

**U.S. ATLANTIC SALMON  
ASSESSMENT COMMITTEE**

**ANNUAL REPORT**

**2001/13**

**ANNUAL REPORT OF THE U.S. ATLANTIC  
SALMON ASSESSMENT COMMITTEE  
REPORT NO. 13 - 2000 ACTIVITIES**

**NASHUA, NEW HAMPSHIRE  
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**PREPARED FOR  
U.S. SECTION TO NASCO**



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## 1. INTRODUCTION

### 1.1. EXECUTIVE SUMMARY

The Annual Meeting of the U.S. Atlantic Salmon Assessment Committee was scheduled to be held in Gloucester, MA, March 5-7, 2001. The meeting was cancelled because of weather.

Stocking data, listed by age/life stage and river of release, and tagging and marking data are summarized for all New England programs. A total of 15,235,000 juvenile salmon (fry, parr, and smolts) was stocked. The Connecticut River received the largest percentage (61.3%); the majority of which was fry. Maine rivers received approximately 20% of the total, followed by the Merrimack River with 14.9%. The total release was an 10.3% increase over that of 1999.

In addition to the juveniles stocked, mature adults were stocked by the Maine, Merrimack, and Connecticut programs. In general, these fish are either spent brood stock or brood stock that are excess to hatchery capacity. All these adults are either river specific or domestic progeny of river specific programs. For 2000, a total of 6,653 captive and domestic adults were released into the rivers of New England.

Throughout New England juvenile and adult salmon were marked with a variety of marks and/or miscellaneous external tags (e.g., PIT tags, VI tags, elastomer tags, Petersen disc tags, etc.). The salmon releases included about 230,700 marked and tagged salmon in 2000. Of the total, approximately 75.8% were released into Maine rivers, 1.7% were released into the Merrimack River drainage, 22.4. % were released into the Connecticut River drainage. Atlantic salmon of all life stages, including fry, were marked.

Documented total adult salmon returns to rivers in New England amounted to 803 salmon in 2000. The majority of the returns was recorded in the rivers of Maine with the Penobscot River accounting for nearly 66.6% of the total New England returns. The Connecticut River adult returns accounted for nearly 9.6% of the New England total and 46.4% of the adult returns outside of Maine. Overall, 33.6% of the adult returns to New England were 1SW salmon and 66.4% were MSW salmon; most (72%) of these fish were of hatchery smolt origin. Of the total returns, approximately 28% were of wild origin (from natural reproduction and from fry plants).

With the December 1999 closure of the Maine directed salmon sport fishery, there is currently no sea-run salmon fishery in New England. The domestic brood stock fishery in the Merrimack River resulted in an estimated 898 salmon landed.

Egg sources for the New England Atlantic salmon culture programs included sea-run salmon, captive and domestic brood stock, and reconditioned kelts. A total of 283 sea-run females, 4,046 captive/domestic females, and 209 female kelts contributed to the egg take. The number of females (4,538) contributing was greater than in 1999 (3,883). The total egg take, 22,240,700, was down from that of 1999 (23,327,000).

## **1.2. BACKGROUND**

The U.S. became a charter member of the 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 NEASC to create such an advisory committee. NEASC is comprised of State and Federal fishery agency chiefs who designated personnel from their staff to serve on the "NASCO Research Committee", which was formed in 1985.

The NASCO Research Committee met semiannually to discuss the terms of reference for upcoming meetings of the International Council for the Exploration of the Seas (ICES) and NASCO, as well to 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 1) annual stock assessment, 2) proposal and evaluation of research needs, and 3) serving the U.S. Section to NASCO.

A key element of the proposal was the development of an annual Assessment Meeting with the main goal of producing an assessment document for the U.S. Commissioners. Additionally, the report would serve as guidance, regarding research proposals and recommendations to the State and Federal fishery agency chiefs through the 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 North Atlantic Salmon which is composed of representatives of member countries is an example.

"Terms of Reference" constitute the task assignments given to the North Atlantic Salmon Working Group by ICES from recommendations received from NASCO, the EEC, and member countries of ICES. 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**

This was a significant year in the history of New England Atlantic salmon recovery and restoration with the listing of salmon populations from eight rivers in Maine comprising the Gulf of Maine Distinct Population Segment of Atlantic salmon under the Endangered Species Act. The National Marine Fisheries Service and the U.S. Fish and Wildlife Service are to be applauded for making the best scientific decision in the worst of political circumstances.

Most rivers in New England again experienced low adult returns. In response, Maine closed its sport fishery for Atlantic salmon. In addition, the threat of Infectious Salmon Anemia virus loomed on the horizon of salmon survival threatening the success of salmon restoration and commercial aquaculture.

The U.S. Atlantic Salmon Assessment Committee meeting scheduled for March 5-7, 2001 was cancelled because of heavy snow and inclement weather throughout much of the region. As a consequence, Terms of Reference are addressed in this report only by abstracts highlighting the topics originally scheduled for discussion. The remainder of the report was reviewed and finalized by a small number of Committee members.

## **2. STATUS OF PROGRAM**

### **2.1. GENERAL PROGRAM UPDATE**

#### **2.1.1. CONNECTICUT RIVER**

The CRASC has continued efforts this year with strong emphasis on hatchery releases, hydro-relicensing, and research. Additionally, the CRASC has devoted increased time to environmental education partnerships, fishway construction, dam removal, habitat restoration, and increased government support. These objectives are increasingly important to the success of the program.

##### **2.1.1.a. Adult Returns**

A total of 77 sea-run Atlantic salmon adults was observed returning to the Connecticut River watershed including: 52 at the Holyoke fishway on the Connecticut River; six at the Rainbow fishway on the Farmington River; 11 at the Decorative Specialties International (DSI) fishway on the Westfield River; and, eight at the Leesville fishway on the Salmon River. The run lasted from May 4 to June 7. A total of 65 salmon was retained for brood stock: 51 were held at the RCNSS, and 14 were held at the WSS.

One salmon escaped capture at the DSI dam and continued up the Westfield River. A total of 10 salmon was radio-tagged and released from the Holyoke fishlift (river km 138) and permitted to continue upstream. Two additional salmon are known to have escaped capture at Holyoke; one of these was later recovered in Smith Brook, Vermont. Four salmon were observed passing Turners Falls (river km 198), five were observed passing Vernon (river km 228), and two were observed passing Bellows Falls (river km 280). Tagged salmon were monitored in the Deerfield, Mill and Westfield Rivers in Massachusetts and the Black and West Rivers in Vermont.

Age and origin information was derived from scales and physical examination of each fish. Origin information on released salmon was determined by examination for presence or absence of adipose fins. Sea-age information on released fish was generally determined by size. All of the 77 observed salmon were stocked as fry. Sea-age of fish was comprised of grilse (N=1) and 2 sea-winter salmon (N=76). Known freshwater ages of wild salmon were 1<sup>+</sup>(N=1),

2<sup>+</sup>(N=67) and 3<sup>+</sup>(N=2). The sex ratio of the salmon was 33 females: 13 males, although these data are incomplete.

The CTDEP benefitted from about 330 volunteer hours during which Connecticut fishways were monitored and maintained. The MAFW received about 120 hours of volunteer assistance from the Westfield River Watershed Association. Their members monitored and maintained the DSI fishway on the Westfield River.

#### **2.1.1.b. Hatchery Operations**

Record numbers of hatchery produced salmon were stocked into the Connecticut River this year, including nearly 50,000 smolts. However, the USFWS sacrificed two upcoming year classes of smolts at the PNFH in Vermont because the parr demonstrated antibiotic resistance as a result of repeated treatments to combat furunculosis. Emergency construction funds were allocated to address the contaminated water source through the construction of a filtration/disinfection influent water treatment system. Prior to the completion of this work, fry (for smolt production) will be held at the WRNFH until after vaccination in the fall, at which time they will be transferred to the PNFH.

#### **Egg Collection**

A grand total of 13,850,000 green eggs was produced at six state and federal hatcheries within the basin. This is about 200,000 more eggs than produced in 1999. Sea run production was down because of low returns.

#### Sea-Run Brood Stock

Sea-run females produced 14.6% (300,000 eggs) of the total eggs from 49 sea-run females (2.0% of the total females spawned) held at the WSS and the RCNSS. A sample of the fertilized eggs from all sea-run crosses was again egg-banked at the WSS and WRNFH for disease screening and subsequent production of future domestic brood stock.

#### Domestic Brood Stock

Domestic females produced 88% (12.2 million eggs) of the total eggs from 2,471 domestic females (93% of the total females spawned) held at the WRNFH, RRSFH, and KSSH.

#### Kelts

Kelts produced 10% (1.3 million eggs) of the total eggs from 142 kelt females (5% of the total females spawned) held at the WSS and NANFH.

### **2.1.1.c. Stocking**

Volunteers donated about 4,600 hours of time to stock Atlantic salmon fry in the Connecticut River watershed including 600 hours for NHFG, 590 hours for CTDEP, 969 hours for VTFW, 1,968 hours for MAFW, and 510 hours for the USFS.

*Juvenile Atlantic Salmon Releases.* A record total of 9,337,900 Atlantic salmon was stocked into the Connecticut River watershed in 2000. Fish were released into the mainstem and 37 tributary systems. The total consisted of 8,598,900 unfed fry (92%), 689,500 fed fry (7%), 600 parr (<1%), 650 one-year smolts (<1%) and 48,200 two-year smolts (1%).

*Adult salmon releases.* The CTDEP released a total of 31 pre-spawning, adult, domestic brood stock in the Salmon, Farmington and Eightmile Rivers to encourage natural reproduction.

### **2.1.1.d. Juvenile Population Status**

#### **Smolt Monitoring**

NUSCO, the USFWS/SOFA and SOCNFWR contracted with GCC to conduct a mark-recapture smolt population estimate in 2000. This was the eighth consecutive year that a study has been conducted by marking smolts at the Cabot Station bypass facility and recapturing them at the bypass facility in the Holyoke Canal. No estimate was made because of poor success with mark and recapture due to high flows.

Based on expanded electrofishing data from index stations and assumed overwinter mortality, it was estimated that 296,800 smolts were produced in tributaries basin wide, of which 246,300 (83%) were produced above Holyoke in 2000. Actual overwinter mortality is unknown and the estimate does not include smolt mortality during migration.

Most smolts have to travel long distances and pass multiple dams to reach Holyoke. Recent research in the Connecticut River tributaries and Maine suggests that overwinter survival is lower than assumed in the electrofishing smolt estimate.

#### **Index Station Electrofishing Surveys**

Juvenile salmon populations were assessed by electrofishing in late summer and fall at nearly 200 index stations throughout the watershed. Sampling was conducted by CTDEP, MAFW, NHFG, USFS, and VTFW. Data are used to evaluate fry stocking, estimate survival rates, and estimate smolt production. All of the data have not been analyzed yet. Preliminary information indicates that while densities and growth of parr varied widely throughout the watershed as usual, it was generally an average survival and excellent growth year. Most smolts produced are again expected to be two year olds, with some yearlings and three olds. The preliminary data analysis suggests that basin wide smolt production in 2001 will be down about 20% from last year's estimate. This is largely due to reduced numbers of fry stocked and below normal first summer survival in 1999.

### **2.1.1.e. Fish Passage**

Holyoke Dam - The Federal Energy Regulatory Commission awarded a new license to the Holyoke Water Power Company for the project in 1999. The Massachusetts 401 Water Quality Certificate was under appeal by HWP but this appeal has recently been resolved. Although outstanding appeals of the license to the FERC remain outstanding, the settlement of the 401 dispute is expected to help resolve those appeals. The 401 settlement is also expected to clear the way for the sale of the project to the City of Holyoke. In the mean time, the agencies are meeting with Holyoke Water Power to implement prescriptions for fish passage that will expand and improve both upstream and downstream passage facilities at the project.

Turners Falls - Northeast Utilities Service Company (NU) and the USGS Conte Anadromous Fish Research Center cooperatively studied upstream shad passage at Turners Falls. Experimental modifications of the Cabot ladder were attempted to see if a change in ladder design would increase passage efficiency. The modified weir sections seemed to be associated with improved passage. However, because of poor overall passage efficiency and conflicting results, the study will be repeated next spring with additional modifications to the ladder.

NU installed a flow deflector in the Cabot sluice (a flip-lip) to reduce bank erosion and maintain use of the bypass during high flow. The flip-lip has not been evaluated as installation was delayed until Fall.

Northfield Mountain Pumped Storage Project - Since 1995, NU has deployed a fixed position guide net to reduce smolt entrainment. The net used in 2000 is similar to the net used the previous season. Net submergence was a problem this year. In addition, the net came free of its anchor twice. Consequently, a new net and flotation system have been designed for testing next spring.

Rainbow - The Connecticut Department of Environmental Protection is working with USFWS engineers to plan replacement of the existing vertical slot ladder with a denil fishway and eel pass at the Rainbow Dam on the Farmington River.

Knightville Fish Passage - The U.S. Army Corps of Engineers made changes to operations in support of downstream passage at the Knightville Dam on the Westfield River. The Corps is still exploring the feasibility of constructing upstream passage at the Knightville Dam.

Townshend Fish Passage - The U.S. Army Corps of Engineers has initiated construction of an electric barrier for the Townshend Dam on the West River. Construction is expected to be completed in Spring 2001.

Deerfield River Projects - Northeast Utilities Service Company and PGE evaluated downstream passage facilities at and Gardners Falls and Deerfield #2, 3 and 4 projects on the Deerfield River. The evaluation indicated that additional changes are needed to improve passage efficiency. Additional passage studies will also be required.

Fifteen Mile Falls Project - The smolt migration study through the Moore and Comerford impoundments was repeated this year. Results indicate that smolts effectively migrated through the reservoirs to the dams. A rare spill event at the dams resulted in the only successful passage. Spill will be evaluated as a possible passage mechanism in the future.

McGoldrick Dam - Removal of the McGoldrick dam on the Ashuelot River in Hinsdale, New Hampshire, was delayed until Summer 2001 because of high flows.

#### **2.1.1.f. Genetics**

The U.S. Geological Survey - Biological Resources Division, through the Conte Anadromous Fish Research Center, again sampled tissue from all sea-run brood stock for genetic monitoring (microsatellite analysis). The work was conducted in cooperation with the National Fish Health Research Lab-Leetown.

All of the sea runs were PIT tagged to ensure individual identification at spawning. Spawning was managed utilizing a breeding protocol developed last year to prevent pairings of closely related fish. It was also utilized to establish a known family mark for progeny. Similarly, marked families from last year's egg take were batched and stocked in the Farmington (88,300 fry) and West Rivers (130,500 fry) in order to assess family survivability in various streams and to assess and identify productive tributaries through later sampling of smolts and returning adults.

The population of spawning sea-run salmon did not meet the minimum requirement for 50 pairs of parents. The sex ratio of returning salmon was again skewed toward females. Consequently, wild male parr were collected in Connecticut and Vermont for spawning with sea runs. Additionally, a 3:1 male to female spawning protocol was implemented at the RCNSS to ensure maximum variability.

A 1:1 spawning ratio was observed for all domestic brood stock spawned at the WRNFH, KSSH, and RRSFH. Planned expansion of the Genetics Marking Project into the domestic brood stock reared at WRNFH was postponed because of staffing concerns at the hatchery.

#### **2.1.1.g. General Program Information**

The CRASC met several times, with the encouragement of Congressional aides from each of the basin states, to develop funding recommendations for the 107<sup>th</sup> Congress. The CRASC is looking for Congress to re-authorize its enabling legislation, restore USFWS Fisheries capabilities, and assist the other cooperating Federal and State agencies with anadromous fish restoration on the Connecticut River at an estimated cost of \$5 million annually for operations and maintenance and \$4 million annually for construction and capital improvements. Lacking this level of additional support, the CRASC is projecting further cuts in egg and fish production which will impact future adult returns. Fish passage and habitat restoration projects will be delayed or eliminated. Critical assessment, evaluation and research will also be reduced or eliminated.

The Connecticut River Salmon Association in Connecticut and the Deerfield/Millers River Chapter of Trout Unlimited together with the Westfield River Watershed Association in Massachusetts are carrying conservation messages to over 2,000 students in 59 schools in the lower watershed annually. In Vermont, the White River Partnership is carrying conservation messages to over 500 students in 12 schools in the White River watershed. This type of educational outreach is beyond the existing capacity of the CRASC but remains an important objective of the restoration program which is being successfully attained through partnerships.

The U.S. Forest Service (USFS) accomplished 10 miles of stream habitat surveys for identification and assessment of salmon habitat in the Green Mountain National Forest. Eight stream and riparian habitat restoration projects, affecting about two river miles, were implemented in the West and White River watersheds in Vermont to improve juvenile salmon rearing habitat. The projects were cooperative efforts between the USFS, USFWS, State natural resource agencies, the White River Partnership, and several non-government organizations interested in stream habitat conservation.

Dr. Mamie Parker replaced Mr. Ron Lambertson as the USFWS Northeast Regional Director and Commissioner on the CRASC. Mr. Ed Parker replaced Mr. Ernie Beckwith as Commissioner for the State of Connecticut. Mr. Tom Menard was appointed by Governor Celucci to serve as the Public Representative to the CRASC for the Commonwealth of Massachusetts.

### **2.1.2. MAINE PROGRAM**

#### **2.1.2 MAINE PROGRAM**

##### **2.1.2.a. Adult Returns**

Adult Atlantic salmon counts were obtained at fishway trapping facilities on the Androscoggin, Aroostook, Narraguagus, Penobscot, Saco, St. Croix, and Union Rivers. Additionally, counts were made at weirs on the Dennys and Pleasant Rivers. The Maine aquaculture industry reared river specific salmon eggs to maturity and provided 1,054 pen-reared adults for stocking into the Dennys, Machias, East Machias, and St. Croix Rivers (numbers noted below). Redd counts were used to monitor the spawning activity of the pen-reared fish and estimate numbers of spawning fish for a number of Maine rivers.

Numbers of pen-reared adults released by river and sex. All stocking occurred during the week of October 16, 2000.				
		Sex		
Drainage	Where	Males	Females	Total
Dennys	Below Adult Weir	3	13	16
	Above Adult Weir	49	47	96
	Total	52	60	112
East Machias	One site	7	9	16
Machias	Throughout	91	85	176
St. Croix	Throughout	338	412	750
<b>Grand Total</b>		<b>488</b>	<b>566</b>	<b>1054</b>

There was no legal rod catch in 2000 as the result of a statewide angling closure that took effect December 28, 1999. It is now unlawful to angle (catch and release), take, or possess any Atlantic salmon from all Maine waters (including coastal waters). Any salmon incidentally caught, must be released immediately, alive and uninjured without being removed from the water.

#### Rivers with Native Atlantic Salmon

**Dennys River.** A weir, located at the head of tide, was operated from June 29 to November 15 to trap upstream migrating adults; evaluating the size of the adult run and intercepting escaped aquaculture fish. Of the two hatchery fish captured at the weir, one was released upstream and the other was included among the 29 suspected aquaculture escapees. Of these, 19 were killed for disease sampling and the remaining 10 were released downstream. Two redd surveys were conducted in an attempt to capture the spatial and temporal distribution of spawning, particularly by pen-reared adults released in October. A total of 60 redds were observed distributed throughout the drainage with more redds observed during the second survey, suggesting that the net-pen fish moved from their release sites and that spawning occurred later than expected. No redds were observed on Lower Cathance Stream during the one survey conducted.

**East Machias River.** Currently the only way to assess spawning escapement within the East Machias River is to count redds. However, an East Machias River weir has been designed and a contractor has been selected through competitive bidding and construction is scheduled for the summer of 2001. This new weir will mean that escapement can be assessed with both counts of adult salmon returns and redds. One redd survey was conducted on the East Machias covering a majority of the available spawning habitat. Ten redds were counted, all distributed downstream of Round Lake.

**Machias River.** The Machias and its major tributaries were surveyed for redds. Twenty-three redds were observed within the drainage, 16 in the mainstem and 7 in the tributaries.

**Pleasant River.** A weir, located just above the head of tide and slightly upstream of the Route One bridge, was operated from May 22 to October 9. Three wild fish (two multi-sea winter and one grilse) were released upstream after measuring length, and taking scale and tissue samples. All three salmon were captured in July. No suspected escaped aquaculture fish were captured. Redd surveys on the upper two reaches (Worcester Camp to Crebo Crossing) and lower two reaches (from Saco Falls to the Route One bridge) of the Pleasant River encountered only one redd. Redd counting in the Pleasant is difficult due to naturally dark colored water, thus, this count is likely an underestimate of spawning activity.

**Narraguagus River.** A fishway trap, operated at the Cherryfield ice control dam from April 28 through October 31, captured 23 sea-run salmon, which were released upstream of the trap. No salmon suspected to be aquaculture escapees were trapped in the Narraguagus River in 2000. This year's trap catch was the smallest recorded since operations at the trap began in 1991. A complete redd survey on the mainstem and four tributaries to the Narraguagus River located 21 redds on the mainstem, with all but one located in the waters downstream of Beddington Lake, and no redds in tributaries (Baker Brook, Gould Brook, Sinclair Brook, and Shorey Brook). The West Branch Narraguagus contains relatively little spawning habitat and is logistically impractical for redd counts. This year's count is the smallest recorded since 1981 when regular spawning ground surveys began.

**Ducktrap River.** There were four redd surveys conducted on the Ducktrap River in 2000 (October 31, November 8, November 28, December 6). During these surveys two redds and one partial dig were observed.

**Sheepscot River.** Spawning habitat in the Sheepscot River was surveyed between October 24 and November 22, 2000. Repeat surveys were made in several sections to observe redds from fish that may have spawned later than usual because of low flows. The lower mainstem was surveyed three times, with a total of five redds observed. Ten redds were observed from Coopers Mills to Kings Mills, which was surveyed once with an additional spot-check of the North Whitefield spawning area. One redd was observed on the upper mainstem. None were located on the West Branch.

#### **Other Maine Atlantic Salmon Rivers**

**Penobscot River.** A portion of the Penobscot River in Veazie and Eddington was closed to all angling effective July 1, 2000. It will remain in effect until a salmon angling season is reopened on the river. This emergency rule enacted by the Maine Department of Marine Resources was the result of enforcement personnel observing the capture of three Atlantic salmon in one evening by striped bass anglers. All three fish were released, but at least one of these fish was foul-hooked and may have suffered significant injuries.

The fishway trap at the Veazie hydroelectric dam was operated from May 7 through November 2, 2000. Upstream migrating adults were captured to gather biological data and to collect salmon for brood stock for production at the CBNFH and GLNFH. A total of 535 adult salmon was captured, the smallest catch recorded since trap operations began at the Veazie dam in

1978. No salmon suspected to be aquaculture escapees were captured. Of the salmon captured, 207 were released in the river upstream of the dam to spawn naturally and the remainder (328 salmon) was transported to CBNFH for use as brood stock.

The Great Northern Paper Company operated an Atlantic salmon trap at the fishway at their Weldon dam facility under an existing agreement with the MASC. This trap, located 60 miles upstream from Bangor, facilitates a count of spawning escapement for salmon that have successfully passed all five main stem dams. The trap was operated daily from June 19 to October 28, 2000, with a total catch of 18 salmon. All fish were counted and released upstream of the trap.

Annual redd count surveys are not usually conducted in the Penobscot watershed upstream of the Veazie dam due to the reliability of population data collected at the Veazie fishway trap, the relatively low spawning escapement, and the physical difficulties in obtaining an accurate estimate on such a large river.

Surveys to locate and count redds were conducted on four tributaries to the Penobscot estuary:

Kenduskeag Stream. Due to high stream flows during the spawning season, three surveys were undertaken to look for redds in areas below the Rte. I-95 bridges where redds have been seen in prior years. Although conditions limited visibility, two redds were observed in the vicinity of Valley Avenue Park.

Souadabscook Stream. Three redd surveys were conducted on this stream between October 30 and November 13 with only one redd located.

Cove Brook. Two redd surveys, conducted two weeks apart, located only one redd relatively high in the drainage.

Marsh Stream. Two searches for redds were conducted on the North Branch of Marsh Stream. Two reaches, Monroe to West Winterport Dam, and above the old dam in Monroe were surveyed on foot by accessing the stream at strategic locations. Another reach from the West Winterport Dam to the Frankfort Dam was canoed. No redds were found on any occasion.

**St. Croix River.** A fishway trap was operated near the head of tide at the Milltown Dam in New Brunswick from June 23 to November 22. A total of 50 salmon was captured, 20 hatchery origin (12 grilse and 8 MSW) and 30 suspected escapees from aquaculture pens. The hatchery origin salmon were retained for brood stock, with 17 transported to the Mactaquac hatchery for spawning. All 30 suspected aquaculture escapees were removed from the river and lethally sampled for fish diseases (all were negative). Teams of solo canoeists inventoried more than 50 kilometers of the St. Croix in an attempt to observe spawning activity and redds of the 750 net-pen salmon stocked. During October, November, and in early December a total of 170 salmon redds was documented. It is likely that additional redds went undetected due to logistical difficulties involved in inventorying this large river and early ice formation.

**Androscoggin River.** Three Atlantic salmon were captured at the Brunswick Dam fishway in 2000, compared to five in 1999. Returns to this river are the result of natural reproduction, straying, or stocking from an education program that allows schools to raise and stock salmon fry.

**Saco River.** Florida Power and Light (FPL) currently operates two fish passage monitoring facilities on the Saco River at head of tide. The Cataract fish lift, located on the East Channel, was operated from early May to late October and 16 salmon were lifted into the headpond and 13 were transported to upriver release locations in the Big Ossipee River. On the West Channel, the Denil fishway-sorting facility was also operated from early May to late October and 20 salmon were released to the headpond. There were two mortalities out of the total of 51 returning salmon to the Saco River. One marked salmon was recovered with a tag identifying the fish as a stray from the Merrimack River in Massachusetts. FPL personnel surveyed spawning habitat above the Cataract project impoundment once on December 13. During this survey, 16 salmon redds were found below the Skelton Dam tailrace.

**Union River.** The Ellsworth dam, although not equipped with an upstream fishway, has trapping facilities below the dam. Pennsylvania Power and Light (PPL), operates the trap from the end of the alewife season through fall to provide passage for Atlantic salmon. The total trap catch was eight Atlantic salmon. However, six of these were suspected aquaculture escapees. One of the aquaculture fish was lethally sampled and the others released below the dam. The two "non-aquaculture" salmon were trucked to upriver release sites in the West Branch.

**Kennebec River.** One redd survey was conducted of the mainstem Kennebec between Waterville and Sidney and four of its tributaries (Bond Brook, Togus Stream, Sevenmile Stream, Messalonskee Stream). Three redds were observed on the main stem below Waterville, two in Messalonskee Stream, and one in Bond Brook. No redds were observed in Sevenmile or Togus streams.

**Passagassawakeag River.** The Passagassawakeag River, located in Waldo County, flows into Belfast Bay. Wescott Stream is the only major tributary. In previous years redds have been observed in the lower Passagassawakeag River. This fall, redd surveys were conducted over a three-week period. High runoff associated with fall rains and snowmelt resulted in poor visibility and unsuccessful searches. No redds were observed.

**St. George River.** The St. George River is located in Waldo and Knox counties. The status of the Atlantic salmon resource in this 56 km river is currently unknown. In an effort to document presence of Atlantic salmon in the river system, one redd survey was conducted on the mainstem. At least two redds were observed in the freshwater tidal portion of the river in the town of Warren.

**Aroostook River.** PDI Canada, Inc. operated a fish trapping and sorting facility at their Tinker Dam Hydro Project on the Aroostook River in New Brunswick under an agreement with ASNM. They reported a total trap catch of 17 salmon (10 MSW and 7 ISW), which were

inspected and released above the dam. These fish are included in the returns to the St. John system having passed through the N.B. Mactaquac counting facilities.

### 2.1.2.b. Hatchery Operations

Collection of native parr from the DPS rivers for brood stock development continued in 2000. In 2000, migrating smolts from the Pleasant River were also collected and brought to the CBNFH. A total of 1,065 parr and smolts were collected from the following rivers: Dennys (131), East Machias (126), Machias (262), Pleasant (127 - 60 smolts, 67 parr), Narraguagus (259) and Sheepscot (160). These fish will be reared to maturity in order to provide river-specific hatchery stocks for future restocking programs in these rivers of origin. All fish were fitted with PIT tags surgically implanted in the gut and tissue samples were collected for genetic characterization. All PIT tags were of the "A" type, except on the Pleasant River, which were of the "B" type.

### 2.1.2.c. Stocking

Of the 2,472,000 million salmon stocked into eight Maine rivers in 2000, most (1,479,000) were released as fry that had started feeding prior to release. Atlantic salmon fry releases in selected Maine rivers since 1995 (rounded to nearest 1,000) are shown below; a complete stocking summary for all life stages and all Maine rivers may be found in Table 2.2.1.

Year	Dennys	E.Machias	Machias	Narrag.	Sheepscot	Penobscot
1995	84,000	0	150,000	105,000	0	617,000
1996	142,000	115,000	233,000	201,000	102,000	1,242,000
1997	192,000	113,000	236,000	196,000	64,000	1,472,000
1998	234,000	191,000	302,000	275,000	267,000	930,000
1999	172,000	210,000	169,000	155,000	302,000	1,500,000
2000	96,000	197,000	209,000	252,000	211,000	513,000

Native Atlantic salmon parr have been collected from the Maine native salmon rivers since 1992. These parr have been raised to sexual maturity at CBNFH, and have been producing eggs for the river-specific program since 1994. The increasing number of adult brood fish, ranging in size from 1.4 to 4.5 kg each, resulted in an increased demand on the water supply at the hatchery. Therefore, as in previous years, a portion of these brood stock (282 salmon) was returned to their rivers of origin in 2000.

The following captive kelts were released into their river of origin: East Machias (68), Machias (93), Narraguagus (96) and Sheepscot (25). All of these salmon, from various age classes were released post-spawn in 2000 and had been previously fitted with type "A" PIT tags in the dorsal sinus. These numbers do not include adults released into the Dennys and Sheepscot rivers in January 2000, as they were reported in the 1999 Assessment Committee report

#### 2.1.2.d. Juvenile Salmon Population Status

Surveys to estimate density or relative abundance were conducted on most of the rivers in Maine with wild or stocked populations of Atlantic salmon (see below). On the Narraguagus, parr densities were generally less than eight parr/100m<sup>2</sup>. However, there was great variability among the sites, with densities ranging from an absence of parr in two low quality runs, to a high of 17.93 parr/100 m<sup>2</sup>. On the Pleasant River no parr were captured at 15 sites and parr densities at all sites were less than three parr/100 m<sup>2</sup>. The data from juvenile abundance surveys in 2000 and previous years are being entered into a standard database that will allow more thorough analysis of population trends relative to a variety of factors (i.e. stocking, spawning escapement, habitat conditions).

Number of sites electrofished to assess juvenile  
salmon populations in Maine rivers.

<u>River</u>	<u>Population Estimate</u>	<u>Relative Abundance</u>
Dennys	3	1
Ducktrap	1	0
East Machias	4	0
Machias	7	18
Narraguagus	35	7
Pleasant	9	21
Sheepscot	7	0
St. Croix	0	4
Union	1	0
Saco	7	0
Penobscot Watershed		
Cove Brook	2	0
Kenduskeag	0	2
Piscataquis	4	0
Aroostook	0	10
Sedgeunkedunk		
<u>Stream</u>	<u>0</u>	<u>1</u>
TOTAL	76	64

A total of 610 smolts was captured at three sites on the Narraguagus River in 2000. Two rotary screw traps were operated at both the Crane Camp (Km 7.65) and Little Falls (Km 11.16) sites from late April through mid-June. A fifth smolt trap was operated through early May immediately downstream of the USGS flow gaging station in Cherryfield (Cable Pool trap, Km 1.37). The captured smolts averaged 178 mm total length (166 mm fork length) and 43.9 g wet weight. The smolt emigration in 2000 was the smallest recorded since smolt trapping began on the Narraguagus River in 1997. The maximum likelihood mark-recapture model estimated was 1,946 smolts; compared with approximately 3,607 in 1999, 2,925 in 1998, and 2,871 in 1997.

### **2.1.2.e. Fish Passage**

Fishways at mainstem Penobscot dams were inspected on a routine basis to ensure proper operation and maintenance procedures. Fishways on tributaries were generally inspected less frequently, unless problems were identified that required attention. Improper fishway maintenance and operation practices severely impacted fish passage on Marsh Stream. An informal agreement was reached with the operators of the Veazie Dam Hydro project to modify turbine operations, improving attraction flow to the fishway.

Six large woody debris jams that impaired fish passage were removed from Old Stream, a tributary to the Machias River. This work improved access from the Machias River to 89 units (100m<sup>2</sup>) of spawning habitat in Old Stream, which is contiguous with juvenile rearing habitat in 303 riffle and 227 run units.

The Atlantic Salmon Commission prepared the permits required for the removal of the East Machias Dam. The dam has not been an impediment to salmon passage since the mid 1970's. However, its removal created a better-defined channel below the dam and exposed natural substrate at the dam site. In addition, repairs were made to Chase Mills Stream Dam (outlet of Gardner Lake in the East Machias drainage) that insured sufficient water to operate the fishway.

### **2.1.2 f. Genetics Collections and Brood stock Evaluation**

Beginning in 1999, all brood stock at CBNFH were PIT tagged and tissue samples were collected for genetic characterization. This activity will allow for the establishment of genetically marked families, which can be tracked through a non-lethal fin sample at various life stages. The need to assess the contribution of fry stocking to the population of Atlantic salmon in Maine continues to be a high priority of the New England Atlantic salmon program.

All incoming river-specific parr brood stock were also genetically sampled and PIT tagged in 2000. (Parr were tagged and sampled in the field to allow for identification of individual fish from each collection site).

Fin samples were collected from all parr-brood stock from the Dennys (131), East Machias (126), Machias (262), Pleasant (60 smolts and 67 parr), Narraguagus (259) and Sheepscot (160) rivers, as well as sea-run adults (328) from the Penobscot River. A total of 124 Atlantic salmon smolts and 79 parr captured on the Pleasant River were sampled. Of these 124 smolts, 28 were brought to the CBNFH for brood stock and 96 were either sacrificed as aquaculture escapees or released downstream.

The genetics of adults returning the Maine rivers, either wild or suspected aquaculture escapees, was also of interest. As a result, tissue samples for genetic analysis were collected from suspected aquaculture fish at all trapping facilities. In addition, genetic samples were taken from the 20 hatchery returns to the St. Croix River, the one wild fish that passed the Dennys River weir, and all but one of the salmon trapped on the Narraguagus.

### **2.1.2.g. General Program Information**

#### **Interagency Data System**

Biologists from the MASC, the NMFS, and the USFWS undertook a joint database development project to facilitate data sharing, standardization, and management to capture the power available on modern desktop computers. This data management system incorporates concepts not previously applied to salmon data management in Maine. Traditional X-Y grid projections of the spatial data elements do not accurately describe the relative positions of habitat features in a riverine environment. Instead, a linear river model with locations described as distance along a virtual river centerline, with a precision of 0.01 km is used. A zero point is established and tributary distances computed from their confluence with the next higher branch in the watershed hierarchy. Locations, using drainage and river Km, were incorporated in site codes for all databases. This allows users to easily query datasets for information collected by other agencies. The individual relational databases share links to a modular library of site names and codes for data features used by multiple databases.

#### **Habitat Information**

Instream Flow Incremental Methodology (IFIM) studies were conducted to support a water use management plan that is part of the *Maine Atlantic Salmon Conservation Plan*. Representative transects were selected to determine the relationship between discharge and juvenile and spawning habitat in five reaches in the Pleasant River (Kleinschmidt Associates 1999A), five reaches on the Narraguagus River and three on Mopang Stream (Kleinschmidt Associates 1999B). Each reach was a river segment having relatively uniform habitat and hydrologic characteristics. Reach boundaries were located based on combined changes in hydrology, geomorphology, and distribution of habitat types. The IFIM studies provide data on the relationships between discharge and habitat for small and large parr and spawning adults within the three rivers (Kleinschmidt Associates 1999a, 1999b). Habitat was indexed as weighted usable area (WUA), the product of quantity (wetted area) and suitability based on HSI models. The quality of the physical habitat (depth, velocity, substrate) for small and large parr and spawning adults within the three rivers has not been assessed before. Previous habitat surveys have quantified habitat area at "typical low flows" and rated the productive capacity of different habitat types, but have not attempted to assign any relative quality within habitat types. The new information provided by the IFIM, in conjunction with hydrologic data, will provide a way to assess the severity and extent of habitat restrictions during summer and winter, the two annual periods of low flow.

