U.S. ATLANTIC SALMON ASSESSMENT COMMITTEE **ANNUAL REPORT 2005/18**

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

REPORT NO. 18 - 2005 ACTIVITIES

GLOUCESTER, MASSACHUSETTS
FEBRUARY 27 – March 2, 2006

PREPARED FOR
U.S. SECTION TO NASCO

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1.0 EXECUTIVE SUMMARY

Total return to USA rivers was 1,313; this is the sum of documented returns to traps and returns estimated on selected Maine rivers. Adult salmon returns to USA rivers with traps or weirs totaled 1,255 fish in 2005, 20% less than observed in 2004. Seventy-one adult (90% CI = 44 - 110) fish were estimated to return to the rivers with Endangered populations, the 4th highest for the 1991-2005 time-series. Most returns occurred in Maine, with the Penobscot River accounting for 75% of the total return. Overall, 24% of the adult returns to the USA were 1SW salmon and 76% were MSW salmon. Most (78%) returns were of hatchery smolt origin and the balance (22%) originated from either natural reproduction or hatchery fry. A total of 13,811,600 juvenile salmon (fry, parr, and smolts) and 3,657 adults were stocked, with 648,258 carrying a variety of marks and/or tags (e.g., PIT tags, visual implant elastomer tags, fin clips etc.). Eggs for USA hatchery programs were taken from 411 sea-run females, 2,580 captive/domestic females, and 102 female kelts. The number of females (3,093) contributing was less than in 2004 (3,618); and total egg take (17,811,000) was less than that of 2004 (20,486,000). Production of farmed salmon in Maine was 5,263 metric tonnes in 2005.

1.1. Introduction to Report

Background

The U.S.A. became a charter member of the North Atlantic Salmon Conservation Organization (NASCO) in 1984. NASCO is charged with the international management of Atlantic salmon stocks on the high seas. Three Commissioners for the U.S. are appointed by the President of the United States and work under the auspices of the U.S. State Department. The Commissioners required advice and input from scientists involved in salmon research and management throughout New England and asked the New England Atlantic Salmon Committee (NEASC) to create an advisory committee. The NEASC, comprised of State and Federal fishery agency chiefs, designated personnel from their staff to serve on the "NASCO Research Committee", which was formed in 1985.

The Research Committee met semiannually to prepare data for upcoming meetings of the International Council for the Exploration of the Sea (ICES), North Atlantic Salmon Working Group, and NASCO. In July of 1988, the Research Committee for the U.S. Section to NASCO was restructured and renamed the U.S. Atlantic Salmon Assessment Committee (USASAC). The Committee was charged with the following tasks: 1) to conduct annual U.S. Atlantic salmon stock assessments, 2) to evaluate ongoing U.S. Atlantic salmon research programs and develop proposals for new research, and 3) to serve as scientific advisors to the U.S. Section of NASCO. The Committee began meeting annually to produce an Atlantic salmon program assessment document. The data summarized allows U.S. representatives to ICES to responds to Terms of Reference from NASCO to the North Atlantic Salmon Working Group. Further the USASAC responds to direct requests for information from the U.S. Commissioners.

Since the 1970s, ICES has provided scientific information and advice in response to requests by international and regional regulatory commissions, and the governments of its member countries, for purposes of fisheries conservation and the protection of the marine environment. ICES is responsible for providing scientific advice used by NASCO parties as a basis for formulating biologically sound management recommendations for the conservation of North Atlantic salmon stocks. ICES assigned the responsibility for the collection and analysis of scientific data for Atlantic salmon stocks in the North Atlantic to the North Atlantic Salmon Working Group. Three or more U.S. representatives participate in the North Atlantic Salmon Working Group, forwarding data summarized by the USASAC. The advice provided by the North Atlantic Salmon Working Group is provided to the NASCO parties at an annual meeting each June.

Members of the U.S. Atlantic Salmon Assessment Committee (Section 5.1) met in Glouchester, Massachusetts from February 27 to March 2, 2006 to address the following Terms of Reference.

1.2 Terms of Reference for Report No. 18 - 2005 Activities

From U.S. Commissioners to NASCO

With respect to Guidelines for the Use of Stock Rebuilding Programs:

1. Provide any appropriate updates to the inventory of US stocks with and without stock rebuilding programs (as described in the NASCO Guidelines for the Use of Stock Rebuilding Programs);
2. Provide stock rebuilding plans that have become available since last years report;
3. Provide any recommended changes to the Guidelines for the Use of Stock Rebuilding Programs on the basis of new scientific information;

With respect to Habitat Protection and Restoration Plans:

1. Provide examples of measures taken to protect habitat and to restore degraded habitat;
2. Review information already in NASCO rivers database to ensure accuracy;
3. Populate the NASCO Rivers database with habitat specific information

From ICES

1. Describe the key events of the 2005 fisheries (including the fishery at St Pierre and Miquelon) and the status of the stocks;
2. Provide an overview of salmon catches and landings, including unreported catches by country and catch and release, and worldwide production of farmed and ranched Atlantic salmon in 2005;
3. Report on significant developments which might assist NASCO with the management of salmon stocks including new or emerging threats to or opportunities for salmon conservation and management;
4. Report on developments in methods to identify origin of Atlantic salmon at a finer resolution than continent of origin (river stocks, country or stock complexes);
5. Describe sampling programmes for escaped farmed salmon, the precision of the identification methods employed and the reliability of the estimates obtained;
6. Assess the genetic effects of introgression of farmed Atlantic salmon on wild salmon populations;
7. Provide a compilation of tag releases by country in 2005;

Terms of Reference will be addressed in this report or in Working Papers (Appendix 5.2). Information related to ICES TOR will be carried to the ICES Working Group on North Atlantic Salmon.

2.0 STATUS OF STOCKS

2.1 Description of Fisheries

Commercial and recreational fisheries for sea-run Atlantic salmon are closed in USA waters (including coastal waters). Estimated unreported catch is zero (metric tonne). Three ages of surplus broodstock were released, totaling 1,395 fish, to support the fishery in the main stem of the Merrimack River and small reach of the Pemigewasset River.

2.2 Adult Returns

Total return to USA rivers was 1,313 (Table 1), a 20% decrease from returns in 2004 (Table 2). Changes from 2004 by river were: Connecticut (+170%), Merrimack (-73%), Penobscot -26%), Saco (+32%), and Narraguagus (+18%). In addition to catches at traps and weirs (1,255), returns were estimated for the eight core populations that comprise the federally endangered Gulf of Maine Distinct Population Segment (GOM DPS). Data on adult returns and redd counts collected from the Narraguagus, Pleasant, and Dennys rivers have been used to estimate returns to core populations within the GOM DPS using a linear regression [ln (returns) = 0.5699 ln(redd count) + 1.3945]. The relationship between these estimates and the returns to the Narraguagus River were used to estimate GOM DPS returns in 2005 because high flows precluded complete redd counts. Total estimated return for the DPS was 71 (90% CI = 44 - 110). The replacement rate for 10 generations of Atlantic salmon starting with returns in 1996 from the 1992 spawning cohort averaged 0.6 and the mean replacement rate has not exceeded 1 during this time period. However, in 4 of the 10 years the upper bound of the 90% confidence limits did exceed 1. The replacement rate for 2005 was 0.73 (0.40 - 1.17) and was the fourth highest in the time series.

The ratio of sea ages from trap catches was used to apportion the estimate and calculate the estimated 2SW spawners. Returns of 2SW fish from traps, weirs, and estimated returns were only 3.4 % of the 2SW conservation spawner requirements for USA, with individual river returns ranging from 0.0 to 10.2 % of spawner requirements (Table 3).

Most returns occurred in Maine, with the Penobscot River accounting for 75% of the total return. Overall, 24% of the adult returns to the USA were 1SW salmon (319) and 76% were MSW salmon (994). Returns of MSW salmon in 2005 were less than those in 2004. Most (78%) returns were of hatchery smolt origin and the balance (22%) originated from either natural reproduction or hatchery fry (Figure 1). The adult return rate (1SW plus 2SW) of hatchery smolts released in the Penobscot River in 2003 was 0.17%, with the 2SW fish return rate 0.12% (Figure 2). Smolt survival on the Penobscot River correlates well with other large restoration programs in the Connecticut and Merrimack rivers. Return rates for wild smolts on the Narraguagus in recent years have mirrored those for the Penobscot, but were between five and ten fold higher.

2.3 Stock Enhancement Programs

During 2005, about 13,811,600 juvenile salmon (92% fry) were released into 14 river systems (Table 4). The number of fish released was less than that in 2004. Fry were stocked in the Connecticut, Merrimack, Saco, Penobscot, and six rivers within the geographic range of the GOM DPS in Maine. The 353,000 parr released in 2005 were primarily the by-products of smolt production programs and included ages 0 and 1 fish. Smolts were stocked in the Penobscot (530,600), Merrimack (50,000), Connecticut (85,100), Dennys (56,700), Pleasant (5,900), and Pawcatuck (16,600) rivers. In addition to juveniles, 3,657 adult salmon were released into USA rivers (Table 5). Most were spent broodstock or broodstock excess to hatchery capacity. However, mature pre-spawn salmon released in the Sheepscot, East Machias and Machias rivers produced redds. In the Merrimack River excess broodstock were released to support a recreational fishery and to enhance spawning in the watershed.

The mature adults stocked into the Dennys, Machias, and Pleasant rivers were added to USA 2SW spawners. Thus, spawners exceeded returns in 2005 and accounting for documented summer mortalities in several rivers, total USA spawners were 1,417.

2.4 Tagging and Marking Programs

Tagging and marking programs facilitated research and assessment programs including: identifying the life stage and location of stocking, evaluating juvenile growth and survival, instream adult and juvenile movement, and estuarine smolt movement. A total of 648,258 salmon released into USA waters in 2005 was marked or tagged. Tags used on parr, smolts and adults included: Floy, Carlin, HI-Z Turb'N, PIT, radio and acoustical, fin clips, and visual implant elastomer. About 13% of the marked fish were released into the Connecticut River watershed, 15% into the Dennys River watershed, and 69% into the Penobscot River (Table 6).

2.5 Farm Production

Production of farmed salmon in Maine was 5,263 metirc tonnes in 2005, a decrease from 8,515 t in 2004. Production in three of the last four years has been less than half of the 13,202 t produced in 2001 (Table 7).

2.6 Special Topics

2.6.1 Anadromous Communities

Atlantic salmon in New England likely co-evolved with alewife (*Alosa pseudoharengus*), blueback herring (*Alosa aestivalis*), American shad (*Alosa sapidissima*), rainbow smelt (*Osmerus mordax*), sea lamprey (*Petromyzon marinus*) and other diadromous fishes. Historically, anadromous fish populations in New England were more robust. At historic abundance levels, clupeid species were significant sources of marine derived nutrients and alternative prey for predators of salmon smolt; rainbow smelt were alternate prey of the same predators and prey for adult salmon; and lamprey spawning physically conditioned salmon spawning habitat. Restoring diadromous fishes and their ecological functions may be key to successful recovery of Atlantic salmon populations in the U.S.A.

Further information on anadromous communities is included in Section 4.1.

2.6.2 Geographic Information System (GIS)

While GIS applications in fisheries management have increased in the last decade, there is still a tendency to use only the software as a basic cartographic tool. As a result, GIS is not an integral part of salmon management and research activities in New England. Examples of landscape analyses related to salmon habitat were presented using a variety of GIS datasets for Maine. The NASCO habitat database, once it is again available for use, is georeferenced to the mouth of a river and contains information on the amount of habitat in all historic New England salmon drainages. For drainages without more detailed GIS coverage, it can serve as a basic habitat dataset.

Further information on GIS is included in Section 4.2.

Table 1. Documented Atlantic salmon returns to USA rivers, 2005. "Natural" includes fish originating from natural spawning and hatchery fry. Returns to traps are compared to five-year averages in Table 10.

RIVER	NUMBER OF RETURNS BY SEA AGE AND ORIGIN								
	1SW		2SW		3SW		Repeat Spawners		
	Hatchery	Natural	Hatchery	Natural	Hatchery	Natural	Hatchery	Natural	TOTAL
Androscoggin	2	0	8	0	0	0	0	0	10
Connecticut	0	23	4	159	0	0	0	0	186
Merrimack	8	0	25	1	0	0	0	0	34
Narraguagus (DPS)	0	1	0	12	0	0	0	0	13
Other GOM DPS [1]	0	4	0	54	0	0	0		58
Pawcatuck	0	0	0	2	0	0	0	0	2
Penobscot	269	6	678	22	0	0	8	2	985
Saco	5	1	12	7	0	0	0	0	25
TOTAL	284	35	727	257	0	0	8	2	1,313

[1] Numbers based on redds, ages and origins are pro-rated based upon distributions for DPS rivers with traps

Table 2. Documented Atlantic salmon returns to the USA, 1967-2005. "Natural" includes fish originating from natural spawning and hatchery fry.

	Sea age					Origin	
Year	1SW	2SW	3SW	Repeat	Total	Hatchery	Natural
1967	71	574	39	89	773	114	659
1968	17	498	12	55	582	314	268
1969	30	430	16	31	507	108	399
1970	9	539	15	16	579	162	417
1971	31	407	11	5	454	177	277
1972	24	946	38	17	1025	495	530
1973	17	622	8	12	659	420	239
1974	52	791	35	25	903	639	264
1975	77	1,250	14	25	1,366	1,126	240
1976	172	836	6	16	1,030	933	97
1977	63	1,027	7	32	1,129	921	208
1978	132	2,254	17	35	2,438	2,060	378
1979	216	987	7	18	1,228	1,039	189
1980	705	3,420	12	51	4,188	3,842	346
1981	975	3,674	30	31	4,710	4,450	260
1982	310	4,439	25	44	4,818	4,474	344
1983	252	1,356	28	21	1,657	1,330	327
1984	551	2,058	19	50	2,678	2,207	471
1985	345	4,185	38	16	4,584	3,900	684
1986	658	4,906	49	11	5,624	4,893	731
1987	1,008	2,446	66	72	3,592	3,093	499
1988	846	2,672	10	70	3,598	3,337	261
1989	1,098	2,557	9	51	3,715	3,288	427
1990	586	3,798	19	41	4,444	3,812	632
1991	292	2,297	6	41	2,636	1,723	913
1992	1,022	2,149	6	14	3,191	2,617	574
1993	404	1,940	11	30	2,385	2,033	352
1994	380	1,212	2	18	1,612	1,260	352
1995	184	1,543	7	15	1,749	1,504	245
1996	572	2,146	11	33	2,762	2,134	628
1997	303	1,397	7	24	1,731	1,295	436
1998	358	1,361	3	23	1,745	1,159	586
1999	386	1,042	3	21	1,452	954	498
2000	270	515	0	18	803	578	225
2001	266	788	6	3	1,063	838	225
2002	436	504	2	20	962	845	117
2003	237	1,192	3	4	1,436	1,242	194
2004	319	1,283	15	18	1,635	1,391	244
2005	319	984	0	10	1,313	1,019	294

[1]Starting in 2003 estimated returns based on redds are included in the table.

Table 3. Two sea winter (2SW) returns for 2005 in relation to spawner requirements for USA rivers

River or group	Spawner Requirement	2SW spawners-2004	Percentage of Requirement
Connecticut	9,727	163	1.68
Merrimack	2,599	26	1.00
Paucatuck	367	2	0.54
Penobscot	6,838	700	10.24
GOM-DPS	1,564	66	4.22
Other Maine rivers	8,104	27	0.33
Total	29,199	984	3.37

Table 4. Number of juvenile Atlantic salmon stocked in USA, 2005.

River	Fry	0 Parr	1 Parr	1 Smolt	2 Smolt	Total
Aroostook	133,000	0	0	0	0	133,000
Connecticut	7,805,000	0	0	0	85,100	7,890,100
Dennys	215,000	21,700	0	56,700	0	293,400
East Machias	216,000	0	0	0	0	216,000
Kennebec	30,000	0	0	0	0	30,000
Machias	476,000	0	200	0	0	476,200
Merrimack	962,000	1,400	400	50,000	0	1,013,800
Narraguagus	352,000	0	0	0	0	352,000
Pawcatuck	5,000	0	0	16,600	0	21,600
Penobscot	1,899,000	295,400	0	530,600	0	2,725,000
Pleasant	76,000	0	0	5,900	0	81,900
Saco	340,000	0	18,000	1,700	0	359,700
Sheepscot	201,000	15,900	0	0	0	216,900
Union	2,000	0	0	0	0	2,000
Total for United States	12,712,000	334,400	18,600	661,500	85,100	13,811,600

Table 5. Stocking summary for captive and domestic adult Atlantic salmon for the USA in 2005 by river.

		Captive Reared Domestic		Sea Run	
River	Purpose	Pre-spawn	Post-spawn	Post-spawn	Total
Dennys	Restoration	0	71	0	71
East Machias	Restoration	115	33	0	148
Machias	Restoration	31	167	0	198
Merrimack	Restoration/Recreation	0	1,395	0	1,395
Narraguagus	Restoration	0	151	0	151
Penobscot	Restoration	0	688	429	1,117
Pleasant	Restoration	458	0	0	458
Sheepscot	Restoration	64	55	0	119
Total United States		**668**	**2,560**	**429**	**3,657**

Table 6. Summary of tagged and marked Atlantic salmon released in USA, 2004. Additional data are in Table 9.1.

		Stock Origin								
MarkCode	LifeHistory	Connecticut	Dennys	East Machias	Merrimack	Narraguagus	Pleasant	Penobscot	Sheepscot	Grand Total
AD	Smolt	82,928								82,928
AD	Parr								15,882	15,882
AP	Adult							688	119	807
BAL	Smolt	592								592
FLOY	Adult				1,395					1,395
HI-Z	Smolt							83		83
PING	Smolt							335		335
PIT	Adult		71	148		151	458	627		1,455
PIT	Parr	453								453
PIT	Smolt	1,179	267							1,446
RAD	Adult	12								12
RAD	Smolt	151						49		200
VIE	Smolt		56,395					345,438		401,833
LV	Parr		43,344					96,996		140,340
RV	Parr							497		497
Grand Total		85,315	100,077	148	1,395	151	458	444,713	16,001	648,258

AD = Adipose Clip, AP = Adipose Punch
VIE = visual implant elastomer; all fish tagged with VIE also had adipose fin clipped
LV = left ventral
RV = right ventral
RAD = radio tag
PIT = passive integrated transponder
PING = ultrasonic acoustic tag
HI-Z = HI-Z Turb'N tag

Table 7. Aquaculture production (metric tones) in New England from 1997 to 2005.

Year	t
1997	13,222
1998	13,222
1999	12,246
2000	16,461
2001	13,202
2002	6,798
2003	6,007
2004	8,515
2005	5,263

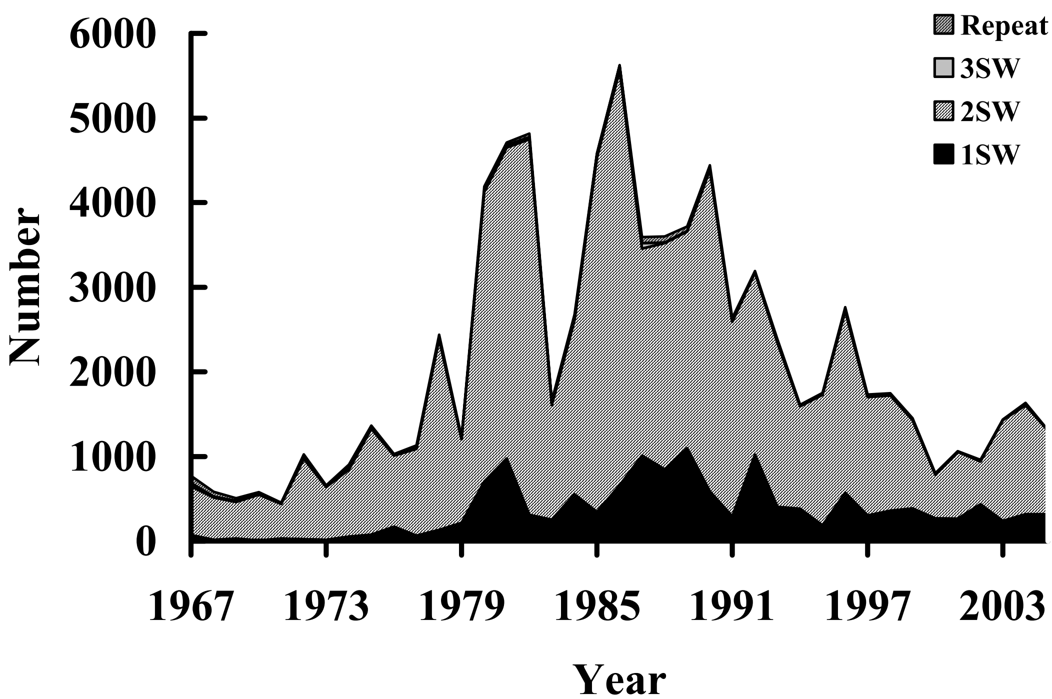

Figure 1. Number and sea age of Atlantic salmon returning to USA rivers.

2.7. Historical Data

Tables referred to in this section can be found in Section 5.3.

2.7.1 Egg Production

Total egg production for Atlantic salmon restoration and recovery programs in New England for the 2005 was 17,626,000 (Table 11). A summary by program and year (Table 12) and grand total of all historical Atlantic salmon egg production for New England salmon rivers (Table 13) is provided. Approximately 69,200 female Atlantic salmon have produced an estimated 462 million eggs for programs throughout the history of salmon enhancement, restoration, and recovery efforts.

2.7.2 Stocking

Approximately 237 million juvenile salmon have been released into the rivers of New England during the period, 1967 – 2005 (Table 14). About 81% of the total have been fry (Table 15). The majority of the juvenile releases have occurred in the Connecticut River (> 117 million), the Penobscot River (> 39 million), and the Merrimack River (> 36 million).

2.7.3. Adult Returns

The number and age structure of returns to New England rivers has varied from 1967 through 2005 (Table 16). Most returns occurred in Maine, with the Penobscot River accounting for 75% of the total return (Table 17).

Return rates for Atlantic salmon stocked as fry for southern New England rivers are tabulated in Tables 18.1 through 18.7. A summary of return rates and age distributions of Atlantic salmon stocked in New England rivers as fry are tabulated in Tables 19 and 20. Summaries of return rates and age distributions of adult salmon that were stocked as fry are not reported for rivers in the State of Maine. Adult salmon return rates and age distribution data for Maine rivers can not be accurately reported until returns from natural reproduction and fry stocking can be distinguished.

3.0 PROGRAM SUMMARIES

3.1 Connecticut River

3.1.1. Adult Returns

A total of 186 sea-run Atlantic salmon adults was observed returning to the Connecticut River watershed: 132 at the Holyoke fishway on the Connecticut River, 15 at the Rainbow fishway on the Farmington River, 12 at the Leesville fishway on the Salmon River and 27 at the Decorative Specialties International (DSI) fishway on the Westfield River. The run lasted from May 11 to July 11. A total of 169 salmon was retained for brood stock at Richard Cronin National Salmon Station (RCNSS).

Two salmon were released into the upper Westfield River. Twelve salmon were radio-tagged and released above Holyoke. Three additional salmon are known to have escaped Holyoke without being captured or tagged. Of the twelve radio-tagged fish, three passed the Turners Falls, Vernon, and Bellows Falls fishways and two also passed the Wilder fishway. These two salmon entered the Ammonoosuc River and ascended past a dam previously assumed to be impassable to salmon. One salmon entered the White River and eight salmon entered the Deerfield River.

Four of the salmon observed were 2SW of hatchery (smolt-stocked) origin. The remaining 182 salmon were of wild (fry-stocked) origin. Sea-age distribution of the wild salmon was 23 grilse and 159 2SW. Freshwater age distribution of wild salmon was 1+ (10%), 2^+ (84%) and 3^+ (6%).

No poaching was documented but there were several reports of salmon being caught and released.

3.1.2. Hatchery Operations

The program achieved 68% of egg production goals, 78% of fry stocking goals, and 85% of smolt stocking goals in 2005.

Currently, a total of 80,000 1+ pre-smolts are in production at the Pittsford National Fish Hatchery (PNFH). They were again marked with an adipose fin clip and vaccinated with a multi-valent vaccine for *Vibrio* and furunculosis in preparation for spring 2006 stocking.

The Warren State Fish Hatchery (WSFH) operated by NHFG procured a chiller to control egg incubation temperatures. Chiller installation was not completed for the 2005 season but it is hoped to be operational by fall, 2006. No fry were produced at WSFH this year and no eggs are currently incubating there. The CTDEP cooperated with a volunteer family to construct and operate a streamside, gravity-fed incubation facility in the lower level of their residence, which is a converted former mill located on Mill Brook, a tributary to the Connecticut River near its mouth. Late in 2004 this facility (Tripp Incubation Facility) accepted 70,000 eyed eggs from Kensington State Salmon Hatchery (KSSH) and produced 43,500 unfed fry that were stocked in

Connecticut streams in 2005. Late in 2005, the facility accepted 73,000 eggs from KSSH for fry stocking in 2006.

Egg Collection
A total of 10.2 million green eggs was produced at five state and federal hatcheries within the program. Sea-run broodstock produced 758,000 eggs from 102 females held at the RCNSS. A sample of the fertilized eggs from all sea-run crosses was egg-banked at the White River National Fish Hatchery (WRNFH) for disease screening and subsequent production of future domestic brood stock. Domestic broodstock produced 9.1 million eggs from 1,382 females held at RCNSS, WRNFH, KSSH, and Roger Reed State Fish Hatchery. Kelt broodstock produced 384,000 eggs from 37 females held at the North Attleboro National Fish Hatchery.

3.1.3. Stocking

Juvenile Atlantic Salmon Releases
A total of 7.9 million juvenile Atlantic salmon was stocked into the Connecticut River watershed in 2005. Totals of 858,000 fed fry and 6.9 million unfed fry were stocked into 41 tributary systems with the assistance of hundreds of volunteers. A total of 85,000 smolts was released into the lower Connecticut River mainstem and the Farmington River.

Surplus Adult Salmon Releases
Domestic broodstock surplus to program needs were made available to the states to create sport fishing opportunities outside the Connecticut River.

3.1.4. Juvenile Population Status

Smolt Monitoring
Northeast Generation Services and the USFWS/SOFA contracted with Greenfield Community College to conduct a mark-recapture smolt population estimate in 2005. This was the thirteenth consecutive year that a study has been conducted on the river mainstem by marking smolts at the Cabot Station bypass facility at Turners Falls and recapturing them at the bypass facility in the Holyoke Canal. The population estimate was 81,000 (+/- 36,000 95% confidence limits).

Based on expanded electrofishing data from index stations and assumed overwinter mortality, it was estimated that 236,000 smolts were produced in tributaries basin wide, of which 170,000 (72%) were produced above Holyoke in 2005. 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 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 220 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. Densities and growth of parr varied widely throughout the watershed. Generally, it was an average survival year with average growth of yearlings but below normal growth of young of the year salmon. Most smolts produced are again expected to be two year olds, with some yearlings and three year olds. The basin wide smolt production estimate for 2006 calculated from expanding electrofishing data from index stations and assumed overwinter survival is 271,000. Electrofishing data from 2005 and previous years were added to the juvenile database for the Assessment Committee.

3.1.5. Fish Passage

Program cooperators continued to work to improve upstream and downstream passage at dams as well as to remove dams. TransCanada purchased the former USGen hydroelectric projects, which includes Fifteen Mile Falls, Wilder, Bellows Falls, and Vernon on the Connecticut River and several dams on the Deerfield River.

Holyoke Dam - The new fish lifts and associated facilities at Holyoke became operational this year and generally appeared to work well. However, adult salmon sometimes lingered in the new fishway flume below trapping facilities for extended periods resulting in three known salmon escapes. Changes in facility operation to prevent salmon escapes are being investigated.

Fifteen Mile Falls Project – Studies were conducted at the upper and lower dams of this three dam project on the upper Connecticut River. At McIndoes Dam, past studies indicated significant turbine passage and poor bypass effectiveness. Based on predicted high survival of turbine passed smolts, TransCanada conducted a turbine mortality study that indicated 100% survival of smolts passing via the fishway and tainter gates and 95-100% survival for turbine passed smolts. TransCanada again operated a smolt sampling device at Moore Dam to collect data on seasonal and diurnal timing and smolt abundance as a precursor to passage facility development at Moore and Comerford. Over 1,400 wild smolts were captured and trucked below McIndoes for release. Bypass efficiency of study hatchery smolts was only 23%, but of those that did not pass 71% came within 5 m of the entrance. Efforts will be made to increase attraction to the bypass this spring.

