in the past, there still remain problems in obtaining the information necessary for the development of the Status Of Program section of the document prior to the meeting. This problem will likely be eliminated for the 1995 meeting because of the change in meeting date. The U.S. Atlantic Assessment Committee agreed to meet in working group format for their seventh annual meeting from February 6 - 10, 1995. The tentative location will remain the same (the Silvio Conte Anadromous Fish Research Center).

The participation of Travis Coley, Tim Roth, Dell Simmons (USFWS - state of Washington) and Billy Connor (USFWS - Idaho) in the meeting as working guests was greatly appreciated by me and the entire Working Group. I believe the entire group benefited. This kind of exchange will be requested for the 1995 meeting.

The committee continued to evolve as documented by the Terms of Reference established for the 1995 meeting. The 1995 meeting will truly be a working meeting with a number of analyses performed during the session.

I and the entire committee thank those individuals at the Silvio Conte Anadromous Fish Research Center who provided the necessary support to the working group during the meeting. In addition, I want to thank Dave Egan and the Connecticut River Atlantic Salmon Association for agreeing to support several members of the working group in relation to lodging/meals.

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

2. STATUS OF PROGRAM

2.1. STOCKING

2.1.1. <u>TOTAL RELEASES</u>

During 1993 the participating resource agencies released approximately 9.8 million juvenile Atlantic salmon into eleven rivers (Table 2.1.1.a. in Appendix 11.2). Included within the table is the contribution of Canada to the release program.

The number of fish released was nearly a 25% increase from the total releases of 1992. This increase was the primary result of a major increase in the number of fry released (7.8 million in 1993 versus 5 million in 1992). The expansion of the fry stocking programs was most notable in the Connecticut River where an increase of over 100% occurred from the previous year (4.1 million in 1993 versus 2 million in 1992).

2.1.2. SUMMARY OF TAGGED AND MARKED FISH

Approximately 682,000 juvenile Atlantic salmon were marked prior to release (Table 2.1.2.a. in Appendix 11.2). Nearly 60% of all smolt (616,500) and five (5) percent (5,140) of all parr older than age 0+ were marked by removing the adipose fin (AD) and implanting CWT. Very few fish were marked by utlizing Carlin tags (186 smolts). The number of fish marked by fin removal only amounted to 60,200.

A more comprehensive look at the Atlantic salmon marking program is presented in Table 2.1.2.b. of Appendix 11.2. Information in this table also includes adult salmon releases marked with various external tags.

2.2. ADULT RETURNS

2.2.1. TOTAL DOCUMENTED RETURNS

Documented total adult salmon returns to rivers in New England amounted to 2,602 salmon (Table 2.2.1.a. in Appendix 11.2). This figure was considerably less than the number of fish recorded in 1992 (3,647). The majority of the returns were recorded in the rivers of Maine with the Penobscot River accounting for nearly 68% of the total New England returns. Rivers not in Maine accounted for only 10.5% of the total with the Connecticut River recording over 70% of the smaller contribution.

2.2.2. ESTIMATED TOTAL RETURNS

Many salmon rivers do not have trapping facilities and the existing fish passage and/or trapping facilities are not considered 100% effective in passing Atlantic salmon. As a result, the information contained in Table 2.2.1.a. (documented adult salmon returns) underestimate total salmon returns to New England.

The Assessment Committee made assumptions based on available data and adjusted the reported returns (Table 2.2.2.a. in Appendix 11.2). Using the adjustment estimators, the documented adult salmon returns were adjusted upward from 2,602 to 3,433. The adjusted returns are considerably less than those estimated for 1992 (3,433 in 1993 versus 5,039 in 1992).

ASSUMPTIONS AND ADJUSTMENT ESTIMATORS

On the Penobscot and St. Croix rivers, a fish passage efficiency of 75% was again used for salmon counts at the lowermost trapping facilities (Anon. 1993). On the Saco River, two new fish passage facilities became operational at the lowermost dam in June of 1993. No adjustment was made for the Saco River trap catch in 1993, although studies to determine the efficiency of those facilities will commence in 1994. A trap efficiency of 90% was again assumed for the Androscoggin River. No adjustment was made for the Aroostook River, due to the location of the trapping facility within the St John River drainage.

Redd counts were again available for several small rivers in Maine (incomplete in some), and data from the Narraguagus River supported the use of the rate of two redds per female used in previous years. A sex ratio of 1:1 was used for spawners, which approximates that observed at trapping facilities in Maine. A 10% mortality rate was again assumed for salmon caught and released in the Maine sport fishery, although there is no data to substantiate the assumption.

Available data for trap efficiencies and angler impacts on Atlantic salmon for southern New England rivers (Connecticut, Pawcatuck, and Merrimack) were reviewed in 1993. The review indicated that trap efficiency is site-specific and variable from year to year. Further, the data suggest that salmon of wild origin have higher rates of passage than hatchery fish. In the absence of detailed studies below individual traps, it appears that the 90% trap efficiency value used in last year's report is reasonable for southern New England rivers with mixed wild and hatchery runs. The 90% value was used again in 1993 and is recommended for use in future years, absent individual facility studies.

The harvest of rod caught salmon on southern New England rivers has been illegal since the early 1980s. Any salmon caught while angling for other species must be released by law. Because harvest is illegal, reports of rod kills are usually anecdotal, unless the angler mistakenly reports the fish as a trophy brown trout. Documented harvest of salmon on the Merrimack River has averaged only 1.1% of trap catch since retention of angled salmon was made illegal and has never exceeded 4% in any year (Stolte 1992). Only one rod-killed salmon was reported on the Merrimack in 1993 based on extensive contacts with bait shops, angling clubs, etc. (R. Iwanowicz, personal communication). Only one rod-killed salmon has been documented in the history of the Pawcatuck River program or 0.7% of trap catch (M. Gibson, personal communication). Documented harvest in the Connecticut River has been almost zero in recent years and never exceeded 4% of trap catch even when harvest was legal.

Reports are received annually of salmon released by anglers on the Connecticut River. Some anglers deliberately target salmon for catch-and-release on the Pawcatuck River (and probably elsewhere). However, most salmon hooked in southern New England rivers probably escape, especially in the mainstem Connecticut River shad fishery which uses light tackle. Most salmon landed are probably released due to angler peer pressure and enforcement efforts.

Available data on evidence of hooking (hook wounds, shad darts, flies, etc.) have been collected in salmon taken for broodstock at several locations. There is considerable annual variation in the hooking rate of salmon taken to Whittemore Salmon Station with a range of 4 to 23% and a total of 13% over seven years. Salmon at Cronin National Salmon Station have had a 7% incidence of hooking over the last two years. Broodstock trapped on the Merrimack River have averaged 4% incidence of hooking from 1983 to 1992.

Less than 10% of the trap catch in the Connecticut and Merrimack rivers has been hooked in recent years based on hook scar data. If a 10% post-hooking mortality rate is applied to both released salmon and those that break the line, less than 1% of the trap catch is killed due to angling that results in release or line breakage. Assuming documentation rates for harvested salmon are 25-50%, total angling mortality is, at most, 3-5%. Based on this analysis, a revised estimate of 3% of trap catch for total angling mortality (harvest plus post-release mortality) was used for 1993 estimates in southern New England rivers compared to a 10% value used for 1992 estimates.

In summary, available data suggest that the assumed 90% efficiency for salmon traps in southern New England is reasonable. Available data suggest the value of 10% of trap catch for angler harvest is too high. A revised estimate of 3% of trap catch for total angling mortality was used for the 1993 estimates and is recommended for use in future years for southern New England rivers until better data are available. It is recommended that creel surveys conducted for American shad should be modified to collect data on creeled and released salmon so more accurate estimates are available.

2.2.3. RETURNS OF TAGGED SALMON

Returns of CWT and Carlin-tagged Atlantic salmon to rivers in New England in 1993 are shown in Table 2.2.3.a. of Appendix 11.2. The information has been sorted by river of return and sea-age. A total of 421 salmon (50 1SW, 366 2SW, 1 3SW, and 4 RS) having CWT returned to the rivers of New England. Adult salmon having Carlin tags totalled 33 (2 1SW and 31 2SW).

During the previous Working Group meeting, the committee recommended that this section of the document be expanded to include more descriptive material. This recommendation was not met but will be carried forward to the meeting scheduled for February of 1995.

2.2.4. SPAWNING ESCAPEMENT, BROODSTOCK COLLECTION, AND EGG TAKE

Spawning escapement information, where available, can be found within Section 2.3. Although some adult salmon utilizing fish passage facilities in the Connecticut River basin were allowed to proceed upstream (not trapped for broodstock), no significant natural reproduction would be expected. All documented salmon returns to the Pawcatuck and Merrimack Rivers were trapped and collected as broodstock (a single rod-killed salmon was documented on the Merrimack River). Adult salmon returning to various rivers in Maine do contribute to natural reproduction. It is likely that the total documented spawning escapement (collectively) to the salmon rivers of Maine did not exceed 550 one-sea-winter (1SW) salmon, 2,000 2SW salmon, and 50 three-sea-winter (3SW) salmon and/or repeat spawners. These numbers would be far less than the numbers required for optimum seeding.

Egg sources for the New England Atlantic salmon culture programs included sea-run salmon, captive/domestic broodstock, and reconditioned kelts. A total of 434 sea-run females, 3,173 captive/domestic broodstock females, and 166 female kelts (164 reconditioned and 2 obtained from the Dennys River) contributed to the egg take. The number of females contributing (3,773) was significantly greater than in 1992 (2,589). This increase is attributed to an increase in the number of captive/domestic female broodstock produced for egg production. The captive/domestic broodstock production program is directed at meeting egg demands for an expected significant increase in salmon fry production for stocking purposes.

As a result of the large numbers of broodstock available in 1993, the largest egg take in the recent history of the New England Atlantic salmon program was realized with nearly 21 million eggs taken (Table 2.2.4.a. in Appendix 11.2). This egg take was nearly seven (7) million larger than the egg take in 1992. The number of eggs taken from sea-run salmon (3.3+ million) was down considerably from the past because of the depressed river returns. However, the egg take from reconditioned kelts was up by 0.6+ million from the take in 1992 and the contribution from captive/domestic broodstock was significantly up (roughly 8 million) from 1992.

2.2.5. SPORT FISHERY

The Maine rivers provide the only legal sport fishery for sea-run Atlantic salmon in New England. The documented sport catch of sea-run Atlantic salmon in Maine during 1993 was 659 fish (152 killed and 507 released) (Table 2.2.5.a. in Appendix 11.2). The sport catch represents an increase from that recorded in 1992 (659 in 1993 versus 600 in 1992). Interestingly the number of salmon caught and killed declined from the previous year while the number of salmon caught and released increased. As in the past, the sport catch on the Penobscot River represented the greatest share of the catch. The exploitation rate that occurred on the Penobscot River was roughly seven (7) percent, similar to the six (6) percent recorded in 1992.

2.3. GENERAL PROGRAM UPDATE

2.3.1. CONNECTICUT RIVER

General

The program continued to place primary emphasis on production of fry with the capability to stock all available habitat and on providing downstream fish passage. Major progress was made in these areas which should greatly increase wild smolt production and survival during outmigration.

Adult Returns

A total of 199 adult Atlantic salmon was documented as returning to the Connecticut River in 1993. Returning salmon were enumerated at Holyoke Dam on the mainstem (170), Rainbow Dam on the Farmington River (14), and below the West Springfield Project on the Westfield River (10). An additional five salmon were captured at miscellaneous locations below Holyoke Dam. The restoration of a salmon run to the Westfield River is part of recent efforts begun in 1989 with the release of salmon fry throughout its upper reaches; this is the second consecutive year salmon have returned to this river. Although a salmon trapping facility does not exist there, a fishway with a trap will be constructed by 1996. Salmon that were retained for broodstock (181) were transported to Richard Cronin National Salmon Station (RCNSS), operated by the USFWS, and Whittemore Salmon Station (WSS), operated by the Connecticut Department of Environmental Protection (CTDEP).

Upstream Releases

Seventeen adult salmon (10% of the 170 lifted over Holyoke Dam) were released and allowed to proceed upstream. One adult salmon escaped the trap at Rainbow Dam and continued upstream on the Farmington River. Eight of the 17 salmon released at Holyoke proceeded upstream past Turners Falls Dam, and seven of those eight continued passed Vernon Dam. One salmon was trapped at the newly constructed Townshend Dam (U.S. Army Corps of Engineers) fish trap on the West River, a tributary between Vernon Dam and Bellows Falls Dam.

Composition of Returns

Data for the 1993 salmon returns are based on a combination of scale readings and physical examination of each salmon. The sample size (184) was composed of 126 salmon (69%) of hatchery origin and 57 salmon (31%) of wild (fry-stocked) origin. All 126 salmon of hatchery origin were 2SW fish; seven of these fish had adipose fin clips and CWT. One salmon of wild origin returned as a 3SW fish; the rest were 2SW fish.

Some of the recovered salmon did not mature and spawn. Therefore, sex determination was limited to a sample size of 178 salmon, which exhibited a sex ratio of 2.1:1 (121 females : 57 males). The sex ratio was 2.0♀:1♂ for hatchery fish and 2.4♀:1♂ for wild fish.

Hatchery smolts stocked in 1991 returned at a rate of 0.4 per thousand. Wild smolts returned at an estimated rate of 0.6 per thousand based on a 1991 wild smolt run estimated using expanded electrofishing data. This estimate does not account for losses that occurred during downstream migration.

Hatchery Production And Incubation

An estimated 6.7 million eggs were taken in the basin in 1993 compared to 6.8 million in 1992 (Table 2.3.1.a. in Appendix 11.2.). Additional out-of-basin egg sources included contributions from Green Lake National Fish Hatchery (GLNFH) in ME and Nashua National

Fish Hatchery (NNFH) in NH (Table 2.3.1.a.). The gamete mixing protocol to enhance genetic diversity was continued with sperm transferred between various stations for fertilization.

Unusually late maturation of sea-run salmon at RCNSS almost resulted in inadequate numbers of pure sea-run eggs needed for the captive-domestic broodstock program at WSS. Sea-run salmon received an injection of carp pituitary extract that synchronized and advanced their maturation. Special spawning assistance was provided by the Northeast Fish Technology Center (USFWS).

The total estimated number of resultant incubating eggs was just over 9.7 million, a record for the program. However, current program goals call for 14 million eggs annually to meet fry stocking needs. Roxbury State Fish Hatchery (RSFH) in VT doubled its incubation capacity in 1993 to 450,000. An additional incubator in 1994 at Kensington State Salmon Hatchery (KSSH) in Connecticut will increase its incubation capacity by 150,000. Available to the program in the fall of 1994 is an additional 1.5 million capacity at Warren State Fish Hatchery (WSFH) in NH.

To ensure quality broodstock, a new egg banking protocol was initiated in 1993 to address fish health and genetic concerns. KSSH agreed to provide all broodstock stations within the program with parr to be used as future captive broodstock. The egg banking procedure involved incubating eggs from 50 RCNSS females, fertilized with milt from 39 RCNSS ripe males (50 males were desired, but only 39 were ripe). Fertilized eggs were placed in 10 hatching jars in a quarantined section of WSS. Ovarian fluid samples were taken and full fish health tests will be performed on all carcasses following spawning. All of the eggs in a hatching jar will be destroyed if any fish that contributed to that jar tests positive to a pathogen. As an additional safeguard, eggs from each jar will be sampled and tested for pathogens after the eggs are eyed; eggs from positive jars will be destroyed. All pathogen-free eyed eggs will then be sent to KSSH for hatching and rearing as future broodstock. This technique may be used annually to ensure all broodstock benefit from a larger and more varied number of parents trapped at different locations.

Stocking

A total of 4,146,800 fry were stocked into the Connecticut River basin. This was the largest number of fry stocked since the start of the program and more than twice the previous record of 2,009,000 in 1992. Connecticut River tributaries that were stocked for the first time were the Black and Williams rivers in VT, and the Sugar and Little Sugar rivers in NH. Program needs call for 9.1 million fry to be stocked on an annual basis to effectively use all available habitat in the Connecticut River basin.

A total of 237,000 O+Parr, a by-product of the 1Smolt program, were released in the fall. A total of 357,700 1Smolt and 3,330 1Parr, both with CWTs, were stocked in the spring. An additional 25,400 1Smolt and 25,400 1Parr, both without CWTs, were stocked in May as a result of the abandoned 2Smolt program at White River National Fish Hatchery (WRNFH). All but 21,900 smolts were stocked below the lowermost dams to avoid mortalities associated with hydropower facilities.

Program Changes

Data analysis indicated poor adult returns of smolts produced at KSSH. It was decided to terminate smolt production at that facility to meet an increased broodstock demand for fry stocking. The need for more fry also led to the establishment of a broodstock program at WRNFH in 1992, in addition to its existing 1Smolt program. Due to concern over the use of river water and the recurrence of furunculosis at WRNFH, the USFWS changed the mission at that station in late 1993. Since disease concerns could be addressed by maintaining either smolt production or broodstock/fry production, the change initially involved removal of multiple year classes of salmon (i.e., broodstock and 2Smolts). Based on analysis of past adult returns, it was determined that the broodstock/fry option could produce over three times the number of adults as the smolt option. Consideration of a USFWS budget shortfall indicated that substantial savings could be saved by supporting the CRASC recommendation of converting WRNFH to a broodstock/fry facility. A new captive-domestic broodstock population will be established in the summer of 1994. The 1994 smolt release from WRNFH and KSSH is anticipated to be the last hatchery smolt release for the program.

Fish Passage

Downstream fish passage operations in 1993 followed essentially the same schedule as in 1992 with the addition of 24-hour operation at some facilities. Several studies and construction projects related to downstream fish passage occurred in response to the Memoranda of Agreement (MOA) signed in 1990 with Northeast Utilities Service Company (NUSCO) and New England Power Company (NEPCO). These MOAs call for downstream fish passage at five mainstem hydroelectric projects by 1994. Progress at these facilities includes the following:

Holyoke Project

NUSCO contracted for physical modeling of an experimental bypass weir designed to improve the efficiency of existing bypasses. This weir will be tested at the Conte Anadromous Fish Research Center (CAFRC) operated by the National Biological Survey (NBS) in 1994. NUSCO proposes to install the new weir at the Hadley Falls Station in the spring of 1994. Logistic and maintenance problems led to the removal of the experimental floating guidewall which was only able to yield a 75% bypass efficiency for smolts at the Hadley Falls Station. The design of a non-floating guidewall should be completed in 1994 with construction possible as early as 1995. To help minimize smolt entrainment in 1994, NUSCO is installing an overlay at the trash racks in addition to the new bypass weir at the bascule gate. Construction of a plunge pool is being considered downstream of the bascule gate discharge site. A partial depth louver array and fish bypass system constructed in 1991 in the First Level Canal at Holyoke was evaluated for a second year. The 1993 study results indicate a mean smolt bypass efficiency of 86%, slightly less than the 91% smolt bypass efficiency achieved in 1992.

Turners Falls Project

NUSCO is exploring the possibility of installing the above-mentioned experimental weir at Cabot Station. Structural modifications at the existing trash rack will entail an overlay with reduced bar spacing to reduce turbine entrainment. Once these modifications are in place, a two-year evaluation will be conducted.

Northfield Project

An additional major downstream issue with NUSCO involves Northfield Mountain Pumped Storage Facility (NMPSF). Previous NUSCO radiotelemetry studies estimated 30 to 50% of the smolts passing the facility were entrained during its pumping cycle. Using mark and recapture techniques, NUSCO estimated the wild smolt population at the Turners Falls Project to be 19,851 ± 4,900. Based on 1993 studies using an entrainment net in the upper reservoir, NUSCO estimated that 2,000 wild and 1,000 hatchery smolts were entrained by the facility. Some smolts were missed during a downtime when the entrainment net was inoperable. Based on estimates from NUSCO, approximately 10% of the smolts attempting to migrate downstream past the plant were entrained and lost from the population. Additional studies will be implemented in 1994 including the use of underwater strobe lights to repel smolts.

Vernon and Bellows Falls Projects

NEPCO began construction of a partial depth louver curtain wall in late 1993 to guide smolts to a fish bypass conduit entrance located between two turbine intakes. A new bypass is also under construction on the west side of the powerhouse. At Bellows Falls Dam (NEPCO), construction was started on an angled curtain wall in the forebay above the power station. The wall will guide fish across the power canal to an existing sluiceway. Vernon should have operational downstream guidance for the spring of 1994 and will be evaluated for two years. The curtain wall at Bellows Falls will be partially constructed by the spring of 1994 and formal evaluation will commence upon its completion.

Wilder Project

NEPCO attempted to confirm the 90% bypass efficiency achieved with a controlled spill at the existing trash sluice using hatchery smolts in 1992 with a similar study using wild smolts in 1993. Initial results show only a 50% efficiency with wild smolts, but it is suspected that significant losses associated with handling contributed to the observed differences. Additional studies are being considered for 1994.

Other Projects

Several other facilities made progress towards fish passage in 1993. The Stanley Works built a downstream smolt bypass facility at Rainbow Dam on the Farmington River. The existing trash sluice was modified with the addition of a bypass pipe and will be operational in 1994. The U.S. Army Corps of Engineers began operation of a new trap and truck facility for upstream passage at the Townshend Dam on the West River. Construction of an angled bar rack and bypass pipe at Crescent Dam on the Westfield River began in the fall of 1993. The facility is expected to be operational by spring 1994. As part of the Federal Energy Regulatory Commission (FERC) relicensing process at the Decorative Specialists, Inc. Dam on the Westfield River (West Springfield Project in MA), the company has proposed an interim spill until permanent facilities are installed. Plans call for permanent upstream and downstream facilities to be operational by spring of 1996.

Downstream passage is being addressed for the Sugar, Williams, and Black Rivers due to expanded fry stocking starting in 1993. The USFWS Ecological Services has notified project developers and the FERC of the need for passage facilities by 1995. Additional relicensing efforts are in process on the Deerfield (MA), Westfield (MA), Passumpsic (VT), and Black (VT) rivers.