#### **Atlantic Salmon Commission Offices and Staff**

The MASC established a new office and completed a variety of staffing changes in 2000. The interim Executive Director was selected to permanently fill the position. All year-round and seasonal Technicians were upgraded to Biologist Specialists, an office was established in Sidney, and a Biologist I was hired to manage Southern Maine rivers. This individual was promoted to Biologist II in Cherryfield, when the incumbent resigned to pursue a Ph.D. A Biologist I position in Bangor was reassigned to the newly created Northern Maine position,

with the resulting vacancy filled by promoting a Biologist Specialist. Another Biologist I in Bangor was upgraded to a Biologist II. A Biologist I was hired to staff the Sidney office, and a Biologist Specialist hired in Bangor. The Senior Biologist assigned to Bangor retired in June and the position was filled in November. There was also turnover at the Bangor secretarial position.

### **Listing of the Gulf of Maine DPS**

In 1997 the USFWS and NMFS withdrew their initial proposal to list the Atlantic salmon under the Endangered Species Act based primarily on the implementation of the Maine State Conservation Plan, international regulation of harvest and evidence of improvement within current stocks. Trout Unlimited, the Atlantic Salmon Federation, and ten other groups challenged the 1997 decision and requested emergency listing, subsequently filing a lawsuit.

In 1999, the USFWS and NMFS received and reviewed the first Conservation Plan accomplishment report from the State. The draft Status Review was also updated confirming that a distinct population segment existed for eight river populations from the Kennebec River in the south to, but not including, the St. Croix River in the north. Atlantic salmon populations within that DPS include the seven rivers previously proposed for listing and Cove Brook. The Status Review established five listing factors:

- \* Current condition of existing freshwater habitat
- \* The impact of commercial, recreational and research utilization
- \* Disease and predation on current populations
  - Seals
  - Striped bass
  - ISA and SSSv
- \* Inadequacies of regulatory mechanisms
  - Water withdrawals
  - Aquaculture practices
- \* Other natural or man-made factors that threaten the existence of current populations

The July 1999 Status Review determined that current salmon populations are endangered and the Services proposed the Gulf of Maine DPS for listing.

On December 18, 2000, Atlantic salmon populations in eight Maine rivers comprising the Gulf of Maine Distinct Population Segment of Atlantic salmon were listed as endangered under the Endangered Species Act by the USFWS and NMFS. These eight rivers are the Dennys, East Machias, Machias, Pleasant, Narraguagus, Ducktrap, Sheepscot and Cove Brook. The agencies responsible for managing salmon have filed for permits that will allow the incidental "take" of Atlantic salmon within the DPS while conducting the usual and necessary activities involved in recovering these populations.

### 2.1.3. MERRIMACK RIVER

#### 2.1.3.a. Adult Returns

A total of 85 Atlantic salmon returned to the Merrimack River in 2000. One fish escaped the trap at Essex Dam and two fish were identified as brood stock, resulting in a total of 82 sea-run fish captured and transported to the Nashua National Fish Hatchery (NNFH). This represented a decrease of 102 fish compared to the total number that returned in 1999 (185 fish). The majority of fish were captured/counted in the spring (80 fish) as opposed to the fall (5 fish).

The returns are categorized as follows:

##### Fry Stocking Origin Adults

<u>Grilse</u>	<u>2SW</u>	<u>3SW</u>	<u>RS</u>
1	23	0	0

##### Parr Stocking Origin Adults

<u>Grilse</u>	<u>2SW</u>	<u>3SW</u>	<u>RS</u>
0	0	0	0

##### Smolt Stocking Origin Adults

<u>Grilse</u>	<u>2SW</u>	<u>3SW</u>	<u>RS</u>
26	32	0	0

The virgin multi-sea-winter component (68% of river returns - 56 fish) was comprised of 28% males (16 fish) and 72% females (40 fish).

The rate of return (adults produced per 1,000 juveniles stocked) for fry-origin adults continued to be relatively low for the ninth consecutive cohort. The current rate of return for the 1996 fry cohort is 0.0178, a decrease of 39% from the 1995 cohort for the same time frame (grilse and 2SW returns only). Fry-origin age classes 2.3, 3.2, and 3.3 have not yet returned. When fish return from these age classes the reported rate of return will be revised.

The rate of return (adults produced per 1,000 juveniles stocked) for smolt-origin adults increased for the sixth consecutive cohort. The rate for the 1998 cohort was 1.50, an increase of 15% above the rate for the 1997 cohort (grilse and 2SW returns only).

#### 2.1.3.b. Hatchery Operations

The majority of the Atlantic salmon fry produced for release in the watershed was provided by the NANFH and the WSFH and was primarily of domestic brood stock parentage. A small proportion of fed fry (8% out of total fry) were produced by the NNFH. Smolts produced for

stocking purposes in 1999 were provided by the GLNFH and were of Penobscot River sea-run parentage.

### **Egg Collection**

#### **Sea-Run Brood stock**

Thirty-eight females were captured at the Essex Dam fishlift and transported to the NNFH, where 38 produced 310,800 eggs. The majority of the eggs were transported to the NANFH to be hatched and released as fry. Some eggs, approximately 2.5 %, were retained at the NNFH for brood stock development.

#### **Captive/Domestic Brood stock**

A total of 596 female brood stock (3+) reared at the NNFH provided an estimated 2,624,700 eggs. Eggs were transported to the NANFH to be held for fry stocking within the Merrimack River basin. Approximately 500,000 of the eggs transported to the NANFH are being incubated for the Pawcatuck River salmon restoration program. In addition to the domestic brood stock, a total of 62 female kelts produced 747,587 eggs at the NANFH. Kelt eggs were fertilized with milt from domestic brood stock from NNFH.

#### **2.1.3.c. Stocking**

Approximately 2.22 million juvenile Atlantic salmon were released in the Merrimack River basin during the period, April - June of 2000. The release included approximately 2.03 million unfed fry, 184,000 fed fry, and 52,450 yearling smolts (GLNFH). Although the majority of the smolts were not marked or tagged, it is possible to determine the origin of adult returns by analyzing the pattern or signature on the scales of fish. Scale analyses are therefore used to differentiate between fish stocked as fry or smolts.

All major tributaries upstream from the Nashua River in NH, excluding the Soucook, Suncook, and Winnepesaukee rivers, were stocked with fry. Numerous small tributaries to the Merrimack River and its principal tributary system, the Pemigewasset River watershed, also were stocked.

The majority of smolts were released into the mainstem of the Merrimack River a short distance downstream from the Essex Dam in Lawrence, MA. Approximately 1,050 smolts were released in the mainstem of the river in New Hampshire as part of studies to test the effectiveness of downstream fish passage facilities at hydroelectric sites.

### 2.1.3.d. Juvenile Population Status

#### Yearling Fry / Parr Assessment

A total of 26 sites in 18 rivers, streams or brooks throughout the basin was sampled in 2000. A stratified sampling scheme was used to determine the abundance of parr. Parr estimates were determined for the basin, regions and geostrata. Habitat was stratified into four regions, where each region has different characteristics that included climate, geography, geology, hydrology, and land use. Estimates derived for geostrata involved sampling within regions in very large rivers [drainage area (da) > 200,000 ha, in large river ( $44,289 \leq da \leq 200,000$  ha), and small rivers and brooks where  $da < 40,500$  ha]. Sampling was directed at yearling parr (age 1+) and involved electrofishing during late summer and early fall. Data collection involved a cooperative effort and included staff from the NHFG, USFS, USFWS, and volunteers.

The 26 sample sites included a total of 387 units (one unit = 100 m<sup>2</sup>) of juvenile habitat. The estimated number of available habitat units in the basin is 65,742 and of the total units available, approximately 59,300 were stocked with fry in 2000. Units sampled represent about 0.58% of the total available and 0.65% of those stocked with fry.

Natural reproduction of Atlantic salmon is not known to occur in the Merrimack River basin. In recent years (including 2000), sexually mature brood stock salmon have been released in headwater areas, but due to low numbers released, their contribution to the production of fry is assumed to be minimal.

Results of assessments in 2000 generally show a below average abundance of yearling parr at seven key index rivers located throughout the watershed. This decrease may be partially attributed to a planned reduction in fry stocking densities (~50%) initiated in 1999. A time series of estimated parr abundance is available for the East Branch Pemigewasset, Pemigewasset, Mad, Baker, Smith, South Branch Piscataquog, and Souhegan rivers. In recent years the stocking density of fry has been decreased ~50% in these rivers to compare previous high stocking rate results. Stocking densities had previously ranged from 36 fry/unit to 96 fry/unit, but in recent years the numbers have ranged from 18 fry/unit to 48 fry/unit. The results of evaluations of yearling parr abundance at these and other sites in the watershed suggest that past high stocking densities have resulted in density dependent factors that adversely affected the growth and survival of parr. Given the shift in stocking densities, direct comparisons to past years levels of abundance need to be interpreted with caution.

The average number of parr per unit during years of high fry stocking densities ranged from a low of 1.0 parr/unit to a high of 5.7 parr/unit. However, yearling parr/unit at sample sites in index rivers (original seven) ranged from a low of 0.5 to a high of 3.4 in 2000. The remaining 19 sites sampled had yearling parr densities ranging from 0.0 to a high of 6.7 (Mad River).

The total number of fry released in the watershed decreased in 1999 to 1.76 million. While the 2.22 million fry stocked in 2000 was well above the 1.76 million target, densities were held at desired levels, resulting in the use of secondary or new habitat. The majority of fry are

released within watershed Region 1, 2 and 4. The headwaters of the watershed are located within Region 1, which is forested with rugged terrain and high peaks. This region represents approximately 32 % of the habitat stocked with fry. Region 2 is forested, interspersed with agricultural lands, large lakes and less mountainous terrain and represents 42% of the total juvenile rearing habitat in the watershed. Region 3 is agricultural with broad valleys and moderately rolling hills and represents 2 % of the habitat stocked in the watershed. Region 4 contains about 17 % of the habitat stocked and is an area interspersed with ponds, wetlands, and sluggish streams with widespread agricultural and developed lands.

### **2.1.3.e. Fish Passage**

#### **Downstream Fish Passage**

PSNH continued to conduct downstream fish passage studies at Garvins Falls Dam and Amoskeag Dam New Hampshire using hatchery reared Atlantic salmon smolts. A louvre and fish bypass in the power canal of the Garvins Falls hydroelectric project, Concord, and a newly installed crestgate at Amoskeag Dam, Manchester, were evaluated in 2000. Observations at Garvins Falls Dam in 1999 indicated that adult brood stock released for angling were congregating along the louvre and at the end of the louvre near the fish collector, and adversely affecting the downstream movement of smolts. The louvres were extended to form an uninterrupted array and electrodes were installed to stun fish at the collector entrance and move them through the bypass. It was surmised that these changes helped keep brood stock from interfering with smolt passage. Results of studies showed that with modifications to the facilities, 84% of the smolts were guided to the downstream end of the louvre array. Fifty-five percent entered the fish collector and 27% passed through the bypass. The system will be further evaluated in 2001 to ensure its effectiveness. In addition, company representatives have indicated that they will pursue headpond level automation where a canal level tracking mechanism is proposed to allow the fish collector at the end of the louvre to move up and down in response to changes in power canal water surface elevations.

At Amoskeag Dam, a study using radio-tagged smolts indicated that the newly installed crestgate (top opening) did not effectively pass smolts while operated with approximately two feet of spill ( $\pm$  100 cfs). Operation of the crestgate in this manner did not appear to be an effective means of passing smolts. Tests will be conducted with larger crestgate openings in 2001. PSNH intends to automate the crestgate to track headpond elevation, a modification that will maintain a fixed crestgate opening despite headpond fluctuations.

#### **Upstream Fish Passage**

Upstream fish passage problems at the Pawtucket Dam fish passage facility, Lowell, MA, were evident in 1999, however Consolidated Hydro, Inc., owner/operator of the facility has made substantial modifications at the site and the results of fish passage studies in 2000 were encouraging. Modifications included changes to the crowder door closing mechanism allowing more rapid closure of the crowder doors, adding a brake to the brail floor hoist, automating the weir gate at the fishway entrance, and strengthening the fish hopper door to improve system

reliability and to minimize breakdowns. The results of studies in 2000 established that lift system modifications substantially improved the internal efficiency of the Lowell fish lift and also demonstrated that fish passage efficiency could be further improved with additional operational modifications. Studies during the 2001 fish passage season at this facility will focus on downstream fish passage issues.

### **Impacts of River Obstructions**

Approximately 60% of the juvenile production habitat in the Merrimack River basin is located in the Pemigewasset River watershed, a major headwater tributary. Smolts migrating from this region encounter seven hydroelectric facilities and one earthen flood control dam. Tributaries throughout the basin also have numerous obstructions impeding the migration of fish with more than 100 dams located in these smaller watersheds. The number of smolts that successfully exit the Merrimack River and enter the ocean is based in large part on the survival of fish as they pass successive dams. Studies and evaluations of fish passage efficiency and effectiveness at most mainstem and a number of tributary dams is ongoing, and these studies have demonstrated that smolt mortality occurs at dams and that seaward migration is impeded or delayed at dams. Water flow regimes, also altered during the period of seaward migration due to the presence of dams, are a factor that can negatively impact migrating smolts. Considerable work is required at both mainstem and tributary dams to improve the effectiveness and efficiency of downstream fish passage facilities.

All returning adult salmon are currently captured at the first dam upstream from tidewater, and the construction of upstream fish passage facilities at dams to provide fish access to spawning habitat is not likely in the near term. The number of adult returns has been low, and target levels have not been reached to trigger the need for construction of upstream fish passage facilities. Fishery resource agencies will continue to consult and coordinate with hydroelectric facility owner/operators and water resource users to construct and improve upstream and downstream fish passage facilities and to ensure the survival of migrating salmon.

#### **2.1.3.f. Genetics**

Existing Atlantic salmon spawning protocols have been maintained at federal hatcheries and no additional work has been conducted in this area in 2000.

#### **2.1.3.g. General Program Information**

##### **Domestic Atlantic Salmon Brood stock Releases**

In the spring and fall of 2000, 3,745 surplus brood stock at the NNFH were released to provide angling opportunities in the mainstem of the Merrimack River and a small reach of the Pemigewasset River. The spring releases included age 2, 3, and 4 fish. Approximately 90% of the age 3<sup>+</sup> fish were non-spawners, and all of the age 4<sup>+</sup> fish had been held and reconditioned in the hatchery prior to release in spring. A total of 1,007 age 3<sup>+</sup> fish were released in November in upper basin fishing areas.

### **Pre-spawner Releases / Natural Reproduction Study**

During the Fall of 2000 broodstock Atlantic salmon were released into the Baker River to expand on past studies performed to determine the potential use of surplus adult salmon broodstock for the natural production of fry within this river system. In 1998, a similar study using a small number of radio-tagged brood stock was performed. In the 1998 study, the brood stock successfully spawned and fry emergence was documented the following spring. In 1999, a study was conducted using sea-run adults. During this study all radio-tagged adults quickly exited the river system and moved a significant distance downstream out of available spawning habitat. Using data from the two previous years, it was decided that a more extensive study, using surplus brood stock from the NNFH, was needed.

The Baker River is a major tributary of the Pemigewasset River. The Pemigewasset River and Winnepesaukee River join to form the Merrimack River. In November 2000, 258 brood stock Atlantic salmon were released into the Baker River. The releases consisted of; ninety-eight, 3 year old females, sixty-two, 2 year old females and ninety-eight 2 year old males. The released fish were in various states of spawning maturity.

Extensive field surveys were conducted by canoe and by wading. All spawning activity was recorded and the locations of excavations flagged riverside and their positions recorded using GPS. Forty-one sites of spawning activities were recorded prior to ice up. The spawning activities at these sites included scratching, test pits and what was thought to be completed redds. Eight of these completed redds were marked with streamers attached to rebar placed at the head of the redd. Initial plans were to extract a egg samples from these completed redds to perform fertilization testing. Four redds were partially excavated. Four eggs were extracted from one of the redds and no eggs were found in the other three. The four eggs froze during transfer to the testing vial and therefore the level of fertilization was not determined.

Current plans are to revisit the completed redds in the Spring 2001 to test for fry emergence. In addition, if the area is not stocked with hatchery fry, there are plans to determine young-of-the-year densities in the study area utilizing electrofishing survey equipment.

### **Atlantic Salmon Domestic Brood stock Sport Fishery**

The NHFG via a permit system manages the Atlantic salmon brood stock fishery. Angled Atlantic salmon that are harvested must be tagged. Creel limits are; one fish per day, five fish per season with a minimum length of 15 inches. The open season for salmon was changed to year-round in 2000. The season for taking salmon is April 1 through September 30 with a catch and release season from October 1 to March 31. In the early winter of 1999 and the spring and fall of 2000, 4,142 surplus brood stock were released for the sport fishery. The winter release included 401-age 3+ fish that were spawned prior to release. The spring release included 2,738 reconditioned-age 3 and age 4 fish that had spawned the previous fall. The early fall release included 1,007-age 3+ non-spawners.

The results of the 2000 sport fishery are presented in Table 2.1.3.g. A total of 1,562 salmon permits were sold in 2000, of this number, 898 anglers reported they had participated in the

Atlantic salmon brood stock fishery. The majority of the anglers were NH residents, 10% were nonresidents. Anglers fished an estimated 19,002 hours during 6,286 fishing trips. They caught an estimated 1,401 fish, released 1,221, and kept 180 salmon. Catch per unit effort was 0.074 salmon per hour (anglers fished about 13.5 hours before catching a salmon). The 898 anglers spent an average of \$162.00 during the season for an estimated total expenditure of \$145,476.

The total number of permits sold in 2000 decreased 7.5% from the 1999 season and was below the six-year mean. However, total effort remained nearly the same as in 1999 with angler trips reduced. It was anticipated that the effort would be reduced because of the unfavorable river conditions during the spring of 2000.

## **Education / Outreach**

### **Adopt-A-Salmon Family**

Adopt-A-Salmon Family (AASF) concluded its seventh highly successful year in June, 2000. Membership in the program was held at about one hundred schools. Similar to previous years, demand for inclusion in AASF program by additional schools continues. However, a reduction in staff and budget shortfalls at the Central New Fisheries Resource Office has placed support for the AASF program at risk. The Outdoor Recreational Planner position that served as coordinator of the program has been vacant since early winter and it is likely that in the future there will be a reduction in the level of support that the USFWS will be able to provide to existing program participants. Admission of additional schools to the program is now contingent upon others dropping out, and continuation of the program in central New England beyond 2001 is questionable at this time. AASF continues to draw positive attention to the effort to restore anadromous fish species to New England rivers. The dropout rate for AASF is low, not surprising given the popularity of the program. While there is an active interest in additional schools participating in the program, schools that inquire about participation in the program and those now enrolled have been advised of the potential for program reduction or termination.

### **Amoskeag Partnership**

The migratory fish program continued to be represented in the Amoskeag Partnership. The partners (PSNH, NHFG, the Audubon Society of NH, and the USFWS) continued to create and implement a broad-based educational outreach program, based at the Amoskeag Fishways facility in Manchester, NH. With the Merrimack River as a general focus, the partnership is offering educational outreach programming to school groups, teachers, the general public, and other targeted audiences. All agencies now participate as active members of the Management and Program committees that provide oversight for the partnership. The partnership was formed to create, manage, and oversee educational activities at the Amoskeag Fishways. The four way collaboration among partners was formed in 1995 to increase visitation to the Amoskeag Fishways by creating new and improved educational programs, expanded year-round hours of operation, and an innovative, hands-on exhibit hall; by strengthening

relationships among organizations involved in migratory fish restoration and conservation activities in New Hampshire; and by broadening the educational focus of the visitor center to encompass more than just the fish passage facility.

#### **2.1.4. PAWCATUCK RIVER**

##### **2.1.4.a. Adult Returns**

One female salmon was captured at the Potter Hill Fishway on the Pawcatuck River in May of 2000. By scale analysis, it was determined that the fish had spent two years at sea after migrating as a one year smolt and was stocked as an age 0+ parr.

##### **2.1.4.b. Hatchery Operations**

###### **Fish Cultural Changes**

The one salmon return from 2000 did not survive past the spring. Five kelts were spawned in the fall, and were successfully rejuvenated. Eight female kelts are being held at ARH. Capacity for raising smolts has increased, and ARH is currently raising 18,000 parr for release as smolts in the spring of 2001.

###### **Egg Collection**

###### Sea-Run Brood stock

A total of 43,200 eggs was collected from five of the nine female kelts. The eggs were fertilized with pooled milt obtained from Nashua National Fish Hatchery. All of the eggs will be retained for subsequent release as 1+ smolts.

###### Captive/Domestic Brood stock

The NANFH incubated 500,000 eggs for the Pawcatuck River.

##### **2.1.4.c. Stocking**

###### Fry Stocking

The NANFH provided 326,000 fry for the stocking effort in May. Stocking of fry throughout the Pawcatuck River Watershed was performed by RI Division of Fish and Wildlife (RIFW) personnel and volunteers from Trout Unlimited, the Wood-Pawcatuck Watershed Association and the public.

###### Parr Stocking

No parr were stocked in 2000.

### Smolt Stocking

No parr were stocked in 2000.

#### **2.1.4.d. Juvenile Population Status**

##### **Fry/Parr Assessment**

Parr were collected by electrofishing at 13 sites in the Pawcatuck River Watershed in the fall of 2000. The 13 sites included a total of 65 units (one unit = 100 m<sup>2</sup>) of juvenile habitat. Units sampled represent about 1.4% of the 4,792 total units of available habitat. Densities of age 1+ parr ranged from 0 to 20 parr/unit at the sampled sites, and averaged 5.5 parr/unit. This mean density estimate is the highest in eight years. Sampling of 0+ parr indicated an average abundance in 2000 with a mean density of 6.5 parr/unit. The sizes of the juveniles sampled were similar to those in past years, with 0+ parr averaging 69.5 mm and 1+ parr averaging 149.6 mm.

##### **Smolt Abundance**

No work was conducted on this topic during 2000 due to personnel changes.

##### **Tagging**

Approximately 10,450 parr were adipose fin clipped in December of 2000 for overwintering in a hatchery pond, and for subsequent smolt release in 2001. This will ensure differentiation between hatchery-reared smolts and pond-reared smolts.

#### **2.1.4.e. Fish Passage**

##### **Upstream Fish Passage**

Problems with upstream fish passage remain at Potter Hill Dam. While salmon have no difficulty ascending the fishway into the trap, attraction flow coming from broken gates on the opposite side of the dam draws migrating fish away from the fishway entrance. The broken gates are thought to detrimentally affect all anadromous species present in the river. It does not appear that salmon are able to pass upstream through the broken gates. The dam is under private ownership by Renewable Resources Inc. The owners have been cited by the State of RI Dam Safety Section to effect repairs but the owners have refused to do so. The dam is not a hydropower dam, thus, regulatory authority to force the owners to repair the dam is severely limited. It is clear that new legislation increasing the ability of the State of RI to deal with the problem is necessary.

##### **Downstream Fish Passage**

No work was conducted on this topic during 2000.

#### **2.1.4.f. Genetics**

No work was conducted on this topic during 2000.

#### **2.1.4.g. General Program Information**

##### **Domestic Atlantic Salmon Domestic Brood stock Releases**

No surplus captive brood stock were released in 2000.

##### **Education/Outreach**

No work was conducted on this topic during 2000.

#### **2.1.5. NEW HAMPSHIRE COASTAL RIVERS**

##### **2.1.5.a. Adult Returns**

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

Six wild adult Atlantic salmon returned to fish ladders in 2000. The Cocheco and Lamprey had two returns in the spring and the Lamprey had two fish in October. In addition one hatchery raised fish returned to the Lamprey in spring.

##### **2.1.5.b. Hatchery Operations**

No adult Atlantic salmon were transported to hatcheries in 2000 for spawning purposes because of the current lack of sufficient, suitable holding facilities in the NHFG hatchery system for adult salmon.

##### **2.1.5.c. Stocking**

In March and April of 2000, approximately 250,000 Atlantic salmon fry were scatter stocked by volunteers into the Lamprey (104,500 fry) and Cocheco (145,600 fry) River systems. Fry were stocked at a density 25 fry/100 m<sup>2</sup> unit in the Lamprey and 42 fry/100 m<sup>2</sup> unit in the Cocheco.

Eyed salmon eggs for the 2000 fry stocking were purchased in the fall of 1999 from Stolt Sea Farms Inc. Approximately 305,000 pure St. John strain eggs were obtained from Stolt Sea Farms' Bingham Hatchery. Fry to be stocked in the Lamprey system were raised at Powder

Mill State Fish Hatchery and fry for release in the Cocheco were raised at Berlin State Fish Hatchery.

#### **2.1.5.d. Juvenile Population Status**

Electrofishing surveys for juvenile salmon at four index sites and two alternates on the rivers produced population estimates for young-of-the-year (YOY) fry ranging from 0 - 2.4 fish/100 m<sup>2</sup> unit. Mean length and weight of YOY at the sites ranged from 85-100 mm and 5-9 grams. Estimates of parr abundance at the sites ranged from 0 - 4.7 fish/100 m<sup>2</sup> unit. Parr ranged in size from 139-162 mm and 27 - 39 grams.

Population estimates at the two index sites and one alternate site in the Cocheco River contrasted significantly. The population estimate for YOY at the Mad River site was 2.4 fish/100 m<sup>2</sup> unit as compared to 0.7 fish/100 m<sup>2</sup> unit at the Cocheco River location. The alternate site on the Ela River had a population estimate for YOY of 0.3 fish/100 m<sup>2</sup> unit. Parr population estimates at the two index sites were 4.7 fish/100 m<sup>2</sup> unit for the Mad River and 0.9 fish/100 m<sup>2</sup> unit for the Cocheco. The Ela River had an estimate of 2.8 fish/100 m<sup>2</sup> unit. Population estimates for YOY in the Mad River and Cocheco River YOY and parr were below the nine year average while the estimate for parr in the Mad River was slightly above the long term average. Mean length and weight for YOY and parr at the index sites were at or above long term average.

Population estimates for YOY and parr at both index sites in the Lamprey River system were very similar to those last year. At the North River index site no fish were captured during electrofishing. At the Lamprey index site the population estimates for YOY and parr were 0.3 and 0.9 fish/100 m<sup>2</sup> unit respectively. These estimates equaled last years as the lowest ever recorded at the Lamprey River site. At the alternate site on the Little River no YOY and only two parr were captured resulting in population estimates of 0 and 0.5 fish/100 m<sup>2</sup> unit. Mean length and weight at the Lamprey River index site for YOY and parr was one of the highest ever observed. No long term averages are available for the alternate sites because of intermittent sampling at those locations.

#### **2.1.5.e. Fish Passage**

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

### **2.1.5.f. Genetics**

No work was conducted in this area in 2000.

### **2.1.5.g. General Program Information**

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

## **2.2. STOCKING**

### **2.2.1. TOTAL RELEASES**

During 2000, the participating agencies released approximately 15,235,000 juvenile salmon into 13 river systems (Table 2.2.1.a in Appendix 9.3). Canada stocked an additional 19,000 0+ parr into the St. Croix from the Canadian side. The number of fish released represented an approximate 11% increase over the 1999 level.

In addition to juveniles, mature adults were also stocked in some river systems (Table 2.2.1.b in Appendix 9.3). In general, these fish were either spent domestic brood stock or pre-spawned domestic brood stock in excess to hatchery capacity and were of river-specific origin. Sea-run kelt releases are not included in this table. In 2000, 6,653 adult salmon were released into the rivers of New England.

### **2.2.2. SUMMARY OF TAGGED AND MARKED FISH**

A total of 230,698 salmon released into New England waters in 2000 was marked or tagged in some manner. Tag types included: Floy, Carlin, PIT, radio and acoustical (ping). Fin clips, fin punches, and elastomer visual implants were also used. Parr, smolts and adults were marked. About 22.4% of the marked fish was released into the Connecticut River system, 1.7% into the Merrimack River system, 74.6% into the Penobscot River, and 1.2% was stocked into six other rivers in Maine.

A comprehensive summary of marked and tagged Atlantic salmon released in New England rivers during 2000 is presented in Tables 2.2.2.a and 2.2.2.b (Appendix 9.3).

## **2.3. ADULT RETURNS**

### **2.3.1. TOTAL DOCUMENTED RETURNS**

A total of 803 adult salmon was documented to have returned to rivers in New England in 2000 (Table 2.3.1. in Appendix 9.3). The majority of the returns was recorded in the rivers of Maine with the Penobscot River accounting for nearly 66.6% of the total New England returns. The

Connecticut River adult returns accounted for nearly 9.6% of the New England returns and 46.4% of the adult returns outside of Maine. Overall, 33.6% of the adult returns to New England were 1SW salmon and 66.4% were MSW salmon. Most of these fish (72%) originated from hatchery smolts and the balance (28%) were of wild origin (natural reproduction and fry plants).

Documented returns of 1SW salmon to New England rivers (270) were down considerably from 1999 (380). MSW returns in 2000 (533) were half those in 1999 (1,072). Overall, the total returns were 55% of those in 1999 (803 in 2000 versus 1,452 in 1999). Changes from 1999 by river program are: Connecticut (-50%), Merrimack (-56%), Penobscot (-45%), Saco (-26%), Narraguagus (-28%), St. Croix (+154%).

### **2.3.2. RETURNS OF TAGGED SALMON**

No marks or tags were reported on adult sea-run salmon that returned to New England waters in 2000.

### **2.3.3. SPAWNING ESCAPEMENT, BROOD STOCK COLLECTION, AND EGG TAKE**

Connecticut River- A total of 12 wild sea-run adult salmon was permitted to ascend the rivers upstream of fishway traps where brood stock are captured. Ten were radio-tagged as part of a utility company sponsored study on the main stem. The movements of these fish are summarized in section 2.1.1.a.

Merrimack River- One sea-run salmon escaped the trap at the Essex Dam.

Maine Rivers- Natural reproduction was documented by redd counts in the 16 rivers with natural populations and in some tributaries of the Penobscot River. Details can be found in section 2.1.2.a. There is no consistent trend relative to last year, but the redd counts remain well below appropriate levels.

Egg sources for the New England Atlantic salmon culture programs included sea-run salmon, captive salmon (fish collected as wild parr and grown to maturity in hatcheries), domestic brood stock (fish grown to maturity in hatcheries from eggs), and reconditioned sea-run kelts. The total number of females spawned in 2000 from each category is as follows: sea run= 283, captive= 439, domestic= 3,607, kelts= 209. The grand total of brood stock spawned (4,538) was more than that in 1999 (3,883). The total egg take (22,240,700) was somewhat lower than that in 1999 (23,326,900). A more detailed accounting of the egg production is contained within Table 2.3.4 in Appendix 9.3.

### **2.3.4. SPORT FISHERY**

Directed fishing for sea-run Atlantic salmon is not currently allowed in New England. The domestic brood stock fishery in the Merrimack River resulted in an estimated catch of 898 fish (1999 = 2,707). This fishery is described in more detail in section 2.1.3.g.

### 3. EMERGING ISSUES

Commercial aquaculture continues to be an issue in Maine where populations of salmon have further declined and salmon populations from eight rivers have been listed as endangered (December 2000). Concern remains over the hybridization of the native North American river-specific stocks with escaped, exotic European or domesticated North American aquaculture stocks.

Development of marking protocols, for use in identifying aquaculture fish at weirs in the rivers, is underway. Additionally, containment and biosecurity plans are under development. Comprehensive equipment disinfection and brood stock isolation and biosecurity are critical since Infectious Salmon Anemia virus (ISAv) has been identified in U.S. waters at the Treat's Island aquaculture site in Cobscook Bay (February 2001).

### 4. TERMS OF REFERENCE

#### 4.1. PROGRAM SUMMARIES FOR CURRENT YEAR

- a. current year's stocking program with breakdowns by time, location, marks and life stage.
- 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.

#### 4.2. HISTORICAL DATA

The historical data were validated by the Assessment Committee and the information can be found in Tables 3.2.a. and 3.2.b. in Appendix 9.3. and in Section 5. (sub-sections 5.1. and 5.2.) of this document.

#### 4.3. TERM OF REFERENCE 3 - A Model for Optimum Fry Stocking Throughout New England

**Development of a Connecticut River Smolt Production Model to Assess Fry Stocking Strategies.** Abstract by Keith H. Nislow, B.H. Letcher (DD, R)

In order to obtain better estimates of tributary-specific and whole-system production of salmon smolts resulting from fry stocking, we are in the process of constructing a model of smolt production in the Connecticut River basin. Our plan is for the model to use index site data to establish pre-smolt densities in rearing tributaries, then use the results of previous and current studies to estimate survival probabilities through outmigration. We have made progress in the following areas:

- 1) Engaging the services of a software engineer,
- 2) Establishing a web site and on-line data interface, and
- 3) Establishing model structure and parameters

#### **4.4. TERM OF REFERENCE 4 - Summary of Smolt Runs**

Term of Reference 4 was addressed below under Term of Reference 10 - Highlighted Abstracts.

#### **4.5. TERM OF REFERENCE 5 - Research Program Update**

The former head of the U.S. delegation to NASCO, Dr. Andy Rosenberg, has left the federal government and is currently a Dean at the University of New Hampshire. Dr. William Hogarth, Acting Assistant Administrator for Fisheries, is serving as acting head of the U.S. delegation. The head of the delegation and the other two Commissioners (Bob Jones and Bucky Owen) are presidential appointees. As such, with a change in administration, they will be requested to submit an offer of resignation. It is unlikely that there will be a change in Commissioners for this year, but there could for 2002 and beyond. During this time of transition, it will be difficult to get a commitment regarding the Assessment Committee research program proposal.

#### **4.6. TERM OF REFERENCE 6 - Modeling Assumptions**

No abstract was provided for this Term of Reference.

#### **4.7. TERM OF REFERENCE 7 - Emerging Applications for Genetics Research**

**Family Differences in Growth and Survival of Juvenile Atlantic Salmon: What Does it Mean and Where Can We Take It?** Abstract by Benjamin H. Letcher, K. Nislow and G.Gries (R,DD,R)

A wide range of biotic and abiotic factors can contribute to variation in growth and survival of Atlantic salmon parr. We explored the extent to which genetic differences contribute to variation by stocking fish (1999) with known parentage into the West Brook, a small stream in Whately, MA, and into seven other streams in MA and VT. We identified family (mother-father pair) of individually-tagged fish using parentage assignment with eight microsatellite loci determined from fin clips.

In the West Brook, we obtained genotypes on 550 fish and 421 were determined to belong to one of the six families stocked in the study area. The fish not belonging to one of the six families were stocked outside of the study area and had moved in since stocking. Fish were not clumped in space within each family. Of the six families, fish from one family were about 35% heavier than fish from the other families when the fish were age-0. By the time fish were age-1, fish from two other families had caught up in mass and differences were less distinct except for one family that had much lower mean mass. The heaviest family was not, however, the most numerous family. Two of the six families were consistently the most numerous while the other four had

similar population estimates. Differences in size and abundance among families in the field were similar to those observed in fish raised at WRNFH and was strikingly similar to variation among the other seven rivers. The strong correspondence between laboratory and field observations and among rivers and the substantial and consistent differences among families suggest that genetic differences can contribute in a significant way to the variation in growth and survival among individuals.