Homestead Dam (West Swanzey Dam)- A feasibility study of removing this Ashuelot River dam has been completed and removal is the least cost option. However the town may decide to buy and repair the dam. A decision is expected this summer.

Vermont Yankee Nuclear Power Plant- A draft discharge permit has been issued which allows a one degree F increase in the thermal discharge limits in the “summer” period (May 16 to October 14) with the exception of May 16 to June 15 pending studies of impacts on salmon smolts. Concerns for smolts include river warming during migration and impacts of the discharge plume on behavior and physiology. The company is likely to soon propose an increase in discharge limits during the “winter” period (October 15 to May 15) and an extension to their operating license set to expire in 2012.

Several fish passage improvement projects were completed with full or partial funding of the USFWS Connecticut River Coordinator's Office including removal of the Pizzini Dam on the Eightmile River, a feasibility study of removing the Homestead Dam on the Ashuelot River, and a culvert retrofit project on Tower Brook.

3.1.6. Genetics

The USGS Biological Resources Division, through the Conte Anadromous Fish Research Center (CAFRC), again sampled tissue from all sea-run brood stock for genetic monitoring (microsatellite analysis). The sea-run broodstock were PIT tagged to ensure individual identification at spawning. This information is necessary to develop the mating scheme that is a deliberate effort to mate salmon that are not closely related. It is also used to create known families so the fry can be genetically "marked" for post stocking evaluation and marked families of domestic brood stock can be created.

Mature male parr, collected from the Williams River, supplemented sea-run males. Mating of sea-run females utilized a 3 male: 1 female breeding matrix in which one cross was sent to the egg bank for future broodstock production and two crosses were incubated to produce genetically marked fry for stocking. Marked sea-run/kelt families from last year's egg take were stocked in the Williams (155,000) and Sawmill Rivers (54,000) in spring of 2005 for mature parr production.

A 1:1 spawning ratio was observed for all domestic brood stock spawned at the WRNFH, KSSH, RCNSS and RRSFH. Prior to 2002, all genetically marked fry were of sea-run origin. Beginning in 1998, genetically identifiable domestic broodstock have been maintained at the WRNFH. In 2001, these fish were spawned and families of domestic eggs were produced with known genetic marks that are stocked in specific tributaries or groups of tributaries for later identification. The resultant fry were stocked in 2002 to expand the marking and program evaluation efforts. This effort is has continued since then. Partial fin clips were taken from 2,600 smolts sampled at Rainbow Dam, Cabot Station (Turners Falls Dam) and Holyoke Dam in 2005 and will be analyzed at CAFRC. Results from the 2004 smolt samples are not yet available.

3.1.7. General Program Information

Ongoing budget difficulties faced by program cooperators, particularly the USFWS, have hampered restoration efforts. Additional funding by Congress and reprogramming of maintenance funds to operations allowed production at USFWS facilities to continue at prior levels. Additional funding for salmon production at WRNFH was provided by the USFS through a cooperative agreement. Additional funding is still needed to meet salmon production goals, conduct needed evaluation and research, and to provide fish passage.

The use of salmon egg incubators in school as a tool to teach about salmon, watersheds and conservation continued to expand throughout the basin. The Connecticut River Salmon Association conducted their Fish Friends program at schools in Connecticut. Trout Unlimited carried a similar message to schools in Massachusetts, as did the Southern Vermont Natural

History Museum, the USFS, and the Vermont Institute of Natural Science in Vermont. Schools in New Hampshire also participated. For the 2005-2006 school year 114 schools representing about 2,200 students participated in this type of salmon education in the four states.

3.1.8. Salmon Habitat Enhancement and Conservation

Program cooperators continued their habitat protection efforts in 2005. CTDEP and USFS completed instream habitat restoration projects. Program cooperators provided information for inclusion in the NASCO habitat database project.

3.2 Maine Program

3.2.1. Adult Returns

Adult Atlantic salmon returns reported for Maine are the sum of counts at fishways and weirs and estimates from redd surveys. Angling for Atlantic salmon is closed statewide, thus in 2005, no fish returned "to the rod". Counts were obtained at fishway trapping facilities on the Androscoggin, Aroostook, Narraguagus, Penobscot, Saco, St. Croix, and Union rivers and at asemi-permanent weir on the Dennys River. The summer of 2005 was wet, resulting in likely optimal conditions for juvenile rearing through July and August. Likewise, fall conditions were suitable for adult dispersal throughout the rivers, however, conditions were very poor for redd counting.

Because there was no rod catch, the number of spawners was assumed to equal returns plus pre-spawn captive broodstock. In 2005, pre-spawn captive broodstock were stocked in the East Machias and Machias Rivers. These fish will be included in spawner numbers forwarded to ICES because the number of ripe fish was known and their reproductive capacity may be comparable to returning 2SW females.

Rivers with Native Atlantic Salmon

Dennys River. The Dennys River adult weir was not operated for most of 2005. However, in September several large aquaculture escapes were reported from Canadian pens, and escapees were captured entering the St. Croix River. We installed a makeshift weir in the Dennys on the footprint of the original weir on 19 September, 2005 and fished it until 8 October, 2005. Ensuing high water on 9 October, 2005 overtopped the weir and buried it in debris. The weir was not fishable again after that, with high water continuously overtopping the weir. Two aquaculture escapees were captured in the weir and six additional escapees were captured in the river. We captured one in a gill net, two by electrofishing, two by angling, and one using a combination of methods. All fish captured were sacrificed and transferred to USDA-APHIS in Eastport, Maine for disease testing. Of the 8 fish (3 males and 5 females), USDA confirmed that none of the fish were sexually mature. Tests for disease on these fish were negative. Prior to 9 October, we knew through observations that there were more fish in the Dennys River that were highly likely to be escaped aquaculture salmon. We do not have an estimate of the numbers, but suspect at a minimum ten additional fish were in the river. Furthermore, fish could have easily moved into the river after 8 October.

No redds were located in the Dennys River, although there were several survey trips. We were unable to conduct redd counts after 8 November due to high water.

East Machias River. Three redds were counted during redd surveys in fall 2005 on the East Machias River. Two of the three redds were in Chase Mill Stream where 111 pre-spawn captive reared brood fish were stocked. Continuous heavy autumnal rains and high water levels decreased the effectiveness of redd surveys this year.

Machias River. We counted a total of 14 redds, covering the majority of the spawning habitat in the Machias drainage. Nine of these were likely created by the 31 pre-spawn adult captive broodstock in Mopang Stream, at the outlet of Second Mopang Lake. The remaining five redds were in different tributaries and likely were from wild returns.

Pleasant River. The Pleasant River weir was not operated in 2005, and will not be operated in subsequent years. In five years of operation, no aquaculture escapes were intercepted at the weir and wild returns were low. No redds were found in the Pleasant River in 2005.

Narraguagus River. The Atlantic Salmon Commission operated a fishway trap and video monitoring system at the Cherryfield ice control dam from May 9 through October 31 to capture upstream migrating adult salmon and to intercept any escaped aquaculture salmon that may enter the river. In 2005 we documented a total of 13 sea-run salmon adults (6 captured in the fishway trap and 7 recorded on the video system). This year's trap catch represents an increase of 3 salmon from the 2004 catch (n=10) and a decrease of 7 salmon from the 2003 catch (n=21). Five females and one male were observed from the six salmon collected in the fishway trap. We are unable to determine sex from the seven fish observed on the video system.

In 2005, we conducted "spot-check" redd counts focusing on known spawning areas used in recent years on the Narraguagus mainstem because unusually high river flows reduced our ability to observe redds. We were able to observe a total of six redds and four test pits at six sites on the mainstem. In addition, one redd was located in Shorey Brook, however no other tributaries were surveyed.

Ducktrap River. On November 21, one redd and four test digs were observed in an area where redds have been observed in the past, however, no spawning salmon were actually observed.

Sheepscot River. The unusually high water in 2005 allowed only one survey of the spawning habitat in the upper portion of the mainstem and West Branch. One redds was found above Weeks Mills.

Cove Brook. No spawning activity was found in Cove Brook during one redd survey on 15 Nov. 2005.

Total Returns to DPS

Scientists estimate the total number of returning salmon to the Gulf of Maine Distinct Population Segment (DPS) using capture data on all DPS rivers with trapping facilities (Dennys, Pleasant, and Narraguagus Rivers) combined with redd count data from the other five rivers of this group. Estimated returns are extrapolated from redd count data using a return-redd regression established from the 1991-2000 Narraguagus River and 2000 Pleasant River assessments by ASC (USASAC 2001). NMFS and ASC updated the regression model in 2005 using the additional three years [$\ln(\text{returns}) = 0.5699 \ln(\text{redd count}) + 1.3945$]. Unfortunately, poor survey conditions precluded sufficient survey coverage to use the new regression for estimating the 2005 returns. The relationship between these estimates and the returns to the Narraguagus River were used to estimate GOM DPS returns in 2005 because high flows precluded complete redd counts. Total estimated return for the DPS was 71 (90% CI = 44 - 110) (Table 3.2.1.1).

Managers need a quantitative measure of recovery of the Gulf of Maine DPS that shows if overall population decline has been halted, and integrates the results of implemented recovery actions with changes in habitat and survival over time. One such measure is replacement rate (RPR). The RPR describes the demographics of each subsequent generation, or cohort, as it ages and replaces the previous one. Current redd-count-based assessments do not allow for cohort analysis that would track a given year-class from spawning through return as 1SW or 2SW fish over two years. But given the predominance of 2SW returns in these populations, a simple calculation of returning adults in year ***n*** divided by the number of returning adults in year n-5 is used. An RPR of 1 would indicate a stable population while below 1 is declining and above 1 growing. The replacement rate for 10 generations of Atlantic salmon starting with returns in 1996 from the 1992 spawning cohort averaged 0.6 and the mean replacement rate has not exceeded 1 during this time period. However, in 4 of the 10 years the upper bound of the 90% confidence limits did exceed 1. The replacement rate for 2005 was 0.73 (0.402 - 1.17) and was the fourth highest in the time series. Contributions of captive reared spawners at CBNFH are not accounted for in this calculation.

Table 3.2.1.1. Regression estimates and confidence intervals (90% CI) of adult Atlantic salmon in the core GOM DPS rivers from 1991 to 2005.

Year	L CI	Average	U CI
1991	234	294	366
1992	199	247	311
1993	221	264	315
1994	154	192	237
1995	131	162	197
1996	227	284	353
1997	128	165	209
1998	154	200	262
1999	137	175	223
2000	80	100	126
2001	90	103	119
2002	28	37	47
2003	62	76	96
2004	62	82	112
2005	44	71	110

Other Maine Atlantic Salmon Rivers

Penobscot River. We captured 985 new sea-run salmon during at the Veazie Dam fishway trap operated daily from May 23 through October 21, 2005. This year the trap gates were open from October 22 through November 1, 2005 allowing for unimpeded swim upriver due to high water conditions that made trap tending dangerous. The first new sea-run salmon was captured May 24 and the last one on October 7. We released 516 salmon back to the river, of which 58 were recaptured once after dropping downstream over the dam and ascending the fishway for a second time. Thirty-three of the recaptured salmon were taken as broodstock upon recapture. All salmon released to the river were marked with an adipose fin punch (AP), or a caudal fin punch (tail punch, UCP) to identify them on recapture and prevent double counting. This year's total catch represents a decrease of 338 fish from the 2004 total catch of 1,323 sea-run salmon.

In 2000, NOAA Fisheries began adipose clipping and tagging a percentage of GLNFH smolts with colored visual implanted elastomer (VIE) tags in order to assess post release scale growth, and adult return success relative to location and timing of release. This year 261 salmon captured at the trap were observed with an adipose fin clip (26.5%), of which 179 had a VIE tag observed at the trap.

A total of ten two-sea-winter male salmon were implanted with ultrasonic tags on June 20 and 21 at the Veazie trap as part of a pilot study being conducted by the Maine Cooperative Fish and Wildlife Research Unit at the University of Maine by principal investigators Joseph Zydlewski and Michael Kinnison, and graduate assistant Christopher Holbrook. Five of the tagged fish were released upstream of the Veazie dam in Orono and five were released into Penobscot Bay in Rockland. Tthe goal of this study was assess the feasibility of using acoustic telemetry tags to describe migratory patterns of adult Atlantic salmon through the Penobscot Bay and River. An array of acoustic telemetry receivers will be used to quantify routes of passage and speeds of migration of two-sea-winter (2SW) adult male salmon (hatchery origin).

Of the five fish released near Rockland, two approached Veazie (detected at Graham Station) in late June, but never passed; two others approached and passed Veazie in early July (one last detected in Piscataquis, one last detected near South Lincoln); and one was never detected. Of the five fish released in Orono, one passed Great Works, Milford, and Howland dams in early July and was last detected in Piscataquis; one dropped below Veazie in late June, spent approximately 3 months in the estuary, then passed above Veazie in late Sept. and was last detected near Eddington boat ramp; one passed below Veazie in late July, ventured as far south as Fort Point, and passed above Veazie in late Sept. (last detected below Great Works in early Oct.); one remained below Great Works from late June to late July, but never passed (was last detected at the Eddington boat ramp in early August); and one was never detected.

Great Lakes Hydro America, LLC (GLHA) continued operation of an Atlantic salmon trap at the fishway at the Weldon Dam in Mattawamkeag. The dam is located 60 miles upstream from Bangor and is the fifth and final mainstem dam encountered by salmon on their upstream migration into the East Branch, Penobscot River. The trap was operated daily from June 10 through October 30. The 2005 trap catch (37 total salmon) consisted of 15 multi-sea winter salmon and 22 one-sea winter salmon (grilse). All trapped fish were counted and permitted to swim from the trap without additional handling to minimize stress.

ASC crews conducted spawning inventories in the Piscataquis and Pleasant Rivers in November 2005, but high flows completely obscured the riverbed and prevented accurate redd counts. The long-term average Piscataquis stream flow in November at the USGS gage station at Dover-Foxcroft is 625 cfs, but during November 2005 flows in excess of 5,000 cfs were recorded.

St. Croix River. The SCIWC operated a fishway trap at the Milltown Dam, St. Stephen, New Brunswick, Canada, located near the head of tide, from 18 May to 25 October. The trap was reopened and operated 15 November to 12 December by the Atlantic Salmon Federation to intercept additional suspected escaped aquaculture salmon. The Milltown trap recovered 42 salmon in 2005, of which seven were of hatchery origin and 35 were of aquaculture origin. All of the aquaculture fish were sacrificed for DFO disease studies, one of the hatchery fish was inadvertently sacrificed and the remaining 6 hatchery fish were retained for broodstock. By comparison, in 2004 eleven restoration and three aquaculture fish were captured.

Androscoggin River. Maine Department of Marine Resources operates a fishway trap on the Androscoggin River. In 2004, a total of ten salmon were trapped and passed upstream. The majority of these fish were of hatchery origin and because there are no smolts or parr stocked in the system these fish are strays. None of these fish were marked or tagged.

Saco River. Florida Power and Light (FPL) currently operates three fish passage-monitoring facilities on the Saco River. The Cataract fish lift, located on the East Channel in Saco was operational from early May to late October. This year 5 salmon were lifted and passed into the Cataract headpond from this facility. On the West Channel in Saco and Biddeford, the Denil fishway-sorting facility was also operational from early May to late October. This facility passed 20 salmon into the headpond. A third passage facility at Skelton Dam was used to re-capture adult salmon for transport to the Ossipee River. FPL transported and released 11 salmon from this facility.

Union River. Pennsylvania Power and Light Company operated the Union River trap for salmon from June 27- October 26th, 2005. Four adult salmon were captured at the Union River trap between August 22nd and September 29th, all four were determined to be aquaculture escapes based on scale growth patterns. All four had an LV clip, used for restoration fish in the Penobscot and by the aquaculture industry.

Kennebec River. Redd counts undertaken by foot on Bond Brook, a tributary of the Kennebec River, in November 2005 located no redds. High flows precluded counts in other tributaries to the lower Kennebec River.

Aroostook River. The Tinker Dam, located five km upstream from the confluence with the St. John River, has a fish trapping and sorting facility operated by PDI Canada, Inc. The 2005 Tinker trap catch was eight salmon (2 MSW and 6 1SW). The Tinker dam fish-lift began 2005 operations on July 4th and continued to October 7th ; was out of service from August 17th to 29th due to low water; and from September 12th to 15th due to mechanical problems. Flood stage river flows were present during October (and November), further reducing fish passage efficiency at the Tinker Dam.

Table 3.2.1.2. Numbers of suspected aquaculture escapes captured at traps on Maine Rivers. Blanks are no data.

YEAR	St Croix	Dennys	Narraguagus	Penobscot	Pleasant	Union
1997	42		0	0		
1998	25		0	0		
1999	23		8	0		63
2000	30	28	0	0	0	3
2001	58	62	1	1	0	2
2002	5	4	0	4	0	6
2003	9	2	0	0	0	0
2004	4	0	0	0	0	0
2005	35	8	0	0		4

3.2.2. Hatchery Operations

Egg Production

Sea-run, captive and domestic broodstock produced 5.9 million eggs (compared to 6.6 million in 2004) for the Maine program during the 2005 spawning efforts: 2.49 million eggs (41%) from Penobscot sea-run broodstock; 2.35 million eggs (38%) from six captive broodstock populations; and 1.31 million eggs (21%) from Penobscot domestic broodstock.

GLNFH Penobscot domestics were spawned from November 8 through November 21. Spawning of sea-run Penobscot broodstock at CBNFH commenced October 27 and was completed on November 15. Penobscot sea-run female (n=296) fecundity averaged 8,403 eggs, which is similar to the past few years.

River specific DPS broodstock were spawned from November 2 through November 17. Spawning protocols for river specific DPS broodstock give priority to first-time spawners; utilizing 1:1 paired matings within specific age classes. Deviation to this protocol occurs when egg requests exceed estimated production from gravid first-time females, in 2005 this occurred in three DPS Rivers (Dennys, Narraguagus, and Machias).

The first Pleasant River pedigree broodstock line, composed of domestic (genetically selected broodstock reared entirely at hatchery) and captive reared components, was spawned at CBNFH in 2005. These 1:1 paired matings consisted of 56 domestic females crossed with captive males, and 43 captive females crossed with domestic males.

Mean daily water temperatures at CBNFH during spawning operations ranged from 7.1 to 9.4 and averaged 8.2 C from October 28 to November 17 2005. This is significantly warmer than last years daily mean water temperature of 7.4 C (range 4.3-10.1) over the same time period (t-test $P<0.01$). Above average air temperatures and frequent rain events since spawning have yielded above average water temperatures during egg development. Daily mean water temperature from November 17, 2005 to February 15, 2006 was significantly higher in 2005-06 (7.5) when compared to 2004-06 (4.3) (t-test $P<0.01$). As of February 15, 2006, this increase in water temperature has resulted in a 21 day advance in egg development over last year. As of this date, the warmer water temperatures have not resulted in an increased mortality to the recently enumerated eyed eggs.

Egg Transfers
All three egg sources (sea-run, captive, and domestic) were used for the Salmon-in-Schools (FWS) and Atlantic Salmon Federation Fish Friends programs, approximately 27,000 eggs were distributed for these educational programs. Domestic Penobscot eggs 461,000 from GLNFH were transferred to the Saco River Hatchery (operated by volunteers from the Saco River Salmon Club) for rearing and release.

In January 2005, Penobscot sea-run eyed eggs (300) were transferred to the USDA National Cold Water Marine Aquaculture Center located in Franklin, ME. See hatchery research section.

The Wild Salmon Resource Center, located in Columbia Falls, received 39,000 Pleasant River domestic (pedigree line) eyed eggs from CBNFH in January 2005. Approximately 6,000 Penobscot domestic eggs were transferred to MASC for remote-site incubators in the Kennebec River. The Sheepscot received 8,800 eggs for similar experimental projects.

In 2005, the Dug Brook Hatchery received 314,000 eyed eggs from the Mactaquac Biodiversity Facility located in Frenchville, NB. These eggs are reared to the fry life stage for the Aroostook River Supplementation Program.

Hatchery Research Activities
Nate Wilke, M.S. candidate at University of Maine in Orono (UMO), worked closely with CBNFH staff during the spawning season in a fourth year of a study to correlate DNA markers with phenotypic traits such as fecundity and morphology. Subsets of spawned fish were sampled for DNA analyses and photographed. Samples of egg size, fecundity and weight were also taken.

Michael Bailey, Ph.D Student at UMO, worked closely with CBNFH staff during 2005 in a multi-year of a study to correlate characteristics of newly released hatchery fry to relative survival in the first 30-60 days in the wild. Samples of fry were collected to measure fry length, fry weight and otolith parameters of stocked fry.

Randy Spencer, M.S. candidate at the UMO and Maine Atlantic Salmon Commission Biologist, worked cooperatively with staff at the GLNFH to compare smolt physiology and behavior for two strains of Atlantic salmon smolts during the migratory window. Pit tags were used to monitor smolt behavior relative to flow direction within experimental tanks at GLNFH, and non-lethal gill biopsies were collected to evaluate Na+ K+ ATPase activity.

The National Cold Water Marine Aquaculture Center continued USDA efforts to develop a biological and economically suitable Atlantic salmon strain for U.S. aquaculture production. The primary aquaculture research objective is genetic improvement of North American origin Atlantic salmon utilizing a family-based selective breeding program. This program has received 300 sea-run Penobscot eyed eggs annually since 2004.

CBNFH personnel continued trial and actual use of spawning software developed in cooperation with researchers from the Conte Anadromous Fish Research Center (Turners Falls, MA) and FWS geneticists (Lamar, PA). The software is designed to optimize matings based on the frequency of shared alleles, where lower percentages of shared alleles are sought to maximize genetic diversity. The software was used to record all matings at CBNFH in 2005, although the optimization aspect was used only in the Pleasant River. It is anticipated that CBNFH will utilize this software to record and genetically optimize all DPS river specific matings in 2006.

CBNFH Broodstock Collection
Collection of juvenile Atlantic salmon from six DPS rivers for the captive broodstock program at CBNFH continued in 2005. Juvenile Atlantic salmon are collected annually from their native rivers and brought to CBNFH for rearing. Once these broodstock have passed health screening procedures and any necessary genetic culling, they are used to provide river-specific fry, parr and smolts for restoration programs in their rivers of origin. In 2005, 1,012 parr were collected from the following rivers: 120 from the Dennys; 105 from the East Machias; 265 from the Machias; 101 from the Pleasant; 256 from the Narraguagus; and 165 from the Sheepscot.

In September 2005, GLNFH retained 1,000 fish from the 2004 year class of sea run Penobscot-strain Atlantic salmon. These fish will be used for F_2 domestic egg production and held at GLNFH for 2-3 years.

A total of 475 sea-run adult salmon (275 females, 160 males and 40 grilse) were collected from the Penobscot River (Veazie Dam) and were spawned at CBNFH in 2005 (compared to 606 in 2004). All Penobscot River adults captured for broodstock were marked with PIT tags and sampled for future genetic characterization. In addition, all Penobscot broodstock were sampled for the presence of Infectious Salmon Anemia virus (ISAv) prior to spawning. No ISAv was detected.

3.2.3. Stocking

Progeny produced from sea-run, captive and domestic broodstock are released into their rivers of origin as fry, parr, and smolt. Surplus adult broodstock are also returned to there river-of-origin.

Fry Stocking
Thirty two fry stocking trips departed CBNFH from May 9 through June 6th, 2005 (Table 3.2.3.1). River discharge during fry stocking was considerably higher than the last two years. River flows averaged 1.8 times the mean daily flow, ranging from 0.7 to 7.6 as determined from the nearest USGS stream gage during these fry stocking trips. Stocking crews noted that discharges in excess of 3 times the daily mean flow should be avoided in most rivers, especially when stocking fish via canoe transport because of safety concerns. One exception to this general rule was noted in the Wassataquoik stocking trip, were biologists canoed at a bank-full flow that exceeded safe boating operations. Although flows downstream in the East Branch Penobscot were only 1.7 times the daily mean flow, water releases from the East Branch Mattagamon impoundment undoubtedly dissipated the East Branch hydrograph. Therefore discharge information at the USGS stream gage 1029200 can not be used to predict flows in the Wassataquoik drainage.

Table 3.2.3.1. Fry Developmental Index (DI) values and environmental variables from CBNFH stocking events.

River	Trip Name	Release Date	D.I.'s for groups	CBNFH Water Temp (C)	River Temp (C)	Discharge (CFS)
Dennys-l	Curry Landing -Weir Site	12-May-05	101	11.0	9.5	363
Dennys-2	Cathance Lake outlet	13-May-05	97, 94	10.5	10.0	203
Dennys-3	Gilman Rips -Curry Landing	16-May-05	98	10.7	10.0	180
East Machias-l	Beaverdam, Seavey, Barrows	6-May-05	96	10.7	13.0	N/A
East Machias-2	Pokey, Palmer, Hadley Lake, downtown	17-May-05	104	10.9	8.0	N/A
East Machias-3	Northern Chase, Clifford, etc.	24-May-05	114, 110	11.1	N/A	N/A
Machias-l	Old Strearm/Mopang	11-May-05	102, 97	11.4	12.0	3,154
Machias-2	Third Lake Stream/West Branch	10-May-05	96	10.1	13.5	2,617
Machias-3	Wigwams/Holmes	18-May-05	102	11.0	10.0	1,706
Machias-4	Great Falls/Whitneyville	20-May-05	105	11.0	11.0	1,707
Machias-5	Multiple Trib run	25-May-05	112, 108	10.8	10.0	2,806
Narraguagus-l	Bracey Ford-Ford/Baker/Gould	9-May-05	99	9.3	9.0	1,775
Narraguagus-2	Little Fa11s-Dam/Lawrence	14-May-05	96	10.9	11.0	706
Narraguagus-3	Humpback -Route 9/Route 9 –lake	17-May-05	104	10.9	9.2	756
Narraguagus-4	Lake-Bog Brook/Deblois-Schoodic	18-May-05	105, 102	11.0	11.0	748
Narraguagus-5	Long/Sprague/ATVer's	23-May-05	109	11.3	9.0	985
Pleasant-l	Saco, Crebo, Ravine, Worster	26-May-05	115, 112	10.3	8.5	203
Sheepscot-l	Mainstem/Trout Brook	6-May-05	86, 91, 91, 91	10.7	10.5	636
Sheepscot-2	West Branch/Choate/Ben Brook	13-May-05	95, 95, 92, 92	10.5	12.0	484
East Branch Penob-l	Seboeis-1	12-May-05	105	11.0	11.0	678
East Branch Penob-2	Mattagamon	18-May-05	111	11.0	9.0	2,891
East Branch Penob-3	Bowlin-Lunksoos	20-May-05	113	11.0	N/A	2,960
East Branch Penob-4	Wassataquoik	24-May-05	114	11.1	4.5	6,234
East Branch Penob-5	Grindstone	2-Jun-05	126, 124	10.7	15.0	4,009
East Branch Penob-6	Seboeis-2	31-May-05	123,121	10.4	12.0	544
Piscataquis Penob-l	Ebeemee	11-May-05	109	11.4	11.0	5,238
Piscataquis-Penob-2	Blanchard-Barrows	18-May-05	111	11.0	8.0	219
Piscataquis-Penob-3	KIW-Roaring Brook	23-May-05	118, 115, 113	11.3	8.0	2,979
Piscataquis-Penob-4	Barrows-Abbott	17-May-05	111, 109	10.9	8.0	239
Piscataquis-Penob-5	Roaring Brook-Brownville Junction	16-May-05	110	10.7	8.0	3,514
Piscataquis-Penob-6	Brownville Junction-Milo	26-May-05	117	10.3	N/A	5,277
Mattawamkeag- Penob l	East and West branches	6-Jun-05	132, 130	13.4	15.6	2,398

Water temperatures were generally warmer at CBNFH compared to the actual river temperature as measured at the start of the daily stocking trip. Water temperatures at CBNFH ranged from 9.3 to 13.4 C (mean 10.9) while river temperatures were 4.5 to 15.6 C (10.3) over the duration of fry stocking. Hatchery and river water temperatures were very similar in early May, but became extremely variable by mid-May. Temperature deviations in late May were also variable, but rivers stocked later in the season generally had warmer water as compared to CBNFH.

Fry development as calculated by the Developmental Index (Kane 1987) ranged from 86-132 during the CBNFH stocking efforts. Mean development values within rivers averaged 91-117 during this same time period. Because Penobscot progeny are normally spawned earlier and stocked later in favor of lower river discharges, the fry have consistently higher DI's over the captive reared DPS fish. Overall, developmental values in 2005 are similar to last years fry releases.