Genetics

Tissue samples from the Connecticut River population of Atlantic salmon have been collected for the past four years. Electrophoretic analysis of these samples in early 1994 will be used to determine the genetic variation existing in the current population and results will be compared to a similar study conducted several years earlier. Results that are ambiguous could be subjected to further analysis using mitochondrial DNA. Results of this study will be used to manage the genetic resources of the Connecticut River.

Management Evaluation and Research

- Habitat inventory surveys were conducted by personnel from the White Mountain National Forest (WMNF) and Green Mountain National Forest (GMNF), U.S. Forest Service (USFS), Vermont Department of Fish and Wildlife (VTFW), New Hampshire Fish and Game Department (NHFG), and the Massachusetts Cooperative Fish and Wildlife Research Unit (MACFWRU). Habitat and water temperature monitoring were also conducted by GMNF for salmon index streams in the forest. Micro-habitat studies were continued by the Vermont Cooperative Fish and Wildlife Research Unit and Dartmouth College.

- Electrofishing surveys were conducted at index monitoring sites by WMNF, GMNF, VTFW, NHFG, CTDEP, MACFWRU, and USFWS to determine fry growth and survival rates, salmon parr densities, and estimates of potential smolt production. These estimates were expanded to produce a basin-wide smolt population estimate, taking into account over-wintering mortality. Based on this expansion, approximately 108,000 smolts were produced above Turners Falls Dam as compared to the NUSCO estimate of approximately 20,000 reaching the dam. While both estimates are somewhat uncertain, the discrepancy between the two seems to indicate significant losses occur during downstream migration. This is especially critical in low flow years as in 1993.

- GMNF staff conducted spring smolt migration studies in four streams in the West and White River systems and fall pre-smolt and parr migration studies in two West River tributaries.

- Habitat restoration projects were completed in the Ammonoosuc, White, and West River systems by GMNF and WMNF staff. Evaluations will continue in 1994.

- The study of the impact of time of release and photoperiod advancement of hatchery smolts continued as coordinated by the CRASC Salmon Studies Workgroup.

- Plans were announced to establish a new fisheries unit in the Northeastern Forest Experiment Station to conduct research essential to the success of the restoration effort.

- Salmon smolts were stocked into a net pen moored at the mouth of the Connecticut River to see if return rates could be enhanced by allowing smolts to recover from stocking stress and exposure to salinity before their release. Physiological results from the CAFRC showed recovery from stress and enhanced smoltification.

- The 2Smolt study program at WRNFH was termintated due to fish health management concerns.

- MACFWRU initiated studies to estimate the impact of piscivores on the survival and distribution of juvenile anadromous fish in the lower Connecticut River. Plans are underway to investigate factors influencing smolt production, overwinter mortality, and downstream migration of Atlantic salmon in the West River.

- The Fish Health Unit (USFWS) continued its studies on the use of oxolinic acid and furunculosis/enteric redmouth vaccine in sea-run broodstock. No incidents of disease attributed to bacterial pathogens occurred in the treated broodstock but all controls became diseased and died.

- The Northeast Fishery Center (USFWS) initiated proposals for testing the efficacy of dietary immunoenhancers to control bacterial furunculosis in fingerling Atlantic salmon and for comparing survival of eggs transported by various methods in order to recommend transport procedures to the CRASC Technical Committee. Studies initiated in 1992 at RCNSS determined that sperm:egg ratios and sperm extender solutions do not cause a decrease in eye-up. It was also determined that LHRHa implanted into the dorsal sinus of male Atlantic salmon tripled milt volume but did not influence egg survival.

- Work continued on the updating of the 1982 Strategic Plan. A working draft was produced by late 1993. Publication is expected in early 1994.

2.3.2. MAINE PROGRAM

General

Additional progress was made in 1993 in implementing the "Prelisting Recovery Plan for Maine Wild Atlantic Salmon Populations". Small numbers of adult broodstock were collected from the Dennys and Machias rivers, and more than 900 parr were collected from the 7 rivers involved. The parr will be utilized for ongoing genetics studies and/or reared to maturity in captivity to provide river-specific eggs for for future fry stocking efforts.

The Maine Atlantic Sea Run Salmon Commission (ASRSC) adopted a grilse-only regulation in 1993 for Northern Maine boundary waters with Canada (i.e. Aroostook and Upper St. John rivers). Additionally, the Maine legislature increased Atlantic salmon fishing license fees from $10 to $15 for residents and $30 to $40 for non-residents. These increases may help to generate additional revenues for future Atlantic salmon restoration activities in Maine.

In October 1993, a genetics working group was established to review all available information regarding the genetic makeup of existing Atlantic salmon populations in Maine. Electrophoresis, DNA, and meristic data from samples collected in 1990, 1992 and 1993 will be summarized and analyzed to address the petition to list the Atlantic salmon under the Endangered Species Act.

Maine Rivers With Wild Salmon Runs

Rod catches on the 7 rivers with wild salmon runs were the lowest recorded since the ASRSC has been in existence (1948). Redd counts conducted on these rivers in the fall of 1993 were also the lowest ever recorded since intensive redd counts began in Maine in the late 1970s. Juvenile population densities, as documented by electrofishing numerous index sites, were also extremely low, although there were a few areas of moderate parr densities in some rivers.

Narraguagus River

The ASRSC has completed the fourth year of an in-depth study of the Narraguagus River Atlantic salmon population and its habitat. A total of 86 adult salmon were captured at the Cherryfield trapping facility, with wild salmon making up approximately 80% of the catch. The 1993 trap catch was the largest recorded during the three years of trap operation but the salmon run is believed to be the smallest recorded in recent years. Changes in fishway and trap operation and favorable flow conditions contributed to a high proportion of the 1993 salmon run represented in the trap catch. A video monitoring system was installed to document salmon ascending the spillway instead of using the fishway. Partial analysis of the tapes indicate that spillway passage was low in 1993. Homewater returns were estimated to number approximately 100-125 salmon, with a sport fishery harvest of 7 salmon. The autumn redd survey counted a total of 109 redds, the lowest complete count on record, and a decline of nearly 70% from a recent high recorded in 1986. Juvenile salmon abundance data were collected at 87 sites with backpack electrofishing gear. In addition, four lower river segments (approximately 12 river miles) were sampled with an electrofishing boat. Juvenile salmon abundance was generally low to moderate, well below previously documented levels. The current low abundance of juveniles is primarily attributable to inadequate spawning escapements in recent years. A total of 1,887 older parr were marked with CWTs in 1993, up from 1,222 in 1992. An additional 174 parr from ten locations in the Narraguagus River were taken to Craig Brook National Fish Hatchery (CBNFH) for captive rearing as broodstock for future fry stocking in the Narraguagus River.

Data entry and verification for Narraguagus River Habitat Studies is complete for the macrohabitat survey and the process of integrating the habitat databases into a GIS system (Arc Info) was initiated in 1993. A survey of substrate embeddedness was conducted at 19 sites throughout the watershed and the final project report will be completed in early 1994.

Attempts to document the presence and extent of agricultural pesticides in the Narraguagus and Pleasant River watersheds continued in 1993. A primary objective was to better understand the occurrence of the herbicide Hexazinone (Velpar). Working with a University of Maine graduate student, sampling was expanded to include both surface and groundwater sites. Low concentrations of Hexazinone was found at virtually all sites sampled in the vicinity of blueberry producing areas (Table 2.3.2.a. in Appendix 11.2). Samples were collected at appropriate times and analyzed for the presence of the highly toxic pesticide Azinphos-methyl (Guthion) and the fungicides Triforine (Funginex) and Benomys (Benlate). Guthion was not detected on any of the July sample dates. The only fungicide detected was Triforine at one site on the Pleasant River, at concentrations of 0.27 and 1.76 ppb. Continued river pH monitoring confirmed earlier indications of periodic pH depressions below 5.0 on the West Branch Narraguagus and lower Pleasant rivers.

Dennys River

A portable weir was operated by USFWS personnel from June 20 to October 7 approximately one mile upstream of the site used in 1992 by ASRSC personnel. Only 3 wild adult salmon (all females) were captured and transported to the CBNFH. An additional 7 salmon of hatchery origin were released upriver of the weir. During weir operations, approximately 40 adult salmon were also observed to be holding below the weir, about one-half of which appeared to be grilse. Because of extreme drought conditions in 1993, the weir was an ineffective method for fish counting and broodstock collections.

In addition to the 3 wild adult broodstock, 182 parr were also collected for future captive broodstock programs. Sampling at juvenile index sites revealed very low parr populations throughout the drainage, with 0+Parr densities ranging from 1.4 - 4.1/unit (100 yd2) and older parr densities from 0.9 - 3.6/unit.

East Machias River

A total of 154 parr were collected from 7 locations throughout the drainage during annual sampling of juvenile index sites in August. These fish will be reared as captive broodstock for future stocking programs. Densities ranged from 4.3 - 33.0/unit for 0+Parr and 2.8 - 13.3/unit for older parr. Additionally, stream obstruction surveys were conducted during July on the mainstem and selected tributaries. While the mainstem was virtually free of obstructions, Northern stream - one of the more important tributaries - was obstructed with many small beaver dams. These obstacles appeared to be passable to salmon, however, as an abundant juvenile population was observed above these obstructions.

Machias River

Two portable weirs were operated by USFWS personnel in the Machias River during 1993.

Fourteen adult salmon were captured in the mainstem weir above Route 9. Only one adult was taken in the Old Stream weir. The weirs were operational from June 21 to September 7 and October 1 for the Old Stream and mainstem weirs, respectively.

Parr were collected (273 from 16 sites) for the river-specific broodstock program during the annual sampling of juvenile index stations throughout the drainage. While juvenile salmon populations were low in most areas, 0+Parr densities ranged from 0.1 - 33.5/unit and older parr from 2.2 - 16.5/unit.

Habitat obstruction surveys were conducted on the major spawning tributaries (Old Stream, New Stream, and Mopang Stream) and 73 obstructions to fish passage were documented. Beaver dams and log jams were breached or removed where possible.

Pleasant River

Habitat obstruction surveys were conducted on over 46 miles of this river and 36 obstructions (mostly beaver dams) were documented. A total of 52 parr was collected for genetics studies.

Sheepscot River

Juvenile salmon population surveys conducted at index sites revealed extremely low parr populations (only 2 0+Parr were captured). A total of 74 older parr was transported to CBNFH to be reared as captive broodstock (and/or genetics studies) for future restocking efforts in the Sheepscot River.

Ducktrap River

A total of 51 parr was collected in October for genetics studies. Overall, juvenile populations (especially 0+Parr) were very low.

Maine Restoration Rivers

Penobscot River

Adult Returns Total Atlantic salmon returns to the Penobscot River in 1993 declined by 26% compared to 1992 (1,769 vs 2,379) and were 34% below the 5-year mean (2,687). Returns of MSW salmon were similar to those observed in 1992 (1,398 vs 1,420), therefore, the decline in total catch was a function of a sharp decline in 1SW returns relative to 1992 (371 vs 959). The 1SW component of the 1993 Penobscot River salmon run was 21% (5-year mean = 25%) compared to a record high (40%) of the 1992 run. Fish of wild origin (those originating from natural reproduction and fry stocking) accounted for 6.8% of the run (5-year mean = 9.8%). This decline in the number of wild-origin salmon was expected, based upon the level of natural spawning 5 years ago. The angling catch on the Penobscot River in 1993 was 124 killed and an estimated 450 released, comparable figures for 1992 were 154 killed and 350 released.

Extended periods of abnormally high river temperatures (>22°C) occurred throughout the summer, exacerbating broodstock collection, reducing angling opportunity, and increasing the probability of heat-induced mortalities for migrating fish. Despite the adverse conditions, 486 of the desired 550 broodstock were collected. Unfortunately, 62 female and 23 male broodstock were lost to a sudden outbreak of "Ich" at CBNFH just prior to spawning.

Fry Stocking A record 1.3 million feeding fry were stocked in the Penobscot River drainage during 1993. Large segments of remote habitat were accessed for the first time by motoring upstream in canoes equipped with outboard motors and synthetic propellers. A pair of 54-quart, oxygen-equipped coolers containing up to 25,000 fry in each cooler were used in each canoe. Transit mortalities were very low, even on fry stocking runs of 10 miles and 6 to 7 hours duration. Using this technique, a 3-canoe team of 6 people dispersed nearly 0.5 million fry into remote areas during a two-day period. Electrofishing surveys at two index sites during late summer revealed densities of up to 32 0+Parr /metric unit. These areas had been stocked at about 60 fry/metric unit.

A new downstream bypass and collection facility at the Weldon Dam hydro project should increase survival for smolts produced above the project, and may provide a means for evaluating fry stocking efforts in the East Branch. Over 3,300 smolts were captured during FERC-required studies conducted by Great Northern Paper Co. in the spring of 1993.

An unexpected consequence of the success of the intensified fry stocking program has been an increase in complaints of salmon parr nuisance hookings by trout anglers. Organized opposition to salmon stocking is beginning to surface in some areas, driven by a declining trout fishery and fears of interspecific competition between native brook trout and stocked Atlantic salmon. In response to these complaints, the Maine Department of Inland Fisheries and Wildlife (IF&W) has prohibited fry stocking in a five-mile segment of the upper East Branch since 1991. This area is characterized by excellent salmon spawning and nursery habitat, which was previously stocked with up to 100,000 fry annually. IF&W has recently promulgated rules designed to increase the native trout population in the area, and has requested that the Salmon Commission review its current policy regarding fry stocking densities. Additional studies may be conducted to determine the most appropriate methods which can be used to restore both trout and salmon populations with minimal impacts to both programs.

The Basin Mills Hydro Project. The Veazie hydro project has been operating on an annual FERC license since 1986. The owner of the dam (Bangor Hydro Electric Co.) delayed re-licensing of Veazie by combining the application with that for a new dam (Basin Mills) four miles upriver in Orono and Bradley. The proposal includes a new 7MW powerhouse on the eastern end of the existing Veazie dam, a new 38MW dam at Basin Mills, and the decommission of an older hydro station at Orono on the Stillwater River.

The Maine Board of Environmental Protection (BEP) approved the project on November 10, 1993 by a 4 to 3 vote and issued the 401 State Water Quality Certificate which is necessary for the FERC permit. Conditions attached to the state permit included the following:

- construction of a fishlift at the Veazie Dam,
- construction of 2 fishlifts or 2 vertical-slot fishways at the Basin Mills Dam,
- provide all funds necessary for the ASRSC and Maine Department of Marine Resources to truck up to 12,000 salmon, 30,000 shad and 150,000 alewives at the Veazie Dam,
- completely remove the remains of the Bangor Dam,
- stock a minimum of 30,000 smolts annually,
- establish a trust fund, administered by the ASRSC, for salmon management activities on the Penobscot River ($100,000 annually, adjusted for inflation),
- create artificial salmon angling "lies" in both the Veazie and Basin Mills tailraces,
- evaluate all of the costs/benefits associated with removal of the Howland Dam, and apply to the Maine DEP to remove the dam no later than September 30, 1998,
- numerous post-construction studies (fish passage, angling, water quality, etc.).

The Penobscot Coalition has challenged the BEP decision in Maine Superior Court. Meanwhile, the FERC licensing process continues, with a cumulative impact analysis currently being conducted. In addition to the Maine BEP/DEP and federal FERC permits, the applicant also is required to obtain permits from the Maine Public Utilities Commission and the Army Corps of Engineers. Court challenges during the permitting process are expected to delay the currently scheduled completion date for the project of 2002.

St. Croix River

A 5-year (1993-1997) Operational Plan for the development and management of diadromous fishes of the St. Croix River was prepared in 1993. The objectives of the plan are: (1) to evaluate the potential and feasibility of restoring Atlantic salmon and American shad, (2) to manage the production and harvest of river herring, and (3) to coordinate the management of all diadromous fishes in the drainage. The St. Croix International Waterway Commission will be responsible for implementing the plan in partnership with fisheries agencies, recreation and conservation agencies, and hydroelectric power producers in the system. Funding for studies conducted in 1993 was provided by the Department of Fisheries & Oceans in Canada and Georgia-Pacific Corporation in Woodland, ME.

Fishway trapping at the Milltown Dam resumed in 1993 and a total of 104 Atlantic salmon and 290,000 river herring were passed. For the first time ever, adult Atlantic salmon broodstock were collected from the St. Croix River and 14 females were spawned at the Mactaquac Hatchery in Fredericton, New Brunswick. A total of 114,000 eggs were transferred to the St. John Hatchery where they will be reared until release as fry and/or parr in the St. Croix River in 1994.

Saco River

A privately-owned hatchery, operated by the Saco River Salmon Club, received its second annual shipment of eyed eggs from the GLNFH. All of the fry produced were distributed by local volunteers in the Ossipee River, a major tributary to the Saco River.

Construction of the fishlift and Denil fishway at the lower two dams of the Cataract Project was completed in 1993 and over 900 American shad and 53 salmon were passed upstream. A comprehensive fish passage agreement for all of the Saco River dams has been agreed upon by staff level personnel of agencies and organizations involved in a 6-month process of negotiations. The agreement is expected to be signed in January of 1994 by CEOs of all the parties involved in the process.

Personnel from the White Mountain National Forest (WMNF) inventoried salmon habitat in 6 miles of the Saco watershed. Field biologists reviewed Saco watershed data and access to headwater streams in the watershed that would be most suitable for initiation of Atlantic salmon fry stocking in the event FY 1994 funding would allow this to take place. Embeddedness data was collected at two sites on headwater streams of the Saco River.

Aroostook River

The trap catch at the Tinker Dam facility was 50% less than that in 1992 (63 vs 123), reflecting the overall poor returns to the St. John River system in 1993. DFO-Canada also trucked 156 salmon from the Mactaquac dam to the lower Aroostook River.

Union River

In a cooperative effort initiated by a private individual, the Union Salmon Association received permission to stock 60,000 salmon fry in the West Branch Union River. The fry were F_2 generation, Penobscot strain fry obtained from Kennebec Aquaculture in Solon, ME. A five-year program to release surplus aquaculture-reared salmon fry into the Union River was reviewed by the Maine Atlantic Salmon Technical Advisory Committee and approved by the ASRSC in December. However, biological constraints associated with the approval make it unlikely that the aquaculture industry will be able to provide any suitable stocks in 1994.

2.3.3. MERRIMACK RIVER

Juvenile Atlantic Salmon Releases

A total of 1,216,446 salmon (1,157,460 fry and 58,986 1Smolt) were released into the basin in the spring of 1993. The USFWS, NHFG, the USFS, and numerous volunteers from Trout Unlimited released the 1,157,460 fry into six tributaries (Souhegan, Piscataquog, Suncook, Contoocook, and Pemigewasset rivers and Black Brook) of the Merrimack with the Pemigewasset River receiving 65% of the total. Approximately 49% of the fry were provided by the North Attleboro National Fish Hatchery (NANFH) and Nashua National Fish Hatchery (NNFH). The remainder were provided by the Berlin State Fish Hatchery (BSFH). The number of fish released was approximately 37% of the estimated carrying capacity of the habitat.

Other than 7,285 smolts that were utilized in downstream fish passage studies, the entire smolt release occurred downstream from the Essex Dam in Lawrence, MA. All smolts received adipose fin clips and CWT.

Adult Atlantic Salmon Returns

Sixty-one (61) adult salmon returned (were observed) to the Merrimack River (18 in May, 36 in June, none in July and August, 6 in September, and one in October. The fishlift at the Essex Dam was not operated during August. One salmon was taken by angling (illegally) downstream from the fishlift with the remainder captured at the fishlift. The 60 captured salmon were transported to the NNFH, held until mature, and artifically spawned.

Characteristics of the Adult Salmon Returns

The adult salmon returns were composed of fish of fry stocking origin (32) and of smolt stocking origin (29). Fish of fry stocking origin consisted of two (2) grilse and 30 2SW salmon. Fish of smolt stocking origin were composed of 28 2SW salmon and one (1) 3SW salmon.

The salmon of fry stocking origin were produced from three different fry releases (1988, 1989, and 1990). Contributions from the 1988 fry release were three age 3.2 salmon. Contributions from the 1989 fry release were 27 age 2.2 salmon. Contributions from the 1990 fry release were two age 2.1 salmon. The 1988 fry release (1,717,800 fry), with age 3.3 salmon yet to return, has produced one of the lowest rates of return recorded in the program, 0.06 adults per 1,000 fry released. The 1988 fry release was also the largest to occur to date. The 1989 fry release (1,033,500 fry), with age 2.3, 3.2, and 3.3 salmon yet to return, has produced a similar rate of return, 0.04 adults per 1,000 fry released. These rates are considerably lower than the long term average of approximately 0.23 adults per 1,000 fry released.

The sex ratio of the returning salmon significantly favored females: 2.8♀ : 1♂ (fry-stocked origin), 1.9♀ : 1♂ (smolt stock origin), and 3♀ : 2♂ (total). The fecundity (eggs/lb. of body weight) was lower for salmon of fry stocking origin (7,596) than for salmon of smolt stocking origin (7,734). Female weights were quite similar for both groups, being 9.7 and 9.6 pounds for fish of fry stocking origin and fish of smolt stocking origin, respectively.

Egg Production

Atlantic salmon eggs for the Merrimack River program originated from two sources, sea-run salmon and captive/domestic brood stock (first generation from Merrimack River sea-run parents). The total egg take from the two sources amounted to 9,986,200 green eggs.

The 42 sea-run females that were held at the NNFH produced 321,600 green eggs. The entire egg production from the sea-run adults was shipped to BSFH except for those eggs necessary to maintain the captive/domestic broodstock program at the NNFH (approximately 20,000 eggs),

A total of 1,573 captive/domestic females, reared at the NNFH and the NANFH were spawned yielding 9,664,600 green eggs. The eggs taken at NANFH (approximately 1.5 million) were kept at that station in order to produce juvenile salmon for the Merrimack River and Pawcatuck River programs. Eggs taken at NNFH were shipped to BSFH (approximately 400,000), WSFH (approximately 2.7 million), NANFH (approximately 3.8 million), and the WRNFH (approximately 1.3 million). The majority of the eggs will be utilized to produce fry for the Merrimack River program. Exceptions are: those eggs shipped to the WRNFH (to be stocked out as fry by the Connecticut River program), 500,000 incubated at the NANFH (to be stocked as fry by the Pawcatuck River program, and approximately 200,000 that will be utilized to produce smolts at the NANFH for the Merrimack River program.