We suggest that we may be able to take advantage of the variation among families to help the Connecticut River population adapt more quickly to conditions in the Connecticut River basin. In the near future, we could determine which families had higher fitness in some traits (growth, survival, timing of smolt emigration, etc.) in the field and use this variation to guide the mating design of the domestic brood stock. Because fish from the same families are both stocked in the field and raised at WRNFH for domestic brood stock, we can use information on the performance of fish in the field to help determine which families to mate together in the hatchery. For example, mating fish from families that have early smolt run timing may result in offspring that have a higher than average run timing. If earlier run timing were adaptive, then more of these offspring would return than fish with later run timing and we may begin to see more rapid adaptation to conditions in the Connecticut River basin. The trick is to select the most appropriate traits of the wild fish on which to base our mating design for the domestic brood stock. The use of identifiable families in the Connecticut River restoration program offers an unprecedented opportunity to design our domestic brood stock matings in a way that may increase the rate of adaptation and improve long-term chances of a successful restoration.

#### **4.8. TERM OF REFERENCE 8 - Habitat Inventory Model**

**Building Functional Atlantic Salmon Databases in a GIS Universe Or: Redefining a River as a One-dimensional Entity.** Abstract by Kenneth F. Beland, M. Anderson, J. Wright, J. F. Kocik (C,A,GG,A)

The availability of user-friendly Windows-based relational databases and desktop GIS software provides biologists with powerful tools for analysis and presentation of data relevant to Atlantic salmon management in Maine rivers. Biologists from the Maine Atlantic Salmon Commission, the National Marine Fisheries Service, and the U.S. Fish and Wildlife Service undertook a joint database development project to facilitate data sharing and capture the power available on modern desktop computers. This data management system uses ArcView for GIS applications and Microsoft Access2000 as a relational database manager. The system incorporates concepts not previously applied to salmon data management in Maine. Traditional X-Y grid projections of the spatial data elements do not accurately describe the relative positions of habitat features in a riverine environment. We developed a linear river model with locations described as distances along a virtual river centerline (River Km), with a precision of 0.01 km. A zero point is established at a prominent feature, such a bridge crossing located near the head of tide. Tributary distances are computed upstream from their confluence with the next higher branch in the watershed hierarchy. We incorporated drainage hierarchy and River Km locations in site codes for all databases. The individual relational databases are also linked to a modular library database of site names and attribute codes (Maine Salmon), which facilitates multi-database queries. The

database and GIS software are dynamically linked through SQL connections that allow the GIS to display the most recently updated Access data. Tools have been developed to use GIS to generate new site location River Km codes and update the modular library database. These innovations will facilitate sharing the most current spatial and tabular data sets for Atlantic salmon data analysis.

**Beyond the “What and Where” Stream Habitat Survey.** Abstract by Joan G. Trial (C)

Habitat surveys have been conducted along a number of Maine rivers to quantify habitat area at “typical low flows”. These surveys define habitat primarily by length, width, and substrate. Water depth, may have been used to differentiate among habitat types, and velocities, if collected, were seldom used to define habitat. Based on the habitat mapping from these surveys, it is clear that habitat for various life stages is not distributed evenly throughout the drainages, but occurs in different frequencies along the rivers. To provide some insight into these distributions, fluvial geomorphologic classes (Rosgen 1996) will be determined for river reaches containing habitat for the different life stages. The classes are based on predictable, measurable physical features such as slope, sinuosity, width/depth ratio, and entrenchment. For example, B streams have fairly steep slope and straight riffle reaches and are likely to have continuous reaches of juvenile rearing habitat. While C reaches, with gentler slopes and alternating pools and riffles within winding channels, will have discontinuous juvenile habitat.

The effects of hydrology on habitat quantity and quality were not assessed in past surveys. However as part of developing water use management plans, Instream Flow Incremental Methodology (IFIM) studies were conducted in five reaches in the Pleasant River, five reaches on the Narraguagus River and three on Mopang Stream (Kleinschmidt Associates 1999a, 1999b). As a result, we now have models of the relationships between discharge and habitat for small and large parr and spawning adults within the three rivers. Habitat was indexed as weighted usable area (WUA), the product of quantity (wetted area) and suitability (relative quality) based on HSI models. The new information provided by the IFIM, in conjunction with hydrologic data, will provide a way to assess the severity and extent of habitat restrictions during summer and winter, the two annual periods of low flow.

Atlantic salmon habitat in Maine has changed dramatically over the last 200 years, as a result of land use practices (i.e. timber harvest, agriculture, dams, channelization, roads, log drives) and natural events (i.e. fires). These forces have altered the hydrologic and geomorphic processes that create and maintain habitat features including channel widths and depths, pool-to-pool spacing, and substrate composition. Maine biologists will be working with the USGS to determine the hydraulic geometry of the channels at 10-15 selected gaging stations in coastal Maine. These data will be used to develop regional curves based on the 1.5 year-return discharge and field determinations of bankfull stage. These regional curves and the fluvial geomorphology measurements will be the basis for assessing the type and magnitude of channel alteration and undertaking restoration projects.

#### 4.9. TERM OF REFERENCE 9 - Fishway Construction and Dam Removal

##### **Coastal America Partnerships for Technical and Financial Assistance to Remove Dams and Restore Anadromous Fisheries in Rivers in Maine.** Abstract by Robert Wengrzynek (HH)

The Coastal America ([www.coastalamerica.gov](http://www.coastalamerica.gov)) partnership is a unique teamwork effort that has contributed to the restoration of anadromous fisheries by removing eight dams and building fish passage at six other sites during the past three years, in Maine. This was accomplished by private landowners working with Federal and State of Maine agencies, non-government organizations, the Penobscot Indian Nation, and private industry. The USDA Natural Resource Conservation Service's Wildlife Habitat Incentives Program (WHIP), the U.S. Fish & Wildlife Service, National Fish & Wildlife Foundation matched private and corporate contributions to accomplish the ambitious goals. The Souadabscook Stream and Brownville's Pleasant River dams, in the Penobscot River watershed are examples of early successes. The removal of these dams was only the beginning steps in larger habitat restoration goals, including removal of many other dams in the Penobscot River Watershed and throughout Maine and will continue to be a benefit to Atlantic salmon habitat throughout New England. It has now been demonstrated in Maine and elsewhere that using common sense, innovative techniques and avoiding complicated processes dam removal and habitat restoration can be accomplished to provide the most efficient access to habitat and improve river and stream hydrology for Atlantic salmon and other anadromous species.

The Coastal America process joins the efforts of Federal agencies with State, local, and private alliances to address environmental problems of our Nation's coasts in an effective collaborative manner. The Federal partners include agencies with responsibilities for the stewardship of coastal resources, those with responsibilities for infrastructure development and maintenance, and those activities that impact coastal environments. The challenge has been to integrate the capabilities of existing resources with State, local and non-governmental efforts to address specific local problems by sharing information, pooling resources, and combining management skills and technical expertise. The Coastal America interagency structure enables national policy issues to be identified and resolved, regional plans and strategies to be developed and local projects to be implemented. Federal partner agencies include: Department of Agriculture, Department of the Air Force, Department of the Army, Department of Commerce, Department of Defense, Department of Energy, Department of Housing and Urban Development, Department of the Interior, Department of the Navy, Department of Transportation, Environmental Protection Agency, and the Executive Office of the President.

Coastal America's new and growing Corporate Wetland Restoration Partnership (CWRP) now involves private industry in the process of restoring our nation's wetlands and riverine habitat. CWRP will provide needed private cost share funds needed to match Federal and State programs, in exchange for improved relationships, publicity, public partnership visibility and resource stewardship.

More recently, the "Innovative Readiness Training" (IRT) program of the Department of Defense has been used around the country to conduct training exercises that have fisheries and

other public benefits by removing dams. This is one tool in the Coastal America process that can be used in conjunction with other programs. The IRT program can save a significant amount of money for Federal and State programs, as well as project sponsors. Before and after photographs these types of projects are dramatic. These accomplishments have led to increase public interest in dam removals and other fish passage in Maine, around the United States and Canada.

Long term success of this type of initiative can only be assured by reducing total project costs and unnecessary, bureaucratic processes that are inherent in many existing agency procedures and organizational structures. One of the Coastal America objectives is to use existing technical and financial resources in a more efficient manner. Each cooperating agency and organization needs to closely examine its procedures and infra-structure for ways to improve efficiency and partnership opportunities that will result in more effective restoration of fisheries habitat. We must continue to demonstrate that "more can be done with less" and that habitat restoration for important species and ecosystems can be done in a cost effective and technically sound manner.

**Dam Removals in the Ashuelot River, New Hampshire.** Abstract by Kenneth Sprankle (Z)

In 1998, the New Hampshire Fish and Game Department (NHFG) initiated an effort to remove three unutilized dams in the Ashuelot River basin, a tributary to the Connecticut River. The proposed removals are part of a migratory fish restoration plan that is targeting American shad, Atlantic salmon, and blueback herring. In the process of contacting dam owners and informing them of pending fish passage issues and their legal responsibilities, the option of breaching was promoted. The owners of the three targeted dams agreed to support removal with various levels of funding support. McGoldrick Dam was the first to have a Wetlands Permit submitted for instream removal work and prompted a number of questions and procedural concerns. Consequently, a statewide River Restoration Task Force was developed consisting of state, federal, and non-government professionals in areas of permitting, engineering, law, archeology/historical, and biology. A model of what steps are necessary to satisfy requirements and address additional concerns was developed. Funding options were identified and expanded in some cases, such as using Clean Water Act grant dollars and a NHFG Fish Habitat Stamp. Several key steps identified as critical in keeping the proposals on track include; having a fish management plan, removal plan, needs assessment with alternatives to removal, prepared information on benefits of removal (ecological, recreational, economic), public notification and involvement, historical agency involvement, and cooperating agency staff support (Task Force). McGoldrick Dam is slated for removal in July of 2001, with the second dam (Town of Winchester) planned for removal in July or August 2001. The third dam (Homestead, in Swanzey) has a number of difficult issues that are being address in a step down sequence, one or more of which may prevent removal as the best alternative to fish passage concerns.

**Fishway Construction Program in Connecticut.** Abstract by Steve Gephard (II)

The CTDEP has recently reorganized and placed the Diadromous Fish Program in its Inland Fisheries Division. This program seeks to restore runs of migratory fishes to historical habitat, often relying on the construction of fishways. Fishways can either be required through several avenues of the regulatory process or can be voluntarily built in a proactive partnership approach.

The latter approach has resulted in more fishways being constructed in Connecticut than the former. Fishways typically target alewife, blueback herring, sea-run brown trout, and sea lamprey and often target American shad, gizzard shad, Atlantic salmon, and American eel. Some fishways are built in inland areas, beyond the range of anadromous species. These fishways target trout and other resident species. When possible, a partnership develops which results in a Town or private NGO owning and operating the fishway. The Inland Fisheries Division provides essential technical assistance, support, and planning services prior to construction and technical assistance and support after construction. Fishways are custom designed for each site and Connecticut fishways include several styles of pool-and-weir, Denil, Steeppass, fish lift, and semi-natural bypass channel. The fishways are funded through a variety of ways, but the Division does not have any fishway funds in its budget. There are currently 24 fishways in Connecticut, two were built in 2000 and as many as eight may be built in 2001. Many others are in various stages of planning.

#### **4.10. TERM OF REFERENCE 10 - High lighted Abstracts**

##### **a. Coldwater Disease: Impact Within Atlantic Salmon Restoration.** Abstract by Rocco C. Cipriano (X)

This presentation reviews the overall impacts of coldwater disease, caused by *Flavobacterium psychrophilum*, within the restoration of Atlantic salmon in the northeastern United States. The review concentrates principally upon enhancement of stocks within the Connecticut River, Merrimack River, Penobscot River and several smaller rivers on the Downeast coast of Maine, where river-specific brood stocks are used to enhance the genetic integrity of the fish within each river system. Consequently, the gametes produced from the limited number of adult salmon returning to each of these river systems are extremely valuable in terms of providing a sufficient number of offspring to continue the restoration effort. In the course of study, chronic symptoms of Bacterial Coldwater Disease, caused by *Flavobacterium psychrophilum*, were noted among a proportion of offspring that are propagated and stocked as smolts. Classical peduncle lesions and chronic mortality were associated with the affected fish. The disease was more pronounced in salmon reared in two-year rather than one-year smolt production cycles. Following the identification of these symptoms, the pathogen was shown to be the etiologic agent of a more acute mortality among yolk-sac fry in Heath incubators. The pathogen was initially associated as a highly significant element of the bacterial microflora among lots of eggs showing reduced viability. Further studies, indicated that *F. psychrophilum* was transmitted vertically from parent to offspring via intra-ovum infection. Bacterial concentrations increased with the age of the egg indicating that the bacterium was indeed growing within the fertilized egg. Subsequently, vertical transmission of *F. psychrophilum* was shown to be widespread throughout the range encompassed by the restoration program. The pathogen, therefore, has a significant role in the production of quality gametes and may be an extremely important factor in the post-stocking survival of salmon fry and smolts.

##### **b. Overview of the U.S. Atlantic Salmon Farming Industry.** Abstract by Ed Baum (KK)

Atlantic salmon farming began at about the same time on both the East and West coasts of the

US. The industries began experimentally in the 1970s (initially rearing pan-size coho salmon), then experienced very rapid growth and expansion in the production of Atlantic salmon in the 1980s (as technology and funding came to North America from Norway). Atlantic salmon are the preferred species for cold water aquaculture in North America, South America, Europe and Australia because of growth characteristics, disease resistance, appeal to consumers and marketing characteristics (long shelf-life, etc.). Production from the industry on the West coast has remained relatively stable, at about 10 million lb. (+/- 5,000 mt.) annually, while east coast production has recently increased to about 34 million lb. (+/- 15,500 mt.) annually. Similarities and differences between the current Atlantic salmon farming industries in the states of Washington and Maine are discussed.

**c. Overview of Narraguagus/Pleasant River smolt projects:**

**Narraguagus River Smolt Assessments.** Abstract by John.F. Kocik, K. F. Beland, and T.F. Sheehan (A,C,A)

We monitored the emigration of Atlantic salmon smolts in the Narraguagus River from April through June using five rotary screw fish traps. Four traps were set downstream of approximately 80% of juvenile rearing habitat in the basin and were used for a mark-recapture population estimate. The fifth trap was set at Cable Pool to evaluate production and over winter pre-smolt residence in lower river habitat. We captured a total of 563 smolts in the Narraguagus River. All were in excellent condition upon removal from the traps, and no trap-related mortality was observed. Smolts averaged 168 mm fork length and 45.6 g wet weight (n =218). We collected scale samples from a sub-sample of 135 smolts. NEFSC personnel have image-analyzed and aged these scales during the summer. Preliminary results suggest that age-2 individuals (95%) continue to dominate Narraguagus River smolt population with a small percentage of age-3 fish (5%) present. The timing of emigration for wild smolts was normally distributed with 7 May being the date of 50% emigration, the earliest peak in our 5-year time series. Utilizing a Darroch maximum likelihood model, our preliminary estimate of the emigrant smolt population in 2000 is 1,940 – the lowest estimate in the 5-year time series. We used simulation modeling of the error bounds on this estimate and basin-wide estimates of large parr abundance to calculate an average over-winter survival of 13 %, a value about average for the time-series. Our initial analyses suggest that poor summer survival may have compromised this cohort as they entered winter. The trap at Cable Pool was used to test our hypothesis that pre-smolts migrate below the smolt traps the previous fall/winter and reside in non-traditional juvenile habitat (deep pools and deadwater) between our lower trap site and the tidal estuary. No smolts were collected in this trap until smolts were detected upriver. The results of this suggest that no presmolt movement to the lower river occurs in late-winter or early spring.

**Smolt Production Dynamics in the Pleasant River.** Abstract by John F. Kocik, T.F. Sheehan, and R. Haas-Castro (A,A,A)

To determine if recent pre-smolt and marine survival estimates on the Narraguagus River are representative of other eastern Maine Atlantic salmon rivers, smolt trapping was expanded to the Pleasant River in 1999. This year marked the second year of qualitative sampling of smolt

emigration in this system. NEFSC and ASC deployed a rotary screw smolt trap near the head of tide in Columbia Falls in mid April, and it was tended daily through early June. We captured 160 smolts (mean total length 176 mm) most of apparent wild origin this spring. The smolt catch was only 26% of the 1999 total of 617 smolts. Catch rates continued to exceed our initial expectations and suggested that this trap was intercepting a higher proportion of the smolts leaving the Pleasant River than any individual trap on the Narraguagus River, where trap efficiency is consistently less than 20 percent. Tissue samples for DNA analysis and scale samples were systematically collected from the Pleasant River smolt run again in 2000. In addition to the probable wild fish, we again captured smolts with fin deformities, coloration, and body form suggesting that they were of hatchery origin. Smolts of obvious aquaculture origin were sacrificed on several dates for disease sampling and physiology testing. Follow-up electrofishing by Atlantic Salmon Commission staff captured several probable hatchery origin juveniles in the Bog Stream subdrainage, where a commercial salmon hatchery is located. NEFSC staff are currently analyzing scales collected in 2000 and conducting image analysis to determine if scale characteristics are distinct enough to facilitate identification of other hatchery origin fish. This study will help to determine the magnitude of hatchery-origin fish and the success of actions taken by the operators of this facility to eliminate escapees in this watershed. In addition, we will be able to compare fin deformities, genetic analysis, and scale imaging as tools to ascertain fish origin.

**d. Estimating Adult Returns in the Gulf of Maine Distinct Population Segment.** Abstract by John F. Kocik and Joan G. Trial (A, H)

The Gulf of Maine Distinct Population Segment (GOM DPS) of Atlantic salmon has been listed as an Endangered Species under the US Endangered Species Act. This assemblage of populations includes all coastal watersheds with native populations of Atlantic salmon north of and including tributaries of the lower Kennebec River (below former Edwards Dam site) to the mouth of the St. Croix River at the US-Canadian border. There are at least eight rivers in the DPS range that still contain functioning populations, albeit at extremely low abundance. These eight rivers are the Dennys, East Machias, Machias, Pleasant, Narraguagus, Ducktrap, and Sheepscot Rivers and Cove Brook. In the Status Review, the health of these populations was determined using population estimates and abundance indices for parr, smolts, and adult Atlantic salmon. Estimating adult returns to these rivers is essential to measuring both the health of these populations and the effectiveness of recovery efforts.

Over the time-series of data available (~ 1973 to present), information on adult abundance can be estimated from catch records, trap and weir catches, and redd counts. Trap and weir catches provide the best assessment tool because they are actual counts and independent of fishery effort. In addition, because fish are handled at these facilities, biologists can collect biological data, scale samples, and tissue samples. The Narraguagus River provides the best time-series of data with trapping for most of the past 25 years. Trap and weir coverage in the other watershed has been sporadic, weir design has varied, and weir efficiency has been highly variable, especially with high water conditions. At present, data from these weir and trap operations are the only quantitative data presented in the U.S. Atlantic Salmon Assessment Committee annual report (e.g., Table 2.3.1 – documented returns). Rivers without counting facilities are classified as

“unknown” returns. This categorization is inaccurate because index-data, in the form of redd counts, are available for many of these rivers. Our intention was to develop a standardized method of using redd counts to index abundance in the GOM DPS. This effort was undertaken independently by the authors but has been reviewed and endorsed by the Maine Atlantic Salmon Technical Committee (28 February 2001) as the best estimate of adult returns for rivers that do not have a trap or weir.

The primary objective of our approach was to use all data available to develop a stochastic estimate of adult returns. Preliminary work by D. Kimball and E. Baum attempted to relate redd counts to adult abundance but these were point estimates that did not include the variability in their models. We believe that it is important to capture the uncertainty and measurement error in these estimates. We define adult returns as the number of Atlantic salmon returning to a river to spawn. This number is distinct from escapement, which is the number of spawning Atlantic salmon. Redd counts index escapement directly, since they are a measure of spawning activity. The time-series of data for the Narraguagus River includes accurate estimates of adult returns and redd counts over all significant spawning reaches. In addition, new weirs on the Pleasant and Dennys River in 2000 and the East Machias in 2002 will allow additional reference points to refine the relationship between redd counts and adult returns (return-redd model). We have used data available through the 2000 spawning season to establish the 2000 return-redd model using a linear regression of the natural log of both values (Figure 1). We then use this return-redd model and its associated error to simulate the most probable adult returns on a river-by-river basis. The result of this model is a stochastic estimate of adult returns for each river, and a composite estimate for the GOM DPS in its entirety (Figure 2). At present, we can only use data from 1991-2000 for this estimate because the redd counting effort was relatively standard for this period.

In our present model, the error associated with the regression accounts for many parameters: 1) mortality from return to spawning (trap handling, fishing-prior to 1999, poaching); 2) natural demographics (sex ratio, age distribution); 3) management activities (pre-spawn release of captive brood stock and marine-reared adults); 4) ecology (spatial distribution of fish, influences of discharge and temperature); 5) survey variables (timing- relative to spawning, visibility-between rivers and years, spatial coverage). This is a working model and it is our intention to work toward being able to partition out as many of these sources of error into component parts. Thus, increasing both the accuracy of the model and the precision of the field methods used to build this model. By focusing and improving our sampling methods and addressing questions using the historic database, we should be able to reconstruct adult returns for an additional 10 or more years and increase the accuracy of future efforts.

We recommend the inclusion of the data generated for these individual rivers (Table 1) as a sub-table of table 2.3.1 for the 2000 adult returns and the addition of a table with the time-series of these data (1991-2000) as an addition to the appendices.

Table 1. Estimates of adult returns to rivers of the Gulf of Maine Distinct population segment in 2000.

<u>River</u>	<u>Count</u>	<u>Type</u>	<u>Estimate</u>	<u>95% CL Low</u>	<u>95% CL High</u>
Cove Brook	1	redd	3	2	5
Ducktrap River	2	redd	5	3	8
East Machias River	10	redd	14	8	22
Machias River	23	redd	24	13	38
Sheepscot River	15	redd	18	10	29
Dennys River	2	trap	2	-	-
Narraguagus River	23	trap	23	-	-
<u>Pleasant River</u>	3	trap	<u>3</u>	=	=
Total			91	64	130

Figure 1. Relationship between adult returns and redds in standard (Panel B) and natural log (Panel A).

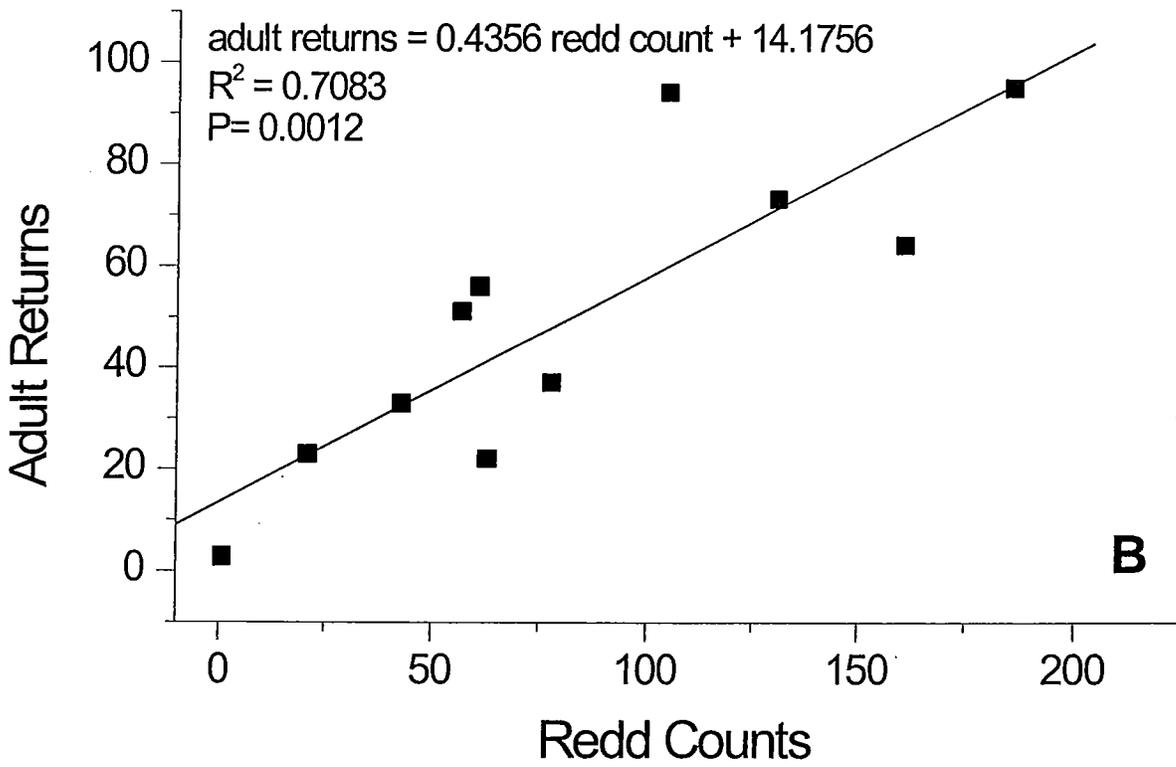
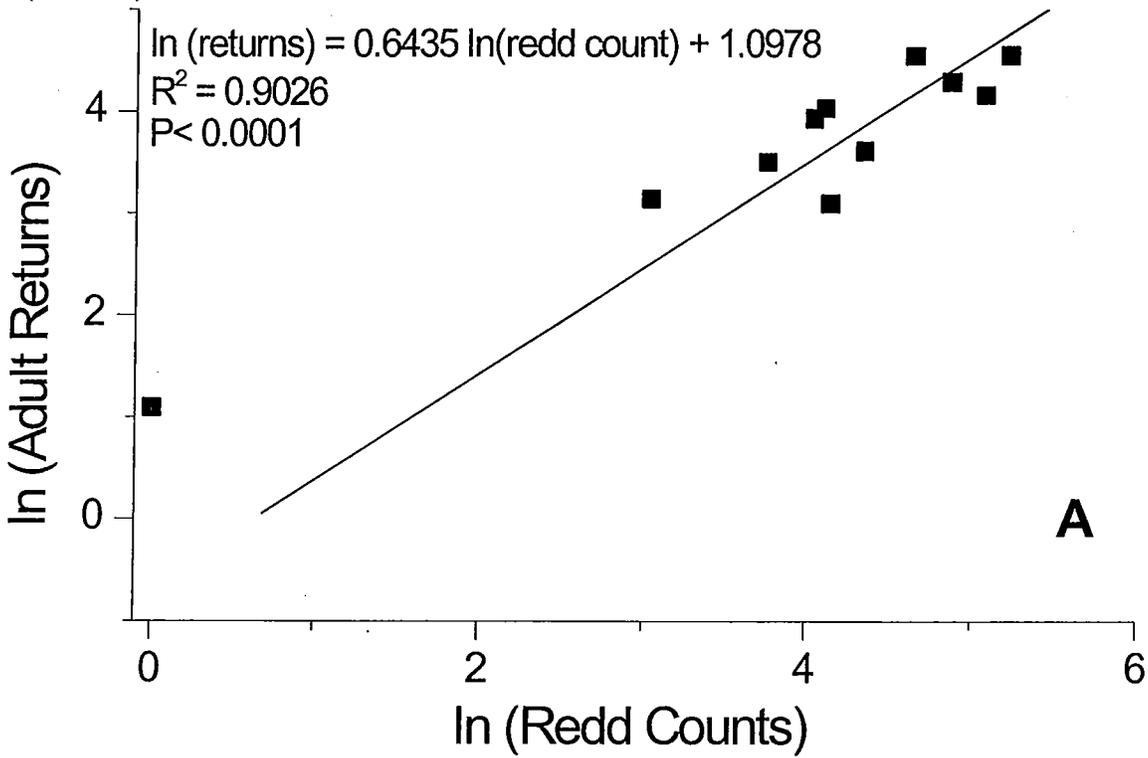
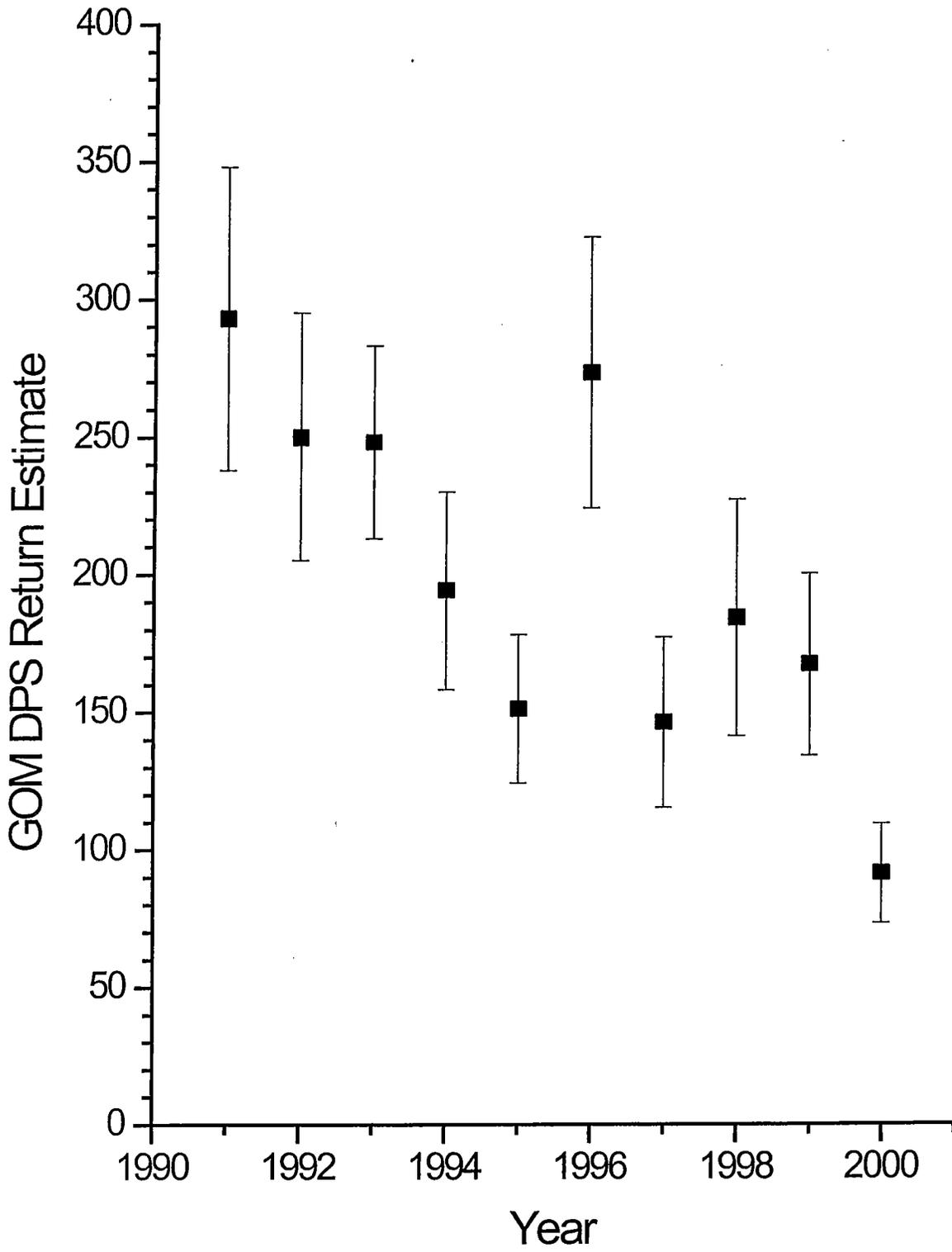


Figure 2. Estimates of total adult returns to the Gulf of Maine Distinct Population Segment (GOM DPS) of Atlantic Salmon.





**e. Stocking of net pen-reared adults in the Denny and St. Croix Rivers:**

**Saint Croix River Adult Stocking Assessment.** Abstract by Timothy F. Sheehan, L. Sochasky, J. Kocik, and D. Finlay (A,G,A,F)

During October 2000, 750 netpen reared, two-sea winter, mature, Atlantic salmon originating from river-specific brood stock from the Dennys, East Machias, and Machias rivers were stocked into the St. Croix River. Stocking rates were determined by stock-specific fecundity estimates and habitat survey data according to established management guidelines. A Memorandum of Understanding outlining this trial program and the need to fully evaluate it was drafted and is intended to be signed by the National Marine Fisheries Service, U.S. Fish & Wildlife Service, State of Maine natural resource agencies, and Atlantic Salmon of Maine. A comprehensive Assessment Plan was developed to monitor the progress of these adults and the progeny of these adults over the next 6 years. This assessment program consists of 6 objectives: 1) evaluation of spawning characteristics of these stocked adults as compared to wild adults 2) assess spawning habitat selection 3) post-spawning disposition (immediate out migrants, kelts, or presumed deceased) and timing of estuary entrance 4) monitoring the stage specific contribution attributable to natural reproduction by these stocked adults 5) estimate fry emergence rates for progeny of these stocked adults and 6) evaluate the reproductive success of progeny originating from these stocked adults. The comprehensive assessment plan was designed to monitor the stage specific effects caused by this restoration program on the St Croix River Atlantic Salmon population and will be ongoing until Fall 2005.

**Dennys River Adult Stocking Assessment.** Abstract by Timothy F. Sheehan, G. Mackey, J. Kocik, and D. Finlay (A,H,A,F)

During October 2000, 96 net pen reared, two-sea winter, mature, Dennys River specific Atlantic salmon were stocked into the Mainstem of the Dennys River. This represents 100% of the minimum egg deposition rate for the Dennys River Drainage as determined by stock-specific fecundity estimates and habitat survey data according to established management guidelines. A Memorandum of Understanding outlining this trial program and the need to fully evaluate it was drafted and is intended to be signed by the National Marine Fisheries Service, U.S. Fish & Wildlife Service, State of Maine natural resource agencies, and Atlantic Salmon of Maine. A comprehensive Assessment Plan was developed to monitor the progress of these adults and the progeny of these adults over the next 6 years. This assessment program consisted of 8 objectives: 1) riverine movements of net pen-reared adults using ultrasonic telemetry; 2) evaluation of spawning characteristics of these stocked adults as compared to wild adults 3) assess spawning habitat selection 4) post-spawning disposition (immediate out migrants, kelts, or presumed deceased) and timing of estuary entrance 5) monitoring the stage specific contribution attributable to natural reproduction by these stocked adults 6) estimate fry emergence rates for progeny of these stocked adults 7) develop stage specific survival estimates within a control site and 8) evaluate the reproductive success of progeny originating from these stocked adults. The comprehensive assessment plan was designed to monitor the stage specific effects caused by this restoration program on the Dennys River Atlantic Salmon population and will be ongoing until Fall 2005.

**f. Effects of Pulsed Acidity on Osmoregulation and Survival of Salmon Smolts.** Abstract by John A. Magee, Masrika Obedzinski, Steve McCormick, and John Kocik (B,R,R,B)

Smolt migration ecology and survival are currently being investigated in the Narraguagus River in eastern Maine, USA. Smolt survival upon entry into seawater seems to be low. Chronically acidic conditions in freshwater are well known to disrupt the osmoregulatory ability of smolts, and cause severe effects on survival once smolts enter seawater. However, rivers in eastern Maine are not chronically acidic, but do receive pulses of elevated acidity and aluminum. This investigation was conducted to determine what effect these pulses have on smolt osmoregulatory physiology, growth and survival.

Atlantic salmon smolts were held in either ambient (Control, mean = pH 6.32), acidified (Chronic, mean = pH 5.25) or periodically-acidified (Pulse, acidified to mean pH 5.2 twice weekly) river water for 36 days. Smolts fed little while in acidified conditions and growth was reduced. In freshwater, Chronic fish experienced increases in hematocrit and plasma potassium and reductions in plasma sodium and chloride. Upon transfer to seawater, Chronic and Pulse fish experienced reductions in hematocrit, increases in plasma sodium, chloride and potassium levels, and suffered mortalities.  $\text{Na}^+, \text{K}^+$ -ATPase and citrate synthase activities were reduced by exposure to acid. For most parameters, the effect of pulse acidity was intermediate to that of chronic acidification. Exposure to acidic conditions, even when short in duration and followed by a two-day recovery period in suitable water (pH 6.5), led to a 35% mortality of smolts upon transfer to seawater. This study highlights the importance of measuring and assessing sublethal stresses in freshwater and their ultimate effects in marine ecosystems.