Eggs, Fry, Parr and Smolt Stocking
During 2005, approximately 4.9 million Atlantic salmon were stocked into the rivers of Maine as fertilized eggs, fry, parr and smolts (Table 5). Of this total, fry accounted for 80% (4.0 million) of the life stages stocked. The six DPS rivers received 1.5 million, Penobscot 1.9 million, Aroostook 142,000, Saco 359,000, Union 1,600, and Presumscot 153 fry.

The Penobscot River received 528,600 age-1 smolts and 295,400 parr. Approximately 2,000 Penobscot sea-run origin smolts were released from stocks reared in conjunction with the USDA National Coldwater Marine Aquaculture Center. CBNFH stocked 5,933 age-1 river-specific smolts in a (3,385) spring and (2,548) fall release into the Pleasant River. The Dennys River also received 56,500 age-1 smolts and 21,600 parr from GLNFH. Additional parr releases occurred in the Saco (18,000) and Sheepscot Rivers (15,900).

Several privately owned, volunteer operated hatcheries were involved in releasing Atlantic salmon into Maine waters. Approximately 34,000 Pleasant River-origin fry, obtained from eggs produced by broodstock at CBNFH. Eyed eggs are transferred to the Wild Salmon Resource Center (hatchery in Columbia Falls) where they are reared and distributed into the Pleasant River and its tributaries by volunteers from this facility.

The Saco River Hatchery, operated by volunteers from the Saco River Salmon Club, reared and released approximately 339,700 fry. The Saco River Hatchery annually receives domestic-origin eyed eggs produced at GLNFH. An additional 1,700 smolts and 18,000 parr were also stocked into the Saco. These Penobscot domestic origin fish were raised at the Pine Tree facility (associated with Saco Hatchery).

Dug Brook Hatchery, operated by Atlantic Salmon for Northern Maine Inc., reared eggs that yielded 142,000 Saint John-origin fry that were stocked into the Aroostook River and it's tributaries from May 26 to June 8, 2005. Stocked fry originated from sea-run (19%) 1SW captive (32%), and MSW (50%) captive reared St. John River salmon spawned at the Mactaquac Biodiversity Facility located in Frenchville, NB.

Instream egg incubation projects were conducted in the Sheepscot (river specific) and Kennebec (Penobscot captive reared) Rivers by MASC staff in 2005, these projects utilized 8,800 and 6,000 eggs, respectively.

In addition to Atlantic salmon reared at federal and private hatcheries, 114 schools and businesses participated in the FWS Salmon-in-Schools (31) and Atlantic Salmon Federation Fish Friends programs (83). Through these programs, participants receive approximately 200 DPS or Penobscot (sea-run or domestic) origin eyed eggs and a curriculum to help educate students and the public about Atlantic salmon. Participants released fry produced from the 200 eggs in May and June, stocking approximately 15,000 fry into designated segments of appropriate river as permitted by the MASC. Fry releases in the Presumpscot and Union Rivers are exclusively from these programs.

Smolts produced from Penobscot River sea-run broodstock were also stocked in the Merrimack River (51,000) in 2005.

Adults
River-specific broodstock reared at CBNFH are routinely released into their natal rivers based on water constraints at the hatchery, the individual contribution of each broodfish to stocked progeny, and the need to maintain adequate numbers of broodstock to meet production and other genetic goals. In 2005, excess broodstock were released to the Sheepscot (119), Dennys (71), East Machias (148), Machias (198), and Narraguagus (151) in October through December. For October releases of broodstock to the Sheepscot, East Machias, and Machias rivers mature females and males were selected. Redds were detected in the vicinity of the stocking points, indicating that released broodstock may have spawned (see Section 3.2.1.).

In December 2005, 429 Penobscot sea-run broodstock were released at the Brewer boat ramp. No sea-run adults were specifically sacrificed for health screening purposes because requirements were met through incidental mortalities and subsequent routine necropsies. In regard to GLNFH's excess adults, 425 (4-year old) and 263 (3-year old) domestic broodstock were released into the Penobscot River.

3.2.4. Juvenile Population Status

Surveys to estimate density or relative abundance of juvenile salmon were conducted on most of the rivers in Maine with wild or stocked populations of Atlantic salmon (Table 3.2.4.1). In 2003, ASC adopted a maximum likelihood depletion model population estimator to estimate juvenile salmon abundance. In instances where depletion was not possible or unsuccessful, either a one run or sum of catches population estimate was included. Fish abundance is presented as fish per unit, where one unit equals 100 m^2.

We sampled for juvenile salmon at 39 Narraguagus locations in 2005, similar to previous efforts. Five sites were located in tributaries to the Narraguagus River and 34 sites were located on the mainstem. We obtained multiple run population estimates at 30 sites. Other sites (n=9) were sampled with single pass electrofishing because parr were absent or present in extremely small numbers. Parr densities were variable among the sites sampled in the mainstem in 2005, with an absence of parr at some low quality sites, to a high of 10.80 parr/100 m2 at Deblois Falls (river km 30.86). Parr densities in tributaries surveyed also varied among the sites, ranging from an absence of parr to 15.33 parr/100 m2 in Baker Brook @ Tote Road (river km 0.60 from the confluence with mainstem). Parr densities tend to be highest in riffle areas with small boulder and cobble substrates.

During the parr surveys, we also collected abundance data for age-0+ parr (YOY). Densities varied among mainstem sites, ranging from an absence of YOY at some sites to 26.36 per 100 m^2 at the Ford Riffle (river km 53.01). YOY densities in tributaries to the Narraguagus River ranged from 1.18 per 100 m^2 in Gould Brook (river km 0.98 from the confluence with mainstem) to 21.09 per 100 m^2 at Baker Brook above Mouth (river km 0.29 from the confluence with mainstem).

We electrofished 25 sites in the Dennys River drainage collecting population estimate and biological data for juvenile salmon (Table 3.2.4.1). On the Sheepscot River, parr densities continue to have a great deal of variability. Similar to 2004 and 2003, in 2004, several sites contained no parr and of the sites with parr, we found densities as high as 23.6 parr/unit. The median density of parr for all sites was 2.7 per/unit (Table 3.2.4.1), higher than the median density in 2004 (0.47 parr/unit). The data collection efforts on both the Dennys and Sheepscot were structured to develop basinwide population estimates.

We electrofished approximately the same number of sites on the East Machias, Machias, Pleasant, and Ducktrap rivers and Cove Brook as in 2003 and 2004. Among these rivers in the GOM DPS, median parr density was highest on the East Machias River (8.4 /100 m^2) and median density of YOY (24.8 /100 m^2) was highest in the Pleasant River (Table 3.2.4.1).

Juvenile densities at sites in other Maine rivers, within and outside the GOM DPS, varied considerably. Sites that were stocked with fry and/or parr in 2004 (Saco, West Branch Pleasant, Sandy Rivers) had the highest densities (Table 3.2.4.1).

Table 3.2.4.1. Juvenile Atlantic salmon population densities (fish/100m^2) based on multiple pass electrofishing estimates in Maine Rivers, 2005.

River	Young-of-the-Year				Parr			
	Min	Median	Max	Sites	Min	Median	Max	Sites
	Population Estimate Sites							
Dennys	0.0	5.5	20.7	23	0.0	2.4	10.6	25
East Machias	0.0	6.0	28.6	6	0.0	8.4	20.1	7
Machias	0.0	2.8	30.3	9	0.0	5.7	22.3	10
Pleasant	1.5	24.8	29.6	3	0.7	5.0	18.6	3
Narraguagus	0.0	3.2	26.4	38	0.0	2.5	15.3	36
Cove Brook	0.0	0.0	0.0	3	0.0	0.0	0.0	3
Ducktrap	0.2	5.1	30.8	4	2.0	6.5	12.6	4
Sheepscot	0.0	2.3	46.7	28	0.0	2.7	23.6	25

River	Young-of-the-Year				Parr			
	Min	Median	Max	Sites	Min	Median	Max	Sites
	Population Estimate Sites							
Mooseleuk Stream (Aroostook)	0.3	0.3	3.2	3	0.3	2.8	5.3	2
Piscataquis River (Penobscot)	9.4	10.5	17.9	4	0.5	8.1	13.5	4
West Branch Piscataquis River (Penobscot)	45.6	45.6	45.6	1	7.8	7.8	7.8	1
Pleasant River (Penobscot)	0.3	0.3	0.3	1	0.1	0.1	0.1	1
West Branch Pleasant River (Penobscot)	0.2	0.2	0.2	1	0.4	0.4	0.4	1
Souadabscook Stream (Penobscot)	0.0	0.0	0.1	3	0.0	0.0	0.0	3
West Branch Souadabscook Stream (Penobscot)	0.0	0.0	0.0	3	0.0	0.0	0.0	3
Kenduskeag Stream (Penobscot)	0.0	0.0	0.0	31	0.0	0.2	11.4	30
Marsh Stream (Penobscot)	0.0	0.0	0.0	3	0.0	0.0	0.0	3
S. Br. Marsh Str. (Penobscot)	0.0	0.0	0.0	3	0.0	0.7	1.5	2
Felts Brook (Penobscot)	0.0	0.0	0.0	1	0.0	0.0	0.0	1
Pierrepaul Brook (Penobscot)	0.0	0.0	0.0	1	0.0	0.0	0.0	1
Sedgeunkedunk Stream (Penobscot)	0.0	0.0	0.0	1				0
Passagassawakeag River	0.0	0.0	0.0	3				0
Sandy River (Kennebec)	0.0	4.3	30.6	13	0.6	3.5	6.7	11
Bond Brook (Kennebec)	0.0	0.0	0.0	1	0.0	0.0	0.0	1
Avon Valley Brook (Kennebec)	10.9	10.9	10.9	1	0.0	0.0	0.0	1
Saco	0.0	1.0	2.1	2	3.7	4.9	6.2	2

Basinwide Estimates of Large Parr Abundance
Assessment scientists have data to estimate the basinwide production of large Atlantic salmon parr (>1+ fish) using a habitat-based stratification method for the Narraguagus River (1991-2005), the Dennys River (2001-2005), and the Sheepscot River (2003 - 2005). This method uses ecological and geographical data to develop spatially discrete habitat-based strata that minimize differences within strata and maximize differences between strata (J.F. Kocik, NOAA Fisheries Personal Communication).

Smolt Abundance
NOAA-National Marine Fisheries Service (NOAA) and the Maine Atlantic Salmon Commission (ASC), conducted seasonal field activities enumerating smolt populations using Rotary Screw Traps (RSTs) in many of Maine's coastal rivers. Summaries for each river follow.

Penobscot River. The Penobscot River has been sampled with RSTs since 2000. Only one RST operated during the first year, but since that time, three traps have been used annually. In 2005, approximately 556K hatchery-reared smolts were released into the system. More than half (345,438) of these smolts were batch-marked with Visual Implant Elastomer (VIE) Tags. Colors and locations of marks (left/right eye/jaw) were dependant on release time and location. A total of 251 smolts were captured during RST operations in 2005, 152 of which were VIE-marked smolts. Naturally reared smolts averaged 177.9 ±16.4 mm fork length (n = 7) and 52.1 ±10.7 g wet weight (n = 7) (Tables 3.2.4.2 and 3.2.4.3), and were on average smaller than the smolt stocked fish. The 2005 hatchery stocked smolts were larger than in past years.

Of the 251 smolts captured, 217 (86.5%) were hatchery-reared smolts and 22 (8.8%) were marked hatchery fish which were released as fall parr in 2004. 11 smolts (4.4%) were naturally reared (wild origin or fry-stocked) and were of age class 2+ or 3+ (Tables 3.2.4.4 and 3.2.4.5), and one smolt's origin and age could not be determined.

Traps were also operated in the Penobscot River tributary the Pleasant River. Over the three weeks (April 19 -June 2) the traps operated, a total of 316 smolts were captured. Of these only 19 were wild/naturally reared; the remainder were stocked as parr in 2002, 2003, or 2004.

Sheepscot River. The Sheepscot River has been the site of RST operations since 2001. Two RSTs were deployed every year since that time, with the exception of 2003, when no traps were set. The operation of two RSTs below Head of Tide Dam in 2005 resulted in the capture of 154 smolts, one of which was captured twice. Scale analysis revealed that 66 (43%) of the smolts caught in the RSTs were released in 2004 as fall parr (Table 3.2.4.4). The 2004 fall parr release was the first of its kind on the river in recent years. The remaining smolts whose origin could be identified (83 smolts, or 54.2%) were naturally reared. Naturally reared smolts averaged 171.0 ± 7.3 mm fork length (n = 77) and 54.5 ± 6.2 g wet weight (n = 77), and the 2005 naturally reared smolts were of smaller average weight and length than the average over the past 4 years) (Tables 3.2.4.2 and 3.2.4.3).

Narraguagus River. Emigration of Atlantic salmon smolts has been monitored on the Narraguagus River since 1996. In 2005, the river was monitored using five RSTs. Smolts were fin-clipped at an upriver site and recaptured downstream in order to perform a stratified population estimate. Using a Darroch maximum likelihood model, we were able to derive a population estimate of 1,298 ± 529 (Table 3.2.4.6). The population has decreased from 1996 to 2003-2005 (Figire 3.2.4.1).

A total of 514 smolts were captured. Scale samples collected from a sub-sample of smolts revealed that the majority of smolts were of age class 2 (89%), with the remainder being of age class 3 (15%) and age class 1 (<1%) (Tables 3.2.4.4 and 3.2.4.5). Age 2 smolts averaged 166.1 ± 2.4 mm fork length (n = 129) and 44.7 ± 2.1 g wet weight (n=127) (Tables 3.2.4.2 and 3.2.4.3). All Narraguagus River smolts were of natural origin, and were of similar size to smolts of previous years.

Dennys River. The Dennys River has been monitored with several different types of smolt traps since 2001. In 2005, approximately 567K hatchery-reared smolts were released into the Dennys River. These smolts were all batch-marked with VIE tags; Colors and location of marks (left/right eye) were dependant on release time and location. Of the 549 smolts captured in the RST in 2005, 452 were VIE marked, 35 were naturally reared, 44 were from fall parr stocking in 2004, and 13 were from fall parr stocking in 2003 (Table 3.2.4.2). Naturally reared smolts averaged 172.3 ± 5.2 mm fork length (n = 35) and 51.2 ± 4.6 g wet weight (n = 34 (Tables 3.2.4.2 and 3.2.4.3). These smolts were larger than in past years.

We attempted to estimate the number of smolts emigrating from the Dennys River using two methods. In the first method, a population estimate was derived by estimating the volumetric proportion of water sampled daily by the RST and then adjusting for trap avoidance. We estimated an emigrating population of 64,069 smolts, 3,795 of which were naturally reared (Table 3.2.4.7). A measure of dispersion has not yet been developed for this estimation technique. In the second method, we used a mark-recapture approach where we used the capture rate of the marked hatchery smolts to create a relationship between the number of smolts captured versus the number of smolts released. Use of this method resulted in a wild smolt estimate of 3344 ±211.

Smolt Run Timing. The cumulative catches of naturally reared smolts in the Sheepscot River and the Narraguagus River indicate that naturally reared smolts migrate earlier in the southern end of their range (Figure 4). Naturally reared smolts from the four Maine rivers Figure 5. The cumulative catches of naturally reared smolts in the Sheepscot River and the Narraguagus River show that naturally reared smolts tend to migrate earlier in the southern end of their range (Figure 3.2.4.2).

Table 3.2.4.2. Mean fork length by origin of smolts captured in Rotary Screw Traps on four rivers in Maine.

	Naturally Reared (age w.2)		Hatchery (age h.1)	
River	2005	5 year average (2001-2005)	2005	5 year average (2001-2005)
Dennys	172.3±5.2 n=35	162.8±2.6 n=223	182.1±2.0 n=347	180.5±1.2 n=1464
Narraguagus	166.1± 2.4 n=129	167.0±0.5 n=2553	N/A	N/A
Penobscot	177.9±16.4 n=7	173.2±2.5 n=150	185.2±3.6 n=174	190.3±0.8 n=2280
Sheepscot*	171.0±7.3 n=77	181.7±2.1 n=390	164.6±7.9 n=65	164.6±7.9 n=65 (data from 2005 only)

* Not sampled in 2003

Table 3.2.4.3. Mean smolt weight by origin of smolts captured in Rotary Screw Traps on four rivers in Maine.

	Naturally Reared (age w.2)		Hatchery (age h.1)	
River	2005	5 year average (2001-2005)	2005	5 year average (2001-2005)
Dennys	51.2±4.6 n=34	40.5±2.6 n=218	63.1±2.2 n=344	61.7±1.2 n=1433
Narraguagus	44.7± 2.1 n=127	46.9±0.7 n=1420	N/A	N/A
Penobscot	52.1±10.7 n=7	49.1±2.1 n=150	63.7±3.3 n=167	69.9±0.8 n=2214
Sheepscot*	54.5±6.2 n=77	62.1±2.0 n=390	50.9±7.2 n=64	50.9±7.2 n=64 (data from 2005 only)

* Not sampled in 2003

Table 3.2.4.4. Smolt age class and origin from scale data and marks of smolts captured in Rotary Screw Traps on four rivers in Maine.

	Naturally Reared			Hatchery		Naturally Reared	Hatchery	Naturally Reared	Hatchery
River	1+	2+	3+	1+	2+	Overall	Overall	5 year average (2001-2005)	5 year average (2001-2005)
Dennys		35		494	13	35	507	44	626
Narraguagus	1	129	15			145		510	0
Penobscot		8	3	239		11	239	37	481
Sheepscot*		79	4	66		83	66	99	16.5

* Not sampled in 2003

Table 3.2.4.5. Pro-rated origin of smolts captured in Rotary Screw Traps on four rivers in Maine.

	2005		5-year average (2001-2005)	
	Naturally Reared	Hatchery	Naturally Reared	Hatchery
Dennys	6.5%	93.5%	5.7%	94.3%
Narraguagus	100.0%	0.0%	100.0%	0.0%
Penobscot	4.4%	95.6%	4.5%	95.5%
Sheepscot*	55.7%	44.3%	91.1%	8.9%

* Not sampled in 2003

Table 3.2.4.6. Estimated numbers of smolts emigrating in the Narraguagus River.

Year	Total Emigration Estimate	95% C.I.
2005	1,298	529
2004	1,344	488
average, 1997-2005	2,292	N/A

Table 3.2.4.7. Estimated numbers of emigrating smolts in the Dennys River.

Year	# of Smolts Stocked	Total Emigration Estimate	95% C.I.	Estimated % of Naturally Reared Smolts
2005	56,713	64,069	N/A	5.9%
2004	56,339	69,520	N/A	8.0%
time series average	56,284	66,106	N/A	5.3%

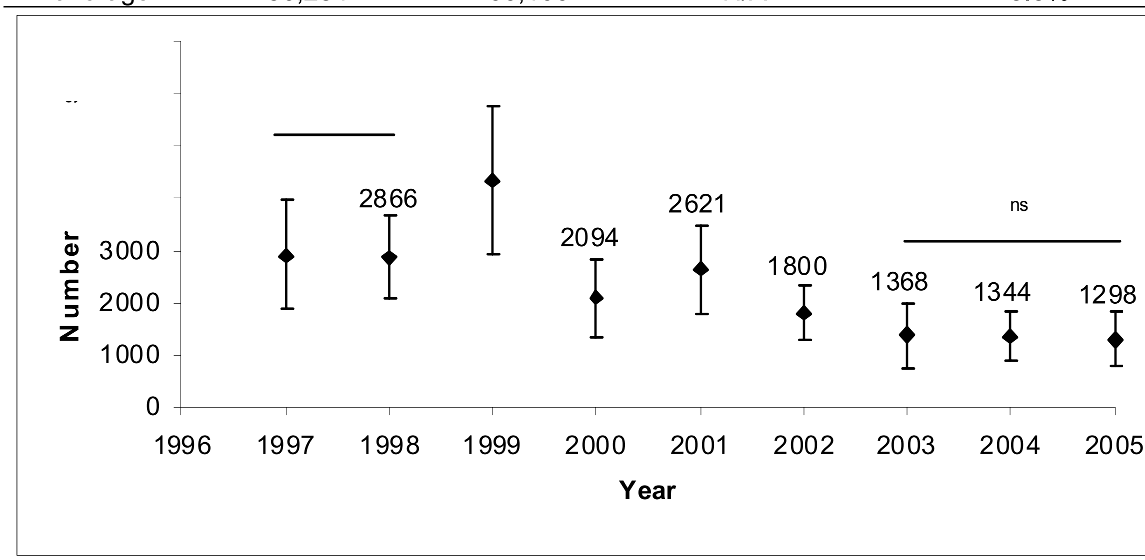

Figure 3.2.4.1. Estimated number of emigrating smolts in the Narraguagus River, 1997-2005. Estimates covered by a common bar are not different (Tukey Test).

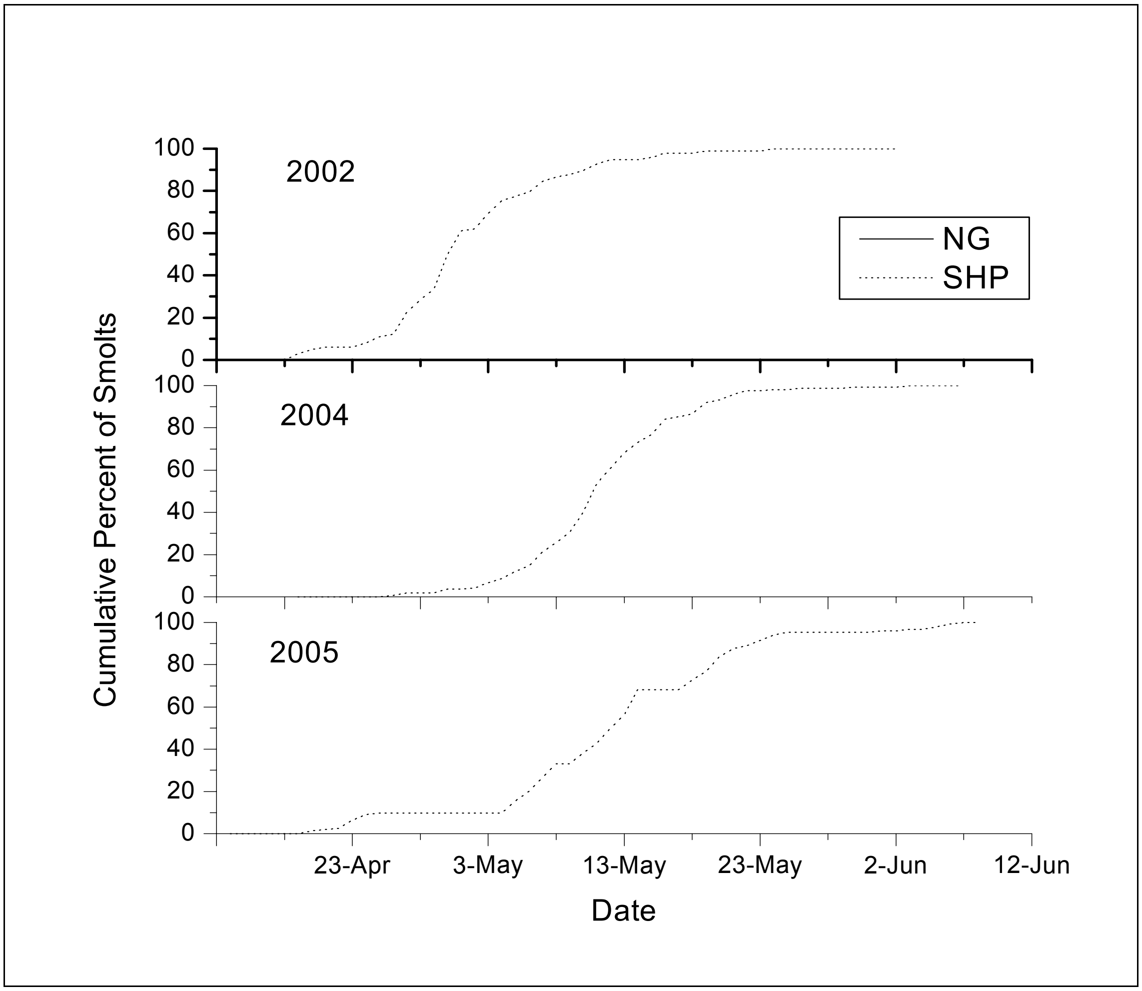

Figure 3.2.4.2. Run timing of smolts on the Narraguagus and Sheepscot Rivers based on cumulative RST catches for years 2002, 2004, and 2005.

Smolt Telemetry Studies

NOAA-National Marine Fisheries Service (NOAA) has used ultrasonic telemetry to assess Atlantic salmon smolt migration since 1997. In 2005, naturally reared (n = 65) and hatchery produced (n=311; 1+) smolts were released at various locations and stocking dates into three different watersheds (Narraguagus, Dennys and Penobscot Rivers). Fish movement was monitored throughout riverine, estuarine, and near-shore marine environments to observe migration dynamics of the outmigrating smolts. Survivorship of smolts to the furthermost quantitative marine array ranged from 11.43 to 62.9 % (Table 3.2.4.8).

Table 3.2.4.8. Survivorship of tagged smolts based on telemetry detections at the start and end of ecological zones.

Ecological Zone	Narraguagus N (%)	Dennys (FW) Early N (%)	Dennys (FW) Late N (%)	Dennys (Est) Early N (%)	Dennys (Est) Late N (%)	Penobscot Early N (%)	Penobscot Mid N (%)	Penobscot Late N (%)
Initial Detection	62 (95.38)	35(100.00)	34 (97.14)	NA	NA	45 (90.00)	49 (98.00)	47 (94.00)
Freshwater	61 (98.39)	34 (97.14)	34 (100.00)	NA	NA	NA	NA	NA
Estuary	53 (86.89)	19 (55.88)	20 (58.82)	27 (77.14)	27 (77.14)	41 (91.11)	41 (83.67)	38 (80.85)
Marine	39 (73.58)	4 (21.05)	6 (30.00)	10 (37.04)	11 (40.74)	24 (58.54)	24 (58.54)	18 (47.37)
Overall	39 (62.90)	4 (11.43)	6 (17.14)	10 (28.57)	11 (31.43)	24 (53.33)	24 (48.98)	18 (38.30)

FW: Freshwater release EST: Estuary release NA: Not Applicable

Narraguagus. Telemetry assessments on the Narraguagus River have been occurring since 1997. In 2005, the array didn't extend into Narraguagus Bay as previous studies (USASAC, 2004) because the telemetry study was being used assess double-crested cormorant harassment adaptive management program. However, 2005 smolt survivorship into the near-shore marine environment was similar to previous years even though harassment activities took place.

Dennys. Telemetry assessments on the Dennys River have been conducted since 2001. Survivorship to Cobscook Bay has been low, so beginning in 2004 an estuary site was added to experimental stocking locations. Survival was slightly greater for the estuary-released fish compared to survival of those released at the freshwater release site.

Penobscot. This was the first year that ultrasonic telemetry was used to assess emigrating hatchery reared Atlantic salmon smolts in Penobscot estuary and Penobscot Bay. Early release groups experienced higher survival than later release groups. These results may be attributable to environmental conditions, predation, or a combination of the two.

Depth tagged smolts were examined separately from the other release groups due to tag size and the timing of surgeries. The earlier release group experienced higher survival than the late release group while the average migration time was similar between the two groups. Average depths of 1.25 and 2.63 meters were observed for the two release groups and depth decreased approximately one meter between the estuary and the marine environment for both depth tagged release groups. Our results suggest that with an early release, the smolt migration is likely to last longer but the smolts have a greater migration survivorship. In addition, depth tag data confirmed our assumption that smolt prefer the top 5 meters of the water column.

3.2.5. Fish Passage

Fisheries agencies in Maine continue to work to improve existing up- and down-stream fish passage, to have fish passage at dams where none exist, and to remove dams and other blocks of habitat connectivity. Thus, fish passage work in Maine focuses on FERC licensed dams on the Penobscot, Kennebec, and Saco rivers and on opportunities to enhance passage throughout historic Atlantic salmon habitat. This includes participating in activities associated with: the Penobscot River Restoration Project, passage facility construction plans at the Lockwood (Florida Power and Light), Benton Falls (Benton Falls Hydro Associates), Burnham (Ridgewood Maine Hydro Partners), Anson and Abenaki (Madison Paper Industries) and Fort Halifax

(Florida Power and Light) projects, removing Sandy River (Town of Madison), and replacing culverts on highways and logging roads. On the Narraguagus River, ASC has been working with the Town of Cherryfield to repair the fishway at the ice control dam. The town has consulted with FWS for engineering plans and the most affordable plan, to line the wood fishway with aluminum, is being persued. FWS has prepared a Biological Opinion for a project at Marion Falls on Cathance Stream. MDOT and Federal Highway Administration (FHA) have included rehabilitating the fishway and eliminating the hydraulic restriction at the existing bridge over Cathance Stream in a project to replace the bridge. There has been progress resolving the conflicts associated with providing fish passage at the West Winterport Dam on the Marsh River, a tributary to the Penobscot River estuary, and Coopers Mills Dam on the Sheepscot River.