The 1993 egg take was, by far, the largest in the history of the Merrimack River salmon program. Because of this large egg take, an extremely large fry plant in 1994 is anticipated.

Fish Passage

Consolidated Hydro, Inc.

A downstream fish passage facility became operational at the Essex Dam in Lawrence, MA during mid-spring. The facility has not been thoroughly tested for effectiveness. However, spent adult American shad appeared to utilize the facility during their downstream movement. Results from limited testing using juvenile clupeids is not yet available from Consolidated Hydro, Inc. (CHI). A number of wild salmon smolts were captured in the facility during late spring and early summer. Actual evaluations will occur in 1994 or 1995.

Modifications to the downstream fish passage structure at the Pawtucket Dam in Lowell was also accomplished in late 1993. This facility will be evaluated as to effectiveness during 1994 and 1995.

Pine Valley Hydroelectric Project

The downstream fish passage facility at this dam on the Souhegan River was evaluated during the spring utilizing hatchery salmon smolts. The facility was extremely effective in passing smolts. Of 616 smolts released, 595 (97%) were captured after using the structure (Ritzi 1993a). Also captured in the trap (April 29th through May 13th) were 1,120 wild smolts. It appears that the upper Souhegan River produced a moderate number of wild smolts from previous fry releases.

Rolfe Canal Hydroelectric Project

Studies at the Rolfe Canal project on the Contoocook River provided very poor downstream fish passage results using hatchery smolts (Ritzi 1993b). Passage effectiveness varied from 1% to 56%. However, the higher figure is based on only 16 smolts released. Modifications to the facility will occur and additional evaluation work will be completed in 1994.

Public Service of NH

The cooperating agencies and Public Service of NH (PSNH) continued to work together in developing a long-term downstream fish passage plan for the three mainstem hydroelectric projects on the Merrimack as well as two mainstem projects on the Pemigewasset River. It is likely that a plan will be completed by late in 1994.

At the present time it appears that acceptable downstream fish passage is available at the Ayers Island Project (the most upstream dam on the Pemigewasset River). Over 60% of the salmon nursery habitat exists upstream of this hydroelectric dam. Downstream fish passage will continue to be evaluated at the Eastman Falls Dam (lowermost dam on the Pemigewasset River immediately downstream from Ayers Island) and the uppermost dam on the Merrimack River (Garvins Falls Dam) during 1994.

Evaluations/Reports

The "Merrimack River Basin - 1992 - Atlantic Salmon Index Site Assessment Report" was completed in July 1993. The report provides the results of 1992 parr sampling at eight sites, and a compilation and summary of the results of parr sampling at these and other selected sites during the period 1984 -1992.

As part of an ongoing program to evaluate hatchery products, Laconia Office of Fishery Assistance collected data from 900 smolts at the NANFH. Length, weight, marks and tag retention were recorded and the results were reported in a summary report entitled "Atlantic Salmon Smolt Statistics for North Attleboro National Fish Hatchery".

Field Activities

The USFWS and the USFS participated in a cooperative effort with staff from PSNH that involved the monitoring of smolt capture facilities at Ayers Island Dam (Bristol, NH) and Garvins Falls Dam (Concord, NH). PSNH operates downstream fish passage facilities at these dams annually from 1 April through 30 June and 30 October through 30 November. The capture facilities at the dams have been installed to test passage efficiency at the dams. They have also been an integral part of assessments to estimate the number of smolts migrating in the basin.

Evaluations were conducted in cooperation with PSNH at Ayers Island Dam to test the effectiveness of using significant spill ($\approx$ 350 cfs) through flashboards to pass fish downstream. Evaluations included the release of approximately 7,000 marked hatchery fish for recapture, and the release of approximately 100 radio tagged smolts used to document passage through flashboard openings and gates. Approximately 253 marked fish were captured at Garvins Falls Dam a distance of 42 river miles downstream from the point of release above Ayers Island Dam. These captures documented passage through gates and complemented data obtained from radio telemetry studies.

Plans for large scale renovations of smolt capture facilities at PSNH dams are now being developed. The plans may include the construction of permanent smolt capture facilities at PSNH mainstem dams. The plans are being formulated in coordination with the Merrimack River Anadromous Fish Restoration Committees.

The NHFG, USFS, and USFWS participated in the annual fall assessment of the fry stocking program in the Merrimack River basin. Parr sampling occurs from August through October and the results are provided in an annual report. The report is distributed to fishery resource agencies and interested individuals and organizations. The index sites are representative of juvenile salmon habitat found throughout the basin. Data were collected for 7 index sites and 7 ancillary sites in the Merrimack River basin: the East Branch Pemigewasset, Pemigewasset, Mad, Baker, Smith, Soucook, South Branch Piscataquog, and Souhegan rivers. Juvenile salmon are collected using standard electrofishing methods and population estimates and indices of relative abundance are calculated using mark-and-recapture and depletion methods.

An index of relative abundance of 1+Parr is used as a measure of cohort strength (Figure 2.3.3.a. in Appendix 11.2). Excluded from the index were 2+Parr since they would have been counted the previous year as 1+Parr. The time series of abundance of age 1+Parr was contrasted with number of fry stocked throughout the basin in each year and with a time series of returns for the same year class which included all salmon life stages: grilse, 2SW, and 3SW. For example, the 1983 cohort represents a composite of age 1+Parr abundance at index sites in 1984. The 1983 cohort return is comprised of salmon of fry origin with a two year river residence that returned in 1986 as grilse, in 1987 as 2SW salmon, and in 1988 as 3SW salmon. Return data for years 1989 through 1991 are incomplete and represent cohorts that remain at sea.

A water quality monitoring program initiated in 1992 by the USFWS was continued in 1993 and included the installation of dataloggers at sites located on the Mad, Pemigewasset, Souhegan, Nashua, and Merrimack rivers. The dataloggers, installed seasonally at tributary and mainstem dams, record and store readings of water temperature, pH, specific conductance/resistivity, total dissolved solids/salinity, and dissolved oxygen. The equipment requires considerable maintenance to ensure reliable and accurate data. Data are reported in the annual index site report.

The USFS monitored water temperatures throughout the summer at Atlantic salmon index sites located within the White Mountain National Forest Boundary. A Forest Monitoring Report was completed, which included an evaluation of Atlantic salmon habitat on those streams inventoried from 1989 through 1992. An inventory of salmon habitat was completed on 20 miles of headwater streams of the Pemigewasset River.

Education/Outreach

USFS (White Mountain National Forest) environmental education/public outreach activities included the following:

1. Participation in the Merrimack River Public Outreach Projects,

2. Aquatic Awareness Day during National Fishing Week,

3. Assistance with planning of the Atlantic salmon interpretive site on the Kancamagus Scenic Byway,

4. Assistance with planning of the Warren State Fish Hatchery interpretive displays at the Visitor Center.

The USFWS embarked on ambitious educational outreach program based out of the Merrimack River Coordinator's office. Two programs were initiated that will utilize the Atlantic salmon restoration program in the Merrimack River to focus on watershed importance and stewardship among elementary school children (5th graders).

The "Adopt a Salmon Family" program was initiated in two schools, the An Wang School in Lowell, MA and the Maple Street School in Contoocook, NH. The year-long program allows students to incubate Atlantic salmon eggs in the classroom and participate in the stocking of Atlantic salmon fry in the spring. In addition, numerous school activities related to the watershed environment, Atlantic salmon, and site visits to the NNFH have occurred and more are planned. A monthly newsletter, "The Salmon Times" is provided to the 5th graders; each issue directed at a specific, relevant topic.

The "Get Hooked on Fishing, Not Drugs" program will occur in the spring and will include the Dare Program based out of Hopkinton, NH and the 5th graders in Bow, NH. The program is presently in the final planning stages.

Captive/Domestic Atlantic Salmon Broodstock Sport Fishery

In 1989 a change was recommended for the fish cultural activities for the Merrimack River Atlantic Salmon Restoration Program. The change was a direct result of the success of the fry stocking program in the basin. The change identified two objectives:

1. Re-direct the role of the NNFH from smolt production to domestic broodstock production. This would allow for the production of six million salmon eggs and the subsequent release of three million fry in the basin.

2. Re-condition captive/domestic broodstock kelts after the first major spawning and release them into the mainstem to provide sport fishing opportunities.

The increase in the production of broodstock required to support the expansion of the fry program has provided an opportunity to implement a unique sport fishery management plan.

Beginning in 1993, 1,500 broodstock were released in portions of the Pemigewasset and Merrimack Rivers. Current population projections of sea run salmon stock development in these rivers suggest that no sport fishery of consequence for migratory salmon would occur during the next decade. Therefore, it is intended that the annual release of broodstock would decrease when the sea run population develops.

The interim fishery provides increased public awareness of anadromous fish restoration and the improvements in water quality throughout the basin. Significant social, economic and biological benefits over a decade earlier than anticipated may be realized with a relatively insignificant increase in program costs. Some of the released broodstock may be fit for

spawning and remain in the river and contribute to the production of sea-run salmon. Others may migrate to sea and return to spawn. In addition, the interim fi
shery provides an opportunity to manage the fishery in advance of managing an actual sea run salmon fishery. Managers can consider the many alternatives available for regulating the fishery that include gear options, and requirements for catch-and-release and the harvest of salmon. A total of 1,500 broodstock were released on two different occasions into six zones within the mainstem of the river in 1993. The fish ranged in size from three to 17 pounds. Each of the salmon was marked with a colored disc tag denoting release zone and release period.

The NHFG managed the fishery. The agency sold 851 permits at a cost of $10.00 each. Each permit included five possession tags and a diary. Mandatory reporting was required and the diary was to be returned following the closure of the season. The permittees came from eight states: NH= 827, MA= 15, CT= 4, FL= 1, ID= 1, ME= 1, NJ= 1, and PA= 1. To date, 486 diaries have been received and 418 contain information indicating participation in the fishery. Information in 68 of the diaries suggested no angling occurred. A total of 564 salmon were landed in conjunction with 2,719 angler trips. While anglers averaged 6.5 trips, an average of 4.8 trips were required to land a salmon. Throughout the season 564 salmon were landed by 158 anglers. It was reported that 340 fish were released with 224 fish harvested. Successful anglers averaged 3.6 salmon in 1,354 trips. The maximum number of salmon landed by a single angler was reported to be 21.

It is difficult to validate the information reported in the diaries but observations by fishery resource personnel indicate that numerous salmon were captured and harvested. A detailed examination of the captive/domestic broodstock sport fishery will be reported in the proceedings of the New England Atlantic Salmon Management Conference to be held in April of 1994.

2.3.4. PAWCATUCK RIVER

Adult Returns

Only one female salmon was trapped at the Potter Hill Dam fishtrap on the Pawcatuck River in June of 1993. The fish had spent two years at sea after migrating as a 2Smolt, as determined by scale analysis. It was part of the 1991 smolt run, estimated to have been the largest in the history of the program. This run was produced by extensive 0^+Parr releases during the fall of 1989. The poor sea return indicates very low marine survival. This trend continues a steady erosion of marine survival since the 1982 smolt class. A total of 7,900 eggs was spawned from the single return and fertilized with milt obtained from male salmon at the NANFH.

Stocking

Fry stocking was emphasized over parr for the first time in 1993. The watershed was stocked with a total of 403,600 juvenile salmon, of which 382,800 were fry. Average stocking density, on a watershed basis, was 77 fry/unit. Salmon fry were obtained from several fderal hatcheries, a private grower, and eggs spawned from 1992 returns to the Pawcatuck River. Fourteen thousand 0+Parr were also stocked in the fall of 1992. The University of Rhode Island Department of Zoology also stocked 2,300 1Smolts in April and 4,500 age 0+Parr in October for a smolt physiology research project.

Fry/Parr Assessment

The 1993 season was the first in which basin wide fry assessment could be conducted. Index stations were sampled on the two major tributaries which form the Pawcatuck River. Fry survival varied widely from 0 to 39% and was related to water levels. Rainfall in 1993 was below the long-term mean and many of the smaller streams were reduced to very low flows. Fry survival was poor in small streams but higher in larger streams. Replication in 1994 will necessary to establish fry survival under normal flow conditions.

2.3.5. NEW HAMPSHIRE COASTAL RIVERS

Adult Returns

The Lamprey and Cocheco River fish ladders were monitored in the months of May, June, and mid-September to mid-November for returning adult salmon. Four fish (3 females and 1 male) returned to the Cocheco River fish ladder in 1993. All returned in October. Eight fish (5 females, 3 males) returned to the Lamprey River. Three returned in June and 5 in October. The fish ranged in length from 60 cm to 93 cm. Preliminary aging indicates that the returns were comprised of six age 2.2 individuals, one age 1.2 fish, two age 2.1 individuals, and the scales from the remaining three fish were unreadable.

All returning fish were transported to state fish hatcheries. Three spring-run and one fall-run fish succumbed to disease prior to spawning. Eggs were taken from 5 females (3 of Cocheco River origin and 2 of Lamprey River origin) with the total egg take amounting to an estimated 34,000 eggs.

Juvenile Stocking

This was the sixth consecutive year in which Atlantic salmon fry had been stocked into coastal New Hampshire rivers. In 1993, a total of 127,000 Atlantic salmon fry were stocked into the Cocheco River System and 67,500 were stocked into the Lamprey River System.

The fry were reared at the BSFH and Twin Mountain State Fish Hatchery and released into the two rivers at a rate of 36 to 72/100 m^2 during the month of April. Seasonal abundance of salmon parr originating from fry releases have been documented by annual electrofishing assessments at index sites. In 1993, the Zippen removal method was used, for the first time, to evaluate parr abundance. In previous years, mark and recapture methodologies were employed with Chapman's formula used to calculate population estimates. Survival of parr at 3 of the 4 index sites was good, considering the high water conditions at the time of stocking and the subsequent near drought conditions experienced throughout the late spring and summer.

The Lamprey River also received: 22,800 Penobscot strain 1Parr. 56,500 Penobscot strain 0+Parr, 1,100 Merrimack strain 1+Parr, and 15,000 Penobscot strain 1Smolts. The Cocheco River received 1,000 Merrimack strain, 1+Parr in December.

In the fall of 1993, surplus age 2+ Atlantic salmon captive/domestic broodstock from the NNFH were stocked in the Lamprey and Cocheco River systems. Approximately 1,000 fish were put into the Lamprey River and about 400 fish went into the Isinglass River (a tributary to the Cocheco River). It is hoped that sufficient numbers of these fish will survive the winter in the river and contribute to a spring fishery for salmon. Prior to stocking, the fish were tagged with sequentially numbered T-bar, streamer tags just below the dorsal fin.

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.

A description of the research activities (those descriptions made available to the working group) necessary for ANACAT are available in Section 5.1.

3.3. HISTORICAL DATA - VALIDATE 1992 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 3.3.a. and 3.3.b. in Appendix 11.2, and in Section 6. (sub-sections 6.1. and 6.2.) of this document. Table 3.3.a. was restructured from year-by-river specific to river-by-year specific. This restructuring provided a much more useful time-series for the data.

3.4. CONTINUE TO SYNTHESIZE AVAILABLE DATA AND MODEL FRY SURVIVAL RATES

Stocking of Atlantic salmon fry has become the preferred method of producing salmon smolts from waters not accessible to spawning adults in New England restoration programs (Gibson 1993). Analyses of fry stocking data have shown that there is a density-dependent component to mortality through the large parr stage, modified by abiotic factors such as water temperature and system productivity (Gibson 1992, 1993). Evidence of density dependent growth was also found when the effects of water temperature were controlled. Electofishing surveys at index stations have been conducted in the Pawcatuck River watershed for Atlantic salmon parr and smolts since 1981. Data from these surveys allow for estimates of overwinter losses of parr to be made in relation to parr age and density. A total of 67 pairs of density observations were available for analysis. The density independent survival rate was estimated at 0.34 (SE = 0.07) and the length effect at -0.02 (SE = 0.004). The fitted model indicated that spring parr density is a linear function of fall density with an inverse length effect, i. e. small 0+ Parr survive at a higher rate than do larger 1+ Parr.

However, when the analysis was performed on only large parr data, the length effect was not significant despite a wide range in large fall parr lengths (14-20 cm). This suggests that the size effect was an artifact of parr age, probably related to low catchability of 0+Parr in the fall.

No evidence of density-dependent mortality was found during the overwinter period in this study. This is in contrast to earlier works which showed density-dependent mortality from stocked fry to 1+ Parr (Gibson 1992, 1993). The obvious conclusion is that numerical regulation occurs early on in a cohort's life, primarily in the first summer. In fact, most stream salmonid studies indicate that losses are greatest and most variable in the month following emergence or stocking (Latta 1962, McFadden et al. 1967, Gee et al. 1978, Elliott 1985). Winter losses may fluctuate widely in response to weather conditions (Rand et al. 1993). The survival estimate for large parr of 36% (95% C. I 29-43%) is below that used for expansion of smolt densities at index sites in the Connecticut River. Rhode Island streams have the mildest winters in the New England program and might be expected to have the highest overwinter survival. Additional study on this life phase is needed, particularly in northern New England and for larger streams and rivers throughout New England. Independent estimates of smolt abundance from downstream migrant studies would also be useful.

3.5. DEVELOP A METHODOLOGY TO CONFIRM SMOLT STATUS BASED ON EXAMINATION OF SELECTED CHARACTERISTICS IN POTENTIAL SMOLTS AND RETURNING ADULTS

The committee considered a study of "Marine Growth and Age at Maturity of Atlantic Salmon". The goal of this paper was to reconstruct the post-smolt growth history for a salmon stock with known annual variation in age of maturity. The index stock investigated was the hatchery component of the salmon run in the Penobscot River, ME, for release years 1973 - 1990. The hatchery program was in transition during this period. Releases were mostly 2Smolts early in the time series, whereas in recent years, releases were mostly 1+Smolts.

The fraction of a cohort that matures annually was established by the ratio of grilse to salmon returns corrected for fishing mortality on the 2SW component of the run. Maturation fraction ranged from 2 to 19% of the cohort during the period and has shown trends or distinct periods of high and low maturation rate. During the late 1970s and again during late 1980s, the fraction increased to 10 to 13% and to 16 to 19%, respectively. During the earlier portions of these decades, the maturation fraction was less than 10% annually.

Post-smolt growth was determined by measurements of circuli spacing deposited during the first year at sea by grilse and 2SW salmon returns to the Penobscot River, ME. Circuli spacing was widest in the post-smolt summer and narrowest in the post-smolt winter for both sea-age groups. In addition, three descriptive indices from the circuli spacing data were identified. Index means of circuli spacing were intended to generally represent spring, summer, and winter growth regimes.

Circuli spacing indices show considerable annual variation and systematic differences between sea-age groups. Spring and summer spacing indices averages were similar to each other and higher than winter averages. It was assumed that this is indicative of higher growth rates in spring and summer than in winter. Also, grilse grow faster than those members of the cohort destined to return as 2SW salmon. Grilse growth was consistently higher during the winter than it was for 2SW salmon.

Hatchery smolt size (as a factor affecting maturation sea-age) was not evaluated in the study because these measurements were unavailable. However, the transition from predominantly 2Smolt to 1Smolt releases raised concerns about the role smolt size may have had on the observed pattern of maturation. To address this concern, the length (mm) of the freshwater zone (taken as the distance from the focus to the end of the freshwater zone along the 360° axis of the scale) was measured for each scale. These lengths were interpreted as an indication of smolt size.

It was found that smolt size, as indicated by the length of the freshwater zone, was generally higher for fish that returned as grilse. For cohorts in the early part of the time series (when the releases were predominantly 2Smolts), the distribution of freshwater zone lengths for 1SW returns were often different than the distribution of freshwater zone lengths for 2SW returns of the same cohort. In later years of the time series (when the releases were predominantly 1Smolts), these distributions were generally overlapping indicating that grilse and 2SW returns were derived from the same size distribution of smolts. This suggests that smolt size may be correlated with maturation. However, there has been an increase in the proportion of 1Smolts in the releases while the maturation fraction has increased. It was felt that this is counter-intuitive from what would have been expected if smolt size were the determinant of maturation. Size at smolting appears to predispose some individuals to early maturation. However, the population trends in maturation observed in this stock must be explained by other causes.

Pearson correlation was used to determine the relationship between maturation fraction and growth. The sensitivity of the model was tested using higher and lower number of circuli pairs in the computation of the index and by centering the indices to the right and left (i.e. earlier or later in the post-smolt year, respectively) of the center circuli pair criteria.

Two significant correlations were found by comparing seasonal circuli spacing indices with returns rates and maturation fraction. The returns rate of grilse and the maturation fraction were significantly correlated with the summer growth index for 2SW returns. In addition, the summer difference index was also significantly correlated with grilse return rate and maturation fraction.

An analysis of model sensitivity showed that the method for calculating index values was robust. Using the mean date of circuli deposition observed for tagged and experimentally-caught fish, the sensitivity analysis indicated that maturation fraction is most influenced by growth in 2SW salmon occurring in late August and early September.

The main finding of this study is the positive correlation between the growth of 2SW salmon during the post-smolt late summer and the fraction of the cohort that matures as grilse.

Hypothetical distributions of summer growth rates for two cohorts, one cohort with a low maturation fraction and another with a high maturation fraction were considered. The results suggest the maturation fraction is correlated to the mean location of the distribution of 2SW growth rates since this distribution is assumed to reflect the fraction of the cohort that exceeds the growth threshold for maturation.

In summary, it was observed that post-smolts grow rapidly during their first spring and summer at sea, with circuli spacing patterns providing evidence of faster growth for individuals that mature as grilse. It appears that the fraction of cohort that matures as grilse is a function of growth of the entire cohort. With knowledge of this mechanism, the possibility of developing predictive models of annual maturation rate exist. However, this correlation does not completely explain what factors cause grilse to mature.

3.6. CONTINUE TO DEVELOP METHODOLOGY TO ESTIMATE HOMEWATER RETURNS TO U.S. RIVERS

No information was presented.

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

Four papers were presented that addressed the effect of near-shore marine temperatures and other environmental variables on juvenile Atlantic salmon and stream water temperatures on the abundance of salmon and timing of smolt migration.