**g. Population Viability Analyses for ESA Listed Salmon Stocks.** Abstract by Christopher M. Legault (A)

Population viability analysis (PVA) is concerned with answering the question "What is the probability that a population will persist until a future date?" In the case of Atlantic salmon this is a particularly important question given their listing as endangered under the Endangered Species Act (ESA). There are many different ways to conduct a PVA, from simple to complex models, packaged software to hand made, general to case specific, etc. Reaching similar conclusions from multiple models strengthens the basis for those conclusions. Two separate approaches are under way for Atlantic salmon; a modified Dennis model and a stage based life history model.

The modified Dennis model is an easy to use approach with only two parameters; the mean and variance of the rate of the change in the population. These two parameters are estimated from observations of a given life stage, usually adult spawners, through time. The Dennis model is based on the idea that without density dependence a population will grow or shrink exponentially over time. The modification is the manner in which the observations are used to represent the total population. Once these two parameters are estimated, projections are conducted which generate the probability of the stock size falling below a given level in a finite future. This method can also be used to set delisting criteria based on a minimum growth rate (the stock has to at least replace itself on average) and minimum population size that has a given probability of dropping below a set level within a finite future (determined through simulation experiments).

This approach is being pursued to define viable salmonid populations for many Pacific salmon evolutionarily significant units which have been listed as endangered or threatened under the ESA and is under way for Atlantic salmon.

A stage based life history model is a way of codifying the biology of the animal. The life cycle of Atlantic salmon has many distinct segments which can be modeled separately, i.e. parr, smolt, marine, spawning adults, etc. These models are much more data intensive than the Dennis model, but allow for more complete hypothesis testing in terms of bottlenecks to recovery. Projections can also be made to calculate delisting criteria or examine alternative management strategies. The influence of hatchery fish is modeled directly and can provide additional data to estimate survivorship rates for different life stages under assumptions of relative hatchery and wild mortality rates. Preliminary work demonstrates the ability to estimate some parameters, but also points to areas that need further study.

#### **4.11 TERM OF REFERENCE 11 - Habitat Restoration**

##### **a. Stream Assessment and Restoration Using Applied Fluvial Geomorphology.** Abstract by Jock Conyngham (LL)

Stream and river channels are self-maintaining entities that must accommodate a broad range of energy and material flows to endure. System form, function, and equilibrium can be fundamentally disrupted by a variety of common changes to hydrologic parameters, sediment inputs, valley land use, and channel management. Applied fluvial geomorphology offers a set of quantitative tools for assessing these phenomena with robust treatment of temporal and spatial scale issues. Implications for Atlantic salmon and aquatic macroinvertebrate population trends as well as strategies for assessment, protection, and restoration will be presented using examples from Maine and elsewhere.

##### **b. Fisheries Habitat Restoration and River Management Programs in Vermont: Changes Over the Past Decade.** Abstract by Steve Roy (JJ)

Significant land use changes and river alterations over the past two centuries have disrupted stream and river processes and altered fish habitats. In the late 1980's, the GMNF initiated a fisheries habitat restoration program on national forest lands in Vermont. Guided by a publicly approved management plan, the GMNF and its Federal, state and private partners began implementing riparian and fish habitat restoration projects in several watersheds. Driven by specific habitat objectives and declining or low stream salmonid populations, the projects were designed to address measured physical habitat limitations within stream reaches using a variety of restoration techniques to improve habitat capability for Atlantic salmon and brook trout. Through restoration of selective river processes and functions, we hypothesized that habitat quality and heterogeneity would improve to benefit salmon, trout and macroinvertebrate populations. Initial results indicated that stream habitat types and channel form can be changed and aquatic biota enhanced. These initial projects have spurred public interest and growth of river management programs in Vermont.

In 1999, a new multi-agency initiative in Vermont for a morphologic approach to river management was formed between the Vermont Agency of Natural Resources, U.S. Fish and Wildlife Service, and the Forest Service. This “natural channel” watershed-based approach to river restoration has stream channel form, function and stability as its foundation but also incorporated fisheries habitat needs from earlier stream restoration efforts. The Trout River Project video is an example of this initiative at work.

**c. Implications of Habitat Restoration for Atlantic Salmon: Results of Long-term Studies in the Connecticut River Basin.** Abstract by Keith Nislow (DD), S. Roy (JJ), C.L. Folt (BB), G.Gries (R)

Current and historic land use change has had a major influence on habitat in salmon restoration streams. One aspect of these changes has been the likely reduction of large woody debris and overall structural complexity. We used habitat restoration efforts in the Green Mountain National Forest, involving addition of large woody debris and other large habitat elements to test their effects on Atlantic salmon habitat and performance, along with effects on potential prey, predators, and competitors. We found significant impacts of habitat restoration on habitat use, availability, and suitability for juvenile salmon, as well as impacts on resident trout populations and macroinvertebrate communities. These results suggest the historical importance of large woody debris in northeastern stream ecosystems, and the implications of allowing restoration of the “natural wood regime” via management and conservation practices. Net effects on salmon production involve complex interactions between different effects, and are the objectives of ongoing research.

## 5. RESEARCH

### 5.1. CURRENT RESEARCH ACTIVITIES

The following includes Atlantic salmon research abstracts that were submitted to the assessment committee in 2000. The capital letters (codes) following the author’s names refer to the address of the research facility or office of the respective authors. The codes were also used in the highlighted Terms of Reference (above). These addresses are listed at the end of the Section.

### SMOLTIFICATION AND SMOLT ECOLOGY

#### Assessment of Intra-basin Smolt Production Dynamics

R. Haas-Castro, T. Sheehan, J. Kocik (A,A,A)

We are developing methods that will allow for the identification of intra-basin juvenile rearing locations of adult Atlantic salmon that have successfully returned to spawn and contribute to the next generation. The identification of these areas will allow managers to direct stocking programs to utilize the optimal habitat and enable researchers to begin to identify the biotic or abiotic factors which may be contributing to that environ. We are performing Scale Pattern Analyses (SPA) on parr scale samples collected from the Narraguagus River, Maine, by ASC personnel during annual juvenile surveys from 1990-1999. The ASC surveys are based on a Basin Wide Geographic and Ecologic Stratification Technique (BGEST) that delineates available

habitat into geographically and ecologically similar strata. The BGEST ecostratification scheme for the Narraguagus River has resulted in the demarcation of the river into the following categories: Coastal Transitional Barrens, Forested Barrens, Upriver forested, Marginal Tributary, and Quality Tributary. SPA involves using computer image analysis to measure intercirculi spacing in fish scales. Intercirculi spacing data can then be used to create a Linear Discriminant Function that will allow for the classification of an unknown sample to BGEST strata. Further investigations can be performed to increase the spatial resolution of our LDF. Preliminary results of SPA using data from 1990-1996 show that parr collected from tributary sites were larger and had larger scales, indicating better growth, than those from other sites. LDF's for data pooled from all years were unable to distinguish BGEST locations; however, the classification accuracy was 74% when grouping tributaries vs. the rest of the river system. Using this grouping, 1996 intercirculi distance data produced a classification accuracy of 78%. This investigation is ongoing and will include examining individual year classes in an effort to eliminate effects of temporal variation in Atlantic salmon growth.

### **Nearshore Ecology of Smolts and Postsmolts**

J.F. Kocik, T.F. Sheehan, and J.L. FitzGerald (A,A,A)

Analysis of telemetry data collected from 1997-1999 in the Narraguagus River system continued this year. During these years, minimums of 100 wild Atlantic salmon smolts were surgically implanted with ultrasonic tags. We prepared, tested, and deployed stationary detection units during mid April in Narraguagus Bay to monitor the emigration of Atlantic salmon smolts. We deployed a total of 26 units in the Narraguagus River (4), Estuary (4), and Bay (18) to evaluate the number of smolts passing ecological transition zones. Preliminary results suggest that a substantial portion of marine mortality may be occurring in nearshore habitats. We also determined the migration routes as they enter the Gulf of Maine. The mouth of Narraguagus Bay has two major corridors: Trafton (3.5 km) and Strout (1.6. km) that are delineated by Dyer Island. Of the smolts detected in the outer marine array, 90% exited the Trafton corridor. Within the Trafton Channel, the majority of smolts were traveling closer to Trafton Island than either shore. These results were consistent in all three years. The results from this study will be used to design an expanded program in 2001 that will include monitoring outside embayments, further into the Gulf of Maine. If feasible we will try to encircle where the Bay encounters the Eastern Maine Coastal Current in 2001. In addition, collaborative work with Canada was initiated this year that will determine if US fish enter the Bay of Fundy and if Canadian fish enter Gulf of Maine regions that NEFSC monitors. This will be accomplished through a coordinated effort where all units deployed will be capable of detecting tags released by both programs.

### **Dennys River Smolt Stocking Assessment**

R. Brown, T.F. Sheehan, Greg Mackey, J. F. Kocik, David Perkins, and Fred Trasko (A,A,B,I,J)

The Maine Technical Advisory Committee (TAC) developed and fishery managers supported the experimental evaluation of river-specific Atlantic salmon smolts in the Dennys River for a minimum of five years (2001-2006). Stocking rates were developed based on retrospective

analysis of Penobscot River stocking and adult return data during the period from 1973 to 1995. Model results indicated that a range of 32,000 (low) to 56,000 (high) would result in a 75% probability of achieving 2SW Atlantic salmon returns of at least 67 (low) or 117 (high) adults. A total of 52,000 smolts will be stocked in 2001. All stocked fish will receive an elastomer mark and adipose fin clip to allow quantitative evaluation of survival in relation to release location and time. A weir based smolt trap will be operated and utilized to evaluate survival immediately prior to entering the marine system. Ultrasonic telemetry investigation are also planned to estimate nearshore marine mortality and migrations routes of these stocked smolts. Seventy fish with surgically implanted ultrasonic pingers will be released and their movements evaluated with an array 12 Automated Pinger Detection Units will be deployed to provide 100% coverage of migration routes through Cobscook Bay. This will be the first quantitative assessment of survival through the freshwater, nearshore, and marine phases of river-specific hatchery stocked smolts for this system.

### **Penobscot Hatchery Smolt Assessment**

R.W. Brown, M. Loughlin and F. Trasko (A, A, J)

In 2000, we initiated a study to evaluate the role of hatchery enhancement programs in Atlantic salmon restoration efforts in the Penobscot River. Adult returns to the Penobscot River in 1999 declined to 972 returning adults, representing less than 10% of the adult escapement objectives for the system. Adult returns from hatchery stocked age 1+ smolts are critical to maintaining suitable returns of sea-run brood stock for future restoration efforts. An important initial step in the identification and evaluation of significant mortality sources for smolts and post-smolts is to evaluate the relative importance of mortality occurring in riverine vs. estuarine and open ocean habitats. Although marine conditions affecting Atlantic salmon survival are largely beyond management control, stock enhancement programs can exert some control over the timing that hatchery produced smolts encounter both in-river and nearshore marine environmental conditions.

In March 2000, we elastomer marked 166,000 hatchery smolts at Green Lake National Fishery Hatchery. These fish were stocked in 13 identifiable lots to evaluate downstream migration and adult return rates from smolts stocked at different times and in different locations in the system. In 2001, we plan to mark and release 168,000 hatchery smolts with only minor revisions to the marking and release plan. Recoveries of marked individuals as returning adults in 2001 and 2002 will allow for the assessment of adult returns in relation to the timing and location of stocking. We anticipate that this information will be useful in refining release strategies of hatchery smolts to optimize resulting adult returns.

### **Penobscot Hatchery Smolt Marine Growth and Survival**

R.W. Brown, R. Haas-Castro, M. Loughlin, and M. Simpson (A, A, A, C)

Improved understanding of the interaction of in-river and nearshore marine environmental conditions in relation to smolt and post-smolt growth and survival would provide valuable information for restoration effort and modeling efforts used to assess Atlantic salmon.

Elastomer marked hatchery smolts that are stocked in the Penobscot River in Spring 2000 and 2001 will be recovered as returning adults in 2001-2004. When marked individuals are recovered, length, weight, and scale samples will be collected from recovered individuals allowing for analysis of growth and survival characteristics in relation to timing of stocking and outmigration. Scale samples were collected from a representative sample of hatchery smolts prior to stocking in 2000. Image analysis of these samples will be used to identify the zone of freshwater (hatchery) growth. Based on this information, we plan to complete image analysis of scales collected from returning adult salmon from the same cohort to analyze growth patterns occurring during the nearshore marine phase immediately after stocking. We plan to relate observed growth patterns to return rates from each release group and nearshore environmental conditions occurring during late April and May immediately following release.

### **Penobscot River Total Smolt Assessment**

R.W. Brown, M. Loughlin, and M. Simpson (A)

We initiated sampling of outmigrating smolts in the lower Penobscot River in the vicinity of Veazie Dam in Spring 2000. This program is designed to produce information and identify logistical constraints required to design a comprehensive smolt evaluation program. To capture migrating smolts, we deployed 8-foot rotary screw traps in suitable areas of water current (3-7 ft/second). Trapping efforts were hampered in 2000 by high water conditions (50 year floods) occurring in late April and again in early May 2000. Despite these problems, a total of 78 trap days of effort were expended resulting in the capture of 74 Atlantic salmon smolts and 1 Atlantic salmon kelt. Length, weight, scale samples, fin clip, and elastomer mark information were collected from sampled smolts. A total of 14 fin clipped and elastomer marked fish were recaptured among the 74 smolts captured during sampling. We observed an apparent bimodal size distribution with a larger mode that appeared to correspond to hatchery smolts, and a smaller mode that appeared to correspond to naturally reared smolts. Image analysis of scale samples will allow for further discrimination of hatchery and wild smolts. Information of the stage-discharge relationship gathered during the Spring 2000 season has enabled us to identify three additional trapping locations for deployment of rotary screw traps during Spring 2001.

### **Initiation of Post-Smolt Trawling Survey in the Penobscot Bay Estuary**

R.W. Brown and C. Tinus (A, A)

Synchronous declines in the survival of Atlantic salmon smolts throughout North America

indicate a sharp decline in marine survival. Many investigators hypothesize that this decline occurs early in the marine phase, as Atlantic salmon smolts transition from freshwater to marine environments. In May 2001, we will initiate a surface pelagic trawl survey in the Penobscot Bay estuary to sample hatchery and naturally reared Atlantic salmon smolts in the marine environment. To capture post-smolts in open marine waters, we will pair trawl a Norwegian designed pelagic net through surface waters. By focusing sampling in the upper Penobscot Bay estuary, we hope to initially describe spatial and temporal distributions of smolts where large number of hatchery and naturally reared smolts occur. Post-smolts will be live captured utilizing a specially designed aluminum aquarium deployed in the codend of the trawl. We will collect basic biological data, genetic samples, conduct an examination for elastomer marks and sea lice, and collect physiological samples from captured fish. Data collected during the initial 2001 survey will allow us to refine the sampling program in future years.

**An Investigation of Drift of Atlantic salmon Fry, *Salmo salar* Immediately After Stocking**  
Abstract by E. Atkinson, G. Mackey, G. Horton, W. Simmons (H)

Atlantic salmon restoration efforts in Maine employ fry stocking as one of the primary population enhancement strategies. However, the initial fate of fry upon release is unknown. Fry quickly disappear upon release, but the distance they may drift is unknown. The behavior of fry after stocking could affect their survival and the quality of habitat they ultimately inhabit. We released 10,000 unfed fry in late morning into the Dennys River, Maine, May 1999. We trapped these fry using fry drift traps at three downstream transects spaced at 50-meter intervals from May 19 to June 14. Eighty-one percent of fry remained in the first 50 meters, with the remainder distributed throughout the next 100 meters. No fry were captured during daylight, with 755 caught after nightfall. Fry movement stopped after seven days. Taken together these data suggest that fry are not swept along with the current when stocked, but find refuge and then move volitionally during low light periods. Management implications of this study are to stock fry at rates that prevent over saturation, but take advantage of fry drift to distribute fry effectively. Further study should focus on effects of current velocity on drift, and difference between fry emerging from gravel and stocked fry.

**Use Of A Pit-Tags To Examine The Effects Of Release Timing On Migration Of Hatchery-Reared And 'Wild' Atlantic Salmon Smolts In The Connecticut River.**

Stephen D. McCormick, A. J. Haro, D. T. Lerner, A. M. Moeckel and M. F. O'Dea, and G. Barbin Zydlewski (R)

With the advent of larger passive integrated transponder (PIT) tags allowing for increased read ranges we have modified tag antenna-systems to develop a method for passively monitoring movements of individuals in the natural environment with only one initial handling, thus allowing us to investigate migration timing associated with variable release sites, river temperatures and river flows. Estimates of detection efficiency using dummy tags indicate that detection efficiency is 85-100%. Migration timing experiments were conducted in spring 1999 and 2000. In 1999, hatchery-reared juvenile Atlantic salmon, *Salmo salar*, were tagged and released either in the Passumpsic River below East Barnett Dam, East Barnett VT or in the West

River at the confluence with the Rock River in Dummerston VT (both primary tributaries of the Connecticut River). A third group of fry stocked 'wild' fish were angled from the fore bay of East Barnett Dam and released below the tailrace. For the 2000 experiments, hatchery-reared juvenile Atlantic salmon were tagged and released into either the Passumpsic River or the West River (similar sights as above) on two dates: 13 April and 2 May. Migration rates and timing were calculated from 'recaptures' at Vernon Dam, Vernon VT (2000 only) and Cabot Power Station, Turners Falls, MA (1999 and 2000) on the Connecticut River. Additionally, as part of an ongoing PIT tagging study at Smith Brook, in Newfane VT (a primary tributary of the West River), migration rate and timing were determined for recaptures at Cabot Station for both years. For 1999 'wild' fish arriving at Cabot (released on various dates) had migration rates between 2.8-8.5 km/day (April), 17.0-22.7 km/day (May 5-6), and 21.3-23.4 (May 11-13). For 2000 hatchery-reared fish the results were, 2.5-8.1 and 8.4-15.6 km/day (for fish released April 13 and May 2<sup>nd</sup> respectively). Results indicate a positive correlation between average speed and river temperature resulting in fish passage occurring predominately within a 9 day period regardless of as much as a 25 day difference in departure time ('wild' fish 1999), a 5-day period with a 17 day difference in release timing (hatchery-reared and released in the Passumpsic and West rivers, 2000) and within 9 days with a 30 day difference in departure time from Smith Brook (2000). Physiological sampling indicates that this timing may be closely regulated by the animals developmental physiology in conjunction with warming river temperatures.

#### **Post-Release Changes In Salmon Smolts From Pittsford National Fish Hatchery.**

Stephen D. McCormick, M. F. O'Dea and A. M. Moeckel (R)

Physiological and endocrine smolt development was examined in fish from Pittsford National Fish Hatchery (PNFH) during rearing (both years) and after release into 'imprint ponds' fed by the Farmington River (1999), or directly into the Farmington River itself (2000). Smolts sampled at the hatchery from January to May 1999 had only moderate smolt development based on gill  $\text{Na}^+$ ,  $\text{K}^+$ -ATPase activity, and hormone profiles. In contrast, fish released into imprint ponds in April had high levels of gill  $\text{Na}^+$ ,  $\text{K}^+$ -ATPase activity, plasma growth hormone, insulin-like growth factor I and thyroxine. Similar results were obtained in spring 2000: in addition to the elevated levels of gill  $\text{Na}^+$ ,  $\text{K}^+$ -ATPase activity of smolts in imprint ponds, migrating hatchery smolts captured at the Rainbow dam bypass also had high gill  $\text{Na}^+$ ,  $\text{K}^+$ -ATPase activity levels that were similar to those of fry-stocked (wild) smolts. It is suggested that in cold-water hatcheries, such as PNFH, physiological smolt development is completed only after fish are released into rivers.

#### **Use Of A Pit-Tag 'Electronic Weir' To Examine Atlantic Salmon Smolt Migration And Winter Survival.**

Stephen D. McCormick, G. Barbin Zydlewski, K. G. Whalen, A. J. Haro, D. T. Lerner, A. M. Moeckel and M. F. O'Dea (R)

Advances in passive integrated transponder (PIT) tag technology, including the low cost of PIT tags, offer the opportunity to locate and individually identify large numbers of fish without

disrupting their natural habitat choice, activity, and behaviors. Because PIT tags are passive, remain viable for a number of years, and have a high retention rate when implanted peritoneally, tagged fish can be both recaptured within rearing habitats and/or detected as they emigrate downstream without trapping or handling the fish. Larger PIT tags have allowed larger read ranges (1.5 m) and permitted us to construct antennas, which can monitor the width of an entire stream. With these tags and antenna-systems, we have developed a method for passively monitoring movements of individuals in the natural environment with only one initial handling. Estimates of detection efficiency using dummy tags and tagged hatchery smolts indicate that detection efficiency is > 93%. In the falls of 1998, 1999 and 2000, 449-460 fry-stocked parr (9-17 cm fork length; 1<sup>+</sup>- and 2<sup>+</sup>-year olds) from Smith Brook, VT (a tributary of the West River) were PIT tagged and their downstream movement was continuously monitored. Each fall there was a substantial downstream movement of parr (5-14% of fish tagged that fall). Fish migrating as smolts the following spring were those that had been greater than 11.5 cm fork length in the fall, whereas fish that remained were those less than 12 cm. In spring 1999 and 2000, the smolt migration began in mid-March and ended in mid-May, with 87% occurring between April 22 and May 9. Most of the smolt migration occurred at night. For fish larger than 11.5 cm fork length in the fall, for which the probability of smolting was nearly 100%, estimates of winter survival were 41% in 1999 and 19% in 2000, with lower survival for previously mature fish. It is expected that application of PIT tag technology as a research tool would add significantly to the understanding of salmon biology and the effectiveness of salmon restoration efforts.

#### **Downstream Migration and Survival of Fry-Stocked Atlantic Salmon Smolts in the Lower Connecticut River Mainstem.**

Alex Haro, T. Castro-Santos and S. McCormick (R)

The downstream migration of acoustically telemetered Atlantic salmon smolts was monitored in the lower Connecticut River mainstem during the spring run in 1999 and 2000. In 1999, 50 actively migrating fry-stocked smolts were captured and tagged at the bypass samplers at Turners Falls and Holyoke Dams (MA) and released below Holyoke Dam (n = 40) or at Windsor Locks, CT (n = 10). In 2000, fry-stocked smolts were collected and tagged at Turners Falls and released at Northfield, MA (n = 108), and Chicopee, MA (n = 15). In addition, hatchery smolts were tagged and released at Northfield (n = 26) and Chicopee (n = 30). Downstream migration was often rapid, with most smolts moving downstream at a rate of 40 to 60 km/d. Minor delays (1-2 d) were noted for some smolts in the reach that included Holyoke Dam. Mortality of smolts was variable between reaches, ranging between 0% and 3% per km within individual reaches (fry-stocked and hatchery smolts pooled). Mortality in undammed reaches was usually less than 1% per km. Mortality of fry-stocked versus hatchery smolts was inconsistent between release sites, but was comparable in lower river reaches. Overall survival to the mouth of the river of fry-stocked smolts released at Northfield (excluding initial post-release mortality) was approximately 25%.

## MARKING

### **Retention of Visual Implant Elastomer tags in Anadromous Atlantic Salmon**

J.L. FitzGerald, and T.F. Sheehan (A,A)

In conjunction with marine growth studies at Industry facilities, NEFSC staff evaluated the apparent retention of Visual Implant Elastomer (VIE) tags as observed from the visual inspection of individual Atlantic salmon smolts reared to adults at commercial netpen facilities. A total of 15,000 individuals were single or double marked (adipose eye and/or lower jaw) prior to transfer to the marine environment. Each river was designated a uniquely colored VIE tag to facilitate stock identification. During the period of May 1998 - December 2000, a total of 3,228 fish were visually assessed for VIE tag retention. Tag retentions were scored on a binomial scale. For double marked individuals, at least one tag (eye or jaw) could be visually detected on all individuals inspected during the first 15 months post tagging. Despite significant differences in weight between rearing sites, tag detection rates remained consistently high for the first 20 months after tagging for both groups of fish but began to decline sharply after this point, particularly for the jaw tags. Use of a UV light increased detection of eye tags from 56.5% to 62.1% at one rearing site 28 months after initial tagging and from 52.2% to 87.8% at 29 months. Use of the UV light increased detection of jaw tags from 24.8% to 78.6% at 28 months after initial tagging and from 14.4% to 72.2% at 29 months. There were statistically significant differences in VIE tag retention rates between netpen facilities which may be related to variation in growth rates, tagging procedures, site-specific environmental factors, or husbandry practices. We concluded that the use of VIE tags in fisheries research and management can be a valuable tool, but that these tags are optimal for use in studies which are shorter in duration than 1.5 years.

### **Detection of Fluorescing Marks in Age-5 Atlantic Salmon Immersed as Sac-fry in Calcein Solutions**

Jerre W. Mohler (N)

In February, 2000, we sacrificed six 5-yr-old Atlantic salmon which were immersed in calcein solutions as sac-fry and sectioned various fin tissues to attempt location of fluorescing marks using microscopy as well as hand-held and benchtop detection devices.

Initially, 6 fish were examined; 3 which were immersed in 125 mg/L and 3 immersed in 250 mg/L calcein for 48 hours, 5 years prior. Fish were sacrificed and fins were removed for dissection. Removal of fins included excision of tissue associated with fin/body articulation sites since some tissue growth may have encased calcein marks over time. A stadie-Riggs tissue slicer and scalpel were used to attempt sectioning of un-fixed tissues since fixation or other chemical expose may destroy the calcein marks if present. Initial examination was performed using fluorescence microscopy and later examination of live fish was performed with hand-held and benchtop devices.

The tissue slicer used for the processing of fin tissues was not able to cut through the intended

tissues due to the size and texture of the fin rays on an adult salmon. Therefore a scalpel was used to attempt tissue sectioning. No calcein marks were found in this manner via fluorescence microscopy on the small number of fish sacrificed for this procedure. Given this, a diversion from the original study plan was decided where a number of 2½-yr-old salmon which had been immersed in calcein as fry were examined with the hand-held and benchtop detection devices to verify the location and presence of calcein marks since these fish had been marked with improved techniques. Calcein marks were readily visible on 100% of the 2½-yr-old fish and were located at the base of the pelvic and pectoral fins when viewed with the detectors. We conclude that the 5-yr-old fish were no longer marked such that practical detection means could uncover a positive calcein mark. Two possible reasons are hypothesized: (1) The calcein mark will not be retained in Atlantic salmon for a 5 year period or (2) The initial marking techniques (static immersion for 48 hours in cold water) did not induce a reliable mark which could be detected at a five-year period.

### **Differential Predation on Calcein-marked Vs. Non-marked Atlantic Salmon Parr by Captive Wild Brook Trout**

Jerre W. Mohler (N)

In July, 2000, we introduced calcein-marked and non-marked Atlantic salmon parr to brook trout predators in flow-controlled indoor raceways to examine differential predation on the two treatment groups. Evaluation of predation was performed through recovery and examination of surviving fish for a calcein mark along with stomach content analysis of brook trout. Four trials were conducted, each consisting of one raceway containing 2 predators and 200 prey for 3 consecutive days. The study employed feeding Atlantic salmon fry of Connecticut River domestic origin which were calcein-marked or non-marked at the sac fry stage (Developmental Index = 85). Each trial consisted of 100 marked and 100 un-marked parr per raceway. At the end of 3 days, predators were removed and remaining parr were captured and scanned for a calcein mark with detection equipment. Numbers of marked and un-marked parr survivors were compared with replicated goodness of fit analysis to determine whether differential predation occurred:

Replicated goodness of fit (G-test) analysis (alpha level 0.05) of the 4 trials showed equivalent survival of calcein-marked and non-marked parr for two trials, while one trial had greater than expected survival of calcein-marked fish and one had greater survival of non-marked fish. Total survivors were 256 calcein-marked and 254 non-marked parr over the 4 trials indicating that calcein-marked Atlantic salmon parr were not preferentially captured or preyed upon by captive wild brook trout. Two brook trout were able to consume between 20 -99 salmon parr over a 3-day period.

## **Using Natural Strontium Isotopic Signatures as Fish Markers: Methodology and Application**

Brian P. Kennedy, J. D. Blum, C. L. Folt, K. H. Nislow (EE, CC, BB, DD)

To distinguish Atlantic salmon (*Salmo salar*) populations in tributaries of the Connecticut River, we studied the incorporation and stability of strontium (Sr) isotopes in juvenile salmon. We established the geologic basis for unique isotopic signatures in 29 salmon sites. Stream-specific Sr isotopic ratios ( $^{87}\text{Sr}/^{86}\text{Sr}$ ) were found in calcified tissues of salmon parr within three months of stocking. We found little seasonal variation in the Sr signatures of stream water or fish tissue. There were no significant differences among the Sr signatures of otoliths, scales and vertebrae. For mature salmon raised under constant conditions, 70% of the Sr isotopic signature in calcified tissues is derived from food sources. We developed a criterion for identifying moving fish based upon the isotopic variability of genetically marked fish. Applying this criterion to our streams, 7% of the fish in our study had incorporated Sr from multiple streams. Sr isotopes distinguished all eight regions in the White River basin and seven of the ten regions in the West River basin. When watersheds are considered together, Sr isotopes differentiated 11 unique signatures from 18 regions. We conclude that Sr isotopes are an effective marking tool, and discuss ways in which they can be combined with other marking techniques over larger spatial scales.

## **CULTURE/LIFE HISTORY**

### **Integrative Measures of Consumption Rates in Fish: Expansion and Application of a Trace Element Approach**

Brian Kennedy, B. Klaue, J. D. Blum, and C. L. Folt (EE, EE, FF, BB)

The inherent difficulties of measuring fish consumption in the field have motivated methodological research by fisheries scientists for decades. One approach exploits the accumulation and turnover of human-dispersed radiocaesium ( $^{137}\text{Cs}$ ) to integratively measure consumption rates over the lifetime of fish. However, this method often requires pooling individuals in geographic areas with low levels of nuclear fallout and is therefore not applicable to individual measurements of consumption on a global basis. Building upon the established models for  $^{137}\text{Cs}$  mass balance in fish, we used inductively-coupled plasma mass spectrometry (ICP-MS) to measure a stable geologically-derived isotope of Cs. We used these measurements to make the first *in situ* determinations of consumption rates of individual post larval age-0 Atlantic salmon (*Salmo salar*). In order to test the reliability of the modified model based upon stable Cs we: (1) performed a sensitivity analysis of model parameters, and (2) parameterized the model with site-specific data, which included gut contents, concentrations of Cs in invertebrate prey, and individual-based assimilation rates. We then applied the method to compare consumption rates of juvenile Atlantic salmon at two sites during three different periods of the growing season. The sensitivity analysis revealed that our consumption estimates were most responsive to three parameters: changes in Cs body burdens between sampling periods, the concentration of Cs in prey items, and assimilation efficiency. The high precision of our Cs measurements using ICP-MS (relative standard deviations of 1 – 2% even at part per trillion

concentration levels) allowed us to minimize measurement error of these three important Cs-based parameters. With the stable Cs method we measured consumption rates of individual salmon fry as small as 0.1 g, and we were able to examine the relationship between independently derived measures of consumption and growth at three times in the first growing season. The assimilation efficiency of Cs measured on field caught age-0 salmon was approximately 60% at both sites. Assimilation efficiency of two other alkali metals with similar biochemistry, Rb and K (63% and 67% respectively), corroborated the reliability of our estimate for Cs assimilation efficiency. Measured differences in the Cs concentrations of common prey taxa underscored the need to quantify fish diet composition before applying this technique, as uncertainties in diet Cs concentration could lead to very different estimates of consumption. Consumption rates at two weeks post-stocking were highly variable in both sites, ranging from no detectable consumption to 8.5 g 100 g<sup>-1</sup> fresh weight (f.w.) day<sup>-1</sup>. By the end of the growing season, consumption rates were less variable (2 – 4 g 100 g<sup>-1</sup> f.w. day<sup>-1</sup>). Within these two sites, there was no significant relationship between consumption and growth at two weeks post stocking, however by the end of the growing season the individual size and consumption rates were significantly correlated.

### **Establishing the Links Between Consumption, Growth and Survival of Juvenile Atlantic Salmon (*Salmo salar*)**

Brian Kennedy, K. Nislow, and C. Folt (EE, DD, BB)

High juvenile mortality is an expected cost of high fecundity, yet the mechanisms for this high mortality can vary greatly among taxa. Previous work on stream salmonids has suggested that the period just after emergence (0 to 6 weeks) is the most critical time for fry survival as a result of limitations on food availability and foraging habitat. However, in streams as well as most other systems, inherent difficulties in measuring consumption rates under field conditions have precluded direct tests of these relationships. We hypothesized that the availability of early season food and foraging habitat limits consumption and growth and establishes a survival bottleneck for age-0 Atlantic salmon. To examine this hypothesis we developed a novel technique to measure long-term consumption of over 500 juvenile Atlantic salmon (*Salmo salar*) fry from six streams that exhibit consistent differences in first year survival. Our study tests the extent to which individual differences in consumption and growth explain fundamental differences in salmon performance over the first critical growing season and across streams.

Our model uses determinations of uptake and turnover of geologically-derived stable caesium (<sup>133</sup>Cs) in salmon fry to measure consumption rates integrated over time scales of weeks to seasons in two consecutive years. Mass-specific consumption (hereafter, consumption) was strongly dependent upon salmon age. Consistent with the hypothesis of energetic stress driving mortality in the early season, consumption in the first 2 – 4 weeks was extremely low (< 15 % of mid and late season consumption rates) in all sites. There were also significant differences among sites. Early season fry from 5 of 6 sites consumed less than predicted to reach maintenance rations (consumption without growth) for Atlantic salmon, and individuals from 2 of 6 sites had consumption values below starvation levels. Consumption increased in the mid (0.030 g g<sup>-1</sup> day<sup>-1</sup>) and late (0.035 g g<sup>-1</sup> day<sup>-1</sup>) seasons although significant site differences persisted. Rankings of sites based upon relative consumption rates were consistent until the late season at

which time the rankings reversed. For example, the 2 sites with starving individuals in the early season had the highest average late season consumption, suggesting compensatory feeding and growth may occur. Also consistent with the hypothesis of energetic stress in the early season, consumption was positively correlated with growth in the early season. This relationship was still obvious in 3 of 6 sites by the end of the growing season. Finally, there was a trend toward increasing underyearling survival in sites where fish consumed more in the early season. Though non-significant, early season consumption explained more of the variance in survival than consumption or growth during any other time interval. Our results compare favorably with the predictions of a habitat-based bioenergetics model for these fish. Bioenergetics model predictions were particularly robust with respect to overall site rankings when compared to our direct measurements for consumption. Thus, both habitat-based and direct consumption-based approaches provided strong empirical and mechanistic support for the hypothesis that there is an early season consumption-growth bottleneck for stream salmonids. Moreover, our integrative consumption measurements indicate that habitat conditions for early season fish may be even more severe than predicted by the bioenergetics model. This study provides evidence for the fundamental mechanisms driving high juvenile mortality in these systems and has general relevance for the management and conservation of salmonids across different environmental conditions.

### **Effects of Short Term Light Deprivation upon Milt Production of Feral Atlantic Salmon**

John W. Fletcher (N)

We determined whether an eleven-day light deprivation holding environment would change milt production characteristics of feral sea-run Atlantic salmon held at Cronin NSS and evaluated potential changes in milt production onset, duration, quantity and quality. Twelve sea-run male Atlantic salmon were collected from returns to the Holyoke Fish Lift and held for spawning at the Cronin NSS. These salmon were tagged with pit tags. From capture until the beginning of the current trial, the males were held in a common tank with 60 females. A distribution trailer with four 1500 L circular fiberglass tanks supplied with flow-through water was used to hold experimental fish. Three males were placed in each tank; two tanks had a gasket sealed lid which excluded light for an eleven-day treatment period while the other two tanks had a plexiglass lid to provide natural photo period. After light manipulation treatment, all salmon were returned to the common holding tanks with the females. Milt was taken from experimental fish once/week for 7 weeks until all females had spawned. On each spawning date the following information was taken: (1) tag number, (2) quantity of milt (3) milt motility recorded as % motile, and (4) spermatocrit.