3.2.6. Genetic sampling

Since 1999, all broodstock at CBNFH have been PIT tagged and sampled for genetic characterization via fin clips. This activity allows for the establishment of genetically identifiable fry and smolt families, which can be tracked through non-lethal fin samples at various life stages. Genetic characterization of broodstock prior to spawning also allows biologists an opportunity to identify and manage undesirable genes, such as those associated with aquaculture escapees. When individual genetic results are used in conjunction with gene optimization software (see section 2.2.2 Hatchery Research Section), matings can be assigned during spawning to achieve specific program goals, such as increasing genetic diversity by eliminating sibling or other closely related family matings.

To reduce handling stress, tag loss, and tagging-related mortality, juvenile broodstock are currently tagged one year post-capture at CBNFH. This allows the fish to reach an appropriate size to allow for intramuscular insertion of PIT tags. In October 2005, 1,058 DPS broodstock (collected in 2004) were PIT tagged, sampled for future genetic characterization, and moved from the CBNFH Receiving Building to broodstock modules. An additional 1,586 Pleasant River domestics (first line of captive reared fish at CBNFH) were also sampled for their potential use in future pedigree lines.

3.2.7. General Program Information

Recovery Plan for GOM DPS
NOAA Fisheries and the US Fish and Wildlife Service released the *Final Recovery Plan for the Gulf of Maine Distinct Population Segment of Atlantic Salmon* in a Notice of Availability published in the Federal Register on Tuesday December 20, 2005. The Final Recovery Plan can be downloaded at http://www.nmfs.noaa.gov/pr/readingrm/Recoverplans/atlantic_salmon_rp.pdf . Requests for a copy of the final recovery plan should be addressed to the Atlantic Salmon Recovery Coordinator, NMFS, Northeast Regional Office, Protected Resources Division, One Blackburn Drive, Gloucester, MA 01930. Questions can be directed to Jessica Pruden, NMFS Atlantic Salmon Recovery Coordinator, by phone at (978) 281-9328 extension 6532 or e-mail at Jessica.Pruden@noaa.gov, Melissa Laser, Maine Atlantic Salmon Commission, by phone at 207/287-9972 or e-mail at melissa.laser@maine.gov, or Mark McCollough, US Fish and Wildlife Service, by phone at (207) 827-5938 or e-mail at mark_mccollough@fws.gov.

Salmonid Pathogens in Northwestern Atlantic Fishes
Tissues from more than 5,000 fish of 22 different species collected during 2000 to 2005 were assayed in efforts to identify potential reservoirs of salmonid pathogens. Fish were taken from the natural environment (rivers, Maine coastal areas, and open ocean) and from net pens containing Infectious Salmon Anemia-diseased salmon. Assays included cell culture for listed salmonid pathogens, direct fluorescent antibody test for *Renibacterium salmoninarum*, and reverse transciptase-polymerase chain reaction specific for ISAV (ISAV-RT-PCR). RT-PCR for Salmon Swimbladder Sarcoma Virus (SSSV-RT-PCR) was performed only on smolts used in streamside experiments. West Greenland salmon were tested by ISAV-RT-PCR only. ISAV-RT-PCR positive results were obtained from two of 44 pollock (*Pollachius virens*) taken from inside net pens containing ISA-diseased salmon, from one alewife (*Alosa pseudoharengus*) taken from the Narraguagus River, and from one of 326 Atlantic salmon (*Salmo salar*) collected from the West Greenland commercial fishery. ISAV was isolated from one of 24 pools of tissue collected from cod (*Gadus morhua*) taken from a well-boat containing harvested clinically diseased salmon. The North American strain of Viral Hemorrhagic Septicemia virus (VHSV) was isolated from one herring (*Clupea harengus harengus*) taken from Maine coastal waters. All fishes tested negative for *R. salmoninarum*. The results indicate that salmonid viruses in wild fish populations in Maine are extremely low, and the source of ISAV in cultured salmon in Maine remains to be determined.

NOAA-Fisheries Service Water Quality
Throughout the 2005 calendar year (January 1 – November 30), NOAA's National Marine Fisheries Service (NOAA) collected water quality data on five of Maine's Atlantic salmon rivers. Data sondes collecting pH and temperature data on the Sheepscot (river km 10.35), Narraguagus (river km 11.08), Pleasant (river km 42.61), and Dennys (river km 0.38) Rivers were deployed the entire year, while one sonde was deployed on the Penobscot (river km 45.72) from April 19 to June 20. "Grab" samples collected from the Sheepscot, Penobscot, and Narraguagus Rivers, and analyzed at the Senator George J. Mitchell Center at the University of Maine, were used to validate pH data from the sondes. River pH values ranged from 4.27 to 7.77. Besides using data sondes and grab samples to collect water quality data, a series of temperature loggers were deployed on the Penobscot, Narraguagus, and Dennys Rivers, as well as several loggers in the Sheepscot, Penobscot, and Narraguagus Rotary Screw Traps (RST) from mid April to mid June. The maximum temperatures ranged from 23^{o}C to 27^{o}C.

Point Stocking, an Alternative Fry Stocking Strategy
In an attempt to reduce some of these costs and simplify scheduling among agencies, ASC began exploring point stocking as an alternative method of stocking in the spring of 2005. Point stocking consists of releasing all the fry designated for a specific reach into one location (typically the upper portion of the reach) as opposed to distributing them throughout the reach, as present methods employ. The point stocking location will have adequate nursery habitat to temporarily support a large number of fry as they volitionally disperse themselves throughout the reach in a more natural manner. The three drainages where selected: 1) Narraguagus River (2 sites stocked, 1 mainstem and 1 tributary site), 2) Sandy River (2 mainstem sites), and 3) East Machias River (3 tributary sites). Follow up electrofishing surveys where conducted in the fall at multiple sites within each study area to provide an overall picture of juvenile salmon movements and densities throughout area downstream of the point stocking site. We plan to duplicate this stocking and electrofishing regime at these locations for a minimum of three years.

Origin of Naturally Reared Adult returns in the Penobscot River
Parentage analyses are being used to determine the origin of naturally reared returning adults to the Penobscot River. In 1999, CBNFH began tracking matings that produced fry stocked in the Penobscot drainage. The first full cohort with the potential for being assigned to individual matings will return in 2005. The objectives of the study are: 1) To identify those from hatchery spawning and therefore fry stocking to refine estimates of natural reproduction, 2) To determine if hatchery produced fry are proportionately contributing to the naturally reared component of the Penobscot salmon run, and 3) To assess fry stocked returns to river reach or tributary. Results from this study will be used to guide future Penobscot River stocking, hatchery and broodstock recommendations and management decisions.

Pike
In summer of 2003, the Department of Inland Fisheries and Wildlife Enfield Regional Office received the first report of northern pike *Esox lucius* in Pushaw Lake. Since that time more pike catches have been reported and confirmed by regional fisheries biologists. Pushaw Stream, the outlet to Pushaw Lake, enters the Penobscot River in an impounded riverine reach formed by the Gilman Falls Dam on the Stillwater River and the mainstem Penobscot River impoundment created by the Milford Dam. Because pike have access to the Milford impoundment, they could easily move upstream and downstream in Penobscot drainage, as pike have been documented to move extensively during annual spring spawning migrations.

Maine Department of Inland Fisheries and Wildlife and ASC have joined in a collaborative effort to determine the status of pike in Pushaw Lake and the surrounding drainage, and to explore the potential options for pike eradication from Pushaw, or to at least control the spread of pike from Pushaw Lake to, and throughout the Penobscot drainage. In fall of 2005, no pike were captured in Pushaw Lake for telemetry studies to identify preferred pike spawning areas in the lake. In February 2006, two pike were captured and tagged and are currently being tracked weekly. A creel clerk has been conducting an angler survey on Pushaw Lake during winter 2006 to gather information on the distribution and abundance of pike throughout the lake. In addition, the clerk provides information to anglers, and camp and homeowners about the implications of this illegal introduction and to build local, regional, and statewide support for containment and control efforts. Finally, a bioengineering committee has been formed to investigate the potential for excluding pike from the Piscataquis and upper Penobscot rivers using exclusionary technology and modifications at existing fishways at dams located in Howland and West Enfield.

Penobscot Fishery Explored
An ad hoc working group to the Maine TAC was charged with conducting a risk assessment of potential mortality associated with a recreational catch and release fishery for Atlantic salmon in the State of Maine. The risk assessment modeling effort ultimately focused on a fall fishery in the Penobscot River below Veazie, with the objectives of producing simulations that relate the effect of angler effort to expected number of fish killed. Simulations based on encounter rates allow informed decision regarding potential mortality associated with the amount of fishing effort that could be expected if a fishery is reestablished. Further, the approach allowed the opportunity to include recaptures and would better simulate overall mortality associated with C&R. Based on recent returns, a September and October fishery below Veazie would expose less than 50 fish to angling. For 50 fish exposed to a fishery, effort below 1,600 angler trips

(average length 4 hours) would result in less than 1 fish killed. A potential regulation is being drafted and will be presented to the Maine Atlantic Commission Board in March.

3.2.8. Salmon Habitat Enhancement and Conservation

Habitat Connectivity

A collaborative multiple agency and private landowner educational opportunity/field workshop was held on improving fish (aquatic) passage using stream simulation design. This workshop was organized by the non-profit group Project SHARE (Salmon Habitat and River Enhancement. As a result of the workshop a bottomless arch culvert was design and permitted to restore stream habitat on a tributary of the West Branch Machias River.

An on-site workshop on Sept.21st started with presentations from the MEFRO, USFWS Maine Ecological Services Field Office, Maine Atlantic Salmon Commission, Maine Land Use Regulatory Commission, Maine Forest Service, Project SHARE and the commercial landowner. Then a perched undersized culvert was removal and a bottomless arched culvert constructed to replace it. The culvert was designed through the group's knowledge of stream simulation modeling. Participants included biologists from the USFWS Gulf of Maine Project Office, and NOAA Fisheries.

NPS Restoration

Project SHARE, watershed stakeholders, and Watershed Councils with funding from a variety of sources including NFWF and ASC, were involved in restoration projects that include re-vegetating NPS sites and reforesting riparian buffers in 2005. SHARE's principle role has been project management and developing corporate partners for a collaborative effort in NPS abatement. NPS sites were selected for restoration in 2005 based on priority criteria established by the SHARE Restoration Working group in cooperation with the landowners.

References:

Kane, T. R. 1987. Monitoring Development of Atlantic Salmon from Fertilization through Yolksac Absorption. USFWS. Northeast Fishery Center. Lamar Fish Technology Center, Information Leaflet 88-02, Lamar, PA.

3.3 Merrimack River

3.3.1 Adult Returns

Thirty-four sea run Atlantic salmon returned to the Essex Dam Fish Lift, MA on the Merrimack River during 2005.Volunteers from New Hampshire Trout Unlimited and Manchester Fly Fishers assisted MADFW and USFWS personnel in trapping and counting returning fish at the fish lift. Salmon were captured and transported to the Nashua National Fish Hatchery (NNFH), and six died in transit to the hatchery or prior to spawning. Of the 34 fish captured, readable scale samples were collected from all. Forty-seven percent (16 fish) of returning adults were females and 50% (17 fish) were males. One fish was a non-spawner. Twenty-five surviving sea run adults were transferred to North Attleboro National Fish Hatchery (NANFH), MA after all fish at the Nashua National Fish Hatchery tested negative for disease pathogens.

Scales from thirty-four Atlantic salmon were analyzed to determine age and origin of the fish. Analyses determined thirty-three to be of hatchery smolt origin (97.1%) and one to be of stocked fry origin (2.9%). Eight (23.5%) smolt origin fish were determined to be grilse (1SW) and twenty-five (76.5%) were two sea winter fish (2SW). The single stocked fry origin adult was a two sea-winter fish.

The current estimated rate of return (#/10,000 fry stocked) for the 2001 fry cohort was 0.018 with two grilse (W2.1) captured last year and one 2SW (W2.2) captured this year (Table 3.3.1.1). The rate of return remains low when compared to rates observed in the late 1980's through the mid 1990's (range: 0.1 to 0.6), and very low when compared with rates observed in the mid 1970's to late 1980's (> 1.0). A potential factor contributing to the very low return rate may have been the exceedingly high flow that occurred during both the spring/summer and fall passage seasons. Salmon mortalities were reported in the lower Merrimack River during the summer of 2005, and these fish may not have been able to locate the entrance to the Essex Dam Fish Lift due to prolonged high flows in spring.

3.3.2. Hatchery Operations

Atlantic salmon fry produced for release in the watershed were provided by the NANFH (65%, 643,800) and the Warren State Fish Hatchery (WSFH),NH (35%, 342,700). The parentage of fry stocked in 2005 was composed of sea run origin fish (40%, 396,214), domestic brood stock (35%, 342,700), and reconditioned kelts (25%, 247,586). All fry of sea run and kelt parentage are part of a genetic characterization/marking program.

Egg Collection
Sea-Run Broodstock
Thirty-four sea run Atlantic salmon were trapped at the Essex Dam in 2005. Thirteen females and 14 males were spawned during fall spawning operations. Fish were spawned between 20 October and 15 November and produced 121,505 eggs. The 13 females produced an average of 9,347 eggs each. Approximately, 110,993 green eggs were shipped to NANFH for incubation and fry production for release in the lower Merrimack River watershed. Approximately 10,512 sea-run eggs (7.6%), were retained at NNFH as future broodstock aliquots. Initial figures indicate 72% eye up rates for eggs retained at NNFH.

Table 3.3.1.1. Fry origin adult Atlantic salmon returns, Merrimack River, Years 1994 – 2001.

Stocking Year	Adult Sea Run Returns of Fry Stocking Origin						Number of Fry Stocked	Return Rate (per 10,000)
	2.1	2.2	2.3	3.1	3.2	Total Returns		
1994	8	45	0	0	1	54	2,816,000	0.19
1995	19	63	0	5	0	87	2,827,000	0.31
1996	4	23	0	0	0	27	1,795,000	0.15
1997	1	3	0	0	0	4	2,000,000	0.02
1998	2	6	0	0	0	8	2,589,000	0.03
1999	1	4	0	0	3	8	1,756,000	0.05
2000	0	11	0	0	0	11[a]	2,217,000	0.050
2001	2	1	-	0	-	3[a]	1,708,000	0.018[a]
2002	-	-	-	-	-	-	1,414,000	-
2003	-	-	-	-	-	-	1,335,000	-
2004	-	-	-	-	-	-	1,541,500	-
2005	-	-	-	-	-	-	962,500	-

[a] Estimate.

The return rate for sea run adults from hatchery smolt origin was also low (Table 3.3.1.2). High flow conditions likely affecting the return rate of hatchery fry origin adults may have contributed to a lower rate of hatchery smolt origin returns.

Table 3.3.1.2. Hatchery smolt origin adult Atlantic salmon returns, Merrimack River, 1996 - 2003.

Stocking Year	Adult Sea Run Returns				Number of Smolts Stocked	Return Rate[a]
	H1.1	H1.2	H1.3	Total Returns		
1996	9	45	0	54	50,000	1.08
1997	11	65	0	76	52,500	1.45
1998	46	32	0	78	51,900	1.50
1999	26	73	0	99	56,400	1.76
2000	5	17	0	22	52,500	0.42
2001	31	129	2	158	49,500	3.19
2002	12	89	0	101	50,000	2.02
2003	17	26	-	43[b]	49,600	0.87[b]
2004	-	-	-	-	50,000	-
2005	-	-	-	-	50,000	-

[a] Return Rate: # adult sea run returns/1,000 smolts stocked.
[b] Estimate.

Captive/Domestic Broodstock
A total of 191 female domestic broodstock reared at the NNFH provided an estimated 690,760 eggs in 2005. The domestic spawning season began on 1 November and ended 22 December, encompassing thirteen spawn events. Approximately, 630,232 eggs were collected from domestic broodstock and shipped to NANFH between 1 November and 8 December. Egg eye up should approach 70%. When these eggs reach the eyed developmental stage, approximately 80% will be transferred to WSFH for fry production and release in the upper Merrimack River watershed. The remaining 20% of the eggs will remain at NANFH for fry production, use in education programs and release in the Pawcatuck River, RI. Approximately 60,528 domestic eggs were retained at NNFH for fry production to support outreach programs.

NANFH collected 697,441 eggs from three year classes (2001 - 2003) of kelts. Sixty-five females and forty-nine males were spawned from 26 October to 8 December. Kelts from the 2004 year class were sacrificed at NNFH after spawning due to a furunculosis infection and concern over spreading the disease.

3.3.3. Stocking

Approximately one million juvenile Atlantic salmon were released in the Merrimack River watershed during the period April - June 2005. The release included approximately 962,500 unfed fry (NANFH), 1,657 parr (NNFH), and 50,000 yearling smolts (GLNFH). Although 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 used to differentiate between fish stocked as fry, parr, or smolts. Parr were not tagged or marked prior to release.

All major tributaries upstream from the Nashua River, NH, excluding the Winnipesaukee River, were stocked with fry. Numerous small tributaries to the Merrimack River and its principal tributary system, the Pemigewasset River, also were stocked.

3.3.4 Juvenile Population Status

The majority of smolts were released into the main stem of the Merrimack River a short distance downstream from the Essex Dam, MA in early April. Smolt stocking has been timed to reduce the potential impacts of predation by striped bass. Bass typically arrive in the estuary and near shore coastal environment in mid to late April. In addition, 132 smolts (49 radio tag, 83 HI-Z Turb'N Tag) were released in the Merrimack River (NH) as part of downstream fish passage studies at hydroelectric sites.

Yearling Fry / Parr Assessment
Seven sites, one in each of seven rivers, were sampled in 2005. In previous years, during the period 1994 – 2003, a stratified sampling scheme was used to determine the abundance of yearling parr in the Merrimack River watershed. Habitat was stratified into four regions, where each region has different characteristics that included climate, geography, geology, hydrology, and land use. This sampling scheme provided the opportunity to determine parr estimates for the basin, regions, and geostrata. Sampling has been directed at yearling parr and involves

electrofishing during late summer and early fall. Data collection involved a cooperative effort and included staff from the NHFG, USFS, USFWS, USACOE and volunteers.

The seven sites represent the traditional "index" sites established as early as 1982 in some rivers, and data derived from sampling at sites provides an extensive time series of parr abundance and density at sites among years. The seven sites included a total of approximately 165.4 units (one unit = 100 m^2) of juvenile habitat. Sites are located on the East Branch Pemigewasset, Pemigewasset, Mad, Baker, Smith, South Branch Piscataquog, and Souhegan rivers. The estimated number of available habitat units in the watershed is 64,900 and of the total units available, approximately 58,000 were stocked with fry in 2005.

During the period 1994 - 2003 stocking density of fry had been altered to evaluate population level responses to different stocking rates. 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 index sites and other sites in the watershed suggested that past high stocking densities had resulted in density dependent factors that adversely affected the growth and survival of parr. Given the shifts in stocking densities, parr abundance and densities presented in Table 3.3.4.1 do not reflect a standardized stocking effort.

Table 3.3.4.1. Estimates for age 1 parr per habitat unit at sample sites in the Merrimack River watershed, 1994 – 2005.

Sample Site	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Mean	SD	CV
				3.6		11.			.3					.4	68
Needleshop			6.1	13.6	5.2	6.4	1.2	1.5	7.6				5.9	4.2	70
Blood															0
Mid Mad	3.3	2.5					6.7	1.9	7.1				4.3	2.4	57
				0.9		*4*	*0.9*		*2.8*					.8	83
S.B. Piscat.*	*3.5*	*2.8*	*8.7*	*3.7*	*5.5*	*3.4*	*1.6*	*2.1*	*4.1*	*0.1*	*1.2*	*1.2*	3.1	2.3	74
ker*	*5.5*			*1.2*	*4*	*3*	*0.5*		*4.9*					.7	56
Stirrup								1.1	4.4				2.8	2.4	85
	1	*.3*		*1.2*	*8*	*1*	*0.2*		*3*					.8	102
Souhegan*	*3.1*	*1.8*	*4.5*	*0.1*	*11.7*	*0.3*	*0.5*	*0.1*	*1.8*	*0.9*	*1.5*	*0.3*	2.2	3.3	148
ood.		.3		1.6		2	3		5.3						61
Pemi Hist*	*0.6*	*8.8*	*0.5*	*1.7*	*1.2*	*1.4*	*4.1*	*1.1*	*3.5*	*2.8*	*4.7*	*5.5*	3	2.5	82
				0.8		1	4.6		2.8					4	54
Lower Mad*	*0.6*	*4.3*	*1.4*	*1.8*	*2.9*	*3.2*	*2.5*	*1.3*	*3.2*				2.4	1.2	50
	1.3	*.8*		*2.7*			*2.7*		*2.1*						35
U. Baker*	*1.9*	*5.5*	*2.1*	*0.8*	*2.4*	*1.1*	*1.4*	*2.5*	*2.3*				2.2	1.4	62
	1	*.2*		*1.4*		*1*	*0.7*		*4.2*	*1*				1.4	65
Mid Pemi		5.2	0.7	1.8	1.8	2.6	1.6	1	2.3				2.1	1.4	66
emi*	*2.7*	*.3*		*0.5*		*7*	*0.2*		*2*					2.2	106
L. S.B. Baker*	*3.4*	*3.4*	*2*	*1.1*	*1.7*	*1.5*	*0.5*	*2*	*2.6*				2	1	48
Mad*	*1.8*	*2.9*	*0.8*	*1.2*	*2.4*	*0.7*	*3*	*0.9*	*2*	*2.2*	*2.1*	*1.9*	1.8	0.8	43
Lower Pemi		3.5	0.3	0.6	1	2.7	1.3	0.6	1.9				1.5	1.2	78
U Souhegan	1.3	0.9	6.5	0.3		0.1	0.3	0.1	0.6				1.3	2.2	170
Mid Piscat.	3.4	1.3	0	0	4.2	0.3	0	0.3					1.2	1.7	143
Black	0.5	1.6	1.4	0.5	3.8	1.6	0		0				1.2	1.2	105
Mill		2.1	0.5	0.3	1.8	1.4	2.2	0.7	0.5				1.2	0.8	66
L. S.B. Piscat.	2.2	0.8			0.4								1.2	0.9	82
Blake	1.6	1.2	0.5										1.1	0.6	50
Beards	0.9	0.5	1.8		3.5	0.4	0.1	0.2	0.9				1	1.1	108
Punch								0.3	1.3				0.8	0.7	85
E.B Pemi*	*1.6*	*3.4*	*0.1*	*0*	*0.1*	*0.5*	*0.5*	*0*	*1*	*1.4*	*0.3*	*0.7*	0.8	1	123
Academy		0.3	0										0.1	0.2	141
Select Mean*	*2.2*	*3.9*	*2.9*	*1.3*	*4.2*	*2.4*	*1.4*	*1.1*	*2.8*	1.4	1.8	2.3	2.4	2	88.1
SD*	*1.4*	*1.9*	*2.7*	*1*	*3.3*	*1.9*	*1.2*	*0.8*	*1.1*	0.9	1.4	1.9	0.9	1	35.8
CV*	*63*	*48*	*92*	*75*	*79*	*82*	*90*	*72*	*38*	63	76	84	38	48	41
Mean													**2.4**	**1.7**	**80**

3.3.5. Fish Passage

Impacts of River Obstructions

Approximately 60% of the juvenile production habitat in the Merrimack River watershed 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. Fish passage studies have been conducted at all seven mainstem hydroelectric generating facilities with the most recent studies continuing in 2005. Tributaries throughout the watershed 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. Fishery resource agencies have recently focused more intensively on mitigating impacts associated with fish passing mainstem dams, and as such, have coordinated with the two principle hydroelectric owner/operators of mainstem dams that include Northeast Utilities - Public Service Company of New Hampshire [five (5) NH mainstem dams] and Enel North America, Inc. [two (2) MA mainstem dams].

Comprehensive fish passage plans, identifying necessary measures, implementation schedules, and study criteria have been developed and implemented throughout the last two decades. A draft annotated list of references identifying fish passage studies to date was compiled and presented at the 2004 stock assessment meeting.

Studies and evaluations of fish passage efficiency and effectiveness at most mainstem and numerous tributary dams have occurred. Studies have demonstrated that smolt mortality occurs at dams due to a variety of reasons (turbine entrainment, passage route, predation) and that seaward migration is impeded or delayed at dams. Water flow regimes, altered during the period of seaward migration due to the presence of dams, can negatively impact migrating smolts. While extensive studies to evaluate smolt passage and survival have been conducted at hydroelectric sites in the watershed, work continues at both mainstem and tributary dams to improve the effectiveness and efficiency of upstream and downstream passage for salmon and a variety of other fish species.

All returning adult salmon are currently captured at Essex Dam, the first upstream dam from tidewater. The construction of additional upstream fish passage facilities at both mainstem and tributary dams to provide fish access to spawning habitat is not likely in the near term. The number of adult returns has been low and while target levels have been identified that require construction of additional fish passage facilities throughout the watershed, they have not been reached so as 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 improve and ensure the survival of migrating salmon and other fish species.

Upstream and Downstream Fish Passage – Mainstem Dams
At Essex Dam, a new lift assembly including hopper, guide rails, and lifting apparatus was installed in fall of 2004. The completion of this critical modification has minimized delays in upstream migration of numerous fish species including Atlantic salmon. Older facilities had become less reliable and prone to failure and malfunction during the fish passage season. The new facilities were operated and tested in fall 2004 and were fully operational in spring 2005.

PSNH continues consultation with fishery resource agencies regarding renewal of an operating license for the Merrimack River Project (Amoskeag, Hooksett and Garvins Falls dams - FERC No. 1893), and as a result, these facilities continued to be examined for operational and structural improvements to benefit a number of fish species. Studies at this project in the spring of 2005 again focused on video monitoring of the Amoskeag Dam fish ladder targeting American shad and eels, and studies in fall were directed at ensuring efficient and effective downstream passage of salmon smolts and other migratory fish species. In addition, an extensive de-watered bypass reach is being considered for additional in stream flows. This development is expected to lead to competing attraction water for fish in the reach and likely require the installation of upstream fish passage facilities on the east side of the dam, opposite the existing powerhouse and fish ladder entrance on the west side of the river.

A smolt passage survival study using the HI-Z Turb'N Tag recapture technique was conducted at the Garvins Falls facility. The study was undertaken to determine if injuries/mortality were occurring during smolt passage through the louver bypass/collector and plunge pool. The sample size for this investigation was set at 50 fish (30 treatment and 20 controls). The treatment fish were released by hand tossing (dropping) the fish approximately three feet into the water just below the first fall of the bypass/collector. This release location ensured the fish would experience the effects of both the plunge pool drop and passage through the exit chute. Control fish were released into the water at the end of the exit chute. During all fish releases the bypass/collector was operated at the full open position (normal setting). The discharge was approximately 80 cfs and the river temperature was 13.0 C (55.4 F).

Recapture rates (physical retrieval of alive and dead fish) of both treatment and control groups were 100%. All the treatment and control fish were alive upon recapture. Two control fish became stuck under rocks in the discharge area and were unrecoverable. These two fish were replaced to insure the pre-determined sample size. The one hour and 48 hour survival assessments for juvenile Atlantic salmon passing the louver system were identical (100%). None of the 30 recaptured treatment fish or the 20 control fish had injuries attributed to the passage through the louver bypass system. All treatment and control fish were actively swimming at the end of the 48 hour post-passage assessment period.

A radio telemetry study was conducted at the Hooksett Falls facility during the spring 2005. Forty-nine radio tagged smolts were released above the Hooksett Dam and their movement past the station was tracked by utilizing antenna coverage of the spillway, headpond, forebay, bypass, and tailrace. Forty smolts were detected using the spillway (the flashboards were not installed during the study due to high water). Five smolts were never detected at the project and four smolts were detected in the headpond but not detected passing over the spillway. The four smolts were assumed to have passed over the spillway but their transmitter signal was not recorded due to radio tag signal “collisions”. No smolts were detected in the forebay or in front of the intake racks and no smolts were ever detected in the tailrace.