A paper was presented that provided a preliminary analysis of migrational corridors for salmon with respect to river and sea-surface water temperatures. The interactive effects of river temperatures and near-shore marine temperatures were explored to better understand the environmental challenges faced by salmon in areas at the southern extent of their range.

Sea-surface temperature (SST) data were collected by a NOAA satellite for areas surrounding the river mouths of the Connecticut, Merrimack, and Penobscot rivers. The areas that encompass marine habitat within 100 km of the mouth of each of the rivers were assessed to determine average, minimum, and maximum water temperatures. Data available span from October 1981 to December 1992.

SST data were compared between the restoration rivers, overall, and during the period of typical smolt migration (15 April to 10 June). SST in the area 100 km from the river mouths differed greatly between rivers, but temperatures in the three rivers were highly correlated over the 11-year period ($p \leq 0.001$; $r^2 = 0.98$). The annual average SST by week was 13.54 C for the Connecticut, 11.3 C for the Merrimack, and 9.8 C for the Penobscot.

Penobscot River temperature data, 1966 - 1982, suggest that smolt migration would likely commence on or about 15 April and end on or about 10 June of the average year. The river is more centrally located within the range of salmon. Therefore, data from this near-shore area was considered a standard and differences among rivers were considered (Figure 3.7.a. in Appendix 11.2.). Using the standard, water temperature in the near-shore areas of the Merrimack and Connecticut rivers was approximately 1.4 C and 3 C warmer, respectively.

Differences in temperature were evident among the three rivers, but the magnitude of the differences may be dampened by differential timing of smolt migration. Because Atlantic salmon are on the southern extent of their range in U.S. tributaries, windows or corridors for migration may be more narrowly defined than in northern systems. Further examination of the temperature differences in near-shore areas and life history trends exhibited in salmon restoration stocks would provide important information on the suitability of restoration stocks to current and historical environmental regimes.

Index sites have been established in the Merrimack River basin that represent a composite of the juvenile salmon rearing or nursery habitat within the basin. Annual sampling at sites has resulted in the development of a reasonable data set depicting the fall abundance of parr. The time series includes an index of the relative abundance of parr and was developed to show captures per unit effort at sites for the period 1983-1992 (see Figure 2.3.3.a. in Appendix 11.2.).

The time series of abundance of age 1+Pparr was contrasted with number of fry stocked annually in the basin and with the number adult returns (grilse, 1SW, 2SW) from the same year class. Abundance of 1+Pparr was used as a measure of cohort strength and is reasonably represented by the number of sea-run fish that returned to the river. Return data for the 1989 year class is incomplete but preliminary data is reported. Deviation in the trend is apparent for the 1986 and 1988 cohorts.

The relationship depicted in Figure 2.3.3.a. may be affected by the number of fry stocked in a year, survival of parr, and other sources of mortality during the seaward migration of smolts, during the post-smolt life stage, and during the period of ocean residence. A confounding factor includes fishing mortality, but for future years this factor will be eliminated because of the closure of the ocean fishery.

Although spot sampling at sites can provide simple and useful indices of relative abundance, more precise information is needed if estimates of parr abundance are to be useful in validating smolt production in the basin. The ability to ensure confident estimates of parr abundance in conjunction with smolt sampling facilities, would provide opportunities to investigate factors associated with overwinter mortality, the seasonal movement of parr, and the specific or cumulative effects of dams or other water development projects on the survival of salmon in the Merrimack River. Investigations related to smolt production and survival are increasing in importance and index site assessments will remain an integral part of these investigations.

Studies to assess parr abundance and smolt production in headwater streams of the Connecticut River were conducted on the Green Mountain National Forest. Fyke netting in Greendale and Utley brooks, tributaries to the West River, yielded significant captures of parr and pre-smolt in September and October. A total of 285 salmon were captured. Length frequency analysis indicated that 38 were pre-smolts (>12 cm). Most fish were trapped in October at a minimum-maximum temperature range of 1.9 C to 12.6 C. Trap retention tests indicated retention rates of 50 to 100%. Capture of pre-smolts was concentrated in mid-October while parr movements were dispersed over the sampling period. Of the captured pre-smolts, 73 - 87% were precocious males. It is difficult to explain the low number of smolts captured in spring when contrasted with the estimates of fall parr abundance. The observed movement of precocious fish may reflect activity associated with a desire to spawn. The low overall capture of salmon in spring and fall suggests high overwinter losses although factors such as trap efficiency and bias in the projections of parr densities need further evaluation.

Smolt emigration in the West and White rivers' tributaries was observed in early May. Observations suggest that smolts may be able to enter Long Island Sound prior to the development of a thermal barrier. Initiation of the smolt run occurred when maximum daily temperature reached about 12 C and when the minimum daily temperature did not drop below 7 C.

Other studies involved the installation of fyke-net weirs on four streams to obtain smolt estimates using a mark-recapture technique. A weir efficiency rate was used to calculate an estimate of the number of smolts emigrating from streams. The estimated potential smolt run was calculated from parr abundance (fall) data and was compared to the estimated number of emigrating smolts calculated from weir data as shown in Table 3.7.a. (Appendix 11.2.).

The total number of smolts captured in 1993 was well below expectation in all streams sampled. Several possibilities may explain the lower than expected numbers of smolts captured, and include the following: (1) smolt estimates from index station data may be inaccurate; (2) overwinter survival rates may be lower than current estimates; (3) pre-smolts may have migrated downstream the previous fall; and (4) the peak in smolt migration may occur when sampling is inefficient.

3.8. PROVIDE A SUMMARY ADDRESSING PROGRESS IN DEVELOPING DOWNSTREAM FISH PASSAGE FOR ATLANTIC SALMON IN NEW ENGLAND RIVERS. THE SUMMARY SHOULD INCLUDE TYPES OF DOWNSTREAM FISH PASSAGE STRUCTURES AND MEASURES OF EFFECTIVENESS

John Warner (Ecological Services, USFWS) presented a summary and addressed the progress in developing downstream fish passage in New England Rivers. Upstream and downstream fish passage are both important components of the Atlantic salmon restoration program in New England. While both components are critical to restoration, recent efforts have concentrated on downstream passage due to the status of the restoration program (fry stocking).

At present, 481 hydroelectric facilities are operational throughout New England. Of these, 93 are situated downstream of current Atlantic salmon fry stocking areas. Previously, downstream passage efforts were expended primarily on mainstem (Connecticut, Merrimack, and Penobscot) hydro facilities. Since 1988, fry production has increased and expanded planting efforts in upstream areas and tributary streams has occurred, increasing the importance of passage at additional facilities.

The status of those hydro projects currently important to Atlantic salmon passage were discussed (Table 3.8.a. in Appendix 11.2.). In 1988, thirty-nine hydro projects were in need of downstream passage and only 3 had downstream passage mechanisms in place. By April of 1994, 21 projects will have final passage facilities of a present total of 71 projects in need of passage. Passage facilities are considered final when USFWS criteria are met and construction is complete. Interim passage indicates that efforts are currently underway to improve a facilities passage potential. This interim solution could be either a temporary measure or part of an assessment study to determine an appropriate passage facility design. The review of the status of some facilities is not yet complete and their status is considered undetermined.

The types of passage facilities in use for Atlantic smolts are comprised mainly of two types; surface bypass without narrow screens are in use in 26 projects and narrow-spaced screen with bypass are in use on 21 projects (Table 3.8.b. in Appendix 11.2.). Some hydro projects have multiple methods in place yielding a total of 61. Although very few of the downstream passage facilities have been assessed, narrowly-spaced screen and bypass systems appear to be the most effective method in use and a louver array has also been shown to be effective (Table 3.8.c. in Appendix 11.2.). Alternative methods in use are partial depth screens (only upper 3-4 m screened), strobe lights (repel fish to preferred areas), and trashrack openings (small bypasses in middle of intake area) which have been relatively unsuccessful (6-66%; Table 3.8.d. in Appendix 11.2.). Many of the surface bypasses without screening are interim in nature, often utilizing existing gates and sluiceways. Tests of these type of bypass facilities have been generally unsuccessful but have had mixed results (Tables 3.8.d.).

By 1996, at least 93 hydro projects will need downstream passage facilities in place for salmon smolts due to expansion of fry stocking locations. Of these, we expect 32 projects will have final facilities in place, but the status of facilities at 57 projects is yet to be determined. Implementation of downstream passage facilities at these sites will be affected by the FERC's actions on relicensing many of the projects in question, as no facilities will be constructed until new licenses are issued. Older licenses and exemptions vary greatly in plans/mandates for passage depending on individual projects and the status of restoration projects at the time they were licensed. The timetable under which these projects are fitted with passage facilities will be determined by the actions taken by the fishery agencies and FERC and the level of cooperation with the project owners.

Group discussion raised the question of the availability of adequate flows through project impoundments, the location of smolts in the water column, and the role of cumulative effects of impoundments. It was suggested that, in general, flow is not thought to be a problem except in some selected impoundments upstream of current reintroduction efforts.

In regards to the suitability of passage only in the upper portion of the water column. It was suggested that on the West Coast, it is typical for smolts in advanced stages of smoltification to be more buoyant than smolts that are lesser developed. Conversely, preliminary evidence indicates that smolts with bacterial kidney disease also migrate closer to the surface.

The question was also raised as to the suitability of utilizing hatchery smolts to quantify the passage of wild smolts through a facility. A consensus was reached that the distinction between the passage of wild and hatchery smolts warrants investigation. Penobscot River investigations will address this question in 1994 using wild and hatchery smolt groups. Concerns were also raised over the handling of smolts. A coordinated effort is being made in February of 1994 to conduct a workshop on smolt handling to consolidate information gained in the region. The group concurred that this was an important step in examining this issue.

The group raised the question of the cumulative effects of passing multiple dams on the fate of outmigrating smolts. It was stated that these cumulative effects need to be investigated utilizing models to assess potential mortalities. Concern was also expressed over the delay effect (ie. downstream migration delays). It was felt that delays may be responsible for poor timing in downstream migration that could cause problems upon reaching the marine environment. The group felt that these concerns were important and further information is needed.

3.9. DEVELOP PROCEDURES FOR COMPUTING AND REPORTING ENVIRONMENTAL VARIABLES AND HABITAT CLASSIFICATION ELEVANT TO HABITAT MEASUREMENT FOR JUVENILE SALMON SURVIVAL AND PRODUCTION MODELING

Habitat use and selection patterns were assessed for juvenile Atlantic salmon in the West Branch of the White River, VT and in the Mad River, NH. Observations were made at monthly intervals, July - October, 1993. Use and selection were compared between size classes in the same river and the same size class in different rivers. Population densities were manipulated at two study sites in both rivers to assess how population density might effect habitat selection. Observations were also made at night to determine nocturnal habitat selection.

Small (<70mm) and large parr were found to segregate by water depth in the West Branch. Small parr preferred 16-25 cm depths while large parr were most frequently found in 26-35 cm depths. Consistent segregation by current speeds was not evident in the West Branch. However, use of focal current speeds were significantly different for the two size classes. Large parr made more frequent use of slow focal current speeds (0-17 cm/s). Small parr made more frequent use of gravel and small home stones (6-200 mm) in the West Branch while large parr used boulders and larger home stones (100-200 mm). Mad River large parr used greater depths, slower current speeds and larger substrates than West Branch large parr. This was attributed to differences in availability between the two rivers. The Mad River was significantly deeper and slower with more boulders and bedrock substrate.

Selection of macrohabitat and microhabitat variables varied between streams and between sites within streams. Consistent selection was only shown for depth. Large parr selected mid-range depths in both rivers.

Population density was shown to effect both micro and macrohabitat selection in the Mad River. At low densities (1.4 - 2.5/unit), riffles, runs, and pools were used proportionately. At moderate densities (2.5 - 5.0/unit), pools were preferred, while at high densities (3.7 - 6.3/unit), riffles were avoided. Only mid-range depths (26-45 cm) were selected at low density while at existing and high densities, mid and upper-range depths (26-65 cm) were selected.

Salmon were found to alter habitat use as water temperatures dropped in late summer and fall. When temperatures dipped below 15 C at night, but increased to 15 C by midday, salmon exhibited a temporary sheltering response. When midday temperatures did not rise above 15 C, salmon moved to deeper and slower areas. Parr disappeared almost entirely when daytime temperatures fell below 10 C, having presumably taken shelter in substrate chambers.

Nighttime observations in the Mad River showed salmon occupied sheltered positions behind or beneath rubble and boulders or along stream margins. They also used slower current speeds and areas with smaller substrates. Additionally, riffles were avoided at night while they were used proportionately during the day.

The results of this study suggest several management implications. Results indicating segregation by size class suggest that small and large parr rearing habitat may need to be assessed independently. Managing for a balance of small and large parr rearing habitat may reduce year-class interactions that have been reported to produce alternating weak year-classes in some streams. Results showing a seasonal change in depth and velocity selection from summer and autumn indicate the need to assess and manage overwintering habitat. These findings are consistent with studies previously reported (Cunjak 1988, Rimmer et al. 1984). Creating the preferred winter habitat conditions through habitat manipulation could potentially improve overwinter survival and maximize smolt production (Roy 1994).

3.10. DEVELOP A MEANS OF COMPARING OBSERVED RECRUITS PER SPAWNER FOR THE PENOBSCOT RIVER WITH AN APPROPRIATE YEAR-CLASS SURVIVAL INDEX. THESE DATA WILL BE USED TO MODEL THE SURVIVORSHIP RELATIVE TO DAM AND ENVIRONMENTAL EFFECTS

No information was available for this term.

4. DISCUSSION TOPIC

4.1. THE PETITION TO LIST THE ATLANTIC SALMON AS AN ENDANGERED SPECIES

Paul Nickerson (USFWS) and Doug Beach (NMFS) led a discussion related to the potential listing of the Atlantic salmon as an endangered species. The discussion is summarized below.

Atlantic salmon populations in five (5) Maine rivers (Dennys, Machias, East Machias, Narraguagus, and Pleasant) with extant native salmon populations were listed as Category 2 candidate species under the Endangered Species Act (ESA) by the USFWS in 1991 in response to rapidly declining adult returns and historic low levels of abundance. The Category 2 designation does not convey an increased level of protection, but does dictate close monitoring and evaluation of those populations to determine if full protection under the Act is warranted.

A "Prelisting Recovery Plan" to detail the actions necessary to effectively evaluate those populations was developed and implemented by the ASRSC and USFWS in 1991 to prioritize management and research objectives. On October 1, 1994, the USFWS received a petition to list the Atlantic salmon as endangered from Restore the North Woods, Jeff Elliot, and the Biodiversity Legal Foundation. The petition covers all anadromous Atlantic salmon populations throughout their historic range in the USA. One month later the petition was resubmitted to NMFS, and the two agencies have agreed to act on the petition jointly.

An initial review of the petition by the agencies within the mandated 90-day finding period determined that the petition has merit (contains substantial information) and therefore deserves further consideration. A synopsis and review of data for specific criteria (habitat degradation, disease, depredation, commercial over-exploitation, lack of adequate regulations, natural or man-made factors) is now in progress to determine which ,if any, U.S. populations of anadromous Atlantic salmon should be listed as threatened or endangered under the ESA. NMFS and USFWS have indicated this review process should be completed by the end of April, 1994 in order to provide sufficient time to document and submit their formal decision prior to expiration of the one year deadline. As of October 1, 1994, the agencies must decide that: (1) based on current information, listing is not warranted, or (2) more information is required before a decision to list or not to list can be made, or (3) listing of some or all of the New England stocks is warranted (as specified by submitted rules).

Genetic variation or uniqueness within species was used in the Pacific Northwest to establish criteria for listing (Waples 1991). Samples for genetic analysis were collected from several Maine rivers in 1990 - 1993 (see Section 5.1, "Genetics"). A synopsis of results to date will be available by the Fall of 1994. The U.S. Atlantic Salmon Assessment Committee therefore recommends the reviewing agencies seek the following information to assist with their decision:

1. Continue and expand the current investigations to determine genetic uniqueness of the populations.

2. River-specific salmon stock information, including historic spawning run disruptions, stock origin, and current management regimes.

The following was developed for the agencies to address in providing information to assist the USFWS and NMFS.

Atlantic Salmon - River Profile

1. River name

2. Extant salmon run Y N

3. Origin of run - Hatchery - Natural - etc. - if both, estimate % of each

4. Is run maintained or supplemented by stocking by stocking Y N

5. Origin of stocks - Describe this as precisely as possible. e.g. returning adults of wild origin - returning adults of hatchery origin - (Penobscot strain) hatchery fish (Narraguagus/Canadian origin, etc.)

6. Is sufficient spawning habitat available and accessible to maintain the population or allow it to increase

7. Is stock at carrying capacity

8. If all stocking ceased, would the run maintain itself? Why or why not?

9. What are the limiting factors/threats in the river? Elsewhere?

10. Year when run was totally eliminated (if it was). First year when run became reestablished either naturally or through stocking.

11. What actions are necessary in or adjacent to the river to improve conditions for salmon.

12. Other information that is pertinent

4.2. REORDING OF SECTION 2

The committee discussed Section 2 (Status of Program) and recommended a number of format changes (to be utilized in Report No. 7 - 1994 activities). The reordering and changes will be as follows:

2. Status of Program
2.1. General Program Update
2.1.1. Connecticut River
2.1.2. Maine Program
2.1.3. Merrimack River
2.1.4. Pawcatuck River
2.1.5. New Hampshire Coastal Rivers

Each of the individual summaries should not exceed five (5) pages will include the following sub-sections in the order written:

Adult Returns - trap catches by time and location, sport fisheries, broodstock, spawning escapement, age and origin information, redd counts, population trends, etc.

Hatchery Operations - egg take by source, fish health/quality, etc.

Stocking - life stages, timing, locations, techniques, densities (metric), deviations from normal, etc.

Juvenile Population Status - techniques used to assess, densities metric), time, location, age and origin, population trends, miration timing for smolts and kelts, environmental influences, etc.

Fish Passage - new/proposed facilities, problem areas, relicensing issues, iciency studies, comprehensive plans, migration timing for smolts and kelts, etc.

Genetics - ongoing studies, purpose(s), Endangered Species, etc.

General Program Information - habitat surveys, regulation changes, aquaculture, instream flows, education/outrreach, etc.

2.2. Stocking
2.2.1. Total Releases
2.2.2. Summary of Tagged and Marked Salmon
2.3. Adult Returns
2.3.1. Total Documented Returns
2.3.2. Estimated Total Returns

2.3.3. Returns of Tagged Salmon
2.3.4. Spawning Escapement, Broodstock Collection, and Egg Take
2.3.5. Sport Fishery

5. RESEARCH

5.1. CURRENT RESEARCH ACTIVITIES

The following is a list of Atlantic salmon related research that was conducted during 1993. The capital letters (codes) following the listing of the authors refers to the address of the research facility (listed at the end of the Section). The information presented is by no means complete, since many of the agencies/research labs did not respond to the Working Group's request for information.

Artificial Propagation

1.Kincaid, Harold (B)
EVALUATE MONOSEX ATLANTIC SALMON POPULATION PRODUCED BY COMBINED GYNOGENESIS AND SEX REVERSAL.

A series of 19 gynogen families were produced fromPenobscot sea-run salmon at the Craig Brook National Fish Hatchery in November 1992 and transported to the NBS Laboratory - Wellsboro for rearing. Pseudo-fertilization used lake trout milt denatured by 15 second exposure to UV-irradiation. Using a 28° C heat shock for 20 minutes starting 20 minutes post-fertilization, gynogen yield at hatch ranged from 0 to 30% (mean 6.3%). Isozyme analysis indicated that all surviving Atlantic salmon were gynogenetic diploid females. Families were divided into three groups at the sac-fry stage, with two groups treated with methyltestosterone to effect sex-reversal; one as a dip treatment at the sac-fry stage and the second as a feed treatment for 60 days started at first feeding. At 10 months, survival rate was similar among the gynogen and gynogen/sex-reversed groups. Attained weight of the gynogen/sex-reversed groups were 25% higher than the gynogen group. Efficiency of sex-reversal will be determined when the fish reach 15 months of age.

Behavior

1. Hockett, Karen (E)
   RETENTION OF THE BIRD PREDATOR AVOIDANCE RESPONSE BY SALMON FRY.

Using a unique experimental design, hatchery fish were reared in environments containing cover, free of cover, and free of human distraction, then tested in a video-taped test chamber. Those fish that had access to some type of cover during hatchery rearing readily sought over when confronted with bird predators. Those hatchery fish reared without cover did not have an avoidance response in the presence of a predator. This study has implications for the "training" of hatchery fish to utilize cover and reduce mortality when stocked in the wild.

2. Seandel, Marco and Carol Folt. (G)
BEHAVIORAL TIME BUDGETS FOR 0+ SALMON IN THE WHITE RIVER, VERMONT.

Young-of-the-year salmon were located and observed for 20 minute periods, in the early morning (0800-1000), late morning (1000-1200) and the early afternoon (1200-1400). Behaviors such as benthic or drift feeding, resting, fighting etc. were noted throughout the observation period. Fish were monitored from two separate sites on the White River in late June, late July and late August. Samples of benthic and drift invertebrates together with data on the territory size, and other microhabitat descriptors (e.g. temperature, cover, flow, depth) were collected for each individual fish or sampling date. The data are presently being analyzed.

<u>Genetics</u>

1. Kincaid, Harold. (B)
GENETIC ANALYSIS OF ATLANTIC SALMON FROM MAINE RIVERS.

Isozyme analysis was completed on the 1992 samples from the Dennys, Machias, Narraguagus, Sheepscot, and Penobscot river stocks. Eleven of 55 loci screened were polymorphic using established starch gel procedures. Mean heterozygosity per locus was h = 0.016. The level of differentiation was Fst = 0.026. Significant differences were found between the Dennys stock and all others examined in the test. Evaluation of meristic and morphometric characteristics found small but significant differences among the five stocks. Results from both the isozyme and morphometric data indicated statistically significant differences among these stocks, but additional genetic and life history data is needed to determine if these differences are biologically significant. DNA analysis of the same 1992 samples being performed by University of Maine has not been completed. A new cooperative framework was established in 1993 for continuation of this work in 1994 by USFWS Region 5, Maine Sea-Run Salmon Commission, NBS Laboratory - Wellsboro, NBS Fish Health Research Laboratory, and NBS Ecology Laboratory - Leetown.