Results showed there were no significant differences in quantity of milt produced, sperm cell volume, or sperm motility in male salmon held in a dark environment vs. those exposed to natural photoperiod. Milt production profiles over the 7-week experiment were similar between treatment groups except that fish kept in the dark gave slightly greater amounts of milt earlier and towards the end of the 7-week experiment than fish under natural photoperiod but results were not statistically different between groups. Maximum milt production for both groups peaked at the fourth week.

## **Hydrography and Plankton in the Narraguagus- Pleasant Bay System**

Incze, Lewis and J. F. Kocik (E,A)

This project was undertaken through a contract with the Bigelow Lab to provide a preliminary assessment of hydrographic conditions and plankton in eastern Maine, from the Narraguagus - Pleasant Bay system out to about the 50 m isobaths. The goals of this study were twofold. First, it was designed to address the environmental conditions that out- and in-migrating salmon face in the region near the mouth of the Narraguagus River. Secondly, its purpose was to better understand the coastal current system as it relates to the life history and recruitment of other living resources, such as lobsters, herring, urchins, and groundfish. Sampling was conducted during the period of May 5 to September 12, 1999. This study revealed that surface temperatures were warmest inshore and coolest at the offshore end of the standard transect. The temperature and salinity front between coastal and offshore conditions was usually located between 12 and 14 km from Fickett Point. The Eastern Maine Coastal Current (EMCC) appeared to be outside this front. The EMCC was about 0.5 psu fresher than the inshore waters on May 5 and saltier than inshore during all subsequent transects. The numerically dominant zooplankton of the upper 6 m fell into the following three groups: 1) an inshore group of *Acartia* spp. Copepods and polychaetes (mostly larval forms) located in the inner bay; 2) a nearshore coastal group dominated by cladocerans and Appendicularia, with barnacle nauplii in early May; and 3) an "offshore" group in or near the edge of the EMCC that was dominated by several species of copepods. This study provided background information for further research of the inshore environment as it relates to the coastal current that dominates transport along the outer coast.

## **Pleasant River Parr Production Studies - (ASC Cooperative)**

J.F. Kocik, K. F. Beland, and M. Obedzinski (A,C,B)

NEFSC and ASC staff collaborated on electrofishing surveys in August and September 2000. The objectives of these surveys were three-fold: conducting a basinwide estimate of large parr abundance, collecting samples to determine the introgression of aquaculture escapees in wild stock, and collecting parr for the establishment of a Pleasant River broodstock for a river-specific program at Craig Brook National Fish Hatchery. A total of 21 sites were completed to conduct a quantitative assessment. In addition, staff conducted 2 days of additional large-scale collections to increase broodstock availability. We captured a total of 63 parr in 19,400 m<sup>2</sup> of juvenile rearing habitat. These densities were extremely low - densities in other rivers suggest densities should range from 0.03 to 0.07 parr per m<sup>2</sup> of habitat (600 - 1,400 for units sampled). Of parr collected, 52 were taken to CBNFH. Eleven parr total were not taken to the hatchery because: facilities were not ready (7), fish were lost in transport (3), or had external signs of disease (1). Staff observed PIT tags in 26 parr from tagging activities in 1999 and 18 out of 53 that were checked for maturity were precocious males. We caught six age-0 Atlantic salmon at three sites (river km 7.06, 9.06 and 9.35). The hatchery has a total of 109 fish- 57 in the smolt tank (which also includes parr collected in June) and 52 in the parr tank.

### **Selected Review of Literature Pertinent to Impacts of Incubation Temperature upon Atlantic Salmon Fry**

John W. Fletcher (N)

The Connecticut River Fish Culturist Sub-Committee requested a review of literature regarding negative impacts of early incubation temperatures greater than 9 °C for Atlantic salmon. Five papers, along with the manual, Atlantic salmon culture for restoration (Gaston 1988) were chosen as representative works concerning Atlantic salmon incubation. The abstract of each paper was included in total. Additionally several tables which presented information relative to survival response or temperature incubation impacts were transcribed. To supplement this information, annotations were drawn from the following papers:

Gaston, P.B. 1988. Atlantic salmon culture for restoration. U.S. Department of Interior. Fish and Wildlife Service, Newton Corner, Massachusetts.

Gunnes, K. 1979. Survival and development of Atlantic salmon eggs and fry at three different temperatures. *Aquaculture* 16(3) 211-218.

Hamor, and E.T. Garside. 1976 Development rates of embryos of Atlantic salmon, *Salmo salar* L., in response to various levels of temperature, dissolved oxygen, and water exchange. *Canadian Journal of Zoology* 54: 1912-1917.

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Petersen, R.H., C.E. Spinney, and A Sreedharan. 1977. Development of Atlantic salmon, *Salmo salar* eggs and alevins under varied temperature regimes. *Journal of the Fisheries Reserve Board of Canada* 34:31-43.

Information excerpted from the papers generally fell within three areas: (1) recommended incubation temperature(s) (2) temperatures where problems were encountered and (3) adaptive significance of variable responses to incubation profiles. Relevant results from all referenced works were summarized and presented as a Technical Information Leaflet (LM-00-08).

### **Effects of Short Term Light Deprivation upon Milt Production of Feral Atlantic Salmon**

John W. Fletcher (N)

We determined whether an eleven-day light deprivation holding environment would change milt production characteristics of feral sea-run Atlantic salmon held at Cronin NSS and evaluated potential changes in milt production onset, duration, quantity and quality. Twelve sea-run male Atlantic salmon were collected from returns to the Holyoke Fish Lift and held for spawning at the Cronin NSS. These salmon were tagged with pit tags. From capture until the beginning of the current trial, the males were held in a common tank with 60 females. A distribution trailer with

four 1500 L circular fiberglass tanks supplied with flow-through water was used to hold experimental fish. Three males were placed in each tank; two tanks had a gasket sealed lid which excluded light for an eleven-day treatment period while the other two tanks had a plexiglass lid to provide natural photo period. After light manipulation treatment, all salmon were returned to the common holding tanks with the females. Milt was taken from experimental fish once/week for 7 weeks until all females had spawned. On each spawning date the following information was taken: (1) tag number, (2) quantity of milt (3) milt motility recorded as % motile, and (4) spermatocrit.

Results showed there were no significant differences in quantity of milt produced, sperm cell volume, or sperm motility in male salmon held in a dark environment vs. those exposed to natural photoperiod. Milt production profiles over the 7-week experiment were similar between treatment groups except that fish kept in the dark gave slightly greater amounts of milt earlier and towards the end of the 7-week experiment than fish under natural photoperiod but results were not statistically different between groups. Maximum milt production for both groups peaked at the fourth week.

### **Forecasts of Atlantic Salmon Transoceanic Migration: Climate Change Scenarios and Anadromy in the North Atlantic**

K. D. Friedland (O)

Atlantic salmon undertake transoceanic migrations as part of their complex anadromous life history. In addition to the impact of climate on growth, maturation, and distribution in the ocean, salmon must home to their natal rivers to spawn, the success of which is likely impacted by ocean conditions. After rearing in freshwater, salmon juveniles employ a range of migration cues to time their seaward migrations. Since they are entering a new set of habitat regimes, the climate-related timing of this migration and the conditions they find in the coastal ocean are critical. We have developed a migration model that can be validated for most stocks of Atlantic salmon from North America and Europe. The probability of migration distribution is determined as a function of swimming potential, current vectors, and migration orientation. The absence of foraging behavior in the model has not significantly compromised its performance, owing to the likelihood that prey co-vary with other environmental variables. The models was run with forecasted surface temperature and currents for the North Atlantic segment of the Climate System Model developed at the National Center for Atmospheric Research. These simulations attempt to define the range of possible impacts climate change may have on salmon populations.

### **Evaluation of Alkalinity Enhancement of Craig Brook National Fish Hatchery Water on Atlantic Salmon Production**

T. Haines, B. Spaulding, B. Watten, P. Sibrell and S. McCormick (P,P,Q,Q,R)

The purpose of this study is the evaluation of alkalinity enhancement of Craig Brook National Fish Hatchery water on Atlantic salmon production. The present hatchery water supply, Craig Pond in East Orland Maine, is generally of high quality except that alkalinity (acid neutralizing

capacity, ANC) is relatively low. This low ANC may allow pH values to fluctuate greatly in response to acidic inputs from rainstorms and snowmelts. In addition, the low pH values can increase the solubility of harmful ions such as aluminum. An experimental limestone dissolution system has been constructed to increase the alkalinity of the water supply. This machine increases the pH by the addition of calcium carbonate, which can provide protection from fluctuation in pH and reduce the solubility of aluminum. Atlantic salmon from the Narraguagus River are being subjected to three different water quality conditions. In each condition, the ANC/alkalinity is increased as follows: control (unaltered Craig Pond water), medium alkalinity (20ppm higher than control) and high alkalinity (40ppm higher than control). Fish are being reared from fertilization of the egg until stocking (as fry) under each water quality condition. Over the length of the experiment, we have completed multiple tests on fry in each condition. Gill tissue was analyzed for ATPase activity. Growth was measured by video taping the fry over set intervals and doing computer measurements from screen captures. Gill arches were sampled and fixed for scanning electron microscopy (SEM). Stress test blood plasma samples and whole body ion samples (Na/K) are currently undergoing analysis. Genetic samples are also being analyzed to determine survival rates in the wild for the spring 2000 fry stocking. From these experiments we have initially concluded the following: There does not seem to be an impact of alkalinity on Na,K-ATPase. Overall growth/length does not seem to be affected in either a positive or negative manner. Scanning electron microscopy of gill tissue does not show abnormal morphological effects. The project is on track to release a second group of fry in the spring of 2001. Additionally, a comprehensive report is planned that will summarize the data and present our results and conclusions.

### **Factors Affecting the Growth of Age-1 and Older Atlantic Salmon Parr in Vermont Tributaries to the Connecticut River**

James R. Olsen and D. L. Parrish (T)

Atlantic salmon stocked into tributaries of the Connecticut River have variable survival and growth rates, which lead to differing densities and age class structures of salmon within and across streams. Our study addresses the effects of environmental and biological factors on the growth rate of age-1 and older Atlantic salmon parr in three tributaries to the Connecticut River, Vermont. We hypothesized that temperature and food availability are the most influential determinants of salmon growth. Therefore, we chose to use bioenergetics modeling as a tool to compare growth because it allowed us to quantify the effects of food consumption and temperature across sites with varying densities and growth rates of salmon. To quantify growth we performed a mark-recapture study in 1999 and 2000 in four sites using individually coded PIT tags and salmon diets were collected and analyzed from captured fish. Water temperatures were recorded in all sites during the entire study. Growth differed among sites with mean intrinsic growth rates ranging from 0.068 in the highest growth site to -0.049 in the lowest growth site. At one site in 1999 a high proportion of salmon were strongly piscivorous, which was associated with the highest growth and may have fulfilled high summer metabolic demands. Summer 1999 thermal conditions were higher than optimum in all sites and near lethal levels in one site, but thermal conditions during the summer 2000 were more moderate. Despite high temperatures, differences in growth rates appear to be regulated more by food availability than temperature.

### **Across Year Variability in Size of Juvenile Atlantic Salmon in the Connecticut River: Insights for Restoration**

Martha Mather, C. Campbell, J. McMenemy (U, V, W)

Although we know that ecological responses differ through time, researchers and managers assume that across-year means depict useful and consistent trends. To examine this assumption, we compare mean and annual trends in density, survival, size, and growth of juvenile Atlantic salmon in the Connecticut River. This juvenile data, obtained from four state agencies, spans 410 miles encompassing over 200 index sites, 125 tributaries, and 23 basins, for over 7 years. Herein, we examine three questions: (1) Is there a consistent, predictable trend of patterns and relationships across years?; (2) Do temporal trends vary across spatial scales?; (3) Do mean trends reflect patterns and relationships observed in individual years? Previous results, using means from 1990-1996, indicate that juvenile salmon performance is exceptionally good in some sites and exceptionally poor in others. When patterns based on means were compared to patterns based on data from individual years annual patterns mirrored mean trends in many years. Years of high and low performance were not the same for all basins. By relating physical and biological conditions in these good or bad years to juvenile salmon performance, we could increase our understanding of which conditions favor high and low survival, density, size, and growth.

### **A Multi-scale Assessment of Juvenile Atlantic Salmon Production in the Connecticut River: Implications for Conservation**

Cara Campbell and M. Mather (V, U)

Management and restoration of stream salmonid species occurs within and across watersheds and requires an understanding of the large-scale factors influencing individuals across the management area. Unfortunately, patterns and mechanisms observed at small-scales can't simply be extrapolated to explain large-scale patterns and processes. Thus, it is necessary to conduct examinations into large-scale patterns and processes to gain a comprehensive understanding of these species-habitat relationships. We incorporated existing environmental and juvenile Atlantic salmon, *Salmo salar*, population data for the Connecticut River watershed from 1990-1996 into a Geographic Information System (GIS) to examine: (1) distribution and abundance at both basin- and watershed-scales, (2) associations among juvenile production variables (survival, density, size, change in length) at each scale, (3) relationships between these salmon production variables and large-scale physical factors (stream order, temperature, elevation, drainage area, gradient) at both scales, and (4) how scale altered these patterns and relationships. Juvenile salmon do not perform equally well at all sites. Site-specific performance differed by scale and juvenile variable examined. Sites were better suited for high densities or large individuals, but not both. Some sites consistently had high survival, while others consistently had low survival. Responses to environmental conditions in terms of survival and density were opposite to those of length and growth. Relationships between salmon production variables and environmental factors were not consistent across scales. Survival and density were generally influenced at the basin-scale, while length and growth at the watershed-scale. Multi-scale analysis proved a useful tool for

illustrating patterns, assessing possible relationships underlying these patterns, and making recommendations for conservation, restoration, and management.

### **Hotspots and Pits: Assessing Basin-wide Mechanisms for Survival and Growth of Juvenile Atlantic Salmon Sites Throughout the Connecticut River Basin**

Mather, M. E., M. Briggs, and C. A. Campbell (U,U,V)

Juvenile salmon interact closely with the stream habitat. Consequently, a predictable relationship between certain abiotic and biotic characteristics of the watershed and fish performance may exist. Campbell and Mather (1999) synthesized density, survival, and size data for fry, 0+, and 1+ Atlantic salmon collected by four state agencies and the United States Forest Service encompassing 290 index sites, 125 tributaries, 23 basins, over seven years, into a Geographic Information System (GIS). One important finding of this synthesis was that at some sites fry to 0+ parr survival was exceptionally high, at other sites 0+ to 1+ survival was exceptionally high, and at other sites survival for both years was poor. Hence, the basin contains "hotspots" or areas of good salmon production and "pits" or areas of poor salmon production. In addition, the basin also contains sites with unusually large individuals or "bubbas" and sites with unusually small individuals, i.e., "runts". In this study, we seek to understand underlying mechanisms for above and below average survival and large and small size throughout the Connecticut River Basin. Specifically, from May-December, 1998 and 1999, at select sites throughout the basin, we collected data on temperature; velocity; discharge, amount, type, or stability of physical habitat; stream morphometry, and food production. In this talk, we provide a preliminary analysis of these data.

### **Within-basin Variation in the Immediate Effects of a Major Flood on Stream Fishes and Invertebrates**

K. H. Nislow, F. J. Magilligan, C. L. Folt, And B. P. Kennedy (DD, EE, BB, EE)

We tested whether differences in immediate flood effects on stream fishes and invertebrate abundance were directly related to differences in flood intensity among streams. In three tributaries of the White River basin, VT, we conducted habitat surveys and sampled invertebrates and fishes before and after a major summer flood. We then estimated a series of hydrologic and hydraulic parameters, ranked the sites with respect to flood magnitude, and tested whether changes in pre- vs. post-flood abundances were most extreme in the most severely flooded sites. Our objectives were to determine 1) thresholds of flood magnitude needed to significantly impact aquatic communities, and 2) aspects of aquatic communities most sensitive to floods. Consistent with our hypothesis, we found the least amount of change in fish and invertebrate abundance in the study site experiencing the lowest-magnitude (~ bankfull) flood. The two remaining sites experienced overbank flooding and major changes in species abundances. Change in invertebrate and fish abundance was greater at the site experiencing greatest geomorphic response (bedload movement and sedimentation), even though hydraulic intensity (velocity, shear stress, unit stream power) was greater at the other site. Aquatic invertebrate and underyearling fish abundance, particularly juvenile rainbow trout and Atlantic salmon were dramatically reduced at this site, while overyearling trout and Atlantic salmon exhibited

record high abundance. These results reinforce that geologic setting can be more important than hydraulic intensity in determining the immediate impact of floods. In addition, they provide direct evidence that particular species and age-classes are resistant to the most extreme floods expected in a given region.

### **Implications Of Climate Change For Growth Opportunity And Recruitment Limitation Of Stream Salmonids In New England**

Keith H. Nislow and C.L. Folt (DD, BB)

We used a spatially-explicit bioenergetics model to evaluate the potential impact of climate change on growth opportunity and recruitment limitation for juvenile Atlantic salmon in New England. Under current and historical climate conditions, high flows and cold water temperatures result in limited growth opportunity and high mortality for newly-emerged or stocked salmon fry in the spring, followed by high growth opportunity and low mortality in the summer. In contrast, model results indicated that earlier spring runoff and higher summer water temperatures predicted by regional climate change scenarios might shift growth opportunity and recruitment limitation from spring to summer. These findings indicate that mechanistic models can be effectively used to directly link climate change to interpretable implications for stream salmonid populations.

### **CONSERVATION/MANAGEMENT**

#### **Stocking Marine-reared Adult Atlantic Salmon in Eastern Maine: a Unique Enhancement Tool?**

T.F. Sheehan, G. Mackey, J. Kocik, D. Finlay, and L. Sochasky (A,H,A,F,G)

As part of a two year feasibility study initiated between private aquaculture companies and federal and state management agencies, Atlantic salmon (*Salmo salar*) were reared to maturity in salt water and stocked in three Maine Rivers. River-specific broodstock from three Atlantic salmon populations were held and spawned in a Federal hatchery. Eyed-eggs were transferred to private aquaculture companies for rearing to smolt stage in freshwater, and maturity in marine sea-cages. During October 2000, 1,038 two sea-winter mature adults were stocked into the Dennys, Machias, and St Croix rivers. Numbers of mature fish released into each river were based on escapement targets, stock-specific fecundity estimates, habitat survey data, and target egg deposition rates according to established management guidelines. Mortality was minimal during the sea-cage to river transfers (2.6%). All stocked fish were PIT tagged and genetically sampled. Individual stocking locations were recorded, allowing for precise movement and interaction data via ultrasonic telemetry and parentage analysis of progeny. Spawning occurred at 25-50% of anticipated levels based on preliminary redd count analysis. Assessment studies are planned through 2006 and should provide valuable population dynamics and genetic interaction data regarding the use of marine-reared adults for enhancement of Atlantic salmon stocks.

### **Spawning Activity of Broodstock Atlantic Salmon in the Baker River Merrimack River Watershed Fall 2000**

Douglas Smithwood and D. Batchelder (Z, AA)

During the Fall of 2000 broodstock Atlantic salmon were released into the Baker River to expand on past studies performed to determine the potential use of surplus adult salmon broodstock for the natural production of fry within this river system. In 1998, a similar study using a small number of radio-tagged broodstock was performed. In the 1998 study, the broodstock successfully spawned and fry emergence was documented the following spring. In 1999, a study was conducted using sea-run adults. During this study all radiotagged adults quickly exited the river system and moved a significant distance downstream out of available spawning habitat. Using the previous two years data, it was determined to perform a more extensive study using surplus broodstock from the Nashua National Fish Hatchery.

The Baker River is a major tributary of the Pemigewasset River. The Pemigewasset River and Winnepesaukee River join to form the Merrimack River. In November 2000, 258 broodstock Atlantic salmon were released into the Baker River. The released stocks comprised: ninety-eight, 3 year old females, sixty-two, 2 year old females and ninety-eight 2 year old males. The released fish were in various states of spawning maturity.

Extensive field surveys were conducted by canoe and by stream wading. All spawning activity was recorded and the locations of excavations flagged riverside and their positions recorded using GPS. Forty-one sites of spawning activities were recorded prior to ice up. The spawning activities at these sites included scratching, test pits and what was thought to be completed redds. Eight of these completed redds were marked with streamers attached to rebar placed at the head of the redd. Initial plans were to extract a egg samples from these completed redds to perform fertilization testing. Four redds were partially excavated. Four eggs were extracted from one of the redds and no eggs were found in the other three. The four eggs froze during transfer to the testing vial and therefore the level of fertilization was not determined.

Current plans are to revisit the completed redds in the Spring 2001 to test for fry emergence. In addition, if the area is not stocked with hatchery fry, there are plans to determine young-of-the-year densities in the study area utilizing electrofishing survey equipment.

### **Tag Retention and Survival of Age 0 Atlantic Salmon Following Surgical Implantation with Passive Integrated Transponder (PIT) Tags**

Gabe Gries and Benjamin Letcher (R)

We evaluated an alternative technique to using hypodermic needles to implant passive integrated transponder (PIT) tags into the body cavity of juvenile salmonids. We used surgery techniques to place PIT tags into the body cavity of 3,037 age 0 Atlantic salmon *Salmo salar*. Tag retention was 99.8% (six fish lost tags) and survival was 94.3% (174 fish died) after fish were held under hatchery conditions for nine months. A single tagger was able to tag 60 to 80 fish per hour. Surgically

implanting PIT tags into the body cavity of age 0 Atlantic salmon proved to be a viable technique and an alternative to using hypodermic needles.

## **STOCK IDENTIFICATION**

### **Origin of Atlantic Salmon Captured in a Mixed Stock Fishery at West Greenland**

R.W. Brown, D. Reddin, P.B. Short, T.L. King, and P. Kanneworf (A, K, K, L, M)

One of the key data inputs to international stock assessments of Atlantic salmon is the origin of Atlantic salmon harvested in mixed stock fisheries. An international sampling program collects biological data, scale and genetic samples from Atlantic salmon sampled from commercial fisheries catch at West Greenland. Both scale and genetic samples are used to characterize the continent-of-origin of captured salmon. Genetically derived continent-of-origin data are then used in an analysis to statistically categorize the origin for a larger sample of Atlantic salmon scale samples collected in West Greenland. Results for genetic samples collected during the 1999 field season were statistically analyzed during fiscal year 2000. Paired scale and genetic samples were used to construct a linear discriminate function to determine continent-of-origin based on scale characteristics. NMFS and Canadian scientists used this tool to analyze scale measurements taken from a larger group of Atlantic salmon sampled in West Greenland. Results from the 1999 sampling indicated that almost 91% of Atlantic salmon sampled in the West Greenland fishery were of North American origin. The proportion of North American fish in this fishery has increased steadily during the 1990's, prompting concerns about trends in pre-fishery abundance of North American and European stocks. Results of this research are integral to the completion of stock assessments of Atlantic salmon through the ICES North Atlantic Salmon Working Group.

### **Stable Isotope Composition of Atlantic Salmon Scales**

K. D. Friedland (O)

Atlantic salmon populations in the North Atlantic have experienced unprecedented declines in abundance during the past two decades. Of greater concern for the management of US salmon populations are the trends in the two seawinter salmon, especially those comprising the populations in the ESA distinct population segment. Although studies of climate and salmon survival suggest recruitment is patterned by events early in the post-smolt year, the apparent tele-connection between stock complexes suggests that factors related to life history events later in the post-smolt year or during the one-seawinter year may be important as well. If growth has decreased in salmon during the post-smolt or one-seawinter years, survival would likely be negatively impacted. Concomitant with the decline in stock abundance of salmon in the North Atlantic, a number of lines of evidence suggest that growth has also declined in the same time period. It is not known if this decline in size at age is a reflection of decreased growth during the post-smolt year or a decline in feeding opportunity when the fish are on the feeding grounds as one seawinter salmon. It is also not known if fish from the DPS are suffering the same decreased growth and tracking with the general pool of salmon in the Northwest Atlantic. There is no direct feeding data to approach these problems; however, many investigators have had success in evaluating feeding position with the analysis of stable isotopes in

fish hard parts, such as scales. The objective of this study is to develop a retrospective time series of stable isotope ratios for the DPS in Maine and the mixed stock samples from the continental stock complex to evaluate the feeding patterns of the stocks over time. Furthermore, retrospective time series of growth will also be developed to provide an explanatory variable in regard to the feeding patterns.

## GENETICS

### **Stock Specific Measures of Marine Growth for Three Remnant Populations of Atlantic Salmon, *Salmo Salar*, from Eastern Maine**

T. F. Sheehan, J. F. Kocik, and E. Atkinson (A,A,H)

We monitored stock-specific marine growth rates for two years from three Atlantic salmon populations in eastern Maine. Individuals were spawned at a Federal hatchery and reared to smolt stage at commercial facilities. Approximately 1,000 individuals from each stock were transferred to two marine sites for two sea-winters of marine grow-out. We tagged each individual with an elastomer injection to allow for stock differentiation. Individuals at each site were reared in a single sea-cage and experienced similar environmental influences and growing conditions. Biological sampling occurred approximately every other month. Standardized photographs were taken of a random sample of individuals after two years of grow-out, and Truss Analysis (multivariate morphometrics) was conducted on the photographs. We tested for stock-specific differences in growth with univariate and multi-variate techniques. Significant differences in growth were evident at each site. Significant differences in growth, between populations reared within a common environment, indicate that these populations do harbor some genetic uniqueness. This information maybe useful in understanding the ecological implications of subtle genetic differences and may help managers better understand the dynamics of these stocks while developing conservation plans.

### **Use of Genetic Marking Techniques to Assess Immigration Vs. In Situ Survival of Age-0 Atlantic Salmon**

Keith H. Nislow ,C.L. Folt, and B.H. Letcher (DD, BB, R)

We used genetic marks (“familyprints”) to determine the extent to which juvenile salmon stocked as unfed fry disperse from stocking sites in their first spring and summer. Genetically marked fry were stocked into ~100m long study sections in different rearing streams in May. These sections were then sampled four months later, and fin clips of all age-0 salmon captured were analyzed to determine whether fish present in the section had been originally stocked there, or had immigrated from another part of the stream. We found that in both 1998 and 1999, a majority of age-0 salmon captured came from outside the study sections. Retention of genetically marked fry averaged 28% (range 17 – 43%) across four study sites in 1999, which was more than 3x the retention rate observed in 1998 (8.5%). These results indicate that a majority of the salmon stocked as unfed fry disperse from their original stocking locations. In addition, lower rates of movement in 1999, a drought year, compared to 1998, a year where many sites experienced both high spring flows and summer floods, suggests that downstream displacement by high flows may be an important mechanism for salmon

dispersal during their first spring and summer.

### **Relative Importance of Heritable Vs. Environmental Variation in Age-0 Atlantic Salmon Growth and Survival in the Connecticut Basin**

Keith H. Nislow, B.H. Letcher and C.L. Folt (DD, R, BB)

We used multiple common environment experiments (MCEE) to assess the relative importance of environmental vs. heritable variation in age-0 salmon growth and survival in the Connecticut basin. We created six families from sea-run adult matings, and stocked the offspring of these families into seven rearing streams, representing a range of environmental conditions in the basin. In addition, we also raised these families under hatchery conditions. We found significant variation in survival and growth among both sites and families. One family, which was largest at the time of stocking, had ~3x greater survival rates than the other families across all sites, while a different family had significantly higher growth rates both in the field and in the hatchery. Overall the ratio of environmental (between-site) to heritable (between-family) variation was ~2:1 for growth rate, and ~10:1 for survival rate. These results point to the potentially important role of heritable variation in providing the raw material for adaptive change in the development of a Connecticut River stock.

### **FISH HEALTH/NUTRITION**

#### **Wild Fish Disease Screening**

S. MacLean (D)

Recent outbreaks of ISA, a viral disease of Atlantic salmon, have occurred in Scotland and Canada, causing high mortality in cultured salmon. When tested for, the virus also was found in various species of wild fishes in Scotland and in salmon returning to rivers in Canada. Aside from the Scottish studies, which demonstrated a broad host species range for ISAv, little is known of the epizootiology of the ISA virus or other salmonid diseases in wild salmon and other marine fishes. NEFSC prepared a contract to conduct a survey of salmonid and non-salmonid wild fishes in the NW Atlantic for the detection of the Infectious Salmon Anemia virus (ISAv) and for *Renibacterium salmoninarum*, the agent of bacterial kidney disease (BKD). The purpose of the survey is two-fold; 1) to determine the presence and distribution of ISAv and BKD in wild fishes using accepted diagnostic methods, and 2) to determine the comparability of the multiple assay methods currently available for ISAv detection (RT-PCR, IFAT, cell culture). A private laboratory with vast experience in fish disease diagnostics has been contracted to perform the assays. To date, the following fishes have tested negative for both pathogens: Atlantic mackerel (N=120), Atlantic herring (N=40), alewife (N=60), and winter flounder (N=60). Fishes for examination have been supplied through the cooperation of several individuals from NMFS and Sea Grant in order to get a broad species and geographical distribution. The assessment of salmonid disease agents in wild fishes will continue in the next fiscal year.

## **Evaluation of Commercially Prepared Transport Systems for Non-lethal Detection of *Aeromonas salmonicida* in Salmonid Fish**

Rocco C. Cipriano and G. L. Bullock (X,Y)

*In vitro* studies indicated that commercially prepared transport systems containing Amie's, Stuart's, and Cary-Blair media worked equally well in sustaining the viability of the fish pathogen *Aeromonas salmonicida*, cause of furunculosis. The bacterium remained viable without significant increase or decrease in cell numbers for up to 48 hours of incubation at 18-20°C in Stuart's Transport Medium and, consequently, obtaining mucus samples in such tubes were compared to on-site detection of *A. salmonicida* by dilution plate counts on Coomassie Brilliant Blue Agar. In three different assays of 100 samples of mucus from Atlantic salmon (*Salmo salar*) infected subclinically with *A. salmonicida*, dilution counts conducted on-site proved more reliable to detect the pathogen than obtaining the samples in the transport system. In such assays, dilution counts detected the pathogen in 34, 41, and 22 samples whereas this was accomplished in only 15, 15, and 3 of the respective samples when the transport system was used. In an additional experiment, Arctic char (*Salvelinus alpinus*) sustaining a frank epizootic of furunculosis were sampled similarly. Here, too, dilution counts were more predictive of the prevalence of *A. salmonicida* and detected the pathogen in 46 mucus samples. By comparison, only 6 samples collected by using the transport system were positive. It was also observed that the transport system supported the growth of other components of the normal bacterial flora of the mucus of these fish and especially predominant were motile aeromonads and *Pseudomonas fluorescens*. In mixed culture growth studies, two representatives of both of the latter genera of bacteria outgrew *A. salmonicida* and, in some cases, to the total exclusion of the pathogen, itself.

## **POPULATION ESTIMATES/TRACKING**

### **Individual-level Modeling of Growth and Survival of Atlantic Salmon Parr in Shorey Brook, ME USA**

Gregg E. Horton and B. H. Letcher (R)

Atlantic salmon were sampled from 37, 20 m long sections representing 33, 100 m<sup>2</sup> units of wetted area in Shorey Brook, a second order tributary to the Narraguagus River, Washington County, Maine between March and December, 2000. Sampling methods were either electrofishing (March, June, September, November, December) or night seining (July, August). A total of 1,007 individual Atlantic salmon were captured during these seven sampling periods; 706 fish were PIT (Passive Integrated Transponder) tagged and the remaining 301 were too small to tag. Based on scale samples from fish captured during the June sample, age-1+ fish were dominant within the population (54%), while age-2+ fish comprised a slightly smaller proportion (43%). Because they were too small to effectively capture in June, age-0+ fish are not included in this age structure summary. Approximately 4,500 fry were stocked in Shorey Brook (representing approximately 44/unit) in early May. Several of these fry were large enough to tag in September although some were still too small (<60 mm fork length). Additionally, 273 brook

trout were PIT tagged which should yield growth and survival information for the potential, primary competitor of Atlantic salmon in Shorey Brook.

Upon recapture of residents within the 37 study sections, individuals were resampled to determine growth rate, precocity, movement, habitat selection, and population survival. Jolly-Seber survival rate estimates for the age-1+ fish ranged from 0.74 between June and July to 0.91 between August and September. Mean growth rates between sampling periods tended to be higher for age-1+ fish as compared to older-aged fish. Growth rates were highest for all age groups between March and June and lowest between July and August. Twenty-three percent of the three PYOY (>age-1) cohorts, combined, were mature.

The smolt trap operated on Shorey Brook from late March through the end of May resulted in a total capture of 46 Atlantic salmon smolts. Eleven of these 46 (24%) had been previously captured during March as evidenced by having a PIT tag present. The remaining 35 were PIT tagged upon capture and, along with the 11 previously tagged fish, released to continue their downstream migration. Ages of emigrating smolts were age-2+ (67%) and age-3+ (33%). Data on rainfall amount, pH, temperature and conductivity have been recorded continuously since March, 2000. Benthic and drifting invertebrate samples were also collected periodically during sampling. Summarization of these data is incomplete. There are plans to continue sampling in 2001 and 2002 which will allow continued tracking of pre-smolt growth and survival rates.

### **Effects of Repeated Anesthetizing of Juvenile Atlantic Salmon with MS-222, Clove Oil and Alka-Seltzer**

Gabe Gries, M. Grader and B. Letcher (R)

To determine effectiveness of various anesthetics on Atlantic salmon growth and behavior, 225 age 0 fish were randomly divided among four treatments (MS-222, clove oil, Alka-Seltzer and control), held under laboratory conditions and sampled periodically over eight months. During sample 1, fish were anesthetized according to their treatment group, PIT tagged, weighed (g) and measured (FL, mm). Induction times to Stage IV and recovery times were recorded. During samples 2, 3 and 4, fish were processed as before, with the exception of control fish. During samples 5, 6 and 7, all fish were anesthetized according to treatment (including controls) and weighed and measured, but induction and recovery times were not recorded. No differences in initial and final lengths and weights were observed among treatment groups suggesting anesthetic type and the use of an anesthetic did not influence overall growth. Results of mixed model analysis indicated that growth trajectory did not differ among the anesthetic treatment groups. Fish anesthetized with clove oil and Alka-Seltzer had the longest recovery times and MS-222 treatment fish had the shortest recovery times. Time to induce stage IV was shortest for clove oil treatment fish. Our results suggest MS-222 or clove oil can be used to anesthetize juvenile Atlantic salmon without influencing growth or survival, but we would not encourage the use of Alka-Seltzer due to negative behavioral effects and long induction and recovery times.

## A Night Seining Technique for Sampling Juvenile Atlantic Salmon in Streams

Gabe Gries and Benjamin Letcher (R)

For many studies of the population dynamics, growth and movement of juvenile Atlantic salmon *Salmo salar* it is necessary to resample tagged individuals multiple times. However, common sampling techniques such as electrofishing can result in physical injury and may have negative effects on fish survival and growth, especially when individuals are repeatedly sampled. Additionally, electrofishing is not always feasible in some systems. We describe an alternative technique to electrofishing that involves sampling at night with hand-held seines and allows for the repeated recapture of individual juvenile Atlantic salmon. We evaluated this night seining technique in the West Brook, Whately, Massachusetts, USA during 1997 and 1998 by sampling PIT-tagged salmon in 47 contiguous 20-meter sections 15 times using night seining, day electrofishing and day seining techniques. All untagged salmon captured were tagged and by the fourth sample, over 94% of the salmon were recaptures with this percentage remaining at or exceeding 94% in subsequent samples. Day seining was not an efficient capture technique, capturing on average only 18.5% of the population estimate (all ages combined). The average percent of the population estimate caught during night seining samples (47.0%) was lower than that for day electrofishing samples (76.3%) (all ages combined). Shorter salmon resulted in a significantly smaller percentage of the population estimate captured during night seining samples, but not during day electrofishing samples. The total number of age-0 salmon captured during night seining samples in 1998 increased 4.5 times after fish attained a mean fork length of just over 60 mm. A greater percentage of brook trout *Salvelinus fontinalis* was captured during day electrofishing samples than during night seining samples (87% vs. 13%), with similar results for brown trout *Salmo trutta* (91% vs. 9%). Effective night seining is limited to small streams (<15 m in width) and may prove useful when electrofishing is impractical, threatened or endangered species exist, or multiple recaptures of individuals are desired.