PSNH plans to conduct a smolt survival study of the Amoskeag Dam crest-gate bypass during the spring of 2006. In addition, they will work cooperatively with the USFWS and NHFGD to operate the Ayers Island Dam fish sampler during the 2006 downstream smolt migration and will continue meeting regularly with the state and federal fishery resource agencies to develop fish passage strategies and monitor the progress of fish passage agreements.

3.3.6. Genetics

Funding was secured in 2002 for genetic analyses of domestic broodstock, sea-runs, and kelts used in hatchery production programs. Fin samples from all sea runs and kelts and a sub-sample of domestic broodstock were obtained and archived for analysis by the USFWS, Northeast Fishery Technology Center. Paired matings in the fall of 2005 were tracked by tissue samples with eggs/fry segregated in hatcheries to enable the identification of parent origin and point of initial stocking in defined geographic regions. These regions are primarily partitioned into lower (sea run parentage fry), middle (kelt parentage fry), and upper watershed (domestic parentage fry).

Sea run fry develop at an earlier date due to the time of spawning, which subsequently leads to targeting lower watershed tributaries for this group in early spring. A primary point of interest is whether fry-origin adult returns are occurring from areas in proportion to stocking densities, or if other mechanisms (improved fitness of sea run fry) or impacts (dams in the upper watershed) are affecting stream reared smolt production and subsequently the proportion of adult returns from these areas. The results of genetic analyses will provide opportunities to better understand genetic relatedness among fish and to subsequently develop improved and refined mating protocols. Laboratory analyses of tissue samples are complete and it is anticipated that results will guide culture and management measures to be implemented in future years. Sea run adults returning in 2006 will be the first fish that can be identified genetically based on parentage and stocking location.

3.3.7. General Program Information

Atlantic Salmon Domestic Broodstock Sport Fishery

The NHFG via a permit system manages an Atlantic salmon broodstock fishery in the mainstem Merrimack River and a lower portion of the Pemigewasset River. Whereas angled Atlantic salmon required an angler tag for harvest in previous years, rule changes have now eliminated the angler tagging requirement. Creel limits are one fish per day, five fish per season with a minimum length of 15 inches. The season is open all year for taking salmon with a catch and release season from 1 October to 31 March. In spring 2005, 952 (age 2 and 3) domestic broodstock were released for the fishery. In fall 2005 an additional 443 (age 2 and age 3) broodstock were released for a combined total release of 1,395 fish to support the fishery in the main stem of the Merrimack River and small reach of the Pemigewasset River.

There is a one year lag time in reporting from angler diaries which results in this summary characterizing the 2004 fishery. There were 1,139 salmon stocked and 1,920 permits sold in 2004 from which an estimated 474 anglers actually fished for salmon. The majority of the anglers were NH residents, 12% were nonresidents. Anglers fished an estimated 7,075 hours during fishing trips. They caught an estimated 801 fish, released 754, and kept 47 salmon. Catch per unit effort indicates that anglers fished approximately 8.8 hours before catching a salmon. The average angler spent about $229 in 2004, and estimated total expenditure by anglers for the season was approximately $109,000.

Broodstock are known to be captured and killed in the fishery for consumption. Studies to determine body burden levels of contaminants (primarily PCBs and Dioxins) in broodstock salmon reared at the NNFH were conducted in spring 2004, and while levels were determined to be elevated, they did not exceed consumption advisory criteria identified by the State of New Hampshire, Department of Environmental Services.

Education / Outreach

Adopt-A-Salmon Family

The 2005 school year marked the thirteen year in which the Adopt-A-Salmon Family Program has been providing outreach and education to school groups in three states including ME, NH and MA in support of Atlantic salmon recovery and restoration efforts. The programs great success can be attributed to a cooperative effort between the NNFH, the Central New England Fishery Resources Office and core group of extremely dedicated volunteers. The program continues to have a diversified approach not only giving students a hands-on experience with all aspects of the Atlantic salmon's life cycle during their school visit to the hatchery in November, but also introducing them to the broader issues of anadromous fish restoration, aquatic habitat conservation and watershed stewardship.

In November, 1,377 students and 114 teachers and parents from twenty schools throughout central New England participated in tours of the NNFH where they observed spawning demonstrations and were able to actually touch freshly fertilized salmon eggs.
In December, the USFWS held the fourth annual Volunteer Appreciation Day where Adopt-A-Salmon Family volunteers received a copy of the book, "Maine Atlantic Salmon - A National Treasure" that was autographed and inscribed by the author.

To date, 44 schools received about 11,000 salmon eggs to be reared in classroom incubators. Throughout the winter and spring salmon eggs are monitored by students until they hatch and are released as fry late in spring into the Merrimack River watershed.

The Amoskeag Fishways Partnership
The Merrimack River Anadromous Fish Restoration Program continued to be represented in The Amoskeag Fishways Partnership [Partnership (www.amoskeagfishways.org)]. Partners that include Public Service of New Hampshire -The Northeast Utilities System, Audubon Society of New Hampshire, NHFG, and the USFWS continue to create and implement award winning environmental education programs based at the Amoskeag Fishways Learning and Visitors Center (Fishways) in Manchester, NH. With the Merrimack River watershed as a general focus, the partnership is offering educational outreach programming to school groups, teachers, the general public, and other targeted audiences.

The Fishways is open throughout the year, offers environmental education programs from pre-school to adult, museum quality exhibits, seasonal underwater viewing windows, family centered special events, live animal programs, and a vacation series for children. Fishways visitation and program participation in 2005 exceeded 20,000 people. Since its inception the Fishways has reached a half-million visitors and more than 6,000 school programs have been delivered to date. The Fishways continues to be an exciting, educational place to attend programs, see wildlife and fish up-close, and to carry out environmental education and conservation programs. All agencies continue to 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 Fishways. The four-way collaboration among partners was formed in 1995 to increase visitation to the 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. On 8 April the partners of the Amoskeag Fishways Partnership celebrated 10 years of success in providing environmental education and promoting wise stewardship of water resources, "bringing to life the magic of the Merrimack" for the people of New Hampshire.

3.3.8. Salmon Habitat Enhancement and Conservation

Habitat Restoration

In 2005 the multi-agency New Hampshire River Restoration Task Force continued to work on identifying dams for removal in the state and pursuing strategic alterations and/or the removal of dams. Proposals target Atlantic salmon habitat in the Merrimack River watershed. On the Contoocook River (Henniker, NH) the West Henniker Dam was breached in August 2004. Breaching the dam dewatered a small impoundment and exposed run and pool habitat for a distance of approximately 1.5 km upriver. Run and pool complexes continued to develop over the last year in the dewatered reach creating and improving juvenile salmon rearing habitat.

Public hearings to address removal issues pertaining to the Merrimack Village Dam, Souhegan River, NH were held throughout 2005. Phase 1 of the feasibility analysis to remove the dam has been completed. Phase I included the cultural resources assessment. Efforts are now underway to obtain funding for Phase II of the study. Phase II would focus on engineering feasibility. The project proponent, Pennichuk Water Works is committed to funding the non-federal share of the cost of this project. The applicant is currently applying for several grants to obtain the federal share of funding for the project. It is anticipated that the dam will be removed in 2007.

In the headwaters of the watershed (Pemigewasset River), review is underway to consider removal of a small dam in North Woodstock that would affect juvenile rearing habit. In addition, two habitat restoration and protection projects are being coordinated with the staff of the White Mountain National Forest. One project involves the use of new temporary bridge technology to protect streams during logging operations. It involves the use of folding bridges manufactured by ADM Welding. They can be quickly installed by a small crew and just as easily removed. These bridges could be used on many timber sales over several years. The second project involves replacing six permanent stream crossings that are currently preventing upstream access to valuable salmon and brook trout habitat. Replacing these crossings will protect downstream habitat and provide access to upstream habitat for salmonids and other aquatic species.

3.4 Pawcatuck River

3.4.1. Adult Returns

Two female sea-run Atlantic salmon were captured in the fish trap at the Potter Hill Fishway in 2005.

3.4.2. Hatchery Operations

Egg Collection
Sea-Run Broodstock
Two female salmon were captured at the Potter Hill Fishway trap in 2005. Both fish and a female kelt that was spawned last year perished at the Perryville Hatchery due to a catastrophic well pump failure in September, 2005. They perished prior to spawning.
Captive/Domestic Broodstock
In order to develop our own source of broodstock, 24 Atlantic salmon of wild origin were held back from the spring smolt stocking in 2005. In 2004, a number of Atlantic salmon of wild origin were retained for a Pawcatuck broodstock program. Unfortunately, these 36 fish perished at the Perryville hatchery during the same well pump malfunction that killed the sea-run returns. Due to the lack of eggs from the Pawcatuck River, eggs incubated at the North Attleboro National Fish Hatchery will be used for Rhode Island's smolt program in 2006-7.

3.4.3. Stocking

Rhode Island Division of Fish and Wildlife (RIDFW) personnel did not stock fry in the Pawcatuck River watershed in 2005. The Salmon in the Classroom program had 24 participating schools and each stocked approximately 200 fry, which were hatched in their classrooms. Also, in 2005, 16,590 smolts were stocked into the Pawcatuck River.

Juvenile Atlantic Salmon Releases
Approximately 5,200 fry from the Salmon in the Classroom program were stocked into the Pawcatuck River watershed. The locations and school groups are listed in Table 3.4.3.1.

In December 2004 approximately 284,000 eggs acquired from Nashua National Fish Hatchery were kept at the Arcadia Warm Water Research Hatchery. Due to federal budget constraints, we were asked to take all of our egg allotment at the end of 2004. This was due to the North Attleboro Federal Hatchery needing to shut down a pump and reduce water temperature by the beginning of December. The number of eggs exceeded the capacity that the Arcadia Hatchery could raise effectively. As a result, all of the eggs perished. In May there were no additional fry available from the Federal hatchery system, therefore large numbers of fry were not stocked into the Pawcatuck River system.

Approximately, 16,580 1 year old smolts of wild origin were raised at the Arcadia Warmwater Research Hatchery. These smolts were adipose fin-clipped and released in March, April and May 2005 at various locations in the Pawcatuck River (Table 3.4.3.2).

Table 3.4.3.1. Summary of fry stocking by the Rhode Island *Salmon in the Classroom* program.

		Number stocked
Bain Middle School	Queens River	200
Bishop Hendricken	Wood River (Arcadia)	200
Bridgeham Middle School	Breakheart Brook	200
Chariho Middle School	Meadow Brook	200
Chariho High School	Meadow Brook	200
Coventry High School	Wood River (WPWA)	200
Cranston Area Career & Tech	Queens River (William Reynolds)	400
Cranston High School East	Parris Brook (Mt. Tom Road)	200
Cranston High School West	Locke Brook (William Reynolds)	200
Davisville Middle School	Falls River	200
Exeter-West Greenwich	Beaver River (BR Schoolhouse Road)	200
Feinstein High School	Falls River (Stepping Stone Falls)	200
Gallagher Middle School	Roaring Brook	200
Jamestown Middle School	Falls River (Frosty Hollow)	200
Middletown Alt. Learning Prog.	Queens River (Mail Road)	200
Mt. St. Charles High School	Ashaway River (Ash. Line & Twine)	200
Narragansett High School	Wood River (off Mechanic Street)	200
N. Providence High School	Tomaquag Brook	200
Rogers High School	Beaver River (off Route 138)	200
South Kingstown High School	Meadow Brook (Carolina Man. Area.)	200
Thompson Middle School	Wood River (Rt. 3 Park)	400
Warwick Vet. Mem. HS	Phillips Brook	200
Winman Junior High School	Roaring Brook	200
Woonsocket High School	Ashaway River (Ash. Line & Twine)	200
Total		5200

Adult Salmon Releases

Approximately 30 adult broodstock acquired from the North Attleboro National Fish Hatchery were released into Carbuncle Pond in December 2005.

3.4.4. Juvenile Population Status

Index Station Electrofishing Surveys

Parr assessments were conducted in the fall of 2005 and depletion electrofishing was used to estimate salmon densities. Maximum likelihood estimates of population size were made using the procedures of Van Deventer and Platts (1989). Twelve stations were sampled in September, October and November. Sampling was made difficult due to unusually high rainfall in October. Total rainfall for October 2005 was 11.6 inches, three times higher than the monthly average of 3.7 inches. As a result of the high water, two stations were sampled with one pass; these stations included the Wood River at the Barberville Dam and the Wood River at the Wyoming Dam.

Parr, 0 years old, ranged in length from 68 mm to 80 mm, with an average of 72.7 mm, and 1 year old parr ranged in length from 89 mm to 215 mm, averaging 133.6 mm. Mean lengths in 2005 were lower than those found in 2004. Mean densities of 0 year old parr and age 1 year old parr were 0.15 and 1.9 per 100 m^2, respectively (Tables 3.4.3.2 and 3.4.3.3). These densities represent a decrease in densities of 0 year old and 1 year old parr. There was a significant decrease in densities of 0 year old parr because large quantities of fry were not stocked in 2005. Overall the densities of 1 year old parr were lower as well, but this may be due to the high flows that were the result of the October rains.

Table 3.4.3.2 Locations of smolt stocking in the Pawcatuck River, Rhode Island.

			Number of smolts stocked
3/31/2005	Merrimack wild - Perryville	Upper Pawcatuck River	3,362
4/1/2005	Merrimack wild - Arcadia	Ashaway River Bridge	1,318
4/4/2005	Merrimack wild - Arcadia	Below Alton Dam	1,318
4/5/2005	Pawcatuck wild - Arcadia	White Rock Landing	1535
4/6/2005	Pawcatuck wild - Arcadia	Below Potter Hill ladder	1294
4/6/2005	Pawcatuck wild - Arcadia	Route 112	1294
4/11/2005	Pawcatuck wild - Arcadia	White Rock	1465
5/5/2005	Merrimack wild - Arcadia pond	Released directly into Roaring Brook	4,994
Total			16,580

Smolt Monitoring
No work was conducted on this topic during 2005.

3.4.5. Fish Passage

Problems with upstream fish passage exist at Potter Hill Dam. Although the existing fish ladder seems to work well at normal and low flows, extremely high water levels in early spring completely flood the ladder, rendering it useless until the water level decreases. In addition, broken gates on the opposite side of the dam are creating attraction flow, which draws fish away from the fish ladder. The dam is under private ownership, and the owner is unwilling to make the necessary repairs. RIDFW is investigating its legal options regarding this issue.

3.4.6. Genetics

No genetics samples were collected in 2005.

3.4.7. General Program Information

No dam removal or fishway construction work was conducted during 2005.

3.4.8. Salmon Habitat Enhancement and Conservation

No habitat enhancement or conservation projects directed solely towards Atlantic salmon were conducted in the watershed during 2005.

4.0 DEVELOPMENTS IN THE MANAGEMENT OF ATLANTIC SALMON

4.1 Anadromous Communities

By Rory Saunders, Theo Willis, and Martha Mather

Atlantic salmon in New England likely co-evolved with alewife (*Alosa pseudoharengus*), blueback herring (*Alosa aestivalis*), American shad (*Alosa sapidissima*), rainbow smelt (*Osmerus mordax*), sea lamprey (*Petromyzon marinus*) and other diadromous fishes. Historically, anadromous fish populations in New England were more robust. During the late 1800s, the annual American shad run on the Penobscot River was estimated at two million. Currently, that number is zero. River herring commercial landings in the Gulf of Maine have dropped from 25 thousand metric tons in the mid 1960s to less than 2 thousand metric tons in the mid 1990s. Maine's commercial landings of rainbow smelt, once as high as 800 metric tones had declined to less than 98 metric tonnes by 1950, and were 0.2 metric tones in 2004. Alewife commercial harvests have experienced similar declines in Maine and elsewhere in New England. At historic abundance levels, clupeid species were significant sources of marine derived nutrients and alternative prey for predators of salmon smolt; rainbow smelt were alternate prey of the same predators and prey for adult salmon; and lamprey spawning physically conditioned salmon spawning habitat. Restoring diadromous fishes and their ecological functions may be key to successful recovery of Atlantic salmon populations in the U.S.A.

The role of marine derived nutrients in Pacific salmon rivers is fairly well documented (Cederholm et al. 1999, Schindler et al. 2003). Post-spawning mortality often results in the deposition of several times more nutrients than required to stimulate stream production and juvenile salmon growth. Smolt emigration may export on average 16% of the phosphorous (P) deposited in freshwater river systems by spawning adults (Moore and Schindler 2004). Vertebrate predators also remove significant amounts of marine derived nutrients from the rivers (Willson and Halupka 1995). In New England, other diadromous species such as alewife, blueback herring, rainbow smelt, and American shad likely added tons of phosporous (P), nitrogen (N), and carbon (C) historically to New England salmon rivers through metabolic activity alone. Durbin et al. (1979) estimated that a single adult alewife contributed 1.2g N and 0.2 g P to the spawning habitat before exiting and as much as 3.6 g N and 0.6 g P if the spawners then died in the pond.

Atlantic salmon also contribute marine derived nutrients to rivers. In the River Imsa, Norway, marine derived nutrients from salmon made up as much as 17% of the total P budget (Jonsson and Jonsson 2003). Adult Atlantic salmon were net importers of nutrients to rivers in north eastern England, although they represented a small portion of the overall nutrient flux through the entire system (Lyle and Elliott 1998). They suggested that nutrient transport by salmonids may be a far more significant component of upland rearing streams.

In addition to precipitous declines of anadromous fish populations, logging, declines in the density and range of beaver, and acid rain (leaching calcium and other ions from the soil) have contributed to imbalanced nutrient budgets in Atlantic salmon streams. The result has been an increasing oligotrophic state of northeastern USA coastal rivers. For example, the Maine

Department of Environmental Protection reported an average baseflow concentrations of 127 $\mu g*L^{-1}$ P in 1969 and 14 $\mu g*L^{-1}$ P for 1999 – 2002 in the Narraguagus River. Atlantic salmon stocking may be contributing to this nutrient imbalance and declining productivity, especially in areas where adult returns are extremely low. Nislow et al. (2004) estimated that stocked and wild Atlantic salmon smolts consistently exported more P from a Scottish stream system than adult salmon or stocked eggs provided. Without improvements to increase the number of adult entering the system and to marine survival, continuing stocking would result in a continuing out flux of P. Using Durbin et al. (1979) values for dead spawners, 527 – 922 alewife carcasses would be required to compensate for the P deficit reported by Nislow et al. (2004). Blueback herring, rainbow smelt and American shad spawn in lotic habitats where their marine derived nutrients would be more readily available to primary producers and bacterial communities in salmon rearing areas (Browder and Garman 1994). If populations of these species increased, their marine derived nutrient contributions would have more potential to balance the skewed nutrient budgets in salmon rivers than alewives.

In New England, increasing striped bass populations are a fisheries management success story. However, these abundant, highly mobile fish are potential predators on emigrating Atlantic salmon smolts, river herring and a variety other diadromous fishes and estuarine resident fishes and invertebrates. The likelihood of predator prey interactions in an estuary depends on the availability and abundance of resident and migratory prey species. Availability of migratory prey is triggered by factors outside of the estuary that influence migrations and create overlapping distributions of anadromous species in time and space. A predator can only eat so much per unit time before it becomes satiated; consequently, it's effect on a prey (individual or species) may be less if more prey individuals or prey species overlap with the predator in time and space (prey buffering). The opportunity for prey switching is more likely to produce stable predator-prey systems where both prey and predator populations coexistence (Krivan 1996). Thus, restoring diverse and abundant anadromous populations should protect the low numbers of smolts emigrating through New England estuaries from striped bass predation.

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4.2 GIS in Atlantic Salmon Management and Assessment

by Jed Wright, Alex Abbott, John Sweka

While GIS applications in fisheries management have increased in the last decade, there is still a tendency to use only the software as a basic cartographic tool. As a result, GIS is not an integral part of salmon management and research activities in New England. A variety of GIS and related datasets are now available for New England that have potential for salmon related landscape analysis.

Historic Atlantic Salmon Rivers of New England

A map of historic Atlantic salmon rivers of New England was prepared by Alex Abbott (Project SHARE/MASC Contractor) for the 2006 USASAC meeting (Appendix 5.5). The rivers on this map either drain directly to coastal waters or represent significant tributaries classified as third or forth order streams. In general, streams shorter than five kilometers and second order streams were not included in the map.

During the 2006 USASAC meeting additional information on drainages was collected from the state and federal biologists present. Information on Connecticut, Massachusetts, New Hampshire, Rhode Island and Vermont drainages was provided by Steve Gephard (Connecticut Department of Environmental Protection, Inland Fisheries Division), Joe Mckeon (USFWS), Jan Rowan (USFWS) and Jay McMenamy (Vermont Department of Fish and Wildlife).

GIS Modeling

GIS and remote sensing datasets have been used successfully to characterize habitat in other regions (Black 2003, Marcus 2002 and Legleiter 2004). GIS systems can provide a rapid means to derive landscape scale variables from existing spatial datasets. These variables are then used as inputs to link landscape and aquatic habitat models (Anderson et. al 2003, Kocovsky 2006 and Sloat et. al 2005). A number of habitat modeling examples were discussed. Attendees requested that GIS specialists working on Atlantic salmon develop simple predictive tools to estimate production potential within un-surveyed drainages. As a result, staff from NOAA-Fisheries Service, U.S. Fish and Wildlife Service, Maine Atlantic Salmon Commission, and geomorphologists from New England universities intend to develop simple models to predict drainage wide habitat estimates using existing GIS datasets in 2006.

The National Hydrography Dataset (NHD), a standardized national approach to mapping water bodies and flow paths through those water bodies, will facilitate landscape modeling for river systems. According to the NHD website: [NHD] is a comprehensive set of digital spatial data that encodes information about naturally occurring and constructed bodies of water, paths through which water flows, and related entities. The information encoded about these features includes classification and other characteristics, delineation, geographic name, position and related measures, a "reach code" through which other information can be related to the NHD, and the direction of water flow (http://nhd.usgs.gov).

NHD is a linear network, similar to the route measuring system (RiverKM) that currently is used on Maine Atlantic salmon rivers. NHD provides a standardized framework for locating point or line information along a drainage network. Further, NHD Plus provides a number of enhanced attributes. Reaches in NHD Plus include information on upstream drainage area, stream order, and land cover and streamflow statistics.

Watershed Characteristics

Examples were used to demonstrate combining GIS compatible Atlantic salmon habitat and population assessment data and other spatial datasets (i.e. existing land cover, geological, elevation) to characterize and compare physical habitat among watersheds. Habitat datasets were summarized to calculate the distribution of mesohabitat types among river systems (Figure 4.2.1). The sequencing of mesohabitat units is used to calculate transition probabilities (e.g. how often a habitat type follows another habitat type) (Table 4.2.1), with comparisons of transition probabilities among drainages possible (Grant 1990). Cumulative proportions of rearing habitat and watershed elevation related to proportions of stream length can be used to document relative location of habitat and compare between watersheds (Figure 4.2.2). Dr. Frank Magilligan and Burch Fischer of Dartmouth College provided another example of characterizing habitat at a watershed scale. Using surficial geology and habitat datasets, they determined the type of surficial geology in which juvenile rearing habitat unit were located (Figure 4.2.3). By comparing the proportions of surficial geology categories the river crosses in the watershed with the proportions for mesohabitat types it is possible to determine if there are significant links to background geological processes.

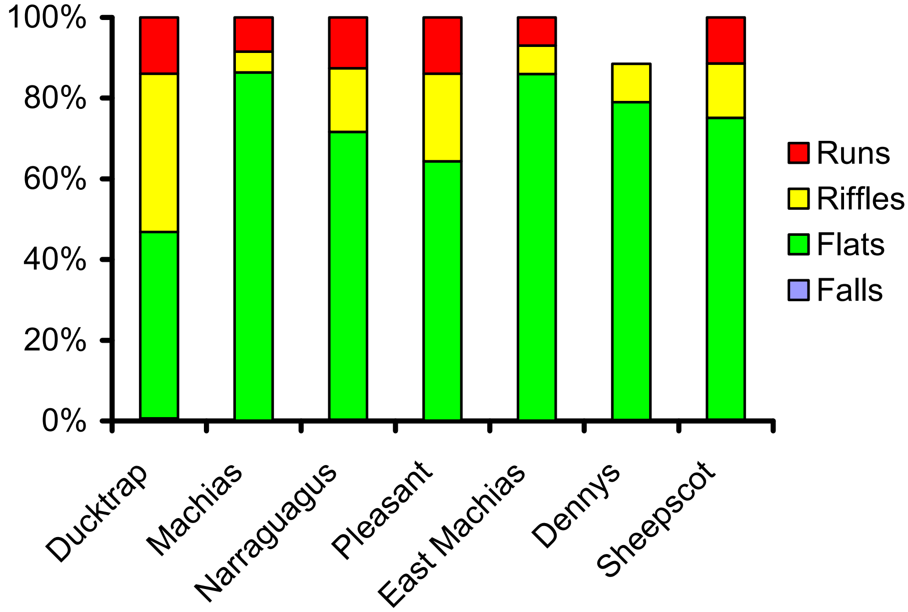

Figure 4.2.1. Habitat feature distribution by river calculated from the Maine Atlantic salmon habitat data using GIS.

Table 4.2.1: Transition probabilities based on the sequencing of mesohabitat units in the Dennys River, Maine.

		Upstream unit						
		High Gradient Riffle	Glide	Run	Deadwater	Low Gradient Riffle	Falls	Pool
Downstream Unit	High Gradient Riffle	0.00	0.06	0.00	0.20	0.02	0.00	0.00
	Glide	0.14	0.00	0.24	0.07	0.13	0.00	0.10
	Run	0.43	0.65	0.00	0.53	0.73	0.33	0.60
	Deadwater	0.14	0.19	0.06	0.00	0.03	0.00	0.10
	Low Gradient Riffle	0.14	0.10	0.67	0.13	0.00	0.00	0.10
	Falls	0.00	0.00	0.00	0.00	0.03	0.00	0.10
	Pool	0.14	0.00	0.02	0.07	0.06	0.67	0.00

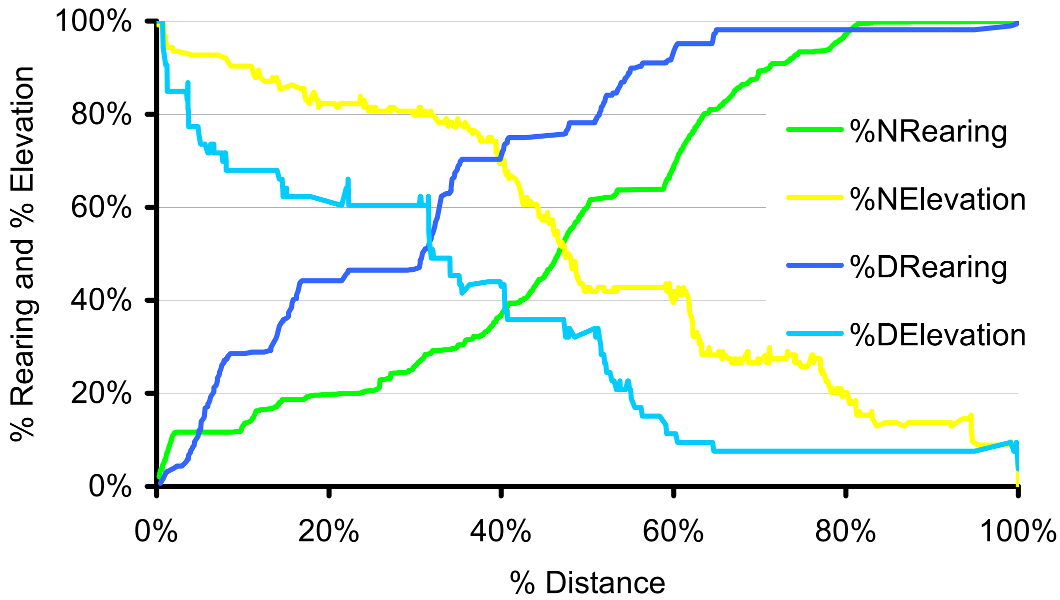

Figure 4.2.2. Cumulative rearing habitat and elevation profiles for the Narraguagus (N) and Dennys (D) rivers related to downstream distance.