<u>Habitat</u>

1. Moreau, D.A. and John Moring. (E)
REFINEMENT AND TESTING OF THE HABITAT SUITABILITY MODEL FOR ATLANTIC SALMON.

A study was completed that examined the selection of holding pools by adult salmon on their upstream migration. From extensive measurements made with salmon and pools in rivers of Maine and New Brunswick, a modification to the Habitat Suitability Index Model was developed and tested that identifies the key characteristics of holding pools.

2. Nislow, Keith and Carol Folt. (G)
INFLUENCE OF HABITAT REMEDIATION ON MACROINVERTEBRATE HABITATS AND COMMUNITIES IN STREAMS OF THE GREEN MOUNTAIN NATIONAL FOREST.

The primary objective of the cooperative research effort with the US Forest Service is to evaluate the effect of stream habitat remediation on physical habitats and invertebrate communities, and the potential implication of these changes for ecosystem processes and fish habitat suitability during the May-October season. Two summer field seasons of data collection have been completed.

Juvenile Studies

1. Folt, Carol and Donna Parrish. (G & F)
ANALYSIS OF FOOD AVAILABILITY FOR ATLANTIC SALMON FRY.

The primary objective of this research project was to evaluate food availability for and feeding preferences of age-0 Atlantic salmon introduced into the West and White rivers, VT, from May through August. Sites include both high and low survival sites as identified in conjunction with State and Federal fisheries biologists. Anticipated completion date: February 1994.

2. Parrish, Donna and Carol Folt. (F & G)
AN EVALUATION OF HABITAT QUALITY FOR AGE-0 ATLANTIC SALMON IN THE WHITE AND WEST RIVERS, VERMONT.

This research program is designed to evaluate habitat quality for age-0 Atlantic salmon, and to relate those data to patterns of salmon survival. It is a companion project to (#1 above) and used habitat data collected at the same sites and times and the data on food availability and fish gut contents. In addition, microhabitat data for each individual fish was recorded and related to variables such as body size and gut content weight.

3. Parrish, Donna and Carol Folt. (F & G)
PREY SELECTION OF AGE-0 ATLANTIC SALMON IN THE WHITE AND WEST RIVERS, VERMONT.

In Spring 1992, age-0 Atlantic salmon were collected (N=195) from six sites on the West and White rivers. Prey selectivities were determined by using the invertebrate data collected in a companion study (#1 above). Stomachs of salmon from West River sites generally contained as much or more food than stomachs from the White River. In general, fish were highly selective, foraging on a small subset of invertebrates. Low diversity of taxonomic groups in the diet emphasized the selectivity of salmon. Diets of fish in the West River appeared more diverse than diets of fish from the White River and the density of invertebrate groups found most often in fish stomachs was significantly greater in the West River than in the White River. The results indicate that types and amounts of food available may influence age-0 salmon survival.

Nutrition

1. Fynn - Aikins, K. (C)
   ATLANTIC SALMON CARBOHYDRATE STUDIES

Analysis of the carbohydrate study done last year has been completed. The results suggest that digestible carbohydrates can be utilized well by salmon. In addition, results show that the dietary protein level (53%) in the commercial feed that is routinely used in Federal fish hatcheries may be too high. Salmon fed the digestible carbohydrate diets (with 42% dietary protein) grew as well as those fed ASD2-30.

2. Ketola, George (C)
   REQUIREMENTS OF ATLANTIC SALMON FOR DIETARY PHOSPHORUS.

Two experiments were conducted using small and large Atlantic salmon *Salmo salar* (initial mean weights 8.4 and 46 g) fed a common basal diet with and without graded levels of supplemental phosphorus (P) as defluorinated rock phosphate. Feeding salmon the basal diet containing 0.22% non-phytin P significantly reduced their growth rate, feed efficiency, and bone ash content. The requirement of non-phytin P by Atlantic salmon for maximum growth and feed efficiency was no more than 0.42% and 0.52% for small and large fish, respectively. The minimum requirement for maximum bone ash development was no more than about 0.52% non-phytin P for both small and large salmon. These results show that the minimum requirement of salmon for non-phytin phosphorus is about 0.52% of diet.

Predation

1. Blackwell, Brad (E)
   PREDATION ON ATLANTIC SALMON SMOLTS IN THE PENOBSCOT RIVER BY DOUBLE-CRESTED CORMORANTS.

This was the second year of a three-year study that addresses the extent of predation on Atlantic salmon hatchery smolts by cormorants in the Penobscot River and estuary. One objective is to estimate the number of smolts consumed each year by cormorants within the river. Other objectives include movements of cormorants, feeding, and flight behavior. Anticipated completion date: December 1994.

2. van den Ende, Oliver (E)
   PREDATION ON ATLANTIC SALMON SMOLTS BY SMALLMOUTH BASS AND CHAIN PICKEREL IN THE PENOBSCOT RIVER, MAINE.

This study examined the role of fish predators in the mortality of downstream-migrating salmon smolts in the Penobscot River. Mr. van den Ende completed a Master of Science thesis using field data (stomach analyses), laboratory studies of the food consumption at various water temperatures, and a bioenergetics model to estimate potential impacts of predation by smallmouth bass and chain pickerel. Although the estimates have broad confidence ranges, this was the first attempt at estimating total mortality from freshwater fishes.

3. Schulze, M. (D)
   ESTIMATING THE IMPACT OF STRIPED BASS ON THE SURVIVAL AND DISTRIBUTION OF JUVENILE ANADROMOUS FISH IN THE LOWER CONNECTICUT RIVER.

The first field season of this two year study has been completed. Striped bass were collected using gillnets, angling and electroshocking. Stomach contents are presently being analyzed. The objectives of this study are: 1) use field surveys to quantify abundance and size distribution of striped bass in the lower Connecticut River; 2) evaluate diet of large striped bass (>300mm); 3) evaluate how striped bass distribution, behavior, and diet changes through time (March-November); 4) evaluate diel pattern of striped bass distribution and foraging behavior in spring, summer, and fall; 5) determine if overlap exists in microhabitat use by (a) striped bass and salmon smolts in the spring and (b) striped bass and juvenile clupeids in the fall; 6) and adapt the generalized bioenergetics model of fish growth for striped bass in the lower Connecticut river and use this model to estimate striped bass consumption of juvenile salmon and clupeids.

Stock Assessment

1. Friedland, Kevin (A)
   RUN RECONSTRUCTION MODEL FOR THE NORTH AMERICAN MULTI-SEAWINTER STOCK.

A run reconstruction model for the North American multi-seawinter stock component was developed. The model estimates fishery area fishing mortality in commercial gill-net fisheries in Canada and Greenland and provides estimates of total salmon stock abundance in the region.

2. Friedland, Kevin (A)
   RISK ASSESSMENT OF CATCH ADVICE FOR THE WEST GREENLAND SALMON FISHERY.

A risk assessment of catch advice for the West Greenland salmon fishery was investigated. Post-smolt survival and salmon abundance was estimated using exponential smoothing and regression forecasts. The statistical properties of these forecasts were evaluated using Monte Carlo simulation.

Stock Identification

1. Friedland, Kevin. (A)
   STOCK IDENTIFICATION MODEL TO SEPARATE WILD AND HUSBANDRY ORIGIN SALMON.

A stock identification model to separate wild and hatchery origin salmon in mixed stock catches was developed. The model uses input data derived from scale morphology. Using image processing techniques, circuli spacing patterns and Fourier descriptors of scale texture are determined for each scale.

2. Friedland, Kevin. (A)
   STOCK IDENTIFICATION MODEL TO IDENTIFY NORTH AMERICAN AND EUROPEAN ORIGIN SALMON.

A stock identification model to identify North American and European origin salmon in mixed stock fisheries was developed. The model uses Fourier shape descriptors of otolith outline shape to identify samples to their respective stock complexes.

Survival

1. Friedland, Kevin. (A)
   POST-SMOLT SURVIVAL OF NORTH AMERICAN AND EUROPEAN ATLANTIC SALMON.

Post-smolt survival of North American and European Atlantic salmon was investigated. Survival of North American stocks is affected by the areal extent of over-wintering habitat in the northwest Atlantic Ocean. A related mechanism was observed for European stocks; however, the effect appears to occur during the spring period.

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WHITESEL, TIMOTHY A. 1992. Springtime Hepatosomatic Indices, Plasma Cortisol Levels, and Hepatic 5'-Monodeiodinase Activities in One-Year-Old Atlantic Salmon From Two Growth Modes. Prog. Fish-Cult. 54(3):174-180. (Dept. Fish & Wildl., 211 Inlow Hall, East. Oreg. State Coll., La Grande 97850)

List of Contributing Institutions

Code	Address
A	National Marine Fisheries Service Northeast Fisheries Science Center 166 Water Street Woods Hole, MA 02543-1097 Phone: 508-548-5123
B	National Biological Survey National Fishery Research & Develop. Lab. R.D. # 4, Box 63 Wellsboro, PA 16901 Phone: 717-724-3322 Fax: 717-724-2525
C	National Biological Survey Tunison Laboratory of Fish Nutrition 3075 Gracie Road Cortland, New York 13045-9357 Phone: 607-753-9391 Fax: 607-753-0259
D	National Biological Survey S.O. Conte Anadromous Fish Research Center P.O. Box 796 One Migratory Way Turners Falls, MA 01376 Phone: 413-863-9475 Fax: 413-863-9810
E	University of Maine Maine Cooperative Fish & Wildlife Research Unit 240 Nutting Hall Orono, Maine 04469 Phone: 207-581-2582
F	University of Vermont Vermont Cooperative Fish & Wildlife Research Unit School of Natural Resources Aikens Center Burlington, VT 05405 Phone: 802-656-4280

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5.2. RESEARCH NEEDS AND DATA DEFICIENCIES

The committee agreed that the information presented under Section 4 (Discussion) of the 1992 Working Group document directly related to this section and is as valid today as it was in 1992. Therefore, that information is included in this document also.

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.

<u>Adults</u>

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.

<u>Broodstock Collection - Genetics</u>

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.

<u>General</u>

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 radio-telemetry 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.

6. HISTORICAL DATA (1970 - 1992)

6.1. STOCKING

The historical stocking information is presented in Table3.3.a. in Appendix 11.2.

6.2. ADULT RETURNS

The historical return information is presented in Table 3.3.b. in Appendix 11.2.

7. TERMS OF REFERENCE FOR 1995 MEETING

The U.S. Atlantic Salmon Assessment Committee agreed to address the following Terms of Reference for the 1995 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 1993 stocking and return data and add to historic database.

4. Continue to synthesize available data and model juvenile survial and growth rates.

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

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

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

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

8. U.S. ATLANTIC SALMON ASSESSMENT COMMITTEE PARTICIPANTS

Ed Baum	Maine Atl. Sea-Run Sal.Comm. Bangor, ME
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
Jay McMenemy	VT Dept. of Fish & Wildlife. N.Springfield, VT
Ted Meyers	U.S. Fish & Wildlife Ser. Sunderland, MA
John O'Leary	MA Div. cf Fish & Wildlife. Westboro, MA
Steve Roy	Green Mt. Nat. Forest. Rutland, VT
Richard Seamans	National Marine Fish. Ser. Gloucester, MA
Larry Stolte, Chairman	U.S. Fish & Wildlife Ser. Nashua, NH

9. PAPERS SUBMITTED

Friedland, Kevin. Marine Growth and Age at Maturity of Atlantic Salmon (*Salmo salar*).

Kocik, John and Kevin Friedland. Preliminary Analysis of Migrational Corridors for Atlantic Salmon: With Particular Reference to the Stocks in the Connecticut, Merrimack, and Penobscot Rivers.

McKeon, Joseph. Composite of Relative Abundance of Age 1+Parr at Index Sites, Merrimack River Basin, 1983 - 1992.

McKinely, Daniel and Steven Roy. Habitat Use and Selection by Juvenile Atlantic Salmon in Two National Forests Streams in Vermont and New Hampshire.

McMenemy, Janes. Review of Estimators for Determining Total Run Sizes of Atlantic Salmon in Southern New England Rivers.

Roy, Steven. Monitoring of Atlantic Salmon Pre-smolt Movement in Two West River Tributaries on the Green Mountain National Forest, 1993.

Roy, Steven. Atlantic Salmon Smolt Monitoring in Tributaries of the West and White Rivers on the Green Mountain National Forest, 1993.

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11. APPENDICES

11.1. TERMS OF REFERENCE FOR 1994 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 1992 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. river.

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

8. Provide a summary addressing progress in developing downstream fish passage for Atlantic salmon in New England rivers. The summary should include types of downstream fish passage structures and measures of effectiveness.

9. Develop procedures for computing and reporting environmental variables and habitat classification relevant to habitat measurement for juvenile salmon survival and production modeling.

10. Develop a means of comparing observed recruits per spawner for the Penobscot River with an appropriate year-class surival index. These data will be used to model the survivorship relative to dam and environmental effects.

11.2. <u>TABLES SUPPORTING THE DOCUMENT</u>

TABLE 2.1.1.a. ATLANTIC SALMON STOCKING SUMMARY FOR NEW ENGLAND IN 1993 BY RIVER SYSTEM AND BY PROGRAM. 1)

RIVER SYSTEM	NUMBER OF FISH 2)						TOTAL
	FRY	0+PARR	1PARR	1+PARR	1SMOLT	2SMOLT	
UNITED STATES							
St. John	0	0	0	0	0	0	0
Aroostook	0	0	0	0	0	0	0
St. Croix	0	101,000	0	0	40,100	0	141,100
Dennys	33,000	0	0	0	0	0	33,000
Pleasant	0	0	0	0	0	0	0
East Machias	0	0	0	0	0	0	0
Machias	0	0	0	0	0	0	0
Narraguagus	0	0	0	0	0	0	0
Union	60,000	111,700	0	0	0	0	171,700
Penobscot	1,320,000	202,300	9,600	0	580,400	0	2,112,300
Ducktrap	0	0	0	0	0	0	0
Sheepscot	0	0	0	0	0	0	0
Saco	167,000	0	0	0	20,100	0	187,100
Cocheco	127,000	0	0	1,000	0	0	128,000
Lamprey	67,500	56,500	22,800	1,100	15,000	0	162,900
Merrimack	1,157,000	0	0	0	59,000	0	1,216,000
Pawcatuck	383,000	14,500	4,000	0	2,300	0	403,800
Connecticut	4,147,000	237,100	28,700	0	382,800	0	4,795,600
TOTAL	7,461,500	723,100	65,100	2,100	1,099,700	0	9,351,500
CANADA							
Upper St. John	361,000	102,800	0	0	0	0	463,800
Aroostook	0	0	0	0	0	0	0
St. Croix	0	0	0	0	0	0	0
TOTAL	361,000	102,800	0	0	0	0	463,800
PROGRAM							
Maine							
United States	1,580,000	415,000	9,600	0	640,600	0	2,645,200
Canada	361,000	102,800	0	0	0	0	463,800
Cocheco	127,000	0	0	1,000	0	0	128,000
Lamprey	67,500	56,500	22,800	1,100	15,000	0	162,900
Merrimack River	1,157,000	0	0	0	59,000	0	1,216,000
Pawcatuck River	383,000	10,000	4,000	0	0	0	397,000
Connecticut River	4,147,000	237,100	28,700	0	382,800	0	4,795,600
TOTAL	7,822,500	821,400	65,100	2,100	1,097,400	0	9,808,500

1) The distinction between USA and Canadian stocking is based on the sources of the fish.
2) The number of fry is rounded to the nearest 1000 fish. All other entries rounded to the nearest 100 fish.

TABLE 2.1.2.a. SUMMARY OF JUVENILE ATLANTIC SALMON MARKING PROGRAMS FOR NEW ENGLAND IN 1993. 1)

PROGRAM	NO. CODED WIRE TAGS 2)		NO. CARLIN TAGS		NO. FIN CLIPS ONLY	
	PARR	SMOLTS	PARR	SMOLTS	PARR	SMOLTS
Maine Program	1,800	199,800	0	200	0	60,200
Merrimack River	0	59,000	0	0	0	0
Pawcatuck River						
Connecticut River	3,300	357,700	0	0	0	0
TOTAL	5,100	616,500	0	200	0	60,200

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 2.1.2.b. ATLANTIC SALMON MARKING DATABASE FOR NEW ENGLAND - 1993.

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	22000	7/18/63	AD	3/93	Connecticut R.	
USFWS	1	smolt	H	Connecticut	CWT	22000	7/19/01	AD	3/93	Connecticut R.	
USFWS	1	smolt	H	Connecticut	CWT	22200	7/19/26	AD	3/93	Connecticut R.	
USFWS	1	smolt	H	Connecticut	CWT	22400	7/19/27	AD	4/93	Connecticut R.	
USFWS	1	smolt	H	Connecticut	CWT	22200	7/19/28	AD	4/93	Connecticut R.	
USFWS	1	smolt	H	Connecticut	CWT	21900	7/19/29	AD	4/93	Connecticut R.	
USFWS	1	smolt	H	Connecticut	CWT	21900	7/19/30	AD	3/93	Connecticut R.	
USFWS	1	smolt	H	Connecticut	CWT	22000	7/19/31	AD	3/93	Connecticut R.	
USFWS	1	smolt	H	Connecticut	CWT	21800	7/19/32	AD	3/93	Connecticut R.	
USFWS	1	smolt	H	Connecticut	CWT	21900	7/19/33	AD	4/93	Connecticut R.	
USFWS	1	smolt	H	Connecticut	CWT	22700	7/19/34	AD	4/93	Connecticut R.	
USFWS	1	smolt	H	Connecticut	CWT	11000	7/19/36	AD	3/93	Connecticut R.	
USFWS	1	smolt	H	Connecticut	CWT	9500	7/19/37	AD	3/93	Connecticut R.	
USFWS	1	smolt	H	Connecticut	CWT	19800	7/19/41	AD	4/93	Connecticut R.	
USFWS	1	smolt	H	Connecticut	CWT	12400	7/19/43	AD	4/93	Connecticut R.	
USFWS	1	smolt	H	Connecticut	CWT	16900	7/19/44	AD	4/93	Connecticut R.	
USFWS	1	smolt	H	Connecticut	CWT	21600	7/19/53	AD	4/93	Connecticut R.	
USFWS	1	smolt	H	Connecticut	CWT	23200	7/19/54	AD	4/93	Connecticut R.	
SUBTOTAL (SMOLT)						**357400**					
USFWS	1	parr	H	Connecticut	CWT	100	7/18/63	AD	3/93	Connecticut R.	
USFWS	1	parr	H	Connecticut	CWT	200	7/19/26	AD	3/93	Connecticut R.	
USFWS	1	parr	H	Connecticut	CWT	100	7/18/63	AD	3/93	Connecticut R.	
USFWS	1	parr	H	Connecticut	CWT	400	7/18/43	AD	4/93	Connecticut R.	
USFWS	1	parr	H	Connecticut	CWT	100	7/19/29	AD	4/93	Connecticut R.	
USFWS	1	parr	H	Connecticut	CWT	2200	7/19/41	AD	4/93	Connecticut R.	
SUBTOTAL (PARR)						**3100**					
TOTAL - CWT, CONNECTICUT RIVER						**360500**			**99.0% (356,900) of smolts and parr retained CWT**		
USFWS	1	smolt	H	Merrimack	CWT	10854	7/19/45	AD	4/93	Merrimack R.	
USFWS	1	smolt	H	Merrimack	CWT	18299	7/19/45	AD	4/93	Merrimack R.	
							7/19/46				
USFWS	1	smolt	H	Merrimack	CWT	8345	7/19/45	AD	4/93	Merrimack R.	
							7/19/46				
							7/19/47				
USFWS	1	smolt	H	Merrimack	CWT	8208	7/19/14	AD	4/93	Merrimack R.	
							7/19/45				
							7/19/46				
USFWS	1	smolt	H	Merrimack	CWT	2119	7/19/38	AD	4/93	Merrimack R.	
USFWS	1	smolt	H	Merrimack	CWT	5995	7/19/38	AD	5/93	Merrimack R.	
USFWS	1	smolt	H	Merrimack	CWT	5166	7/19/38	AD	5/93	Merrimack R.	
TOTAL - CWT, MERRIMACK RIVER						**58986**			**92.6% (54,621) of smolts retained CWT**		

TABLE 2.1.2.b. ATLANTIC SALMON MARKING DATABASE FOR NEW ENGLAND – 1993.