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## **6. HISTORICAL DATA (1970 - 2000)**

### **6.1. STOCKING**

The historical stocking information is presented in Table 3.2.a. in Appendix 9.3. Approximately 165 million juvenile salmon have been released into the rivers of New England during the period, 1970 - 2000. About 77% of the total have been fry. The majority of the juvenile releases have occurred in the Connecticut River (over 77.7 million), the Penobscot River (over 28.6 million), and the Merrimack River (over 29 million).

## **6.2. ADULT RETURNS**

The historical return information is presented in Table 3.2.b. in Appendix 9.3. Total returns to New England rivers from 1970 through 2000 now equals 76,347. The majority of the returns have occurred in Maine rivers (90.3%) followed by the returns to the Connecticut River (6.4%), and the Merrimack River (3.0%). The Penobscot River alone accounts for 71% of the total.

## **7. TERMS OF REFERENCE FOR 2002 MEETING**

The U.S. Atlantic Salmon Assessment Committee agreed to address the following Terms of Reference for the 2002 meeting:

1. Program summaries for current year (2001) to include:
  - a. current year's stocking program with breakdowns by time, location, marks and lifestage.
  - b. current year's returns by sea age, marked vs. unmarked, and wild vs. hatchery.
  - c. general summary of program activities including regulation changes, angling catch, and program direction.
2. Update historical databases.
3. Additional Terms of Reference will be developed at a special meeting on July 12, 2001.

## **8. LITERATURE CITED**

All references are located in previous sections.

## **9. U.S. ATLANTIC SALMON ASSESSMENT COMMITTEE MEMBERS**

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**10. APPENDICES****10.1. LIST OF ALL PARTICIPANTS**

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## 10.2. Glossary of Abbreviations

Adopt A Salmon Family	AASF
Arcadia Research Hatchery	ARH
CT River Atlantic Salmon Association	CRASA
Biological Resource Division	BRD
Connecticut Dept of Environmental Protection	CTDEP
Connecticut River Atlantic Salmon Commission	CRASC
Craig Brook National Fish Hatchery	CBNF
Decorative Specialities International	DSI
Developmental Index	DI
Federal Energy Regulatory Commission	FERC
Greenfield Community College	GCC
Green Lake National Fish Hatchery	GLNFH
International Council for the Exploration of the Seas	ICES
Kensington State Salmon Hatchery	KSSH
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Sunderland Office of Fisheries Assistance	SOFA
University of Massachusetts / Amherst	UMASS
U. S. Army Corps of Engineers	USACOE
U. S. Atlantic Salmon Assessment Committee	USASAC
U. S. Generating Company	USGen
U. S. Geological Survey	USGS
U. S. Fish and Wildlife Service	USFWS
U. S. Forest Service	USFS
Vermont Fish and Wildlife	VTFW
Warren State Fish Hatchery	WSFH
White River National Fish Hatchery	WRNFH
Whittemore Salmon Station	WSS

### 10.3. TABLES AND FIGURES SUPPORTING THE DOCUMENT

**TABLE 2.1.3.g. RESULTS OF THE DOMESTIC ATLANTIC SALMON BROODSTOCK SPORT FISHERY IN THE MERRIMACK RIVER FOR 1993 - 2000.**

Category	1993	1994	1995	1996	1997	1998	1999	2000
Number of salmon stocked	1591	1982	2735	3003	3610	2878	3317	4146
Total permits sold	930	1,708	2,387	2,066	1,989	1,939	1,689	1,562
% Non-residents	3	9	7	10	8	11	10	10
Diary reporting rate (%)	61	61	60	27	22	22	19	16
Estimated no. of anglers that fished	715	1,250	1,683	1,355	1,352	1,203	1,182	898
% of anglers utilizing fly fishing	76	77	69	76	74	83	81	85
% of anglers utilizing artificial lures	24	14	20	16	16	9	9	10
% of anglers utilizing both fly fishing and artificial lures	0	9	11	8	10	8	10	5
Angler success in fly fishing areas (% catching at least 1 salmon)	35	26	30	27	32	27	44	31
Angler success in fly/lure area (% catching at least 1 salmon)	28	24	31	30	31	37	41	43
Estimated total hours of fishing effort	14,779	21,726	29,205	22,206	24,802	21,413	21,276	19,002
Estimated hours per salmon landed	14.9	23.5	15.9	14.4	14.6	13.9	7.9	13.5
Estimated no. of angler trips	4,651	6,258	9,746	6,958	8,736	7,459	8,274	6,286
Estimated no. of salmon caught and released	594	577	1,105	1,080	1,132	1,071	2,104	1,221
Estimated no. of salmon caught and kept	400	345	737	461	573	457	603	180
Estimated total catch (released and kept)	994	922	1,841	1,541	1,705	1,528	2,707	1,401
Estimated expenditures per angler (\$)	\$92	\$84	\$132	\$131	\$110	\$245	\$184	\$162
Estimated total expenditures by anglers (\$)	\$66,000	\$105,000	\$221,584	\$177,506	\$148,720	\$294,735	\$217,488	\$145,476

**TABLE 2.2.1.a. JUVENILE ATLANTIC SALMON STOCKING SUMMARY FOR NEW ENGLAND IN 2000.** <sup>1</sup>

RIVER	NUMBER OF FISH STOCKED BY LIFESTAGE <sup>2</sup>						TOTAL
	FRY	0+PARR	1PARR	1+PARR	ISMOLT	2SMOLT	
<b>UNITED STATES</b>							
Aroostook	0	0	0	0	0	0	0
St. Croix	1,000	0	0	0	20,000	0	21,000
Dennys	96,000	30,500	0	0	0	0	126,500
East Machias	197,000	0	0	0	0	0	197,000
Machias	209,000	0	0	0	0	0	209,000
Pleasant	0	0	0	0	0	0	0
Narraguagus	252,000	0	0	0	0	0	252,000
Union	0	0	0	0	0	0	0
Penobscot	513,000	288,800	700	0	563,200	0	1,365,700
Ducktrap	0	0	0	0	0	0	0
Sheepscot	211,000	0	0	0	0	0	211,000
Androscoggin	0	0	0	0	0	0	0
Saco	599,000	48,200	0	0	22,600	0	669,800
Coheco	146,000	0	0	0	0	0	146,000
Lamprey	104,000	0	0	0	0	0	104,000
Merrimack	2,217,000	0	0	0	52,500	0	2,269,500
Pawcatuck	326,000	0	0	0	0	0	326,000
Connecticut	9,288,000	600	0	0	700	48,200	9,337,500
<b>TOTAL</b>	<b>14,159,000</b>	<b>368,100</b>	<b>700</b>	<b>0</b>	<b>659,000</b>	<b>48,200</b>	<b>15,235,000</b>
<b>CANADA</b>							
Aroostook	0	0	0	0	0	0	0
St. Croix	0	19,000	0	0	0	0	19,000
<b>TOTAL</b>	<b>0</b>	<b>19,000</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>19,000</b>
<b>PROGRAM</b>							
<b>Maine</b>							
United States	2,078,000	367,500	700	0	605,800	0	3,052,000
Canada	0	19,000	0	0	0	0	19,000
Coheco	146,000	0	0	0	0	0	146,000
Lamprey	104,000	0	0	0	0	0	104,000
Merrimack River	2,217,000	0	0	0	52,500	0	2,269,500
Pawcatuck River	326,000	0	0	0	0	0	326,000
Connecticut River	9,288,000	600	0	0	700	48,200	9,337,500
<b>TOTAL</b>	<b>14,159,000</b>	<b>387,100</b>	<b>700</b>	<b>0</b>	<b>659,000</b>	<b>48,200</b>	<b>15,254,000</b>

<sup>1</sup> The distinction between USA and Canadian stocking is based on the sources of the fish or eggs.

<sup>2</sup> The number of fry is rounded to the nearest 1000 fish. All other entries rounded to the nearest 100 fish.

**TABLE 2.2.1.b. CAPTIVE AND DOMESTIC ADULT ATLANTIC SALMON STOCKING SUMMARY FOR NEW ENGLAND IN 2000 BY RIVER, SEASON, AND YEAR CLASS. <sup>1</sup>**

RIVER	NUMBER RELEASED BY SEASON AND YEAR CLASS										TOTAL	
	Spring / Early Summer					Autumn						
	1994	1995	1996	1997	1998	1994	1995	1996	1997	1998		
<b>UNITED STATES</b>												
Aroostook	0	0	0	0	0	0	0	0	0	0	0	0
St. Croix <sup>2</sup>	0	0	0	0	0	0	702	0	0	0	0	702
Dennys <sup>2</sup>	0	0	0	0	0	0	112	0	0	0	0	112
East Machias <sup>3</sup>	0	0	0	0	0	0	86	0	0	0	0	86
Machias <sup>4</sup>	0	0	0	0	0	62	178	28	0	0	0	268
Pleasant	0	0	0	0	0	0	0	0	0	0	0	0
Narraguagus	0	0	0	0	0	98	0	0	0	0	0	98
Union	0	0	0	0	0	0	0	0	0	0	0	0
Penobscot	0	0	0	0	0	0	0	608	774	0	0	1,382
Ducktrap	0	0	0	0	0	0	0	0	0	0	0	0
Sheepscot	0	0	0	0	0	26	0	0	0	0	0	26
Saco	0	0	0	0	0	0	0	0	0	0	0	0
Cocheco	0	0	0	0	0	0	0	0	0	0	0	0
Lamprey	0	0	0	0	0	0	0	0	0	0	0	0
Merrimack	0	0	422	2,011	305	0	0	0	1,105	153	0	3,996
Pawcatuck	0	0	0	0	0	0	0	0	0	0	0	0
Connecticut	0	0	0	0	0	0	0	0	0	31	0	31
<b>TOTAL</b>	<b>0</b>	<b>0</b>	<b>422</b>	<b>2,011</b>	<b>305</b>	<b>186</b>	<b>1,078</b>	<b>636</b>	<b>1,879</b>	<b>184</b>	<b>0</b>	<b>6,701</b>
<b>CANADA</b>												
Aroostook	0	0	0	0	0	0	0	0	0	0	0	0
St. Croix <sup>2</sup>	0	0	0	0	0	0	48	0	0	0	0	48
<b>TOTAL</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>48</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>48</b>
<b>PROGRAM</b>												
Maine												
United States	0	0	0	0	0	186	1,078	636	774	0	0	2,674
Canada	0	0	0	0	0	0	48	0	0	0	0	48
Cocheco	0	0	0	0	0	0	0	0	0	0	0	0
Lamprey	0	0	0	0	0	0	0	0	0	0	0	0
Merrimack River	0	0	422	2,011	305	0	0	0	1,105	153	0	3,996
Pawcatuck River	0	0	0	0	0	0	0	0	0	0	0	0
Connecticut River	0	0	0	0	0	0	0	0	0	31	0	31
<b>TOTAL</b>	<b>0</b>	<b>0</b>	<b>422</b>	<b>2,011</b>	<b>305</b>	<b>186</b>	<b>1,126</b>	<b>636</b>	<b>1,879</b>	<b>184</b>	<b>0</b>	<b>6,749</b>

<sup>1</sup> Year class refers to year of collection in the wild or egg take.

<sup>2</sup> All fish were raised in net pens.

<sup>3</sup> Sixteen fish were raised in net pens.

<sup>4</sup> One hundred seventy six fish were raised in net pens.

**TABLE 2.2.2.a. SUMMARY OF JUVENILE AND ADULT ATLANTIC SALMON MARKING PROGRAMS IN NEW ENGLAND, 2000.**

Mark	Stage	Connecticut	St. Croix	Dennys	E. Machias	Machias	Pleasant	Merrimack	Penobscot	Union	Narraguagus	Sheepscot	Saco	Total
Clip	adult	31	750	112	16	176	0	0	0	0	0	0	0	1,085
	parr	0	0	0	0	0	0	0	0	0	660	0	0	660
	smolt	47,857	0	0	0	0	0	0	0	0	46	0	0	47,903
	Total	47,888	750	112	16	176	0	0	0	0	706	0	0	49,648
VIE	parr	0	0	0	0	0	0	0	0	0	0	0	0	0
	smolt	118	0	0	0	0	0	0	171,900	0	0	0	0	172,018
	adult	0	702	112	16	176	0	0	0	0	0	0	0	1,006
Floy	adult	2	0	0	0	0	0	3,996	0	0	0	0	0	3,998
	smolt	140	0	0	0	0	0	0	0	0	0	0	0	140
Ping	smolt	0	0	0	0	0	0	0	0	0	0	0	0	0
	adult	0	0	60	16	16	0	0	0	0	0	0	0	92
PIT	parr	3,037	0	0	0	0	0	0	0	0	660	0	0	3,697
	smolt	380	0	0	0	0	0	0	0	0	46	0	0	426
	adult	0	750	112	86	268	0	0	271	0	98	26	0	1,611
Radio	smolt	204	0	0	0	0	0	0	0	0	0	0	0	204
	adult	10	0	0	0	0	0	0	0	0	0	0	0	10
Carlin	adult	0	48	0	0	0	0	0	0	0	0	0	0	48
All	adult	43	750	112	86	268	0	3,996	271	0	98	26	0	5,650
	parr	3,037	0	0	0	0	0	0	0	0	1,320	0	0	4,357
	smolt	48,699	0	0	0	0	0	0	171,900	0	92	0	0	220,691
<b>Grand Total</b>		<b>51,779</b>	<b>750</b>	<b>112</b>	<b>86</b>	<b>268</b>	<b>0</b>	<b>3,996</b>	<b>172,171</b>	<b>0</b>	<b>1,510</b>	<b>26</b>	<b>0</b>	<b>230,698</b>

Notes:

Clip = all clips combined

VIA = visual implant alpha-numeric

VIE = visual implant elastomers

Ping = internally implanted ultra-sonic pinger

TABLE 2.2.2.b. ATLANTIC SALMON MARKING DATABASE FOR NEW ENGLAND - 2000.

PLACE OF RELEASE	MARKING AGENCY	AGE	LIFE STAGE	H, W, C, D	STOCK ORIGIN	TAG/MARK	NUMBER MARKED	CODE OR SERIAL	AUX MARK	RELEASE DATE	COMMENTS
Connecticut R.	USGS	2	smolt	H	Connecticut	PIT	80		VIE	Apr-00	Passumpscic R. Study VT
Connecticut R.	USGS	1	smolt	H	Connecticut	PIT	90		VIE	May-00	Passumpscic R. Study VT
Connecticut R.	USGS	1	smolt	H	Connecticut	PIT	90		VIE	May-00	West R. Study VT
Connecticut R.	USGS	1	smolt	H	Connecticut	PIT	60		VIE	May-00	Connecticut Mainstem Study
Connecticut R.	USGS	1	smolt	H	Connecticut	PIT	60		VIE	Jun-00	Connecticut Mainstem Study
Connecticut R.	USGS	1+2+	par	W	Connecticut	PIT	460		VIE	Oct-00	West R. Study VT
Connecticut R.	USGS	1+2+	par	W	Connecticut	PIT	126		VIE	Oct-00	White R. Study VT
Connecticut R.	USGS	1+2+	par	W	Connecticut	PIT	15		VIE	Sep-00	Passumpscic/Moose Study VT
Connecticut R.	USGS	1+2+	par	W	Connecticut	PIT	92		VIE	Sep-00	Maidstone R. Study VT
Connecticut R.	USGS	1+2+	par	W	Connecticut	PIT	16		VIE	Sep-00	White/Tweed Study VT
Connecticut R.	CTDEP	2	smolt	H	Connecticut	AD	22,219			Apr-00	Farmington R. CT
Connecticut R.	USFWS	2	smolt	H	Connecticut	AD	25,638			Apr-00	Connecticut Mainstem MA
Connecticut R.	PGE ENERGY	4	adult	W	Connecticut	Radio Tag	10		PIT	May-99	Deerfield R. Study MA
Connecticut R.	CTDEP	2	adult	D	Connecticut	AD	13			Oct-00	Salmon R. CT
Connecticut R.	CTDEP	4	adult	D	Connecticut	FLOY	2	01899-01900		Apr-00	Farmington R. CT
Connecticut R.	CTDEP	2	adult	D	Connecticut	AD	14			Oct-00	Farmington R. CT
Connecticut R.	CTDEP	2	adult	D	Connecticut	AD	4			Oct-00	Eightmile R. CT
Connecticut R.	VTCFWRU	1+, 2+	par	H	Connecticut	FLOY	140	1125-1300	AD	Apr-00	Farmington R. CT
Connecticut R.	VTCFWRU	1+, 2+	par	W	Connecticut	PIT	96		VIE	May-Sep-00	UYVM West Study
Connecticut R.	VTCFWRU	1+, 2+	par	W	Connecticut	VIE	68		VIE	Aug-00	UYVM West Study
Connecticut R.	VTCFWRU	1+, 2+	par	W	Connecticut	PIT	48		VIE	Jun-00	UYVM BlackStudy
Connecticut R.	VTCFWRU	1+, 2+	par	W	Connecticut	VIE	20		VIE	Aug-00	UYVM BlackStudy
Connecticut R.	VTCFWRU	1+, 2+	par	W	Connecticut	PIT	184		VIE	May-Oct-00	UYVM Williams Study
Connecticut R.	VTCFWRU	1+, 2+	par	W	Connecticut	VIE	65		VIE	Aug-00	UYVM Williams Study
Connecticut R.	USGS	0+	par	W	Connecticut	PIT	2,000			Sep-00	West Brook Study MA
Connecticut R.	PGE	1	smolt	H	Connecticut	VIE	118			May-00	Deerfield R. Study MA
Connecticut R.	PGE	1	smolt	H	Connecticut	Radio Tag	54			May-00	Deerfield R. Study MA
Connecticut R.	PGE	1	smolt	H	Connecticut	Radio Tag	150			May-00	Connecticut Mainstem Study
TOTAL TAG/MARK, CONNECTICUT RIVER							51,932				
Merrimack R.	NHFG	3	adult	D	Merrimack	FLOY	279	White		Mar-00	Bristol
Merrimack R.	NHFG	3	adult	D	Merrimack	FLOY	150	Blue		Mar-00	Garvins
Merrimack R.	NHFG	3	adult	D	Merrimack	FLOY	63	Red		Mar-00	Franklin
Merrimack R.	NHFG	3	adult	D	Merrimack	FLOY	139	Green		Mar-00	Boscowen
Merrimack R.	NHFG	3	adult	D	Merrimack	FLOY	88	Orange		Mar-00	Hooksett
Merrimack R.	NHFG	3	adult	D	Merrimack	FLOY	75	Blue		Mar-00	Garvins
Merrimack R.	NHFG	4	adult	D	Merrimack	FLOY	30	Yellow		Mar-00	Sewalls Falls
Merrimack R.	NHFG	4	adult	D	Merrimack	FLOY	68	Red		Mar-00	Franklin
Merrimack R.	NHFG	4	adult	D	Merrimack	FLOY	100	Yellow		Apr-00	Sewalls Falls
Merrimack R.	NHFG	4	adult	D	Merrimack	FLOY	150	White		Apr-00	Bristol
Merrimack R.	NHFG	3	adult	D	Merrimack	FLOY	155	Green		Apr-00	Boscowen

PLACE OF RELEASE	MARKING AGENCY	LIFE STAGE	H, W, C, D	STOCK ORIGIN	TAG/MARK	NUMBER MARKED	CODE OR SERIAL	AUX MARK	RELEASE DATE	COMMENTS
Merrimack R.	NHFG	2 adult	D	Merrimack	FLOY	145	Red		Apr-00	Franklin
Merrimack R.	NHFG	3 adult	D	Merrimack	FLOY	289	Red		May-00	Franklin
Merrimack R.	NHFG	3 adult	D	Merrimack	FLOY	331	Green		May-00	Boscawen
Merrimack R.	NHFG	3 adult	D	Merrimack	FLOY	165	Yellow		May-00	Sewalls Falls
Merrimack R.	NHFG	2 adult	D	Merrimack	FLOY	160	Orange		May-00	Hooksett
Merrimack R.	NHFG	4 adult	D	Merrimack	FLOY	224	Yellow		May-00	Sewalls Falls
Merrimack R.	NHFG	3 adult	D	Merrimack	FLOY	127	White		May-00	Bristol
Merrimack R.	NHFG	3 adult	D	Merrimack	FLOY	527	Purple		Oct-00	Bristol
Merrimack R.	NHFG	3 adult	D	Merrimack	FLOY	480	Grey		Oct-00	Franklin
Merrimack R.	USFWS	2 adult	D	Merrimack	FLOY	153	Orange		Nov-00	Baker River Study
Merrimack R.	USFWS	3 adult	D	Merrimack	FLOY	98	Orange		Nov-00	Baker River Study
TOTAL TAG/MARK, MERRIMACK RIVER						3996				
Penobscot R.	USFWS/NMFS	1 smolt	H	Penobscot	VIE	24900		AD	Apr-00	right eye Green
Penobscot R.	USFWS/NMFS	1 smolt	H	Penobscot	VIE	25200		AD	May-00	left eye Red
Penobscot R.	USFWS/NMFS	1 smolt	H	Penobscot	VIE	25000		AD	Apr-00	left eye Green
Penobscot R.	USFWS/NMFS	1 smolt	H	Penobscot	VIE	16700		AD	Apr-00	right eye Yellow
Penobscot R.	USFWS/NMFS	1 smolt	H	Penobscot	VIE	1300		AD	May-00	right eye Blue
Penobscot R.	USFWS/NMFS	1 smolt	H	Penobscot	VIE	1100		AD	May-00	right jaw Purple
Penobscot R.	USFWS/NMFS	1 smolt	H	Penobscot	VIE	1100		AD	May-00	right eye Purple
Penobscot R.	USFWS/NMFS	1 smolt	H	Penobscot	VIE	1000		AD	May-00	right jaw Blue
Penobscot R.	USFWS/NMFS	1 smolt	H	Penobscot	VIE	1100		AD	May-00	left eye Blue
Penobscot R.	USFWS/NMFS	1 smolt	H	Penobscot	VIE	24800		AD	May-00	left eye Yellow
Penobscot R.	USFWS/NMFS	1 smolt	H	Penobscot	VIE	24700		AD	May-00	right eye Red
Penobscot R.	USFWS/NMFS	1 smolt	H	Penobscot	VIE	25100		AD	Apr-00	left eye Orange
TOTAL TAG/MARK, PENOBSCOT RIVER						172000				
St. Croix R.	NMFS/ASC/USFWS	4 adult	H/N	St. Croix	PIT/Carlin	48		AD	Oct-00	Type B PIT tags/Blue Carlin
St. Croix R.	NMFS/ASC/USFWS	4 adult	H/N	East Machias	VIE/PIT	235		AD	Oct-00	rt. Eye and rt. Lower jaw Yellow VIE; Type B PIT tag
St. Croix R.	NMFS/ASC/USFWS	4 adult	H/N	Machias	VIE/PIT	92		AD	Oct-00	rt. Eye and rt. Lower jaw Red; Type B PIT tag
St. Croix R.	NMFS/ASC/USFWS	4 adult	H/N	Dennys	VIE/PIT	89		AD	Oct-00	rt. Eye and rt. Lower jaw Orange; Type B PIT tag
St. Croix R.	NMFS/ASC/USFWS	4 adult	H/N	Mixed	VIE/PIT	286		AD	Oct-00	mixed VIE marks; Type B PIT tags
TOTAL TAG/MARK, ST. CROIX RIVER						750				
Dennys R.	NMFS/ASC/USFWS	4 adult	H/N	Dennys	VIE/PIT/Ping	112		AD	Oct-00	rt. Eye and rt. lower jaw Orange; Type B PIT tag 60 Ping tags
TOTAL TAG/MARK, DENNYS RIVER						112				
Narraganset R.	USFWS	7 adult	C	Narraganset	PIT	98		AD	Nov-00	Type A PIT tags
Narraganset R.	USGS/NMFS	2 smolt	W	Narraganset	PIT	46		AD	Apr-00	Type B PIT tags (aging not yet complete)
Narraganset R.	USGS/NMFS	1 parr	W	Narraganset	PIT	660		AD	Mar-00	Type B PIT tags (aging not yet complete)
TOTAL TAG/MARK, NARRAGANSET RIVER						804				
Sheepsfoot	USFWS	7 adult	C	Sheepsfoot	PIT	26			Nov-00	Type A PIT tags
TOTAL TAG/MARK, SHEEPSFOOT RIVER						26				
Machias R.	USFWS	7 adult	C	Machias	PIT	62			Dec-00	Type A PIT tags
Machias R.	USFWS	6 adult	C	Machias	PIT	2			Dec-00	Type A PIT tags

PLACE OF RELEASE	MARKING AGENCY	LIFE STAGE	H, W, C, D	STOCK ORIGIN	TAG/MARK	NUMBER MARKED	CODE OR SERIAL	AUX MARK	RELEASE DATE	COMMENTS
Machias R.	USFWS	5 adult	C	Machias	PIT	28			Dec-00	Type A PIT tags
Machias R.	NMFS/ASC/USFWS	4 adult	H/N	Machias	VIE/PIT/Ping	176			Oct-00	rt. Eye and rt. Lower jaw Yellow VIE; Type B PIT tags; 16 Ping tags
TOTAL TAG/MARK, MACHIAS RIVER						268				
East Machias R.	USFWS	7 adult	C	East Machias	PIT	54			Nov-00	Type A PIT tags
East Machias R.	USFWS	6 adult	C	East Machias	PIT	1			Nov-00	Type A PIT tags
East Machias R.	USFWS	5 adult	C	East Machias	PIT	15			Nov-00	Type A PIT tags
East Machias R.	NMFS/ASC/USFWS	4 adult	H/N	East Machias	VIE/PIT/Ping	16			Oct-00	rt. Eye and rt. Lower jaw Yellow VIE; Type B PIT tags; 16 Ping tags
TOTAL TAG/MARK, E. MACHIAS RIVER						86				
GRAND TOTAL TAG/MARK						229,806				

Notes:

- H=hatchery
- N=raised in net pen
- W=wild
- C=captive, wild origin held in hatchery then released
- D=domestic, entire life cycle in hatchery
- VIA=visual implant alpha-numeric
- VIE=visual implant elastomers
- AD = adipose clip
- AP=hole punched in adipose fin (AD punch)
- LV=left ventral fin clip
- RV=right ventral fin clip
- Ping=internally implanted ultrasonic pinger

**TABLE 2.3.1. DOCUMENTED ATLANTIC SALMON RETURNS TO NEW ENGLAND RIVERS IN 2000.**

RIVER	NUMBER OF RETURNS BY SEA AGE AND ORIGIN <sup>1</sup>								TOTAL
	1SW		2SW		3SW		RS		
	Hatchery	Wild	Hatchery	Wild	Hatchery	Wild	Hatchery	Wild	
Penobscot River <sup>2</sup>	166	17	265	70	0	0	15	2	535
Union River	1	0	1	0	0	0	0	0	2
Narraguagus River <sup>2</sup>	0	13	1	8	0	0	0	1	23
Pleasant River	0	1	0	2	0	0	0	0	3
Machias River									Unknown
East Machias River									Unknown
Dennys River	1	0	1	0	0	0	0	0	2
St. Croix River	10	0	10	0	0	0	0	0	20
Kennebec River									Unknown
Androscoggin River	0	0	3	0	0	0	0	0	3
Sheepscot River									Unknown
Ducktrap River									Unknown
Saco River	31	0	14	4	0	0	0	0	49
Cochecho River	0	0	0	2	0	0	0	0	2
Lamprey River	0	2	0	2	0	0	0	0	4
Merrimack River	26	1	32	23	0	0	0	0	82
Pawcatuck River	0	0	1	0	0	0	0	0	1
Connecticut River	0	1	0	76	0	0	0	0	77
<b>TOTAL</b>	<b>235</b>	<b>35</b>	<b>328</b>	<b>187</b>	<b>0</b>	<b>0</b>	<b>15</b>	<b>3</b>	<b>803</b>

<sup>2</sup> Includes origins and ages determined from scale sample reading, observations of fin deformities, marks, and/or tags on fish. The remaining ages and origins are pro-rated based upon distributions for randomly selected sample days at ASC trapping facilities.

**TABLE 2.3.4. SUMMARY OF ATLANTIC SALMON EGG PRODUCTION IN NEW ENGLAND FACILITIES IN 2000. <sup>1</sup>**

SOURCE RIVER	ORIGIN	FEMALES SPAWNED	TOTAL EGG PRODUCTION	NO. OF EGGS PER FEMALE
Penobscot River	Sea-run	196	1,558,900	7,954
Merrimack River	Sea-run	38	310,800	8,179
Pawcatuck River	Sea-run	0	0	0
Connecticut River	Sea-run	49	300,000	6,122
<b>TOTAL SEA-RUN</b>		<b>283</b>	<b>2,169,700</b>	<b>7,667</b>
Penobscot River	Domestic	540	1,334,000	2,470
Merrimack River	Domestic	596	2,624,700	4,404
Connecticut River	Domestic	2,471	12,200,000	4,937
Dennys River	Captive <sup>2</sup>	64	282,900	4,420
East Machias River	Captive	68	394,000	5,794
Sheepscot River	Captive	60	246,100	4,102
Machias River	Captive	110	416,800	3,789
Narraguagus River	Captive	137	431,700	3,151
<b>TOTAL CAPTIVE/DOMESTIC</b>		<b>4,046</b>	<b>17,930,200</b>	<b>4,432</b>
Merrimack River	Kelt	62	747,600	12,058
Connecticut River	Kelt	142	1,350,000	9,507
Pawcatuck River	Kelt	5	43,200	8,640
<b>TOTAL KELT</b>		<b>209</b>	<b>2,140,800</b>	<b>10,243</b>
<b>GRAND TOTAL</b>		<b>4,538</b>	<b>22,240,700</b>	<b>4,901</b>

<sup>1</sup> Egg production rounded to nearest 100 eggs.

<sup>2</sup> Captive refers to adults produced from wild parr that were captured and reared to maturity in the hatchery.

**Table 2.3.5. ESTIMATED 2000 SPORT CATCH OF ATLANTIC SALMON IN MAINE.**

RIVER	TOTAL HARVEST	EST. NO. RELEASED	TOTAL ANGLED 2000	TOTAL ANGLED 1999
St. Croix	Fishery is closed effective 12/99		0	0
Dennys	Fishery is closed effective 12/99		0	3
East Machias	Fishery is closed effective 12/99		0	1
Machias	Fishery is closed effective 12/99		0	0
Pleasant	Fishery is closed effective 12/99		0	0
Narraguagus	Fishery is closed effective 12/99		0	8
Union	Fishery is closed effective 12/99		0	0
Penobscot	Fishery is closed effective 12/99		0	200
Ducktrap	Fishery is closed effective 12/99		0	0
Sheepscot	Fishery is closed effective 12/99		0	0
Kennebec	Fishery is closed effective 12/99		0	0
Saco	Fishery is closed effective 12/99		0	0
Aroostook	Fishery is closed effective 12/99		0	0
Misc.	Fishery is closed effective 12/99		0	0
<b>TOTAL</b>			<b>0</b>	<b>212</b>

**TABLE 3.2.a. ATLANTIC SALMON STOCKING SUMMARY FOR NEW ENGLAND BY RIVER.**

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

RIVER / YEAR	NUMBER OF FISH STOCKED BY LIFESTAGE						TOTAL
	FRY	0+PARR	1PARR	1+PARR	1SMOLT	2SMOLT	
<b>UPPER ST. JOHN</b>							
Total, 1979-1985	0	2,100	0	0	0	2,700	4,800
1986	0	0	0	0	0	0	0
1987	306,000	60,000	0	0	0	0	366,000
1988	128,000	779,400	4,800	0	0	0	912,200
1989	66,000	0	0	0	0	10,300	76,300
1990	110,000	21,000	9,900	0	0	9,600	150,500
1991	228,000	139,300	0	0	5,100	5,100	377,500
1992	400,000	136,100	0	0	0	0	536,100
1993	361,000	102,800	0	0	0	0	463,800
1994	566,000	216,000	0	0	0	0	782,000
1995	0	0	0	0	0	0	0
1996	0	0	0	0	0	0	0
1997	0	0	0	0	0	0	0
1998	0	0	0	0	0	0	0
1999	0	0	0	0	0	0	0
2000	0	0	0	0	0	0	0
Total, 1986-2000	2,165,000	1,454,600	14,700	0	5,100	25,000	3,664,400
<b>GRAND TOTAL</b>	<b>2,165,000</b>	<b>1,456,700</b>	<b>14,700</b>	<b>0</b>	<b>5,100</b>	<b>27,700</b>	<b>3,669,200</b>

<b>AROOSTOOK</b>							
Total, 1978-1985	0	28,300	20,400	0	5,200	2,600	56,500
1986	84,000	0	0	1,800	0	0	85,800
1987	41,000	0	0	0	0	0	41,000
1988	43,000	0	0	0	0	0	43,000
1989	313,000	242,200	0	0	0	10,000	565,200
1990	69,000	0	0	0	27,400	7,600	104,000
1991	74,000	46,600	0	0	0	9,600	130,200
1992	0	0	16,400	0	0	0	16,400
1993	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0
1995	4,000	0	0	0	0	0	4,000
1996	0	0	0	0	0	0	0
1997	578,000	0	0	0	0	0	578,000
1998	142,000	0	0	0	0	0	142,000
1999	163,000	0	0	0	0	0	163,000
2000	0	0	0	0	0	0	0
Total, 1986-2000	1,511,000	288,800	16,400	1,800	27,400	27,200	1,872,600
<b>GRAND TOTAL</b>	<b>1,511,000</b>	<b>317,100</b>	<b>36,800</b>	<b>1,800</b>	<b>32,600</b>	<b>29,800</b>	<b>1,929,100</b>

NUMBER OF FISH STOCKED BY LIFESTAGE							
RIVER / YEAR	FRY	0+PARR	1PARR	1+PARR	1SMOLT	2SMOLT	TOTAL
<b>ST. CROIX</b>							
Total, 1981-1985	333,000	67,300	102,200	0	192,000	20,100	714,600
1986	193,000	0	0	0	73,500	0	266,500
1987	255,000	0	41,000	0	59,800	0	355,800
1988	0	0	0	0	78,700	0	78,700
1989	0	0	0	0	50,600	0	50,600
1990	255,000	0	0	0	65,800	0	320,800
1991	51,000	40,000	0	0	60,200	0	151,200
1992	85,000	56,500	14,900	0	50,300	0	206,700
1993	0	101,000	0	0	40,100	0	141,100
1994	87,000	38,600	0	0	60,600	0	186,200
1995	1,000	0	0	0	0	0	1,000
1996	0	52,100	0	0	15,600	0	67,700
1997	1,000	400	0	0	0	0	1,400
1998	2,000	31,700	0	200	0	0	33,900
1999	1,000	22,500	0	0	21,300	0	44,800
2000	1,000	0	0	0	0	0	0
Total, 1986-2000	932,000	342,800	55,900	200	576,500	0	1,906,400
<b>GRAND TOTAL</b>	<b>1,265,000</b>	<b>410,100</b>	<b>158,100</b>	<b>200</b>	<b>768,500</b>	<b>20,100</b>	<b>2,621,000</b>
<b>DENNYS</b>							
Total, 1975-1985	20,000	0	3,000	0	53,400	28,300	104,700
1986	0	8,300	0	0	5,400	0	13,700
1987	24,000	0	0	0	9,000	0	33,000
1988	30,000	0	0	0	25,700	0	55,700
1989	12,000	0	0	0	12,100	0	24,100
1990	20,000	0	0	0	25,800	0	45,800
1991	25,000	0	400	0	11,700	0	37,100
1992	0	0	0	0	0	0	0
1993	33,000	0	0	0	0	0	33,000
1994	20,000	0	0	0	0	0	20,000
1995	84,000	0	0	0	0	0	84,000
1996	142,000	0	0	0	0	900	142,900
1997	192,000	0	0	0	0	0	192,000
1998	233,000	10,400	0	0	9,600	0	253,000
1999	172,000	3,000	0	0	0	0	175,000
2000	96,000	30,500	0	0	0	0	126,500
Total, 1986-2000	1,083,000	52,200	400	0	99,300	900	1,235,800
<b>GRAND TOTAL</b>	<b>1,103,000</b>	<b>52,200</b>	<b>3,400</b>	<b>0</b>	<b>152,700</b>	<b>29,200</b>	<b>1,340,500</b>