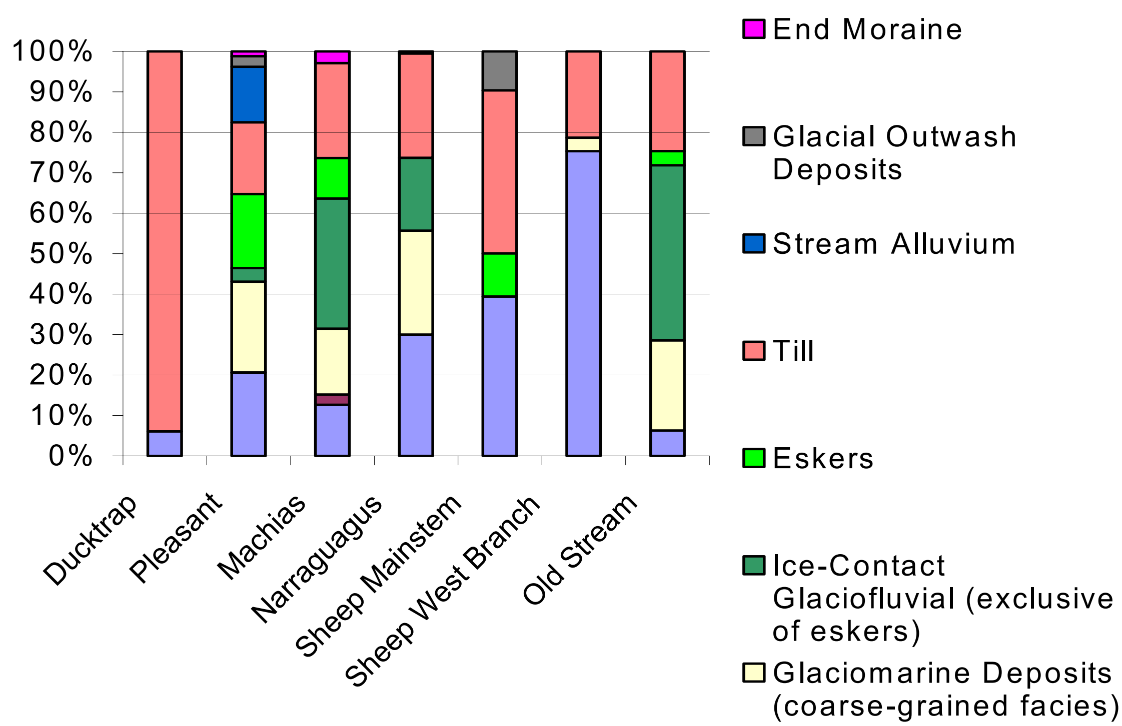

Figure 4.2.3. Proportion of juvenile rearing habitat found within different surficial geologic categories on selected Maine rivers.

In a more detailed example, historic temperature logger data were used to: (1) determine trends in summer temperature regimes, (2) create maps of suitable thermal habitat and compare these to maps of physical habitat, (3) compare thermal habitat suitability of Atlantic salmon parr vs. smallmouth bass, and (4) create maps of potential Atlantic salmon parr growth based on thermal conditions. The example focused on the Sheepscot and Narraguagus Rivers because these rivers currently have the greatest spatial and temporal coverage by temperature loggers. Daily summer temperatures (May 1 – Sept 10) from 2001 – 2004 were averaged on a weekly basis and GIS techniques were used to interpolate stream temperatures between logger sites. Interpolated temperatures were overlaid on maps of rearing habitat and classified according to the potential for growth based on a bioenergetics model for Atlantic salmon parr. Comparison of Atlantic salmon and smallmouth bass bioenergetics models suggests that relative growth potential is greater for smallmouth bass when temperatures exceed 20°C. Using 20°C as a threshold, maps were created showing the species most suited for temperatures during each week of the summer (Figure 4.2.4).

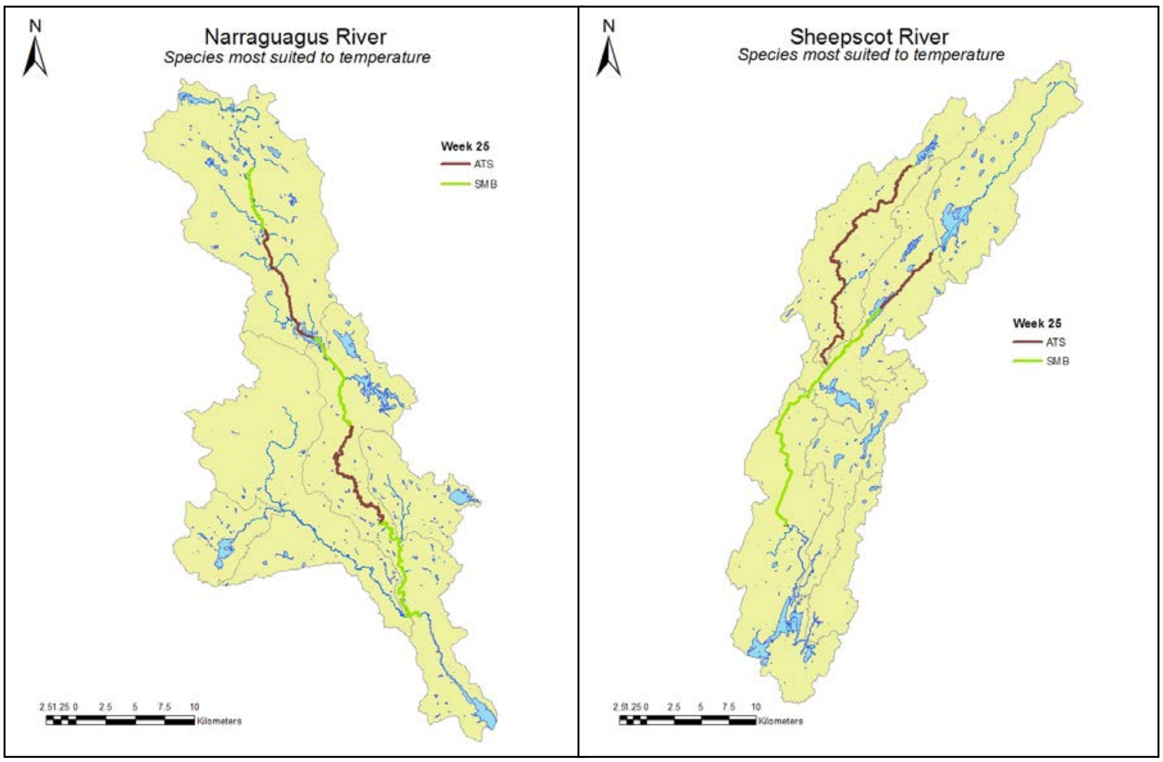

Figure 4.2.4. Example of thermal suitability for Atlantic salmon (ATS) and smallmouth bass (SMB) in the Narraguagus and Sheepscot Rivers for standard week 25 (June 18 – 24).

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4.3 Contaminants Update

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In the 2005 USASC report we stated that contaminant levels in hatchery fish were generally 10-100 times lower than those reported to cause sublethal effects in salmonids. Here we update this information to point out that for PCBs and dioxins, the concentrations in farmed and hatchery fish (16 – 90 ppb PCBs; 0.2 – 3 pptrillion dioxin) fall within the low end of those associated with adverse effects of these compounds in salmonids (20-200 ppb PCBs; 20-300 pptrillion dioxins) (Carvalho and Tillitt 2004; Cook et al. 2003; Berntssen et al. 2003; Meador 2002). This does not change our original conclusion that adverse effects of feed contaminants are best determined by measuring performance fitness of hatchery fish. Indeed, it makes such studies even more important as it makes clear that hatchery and farmed fish contain chemicals whose levels are likely to be sufficient to provoke threshold adverse effects, particularly since mixture effects are known to be at least additive with respect to the dioxin-like contaminants. As soon as possible, efforts should be made to include chemical characterization of salmon for the brominated and bromo/chloro hybrid dioxins/furans because of the former's presence in the New York / New Jersey Harbor Estuary (Litten et al 2003), which is near the historic southern reproductive range limit of the Atlantic salmon.

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4.4 Sampling for Aquaculture escapes and introgression with wild populations

The only sampling for aquaculture escapes in the USA occurs when fisheries agencies examine returns to traps or weirs. Since 2003, a portion of the industry smolts has carried external marks (2003 LV, 2004 LV or CWT, 2005 BV). However, most carry no mark or tag, and distinguishing aquaculture escapes at traps is based on body morphology, fin condition, and scale pattern. Using only scale images alone, readers were able to correctly deny or permit upstream passage 80% of the time. Additional information increases the accuracy of the decisions. Aquaculture companies have proposed genetic marking based on maintaining databases of parental genotypes, matings, and tracking progeny at hatcheries to satisfy permit conditions for a unique company mark.

Genetic screening of the broodstock at Craig Brook National Fish Hatchery for potential escapees from aquaculture facilities, or strays from outside the region is currently conducted to determine continent-of-origin based on the large differences in allele frequencies between populations from different continents (King et al. 2001). The numbers of parr and adults with non-North American lineage collected as broodstock for USA restoration efforts have varied among rivers over time (Table 4.4.1). Consistent with these screening results, Lage and Kornfield (2006) found one fish with a European/Newfoundland mtDNA haplotype in Dennys 1995 broodstock. The genetic screening detects possible juvenile escapes from aquaculture hatcheries (on the Pleasant and East Machias) or introgression from spawning aquaculture escapes with non-North American ancestors. However, in the past genetic screening protocols were not standardized and information was not always available before spawning or stocking. Consequently, of the 72 individuals identified as non-North American origin (Table 4.4.1), 21 captive broodstock were spawned. The matings produced 52 families, 41 of which were stocked in the Dennys and Pleasant rivers. Offspring identified from these families, if collected as broodstock, will not be spawned.

Table 4.4.1. The number of individuals, listed by drainage and year, identified for removal from the CBNFH broodstock due to assignment to non-North American populations.

River	Collection Year								
	1994	1995	1996	1998	1999	2000	2001	2002	2003
Parr									
Dennys	0	2	0	13	0	1	1	2	3
East Machias	0	0	0	1	0	0	0	0	0
Machias	0	0	0	1	0	3	0	1	0
Narraguagus	0	0	0	0	0	0	0	3	3
Pleasant	0	0	0	0	4	13	0	0	1
Sheepscot	3	0	1	0	0	0	0	0	2
Adults									
Penobscot	0	0	0	0	0	5	9	0	0

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4.5 Habitat Protection and Restoration

4.5.1 Examples of Measures to Restore Degraded Habitat, USA 2005

State and federal agencies work with Towns and conservation groups to restore degraded Atlantic salmon habitat in the US. Projects include the removal of dams, the modification of road crossings, and instream work to repair damaged habitat and install structures to encourage long-term natural function. Examples of such projects implemented in 2005 are listed below:

Removal of the Pizzini Dam (Connecticut)- This small concrete dam inhibited the passage of adult salmon during low flows, blocked passage of juvenile salmon, impounded natural flowing water, and caused siltation of rocky substrate, eliminating the value of the impounded water for juvenile Atlantic salmon. A partnership of conservation groups and the State fisheries agency planned and executed a total removal of this structure. Field work lasted one day.

The Pizzini Dam, Eightmile River, CT

The same location following dam removal.

Tower Brook Culvert Repair, (Massachusetts)- A perched outlet and excessive water velocities within a corrugated culvert precluded upstream passage of juvenile Atlantic salmon. Renovations included the installation of downstream rock weirs to backflood the outlet, placement of substrate inside the culvert to reduce velocities, and vegetative plantings to stabilize steep, erodable riverbanks. The project was a partnership with the Town, State, and federal governments.

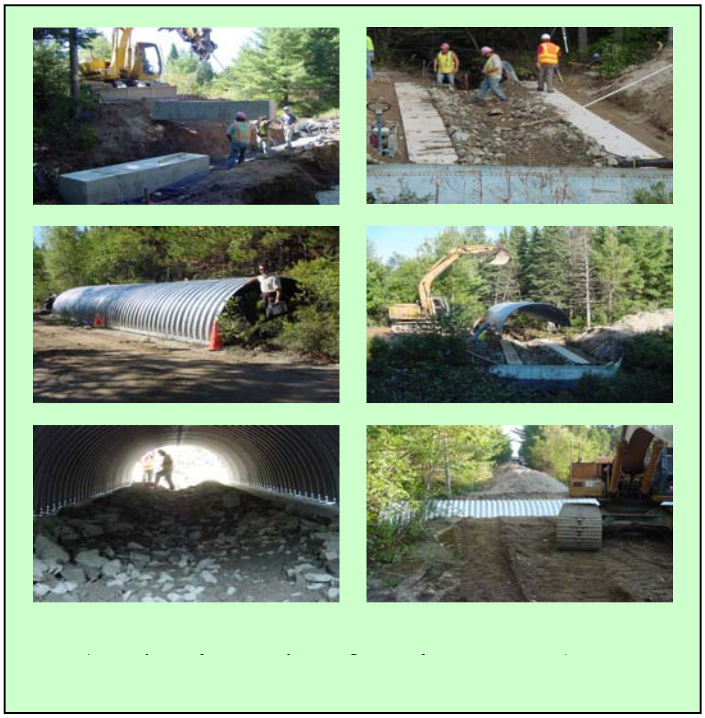
Measuring velocities inside Town Brook culvert.

A downstream rock weir backfloods the outlet.

Homestead Woolen Mill Dam Removal, (New Hampshire)- This dam blocks the migration of adult and juvenile Atlantic salmon and impounds formerly flowing water, resulting in siltation of salmon habitat. Its removal will allow full fish passage and restoration of functional salmon habitat. A study in 2005 designed a removal project and provided cost estimates. Approval is expected in 2006.

Restoration of stream channel and riparian habitat (Vermont)- Habitat that once supported native salmon has been degraded due to poor land use, such as logging. Streams become too wide and shallow, riverbanks erode, substrate becomes heavily silted, there is a loss of instream cover, and the water warms. In 2005, the US Forest Service repaired stretches of degraded riparian habitat along two miles (3.2 km) of stream and restructured two miles (3.2 km) of stream channel in the Green Mountain National Forest.

<u>Replacement of impassable culvert with bottomless arch span (Maine)</u>- Undersized and inappropriately installed culverts can become perched and impossible for salmon to pass through. This project on a tributary of the Machias River replaced such a culvert with an inverted half culvert with natural substrate. Maine Atlantic Salmon Commission, the Maine Department of Transportation, the US Fish & Wildlife Service, and conservation groups cooperatated on the project. The first set of photos show the old culvert; the second set shows the installation of the new crossing.



4.5.2 NASCO Rivers Database

The NASCO Rivers database was not available as a stand-alone database or on the NASCO website to review existing USA data and add habitat information. Maine has prepared habitat data to populate the baseline data and USASC members responsible for data entry for their programs are prepared to review existing data. Both these tasks will be completed when the NASCO website caries the database.

4.6 NASCO Guidelines for the Use of Stock Rebuilding Programs

4.6.1. Inventory

No new stock rebuilding programs were initiated in the USA in 2005.

4.6.2 Plans made available in 2005

Maine Broodstock Management Plan and Stocking Strategies

Biologists from U. S. Fish and Wildlife Service, Maine Atlantic Salmon Commission (MASC), and University of Maine completed a Broodstock Management Plan for the Distinct Population Segment River populations in Maine. This plan includes descriptions of hatchery operations, data management, genetic and demographic considerations for hatchery production, as well as detailed descriptions of key concepts and procedures outlined in calendar format. The plan provides both theoretical foundations for broodstock management and specific operational guidelines to optimize management of the captive populations and minimize the risk of genetic changes due to captive rearing. As a companion document, the MASC completed an interim-stocking plan that outlines the pros and cons of stocking various life history stages in regard to ecological and genetic considerations, and outlines approaches used to determine the number of fish to stock at various life history stages. This document also includes rationale for adaptive management of restoration stocking efforts. Taken together, these documents provide comprehensive guidelines to better manage captive broodstock populations and effectively use hatchery products for Atlantic salmon restoration in Maine.

4.6.3 Recommended Changes

The USASAC made no recommendations for changes to NASCO Guidelines for the Use of Stock Rebuilding Programs.

4.7 Research

Abstracts were compiled with the goal of providing a snapshot of active research projects. We are also considering identifying the abstracts based on any previous distribution, e.g. peer review paper, abstract of current work, poster presentation, etc.

4.7.1 Conservation Or Management

Incubation Capacity of Streamside Incubators

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The egg incubation capacity of decommissioned refrigerators as streamside incubators was tested in 2004. Two incubators were designed to allow incoming water to flow under a false floor and up through 8 layers of poultry nesting material 127cm long and 74cm wide. Incubators were deployed in February and connected to a gravity fed water pipe laid in a small tributary of the Sandy River. Each incubator received 42 L/minute. Eggs were loaded at a different density in each incubator. One incubator received 40,000-eyed eggs yielding a density of 0.55 eggs/cm^2 and one received 90,000-eyed eggs yielding a density of 1.25 eggs/cm^2. Incubators and temperature were monitored until egg development reached approximately 95%. All fry were removed, counted and weighed. Observations and counts indicate the high-density incubator had over 60% mortality and the low-density incubator had less than 10% mortality. The results indicate safe egg densities may be 0.55 eggs/cm2 for a refrigerator-sized incubator. It was also noted that temperature fluctuated due to a warm spring season, which could have exacerbated mortality. Newly designed re-circulation systems and filter chambers will be discussed.

Use of Instream Incubators for Green and Eyed Eggs

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In an effort to investigate low-cost enhancement techniques for use by volunteers the Sidney office of the Maine Atlantic Salmon Commission in 2004 deployed 12 wire cage instream incubators with a capacity of 3000 Atlantic salmon eggs each. Six sites were chosen on tributaries to the Sandy and Sheepscot rivers for planting in appropriate habitat. Two incubators with two treatments were placed on three sites in the Sandy River and three on the Sheepscot River. Six incubator boxes were filled at the hatching facility with Penobscot and Sheepscot origin green eggs after fertilization and transported in coolers to the recipient waters and placed at each site. Eyed eggs were similarly loaded into six incubators at the hatchery and transported to each site in February. All boxes were buried and secured in place. In June 2005 all incubators were removed and examined. Unfortunately no green egg development was observed.

However, eyed eggs produced alevin. We also noted severe mortality in the upper portion of the eye egg incubators. A review of the project indicated that sediment overwhelmed alevin in the upper trays of the eyed egg incubators and inadvertent movement during transport of green eggs may have caused development to stop.

Designing road-stream crossings to accommodate aquatic organism passage

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Forestry and recreational roads constitute a large part of the road system in Maine. Scattered throughout this road system are a significant number of road-stream crossings that disrupt the form and function of stream channels. Culverts were installed exclusively to pass water and create a crossing; however, they have fragmented the aquatic habitat and impeded passage for aquatic organisms. Habitat connectivity in a watershed is as important on the mainstem of the river as it is on the smallest of tributaries. Re-establishing habitat connectivity through installation of natural crossings would provide access to spawning and rearing grounds and restore thermal refuges for coldwater fish. Recently there has been an effort in Downeast Maine to inventory and prioritize passage improvement projects at road-stream crossings. This process will determine, at individual sites, the potential for culvert replacement with a natural stream bottom crossing or culvert removal and road discontinuation. The replacement culverts will create a road crossing that is invisible to the stream and passable to all aquatic organisms and most terrestrial animals. An interdisciplinary team of professionals including watershed groups, landowners, contractors, engineers, and state and federal agencies are collaborating to make assessments on what is best for the aquatic resource while maintaining the road infrastructure. Presented is a case study on a small tributary in the Machias River drainage.

Habitat Variability at Different Stream Flows for the Narraguagus River, Maine

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The Atlantic Salmon Commission uses ground surveys to map salmon habitat within river systems that allow reasonable calculations of area by habitat type. For each habitat type observed, length and wetted width are recorded for area calculations. These data in combination with electrofishing survey data are used to estimate basin wide population abundance of juvenile Atlantic salmon within that river system. However, the river flow at the time of the habitat survey may misrepresent the available habitat. Flow is a determining factor for area calculations, depending on the site characteristics; changes in flow can significantly increase or decrease wetted width and/or depth. Thus, habitat units calculated during these initial surveys might not be representative of actual habitat present at the summer "base flow". We determined the "base flow" (August median) on the Narraguagus River to be approximately 60 cubic feet per second (cfs) based on over 50 years of U.S. Geological Survey Water Resources Data. We are measuring length and wetted width for over 40 electrofishing sites (used in the basin wide juvenile Atlantic salmon population estimate) within the Narraguagus River at three different flows to determine the change in total habitat units ($100m^2$) at each flow. We selected a high flow of approximately 100cfs and a low flow of approximately 30 cfs to re-measure the sites. Preliminary data indicate that tributary sites are most affected by varying flows conditions because of the increased amount of fluctuation in wetted widths. Habitat units measured at these sites varied from approximately 4 to 45 percent from the base flow measurements. This is largely due to the narrow characteristics associated with these tributary sites. Less variation was detected in the mainstem sites, which typically have greater widths. Mainstem sites varied from approximately 0 to 16 percent from the base flow measurements. Additional site measurements will be collected in 2006 as conditions permit.

Smolt rearing origins from scales: scale readers vs. computers

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Identification of the source of Atlantic salmon that survive to advanced life stages (smolts and adults) must be accomplished to evaluate the effectiveness of stocking strategies. In Maine's Penobscot and Dennys Rivers, smolt production occurs as a result of natural spawning and also by fry, parr, and smolt stocking. Using scales sampled from smolts collected by a rotary screw trap in the Pleasant River tributary of the Penobscot River, we conducted a scale reading study to determine the degree to which biologists can visually distinguish (with the aid of only a microscope) between scales from naturally and hatchery-reared smolts. Hatchery-reared smolts had been ventral-fin-clipped and stocked as parr 20 months or 8 months prior to capture. No smolts had been stocked in the Pleasant River. Three experienced scale readers assigned age and origin (Parr20, Parr8, or naturally reared) to 177 scale samples. Readers accurately classified the stocking group of Parr8 in 75-94% of the cases. Accuracy for Parr20 was much lower, 10-53%, but the misclassification was mostly into the Parr8 category rather than into the naturally reared category. A second study objective was to investigate the utility of computer-assisted scale pattern analyses in reliably determining smolt-rearing origins. We derived a linear discriminant function (LDF) from measurements of scale growth variables (radius, circuli numbers and spacings, etc.). The LDF correct classification rate was 85% for Parr8 and 86% for Parr20. Scale feature measurements from Dennys River smolts were also analyzed using linear discriminant functions to distinguish among the above groups as well as smolt stocked fish. LDF correct classification rates were all above 90%. Quantifiable differences exist in the growth characteristics of parr-stocked and smolt-stocked individuals that can be reliably inferred not only through scale pattern analysis, but also visually by experienced scale readers.

Review of captive adult salmon as a restoration approach in Maine

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Maine Atlantic salmon stocks remain at extremely low levels. Although captive broodstock programs for six populations have been in place and extensive stocking of fry, parr and smolts has occurred, the populations remain at critically low levels. In addition to stocking juvenile life history stages, sexually mature adult salmon have been stocked on several occasions over the last ten years. The fish stocked have differed markedly in rearing history, with juveniles derived from the wild or domestic sources and adult fish reared to maturity in marine net pens or freshwater hatcheries. Monitoring of the reproductive effort and success of these fish indicates that they generally achieved relatively little reproductive output, with some exceptions (additional genetic analyses pending). Nevertheless, use of stocked adult salmon as natural spawners remains a tenable restoration method. Although this approach affords managers less control over the number of eggs successfully reared to fry (or older life history stages) and the spatial distribution of the offspring in the rivers, the fry that do emerge are derived from natural spawning (mate choice, competition for mates or spawning locations, choice of spawning location, etc.) and natural incubation and emergence conditions. These factors are lacking in our current hatchery fry production method. Whether these factors are important to the success of individual fish, and by extension to the restoration of these populations, must be evaluated. Finally, we present some considerations for adult stocking that may improve the likelihood of success.

Assessment of Watershed Scale Habitat Features on the Survival of Juvenile Atlantic Salmon

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Current Atlantic salmon recovery efforts rely heavily on the stocking of juvenile Atlantic salmon with the majority of fish being stocked as fry. In order for recovery efforts to be successful there is a need to identify areas of watersheds that yield the greatest fry to parr survival and contribute most to the outmigrating smolt population. Identification of such areas will allow managers to refine fry stocking practices to increase survival to the parr stage and optimize the number of outmigrating smolts per the number of fry stocked. Also, identification of critical juvenile Atlantic salmon production areas will help guide future salmon habitat enhancement and

restoration efforts. The objectives of this study are: (1) determine quantitative relationships between inter-stage survival of juvenile Atlantic salmon and macrohabitat variables such as watershed area, temperature, pH/Alkalinity, stream gradient, abundance of non-salmon species, and abundance of predatory species, and (2) use genetically marked fry to identify the rearing locations of outmigrating Atlantic salmon smolts and assess relative survival to the smolt stage from various stocking locations. Sheepscot River 2004 broodstock at Craig Brook National Fish Hatchery were genotyped using highly polymorphic microsatellite DNA markers. Using genetic parentage analysis as a "mark", we will be able to identify stocking location, and use the recapture and abundance of the marked fish to evaluate survival. Within a given river reach, a single genetic group of fry was stocked in May 2005. Estimation of survival to parr stages began in the September 2005. Age-0 parr survival was assessed at 27 electrofishing sites throughout the watershed. A subsample of parr had a fin clip taken for genetic analysis to determine the degree of immigration from fish stocked in other river reaches. Abundance of non-salmon species was also estimated at each electrofishing site. Survival of age-0 parr to the age-1 parr stage will be assessed during the early fall of 2006 in the same manner. Survival to the smolt stage will be assessed using a rotary screw trap near the Head Tide Dam on the mainstem of the Sheepscot River in the spring 2007. Upon collection, smolts will have a fin clip taken for parentage analysis which will identify the location of stocking as fry. Multiple regression analysis will be used to determine relationships between site level survival to each lifestage and macrohabitat features such as watershed area, stream gradient, temperature (proportion of time within the range for positive salmon growth), minimum and mean pH/Alkalinity, and biological components such as the abundance and biomass of non-salmon species and predatory species.

Assessment of Thermal Habitat for Maine's DPS Atlantic Salmon

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Physical habitat in Maine Atlantic salmon DPS rivers has been mapped, classified, and quantified. However, less is known about thermal habitat. Physical habitat may be adequate for spawning and juvenile rearing, but may still be limiting due to elevated temperature. Also, elevated stream temperatures may be more suitable for invasive species such as smallmouth bass, which tend to have higher thermal preferences (and tolerances). The objectives of this study were to use historical temperature logger data to: (1) determine trends in summer temperature regimes, (2) create maps of suitable thermal habitat and compare these to maps of physical habitat, (3) compare thermal habitat suitability of Atlantic salmon parr vs. smallmouth bass, and (4) create maps of potential Atlantic salmon parr growth based on thermal conditions. The current study focused on the Sheepscot and Narraguagus Rivers because these rivers currently have the greatest spatial and temporal coverage by temperature loggers. Daily summer temperatures (May 1 – Sept 10) from 2001 – 2004 were averaged on a weekly basis and GIS techniques were used to interpolate stream temperatures between logger sites. Interpolated temperatures were overlaid on maps of rearing habitat and classified according to the potential for growth based on a bioenergetics model for Atlantic salmon parr. Comparison of Atlantic salmon and smallmouth bass bioenergetics models suggests that relative growth potential is greater for smallmouth bass when temperatures exceed 20^oC. Using 20^oC as a threshold, maps were created showing the species most suited for temperatures during each week of the summer. Maps of weekly temperatures were combined with the Atlantic salmon parr bioenergetics model to predict age-0 parr growth throughout the watersheds assuming parr were consuming 40% of theoretical maximum consumption. Predicted parr size was compared to observed size from electrofishing surveys. Long-term datasets showed temperatures significantly increased through time. However, temperatures of rearing habitat remained within the range of temperatures required for parr growth. Stream temperatures exceeded 20^oC over nearly all portions of the Sheepscot and Narraguagus rivers during the middle of summer, and although this may still be conducive for Atlantic salmon parr growth, smallmouth bass may be better adapted to temperature regimes during this portion of the summer. Predictions of Atlantic salmon parr growth based on temperature were not correlated with observed growth from electrofishing surveys. Differences in prey availability along stream gradients, which were not accounted for in our model, are likely responsible for the lack of predictive power. Nevertheless, our mapping of temperature regimes in these rivers will aid managers in prioritizing fry stocking and habitat restoration efforts. Future analysis will include earlier years of data, expand to other rivers as data becomes available, and incorporate variability in invertebrate production along stream gradients.