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	Penobscot	CWT	20666	7/18/30	AD	4/93	Penobscot R.	
USFWS	1	smolt	H	Penobscot	CWT	27502	7/18/42	AD	4–5/93	Penobscot R.	
USFWS	1	smolt	H	Penobscot	CWT	16978	7/18/43	AD	5/93	Penobscot R.	
USFWS	1	smolt	H	Penobscot	CWT	26217	7/18/44	AD	5/93	Penobscot R.	
USFWS	1	smolt	H	Penobscot	CWT	8901	7/18/62	AD	5/93	Penobscot R.	
USFWS	1	smolt	H	Penobscot	CWT	22378	7/19/49	AD	5/93	Penobscot R.	
USFWS	1	smolt	H	Penobscot	CWT	26471	7/19/50	AD	5/93	Penobscot R.	
USFWS	1	smolt	H	Penobscot	CWT	24738	7/19/51	AD	4/93	Penobscot R.	
USFWS	1	smolt	H	Penobscot	CWT	25993	7/19/52	AD	4/93	Penobscot R.	
TOTAL – CWT, PENOBSCOT RIVER						199844		98.3% (196,444) of smolts retained CWT			
ASRSC	0	parr	W	Narraguagus	CWT		Sequential	AD		Narraguagus R.	
ASRSC	1	parr	W	Narraguagus	CWT		498 – 5034	AD		Narraguagus R.	
TOTAL – CWT, NARRAGUAGUS RIVER						1840					
GNP	1	smolt	H	Penobscot	CARLIN	186	900000		5/93	Penobscot R.	Green
							900200				
TOTAL – CARLIN TAGS PENOBSCOT RIVER						186					
GNP	4+	kelt	W	Penobscot	FLOY	69	9286–9399		5/93	Penobscot R.	Orange
GNP	4+	kelt	W	Penobscot	FLOY	13	9401–9435		9/93	Penobscot R.	Orange
TOTAL – FLOY & STREAMERS						82					
USFWS	1	smolt	H	Penobscot		20032		AD	4/93	St. Croix R.	Not Coded-Wire-Tagged
USFWS	1	smolt	H	Penobscot		10039		LV	5/93	St. Croix R.	
USFWS	1	smolt	H	Penobscot		10034		RV	5/93	St. Croix R.	
USFWS	1	smolt	H	Penobscot		20053		LV	4/93	Saco R.	
TOTAL – FIN CLIPS						60158					

TABLE 2.2.1.a. DOCUMENTED ATLANTIC SALMON RETURNS TO NEW ENGLAND RIVERS IN 1993. 1)

RIVER	NUMBER OF ATLANTIC SALMON BY SEA AGE								TOTAL FOR 1993	
	1SW		2SW		3SW		RS			
	Hat	Wild	Hat	Wild	Hat	Wild	Hat	Wild		
Penobscot River	349	22	1,279	92	7	1	13	6	1,769	2)
Aroostook River	50	69	14	86					219	3)
Union River										
Narraguagus River	0	6	16	66	0	0	4	2	94	4)
Pleasant River										
Machias River	0	1	2	12	0	0	0	0	15	5)
East Machias River										
Dennys River	7	0	2	4	0	0	0	0	13	6)
St. Croix River	5	4	76	18	0	0	0	2	105	
Kennebec River	0	0	2	0	0	0	0	0	2	
Androscoggin River	1	1	33	9	0	0	0	0	44	
Sheepscot River	0	0	9	0	0	0	0	0	9	
Ducktrap River										
Saco River	4	0	54	0	0	0	1	0	59	7)
Cocheco River	0	1	0	2	0	1	0	0	4	
Lamprey River	0	1	0	7	0	0	0	0	8	
Merrimack River	0	2	28	30	1	0	0	0	61	
Pawcatuck River	0	1	0	0	0	0	0	0	1	
Connecticut River	0	0	137	61	0	1	0	0	199	
TOTAL	416	108	1,652	387	8	3	18	10	2,602	

1) These are considered minimum numbers; reflecting only trap counts and rod catches.
2) Does not include 5 salmon angled above Veazie counting station.
3) 1993 data includes Tinker Trap catch and fish trucked above Tinker Dam (1SW and MSW where MSW includes 2SW, 3SW, and Repeat Spawners).
4) Includes one salmon observed bypassing fishway in 1993.
5) Incomplete count from portable weir.
6) Includes 10 salmon captured with a portable weir - incomplete count.
7) New fish passage/counting facilities operational in June - incomplete count.

TABLE 2.2.2.a. INDICIES AND ESTIMATED ABUNDANCE OF ATLANTIC SALMON RETURNS TO NEW ENGLAND RIVERS IN 1993.

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

RIVER	RECREATIONAL FISHERY				TRAP CATCH			REDD COUNTS		ESTIMATED ABUNDANCE
	Creel / Reporting		Estimator							
	Release	Harvest	(3% / Trap)	Est. Total	100%	90%	75%	Total	Partial	
Aroostook (1)	0	0		0	219					219
St. Croix	0	1		1			139			140
Dennys (2)	1	3		3				25		31
East Machias	3	0		0					17	17
Machias (2)	12	0		1					45	58
Pleasant	0	0		0					22	22
Narraguagus	20	7		9	87					96
Union (3)	0	0		0						0
Penobscot	450	119		164			2200			2364
Ducktrap	0	0		0				20		20
Sheepscot	5	9		10				33		43
Kennebec	10	2		3						3
Androscoggin	0	0		0		49				49
Saco (4)	6	6		7	53					60
Cocheco	0	0	0	0		4				4
Lamprey	0	0	0	0		9				9
Merrimack	0	1	2	3		67				70
Pawcatuck	0	0	0	0		1				1
Connecticut	0	0	6	6		221				227
TOTALS	507	148	8	207	359	351	2339	78	84	3433

(1) Trap catch = 63 and 156 trucked into system.

(2) Salmon removed for broodstock Dennys (7), Machias (12)

(3) Stocked in 1993 for the first time since 1990

(4) Note: incomplete count due to late operation of two new passage facilities

TABLE 2.2.3.a. SUMMARY OF 1993 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	7	0	0	7
Merrimack River						
Trap	CWT	0	28	1	0	29
Rod	CWT	0	0	0	0	0
Penobscot River 1)						
Trap	CWT	48	311	0	4	363
Rod	CWT	1	5	0	0	6
Trap	Carlin	1	30	0	0	31
Rod	Carlin	1	1	0	0	2
Other Rivers in Maine 1,2)						
Trap	CWT	1	15	0	0	16
Rod	CWT	0	0	0	0	0
TOTAL	CWT	50	366	1	4	421
	Carlin	2	31	0	0	33

1) It is assumed that any Atlantic salmon in Maine with an adipose finclip also carried a CWT.
2) Includes 1 1SW Adipose clipped fish from the Narraguagus River - confirmed wild origin.

TABLE 2.2.4.a. SUMMARY OF ATLANTIC SALMON EGG PRODUCTION IN NEW ENGLAND FACILITIES IN 1993 1).

SOURCE RIVER	ORIGIN	FEMALES SPAWNED	TOTAL EGG TAKE	NO. OF EGGS PER FEMALE
Dennys River	Sea-run	3	19,400	6,467
Machias River	Sea-run	7	50,000	7,143
Penobscot River	Sea-run	255	1,882,000	7,380
Cocheco River	Sea-run	3	21,400	7,133
Lamprey River	Sea-run	2	12,600	6,300
Merrimack River	Sea-run	42	321,600	7,657
Pawcatuck River	Sea-run	1	7,900	7,900
Connecticut River	Sea-run	121	1,053,800	8,709
TOTAL SEA-RUN		**434**	**3,368,700**	**7,762**
Penobscot River	Domestic	886	2,292,000	2,587
Merrimack River	Domestic	1,573	9,664,600	6,144
Connecticut River	Domestic	714	3,878,700	5,432
TOTAL DOMESTIC		3,173	**15,835,300**	**4,991**
Dennys River	Kelts	2	8,600	4,300
Connecticut River	Kelts	164	1,767,600	10,778
TOTAL KELTS		**166**	**1,776,200**	**10,700**
GRAND TOTAL		**3,773**	**20,980,200**	**5,561**

1) Egg takes rounded to nearest 100 eggs.

TABLE 2.2.5.a. DOCUMENTED 1993 SPORT CATCH OF ATLANTIC SALMON IN MAINE.

RIVER	NO. SALMON HARVESTED 1SW	2SW	3SW	RS	TOTAL HARVEST	EST. NO. RELEASED	TOTAL ANGLED 1993	TOTAL ANGLED 1992
St. Croix	1	0	0	0	1	0	1	2
Dennys	2	1	0	0	3	1	4	12
East Machias	0	0	0	0	0	3	3	9
Machias	0	0	0	0	0	12	12	10
Pleasant	catch and release						0	0
Narraguagus	0	7	0	0	7	20	27	62
Union	0	0	0	0	0	0	0	0
Penobscot 1)	14	108	0	2	124	450	574	497
Ducktrap	0	0	0	0	0	0	0	0
Sheepscot	0	9	0	0	9	5	14	7
Kennebec	0	2	0	0	2	10	12	0
Saco	0	6	0	0	6	6	12	0
Misc	0	0	0	0	0	0	0	1
TOTAL	17	133	0	2	152	507	659	600

1) The Penobscot sport catch includes salmon (5 fish) previously captured in fishway trapping facilities.

TABLE 2.3.1.a. Atlantic Salmon Egg Production and Incubation in the Connecticut River Basin.

Station	Domestic	Kelts	Sea-Runs	Egg Take TOTAL	Incubation TOTAL
Berkshire NFH	0	1,208,577	0	1,208,577	**0**
Cronin NSS	653,776	82,157	997,062	1,732,995	0
Green Lake NFH*	1,775,580	0	0	1,775,580	**0**
Kensington SSH	1,683,808	0	0	1,683,808	1,813,829
Nashua NFH*	1,245,375	0	0	1,245,375	0
Roger Reed SFH	1,508,095	0	0	1,508,095	1,069,069
Roxbury SFH	33,000	0	0	33,000	323,000
White River NFH	0	0	0	0	6,515,206
Whittemore SS	0	476,911	56,763	533,674	0
TOTAL	**6,899,634**	**1,767,645**	**1,053,825**	**9,721,104**	**9,721,104**

* These figures reflect only the contribution for the Connecticut River program, and not total production at these stations.

TABLE 2.3.2.a. Hexazinone (Velpar) Water Sample Analysis Data, 1992–1993.

Site	Location	23-Nov-92	22-Dec-9	20-Jan-9	3-Feb-93	10-Mar-9	24-Mar-9	22-Apr-9	6-May-93	11-May-9	19-May-9	25-May-9	08-Jun-93	22-Jun-9	30-Jun-9	20-Jul-93	Average per site
MAINSTEM NARRAGUAGUS																	
M-1	Stud Mill Road						ND										0.00
M-4	Rte. 9 Xing				ND	ND	ND	ND		ND		ND	ND	ND	ND	ND	0.00
M-7	Deblois 193X		ND	ND	ND	0.19	ND	ND		ND		ND	ND	ND	ND	ND	0.02
M-8	Poplar Hill							ND					0.28			0.32	0.20
M-10	Below Wyman disch.		ND	0.51	0.41	0.51	0.23	ND				0.29	0.24		0.47	0.72	0.34
TRIBUTARIES																	
S-16.1	Schoodic 193X	0.75	0.83		1.69		0.75	0.34				0.85	0.81	1.27	2.17	2.8	1.23
G-26	Great Falls 193X	1.78	1.12	4.79	4.1	3.24	1.82	0.54				2.16	1.46		2.19	4.61	2.53
WEST BRANCH NARRAGUAGUS																	
W-11	Snowmobile bridge	0.39		0.8						0.44		0.63	0.27				0.51
W-13	Sprague Falls		ND		0.21	0.21	ND	ND				0.24	0.22	0.43	0.29	0.63	0.22
PLEASANT RIVER																	
P-4	Saco Falls		0.36				0.37	0.19				0.58	0.55	0.98	1.16	1.53	0.72
P-10	Crebo Crossing			0.29	0.19			ND	ND			0.24	ND		0.57	1.07	0.30
GROUNDWATER SITES																	
GW-1	Pork Brook Barrens										21.2		29.09		32.51	27.41	27.55
GW-2	Pine Ridge										1.47						1.47
GW-3	Columbia Town Hall										0.13						0.13
GW-4	Narraguagus High School										ND						0.00
DEBLOIS HATCHERY SITES																	
HGW-4	Well #4								1.2	1.24		1.31	1.32	0.43	0.4	0.42	0.90
H-1	Spring Pond								5.55	5.34		6.79	5.01	4.54		5.61	5.47
H-2	Bog Stream								1.45	1.89		2.11	1.74	2.1	2.28	2.83	2.06

Note: Hexazinone (Velpar) in ppb
Detection Limit is 0.1 ppb
ND=No Detection

FIGURE 2.3.3.a.

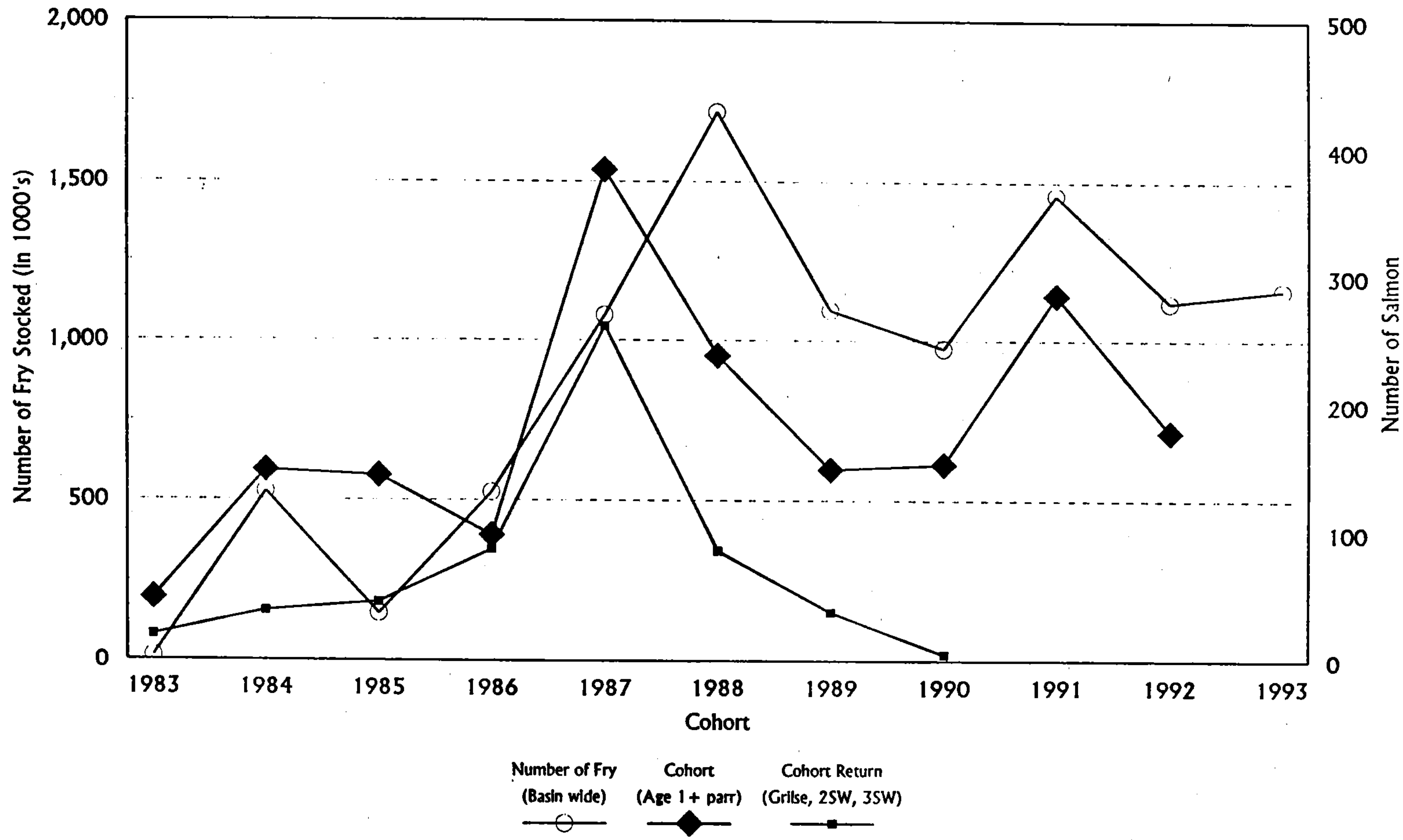
Number of Fry Stocked (in 1000's)
2,000
1,500
1,000
500
0
Number of Salmon
500
400
300
200
100
0
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
Cohort
Number of Fry (Basin wide)
Cohort (Age 1+ parr)
Cohort Return (Grilse, 2SW, 3SW)

TABLE 3.3.a. ATLANTIC SALMON STOCKING SUMMARY FOR NEW ENGLAND BY RIVER
1970 THROUGH 1992
NUMBER OF FRY ROUNDED TO NEAREST 1000 - ALL OTHER ENTRIES ROUNDED TO NEAREST 100

RIVER / YEAR	NUMBER OF FISH						
	FRY	0+PARR	1PARR	1+PARR	1SMOLT	2SMOLT	TOTAL
UPPER ST. JOHN							
1970	0	0	0	0	0	0	0
1971	0	0	0	0	0	0	0
1972	0	0	0	0	0	0	0
1973	0	0	0	0	0	0	0
1974	0	0	0	0	0	0	0
1975	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0
1979	0	2100	0	0	0	0	2100
1980	0	0	0	0	0	2700	2700
1981	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0
1990	110000	21000	9900	0	0	10300	10300
1991	228000	139300	0	0	0	9600	150500
1992	400000	136100	0	0	5100	5100	377500
			0	0	0	0	536100
TOTAL	738000	298500	9900	0	5100	27700	1079200

TABLE 3.3.a. Continued

RIVER / YEAR		FRY	0+PARR	1PARR	1+PARR	1SMOLT	2SMOLT	TOTAL
AROOSTOOK								
	1970	0	0	0	0	0	0	0
	1971	0	0	0	0	0	0	0
	1972	0	0	0	0	0	0	0
	1973	0	0	0	0	0	0	0
	1974	0	0	0	0	0	0	0
	1975	0	0	0	0	0	0	0
	1976	0	0	0	0	0	0	0
	1977	0	0	0	0	0	0	0
	1978	0	0	0	0	5200	0	5200
	1979	0	3100	0	0	0	0	3100
	1980	0	0	0	0	0	2600	2600
	1981	0	25200	20400	0	0	0	45600
	1982	0	0	0	0	0	0	0
	1983	0	0	0	0	0	0	0
	1984	0	0	0	0	0	0	0
	1985	0	0	0	0	0	0	0
	1986	0	0	0	0	0	0	0
	1987	41000	0	0	0	0	0	41000
	1988	43000	0	0	0	0	0	43000
	1989	313000	242200	0	0	0	10000	565200
	1990	69000	0	0	0	27400	7600	104000
	1991	74000	0	0	0	0	9600	83600
	1992	0	0	16400	0	0	0	16400
TOTAL		540000	270500	36800	0	32600	29800	909700

TABLE 3.3.a. Continued

RIVER / YEAR	FRY	0+PARR	1PARR	1+PARR	1SMOLT	2SMOLT	TOTAL
ST. CROIX							
1970	0	0	0	0	0	0	0
1971	0	0	0	0	0	0	0
1972	0	0	0	0	0	0	0
1973	0	0	0	0	0	0	0
1974	0	0	0	0	0	0	0
1975	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0
1979	0	0	0	0	0	0	0
1980	0	0	0	0	0	0	0
1981	0	0	0	0	0	20000	20000
1982	101000	20900	50000	0	19900	100	191900
1983	0	0	25500	0	20000	0	45500
1984	54000	0	13800	0	92500	0	160300
1985	178000	46400	12900	0	59600	0	296900
1986	0	0	0	0	73500	0	73500
1987	266000	0	41000	0	59800	0	366800
1988	0	0	0	0	78700	0	78700
1989	0	0	0	0	50600	0	50600
1990	255000	0	0	0	65800	0	320800
1991	51000	40000	0	0	60200	0	151200
1992	85000	56500	14900	0	50300	0	206700
TOTAL	990000	163800	158100	0	630900	20100	1962900

TABLE 3.3.a. Continued

RIVER / YEAR		FRY	0+PARR	1PARR	1+PARR	1SMOLT	2SMOLT	TOTAL
DENNYS								
	1970	0	0	0	0	0	0	0
	1971	0	0	0	0	0	0	0
	1972	0	0	0	0	0	0	0
	1973	0	0	0	0	0	0	0
	1974	0	0	0	0	0	0	0
	1975	0	0	3000	0	0	4200	7200
	1976	0	0	0	0	0	8900	8900
	1977	0	0	0	0	0	0	0
	1978	0	0	0	0	30200	0	30200
	1979	0	0	0	0	10200	0	10200
	1980	0	0	0	0	0	15200	15200
	1981	0	0	0	0	0	0	0
	1982	0	0	0	0	0	0	0
	1983	20000	0	0	0	5200	0	25200
	1984	0	0	0	0	3300	0	3300
	1985	0	0	0	0	4500	0	4500
	1986	0	8300	0	0	5400	0	13700
	1987	24000	0	0	0	9000	0	33000
	1988	20000	0	0	0	25700	0	45700
	1989	12000	0	0	0	12100	0	24100
	1990	20000	0	0	0	25800	0	45800
	1991	25000	0	400	0	11700	0	37100
	1992	0	0	0	0	0	0	0
TOTAL		121000	8300	3400	0	143100	28300	304100

TABLE 3.3.a. Continued

RIVER / YEAR	FRY	0+PARR	1PARR	1+PARR	1SMOLT	2SMOLT	TOTAL
PLEASANT							
1970	0	0	0	0	0	0	0
1971	0	0	0	0	0	0	0
1972	0	0	0	0	0	0	0
1973	0	0	0	0	0	0	0
1974	0	0	0	0	0	0	0
1975	0	0	0	0	0	3000	3000
1976	0	0	0	0	0	1000	1000
1977	0	0	0	0	3100	0	3100
1978	0	0	0	0	3100	0	3100
1979	0	0	0	0	0	0	0
1980	0	0	0	0	200	10000	10200
1981	0	0	0	0	0	4100	4100
1982	0	0	0	0	5000	0	5000
1983	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0
1985	33000	0	0	0	4100	0	37100
1986	0	0	0	0	6500	0	6500
1987	25000	0	0	0	7500	0	32500
1988	25000	0	0	0	10500	0	35500
1989	26000	2500	0	0	7300	0	35800
1990	30000	0	0	0	10500	0	40500
1991	23000	0	0	0	0	0	23000
1992	0	0	0	0	0	0	0
TOTAL	162000	2500	0	0	57800	18100	240400

TABLE 3.3.a. Continued

RIVER / YEAR		FRY	0+PARR	1PARR	1+PARR	1SMOLT	2SMOLT	TOTAL
EAST MACHIAS								
	1970	0	0	0	0	0	0	0
	1971	0	0	0	0	0	0	0
	1972	0	0	0	0	0	0	0
	1973	0	0	0	0	0	2000	2000
	1974	0	0	0	0	0	0	0
	1975	0	0	0	0	0	3000	3000
	1976	0	0	0	0	0	3900	3900
	1977	0	0	0	0	0	0	0
	1978	0	0	0	0	12200	0	12200
	1979	0	0	0	0	5200	0	5200
	1980	0	0	0	0	0	15900	15900
	1981	0	0	0	0	0	0	0
	1982	0	0	0	0	0	5600	5600
	1983	0	0	0	0	0	0	0
	1984	0	0	8700	0	0	0	8700
	1985	13000	0	0	0	4500	0	17500
	1986	8000	0	0	0	5300	0	13300
	1987	0	0	0	0	9000	0	9000
	1988	10000	0	0	0	20700	0	30700
	1989	30000	6500	8000	0	15300	0	59800
	1990	42000	0	10100	0	10100	0	62200
	1991	27000	0	8300	0	15300	0	50600
	1992	0	0	0	0	0	0	0
TOTAL		130000	6500	35100	0	97600	30400	299600