NUMBER OF FISH STOCKED BY LIFESTAGE							
RIVER / YEAR	FRY	0+PARR	1PARR	1+PARR	1SMOLT	2SMOLT	TOTAL
<b>PLEASANT</b>							
Total, 1975-1985	33,000	0	0	0	12,400	18,100	63,500
1986	25,000	0	0	0	6,500	0	31,500
1987	25,000	0	0	0	7,500	0	32,500
1988	25,000	0	1,800	0	10,500	0	37,300
1989	26,000	2,500	0	0	7,300	0	35,800
1990	30,000	0	0	0	10,500	0	40,500
1991	23,000	0	0	0	0	0	23,000
1992	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0
1995	0	0	0	0	0	0	0
1996	0	0	0	0	0	0	0
1997	0	0	0	0	0	0	0
1998	0	0	0	0	0	0	0
1999	0	0	0	0	0	0	0
2000	0	0	0	0	0	0	0
Total, 1986-1999	154,000	2,500	1,800	0	42,300	0	200,600
<b>GRAND TOTAL</b>	<b>187,000</b>	<b>2,500</b>	<b>1,800</b>	<b>0</b>	<b>54,700</b>	<b>18,100</b>	<b>264,100</b>
<b>EAST MACHIAS</b>							
Total, 1973-1985	13,000	0	8,700	0	21,900	30,400	74,000
1986	8,000	0	0	0	5,300	0	13,300
1987	10,000	0	0	0	9,000	0	19,000
1988	10,000	0	7,500	0	20,700	0	38,200
1989	30,000	6,500	8,000	0	15,300	0	59,800
1990	42,000	0	10,100	0	10,100	0	62,200
1991	27,000	0	8,300	0	15,300	0	50,600
1992	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0
1995	0	0	0	0	0	0	0
1996	115,000	0	0	0	0	0	115,000
1997	113,000	0	0	0	0	0	113,000
1998	190,000	0	0	0	10,800	0	200,800
1999	210,000	1,000	0	0	0	0	211,000
2000	197,000	0	0	0	0	0	197,000
Total, 1986-2000	952,000	7,500	33,900	0	86,500	0	1,079,900
<b>GRAND TOTAL</b>	<b>965,000</b>	<b>7,500</b>	<b>42,600</b>	<b>0</b>	<b>108,400</b>	<b>30,400</b>	<b>1,153,900</b>

NUMBER OF FISH STOCKED BY LIFESTAGE							
RIVER / YEAR	FRY	0+PARR	1PARR	1+PARR	1SMOLT	2SMOLT	TOTAL
<b>MACHIAS</b>							
Total, 1970-1985	0	12,500	7,000	0	65,700	42,200	127,400
1986	8,000	8,000	0	0	0	0	16,000
1987	0	12,500	12,300	0	13,600	0	38,400
1988	30,000	0	31,500	0	30,900	0	92,400
1989	49,000	13,800	28,000	0	23,100	0	113,900
1990	75,000	10,100	17,600	0	26,100	0	128,800
1991	13,000	30,000	21,400	0	21,100	0	85,500
1992	14,000	0	0	0	0	0	14,000
1993	0	0	0	0	0	0	0
1994	50,000	0	0	0	0	0	50,000
1995	150,000	0	0	0	0	0	150,000
1996	233,000	0	0	0	0	1,900	234,900
1997	236,000	0	0	0	0	0	236,000
1998	300,000	5,900	0	0	10,800	0	316,700
1999	169,000	1,000	0	0	0	0	170,000
2000	209,000	0	0	0	0	0	209,000
Total, 1986-2000	1,536,000	81,300	110,800	0	125,600	1,900	1,855,600
<b>GRAND TOTAL</b>	<b>1,536,000</b>	<b>93,800</b>	<b>117,800</b>	<b>0</b>	<b>191,300</b>	<b>44,100</b>	<b>1,983,000</b>
<b>NARRAGUAGUS</b>							
Total, 1970-1985	10,000	7,800	0	0	19,800	79,100	116,700
1986	0	0	0	0	7,500	0	7,500
1987	15,000	0	0	0	9,000	0	24,000
1988	20,000	13,000	5,600	0	15,700	0	54,300
1989	29,000	9,500	7,000	0	22,100	4,900	72,500
1990	0	0	0	0	16,800	0	16,800
1991	0	0	0	0	15,200	0	15,200
1992	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0
1995	105,000	0	0	0	0	0	105,000
1996	196,000	0	0	0	0	0	196,000
1997	207,000	0	2,000	0	700	0	209,700
1998	274,000	14,400	0	0	0	0	288,400
1999	155,000	18,200	0	0	1,000	0	174,200
2000	252,000	0	0	0	0	0	252,000
Total, 1986-2000	1,253,000	55,100	14,600	0	88,000	4,900	1,415,600
<b>GRAND TOTAL</b>	<b>1,263,000</b>	<b>62,900</b>	<b>14,600</b>	<b>0</b>	<b>107,800</b>	<b>84,000</b>	<b>1,532,300</b>

NUMBER OF FISH STOCKED BY LIFESTAGE							
RIVER / YEAR	FRY	0+PARR	1PARR	1+PARR	1SMOLT	2SMOLT	TOTAL
<b>UNION</b>							
Total, 1971-1984	7,000	0	0	0	219,800	251,000	477,800
1986	7,000	0	0	0	48,400	0	55,400
1987	7,000	0	0	0	40,100	0	47,100
1988	0	0	0	0	30,600	0	30,600
1989	0	0	0	0	20,400	0	20,400
1990	0	0	0	0	20,400	0	20,400
1991	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0
1993	60,000	111,700	0	0	0	0	171,700
1994	0	0	0	0	0	0	0
1995	0	54,800	0	0	0	0	54,800
1996	0	53,500	0	0	0	0	53,500
1997	12,000	69,300	0	0	0	0	81,300
1998	165,000	0	0	0	0	0	165,000
1999	165,000	82,100	0	0	0	0	247,100
2000	0	0	0	0	0	0	0
Total, 1986-2000	416,000	371,400	0	0	159,900	0	947,300
<b>GRAND TOTAL</b>	<b>423,000</b>	<b>371,400</b>	<b>0</b>	<b>0</b>	<b>379,700</b>	<b>251,000</b>	<b>1,425,100</b>
<b>PENOBSCOT</b>							
Total, 1971-1985	754,000	135,700	550,100	9,100	1,658,800	2,061,000	5,168,700
1986	226,000	25,700	58,600	0	520,200	69,000	899,500
1987	333,000	58,100	101,100	0	456,800	82,400	1,031,400
1988	431,000	0	51,400	0	599,900	87,100	1,169,400
1989	77,000	104,100	179,600	0	351,300	65,300	777,300
1990	317,000	166,500	155,300	0	413,200	15,900	1,067,900
1991	398,000	202,600	104,100	0	657,800	15,000	1,377,500
1992	925,000	278,200	106,600	0	816,600	8,100	2,134,500
1993	1,320,000	202,300	9,600	0	580,400	0	2,112,300
1994	949,000	0	2,400	0	567,600	0	1,519,000
1995	502,000	325,000	5,600	0	568,400	0	1,401,000
1996	1,242,000	226,000	17,500	0	552,200	0	2,037,700
1997	1,469,000	310,900	4,200	0	580,200	0	2,364,300
1998	930,000	337,400	13,400	0	571,800	0	1,852,600
1999	1,498,000	229,600	1,500	0	567,300	0	2,296,400
2000	513,000	288,800	700	0	563,200	0	1,365,700
Total, 1986-2000	11,130,000	2,755,200	811,600	0	8,366,900	342,800	23,406,500
<b>GRAND TOTAL</b>	<b>11,884,000</b>	<b>2,890,900</b>	<b>1,361,700</b>	<b>9,100</b>	<b>10,025,700</b>	<b>2,403,800</b>	<b>28,575,200</b>

RIVER / YEAR	NUMBER OF FISH STOCKED BY LIFESTAGE						TOTAL
	FRY	0+PARR	1PARR	1+PARR	1SMOLT	2SMOLT	
<b>DUCKTRAP</b>							
1986	8,000	0	0	0	0	0	8,000
1987	15,000	0	0	0	0	0	15,000
1988	10,000	0	0	0	0	0	10,000
1989	17,000	0	0	0	0	0	17,000
1990	18,000	0	0	0	0	0	18,000
1991	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0
1995	0	0	0	0	0	0	0
1996	0	0	0	0	0	0	0
1997	0	0	0	0	0	0	0
1998	0	0	0	0	0	0	0
1999	0	0	0	0	0	0	0
2000	0	0	0	0	0	0	0
Total, 1986-2000	68,000	0	0	0	0	0	68,000
<b>GRAND TOTAL</b>	<b>68,000</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>68,000</b>
<b>SHEEPSCOT</b>							
Total, 1971-1985	20,000	0	0	0	23,400	7,100	50,500
1986	10,000	11,600	0	0	7,500	0	29,100
1987	15,000	8,200	0	0	9,000	0	32,200
1988	40,000	12,300	0	0	10,200	0	62,500
1989	29,000	13,600	10,000	0	10,200	0	62,800
1990	27,000	10,100	10,000	0	17,500	0	64,600
1991	18,000	15,000	600	0	14,400	0	48,000
1992	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0
1995	0	0	0	0	0	0	0
1996	102,000	0	0	0	0	0	102,000
1997	64,000	0	0	0	0	0	64,000
1998	256,000	9,300	0	0	0	0	265,300
1999	302,000	4,700	0	0	0	0	306,700
2000	211,000	0	0	0	0	0	211,000
Total, 1986-2000	1,074,000	84,800	20,600	0	68,800	0	1,248,200
<b>GRAND TOTAL</b>	<b>1,094,000</b>	<b>84,800</b>	<b>20,600</b>	<b>0</b>	<b>92,200</b>	<b>7,100</b>	<b>1,298,700</b>

NUMBER OF FISH STOCKED BY LIFESTAGE							
RIVER / YEAR	FRY	0+PARR	1PARR	1+PARR	1SMOLT	2SMOLT	TOTAL
<b>SACO</b>							
Total, 1975-1985	0	47,100	23,600	0	30,500	9,500	110,700
1986	0	0	10,000	0	35,200	0	45,200
1987	0	0	69,800	0	22,000	0	91,800
1988	47,000	0	0	0	25,100	0	72,100
1989	0	37,800	49,600	0	9,900	0	97,300
1990	0	30,100	47,800	0	10,600	0	88,500
1991	111,000	0	0	0	10,300	0	121,300
1992	154,000	50,200	400	0	19,800	0	224,400
1993	167,000	0	0	0	20,100	0	187,100
1994	190,000	0	0	0	20,000	0	210,000
1995	376,000	0	0	0	19,700	0	395,700
1996	0	45,000	0	0	20,000	0	65,000
1997	97,000	63,300	0	0	20,200	0	180,500
1998	429,000	50,000	0	0	21,300	0	500,300
1999	688,000	47,000	0	0	20,100	0	755,100
2000	599,000	48,200	0	0	22,600	0	669,800
Total, 1986-2000	2,858,000	371,600	177,600	0	296,900	0	3,704,100
<b>GRAND TOTAL</b>	<b>2,858,000</b>	<b>418,700</b>	<b>201,200</b>	<b>0</b>	<b>327,400</b>	<b>9,500</b>	<b>3,814,800</b>
<b>COCHECO</b>							
1988	2,000	0	0	0	0	0	2,000
1989	106,000	0	0	0	0	0	106,000
1990	32,000	50,000	9,500	0	0	0	91,500
1991	138,000	0	0	0	0	0	138,000
1992	128,000	0	0	0	0	0	128,000
1993	127,000	0	0	1,000	0	0	128,000
1994	149,000	0	0	0	5,300	0	154,300
1995	114,000	0	0	0	0	0	114,000
1996	126,000	0	0	0	0	0	126,000
1997	128,000	0	0	0	0	0	128,000
1998	96,000	0	0	0	0	0	96,000
1999	157,000	0	0	0	0	0	157,000
2000	146,000	0	0	0	0	0	146,000
Total, 1988-2000	1,449,000	50,000	9,500	1,000	5,300	0	1,514,800
<b>GRAND TOTAL</b>	<b>1,449,000</b>	<b>50,000</b>	<b>9,500</b>	<b>1,000</b>	<b>5,300</b>	<b>0</b>	<b>1,514,800</b>

NUMBER OF FISH STOCKED BY LIFESTAGE							
RIVER / YEAR	FRY	0+PARR	1PARR	1+PARR	1SMOLT	2SMOLT	TOTAL
<b>LAMPREY</b>							
Total, 1978-1985	0	0	0	0	118,300	32,800	151,100
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	146,000	0	0	0	0	0	146,000
1990	50,000	87,000	11,400	0	0	0	148,400
1991	110,000	68,200	0	0	0	0	178,200
1992	127,000	12,700	0	0	0	0	139,700
1993	68,000	56,500	28,800	1,100	15,000	0	169,400
1994	98,000	56,300	7,800	0	0	0	162,100
1995	91,000	57,100	0	0	4,800	0	152,900
1996	115,000	37,000	8,400	1,000	0	0	161,400
1997	141,000	52,900	0	0	0	0	193,900
1998	95,000	0	0	0	3,300	0	98,300
1999	127,000	0	0	0	0	0	127,000
2000	104,000	0	0	0	0	0	104,000
Total, 1986-2000	1,272,000	427,700	56,400	2,100	23,100	0	1,781,300
<b>GRAND TOTAL</b>	<b>1,272,000</b>	<b>427,700</b>	<b>56,400</b>	<b>2,100</b>	<b>141,400</b>	<b>32,800</b>	<b>1,932,400</b>
<b>MERRIMACK</b>							
Total, 1976-1985	1,233,000	162,500	44,100	127,600	182,000	508,300	2,257,500
1986	525,000	0	31,500	0	39,900	64,100	660,500
1987	1,078,000	0	99,300	0	141,600	0	1,318,900
1988	1,718,000	0	129,600	0	94,400	0	1,942,000
1989	1,034,000	60,000	88,600	0	58,600	0	1,241,200
1990	975,000	0	5,600	29,700	116,900	0	1,127,200
1991	1,458,000	0	0	0	62,000	58,100	1,578,100
1992	1,118,000	0	100	0	96,400	0	1,214,500
1993	1,157,000	0	0	0	59,000	0	1,216,000
1994	2,816,000	0	0	0	85,000	0	2,901,000
1995	2,827,000	0	12,700	0	70,800	0	2,910,500
1996	1,795,000	0	0	4,900	50,000	0	1,849,900
1997	1,977,000	5,000	4,700	5,300	52,500	5,400	2,049,900
1998	2,589,000	0	0	6,800	51,900	0	2,647,700
1999	1,756,013	0	0	4,350	56,407	0	1,816,770
2000	2,217,000	0	0	0	52,500	0	2,269,500
Total, 1986-2000	25,040,013	65,000	372,100	51,050	1,087,907	127,600	26,743,670
<b>GRAND TOTAL</b>	<b>26,273,013</b>	<b>227,500</b>	<b>416,200</b>	<b>178,650</b>	<b>1,269,907</b>	<b>635,900</b>	<b>29,001,170</b>

NUMBER OF FISH STOCKED BY LIFESTAGE							
RIVER / YEAR	FRY	0+PARR	1PARR	1+PARR	1SMOLT	2SMOLT	TOTAL
<b>PAWCATUCK</b>							
Total, 1979-1985	10,000	214,700	109,400	0	800	0	334,900
1986	0	50,700	15,000	0	0	0	65,700
1987	3,000	46,200	4,700	0	1,000	0	54,900
1988	150,000	59,600	7,100	0	5,400	0	222,100
1989	0	379,900	35,800	0	6,500	0	422,200
1990	0	83,500	55,000	0	7,500	0	146,000
1991	0	101,000	1,000	0	2,000	500	104,500
1992	0	70,800	2,500	0	5,000	0	78,300
1993	383,000	14,500	4,000	0	2,300	0	403,800
1994	557,000	0	0	0	0	0	557,000
1995	367,000	52,200	0	0	0	0	419,200
1996	289,000	136,100	0	0	5,000	0	430,100
1997	100,000	0	14,000	0	11,500	0	125,500
1998	910,000	0	6,100	8,600	5,700	0	930,400
1999	591,000	0	0	0	3,900	0	594,900
2000	326,000	0	0	0	0	0	326,000
Total, 1986-2000	3,676,000	994,500	145,200	8,600	55,800	500	4,880,600
<b>GRAND TOTAL</b>	<b>3,686,000</b>	<b>1,209,200</b>	<b>254,600</b>	<b>8,600</b>	<b>56,600</b>	<b>500</b>	<b>5,215,500</b>
<b>CONNECTICUT</b>							
Total, 1967-1985	2,410,000	646,600	702,200	218,700	721,700	963,200	5,662,400
1986	176,000	188,400	267,100	0	290,500	0	922,000
1987	1,180,000	383,200	345,100	0	206,000	0	2,114,300
1988	1,310,000	72,200	75,200	0	395,300	0	1,852,700
1989	1,243,000	268,700	76,800	0	217,700	0	1,806,200
1990	1,271,000	341,600	25,400	0	475,900	0	2,113,900
1991	1,725,000	306,200	33,100	0	351,000	0	2,415,300
1992	2,009,000	313,900	11,500	0	313,300	0	2,647,700
1993	4,147,000	237,100	28,700	0	382,800	0	4,795,600
1994	5,979,000	37,000	2,300	12,900	375,100	0	6,406,300
1995	6,818,000	4,500	0	0	1,300	0	6,823,800
1996	6,675,000	12,400	0	3,600	11,500	0	6,702,500
1997	8,526,000	8,800	0	0	1,400	0	8,536,200
1998	9,119,000	3,000	0	7,700	1,700	0	9,131,400
1999	6,428,000	1,000	0	0	22,600	0	6,451,600
2000	9,288,000	600	0	0	700	48,200	9,337,500
Total, 1986-2000	65,894,000	2,178,600	865,200	24,200	3,046,800	48,200	72,057,000
<b>GRAND TOTAL</b>	<b>68,304,000</b>	<b>2,825,200</b>	<b>1,567,400</b>	<b>242,900</b>	<b>3,768,500</b>	<b>1,011,400</b>	<b>77,719,400</b>

RIVER / YEAR	NUMBER OF FISH STOCKED BY LIFESTAGE						TOTAL
	FRY	0+PARR	1PARR	1+PARR	1SMOLT	2SMOLT	
<b>GRAND TOTAL BY RIVER</b>							
Upper St. John	2,165,000	1,456,700	14,700	0	5,100	27,700	3,669,200
Aroostook	1,511,000	317,100	36,800	1,800	32,600	29,800	1,929,100
St. Croix	1,265,000	410,100	158,100	200	768,500	20,100	2,621,000
Dennys	1,103,000	52,200	3,400	0	152,700	29,200	1,340,500
Pleasant	187,000	2,500	1,800	0	54,700	18,100	264,100
East Machias	965,000	7,500	42,600	0	108,400	30,400	1,153,900
Machias	1,536,000	93,800	117,800	0	191,300	44,100	1,983,000
Narraguagus	1,263,000	62,900	14,600	0	107,800	84,000	1,532,300
Union	423,000	371,400	0	0	379,700	251,000	1,425,100
Penobscot	11,884,000	2,890,900	1,361,700	9,100	10,025,700	2,403,800	28,575,200
Ducktrap	68,000	0	0	0	0	0	68,000
Sheepscot	1,094,000	84,800	20,600	0	92,200	7,100	1,298,700
Saco	2,858,000	418,700	201,200	0	327,400	9,500	3,814,800
Cochecho	1,449,000	50,000	9,500	1,000	5,300	0	1,514,800
Lamprey	1,272,000	427,700	56,400	2,100	141,400	32,800	1,932,400
Merrimack	26,273,013	227,500	416,200	178,650	1,269,907	635,900	29,001,170
Pawcatuck	3,686,000	1,209,200	254,600	8,600	56,600	500	5,215,500
Connecticut	68,304,000	2,825,200	1,567,400	242,900	3,768,500	1,011,400	77,719,400
<b>SUMMARY TOTALS</b>	<b>127,306,013</b>	<b>10,908,200</b>	<b>4,277,400</b>	<b>444,350</b>	<b>17,487,807</b>	<b>4,635,400</b>	<b>165,058,170</b>
Note: River summaries vary by time-series length.							

**TABLE 3.2.b. DOCUMENTED ATLANTIC SALMON RETURNS TO NEW ENGLAND RIVERS**

Documented returns include only trap and rod caught salmon. The number of returns are unknown where shaded.

Returns from juveniles of hatchery origin include 0+Parr, 1Parr, 1+Parr, 1Smolt, and 2Smolt releases.

Returns of wild origin include adults produced from natural reproduction and adults produced from fry releases.

RIVER	YEAR	HATCHERY ORIGIN				WILD ORIGIN				TOTAL
		1-S-W	2-S-W	3-S-W	REPEAT	1-S-W	2-S-W	3-S-W	REPEAT	
<b>PENOBSCOT</b>										
	Total, 1967-1985	2,947	19,541	121	251	68	563	9	8	23,508
	1986	534	3,620	14	8	17	332	3	1	4,529
	1987	749	1,477	29	49	19	162	5	20	2,510
	1988	716	1,993	6	52	14	64	0	10	2,855
	1989	867	2,005	4	36	67	103	1	4	3,087
	1990	430	2,520	14	26	93	254	3	2	3,342
	1991	176	1,085	4	21	40	427	0	4	1,757
	1992	932	1,174	0	5	27	236	1	4	2,379
	1993	349	1,279	7	13	22	92	1	6	1,769
	1994	265	630	2	5	48	93	0	6	1,049
	1995	158	1,077	7	9	6	84	0	1	1,342
	1996	482	1,187	6	14	13	335	3	5	2,045
	1997	241	914	4	13	6	174	2	1	1,355
	1998	240	796	0	10	29	130	1	4	1,210
	1999	225	568	0	9	46	110	0	10	968
	2000	166	265	0	15	17	70	0	2	535
	Total, 1986-2000	6,530	20,590	97	285	464	2,666	20	80	30,732
	<b>GRAND TOTAL</b>	<b>9,477</b>	<b>40,131</b>	<b>218</b>	<b>536</b>	<b>532</b>	<b>3,229</b>	<b>29</b>	<b>88</b>	<b>54,240</b>

**UNION**

	Total, 1973-1985	258	1,537	7	23	0	4	0	0	1,829
	1986	7	59	1	0	0	0	0	0	67
	1987	19	43	0	1	0	0	0	0	63
	1988	0	45	0	0	0	2	0	0	47
	1989	4	25	1	0	0	0	0	0	30
	1990	1	20	0	0	0	0	0	0	21
	1991	1	1	0	0	1	5	0	0	8
	1992	0	4	0	0	0	0	0	0	4
	1993	0	0	0	0	0	0	0	0	0
	1994									
	1995									
	1996	6	62	0	0	0	1	0	0	69
	1997	0	8	0	0	0	0	0	0	8
	1998	2	7	0	4	0	0	0	0	13
	1999	3	3	0	0	0	3	0	0	9
	2000	1	1	0	0	0	0	0	0	2
	Total, 1986-2000	44	278	2	5	1	11	0	0	341
	<b>GRAND TOTAL</b>	<b>302</b>	<b>1,815</b>	<b>9</b>	<b>28</b>	<b>1</b>	<b>15</b>	<b>0</b>	<b>0</b>	<b>2,170</b>

RIVER	YEAR	HATCHERY ORIGIN				WILD ORIGIN				TOTAL
		1-S-W	2-S-W	3-S-W	REPEAT	1-S-W	2-S-W	3-S-W	REPEAT	
<b>NARRAGUAGUS</b>										
	Total, 1967-1985	75	510	19	42	17	1,852	68	113	2,696
	1986	0	20	0	0	2	23	0	0	45
	1987	0	11	0	0	0	24	0	2	37
	1988	1	10	0	0	2	24	0	1	38
	1989	3	9	0	0	1	26	0	0	39
	1990	1	22	0	0	0	27	0	1	51
	1991	3	19	0	5	8	53	0	7	95
	1992	6	19	0	1	11	32	0	4	73
	1993	0	16	0	4	6	66	0	2	94
	1994	1	0	0	0	4	42	0	4	51
	1995	0	0	0	0	0	51	0	5	56
	1996	1	7	0	0	9	42	0	5	64
	1997	0	2	0	0	1	30	0	4	37
	1998	0	0	0	0	1	18	0	3	22
	1999	0	2	0	0	6	23	0	1	32
	2000	0	1	0	0	13	8	0	1	23
	Total, 1986-2000	16	138	0	10	64	489	0	40	757
	<b>GRAND TOTAL</b>	<b>91</b>	<b>648</b>	<b>19</b>	<b>52</b>	<b>81</b>	<b>2,341</b>	<b>68</b>	<b>153</b>	<b>3,453</b>

<b>PLEASANT</b>										
	Total, 1967-1985	5	8	0	0	10	189	2	2	216
	1986	0	0	0	0	0	19	0	0	19
	1987	0	4	0	0	0	5	0	0	9
	1988									
	1989	0	0	0	0	0	0	0	0	0
	1990	0	0	0	0	0	0	0	0	0
	1991	0	0	0	0	0	0	0	0	0
	1992	0	0	0	0	0	0	0	0	0
	1993	0	0	0	0	0	0	0	0	0
	1994	0	0	0	0	1	1	0	0	2
	1995									
	1996									
	1997	0	0	0	0	0	1	0	0	1
	1998									
	1999									
	2000	0	0	0	0	1	2	0	0	3
	Total, 1986-2000	0	4	0	0	2	28	0	0	34
	<b>GRAND TOTAL</b>	<b>5</b>	<b>12</b>	<b>0</b>	<b>0</b>	<b>12</b>	<b>217</b>	<b>2</b>	<b>2</b>	<b>250</b>

RIVER	YEAR	HATCHERY ORIGIN				WILD ORIGIN				TOTAL
		1-S-W	2-S-W	3-S-W	REPEAT	1-S-W	2-S-W	3-S-W	REPEAT	
<b>MACHIAS</b>										
	Total, 1967-1985	26	303	9	2	25	1,540	41	127	2,073
	1986	2	16	0	0	2	24	0	2	46
	1987	0	0	0	0	0	4	0	0	4
	1988	0	0	0	0	0	6	0	2	8
	1989	3	4	0	0	4	5	0	0	16
	1990	0	1	0	0	0	1	0	0	2
	1991	1	0	0	0	1	0	0	0	2
	1992	0	3	0	0	0	0	0	0	3
	1993	0	2	0	0	1	12	0	0	15
	1994									
	1995									
	1996									
	1997									
	1998									
	1999									
	2000									
	Total, 1986-2000	6	26	0	0	8	52	0	4	96
	<b>GRAND TOTAL</b>	<b>32</b>	<b>329</b>	<b>9</b>	<b>2</b>	<b>33</b>	<b>1,592</b>	<b>41</b>	<b>131</b>	<b>2,169</b>

<b>EAST MACHIAS</b>										
	Total, 1967-1985	6	181	1	2	9	288	0	8	495
	1986	0	5	0	0	0	8	0	0	13
	1987	0	8	0	0	0	5	1	0	14
	1988	1	8	0	0	0	5	0	0	14
	1989	12	10	0	0	2	6	0	1	31
	1990	1	30	0	0	0	16	0	1	48
	1991	1	2	0	0	1	1	0	0	5
	1992	0	6	0	0	0	0	0	0	6
	1993	0	0	0	0	0	0	0	0	0
	1994									
	1995									
	1996									
	1997									
	1998									
	1999									
	2000									
	Total, 1986-2000	15	69	0	0	3	41	1	2	131
	<b>GRAND TOTAL</b>	<b>21</b>	<b>250</b>	<b>1</b>	<b>2</b>	<b>12</b>	<b>329</b>	<b>1</b>	<b>10</b>	<b>626</b>

RIVER	YEAR	HATCHERY ORIGIN				WILD ORIGIN				TOTAL
		1-S-W	2-S-W	3-S-W	REPEAT	1-S-W	2-S-W	3-S-W	REPEAT	
<b>DENNYS</b>										
	Total, 1967-1985	10	249	0	0	18	673	3	10	963
	1986	0	7	0	0	0	8	0	0	15
	1987	0	0	0	0	0	1	0	0	1
	1988	0	3	0	0	0	6	0	0	9
	1989	1	10	0	0	0	1	0	0	12
	1990	1	20	0	1	0	11	0	0	33
	1991	1	0	0	0	0	6	0	0	7
	1992	1	3	0	0	0	1	0	0	5
	1993	7	2	0	0	0	4	0	0	13
	1994	0	0	0	0	1	5	0	0	6
	1995	0	0	0	0	0	5	0	0	5
	1996	0	0	0	0	3	7	0	0	10
	1997	0	0	0	0	0	0	0	0	0
	1998	0	0	0	0	0	1	0	0	1
	1999									
	2000	1	1	0	0	0	0	0	0	2
	Total, 1986-2000	12	46	0	1	4	56	0	0	119
	<b>GRAND TOTAL</b>	<b>22</b>	<b>295</b>	<b>0</b>	<b>1</b>	<b>22</b>	<b>729</b>	<b>3</b>	<b>10</b>	<b>1,082</b>

<b>ST. CROIX</b>										
	Total, 1981-1985	233	271	24	0	158	188	20	0	894
	1986	34	116	13	0	33	116	13	0	325
	1987	108	63	1	0	94	103	6	0	375
	1988	76	229	0	3	18	61	0	1	388
	1989	78	66	0	1	44	44	0	8	241
	1990	6	59	0	7	12	26	0	2	112
	1991	41	90	0	0	16	38	0	4	189
	1992	1	0	0	0	0	0	0	0	1
	1993	5	76	0	0	4	18	0	2	105
	1994	23	17	0	1	24	19	0	0	84
	1995	7	15	0	0	8	16	0	0	46
	1996	13	77	0	0	10	32	0	0	132
	1997	26	2	0	0	0	0	0	0	28
	1998	20	3	0	0	12	6	0	0	41
	1999	1	2	0	0	7	3	0	0	13
	2000	10	10	0	0	0	0	0	0	20
	Total, 1986-2000	449	825	14	12	282	482	19	17	2,100
	<b>GRAND TOTAL</b>	<b>682</b>	<b>1,096</b>	<b>38</b>	<b>12</b>	<b>440</b>	<b>670</b>	<b>39</b>	<b>17</b>	<b>2,994</b>

RIVER	YEAR	HATCHERY ORIGIN				WILD ORIGIN				TOTAL
		1-S-W	2-S-W	3-S-W	REPEAT	1-S-W	2-S-W	3-S-W	REPEAT	
<b>KENNEBEC</b>										
	Total, 1975-1985	6	109	4	0	0	3	0	0	122
	1986	0	0	0	0	0	0	0	0	0
	1987	0	2	1	0	0	2	0	0	5
	1988	4	15	0	1	0	0	0	0	20
	1989	1	16	0	0	0	0	0	0	17
	1990	1	41	0	0	0	4	0	0	46
	1991	0	4	0	0	0	0	0	0	4
	1992	0	0	0	0	0	0	0	0	0
	1993	0	2	0	0	0	0	0	0	2
	1994									
	1995									
	1996									
	1997									
	1998									
	1999									
	2000									
	Total, 1986-2000	6	80	1	1	0	6	0	0	94
	<b>GRAND TOTAL</b>	<b>12</b>	<b>189</b>	<b>5</b>	<b>1</b>	<b>0</b>	<b>9</b>	<b>0</b>	<b>0</b>	<b>216</b>

<b>ANDROSCOGGIN</b>										
	Total, 1983-1985	6	113	1	0	0	12	0	1	133
	1986	0	72	1	0	0	8	0	0	81
	1987	2	20	3	0	0	1	0	0	26
	1988	2	11	0	0	1	0	0	0	14
	1989	1	17	0	0	0	1	0	0	19
	1990	6	168	0	1	1	9	0	0	185
	1991	0	9	0	0	0	12	0	0	21
	1992	2	9	0	0	1	3	0	0	15
	1993	1	33	0	0	1	9	0	0	44
	1994	2	16	0	1	0	6	0	0	25
	1995	2	12	0	0	0	2	0	0	16
	1996	2	19	1	0	1	16	0	0	39
	1997	0	0	0	0	0	1	0	0	1
	1998	0	4	0	0	0	0	0	0	4
	1999	0	1	0	0	1	3	0	0	5
	2000	0	3	0	0	0	0	0	0	3
	Total, 1986-2000	20	394	5	2	6	71	0	0	498
	<b>GRAND TOTAL</b>	<b>26</b>	<b>507</b>	<b>6</b>	<b>2</b>	<b>6</b>	<b>83</b>	<b>0</b>	<b>1</b>	<b>631</b>

RIVER		HATCHERY ORIGIN				WILD ORIGIN				TOTAL
YEAR	1-S-W	2-S-W	3-S-W	REPEAT	1-S-W	2-S-W	3-S-W	REPEAT		
<b>SHEEPSCOT</b>										
Total, 1967-1985	0	0	0	0	22	298	9	0	329	
1986	0	0	0	0	1	10	0	0	11	
1987	2	7	0	0	1	5	0	0	15	
1988	1	0	0	0	0	0	0	0	1	
1989	1	1	0	0	2	1	0	0	5	
1990	1	8	0	0	0	0	0	0	9	
1991	0	4	0	0	0	0	0	0	4	
1992	1	2	0	0	1	2	1	0	7	
1993	0	9	0	0	0	0	0	0	9	
1994	0	5	0	0	3	12	0	0	20	
1995	0	2	0	0	0	22	0	0	24	
1996	0	0	0	0		8	0	0	8	
1997	0	0	0	0	0	0	0	0	0	
1998										
1999										
2000										
Total, 1986-2000	6	38	0	0	8	60	1	0	113	
<b>GRAND TOTAL</b>	<b>6</b>	<b>38</b>	<b>0</b>	<b>0</b>	<b>30</b>	<b>358</b>	<b>10</b>	<b>0</b>	<b>442</b>	

<b>DUCKTRAP</b>										
1985	0	0	0	0	0	15	0	0	15	
1986	0	0	0	0	3	12	0	0	15	
1987	0	0	0	0	0	0	0	0	0	
1988	0	0	0	0	0	0	0	0	0	
1989	0	0	0	0	0	0	0	0	0	
1990	0	0	0	0	0	3	0	0	3	
1991	0	0	0	0	0	0	0	0	0	
1992	0	0	0	0	0	0	0	0	0	
1993	0	0	0	0	0	0	0	0	0	
1994										
1995										
1996										
1997										
1998										
1999										
2000										
Total, 1986-2000	0	0	0	0	3	15	0	0	18	
<b>GRAND TOTAL</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>3</b>	<b>30</b>	<b>0</b>	<b>0</b>	<b>33</b>	