4.7.2 Culture Or Life History

Selective Mortality of Newly Released Atlantic Salmon Fry

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In order to understand selective mortality of newly stocked Atlantic salmon fry, we will employ a cohort analysis approach based on otolith back calculations, analogous to that of Good et al. (2001). Immediately prior to stocking fry in a study section a random sample of approximately 100-200 fry will be taken. Remaining fry will then be stocked by federal and state biologists using standard practices (usually distributed over a km. or more). After the potential selection period of 30-60 days, samples of 50-150 fry will be recaptured by electrofishing over a large area (e.g., 100-500 m) from within each stocking reach. All fry will be preserved in 95% ETOH for subsequent analyses. We will work with ASC biologists to choose 6 different stocking locations in the Penobscot drainage. If possible, up to 4 locations will receive groups of fry of manipulated developmental age. The fish with manipulated development will be thermally marked with chillers or heaters to insure proper recognition at time of recapture. Body length and weight will be measured on preserved fry, and otoliths will be removed under a dissecting scope with aid of polarizing filters. Otoliths will be digitally photographed under a phase contrast compound scope and subsequently measured. All otoliths will be measured from the focus to a standard position on the discernable edge and development manipulations will be identified from thermal marks. Distance from the focus to the stocking check and distance from the stocking check to the outer edge will be measured on otoliths from recaptured fish. If the stocking check is not clearly visible the stocking check will be defined by back calculating the daily growth rings to the estimated time of stocking. Fry collected from the hatchery will be used to develop a regression relationship between otolith size and fry body size at stocking that can be used to estimate size at stocking of recaptured fry, and distance from the stocking check to the outer edge will be used to estimate post-stocking growth increment. Variation in developmental stage at stocking (within our manipulation groups or in non-manipulated groups) will be measured by relative numbers of daily growth rings prior to stocking. Selection gradients associated with fry size and developmental stage will be estimated by comparison of the pre-release and recapture distributions of size or development values.

Growth and Survival of Juvenile Atlantic Salmon in Shorey Brook, Beddington, Maine

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In order to look at fine scale aspects of juvenile salmon ecology (including but not limited to: life history variation, survival, behavior and timing of smolting) we used mark recapture methodology with juvenile Atlantic salmon in a DPS river. Since 2000, Shorey Brook has used passive integrated transponders (PIT) to investigate life history variation, survival, and growth of juvenile Atlantic salmon in Shorey Brook, a tributary of the Narraguagus River. The project was originally conducted by USGS S.O. Conte Laboratory and in 2003 turned over to the University of Maine. All Atlantic salmon and brook trout over 60mm captured within the study section (37 20m sections), were implanted with PIT tags from 2000 to 2004. Hundreds of fish were tagged during the duration of the study with thousands of recapture events. Some fish were recaptured over 20 times. With the use of stationary antennas to record fish leaving the system, we have developed fine scale survival estimates as well as estimates of smolt production. In addition, the PIT antenna system produced evidence of adults returning to Shorey Brook in the Fall of 2005. Most of the remainder of the 2003 cohort should leave the systems as smolts in the spring of 2006. After the smolts leave the system the PIT antenna system will be removed from Shorey Brook.

Inferring selective mortality in hatchery raised Atlantic salmon (*Salmo salar*) fry

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Atlantic salmon (*Salmo salar*) restoration efforts in Maine employ fry stocking as one of the primary population enhancement strategies. The earliest periods of fry development are thought to represent the greatest phases of mortality in most fishes, including salmonids. In the wild, larger size, faster growth, or more advanced developmental state during these periods are often hypothesized to convey better survival; however, there is little data on the actual survival of newly emerged Atlantic salmon fry based on these characters. Hatchery rearing may reduce mortality up to stocking in hatched fry; however, it may also disrupt the natural match between fry characteristics and the features of their natal habitats, causing natural selection to act strongly on stocked fry in the wild. This may have important implications for later aspects of the life history and productivity of fry-stocked fish. We have designed, and are now implementing, a series of experiments to assess patterns of size, growth and development related survival patterns for fry spending between 30 and 60 days in the wild. Our approaches all rely on reconstruction of attributes of fry at stocking using characters of growth rings in otoliths. Developing relationships between fry biology and otolith characters has been challenging. Nonetheless, we believe these experiments will provide important insights into the features of fry best suited for restoration efforts.

Evaluation of Atlantic salmon kelt broodstock diets

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Reproduction from Atlantic salmon (ATS) kelts represents valuable genetic and numeric contributions to restoration fry stocking. However, survival, maturation and gamete quality of kelts has been inconsistent. Nutritional variability and seasonal availability of raw ingredients found in the standard formulation are viewed as potential problems.
The present study examines the nutritional effect of two diets (standard *vs.* USGS) upon kelt reproductive success. Biochemistry of the standard diet was examined by comparing mineral and lipid profiles of eggs from wild sea-run ATS and hatchery rejuvenated kelts collected in 2000. The analyses showed that kelt eggs were deficient in copper and selenium and contained excessive amounts of manganese relative to sea-run eggs. The standard diet was found to contain high levels of copper, zinc, manganese and selenium. A five fold reduction of mineral premix was recommended to correct the mineral imbalance found in the standard diet at study inception in 2001. An alternative USGS diet formulation based upon advances in nutritional research moved to processed meals and lower levels of minerals in readily absorbed chelated form. Merrimack and Connecticut River ATS kelts at North Attleboro NFH received standard and USGS diets from rejuvenation in 2001, 2002 to spawning in 2003 and 2004. Evaluation of gamete quality as measured by survival to eye-up was determined for each mature female from a diet-river group by fertilization with milt from all males representing that group; viability of each

male from a diet-river group was measured against a pooled composite of cohort eggs. Individual performance within trial groups varied greatly (Std. Dev. ~ 24 %). Although increase in kelt age ($P = 0.04$) negatively impacted gamete viability, differences were not detected for river of origin ($P = 0.67$) or between standard (73%) and USGS diets (66%), ($P = 0.31$).

4.7.3 Fish Health

Waterborne transmission of ISAV in marine waters: studies from the Quoddy region of Maine and New Brunswick

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Passive dispersal of virus by water is considered a probable means of distribution of Infectious Salmon Anemia in marine waters. The relevance of this means of transmission in the field has been presumed, but not clearly demonstrated; however, the implications to disease management and zonation strategies in the bi-national Quoddy region of Maine and New Brunswick are significant. Historical context and laboratory evidence is presented that led the authors to develop and implement an epidemiologic field study to try to identify the impacts of tidal flow on the distribution of ISA virus in the Passamaquoddy Bay and adjacent waters. The relationship between circulation patterns and the spatial and temporal incidence of ISA in the 2002 production year class of Atlantic salmon is evaluated. Findings, management implications and ongoing concerns are discussed.

Liming a Downeast river to buffer episodic events of low pH and high exchangeable aluminum suspected of adversely affecting the health Atlantic salmon smolts

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Rivers in Downeast Maine tend to have very low buffering capacity and experience depressed pH levels and increased exchangeable aluminum concentrations during high flows caused by runoff from snow melt and rain events. These events occur most frequently in the spring and fall and can result in depressed pH values for up to a week at a time. Atlantic salmon smolts exposed to river pH less than 6.0 and exchangeable aluminum concentrations greater than 50 ug/l over a 48 hour time period are shown to be impaired physiologically, resulting in reduced saltwater tolerance, and in some cases death (McCormick, unpublished data). An experimental river-liming project is being designed to determine if liming can increase smolt health and survival as they transition from fresh to saltwater. It is proposed to use a fully automated lime doser to apply a calcium carbonate solution to the lower 3 km of the Dennys River during storm events that result in pH depressions. This section of river represents more than ¼ of all salmon spawning and rearing habitat in the mainstem Dennys River. Assessments of water chemistry, salmon populations and physiology, hydrology and aquatic ecosystems are currently underway to aid in the design and logistics of the project.

Assessment of water chemistry in Downeast Maine rivers and its impacts to Atlantic salmon smolt health and survival

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Episodic low pH and high aluminum associated with anthropogenic acidification has been identified as a possible threat to Atlantic salmon (*Salmo salar*) recovery in the gulf of Maine distinct population segment (DPS). Low pH and high aluminum can impair a smolts ability to successfully migrate and sometimes results in direct mortality. The level in which pH and aluminum impacts smolts depend on other water chemistry conditions, particularly acid neutralizing capacity (ANC) and dissolved organic carbon (DOC). In 2003, a committee was formed to investigate water chemistry impacts on Atlantic salmon survival as part of an effort to investigate if river liming would serve as an effective tool to mitigate for anthropogenic acidification. This was accomplished through documentation of spatial and temporal patterns of episodic low pH and high aluminum across DPS watersheds and monitoring of the physiological response of Atlantic salmon to these conditions. Preliminary findings indicate that smolts in Downeast rivers exhibit signs of stress when river pH falls below 5.6. The Pleasant River is the only mainstem among the Dennys, Machias, East Machias, Pleasant and Narraguagus rivers that has been documented to experience pH episodes below 5.6 during the spring smolt migration. Nine tributaries are documented to have had at least one occurrence of pH less then 5.6. Many more rivers and tributaries experience pH episodes below 5.6 in the fall time though less is known to what extent these events may be impairing eggs or parr, or what the cumulative impacts of these events may be. Even though gill aluminum concentrations were low in the 2004, 2005 streamside studies, more work is needed to determine to what extent aluminum in the Downeast rivers may be impacting smolts.

4.7.4 Marking

No abstracts submitted.

4.7.5 Population Estimates Or Tracking

Smolt migration and fall movement of juvenile Atlantic salmon in a restoration stream of the Connecticut River, USA

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Advances in passive integrated transponder (PIT) tag technology offer the opportunity to locate and individually identify large numbers of fish without disrupting their natural habitat choice, activity, and behaviors. Using 23 mm TIRIS PIT tags that permit large read ranges (2 m), we have developed a method for passively monitoring downstream migration and movement of juvenile Atlantic salmon 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%. Each autumn from 1998-2005, we have PIT tagged 302-460 fry-stocked parr (9-17 cm fork length; 1^+- and 2^+-year olds) from Smith Brook, VT (a tributary of the Connecticut River) and continuously monitored their downstream movement. Each fall there was a substantial downstream movement of parr (5-20% of fish tagged that fall), with relatively little movement in winter and summer. The smolt migration began in mid-March and ended in mid-May, with 90% occurring between April 20 and May 12. Most of the smolt migration occurred at night. From spring 1999-2003 the median date of migration varied by only 6 days over the 6 years, perhaps indicative of the photoperiodic control of smolt migration. Smolt migration in spring 2004 was earlier by 6 days than in any previous year, and although warmer than most other years was a nonlinear response to temperature. There was no apparent relationship of smolt migration to flow. There was a strong relationship between degree days in April and the median date of migration, whereas the relationship between first date of 10 ^{o}C and median date of migration was weaker. There was a strong positive relationship between size at tagging in the fall and probability of smolting, with immature fish larger than 11.5 cm fork length having a probability of smolting nearly 100%. Estimates of winter survival for immature fish > 11.5% varied substantially from year-to-year and were between 28-68%. Estimates of smolt recruitment for all fish (mature and immature fish) also varied from year-to-year and were between 19-42%.

Movements and fate of sonically tagged, experimentally "escaped" farmed Atlantic salmon from the border area between Maine and New Brunswick of east coast North America

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We sonically tagged then experimentally "escaped" farmed Atlantic salmon from a cage site in Cobscook Bay, Maine, USA, to document movement patterns and fates of the fish. Intense tidal currents dominate Cobscook Bay and the surrounding Bay of Fundy region. Fish were liberated in either the winter or spring. Tagged salmon dispersed away from the cage sites within a few hours post-release. There were high mortalities of the fish within Cobscook Bay and the surrounding coastal region (56% of winter release fish; 84% of the spring group) probably due to

seal predation. Surviving fish exited the coastal zone to the Bay of Fundy primarily by following the dominant tidal currents in the region through Canadian waters. No sonically tagged fish was detected during the autumn spawning season in any of 40 monitored Atlantic salmon rivers draining to the Bay of Fundy.

Movements of pre-Spawn Atlantic salmon in Penobscot Bay and River: a pilot study using acoustic telemetry

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Previous research has revealed extensive information on the freshwater stages of Atlantic salmon life history in the Gulf of Maine Distinct Population Segment, but the behavior of pre-spawn adults, particularly in the marine and estuarine environments, remains unclear. Migrating adults may incur significant mortality or delay at dams or through other sections of the river, representing critical impediments to restoration. In this study, we assessed the feasibility of acoustic telemetry as a method to describe patterns of upstream movement and migratory success over more than 200 km of the Penobscot Bay and River. Ten two-sea-winter (2SW) adult male salmon of hatchery origin were surgically implanted with acoustic transmitters; five of these were released in Penobscot Bay (near Rockland) and five were released above Veazie Dam (in Orono). An array of acoustic telemetry receivers provided detailed information on movement rates and path choice, including depth at detection. Detection efficiencies were robust, with minimal missed detections. Although all salmon were released in late June, only three had passed the Milford Dam (approx. 14 km upstream of Veazie Dam) by late October. These data suggest that dams are a severe impediment to migrating salmon. We recommend the use of acoustic telemetry in future assessments of migrating Atlantic salmon in the Penobscot River.

Ultrasonic Telemetry: Supporting adaptive management towards Atlantic salmon recovery

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Declining abundance of Maine's remnant Atlantic salmon populations over the past few decades prompted their listing in 2000 as a federally endangered species. Since 1997, NOAA-Fisheries Service has been using ultrasonic telemetry to assess the emigrating smolt dynamics of these populations. Telemetry arrays were designed to monitor migration behavior and timing, and survival through the riverine, estuarine, and near-shore marine environments. The data collected have provided insight into several emigration threats that may be impeding recovery. Data from telemetry work has been used to formulate hypotheses about factors that negatively effect populations and managers are testing these theories through mitigation measures such as avian deterrent activities, pilot liming projects, and alternative stocking strategies. The ultrasonic telemetry work has generated an improved understanding of smolt emigration dynamics and fostered the development of adaptive management strategies to enhance the recovery of the remnant salmon populations in Maine.

Integrating estuarine environmental modeling, telemetry data, and visualization to understand migration ecology of Atlantic salmon in eastern Maine

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To better understand the emigration ecology of Atlantic salmon smolts in eastern Maine rivers, we tracked salmon smolts in the Narraguagus River using ultrasonic tags and a large array of fixed receivers that monitored fish movements from river kilometer 7.65 seaward into the Gulf of Maine. Telemetry information was related to environmental data using advanced modeling and visualization techniques. In spring 2003, a series of instruments was placed in the Narraguagus River and surrounding regions to collect data on current patterns, water levels, temperature, and salinity to calibrate and verify the numerical model. The modeling efforts have proved useful in developing critical insights on the processes affecting Atlantic salmon emigration dynamics in eastern Maine and in identifying mortality factors constraining the recovery of the populations.

4.7.6 Smoltification And Smolt Ecology

Thresholds for the impact of acid and aluminum on Atlantic salmon smolts: laboratory and field studies

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Previous work has established that smolts are more sensitive to acid and aluminum than most other life stages of Atlantic salmon. Recent work also indicates that relatively short-term exposure (several days) to acid and aluminum can cause mortality and reduce salinity tolerance.

We conducted laboratory and field studies to determine the levels of acid and aluminum that affect survival, salinity tolerance, and stress in Atlantic salmon smolts. In the laboratory, fish were exposed to three levels of pH (6.0, 5.6, 5.2) and four levels of aluminum (total aluminum: 0, 40, 80, 175 µg/l) for two days. All smolts died at low pH and high aluminum, and intermediate levels of acid and aluminum resulted in moderate mortality, loss of salinity tolerance, loss of plasma ions in fresh water and increased stress. Cage studies in southern Vermont streams indicated that similar thresholds of impact occur in natural stream waters over a 3 to 6 day period. The results indicate that an interaction of low pH and aluminum cause mortality and loss of salinity tolerance in Atlantic salmon smolts. Poorly buffered streams in New England may therefore have limited smolt production as a result of acid precipitation.

Using RNA-DNA ratios to assess growth of field collected hatchery Atlantic salmon smolts

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RNA-DNA ratios have been used as an index of growth in fishes at various life stages from larvae to adults. This technique, typically requiring sacrifice of the fish, was evaluated for its potential use in field assessments of feeding/growth of hatchery released Atlantic salmon (*Salmo salar*) smolts. Laboratory experiments and field studies were conducted to assess the sensitivity of RNA-DNA ratios to a short-term (one week) starvation history, and to monitor RNA-DNA ratios of field collected hatchery smolts for comparison with ratios of the original hatchery stock. Muscle samples, weights, and lengths were taken from 60 control fish and 60 Marical-treated fish. All fish were PIT tagged and held at ambient temperature without food for one week, after which time a second set of samples were taken from the individual fish, providing matched baseline and post-starvation samples. Sixty-four cohorts of the experimental fish were captured from the marine environment after river release (33 Marical-treated fish; 31 control fish) and were weighed and sampled for RNA-DNA assay. Both Marical and control fishes were of similar baseline weight and length. Under experimental conditions, Marical and control fish performed similarly in terms of weight loss, RNA-DNA ratios and specific growth rate after one week without food (i.e., there was no significant difference between the two fish groups). However, there was wide variation in weights of field-collected fish. It appears that the Marical-treated fish grew while the control fish did not based on the change in mean weight from that of the mean baseline weight of the lab cohort. However, there was no significant difference in weight of Marical fish vs. control fish, nor in the mean of the nucleic acid ratios of Marical and control fish. Temperature history, however, will be important in interpreting these data. Two factors may be confounding the results of the field-collected fish; tissue type and temperature. Muscle samples of approximately two-thirds of the captured fish had a distinctly different tissue layer beneath the skin and above the white muscle. This tissue was easily separated from the

skin, appeared light brown, oily and macroscopically similar to muscle. The assays were conducted including this tissue with the white muscle. We are uncertain if this tissue is a thin layer of dark muscle; if it is, it may have affected the ratios. Secondly, field captured smolts were collected at stations with temperatures ranging from 6.1-11.2^{o} C (mean 8.8^{o} C). As temperature affects the biochemical reactions involved in protein production and rRNA activity, the various temperatures encountered by the fish may confound interpretation of the RNA/DNA results. We are planning to investigate the possible affect of brown tissue on the RNA-DNA ratios, and to conduct a laboratory calibration experiment to define the relationship between temperature, RNA-DNA ratio and growth rate. This will enable us to collect smolts from the field at various temperatures and assign a specific growth rate to the fish.

A comparison of responses of Atlantic salmon parr and smolts to acid/aluminum exposure and detection of gill aluminum accumulation using non-lethal gill biopsy

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Acid rain coupled with increased aluminum (Al) is a potential cause of Atlantic salmon decline in many North American rivers including those of eastern Maine. Smolts appear to be the most sensitive of the salmon life stages to acid/Al (AA), however the mechanism(s) underlying increased sensitivity are unknown. Our objectives were: to validate non-lethal, gill biopsy for measuring gill Al, to confirm that smolts are more sensitive to AA than parr, and to identify the mechanism(s) underlying increased sensitivity. Parr and smolts were exposed to control and AA conditions in both the lab and the field and sampled after 2 and 6 d. In both locations, AA caused a dose-dependent elevation of gill Al. Gill Al measured by the gill arch method did not differ from gill Al measured by non-lethal gill biopsy. In the lab and field, gill Al increased > 7-fold after 2 d in both life stages. After 6 d, parr gill Al was 2-fold > than smolts. In the lab, plasma chloride of AA smolts decreased 11 %, and glucose increased 3-fold after 6 d, however, parr chloride and glucose were unaffected. Gill Na^{+},K^{+}-ATPase activity (NKA) of both life stages was unaffected. In the field, plasma chloride decreased 8.3 % in AA parr and 27 % in smolts after 2 d. Parr chloride continued to decline, but partially recovered in smolts. Plasma glucose increased > 2-fold in AA parr and smolts after 2 d. Gill NKA decreased 45 % in AA parr and smolts after 6 d. Our results demonstrate that measurement of gill Al using non-lethal gill biopsy provides a valid indicator of AA exposure. In addition, smolt ion regulatory ability is more sensitive to AA than that of parr, however neither decreased gill NKA nor elevated gill Al appear to be mechanisms of increased sensitivity.

Physiological and behavioral effects of PCBs (Aroclor 1254) on larval survival and smolt development of Atlantic salmon

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The possible sub-lethal alterations in development due to PCBs in fish have not been widely examined. PCBs are a widespread aquatic contaminant and are present in relatively high concentrations in both wild and hatchery raised Atlantic salmon. In this study, we examined the effects of PCBs (Aroclor 1254) on larval survival and smolt development of Atlantic salmon. In separate experiments, animals were exposed as yolk-sac larvae or as smolts to 1 ppb (PCB1) or 10 ppb (PCB10) aqueous Aroclor 1254, or vehicle for 21 days. After exposure, larvae were maintained at ambient conditions for one year. Both groups were assessed for endocrine, osmoregulatory, and behavioral disruption of smolt development at the peak of smolting. There were no mortalities in either experiment, however, both PCB1 and PCB10 treated larvae exhibited a 15% increase in the rate of opercula movement after 14 and 21 days of exposure; indicative of respiratory stress. Plasma concentrations of cortisol, growth hormone, insulin-like growth factor I, and thyroid hormones were not significantly impacted in either experiment; however, plasma triiodothyronine was reduced in PCB1-exposed smolts. Smolt exposure to PCB10 caused a 50% decrease in gill Na^+,K^+-ATPase activity and a 10% loss of plasma chloride in freshwater. Fish exposed as larvae did not exhibit osmoregulatory impairment. Larval exposure to PCB1 did not affect subsequent seawater preference, but reduced behavioral preference in fish treated as smolts. PCB10 dramatically decreased seawater preference regardless of developmental stage at the time of exposure. We conclude that while the effects of PCBs may vary according to timing of exposure, exposures are likely to occur repeatedly throughout development during freshwater residence. This suggests that PCBs are inhibitory to preparatory adaptations for seawater entry that occur during smolting and are likely to affect migration timing, the capacity for ion homeostasis during seawater entry, as well as increase vulnerability to predation and thus ultimately reduce ocean survival.

Effect of sub-lethal concentrations of atrazine, hexazinone, chlorothalonil and phosmet on Atlantic salmon

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Hexazinone (HEX) and atrazine (ATZ) are highly mobile herbicides that are widely used along rivers in the United States. Both compounds can be potentially harmful to Atlantic salmon (*Salmo salar*), which have been recently listed as an endangered species. Larvae were exposed

to 100 ppb HEX, 10 ppb or 100 ppb ATZ for 21 d at 10 ^oC. After exposure as larvae, fish were reared for one year and exposed as smolt to 100 ppb ATZ for 13 days at 10 ^oC. There was no effect of either contaminant on larval survival or whole larvae Na^+ and Ca^{2+} content. Exposure to 100 ppb HEX, 10 and 100 ppb ATZ caused an increase in opercular movement. ATZ 100 ppb caused a significant weight loss. Gill Na^+ ,K^+,-ATPase activity, salinity tolerance, plasma cortisol, Na^+ and Ca^{2+} were not affected by exposure to herbicides as larvae. Plasma cortisol increased significantly in FW smolts treated with 100 ppb ATZ, and increased to a greater degree in fish that had been treated with 100 ppb HEX as larvae. We conclude that under the conditions imposed in this study HEX affects larval respiration and ATZ has a substantial impact on larval metabolism and growth. A second herbicide exposure as smolts did not affect smolt development but did impact plasma cortisol. Maine Rivers are also contaminated by acid precipitation and the pesticides chlorothalonil (CTL) and phosmet (PHO). In a second experiment, forty five larvae per tank at pH 6.5 or 5.0 were exposed for 12 d to 10 ppb ATZ, HEX, PHO or CTL. Larval growth rate and total Ca^{2+} decreased in all treatments at pH 5.0, while growth rate of larvae was reduced by CTL and PHO regardless of pH. Only PHO reduced total Na^+ under acidic conditions and decreased cholinesterase activity at both pHs. We conclude that acid water causes ionoregualtory disturbance and reduces growth rate when in combination with pesticides, and, regardless of pH, the insecticide PHO decreases enzymes involved in nerve transmission.

Long-term Seawater Performance of Atlantic Salmon with Different Freshwater Experiences

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Gill Na^+,K^+-ATPase activity is highly variable during smolting and can vary with environmental conditions, yet is used by natural resource agencies as a predictor of seawater performance, we want to determine whether it is a true predictor of long-term seawater performance. In 2006, two groups of fish will be used to determine the predictability of long term seawater performance using gill Na^+,K^+-ATPase activity: hatchery fish and streamside-reared fish. Fish (with known levels of gill Na^+,K^+-ATPase activity) will be moved to a seawater facility where they will be monitored daily. All fish will be non-lethally sampled every 2 weeks through August for performance. Measurements that will be taken for all individuals include: fork length, weight, scales (a minimal number with forceps), and picture for landscape analysis (quantification of body shape). Specific growth rates for all individuals from the hatchery will be calculated and correlated to freshwater gill Na^+,K^+-ATPase activity. For streamside reared fish (with known water quality history) specific growth in seawater will be correlated with freshwater gill Na^+,K^+-ATPase activity and compared among sites with varying water quality. On several occasions (24 and 72 h; 2, 4, 8, and 16 weeks after seawater transfer) 20 fish will be lethally sampled to determine a potential time period of osmoregulatory difficulty. Blood will be drawn to

determine plasma ion concentration and osmolality to examine osmoregulatory performance. Gill samples will be taken to determine final gill Na^+,K^+-ATPase activity. Tissue will be sampled for RNA/DNA ratios at the 72 h and 2-week lethal time points. Sex and degree of maturity/gonadal development will be determined and scale samples will be taken for examining the timing of ring deposition. Freshwater gill Na^+,K^+-ATPase activity will be correlated with individual specific growth rates, final gill Na^+,K^+-ATPase activity, and final degree of maturity.

Descaling impairs osmoregulation in seawater challenged Atlantic salmon smolts

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Descaling is a commonly observed injury in Atlantic salmon smolts migrating in watersheds that have dams with poor downstream passage. These injuries are particularly observed towards the end of the migratory season. The effect of this type of injury on the ability to osmoregulate upon seawater entry was investigated using hatchery smolts. A series of seawater transfers was conducted three times to reflect “early”, “middle” and “late” periods of migration (April 25, May 11 and May 31). Before each transfer, 120 fish were anesthetized and measured (length and weight). Half served as controls and received no injury. The other half received a descaling injury of 20 % of the body surface. Immediately after recovery, 15 control and 15 treatment fish were subjected to a 35 ppt seawater challenge. After 24 h blood was collected (for plasma osmolality, hematocrit, and on day 7 septic bacterial load) and gill biopsies taken to measure gill Na^+,K^+-ATPase activity. Three additional seawater challenges were carried out at 1, 3, and 7 days after the initial sampling. Gill Na^+,K^+-ATPase activity levels indicate that the time series spanned the period from early smolting (increasing activity) to desmolting (decreasing activity). In each group, descaled fish showed greater osmotic perturbation than control fish. Control fish stabilized within 7 days for early and middle series; however, descaled fish failed to recover in this time frame. For the “late” fish, plasma osmolality was elevated in both groups; descaled fish did not differ from controls at days 3 and 7. No clear pattern of septic bacterial load and treatment was apparent. The evidence suggests that descaling impairs osmoregulatory performance during smolting and full recovery does not occur within 7 days. Therefore, descaled smolts entering seawater within 7 days of the injury may have compromised long-term survival.

Penobscot River salmon smolts: movements, survival, and path choice during a flood year

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The Penobscot River supports the largest run of Atlantic salmon in the United States; however, populations in this and neighboring systems have recently experienced precipitous declines. Restoration efforts have included extensive hatchery supplementation, and the majority of returning adults are believed to be the product of hatchery smolt stocking. In this study, we use acoustic telemetry to describe movements of both hatchery and naturally reared smolts in order to quantify path choice, transit times and loss to the system (mortality). These factors are related to smolt condition, supplementation practices and the impacts of hydroelectric facilities. A total of 335 smolts were surgically implanted with acoustic transmitters and released at four locations in the Penobscot River and tributaries in the spring of 2005. Hatchery smolts were released in the Mattawamkeag River (n=40), the Penobscot River, Howland (n=150), and the Pleasant River, Milo (n=85) in mid-late April. Wild smolts (n=60) were captured during emigration, tagged, and released in the Penobscot River below Weldon Dam in late May. Tagged smolts were detected by an array of acoustic receivers spanning more than 150 km of the Penobscot River and its estuary. Peak discharge (107,000 cfs) during the study period was above the 90th percentile for the last 102 years of data, resulting in variable reach detection efficiencies. Nonetheless, preliminary results suggest that the majority of losses occurred in upper reaches, with small losses in the vicinity of dams. On average, hatchery smolts took 21 (SE ±.0.49) days to reach the estuary, whereas later migrating wild smolts took 3.5 (SE ±.0.22) days. These results indicate that survival to the estuary varied by rearing, stocking location and release date.