TABLE 3.3.a. Continued

RIVER / YEAR	FRY	0+PARR	1PARR	1+PARR	1SMOLT	2SMOLT	TOTAL
MACHIAS							
1970	0	0	0	0	0	10700	10700
1971	0	0	0	0	5100	3400	8500
1972	0	0	0	0	8500	4400	12900
1973	0	0	0	0	0	6100	6100
1974	0	0	0	0	0	6500	6500
1975	0	0	0	0	0	0	0
1976	0	0	0	0	5300	11100	16400
1977	0	0	0	0	0	0	0
1978	0	0	0	0	10200	0	10200
1979	0	0	0	0	10200	0	10200
1980	0	0	0	0	0	0	0
1981	0	0	0	0	0	0	0
1982	0	0	0	0	5500	0	5500
1983	0	12500	0	0	0	0	12500
1984	0	0	0	0	15800	0	15800
1985	0	0	7000	0	5100	0	12100
1986	8000	8000	0	0	0	0	16000
1987	0	12500	12300	0	13600	0	38400
1988	15000	0	6800	0	30900	0	52700
1989	49000	13800	28000	0	23100	0	113900
1990	75000	10100	17600	0	26100	0	128800
1991	13000	30000	21400	0	21100	0	85500
1992	14000	0	0	0	0	0	14000
TOTAL	174000	86900	93100	0	180500	42200	576700

TABLE 3.3.a. Continued

RIVER / YEAR	FRY	0+PARR	1PARR	1+PARR	1SMOLT	2SMOLT	TOTAL
NARRAGUAGUS							
1970	0	0	0	0	0	11800	11800
1971	0	0	0	0	0	2900	2900
1972	0	0	0	0	0	15700	15700
1973	0	0	0	0	0	5600	5600
1974	0	0	0	0	0	0	0
1975	0	0	0	0	0	5000	5000
1976	0	0	0	0	0	8400	8400
1977	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0
1979	0	0	0	0	10100	0	10100
1980	0	0	0	0	0	20400	20400
1981	0	0	0	0	0	4100	4100
1982	0	0	0	0	0	5200	5200
1983	0	7800	0	0	0	0	7800
1984	0	0	0	0	5200	0	5200
1985	10000	0	0	0	4500	0	14500
1986	0	0	0	0	7500	0	7500
1987	15000	0	0	0	9000	0	24000
1988	20000	13000	5600	0	15700	0	54300
1989	29000	9500	7000	0	22100	4900	72500
1990	0	0	0	0	16800	0	16800
1991	0	0	0	0	15200	0	15200
1992	0	0	0	0	0	0	0
TOTAL	74000	30300	12600	0	106100	84000	307000

TABLE 3.3.a. Continued

RIVER / YEAR	FRY	0+PARR	1PARR	1+PARR	1SMOLT	2SMOLT	TOTAL
UNION							
1970	0	0	0	0	0	0	0
1971	0	0	0	0	8100	0	8100
1972	0	0	0	0	0	7700	7700
1973	0	0	0	0	0	19600	19600
1974	0	0	0	0	9900	20400	30300
1975	0	0	0	0	0	31300	31300
1976	0	0	0	0	1800	31800	33600
1977	0	0	0	0	13000	22500	35500
1978	0	0	0	0	0	31900	31900
1979	0	0	0	0	12900	29900	42800
1980	0	0	0	0	30600	0	30600
1981	0	0	0	0	0	29400	29400
1982	0	0	0	0	5900	26500	32400
1983	0	0	0	0	41600	0	41600
1984	0	0	0	0	50200	0	50200
1985	7000	0	0	0	45800	0	52800
1986	7000	0	0	0	48400	0	55400
1987	7000	0	0	0	40100	0	47100
1988	0	0	0	0	30600	0	30600
1989	0	0	0	0	20400	0	20400
1990	0	0	0	0	20400	0	20400
1991	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0
TOTAL	21000	0	0	0	379700	251000	651700

TABLE 3.3.a. Continued

RIVER / YEAR		FRY	0+PARR	1PARR	1+PARR	1SMOLT	2SMOLT	TOTAL
PENOBSCOT								
	1970	0	25000	0	0	0	28500	53500
	1971	0	0	15800	0	52600	0	68400
	1972	129000	0	0	0	0	73800	202800
	1973	0	0	0	0	12400	95800	108200
	1974	0	0	35100	9100	34300	65900	144400
	1975	0	0	12300	0	15800	94800	122900
	1976	0	0	83800	0	54700	180100	318600
	1977	0	0	0	0	113800	224700	338500
	1978	0	0	126800	0	61100	141400	329300
	1979	95000	0	0	0	50000	246300	391300
	1980	0	0	0	0	369000	215600	584600
	1981	202000	25400	50300	0	24700	174800	477200
	1982	248000	50900	206400	0	107400	222300	835000
	1983	0	0	31900	0	275300	161400	468600
	1984	80000	34400	0	0	481500	135600	731500
	1985	144000	59500	17600	0	476500	104400	802000
	1986	94000	25700	0	0	520200	69000	708900
	1987	335000	58100	101100	0	456800	82400	1033400
	1988	201000	0	1900	0	599900	87100	889900
	1989	77000	104100	179600	0	351300	65300	777300
	1990	317000	166500	155300	0	413200	15900	1067900
	1991	398000	202600	104100	0	657800	15000	1377500
	1992	925000	278200	106600	0	817000	8100	2134900
TOTAL		3245000	1030400	1228600	9100	5945300	2508200	13966600

TABLE 3.3.a. Continued

RIVER / YEAR		FRY	0+PARR	1PARR	1+PARR	1SMOLT	2SMOLT	TOTAL
DUCKTRAP								
	1970	0	0	0	0	0	0	0
	1971	0	0	0	0	0	0	0
	1972	0	0	0	0	0	0	0
	1973	0	0	0	0	0	0	0
	1974	0	0	0	0	0	0	0
	1975	0	0	0	0	0	0	0
	1976	0	0	0	0	0	0	0
	1977	0	0	0	0	0	0	0
	1978	0	0	0	0	0	0	0
	1979	0	0	0	0	0	0	0
	1980	0	0	0	0	0	0	0
	1981	0	0	0	0	0	0	0
	1982	0	0	0	0	0	0	0
	1983	0	0	0	0	0	0	0
	1984	0	0	0	0	0	0	0
	1985	15000	0	0	0	0	0	15000
	1986	8000	0	0	0	0	0	8000
	1987	15000	0	0	0	0	0	15000
	1988	0	0	0	0	0	0	0
	1989	17000	0	0	0	0	0	17000
	1990	18000	0	0	0	0	0	18000
	1991	0	0	0	0	0	0	0
	1992	0	0	0	0	0	0	0
TOTAL		73000	0	0	0	0	0	73000

TABLE 3.3.a. Continued

RIVER / YEAR		FRY	0+PARR	1PARR	1+PARR	1SMOLT	2SMOLT	TOTAL
SHEEPSCOT								
	1970	0	0	0	0	0	0	0
	1971	0	0	0	0	1000	0	1000
	1972	0	0	0	0	0	0	0
	1973	0	0	0	0	0	1000	1000
	1974	0	0	0	0	0	0	0
	1975	0	0	0	0	0	2500	2500
	1976	0	0	0	0	3000	0	3000
	1977	0	0	0	0	0	0	0
	1978	0	0	0	0	0	0	0
	1979	0	0	0	0	0	0	0
	1980	0	0	0	0	0	0	0
	1981	0	0	0	0	0	0	0
	1982	0	0	0	0	5300	0	5300
	1983	0	0	0	0	5200	0	5200
	1984	0	0	0	0	5000	0	5000
	1985	20000	0	0	0	3900	3600	27500
	1986	0	11600	0	0	7500	0	19100
	1987	15000	8200	0	0	9000	0	32200
	1988	40000	12300	0	0	10200	0	62500
	1989	29000	13600	10000	0	10200	0	62800
	1990	27000	10100	10000	0	17500	0	64600
	1991	18000	15000	600	0	14400	0	48000
	1992	0	0	0	0	0	0	0
TOTAL		149000	70800	20600	0	92200	7100	339700

TABLE 3.3.a. Continued

RIVER / YEAR		FRY	0+PARR	1PARR	1+PARR	1SMOLT	2SMOLT	TOTAL
SACO								
	1970	0	0	0	0	0	0	0
	1971	0	0	0	0	0	0	0
	1972	0	0	0	0	0	0	0
	1973	0	0	0	0	0	0	0
	1974	0	0	0	0	0	0	0
	1975	0	0	0	0	0	9500	9500
	1976	0	0	0	0	0	0	0
	1977	0	0	0	0	0	0	0
	1978	0	0	0	0	0	0	0
	1979	0	0	0	0	0	0	0
	1980	0	0	0	0	0	0	0
	1981	0	0	0	0	0	0	0
	1982	0	47100	0	0	0	0	47100
	1983	0	0	0	0	20300	0	20300
	1984	0	0	0	0	5100	0	5100
	1985	0	0	23600	0	5100	0	28700
	1986	0	0	0	0	35200	0	35200
	1987	0	0	0	0	22000	0	22000
	1988	0	0	0	0	25100	0	25100
	1989	0	37800	49600	0	9900	0	97300
	1990	0	30100	47800	0	10600	0	88500
	1991	111000	0	0	0	10300	0	121300
	1992	154000	50200	400	0	19800	0	224400
TOTAL		265000	165200	121400	0	163400	9500	724500

TABLE 3.3.a. Continued

RIVER / YEAR	FRY	0+PARR	1PARR	1+PARR	1SMOLT	2SMOLT	TOTAL
COCHECO							
1970	0	0	0	0	0	0	0
1971	0	0	0	0	0	0	0
1972	0	0	0	0	0	0	0
1973	0	0	0	0	0	0	0
1974	0	0	0	0	0	0	0
1975	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0
1979	0	0	0	0	0	0	0
1980	0	0	0	0	0	0	0
1981	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0
1988	2000	0	0	0	0	0	2000
1989	106000	0	0	0	0	0	106000
1990	32000	50000	9500	0	0	0	91500
1991	138000	0	0	0	0	0	138000
1992	128000	0	0	0	0	0	128000
TOTAL	406000	50000	9500	0	0	0	465500

TABLE 3.3.a. Continued

RIVER / YEAR	FRY	0+PARR	1PARR	1+PARR	1SMOLT	2SMOLT	TOTAL
LAMPREY							
1970	0	0	0	0	0	0	0
1971	0	0	0	0	0	0	0
1972	0	0	0	0	0	0	0
1973	0	0	0	0	0	0	0
1974	0	0	0	0	0	0	0
1975	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0
1978	0	0	0	0	19600	0	19600
1979	0	0	0	0	8600	5800	14400
1980	0	0	0	0	39900	8400	48300
1981	0	0	0	0	19500	12200	31700
1982	0	0	0	0	30700	6400	37100
1983	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0
1989	146000	0	0	0	0	0	146000
1990	50000	87000	11400	0	0	0	148400
1991	110000	68200	0	0	0	0	178200
1992	127000	12700	0	0	0	0	139700
TOTAL	433000	167900	11400	0	118300	32800	763400

TABLE 3.3.a. Continued

RIVER / YEAR		FRY	0+PARR	1PARR	1+PARR	1SMOLT	2SMOLT	TOTAL
MERRIMACK								
	1970	0	0	0	0	0	0	0
	1971	0	0	0	0	0	0	0
	1972	0	0	0	0	0	0	0
	1973	0	0	0	0	0	0	0
	1974	0	0	0	0	0	0	0
	1975	36000	0	0	0	0	0	36000
	1976	63000	75900	0	16600	0	2100	157600
	1977	72000	0	0	700	0	31000	103700
	1978	106000	0	0	0	21300	25900	153200
	1979	77000	0	0	0	15000	24700	116700
	1980	126000	0	0	0	2300	28700	157000
	1981	57000	0	0	0	2600	98300	157900
	1982	50000	81600	0	95500	5400	65600	298100
	1983	8000	5000	15000	5000	47000	62900	142900
	1984	526000	0	23300	9800	24400	43800	627300
	1985	148000	0	5800	0	64000	125300	343100
	1986	525000	0	31500	0	39900	64100	660500
	1987	1078000	0	99300	0	141600	0	1318900
	1988	1718000	0	129600	0	94400	0	1942000
	1989	1034000	60000	88600	0	58600	0	1241200
	1990	975000	0	5600	29700	116900	0	1127200
	1991	1458000	0	0	0	62000	58100	1578100
	1992	1118000	0	100	0	96400	0	1214500
TOTAL		9175000	222500	398800	157300	791800	630500	11375900

TABLE 3.3.a. Continued

RIVER / YEAR	FRY	0+PARR	1PARR	1+PARR	1SMOLT	2SMOLT	TOTAL
PAWCATUCK							
1970	0	0	0	0	0	0	0
1971	0	0	0	0	0	0	0
1972	0	0	0	0	0	0	0
1973	0	0	0	0	0	0	0
1974	0	0	0	0	0	0	0
1975	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0
1979	0	136000	0	0	0	0	136000
1980	0	1000	0	0	0	0	1000
1981	0	2000	108000	0	800	0	110800
1982	2000	1000	0	0	0	0	3000
1983	0	700	0	0	0	0	700
1984	0	23000	0	0	0	0	23000
1985	8000	51000	1400	0	0	0	60400
1986	0	50700	15000	0	0	0	65700
1987	3000	46200	4700	0	1000	0	54900
1988	150000	59600	7100	0	5400	0	222100
1989	0	379900	35800	0	6500	0	422200
1990	0	83500	55000	0	7500	0	146000
1991	0	101000	1000	0	2000	500	104500
1992	0	70800	2500	0	5000	0	78300
TOTAL	163000	1006400	230500	0	28200	500	1428600

TABLE 3.3.a. Continued

RIVER / YEAR		FRY	0+PARR	1PARR	1+PARR	1SMOLT	2SMOLT	TOTAL
CONNECTICUT								
	1970	0	0	0	0	0	0	0
	1971	60000	15000	7800	2900	5600	12400	103700
	1972	0	0	2700	2300	4600	13100	22700
	1973	0	15000	1000	21100	1400	31900	70400
	1974	16000	0	9400	15600	10400	44000	95400
	1975	31900	0	1700	16400	2800	70000	122800
	1976	26600	0	5000	24200	4000	30500	90300
	1977	49500	0	0	15400	0	99200	164100
	1978	50000	0	0	36600	0	94300	180900
	1979	53500	0	0	38400	0	145100	237000
	1980	286000	0	0	11500	0	51800	349300
	1981	168000	182700	1900	3600	5300	73300	434800
	1982	294000	9400	25100	9600	28100	180800	547000
	1983	226000	115400	293800	400	89100	8900	733600
	1984	625000	178600	241200	11400	312300	0	1368500
	1985	422000	130500	110700	0	255000	0	918200
	1986	176000	188400	267100	0	290500	0	922000
	1987	1180000	383200	345100	0	206000	0	2114300
	1988	1310000	72200	75200	0	395300	0	1852700
	1989	1243000	268700	76800	0	217700	0	1806200
	1990	1271000	341600	25400	0	475900	0	2113900
	1991	1725000	306200	33100	0	351000	0	2415300
	1992	2009000	313900	11500	0	313300	0	2647700
TOTAL		11222500	2520800	1534500	209400	2968300	855300	19310800

TABLE 3.3.a. Continued

GRAND TOTAL BY RIVER (1970 THROUGH 1992)

RIVER	NUMBER OF FISH						
	FRY	0+PARR	1PARR	1+PARR	1SMOLT	2SMOLT	TOTAL
Upper St. John	738000	298500	9900	0	5100	27700	1079200
Aroostook	540000	270500	36800	0	32600	29800	909700
St. Croix	990000	163800	158100	0	630900	20100	1962900
Dennys	121000	8300	3400	0	143100	28300	304100
Pleasant	162000	2500	0	0	57800	18100	240400
East Machias	130000	6500	35100	0	97600	30400	299600
Machias	174000	86900	93100	0	180500	42200	576700
Narraguagus	74000	30300	12600	0	106100	84000	307000
Union	21000	0	0	0	379700	251000	651700
Penobscot	3245000	1030400	1228600	9100	5945300	2508200	13966600
Ducktrap	73000	0	0	0	0	0	73000
Sheepscot	149000	70800	20600	0	92200	7100	339700
Saco	265000	165200	121400	0	163400	9500	724500
Cocheco	406000	50000	9500	0	0	0	465500
Lamprey	433000	167900	11400	0	118300	32800	763400
Merrimack	9175000	222500	398800	157300	791800	630500	11375900
Pawcatuck	163000	1006400	230500	0	28200	500	1428600
Connecticut	11222500	2520800	1534500	209400	2968300	855300	19310800

TABLE 3.3.b. HISTORICAL ATLANTIC SALMON RETURNS TO NEW ENGLAND RIVERS 1970 THROUGH 1992 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 / YEAR	HATCHERY ORIGIN				WILD ORIGIN				
	1-S-W	2-S-W	3-S-W	REPEAT	1-S-W	2-S-W	3-S-W	REPEAT	TOTAL
PENOBSCOT									
1970	7	124	1	2	0	2	0	0	136
1971	21	89	1	1	0	2	0	0	114
1972	11	311	4	1	0	10	0	0	337
1973	10	290	2	7	0	2	0	0	311
1974	31	516	24	9	0	1	0	0	581
1975	45	917	11	19	0	8	0	0	1000
1976	75	563	4	6	0	20	0	0	668
1977	44	581	4	12	0	3	0	0	644
1978	123	1547	12	26	0	55	0	0	1763
1979	203	671	3	15	0	8	0	0	900
1980	652	2570	2	38	0	18	2	0	3282
1981	888	2454	12	24	3	18	2	0	3401
1982	155	3886	20	20	13	55	1	3	4153
1983	179	705	6	13	5	51	1	1	961
1984	239	1387	6	45	25	107	2	0	1811
1985	244	2868	6	9	22	202	1	4	3356
1986	534	3620	14	8	17	332	3	1	4529
1987	749	1477	29	49	19	162	5	20	2510
1988	716	1993	6	52	14	64	0	10	2855
1989	867	2005	4	36	67	103	1	4	3087
1990	430	2520	14	26	93	254	3	2	3342
1991	176	1085	4	21	40	427	0	4	1757
1992	932	1174	0	5	27	236	1	4	2379
TOTAL	7331	33353	189	444	345	2140	22	53	43877
UNION									
1970									
1971									
1972									
1973	3	72	0	0	0	0	0	0	75
1974	6	13	1	0	0	0	0	0	20
1975	23	56	0	0	0	0	0	0	79
1976	90	158	0	0	0	0	0	0	248
1977	13	222	1	8	0	0	0	0	244
1978	4	147	2	4	0	0	0	0	157
1979	6	38	0	1	0	0	0	0	45
1980	42	197	0	1	0	0	0	0	240
1981	10	284	1	0	0	0	0	0	295
1982	30	118	1	7	0	0	0	0	156
1983	25	116	1	2	0	4	0	0	148
1984	3	37	0	0	0	0	0	0	40
1985	3	79	0	0	0	0	0	0	82
1986	7	59	1	0	0	0	0	0	67
1987	19	43	0	1	0	0	0	0	63
1988	0	45	0	0	0	2	0	0	47
1989	4	25	1	0	0	0	0	0	30
1990	1	20	0	0	0	0	0	0	21
1991	1	1	0	0	1	5	0	0	8
1992	0	4	0	0	0	0	0	0	4
TOTAL	290	1734	9	24	1	11	0	0	2069

TABLE 3.3.b. Continued

STREAM SYSTEM / YEAR	HATCHERY ORIGIN				WILD ORIGIN				
	1-S-W	2-S-W	3-S-W	REPEAT	1-S-W	2-S-W	3-S-W	REPEAT	TOTAL
NARRAGUAGUS									
1970	1	13	0	0	0	120	7	5	146
1971	2	33	0	0	3	67	3	0	108
1972	1	81	7	0	3	211	17	13	333
1973	2	22	2	2	1	135	3	3	170
1974	3	20	2	1	1	118	6	12	163
1975	0	2	0	0	0	103	2	4	111
1976	0	4	0	0	0	25	0	3	32
1977	2	5	0	0	1	105	0	11	124
1978	0	35	0	0	0	94	2	2	133
1979	0	9	0	0	0	49	0	0	58
1980	0	0	0	0	0	112	0	3	115
1981	1	20	0	1	0	49	0	2	73
1982	0	11	0	1	0	57	0	10	79
1983	2	17	0	0	0	69	0	2	90
1984	0	10	0	0	0	57	0	1	68
1985	0	0	0	0	0	56	0	1	57
1986	0	20	0	0	2	23	0	0	45
1987	0	11	0	0	0	24	0	2	37
1988	1	10	0	0	2	24	0	1	38
1989	3	9	0	0	1	26	0	0	39
1990	1	22	0	0	0	27	0	1	51
1991	3	19	0	5	8	53	0	7	95
1992	6	19	0	1	11	32	0	4	73
TOTAL	28	392	11	11	33	1636	40	87	2238
PLEASANT									
1970	0	0	0	0	0	1	0	0	1
1971	0	0	0	0	0	1	0	0	1
1972	0	0	0	0	0	1	0	0	1
1973	0	0	0	0	0	2	0	0	2
1974	0	0	0	0	2	27	1	0	30
1975	0	0	0	0	1	6	1	0	8
1976	0	0	0	0	0	1	0	0	1
1977	0	0	0	0	0	3	0	0	3
1978	0	0	0	0	0	16	0	0	16
1979	0	0	0	0	0	8	0	0	8
1980	0	0	0	0	0	5	0	0	5
1981	0	0	0	0	0	23	0	0	23
1982	4	8	0	0	0	6	0	1	19
1983	0	0	0	0	2	35	0	1	38
1984	0	0	0	0	1	16	0	0	17
1985	0	0	0	0	3	28	0	0	31
1986	0	0	0	0	0	19	0	0	19
1987	0	4	0	0	0	5	0	0	9
1988									
1989	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0
TOTAL	4	12	0	0	9	203	2	2	232