RIVER	YEAR	HATCHERY ORIGIN				WILD ORIGIN				TOTAL
		1-S-W	2-S-W	3-S-W	REPEAT	1-S-W	2-S-W	3-S-W	REPEAT	
<b>SACO</b>										
	Total, 1977-1985	2	58	0	0	0	0	0	0	60
	1986	0	36	1	0	0	0	0	0	37
	1987	4	34	1	0	0	1	0	0	40
	1988	1	37	0	0	0	0	0	0	38
	1989	2	16	0	1	0	0	0	0	19
	1990	4	68	0	0	0	1	0	0	73
	1991	0	4	0	0	0	0	0	0	4
	1992	0	0	0	0	0	0	0	0	0
	1993	4	54	0	1	0	0	0	0	59
	1994	6	17	0	0	0	0	0	0	23
	1995	0	34	0	0	0	0	0	0	34
	1996	11	39	1	3	0	0	0	0	54
	1997	5	23	0	0	0	0	0	0	28
	1998	9	7	0	0	4	7	1	0	28
	1999	10	11	0	0	12	31	2	0	66
	2000	31	14	0	0	0	4	0	0	49
	Total, 1986-2000	87	394	3	5	16	44	3	0	552
	<b>GRAND TOTAL</b>	<b>89</b>	<b>452</b>	<b>3</b>	<b>5</b>	<b>16</b>	<b>44</b>	<b>3</b>	<b>0</b>	<b>612</b>
<b>COCHECO</b>										
	1990									
	1991									
	1992	0	0	0	0	0	1	0	0	1
	1993	0	0	1	1	1	2	0	0	5
	1994	0	0	0	0	0	0	0	0	0
	1995	0	0	0	0	0	1	0	0	1
	1996	0	0	0	0	2	0	0	0	2
	1997	0	0	0	0	0	0	0	0	0
	1998	0	0	0	0	0	0	0	0	0
	1999	0	0	0	0	2	1	0	0	3
	2000	0	0	0	0	0	2	0	0	2
	Total, 1990-2000	0	0	1	1	5	7	0	0	14
	<b>GRAND TOTAL</b>	<b>0</b>	<b>0</b>	<b>1</b>	<b>1</b>	<b>5</b>	<b>7</b>	<b>0</b>	<b>0</b>	<b>14</b>

RIVER		HATCHERY ORIGIN				WILD ORIGIN				TOTAL
YEAR	1-S-W	2-S-W	3-S-W	REPEAT	1-S-W	2-S-W	3-S-W	REPEAT		
<b>LAMPREY</b>										
Total, 1979-1986	10	17	1	0	0	0	0	0	0	28
1986	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	2	0	0	0	2
1993	0	0	0	0	1	7	0	0	0	8
1994	0	0	0	0	0	3	0	0	0	3
1995	0	0	0	0	0	1	0	0	0	1
1996	0	0	0	0	0	1	0	0	0	1
1997	0	0	0	0	0	0	0	0	0	0
1998	0	0	0	0	0	0	0	0	0	0
1999	0	0	0	0	6	0	0	0	0	6
2000	0	0	0	0	2	2	0	0	0	4
Total, 1986-2000	0	0	0	0	9	16	0	0	0	25
<b>GRAND TOTAL</b>	<b>10</b>	<b>17</b>	<b>1</b>	<b>0</b>	<b>9</b>	<b>16</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>53</b>

<b>MERRIMACK</b>										
Total, 1978-1985	82	200	6	0	26	140	11	0	0	465
1986	19	33	0	0	4	44	3	0	0	103
1987	8	94	4	0	2	26	5	0	0	139
1988	4	16	2	0	4	38	1	0	0	65
1989	3	24	1	0	0	55	1	0	0	84
1990	3	115	1	0	24	104	1	0	0	248
1991	1	76	0	0	0	254	1	0	0	332
1992	17	66	2	0	14	100	0	0	0	199
1993	0	27	1	1	2	30	0	0	0	61
1994	0	2	0	0	1	18	0	0	0	21
1995	2	18	0	0	0	14	0	0	0	34
1996	11	44	0	3	3	13	0	2	0	76
1997	9	43	0	4	9	5	0	1	0	71
1998	11	45	1	0	19	47	0	0	0	123
1999	46	65	1	0	9	64	0	0	0	185
2000	26	32	0	0	1	23	0	0	0	82
Total, 1986-2000	160	700	13	8	92	835	12	3	0	1,823
<b>GRAND TOTAL</b>	<b>242</b>	<b>900</b>	<b>19</b>	<b>8</b>	<b>118</b>	<b>975</b>	<b>23</b>	<b>3</b>	<b>0</b>	<b>2,288</b>

RIVER	YEAR	HATCHERY ORIGIN				WILD ORIGIN				TOTAL
		1-S-W	2-S-W	3-S-W	REPEAT	1-S-W	2-S-W	3-S-W	REPEAT	
<b>PAWCATUCK</b>										
	Total, 1981-1985	1	102	0	0	0	0	0	0	103
	1986	0	0	0	0	0	0	0	0	0
	1987	0	1	0	0	0	0	0	0	1
	1988	0	5	1	0	0	0	0	0	6
	1989	0	6	0	0	0	0	0	0	6
	1990	0	8	0	0	0	0	0	0	8
	1991	0	5	0	0	0	0	0	0	5
	1992	0	6	0	0	0	0	0	0	6
	1993	0	2	0	0	0	1	0	0	3
	1994	0	2	0	0	0	0	0	0	2
	1995	0	2	0	0	0	0	0	0	2
	1996	0	2	0	0	0	0	0	0	2
	1997	0	0	0	0	0	3	0	0	3
	1998	0	0	0	0	1	2	0	0	3
	1999	1	6	0	0	0	4	0	0	11
	2000	0	1	0	0	0	0	0	0	1
	Total, 1986-2000	1	46	1	0	1	10	0	0	59
	<b>GRAND TOTAL</b>	<b>2</b>	<b>148</b>	<b>1</b>	<b>0</b>	<b>1</b>	<b>10</b>	<b>0</b>	<b>0</b>	<b>162</b>

<b>CONNECTICUT</b>										
	Total, 1969-1985	27	1,284	21	0	2	45	0	0	1,379
	1986	0	275	0	0	0	43	0	0	318
	1987	0	343	5	0	0	0	5	0	353
	1988	1	93	0	0	0	1	0	0	95
	1989	1	58	0	0	1	48	1	0	109
	1990	1	226	0	0	0	36	0	0	263
	1991	0	168	1	0	0	34	0	0	203
	1992	3	353	1	0	5	127	1	0	490
	1993	0	136	0	0	0	61	1	0	198
	1994	1	263	0	1	0	61	0	0	326
	1995	1	158	0	0	0	29	0	0	188
	1996	0	143	0	0	5	111	0	1	260
	1997	0	0	0	1	6	191	1	0	199
	1998	0	0	0	0	10	288	0	2	300
	1999	0	0	0	0	11	142	0	1	154
	2000	0	0	0	0	1	76	0	0	77
	Total, 1986-2000	8	2,216	7	2	39	1,248	9	4	3,533
	<b>GRAND TOTAL</b>	<b>35</b>	<b>3,500</b>	<b>28</b>	<b>2</b>	<b>41</b>	<b>1,293</b>	<b>9</b>	<b>4</b>	<b>4,912</b>

RIVER	HATCHERY ORIGIN				WILD ORIGIN				TOTAL
	YEAR	1-S-W	2-S-W	3-S-W	REPEAT	1-S-W	2-S-W	3-S-W	
<b>GRAND TOTAL BY RIVER</b>									
PENOBSCOT	9,477	40,131	218	536	532	3,229	29	88	54,240
UNION	302	1,815	9	28	1	15	0	0	2,170
NARRAGUAGUS	91	648	19	52	81	2,341	68	153	3,453
PLEASANT	5	12	0	0	12	217	2	2	250
MACHIAS	32	329	9	2	33	1,592	41	131	2,169
E. MACHIAS	21	250	1	2	12	329	1	10	626
DENNYS	22	295	0	1	22	729	3	10	1,082
ST. CROIX	682	1,096	38	12	440	670	39	17	2,994
KENNEBEC	12	189	5	1	0	9	0	0	216
ANDROSCOGGIN	26	507	6	2	6	83	0	1	631
SHEEPSCOT	6	38	0	0	30	358	10	0	442
DUCKTRAP	0	0	0	0	3	30	0	0	33
SACO	89	452	3	5	16	44	3	0	612
COCHECO	0	0	1	1	5	7	0	0	14
LAMPREY	10	17	1	0	9	16	0	0	53
MERRIMACK	242	900	19	8	118	975	23	3	2,288
PAWCATUCK	2	148	1	0	1	10	0	0	162
CONNECTICUT	35	3,500	28	2	41	1,293	9	4	4,912
<b>TOTAL</b>	<b>11,054</b>	<b>50,327</b>	<b>358</b>	<b>652</b>	<b>1,362</b>	<b>11,947</b>	<b>228</b>	<b>419</b>	<b>76,347</b>

Note: Returns are presented beginning 2 years after first stocking efforts or from earliest available records. For the Penobscot, Narraguagus, Pleasant, Machias, East Machias, Dennys, and Sheepscoot, data are presented only since 1967.

**TABLE 3.2.c. SUMMARY OF ATLANTIC SALMON EGG PRODUCTION IN NEW ENGLAND FACILITIES. <sup>1</sup>**

Year	Sea-run			Domestic			Captive <sup>2</sup>			Kelt			Total		
	No. Females	Total Egg Production	Eggs/Female	No. Females	Total Egg Production	Eggs/Female	No. Females	Total Egg Production	Eggs/Female	No. Females	Total Egg Production	Eggs/Female	No. Females	Total Egg Production	Eggs/Female
<b>Cochecho</b>															
1993	3	21,400	7,133												
<b>Total</b>	<b>3</b>	<b>21,400</b>	<b>7,133</b>										<b>3</b>	<b>21,400</b>	<b>7,133</b>
<b>Connecticut</b>															
1977-85		2,499,800			2,755,300						1,826,900			7,082,000	
1986		842,000			2,670,000						88,000			3,600,000	
1987		1,318,900			1,668,600						696,200			3,683,700	
1988		280,000			3,124,000						887,000			4,291,000	
1989		89,600			3,502,500						551,400			4,143,500	
1990	129	1,105,900	8,573	426	2,664,600	6,255				57	498,500	8,746	612	4,269,000	6,975
1991	79	651,000	8,241	637	3,455,500	5,425				52	486,100	9,348	768	4,592,600	5,980
1992	236	1,890,800	8,012	650	3,924,800	6,038				96	1,013,000	10,552	982	6,828,600	6,954
1993	121	1,053,800	8,709	714	3,878,700	5,432				164	1,767,600	10,778	999	6,700,100	6,707
1994	151	1,223,800	8,105	1,094	7,550,800	6,902				208	2,427,700	11,672	1,453	11,202,300	7,710
1995	101	945,500	9,361	1,258	7,555,400	6,006				183	2,159,300	11,799	1,542	10,660,200	6,913
1996	115	938,300	8,159	1,732	11,844,900	6,839				206	2,221,200	10,783	2,053	15,004,400	7,309
1997	110	770,700	7,006	1,809	11,602,300	6,414				188	2,003,300	10,656	2,107	14,376,300	6,823
1998	185	1,452,500	7,851	1,140	7,029,500	6,166				156	1,493,500	9,574	1,481	9,975,500	6,736
1999	83	621,500	7,488	1,862	11,172,900	6,000				193	1,813,200	9,395	2,138	13,607,600	6,365
2000	49	300,000	6,122	2,471	12,200,000	4,937				142	1,350,000	9,507	2,662	13,850,000	5,203
1986-00	1,359	13,484,300	8,060	13,793	93,844,500	6,009				1,645	19,456,000	10,476	16,797	126,784,800	6,612
<b>Total</b>		<b>15,984,100</b>			<b>96,599,800</b>						<b>21,282,900</b>			<b>133,866,800</b>	





Year	Sea-run			Domestic			Captive <sup>2</sup>			Kelt			Total		
	No. Females	Total Egg Production	Eggs/ Female	No. Females	Total Egg Production	Eggs/ Female	No. Females	Total Egg Production	Eggs/ Female	No. Females	Total Egg Production	Eggs/ Female	No. Females	Total Egg Production	Eggs/ Female
<b>Narragausus</b>															
1962-71		1,303,100												1,303,100	
1994				59	145,700	2,469							59	145,700	2,469
1995							115	394,400	3,430				115	394,400	3,430
1996							117	434,300	3,712				117	434,300	3,712
1997							172	516,800	3,005				172	516,800	3,005
1998							186	490,000	2,634				186	490,000	2,634
1999							134	542,100	4,046				134	542,100	4,046
2000							64	431,700	6,745				64	431,700	6,745
1994-00				59	145,700	2,469	788	2,809,300	3,565				847	2,985,000	3,489
Total		1,303,100		59	145,700	2,469	788	2,809,300	3,565				847	2,985,000	3,489
<b>Orland</b>															
1967	5	41,100	8,220										5	41,100	8,220
1968	31	207,900	6,706										31	207,900	6,706
1969	3	20,600	6,867										3	20,600	6,867
Total	39	269,600	6,913										39	269,600	6,913
<b>Pawcatuek</b>															
1992	4	35,600	8,900										4	35,600	8,900
1993	1	7,900	7,900										1	7,900	7,900
1994	1	7,000	7,000										1	7,000	7,000
1996	1	16,900	16,900										1	16,900	16,900
1997	1	8,200	8,200										1	8,200	8,200
1999	6	61,300	10,217										6	61,300	10,217
2000							5	43,200	8,640				5	43,200	8,640
Total	14	136,900	9,779				5	43,200	8,640				19	180,100	9,479

Year	Sea-run			Domestic			Captive <sup>2</sup>			Kelt			Total		
	No. Females	Total Egg Production	Eggs/Female	No. Females	Total Egg Production	Eggs/Female	No. Females	Total Egg Production	Eggs/Female	No. Females	Total Egg Production	Eggs/Female	No. Females	Total Egg Production	Eggs/Female
<b>Penobscot</b>															
1986	295	2,376,100	8,055										295	2,376,100	8,055
1987	271	2,150,200	7,934										271	2,150,200	7,934
1988	226	1,610,700	7,127										226	1,610,700	7,127
1989	316	2,427,200	7,681										316	2,427,200	7,681
1990	300	2,041,700	6,806										300	2,041,700	6,806
1991	340	2,427,000	7,138										340	2,427,000	7,138
1992	351	2,448,000	6,974	614	1,518,700	2,473							965	3,966,700	4,111
1993	255	1,881,900	7,380	886	2,292,000	2,587							1,141	4,173,900	3,658
1994	215	1,669,900	7,767	645	1,654,700	2,565							860	3,324,600	3,866
1995	380	2,735,600	7,199										380	2,735,600	7,199
1996	380	2,635,000	6,934										380	2,635,000	6,934
1997	313	2,224,900	7,108	639	1,381,100	2,161							952	3,606,000	3,788
1998	392	2,804,100	7,153	560	1,456,200	2,600							952	4,260,300	4,475
1999	286	2,418,500	8,456	371	1,300,300	3,505							657	3,718,800	5,660
2000	196	1,558,900	7,954	540	1,334,000	2,470							736	2,892,900	3,931
1986-00	4,516	33,409,700	7,398	4,255	10,937,000	2,570							8,771	44,346,700	5,056
<b>Total</b>	<b>17,067</b>	<b>146,010,300</b>	<b>8,555</b>	<b>4,255</b>	<b>10,937,000</b>	<b>2,570</b>							<b>21,322</b>	<b>156,947,300</b>	<b>7,361</b>
<b>Sheepsco</b>															
1995	11	78,500	7,136				22	44,400	2,018				33	122,900	3,724
1996	7	46,800	6,686				36	66,000	1,833				50	178,900	3,578
1997							75	257,300	3,431				88	375,800	4,270
1998							98	343,300	3,503				115	524,800	4,563
1999							49	218,200	4,453				57	310,300	5,444
2000							60	246,100	4,102				60	246,100	4,102
<b>Total</b>	<b>18</b>	<b>125,300</b>	<b>6,961</b>				<b>340</b>	<b>1,175,300</b>	<b>3,457</b>				<b>403</b>	<b>1,758,800</b>	<b>4,364</b>

Year	Sea-run			Domestic			Captive <sup>2</sup>			Kelt			Total		
	No. Females	Total Egg Production	Eggs/ Female	No. Females	Total Egg Production	Eggs/ Female	No. Females	Total Egg Production	Eggs/ Female	No. Females	Total Egg Production	Eggs/ Female	No. Females	Total Egg Production	Eggs/ Female
<b>St. Croix</b>															
1993	15	114,000	7,600										15	114,000	7,600
1994	11	80,000	7,273										11	80,000	7,273
1995	10	76,700	7,670										10	76,700	7,670
<b>Total</b>	<b>36</b>	<b>270,700</b>	<b>7,519</b>										<b>36</b>	<b>270,700</b>	<b>7,519</b>
<b>Union</b>															
1974-84	490	3,702,200	7,556										490	3,702,200	7,556
1985	37	285,700	7,722										37	285,700	7,722
1986	23	211,000	9,174										23	211,000	9,174
1987	18	161,100	8,950										18	161,100	8,950
1988	10	80,700	8,070										10	80,700	8,070
1989	8	67,200	8,400										8	67,200	8,400
1990	14	103,000	7,357										14	103,000	7,357
<b>1985-90</b>	<b>110</b>	<b>908,700</b>	<b>8,261</b>										<b>110</b>	<b>908,700</b>	<b>8,261</b>
<b>Total</b>	<b>600</b>	<b>4,610,900</b>	<b>7,685</b>										<b>600</b>	<b>4,610,900</b>	<b>7,685</b>
<b>GRAND</b>															
<b>TOTAL</b>	<b>19,414</b>	<b>180,712,400</b>	<b>8,374</b>	<b>11,638</b>	<b>148,223,100</b>	<b>11,557</b>	<b>2,508</b>	<b>9,012,200</b>	<b>3,593</b>	<b>1,860</b>	<b>23,518,200</b>	<b>10,467</b>	<b>32,928</b>	<b>361,466,000</b>	<b>9,942</b>

<sup>1</sup> Egg production rounded to nearest 100 eggs.

<sup>2</sup> Captive refers to adults produced from wild parr that were captured and reared to maturity in the hatchery.

Note: Totals of eggs/female include only the years for which information on number of females is available.

Note: Connecticut data are preliminary prior to 1990.

**TABLE 3.7.a. SUMMARY RETURN RATES (%) FOR NEW ENGLAND ATLANTIC SALMON THAT WERE STOCKED AS FRY.**

Year Stocked	Merrimack	Pawcatuck	Connecticut River Basin	Connecticut (above Holyoke)	Salmon	Farmington	Westfield
1974	—	—	0.000	0.000	—	—	—
1975	0.000	—	0.000	0.000	—	—	—
1976	0.000	—	0.000	0.000	—	—	—
1977	0.000	—	0.000	0.000	—	—	—
1978	0.017	—	0.014	0.014	—	—	—
1979	0.056	—	0.006	0.000	—	0.010	—
1980	0.034	—	0.006	0.020	—	0.000	—
1981	0.142	—	0.011	0.013	—	0.000	—
1982	0.096	—	0.016	0.024	—	0.009	—
1983	0.275	—	0.001	0.001	—	0.001	—
1984	0.009	—	0.001	0.000	—	0.002	—
1985	0.040	—	0.011	0.012	—	0.009	—
1986	0.021	—	0.016	0.028	—	0.001	—
1987	0.026	—	0.004	0.004	0.002	0.007	—
1988	0.006	—	0.008	0.010	0.007	0.004	0.000
1989	0.004	—	0.005	0.006	0.000	0.007	0.001
1990	0.002	—	0.005	0.007	0.000	0.004	0.001
1991	0.001	—	0.002	0.003	0.000	0.001	0.002
1992	0.001	—	0.006	0.009	0.003	0.003	0.004
1993	0.001	0.001	0.004	0.004	0.002	0.007	0.006
1994	0.002	0.000	0.005	0.005	0.002	0.004	0.007
1995	0.003	0.001	0.002	0.002	0.000	0.004	0.002
1996	0.002	0.000	0.001	0.001	0.006	0.002	0.002
1997	0.000	0.000	0.000	0.000	0.000	0.000	0.000
<b>Mean*</b>	<b>0.034</b>	<b>0.001</b>	<b>0.006</b>	<b>0.007</b>	<b>0.002</b>	<b>0.004</b>	<b>0.003</b>
<b>SD</b>	<b>0.065</b>	<b>0.000</b>	<b>0.005</b>	<b>0.008</b>	<b>0.003</b>	<b>0.003</b>	<b>0.002</b>

\*Does not include 1997 and unknown 5 year old returns from 1996.

Note - Maine Rivers not reported in this table until adult returns from natural reproduction and fry stocking can be distinguished.

**TABLE 3.7.b. SUMMARY AGE DISTRIBUTIONS OF NEW ENGLAND ATLANTIC SALMON THAT WERE STOCKED AS FRY.**

River	Mean age class (smolt age-sea age) distribution (%)										Mean age (years) distribution (%)					
	1.1	1.2	1.3	2.1	2.2	2.3	3.1	3.2	3.3	4.2	2	3	4	5	6	
Merrimack	0.3	2.8	0.4	8.8	69.3	4.4	3.6	9.7	0.6	0.1	0.3	11.6	73.3	14.1	0.7	
Connecticut Basin	0.0	8.0	0.0	2.9	83.8	1.0	0.0	4.4	0.0	0.0	10.9	84.6	5.5	0.0	0.0	
CT R. Above Holyoke	0.0	4.2	0.0	2.4	87.9	1.0	0.0	4.7	0.0	0.0	0.0	6.3	87.9	5.7	0.0	
Farmington	0.2	27.2	0.0	3.6	64.5	1.5	0.0	3.4	0.0	0.0	0.2	30.8	64.5	4.9	0.0	
Westfield	0.0	0.0	0.0	5.0	91.6	0.0	0.0	3.4	0.0	0.0	0.0	5.0	91.6	3.4	0.0	
<b>Mean</b>	<b>0.1</b>	<b>8.4</b>	<b>0.1</b>	<b>4.5</b>	<b>79.5</b>	<b>1.6</b>	<b>0.7</b>	<b>5.1</b>	<b>0.1</b>	<b>0.0</b>	<b>2.3</b>	<b>27.7</b>	<b>64.6</b>	<b>5.6</b>	<b>0.1</b>	

Program summary age distributions vary in time series length, refer to specific tables for number of years utilized.

Note - Note - Maine Rivers not reported in this table until such times as adult returns from natural reproduction and fry stocking can be distinguished



**TABLE 3.7.d. PAWCATUCK RIVER RETURN RATES FOR ATLANTIC SALMON THAT WERE STOCKED AS FRY.**

Year Stocked	Total fry stocked (1000s)	Mean density (fry/100m <sup>2</sup> )	Total returns	Return rate (% of fry)	Age class (smolt age-sea age) distribution (%)										Age (years) distribution (%)					
					1.1	1.2	2.1	2.2	2.3	3.1	3.2	3.3	4.2	2	3	4	5	6		
1993	383	79.9	3	0.001	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	
1994	557	116.2	2	0.000	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	
1995	367	76.6	4	0.001	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	n/a	n/a	0.0	0.0	100.0	0.0	n/a	
1996	289	60.3	0	0.000	0.0	0.0	0.0	0.0	n/a	0.0	0.0	n/a	n/a	n/a	0.0	0.0	0.0	n/a	n/a	
1997	100	55.6	0	0.000	0.0	0.0	0.0	n/a	0.0	0.0	n/a	n/a	n/a							
<b>Total*</b>	<b>1696</b>	<b>77.7</b>	<b>9</b>	<b>0.001</b>	<b>0.0</b>	<b>0.0</b>	<b>100.0</b>	<b>0.0</b>	<b>0.0</b>	<b>100.0</b>	<b>0.0</b>	<b>0.0</b>								

\*The mean is shown for densities, return rates, and ages. The mean return rate does not include unknown 5 year old returns from 1996 and subsequent cohorts that may still return. Mean ages only include years with 1 or more returns.

Note: Return rates are calculated from stocked fry and do not include natural fry production.





**TABLE 3.7.g. FARMINGTON RIVER RETURN RATES FOR ATLANTIC SALMON THAT WERE STOCKED AS FRY.**

Year Stocked	Total fry stocked (1000s)	Unfed fry stocked (1000s)	Fed fry stocked (1000s)	Mean density (fry/100m <sup>2</sup> )	Coefficient of variation	Total returns	Return rate (% of fry)	Age class (smolt age-sea age) distribution (%)										Age (years) distribution (%)												
								1.1	1.2	1.3	2.1	2.2	2.3	3.1	3.2	3.3	4.2	2	3	4	5	6								
1979	29	29	0	unknown	n/a	3	0.010	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0			
1980	197	197	0	167.0	0.00	0	0.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
1981	18	18	0	17.0	0.00	0	0.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1982	166	166	0	145.0	0.00	15	0.009	0.0	0.0	0.0	0.0	86.7	13.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	86.7	13.3	0.0	0.0	0.0		
1983	157	157	0	135.0	0.00	1	0.001	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	
1984	128	128	0	113.0	0.00	2	0.002	0.0	0.0	0.0	0.0	50.0	0.0	0.0	50.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0	50.0	0.0	0.0	0.0	0.0	
1985	136	136	0	119.0	0.00	12	0.009	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	
1986	79	79	0	123.0	0.00	1	0.001	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0
1987	68	0	68	75.0	0.00	5	0.007	0.0	0.0	0.0	0.0	80.0	0.0	0.0	20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	80.0	20.0	0.0	0.0	0.0	0.0	0.0
1988	333	0	333	55.7	0.36	13	0.004	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0
1989	279	0	279	46.0	0.14	19	0.007	0.0	63.2	0.0	10.5	26.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	73.7	26.3	0.0	0.0	0.0	0.0	0.0
1990	270	0	270	60.5	0.46	11	0.004	0.0	45.5	0.0	0.0	45.5	0.0	0.0	9.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	45.5	45.5	9.1	0.0	0.0	0.0	0.0
1991	265	0	265	unknown	n/a	2	0.001	0.0	50.0	0.0	0.0	0.0	0.0	0.0	50.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0	0.0	50.0	0.0	0.0	0.0	0.0
1992	553	147	407	53.0	0.27	15	0.003	0.0	20.0	0.0	0.0	66.7	0.0	0.0	13.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.0	66.7	13.3	0.0	0.0	0.0	0.0
1993	772	403	370	46.7	0.42	52	0.007	0.0	13.5	0.0	5.8	76.9	0.0	0.0	3.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.2	76.9	3.8	0.0	0.0	0.0
1994	1097	565	531	66.4	0.45	49	0.004	0.0	30.6	0.0	4.1	63.3	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	34.7	63.3	2.0	0.0	0.0	0.0	0.0
1995	1146	660	486	62.0	0.49	42	0.004	2.4	38.1	0.0	4.8	52.4	0.0	0.0	2.4	n/a	n/a	n/a	n/a	n/a	n/a	n/a	2.4	42.9	52.4	2.4	n/a	n/a	n/a	n/a
1996	912	515	397	57.6	0.47	18	0.002	0.0	61.1	0.0	11.1	27.8	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.0	72.2	27.8	n/a	n/a	n/a	n/a	n/a
1997	1480	1003	476	63.5	0.45	0	0.000	0.0	0.0	0.0	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.0	0.0	n/a	n/a	n/a	n/a	n/a	n/a
<b>Total*</b>	<b>8084</b>	<b>4203</b>	<b>3880</b>	<b>82.7</b>	<b>0.21</b>	<b>260</b>	<b>0.004</b>	<b>0.2</b>	<b>27.2</b>	<b>0.0</b>	<b>3.6</b>	<b>64.5</b>	<b>1.5</b>	<b>0.0</b>	<b>3.4</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.2</b>	<b>30.8</b>	<b>64.5</b>	<b>4.9</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>

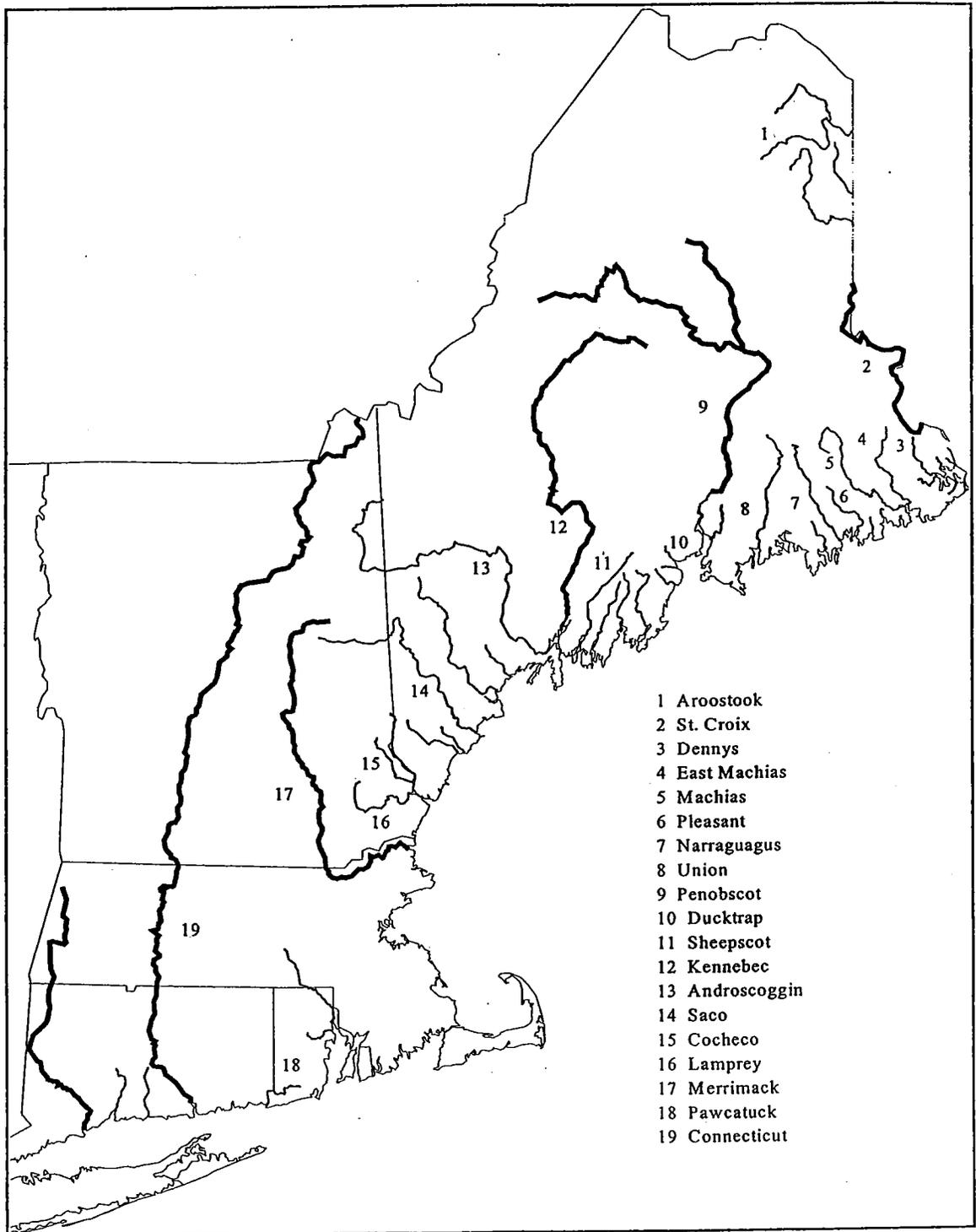
\*The mean is shown for densities, variation, return rates, and ages. The mean return rate does not include unknown 5 year old returns from 1996 and subsequent cohorts that may still return. Mean ages only include years with 10 or more returns. Mean density is the mean of individual stocking sheets.

Note: Return rates are calculated from stocked fry and do not include natural fry production.





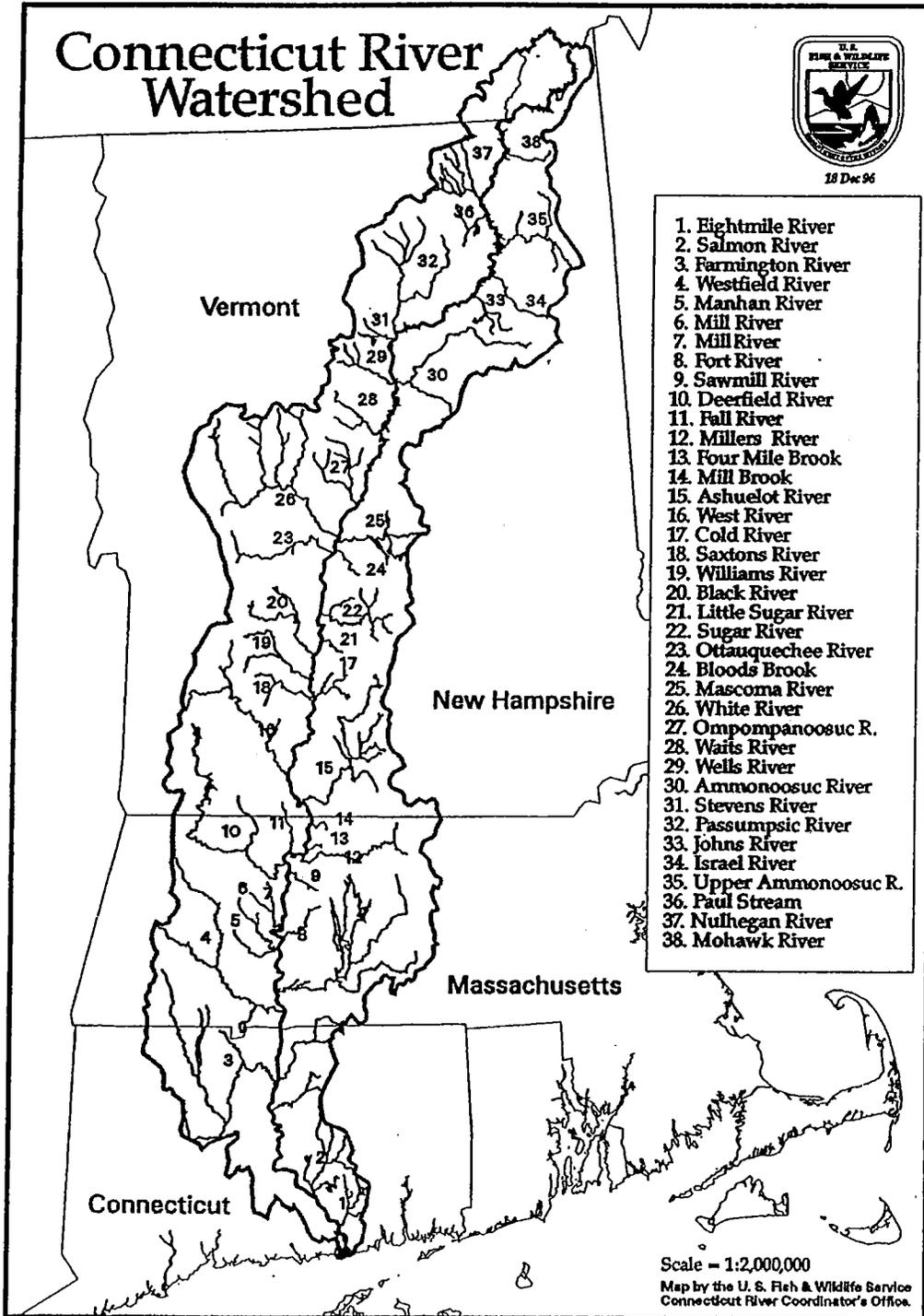
## Important Atlantic Salmon Rivers of New England



# Connecticut River Watershed



18 Dec 96



1. Eightmile River
2. Salmon River
3. Farmington River
4. Westfield River
5. Manhan River
6. Mill River
7. Mill River
8. Fort River
9. Sawmill River
10. Deerfield River
11. Fall River
12. Millers River
13. Four Mile Brook
14. Mill Brook
15. Ashuelot River
16. West River
17. Cold River
18. Saxtons River
19. Williams River
20. Black River
21. Little Sugar River
22. Sugar River
23. Ottauquechee River
24. Bloods Brook
25. Mascoma River
26. White River
27. Ompompanoosuc R.
28. Waits River
29. Wells River
30. Ammonoosuc River
31. Stevens River
32. Passumpsic River
33. Johns River
34. Israel River
35. Upper Ammonoosuc R.
36. Paul Stream
37. Nulhegan River
38. Mohawk River

Scale = 1:2,000,000  
 Map by the U. S. Fish & Wildlife Service  
 Connecticut River Coordinator's Office.

## Important Atlantic Salmon Rivers of Maine