TABLE 3.3.b. Continued

STREAM SYSTEM / YEAR	HATCHERY ORIGIN				WILD ORIGIN				
	1-S-W	2-S-W	3-S-W	REPEAT	1-S-W	2-S-W	3-S-W	REPEAT	TOTAL
MACHIAS									
1970	0	13	1	0	0	211	6	9	240
1971	2	26	1	0	1	137	5	4	176
1972	5	69	4	0	3	180	5	3	269
1973	0	7	0	0	0	28	0	0	35
1974	4	6	0	0	0	26	0	0	36
1975	0	10	0	0	5	36	0	0	51
1976	2	5	0	0	0	18	0	0	25
1977	2	8	0	0	0	15	0	0	25
1978	0	15	0	0	0	87	0	3	105
1979	0	8	0	0	0	58	0	0	66
1980	0	13	0	0	0	58	0	7	78
1981	0	19	0	0	0	31	0	3	53
1982	0	0	1	0	1	52	0	2	56
1983	0	0	0	0	0	16	0	1	17
1984	0	8	0	0	2	21	0	2	33
1985	0	5	0	0	0	25	0	2	32
1986	2	16	0	0	2	24	0	2	46
1987	0	0	0	0	0	4	0	0	4
1988	0	0	0	0	0	6	0	2	8
1989	3	4	0	0	4	5	0	0	16
1990	0	1	0	0	0	1	0	0	2
1991	1	0	0	0	1	0	0	0	2
1992	0	3	0	0	0	0	0	0	3
TOTAL	**21**	**236**	**7**	**0**	**19**	**1039**	**16**	**40**	**1378**
EAST MACHIAS									
1970	0	0	0	0	0	1	0	0	1
1971	0	1	0	0	0	5	0	0	6
1972	0	1	0	0	0	3	0	0	4
1973	0	1	0	0	0	5	0	0	6
1974	0	1	0	0	0	1	0	0	2
1975	0	8	0	0	0	20	0	2	30
1976	2	16	0	2	0	0	0	0	20
1977	0	9	1	0	0	19	0	1	30
1978	0	13	0	0	0	46	0	0	59
1979	0	7	0	0	0	18	0	0	25
1980	0	24	0	0	2	34	0	2	62
1981	4	67	0	0	4	24	0	1	100
1982	0	15	0	0	0	22	0	0	37
1983	0	3	0	0	0	5	0	0	8
1984	0	9	0	0	3	33	0	2	47
1985	0	0	0	0	0	30	0	0	30
1986	0	5	0	0	0	8	0	0	13
1987	0	8	0	0	0	5	1	0	14
1988	1	8	0	0	0	5	0	0	14
1989	12	10	0	0	2	6	0	1	31
1990	1	30	0	0	0	16	0	1	48
1991	1	2	0	0	1	1	0	0	5
1992	0	6	0	0	0	0	0	0	6
TOTAL	**21**	**244**	**1**	**2**	**12**	**307**	**1**	**10**	**598**

TABLE 3.3.b. Continued

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
DENNYS									
1970	0	0	0	0	0	49	0	0	49
1971	0	0	0	0	0	19	0	0	19
1972	0	0	0	0	0	61	0	0	61
1973	1	0	0	0	0	40	0	0	41
1974	0	0	0	0	3	43	0	3	49
1975	0	0	0	0	0	40	0	0	40
1976	0	0	0	0	2	13	0	5	20
1977	0	0	0	0	0	26	0	0	26
1978	0	37	0	0	0	38	0	0	75
1979	0	0	0	0	0	36	0	2	38
1980	0	117	0	0	0	73	0	0	190
1981	6	74	0	0	0	43	3	0	126
1982	3	15	0	0	6	14	0	0	38
1983	0	0	0	0	0	28	0	0	28
1984	0	0	0	0	7	61	0	0	68
1985	0	6	0	0	0	14	0	0	20
1986	0	7	0	0	0	8	0	0	15
1987	0	0	0	0	0	1	0	0	1
1988	0	3	0	0	0	6	0	0	9
1989	1	10	0	0	0	1	0	0	12
1990	1	20	0	1	0	11	0	0	33
1991	1	0	0	0	0	6	0	0	7
1992	1	3	0	0	0	1	0	0	5
TOTAL	**14**	**292**	**0**	**1**	**18**	**632**	**3**	**10**	**970**
ST. CROIX									
1970									
1971									
1972									
1973									
1974									
1975									
1976									
1977									
1978									
1979									
1980									
1981	25	14	1	0	24	14	1	0	79
1982	28	1	0	0	56	13	1	0	99
1983	14	62	4	0	11	28	3	0	122
1984	138	50	5	0	39	11	1	0	244
1985	28	144	14	0	28	122	14	0	350
1986	34	116	13	0	33	116	13	0	325
1987	108	63	1	0	94	103	6	0	375
1988	76	229	0	3	18	61	0	1	388
1989	78	66	0	1	44	44	0	8	241
1990	6	59	0	7	12	26	0	2	112
1991	41	90	0	0	16	38	0	4	189
1992	1	0	0	0	0	0	0	0	1
TOTAL	**577**	**894**	**38**	**11**	**375**	**576**	**39**	**15**	**2525**

TABLE 3.3.b. Continued

STREAM SYSTEM / YEAR	HATCHERY ORIGIN				WILD ORIGIN				
	1-S-W	2-S-W	3-S-W	REPEAT	1-S-W	2-S-W	3-S-W	REPEAT	TOTAL
SHEEPSCOT									
1970	0	0	0	0	1	5	0	0	6
1971	0	0	0	0	2	27	1	0	30
1972	0	0	0	0	1	18	1	0	20
1973	0	0	0	0	1	18	1	0	20
1974	0	0	0	0	1	18	1	0	20
1975	0	0	0	0	1	10	0	0	11
1976	0	0	0	0	1	9	0	0	10
1977	0	0	0	0	1	22	1	0	24
1978	0	0	0	0	2	32	1	0	35
1979	0	0	0	0	1	7	0	0	8
1980	0	0	0	0	2	27	1	0	30
1981	0	0	0	0	1	14	0	0	15
1982	0	0	0	0	1	14	0	0	15
1983	0	0	0	0	1	11	0	0	12
1984	0	0	0	0	1	20	1	0	22
1985	0	0	0	0	1	5	0	0	6
1986	0	0	0	0	1	10	0	0	11
1987	2	7	0	0	1	5	0	0	15
1988	1	0	0	0	0	0	0	0	1
1989	1	1	0	0	2	1	0	0	5
1990	1	8	0	0	0	0	0	0	9
1991	0	4	0	0	0	0	0	0	4
1992	1	2	0	0	1	2	1	0	7
TOTAL	6	22	0	0	24	275	9	0	336
DUCKTRAP									
1970									
1971									
1972									
1973									
1974									
1975									
1976									
1977									
1978									
1979									
1980									
1981									
1982									
1983									
1984									
1985	0	0	0	0	0	15	0	0	15
1986	0	0	0	0	3	12	0	0	15
1987	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	3	0	0	3
1991	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0
TOTAL	0	0	0	0	3	30	0	0	33

TABLE 3.3.b. Continued

STREAM SYSTEM / YEAR	HATCHERY ORIGIN 1-S-W	2-S-W	3-S-W	REPEAT	WILD ORIGIN 1-S-W	2-S-W	3-S-W	REPEAT	TOTAL
KENNEBEC									
1970									
1971									
1972									
1973									
1974									
1975	2	30	0	0	0	1	0	0	33
1976	0	2	2	0	0	0	0	0	4
1977	0	2	0	0	0	0	0	0	2
1978	0	2	0	0	0	0	0	0	2
1979	0	18	0	0	0	2	0	0	20
1980	1	3	0	0	0	0	0	0	4
1981	1	13	0	0	0	0	0	0	14
1982	1	22	1	0	0	0	0	0	24
1983	1	16	1	0	0	0	0	0	18
1984	0	1	0	0	0	0	0	0	1
1985	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0
1987	0	2	1	0	0	2	0	0	5
1988	4	15	0	1	0	0	0	0	20
1989	1	16	0	0	0	0	0	0	17
1990	1	41	0	0	0	4	0	0	46
1991	0	4	0	0	0	0	0	0	4
1992	0	0	0	0	0	0	0	0	0
TOTAL	**12**	**187**	**5**	**1**	**0**	**9**	**0**	**0**	**214**
ANDROSCOGGIN									
1970									
1971									
1972									
1973									
1974									
1975									
1976									
1977									
1978									
1979									
1980									
1981									
1982									
1983	1	16	0	0	0	3	0	1	21
1984	4	79	1	0	0	7	0	0	91
1985	1	18	0	0	0	2	0	0	21
1986	0	72	1	0	0	8	0	0	81
1987	2	20	3	0	0	1	0	0	26
1988	2	11	0	0	1	0	0	0	14
1989	1	17	0	0	0	1	0	0	19
1990	6	168	0	1	1	9	0	0	185
1991	0	9	0	0	0	12	0	0	21
1992	2	9	0	0	1	3	0	0	15
TOTAL	**19**	**419**	**5**	**1**	**3**	**46**	**0**	**1**	**494**

TABLE 3.3.b. Continued

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
SACO									
1970									
1971									
1972									
1973									
1974									
1975									
1976									
1977									
1978									
1979									
1980									
1981									
1982									
1983									
1984									
1985	2	58	0	0	0	0	0	0	60
1986	0	36	1	0	0	0	0	0	37
1987	4	34	1	0	0	1	0	0	40
1988	1	37	0	0	0	0	0	0	38
1989	2	16	0	1	0	0	0	0	19
1990	4	68	0	0	0	1	0	0	73
1991	0	4	0	0	0	0	0	0	4
1992	0	0	0	0	0	0	0	0	0
TOTAL	13	253	2	1	0	2	0	0	271
COCHECO									
1970									
1971									
1972									
1973									
1974									
1975									
1976									
1977									
1978									
1979									
1980									
1981									
1982									
1983									
1984									
1985									
1986									
1987									
1988									
1989									
1990									
1991									
1992	0	0	0	0	0	1	0	0	1
TOTAL	0	0	0	0	0	1	0	0	1

TABLE 3.3.b. Continued

STREAM SYSTEM / YEAR	HATCHERY ORIGIN				WILD ORIGIN				
	1-S-W	2-S-W	3-S-W	REPEAT	1-S-W	2-S-W	3-S-W	REPEAT	TOTAL
LAMPREY									
1970									
1971									
1972									
1973									
1974									
1975									
1976									
1977									
1978									
1979	2	0	0	0	0	0	0	0	2
1980	2	5	0	0	0	0	0	0	7
1981	2	0	0	0	0	0	0	0	2
1982	2	9	0	0	0	0	0	0	11
1983	2	0	1	0	0	0	0	0	3
1984	0	3	0	0	0	0	0	0	3
1985	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	2	0	0	2
TOTAL	**10**	**17**	**1**	**0**	**0**	**2**	**0**	**0**	**30**
MERRIMACK									
1970									
1971									
1972									
1973									
1974									
1975									
1976									
1977									
1978									
1979									
1980									
1981									
1982	3	14	0	0	4	2	0	0	23
1983	7	54	5	0	1	41	6	0	114
1984	64	20	0	0	16	12	3	0	115
1985	8	112	1	0	5	85	2	0	213
1986	19	33	0	0	4	44	3	0	103
1987	8	94	4	0	2	26	5	0	139
1988	4	16	2	0	4	38	1	0	65
1989	3	24	1	0	0	55	1	0	84
1990	3	115	1	0	24	104	1	0	248
1991	1	76	0	0	0	254	1	0	332
1992	17	66	2	0	14	100	0	0	199
TOTAL	**137**	**624**	**16**	**0**	**74**	**761**	**23**	**0**	**1635**

TABLE 3.3.b. Continued

STREAM SYSTEM / YEAR	HATCHERY ORIGIN				WILD ORIGIN				
	1-S-W	2-S-W	3-S-W	REPEAT	1-S-W	2-S-W	3-S-W	REPEAT	TOTAL
PAWCATUCK									
1970									
1971									
1972									
1973									
1974									
1975									
1976									
1977									
1978									
1979									
1980									
1981									
1982	0	38	0	0	0	0	0	0	38
1983	1	37	0	0	0	0	0	0	38
1984	0	26	0	0	0	0	0	0	26
1985	0	1	0	0	0	0	0	0	1
1986	0	0	0	0	0	0	0	0	0
1987	0	1	0	0	0	0	0	0	1
1988	0	5	1	0	0	0	0	0	6
1989	0	6	0	0	0	0	0	0	6
1990	0	8	0	0	0	0	0	0	8
1991	0	5	0	0	0	0	0	0	5
1992	0	6	0	0	0	0	0	0	6
TOTAL	**1**	**133**	**1**	**0**	**0**	**0**	**0**	**0**	**135**
CONNECTICUT									
1970									
1971									
1972									
1973									
1974	0	1	0	0	0	0	0	0	1
1975	0	3	0	0	0	0	0	0	3
1976	0	2	0	0	0	0	0	0	2
1977	0	7	0	0	0	0	0	0	7
1978	3	90	0	0	0	0	0	0	93
1979	4	50	4	0	0	0	0	0	58
1980	4	164	7	0	0	0	0	0	175
1981	6	513	10	0	0	0	0	0	529
1982	3	57	0	0	0	10	0	0	70
1983	0	39	0	0	0	0	0	0	39
1984	7	65	0	0	2	18	0	0	92
1985	0	293	0	0	0	17	0	0	310
1986	0	275	0	0	0	43	0	0	318
1987	0	343	5	0	0	0	5	0	353
1988	1	93	0	0	0	1	0	0	95
1989	1	58	0	0	1	48	1	0	109
1990	1	226	0	0	0	36	0	0	263
1991	0	168	1	0	0	34	0	0	203
1992	3	353	1	0	5	127	1	0	490
TOTAL	**33**	**2800**	**28**	**0**	**8**	**334**	**7**	**0**	**3210**
GRAND TOTAL	8507	41595	312	496	924	8001	162	218	60246

TABLE 3.3.b. Continued

GRAND TOTAL BY RIVER

RIVER SYSTEM	HATCHERY ORIGIN				WILD ORIGIN				
	1-S-W	2-S-W	3-S-W	REPEAT	1-S-W	2-S-W	3-S-W	REPEAT	TOTAL
PENOBSCOT	7331	33353	189	444	345	2140	22	53	43877
UNION	290	1734	9	24	1	11	0	0	2069
NARRAGUAGUS	28	392	11	11	33	1636	40	87	2238
PLEASANT	4	12	0	0	9	203	2	2	232
MACHIAS	21	236	7	0	19	1039	16	40	1378
E. MACHIAS	21	244	1	2	12	307	1	10	598
DENNYS	14	292	0	1	18	632	3	10	970
ST. CROIX	577	894	38	11	375	576	39	15	2525
KENNEBEC	12	187	5	1	0	9	0	0	214
ANDROSCOGGIN	19	419	5	1	3	46	0	1	494
SHEEPSCOT	6	22	0	0	24	275	9	0	336
DUCKTRAP	0	0	0	0	3	30	0	0	33
SACO	13	253	2	1	0	2	0	0	271
COCHECO	0	0	0	0	0	1	0	0	1
LAMPREY	10	17	1	0	0	2	0	0	30
MERRIMACK	137	624	16	0	74	761	23	0	1635
PAWCATUCK	1	133	1	0	0	0	0	0	135
CONNECTICUT	33	2800	28	0	8	334	7	0	3210
TOTAL	8517	41612	313	496	924	8004	162	218	60246

FIGURE 3.7.a.

Difference in Average SST Compared to Penobscot River

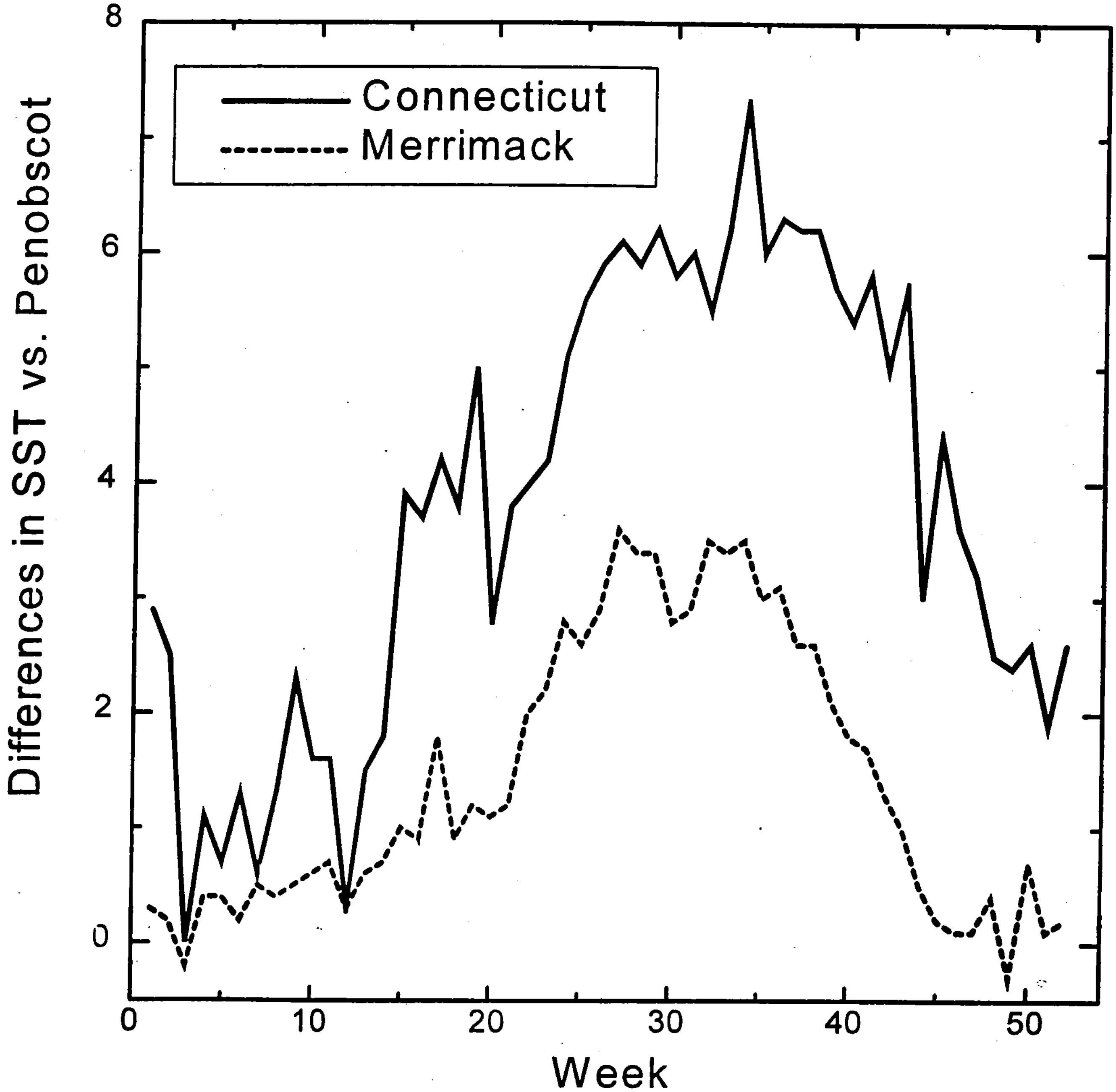

Table 3.7.a. Estimated 1993 Smolt Run Projected From Fall 1992 Index Station Data Vs Smolt Run Estimates Projected From Weir Site Captrues.

Estimator	Rearing Units	Smolts/Unit	Smolts
Index Site	421	3.6*	1,515
Weir	421	0.3	113

* Estimate based on 65% overwinter survival rate.

Table 3.8.a. The Status of Downstream Passage at Hydroelectric Projects Below Atlantic Salmon Fry Stocking Areas.

STATUS	1988	1990	1992	1994	1996
Final	3	6	14	21	32
Interim	10	24	32	30	3
None	26	28	22	20	1
Unknown	0	0	0	0	57
TOTAL	**39**	**58**	**68**	**71**	**93**

Table 3.8.b. Types of Downstream Passage Facilities in use for Smolts at Hydro Projects in New England.

TYPE	NUMBER OF PROJECTS
Surface Bypass W/O Narrow Screen	26
Narrow-Spaced Screen and Bypass	21
Partial Depth Screen and Bypass	5
Trashrack Opening/Sluice	3
Strobe Lights	3
Canal Closure	2
Louver	1

Table 3.8.c. Successful Downstream Passage Facility Tests on Atlantic Salmon Smolts.

PROJECT	TYPE	PASSAGE EFFICIENCY
Pine Valley Project Souhegan River	Angled Screen and Bypass With 1 Inch Spacing	95 %
Wilder Project Connecticut River	Surface Spill at Gate	90 %
Holyoke Canal Connecticut River	Louver Array and Bypass	91 %
Ayers Island Pemigewasset River	Surface Spill at Flashboard	--

Table 3.8.d. Unsuccessful downstream Passage Facility Tests on Atlantic Salmon Smolts.

PROJECT	TYPE	BYPASS EFFICIENCY
Ayers Island (Old) Pemigewasset River	Small Surface Bypass	0 %
Rolfe Canal Contoocook River	Partial Depth 1 Inch Screening	6.3 %
West Enfield Penobscot River	Trashrack Opening/Strobes	8 %
Lowell Merrimack River	Surface Bypass w/o Screening	2 % (74 % **)
Eastman Falls Pemigewasset River	Surface Bypass w/o Screening	2 % (50 % **)
Amoskeag Merrimack River	Surface Bypass w/o Screening	50 % **
Garvins Falls Merrimack River	Surface Bypass w/o Screening	16 % (60 % **)
Mattaceunk Penobscot River	Partial Depth Screening/Strobes/trashrack openings/bypass	59 %
Hadley Falls Connecticut River	Surface Spill at Bascule Gate	60 %
Turners Falls (Cabot) Connecticut River	Surface Bypass at Log Sluice and Trashrack Opengs w/o Screening	66 %

11.3. LIST OF ALL PARTICIPANTS

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