Assessment of water chemistry in downeast Maine rivers and effects on Atlantic salmon smolts

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Episodic low pH and high aluminum associated with anthropogenic acidification has been identified by the Maine Atlantic Salmon Technical Advisory Committee as a possible threat to Atlantic salmon (*Salmo salar*) recovery in the Gulf of Maine distinct population segment (DPS). Low pH and high aluminum can impair a smolt's ability to successfully migrate and sometimes results in direct mortality. The level to which pH and aluminum impact smolts depends on other water chemistry conditions, particularly acid neutralizing capacity (ANC) and dissolved organic

carbon (DOC). In 2003 we began investigating water chemistry effects on Atlantic salmon smolts by 1) documenting spatial and temporal patterns of episodic low pH and high aluminum across DPS watersheds and 2) monitoring the physiological response of Atlantic salmon to these conditions using streamside exposure studies. Preliminary findings indicate that smolts in Downeast rivers exhibit signs of stress, indicated by elevated plasma glucose and depressed plasma chloride levels, when river pH falls below 5.6. Among the Dennys, Machias, East Machias, Pleasant and Narraguagus rivers, the Pleasant River is the only mainstem documented to experience pH episodes below 5.6 during the spring smolt migration. Nine tributaries are documented to have had at least one occurrence of pH less then 5.6. Many more rivers and tributaries experience pH episodes below 5.6 in the autumn though less is known about the effects (immediate or cumulative) on eggs or parr. Even though gill aluminum concentrations were low in the 2004 and 2005 streamside studies, more work is needed to determine to what extent aluminum in the Downeast rivers may be impacting smolt survival.

Comparing the migratory behavior and physiology of Atlantic salmon smolts from Dennys and Penobscot River stocks

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Hatchery-reared Dennys River smolts stocked into the Dennys River return at a much lower rate than hatchery-reared Penobscot River smolts stocked into the Penobscot River. Reduced survival of the Dennys smolts may reflect river-specific environmental differences or result from stock-specific differences in smolt behavior and physiology that diminish performance. We built three experimental tanks at the Green Lake National Fish Hatchery to examine and compare stock-specific activity patterns during smoltification and the associated transition from territorial to downstream migratory behavior. Flow within the 1.5m diameter tanks was circular at 0.1 - 0.7 m s^{-1} around a 77cm diameter central crowder, which was offset to direct flow and moving fish through a narrow, 15cm wide galley against the tank wall that was equipped with a paired Passive Integrated Transponder (PIT) tag antennae array. Dennys River and Penobscot River smolts were PIT tagged and placed in the tanks (10 of each stock per tank) for two-week trial intervals from March-July 2005. The frequency and direction of smolt movements ("upstream" against tank flow or "downstream" with tank flow) was monitored continuously. We also collected non-lethal gill biopsies from each smolt at the beginning and end of each trial to assay Na+ -K+ ATPase activity, a potential indicator of saltwater tolerance and migratory fitness. Analysis of length, weight, gender, gill Na+-K+ATPase activity, and behavior will be considered.

Developing a model of smolt migration in the Connecticut River

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In this study, we are asking what types of variation might affect success in smolt migration? We are continuing our work of modeling the timing of movement, the distance smolts need to travel, effects of dams (number, type, passage facilities), water velocity, swimming behavior, differing annual thermal regimes, and predators (number, type, location). Components of the model are water velocity, temperature, delay at dams, and mortality. Model runs are set up as experiments to answer specific questions. The value of this approach is that results will document the range of behavioral responses of successful smolts in the Connecticut River.

4.7.8 Stock Identification Or Genetics

No abstracts submitted.

5.0 APPENDICES

5.1 List of Attendees

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5.2 List of Program Summary and Technical Working Papers including PowerPoint Presentation Reports.

Number	Authors	Title
PS06-01	Veronica Mason	Pawcatuck River Atlantic salmon restoration, 2005 (PPT)
PS06-02	Jay McMenamy	Connecticut River Atlantic salmon restoration, 2005 (PPT)
PS06-03	Joseph McKeon	Merrimack River Atlantic salmon restoration, 2005 (PPT)
PS06-04	Joan Trial	Maine Atlantic salmon restoration, 2005 (PPT)
WP06-01	Sharon A. MacLean	Salmonid pathogens in northwestern Atlantic fishes
WP06-02	Christine A. Lipsky James P. Hawkes John F. Kocik Greg Mackey	Update on Maine River Atlantic Salmon Smolt Studies: 2005.
WP06-03	James P. Hawkes Edward M. Hastings	Update on Coastal Maine River Atlantic Salmon Smolt Telemetry Studies: 2005
WP06-04	Edward M. Hastings	Atlantic Salmon Smolt and Parr Marking Project Overview: 2000 – 2005
WP06-05	Richard Dill Meredith Bartron	Use of genetic analysis to determine origin of naturally reared Atlantic salmon in the Penobscot River
WP06-06	Dave Bean Samantha Horn-Olsen	Maine and neighboring Canadian Commercial Aquaculture Activities and Production
WP06-07	John Sweka Richard Dill Joan Trial	Assessment of Thermal Habitat for Maine Atlantic Salmon (PPT)
WP06-08	Chris Legault Tim Sheehan	No BEER (Bayesian Estimation of Emigration Rates) (PPT)
WP06-09	Jim Hawkes Rory Saunders Adam Vashon	Managing the Impacts of Cormorant Predation on Endangered Atlantic Salmon Smolts (PPT)
WP06-10	Dan Kircheis Richard Dill Mariska Obedzinski Steven McCormick et al.	Effects of low pH and high aluminum on Atlantic salmon smolts in Eastern Maine and liming project feasibility analysis
WP06-11	Paul Music James Loftin James Hawkes Luke Whitman, et al.	Assessment of Rotary Screw Trap Conditions on Emigrating Atlantic Salmon Smolts
WP06-12	Esther Cushing	NOAA Northeast Salmon Team GIS Overview (PPT)
WP06-13	Joan Trial Greg Mackey	Strategy for Adaptive Electrofishing Sampling and Catch per Unit Effort. (WP and PPT)
WP06-14	Joan Trial Christopher Legault Timothy Sheehan	2005 ICES North Atlantic Salmon Working Group Meeting (PPT only)
WP06-15	Meredith Bartron	Summary of screening for non-North American lineage individuals in the Craig Brook National Fish Hatchery broodstock. (PPT only)

WP06-16	Graham S. Goulette James P. Hawkes	Overview of NOAA-Fisheries Service Atlantic Salmon Water Quality Report: 2005.
WP06-17	Mitch Simpson	Point Stocking, an Alternative Fry Stocking Strategy.
WP06-18	Theodore V. Willis	The role of marine derived nutrients in Atlantic salmon freshwater habitats (with PPT)
WP06-19	Martha Mather	Can The Presence Of Alternate Prey Affect Survival Of Atlantic Salmon Via Prey Buffering: Some Food for Thought (PPT with abstract)
WP06-20	Rory Saunders	Historic and Contemporary Riverine Fish Communities in Maine and Their Importance to Atlantic Salmon (PPT with abstract)
WP06-21	John F. Kocik Greg Mackey John Sweka	Basinwide estimates of juvenile Atlantic salmon populations in large river systems (PPT)
WP06-22	Timothy Sheehan Dave Reddin Helle Siegstad Timothy King	An Overview of the 2005 West Greenland Atlantic Salmon fishery (PPT)
WP06-23	Mike Pietrak Chris Legault Ken Beland	Atlantic salmon scale reading at trapping facilities: Can we tell who's who? (PPT)
WP06-24	Jed Wright	Multi-scale Habitat Characterization in a Digital Geomantic Analytic Framework Or Maps, Rocks, Water and Fish (PPT)
WP06-25	Richard Dill Ruth Haas-Castro Ed Hastings Christine Lipsky	Naming Convention for freshwater age of hatchery stocked parr (PPT)
WP06-26	Alex O. Abbott	The Current Status of Atlantic Salmon GIS Data (PPT)
WP06-27	Donna Parrish, Martha Marther, Elizabeth Marschall Jay McMenemy	Modeling Atlantic Salmon: Connecticut River/Salmon Migration Simulation System (PPT)

5.3 Glossary of Abbreviations

Adopt-A-Salmon Family	AASF
Arcadia Research Hatchery	ARH
Central New England Fisheries Resource Office	CNEFRO
Connecticut River Atlantic Salmon Association	CRASA
Connecticut Department of Environmental Protection	CTDEP
Connecticut River Atlantic Salmon Commission	CRASC
Craig Brook National Fish Hatchery	CBNFH
Decorative Specialities International	DSI
Developmental Index	DI
Distinct Population Segment	DPS
Federal Energy Regulatory Commission	FERC
Geographic Information System	GIS
Greenfield Community College	GCC
Green Lake National Fish Hatchery	GLNFH
International Council for the Exploration of the Sea	ICES
Kensington State Salmon Hatchery	KSSH
Maine Atlantic Salmon Commission	MASC
Maine Department of Transportation	MDOT
Massachusetts Division of Fisheries and Wildlife	MAFW
Massachusetts Division of Marine Fisheries	MAMF
Nashua National Fish Hatchery	NNFH
National Academy of Sciences	NAS
National Marine Fisheries Service	NMFS
New England Atlantic Salmon Committee	NEASC
New Hampshire Fish and Game Department	NHFG
New Hampshire River Restoration Task Force	NHRRTF
North Atlantic Salmon Conservation Organization	NASCO
North Attleboro National Fish Hatchery	NANFH
Northeast Utilities Service Company	NUSCO
Passive Integrated Transponder	PIT
PG&E National Energy Group	PGE
Pittsford National Fish Hatchery	PNFH
Power Point, Microsoft	PPT
Public Service of New Hampshire	PSNH
Rhode Island Division of Fish and Wildlife	RIFW
Richard Cronin National Salmon Station	RCNSS
Roger Reed State Fish Hatchery	RRSFH
Roxbury Fish Culture Station	RFCS
Salmon Swimbladder Sarcoma Virus	SSSV
Silvio O. Conte National Fish and Wildlife Refuge	SOCNFWR
Southern New Hampshire Hydroelectric Development Corp	SNHHDC
Sunderland Office of Fishery 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 Fishery Hatchery	WSFH
White River National Fish Hatchery	WRNFH
Whittemore Salmon Station	WSS

5.4 Glossary of Definitions

GENERAL

Domestic Broodstock	Salmon that are progeny of sea-run adults and have been reared entirely in captivity for the purpose of providing eggs for fish cultural activities.
Freshwater Smolt Losses	Smolt mortality during migration downstream, which may or may not be ascribed to a specific cause.
Spawning Escapement	Salmon that return to the river and successfully reproduce on the spawning grounds.
Egg Deposition	Salmon eggs that are deposited in gravelly reaches of the river.
Fecundity	The number of eggs a female salmon produces, often quantified as eggs per female or eggs per pound of body weight.
Fish Passage	The provision of safe passage for salmon around a barrier in either an upstream or downstream direction, irrespective of means.
Fish Passage Facility	A man-made structure that enables salmon to pass a dam or barrier in either an upstream or downstream direction. The term is synonymous with fish ladder, fish lift, or bypass.
Upstream Fish Passage Efficiency	A number (usually expressed as a percentage) representing the proportion of the population

	approaching a barrier that will successfully negotiate an upstream or downstream fish passage facility in an effort to reach spawning grounds.
Goal	A general statement of the end result that management hopes to achieve.
Harvest	The amount of fish caught and kept for recreational or commercial purposes.
Nursery Unit / Habitat Unit	A portion of the river habitat, measuring 100 square meters, suitable for the rearing of young salmon to the smolt stage.
Objective	The specific level of achievement that management hopes to attain towards the fulfillment of the goal.
Restoration	The re-establishment of a population that will optimally utilize habitat for the production of young.
Salmon	A general term used here to refer to any life history stage of the Atlantic salmon from the fry stage to the adult stage.
Captive Broodstock	Captive broodstock refers to adults produced from wild parr that were captured and reared to maturity in the hatchery.
Sea-run Broodstock	Atlantic salmon that return to the river, are captured alive, and held in confinement for the purpose of providing eggs for fish culture activities.
Strategy	Any action or integrated actions that will assist in achieving an objective and fulfilling the goal.
Wild Atlantic Salmon	Salmon that are the product of natural reproduction or the stocking of fry. Stocked fry are included because of the difficulty associated with discriminating between salmon produced through natural reproduction and those produced as a result of the stocking of fry.

LIFE HISTORY RELATED

Green Egg	The stage from spawning until faint eyes appear.
Eyed Egg	The stage from the appearance of faint eyes until hatching.
Fry	
Sac Fry	The period from hatching until end of primary dependence on the yolk sac.
Feeding Fry	The period from the end of the primary dependence on the yolk sac (initiation of feeding) to June 30 of the same year.
Fed Fry	Fry stocked subsequent to being fed an artificial diet. Often used interchangeably with the term "feeding fry" when associated with stocking activities.
Unfed Fry	Fry stocked without having been fed an artificial diet or natural diet. Most often associated with stocking activities.
Parr	Life history stage immediately following the fry stage until the commencement of migration to the sea as smolts.
Age 0 Parr	The period from August 15 to December 31 of the year of hatching.
Age 1 Parr	The period from January 1 to December 31 one year after hatching.
Age 2 Parr	The period from January 1 to December 31 two years after hatching.
Smolt	An actively migrating young salmon that has undergone the physiological changes to survive the transition from freshwater to saltwater.
1 Smolt	The period from January 1 to June 30 of the year of migration. The migration year is one year after hatch.
2 Smolt	The period from January 1 to June 30 of the year of migration. The migration year is two years after hatch.

3 Smolt	The period from January 1 to June 30 of the year of migration. The migration year is three years after hatch.
Post Smolt	The period from July 1 to December 31 of the year the salmon became a smolt.
1SW Smolt	A salmon that survives past December 31 since becoming a smolt.
Grilse	A one-sea-winter (SW) salmon that returns to the river to spawn. These fish usually weigh less than five pounds.
Multi-Sea-Winter Salmon	All adult salmon, excluding grilse that return to the river to spawn. Includes terms such as two-sea-winter salmon, three-sea-winter salmon, and repeat spawners. May also be referred to as large salmon.
2SW Salmon	A salmon that survives past December 31 twice since becoming a smolt.
3SW Salmon	A salmon that survives past December 31 three times since becoming a smolt.
4SW Salmon	A salmon that survives past December 31four times since becoming a smolt.
Kelt	A stage after a salmon spawns. For domestic salmon, this stage lasts until death. For wild fish, this stage lasts until it returns to homewaters to spawn again.
Reconditioned Kelt	A kelt that has been restored to a feeding condition in captivity.
Repeat Spawners	Salmon that return numerous times to the river for the purpose of reproducing. Previous spawner.

5.5 Map of Historic Atlantic Salmon Rivers

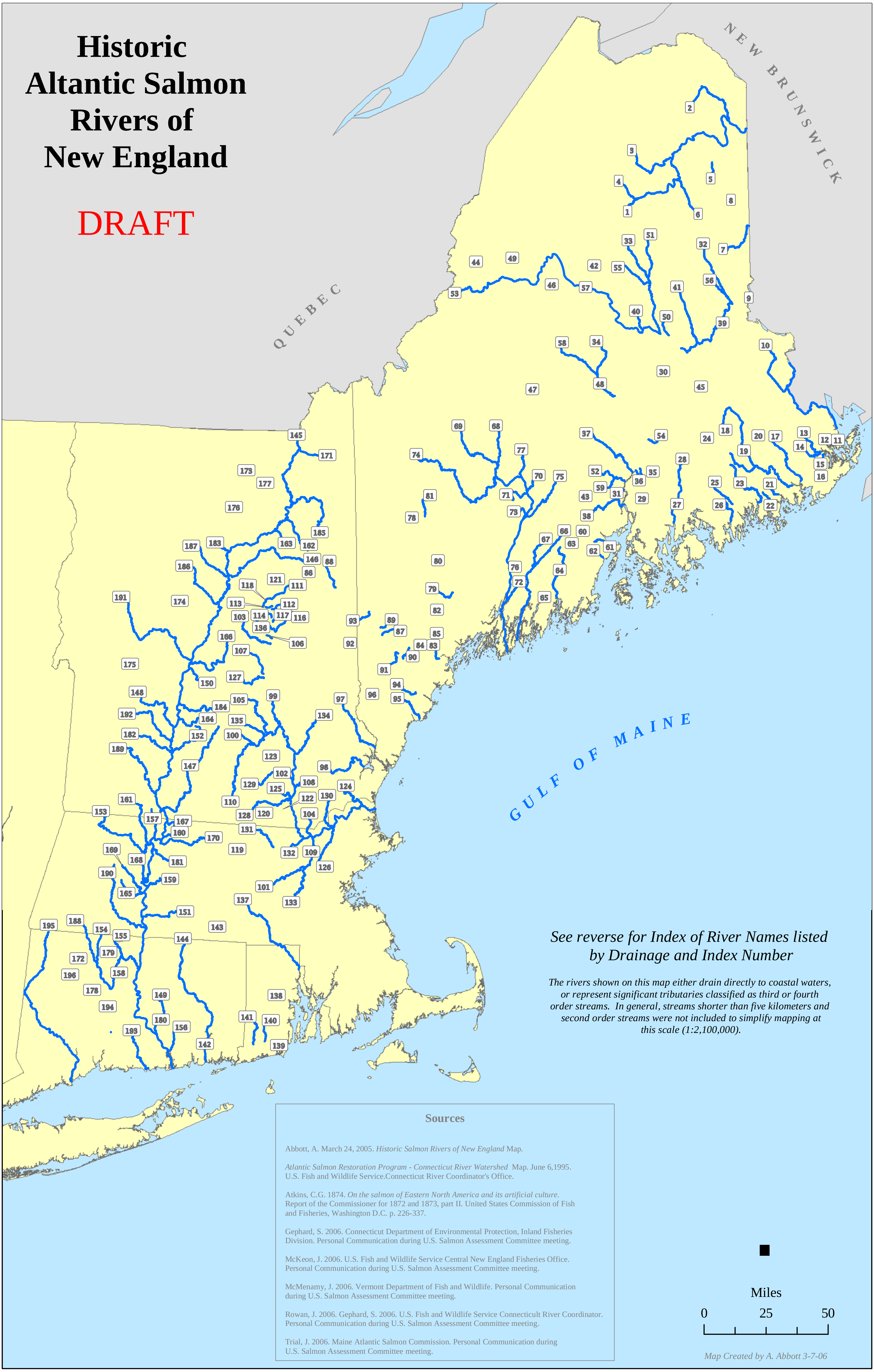
On two following pages.

5.6 Tables Supporting the Document

On separately numbered pages following the map.

Historic Altantic Salmon Rivers of New England

DRAFT



See reverse for Index of River Names listed by Drainage and Index Number

The rivers shown on this map either drain directly to coastal waters, or represent significant tributaries classified as third or fourth order streams. In general, streams shorter than five kilometers and second order streams were not included to simplify mapping at this scale (1:2,100,000).

Sources

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Map Created by A. Abbott 3-7-06

Historic Atlantic Salmon Rivers of New England – Index

Drainage	River Name	Index
Aroostook	Aroostook River	1
	Little Madawaska River	2
	Big Machias River	3
	Mooseleuk Stream	4
	Presque Isle Stream	5
	Saint Croix Stream	6
St. John	Meduxnekeag River	7
	North Branch Meduxnekeag River	8
St. Croix	Saint Croix River	9
	Tomah Stream	10
Boyden	Boyden Stream	11
Pennamaquan	Pennamaquan River	12
Dennys	Dennys River	13
	Cathance Stream	14
Hobart	Hobart Stream	15
Orange	Orange River	16
East Machias	East Machias River	17
Machias	Machias River	18
	Mopang Stream	19
	Old Stream	20
Chandler	Chandler River	21
Indian	Indian River	22
Pleasant	Pleasant River	23
Narraguagus	Narraguagus River	24
	West Branch Narraguagus River	25
Tunk	Tunk Stream	26
Union	Union River	27
	West Branch Union River	28
Penobscot	Orland River	29
	Penobscot River	30
	Cove Brook	31
	East Branch Mattawamkeag River	32
	East Branch Penobscot River	33
	East Branch Pleasant River	34
	Eaton Brook	35
	Felts Brook	36
	Kenduskeag Stream	37
	Marsh Stream	38
	Mattawamkeag River	39
	Millinocket Stream	40
	Molunkus Stream	41
	Nesowadnehunk Stream	42
	North Branch Marsh Stream	43
	North Branch Penobscot River	44
	Passadumkeag River	45
	Pine Stream	46
	Piscataquis River	47
	Pleasant River (Penobscot)	48
	Russell Stream	49
	Salmon Stream	50
	Seboeis River	51
	Souadabscook Stream	52
	South Branch Penobscot River	53
	Sunkhaze Stream	54
	Wassataquoik Stream	55
	West Branch Mattawamkeag River	56
	West Branch Penobscot River	57
	West Branch Pleasant River	58
	West Branch Souadabscook Stream	59
Passagassawakeag	Passagassawakeag River	60
Little	Little River	61
Ducktrap	Ducktrap River	62
Saint George	Saint George River	63
Medomak	Medomak River	64
	Pemaquid River	65
Sheepscot	Sheepscot River	66
	West Branch Sheepscot River	67
Kennebec	Kennebec River	68
	Carrabassett River	69
	Carrabassett Stream	70
	Craigin Brook	71
	Eastern River	72
	Messalonskee Stream	73
	Sandy River	74
	Sebasticook River	75
	Togus Stream	76
	Wesserunsett Stream	77
Androscoggin	Androscoggin River	78
	Little Androscoggin River	79
	Nezinscot River	80
	Webb River	81
Royal River	Royal River	82
Presumpscot	Presumpscot River	83
	Mill Brook (Presumpscot)	84
	Piscataqua River (Presumpscot)	85
Saco	Saco River	86
	Breakneck Brook	87
	Ellis River	88
	Hancock Brook	89
	Josies Brook	90
	Little Ossipee River	91
	Ossipee River	92
	Shepards River	93
	Swan Pond Brook	94
Kennebunk	Kennebunk River	95
Mousam	Mousam River	96
Cocheco	Cocheco River	97
Lamprey	Lamprey River	98
Merrimack	Merrimack River	99
	Amey Brook	100
	Assabet River	101
	Baboosic Brook	102
	Baker River	103
	Beaver Brook	104
	Blackwater River	105
	Bog Brook	106
	Cockermouth River	107
	Cohas Brook	108
	Concord River	109
	Contoocook River	110
	East Branch Pemigewasset River	111
	Eastman Brook	112
	Glover Brook	113
	Hubbard Brook	114
	Mad River	116
	Mill Brook (Merrimack)	117
	Moosilauke Brook	118
	Nashua River	119
	Nissitissit River	120
	Pemigewasset River	121
	Pennichuck Brook	122
	Piscataquog River	123
	Powwow River	124
	Pulpit Brook	125
	Shawsheen River	126
	Smith River	127
	Souhegan River	128
	South Branch Piscataquog River	129
	Spicket River	130
	Squannacook River	131
Merrimack	Stony Brook	132
	Sudbury River	133
	Suncook River	134
	Warner River	135
	West Branch Brook	136
Blackstone	Blackstone River	137
Pawtuxet	Pawtuxet River	138
Pawcatuck	Pawcatuck River	139
	Beaver River	140
	Wood River	141
Thames	Thames River	142
	Quinebaug River	143
	Shetucket River	144
Connecticut	Connecticut River	145
	Ammonoosuc River	146
	Ashuelot River	147
	Black River	148
	Blackledge River	149
	Bloods Brook	150
	Chicopee River	151
	Cold River	152
	Deerfield River	153
	East Branch Farmington River	154
	East Branch Salmon Brook	155
	Eightmile River	156
	Fall River	157
	Farmington River	158
	Fort River	159
	Fourmile Brook	160
	Green River	161
	Israel River	162
	Johns River	163
	Little Sugar River	164
	Manhan River	165
	Mascoma River	166
	Mill Brook (Connecticut)	167
	Mill River (Hatfield)	168
	Mill River (Northhampton)	169
	Millers River	170
	Mohawk River	171
	Nepaug River	172
	Nulhegan River	173
	Ompompanoosuc River	174
	Ottauquechee River	175
	Passumpsic River	176
	Paul Stream	177
	Pequabuck River	178
	Salmon Brook	179
	Salmon River	180
	Sawmill River	181
	Saxtons River	182
	Stevens River	183
	Sugar River	184
	Upper Ammonoosuc River	185
	Waits River	186
	Wells River	187
	West Branch Farmington River	188
	West River	189
	Westfield River	190
	White River	191
	Williams River	192
Hammonasset	Hammonasset River	193
Quinnipiac	Quinnipiac River	194
Housatonic	Housatonic River	195
	Naugatuck River	196

Table 9.1. Atlantic salmon marking database for New England; marked fish released in 2005 .

Marking Agency	Age	Life Stage	H/W	Stock Origin	Primary Mark or Tag	Number Marked	Secondary Mark or Tag	Release Date	Release Location
Klein	2	Smolt	H	Connecticut	PIT	285	AD	May	Connecticut
NAI	4	Adult	W	Connecticut	RAD	7	PIT	June	Connecticut
NAI	4	Adult	W	Connecticut	RAD	5	PIT	May	Connecticut
NAI	2	Smolt	H	Connecticut	PIT	894	AD	June	Connecticut
NAI	2	Smolt	H	Connecticut	RAD	151	AD	June	Connecticut
NAI	2	Smolt	H	Connecticut	BAL	592	AD	May	Connecticut
USFWS	2	Smolt	H	Connecticut	AD	47,096		April	Connecticut
USFWS	2	Smolt	H	Connecticut	AD	35,832		Mar	Connecticut
USGS	1	Parr	W	Connecticut	PIT	453	VIE	Nov	Connecticut
CBNFH		Adult	H	Dennys	PIT	71		Nov	Dennys
NOAA	0		H	Dennys	LV	43,344		Oct	Dennys
NOAA	1	Smolt	H	Dennys	VIE	29,727	AD	April	Dennys
NOAA	1	Smolt	H	Dennys	VIE	26,668	AD	May	Dennys
UOM	1	Smolt	H	Dennys	PIT	55	AD	April	Dennys
UOM	1	Smolt	H	Dennys	PIT	174	AD	June	Dennys
UOM	1	Smolt	H	Dennys	PIT	38	AD	May	Dennys
CBNFH		Adult	H	East Machias	PIT	148		Nov	East Machias
NHFG	2	Adult	H	Merrimack	FLOY	422		May	Merrimack
NHFG	2 & 3	Adult	H	Merrimack	FLOY	443		Sept	Merrimack
NHFG	3	Adult	H	Merrimack	FLOY	430		May	Merrimack
NHFG	2	Adult	H	Merrimack	FLOY	100		June	Merrimack
CBNFH		Adult	H	Narraguagus	PIT	151		Nov	Narraguagus
ASC	0		H	Penobscot	LV	676		Sept	Penobscot
ASC	0		H	Penobscot	RV	497		Sept	Penobscot
CBNFH		Adult	H	Penobscot	PIT	429		Dec	Penobscot

Marking Agency	Age	Life Stage	H/W	Stock Origin	Primary Mark or Tag	Number Marked	Secondary Mark or Tag	Release Date	Release Location
CBNFH		Adult	H	Penobscot	PIT	198		Nov	Penobscot
GLNFH		Adult	H	Penobscot	AP	688		Nov	Penobscot
NOAA	0		H	Penobscot	LV	96,320		Sept	Penobscot
NOAA	1	Smolt	H	Penobscot	VIE	172,699	AD	April	Penobscot
NOAA	1	Smolt	H	Penobscot	VIE	177	AD	May	Penobscot
NOAA	1	Smolt	H	Penobscot	VIE	172,562		April	Penobscot
PSNH	1	Smolt	H	Penobscot	HI-Z	83		May	Merrimack
PSNH	1	Smolt	H	Penobscot	RAD	49		May	Merrimack
USGS	1	Smolt	H	Penobscot	PING	275		April	Penobscot
USGS	1,2	Smolt	W	Penobscot	PING	60		May	Penobscot
CBNFH		Adult	H	Pleasant	PIT	458		April	Pleasant
ASC	0		H	Sheepscot	AD	15,882		Sept	Sheepscot
CBNFH		Adult	H	Sheepscot	PIT	119		Nov	Sheepscot

TAG/MARK CODES: AD = adipose clip; RAD = radio tag; AP = adipose punch; RV = RV Clip; BAL = Balloon tag; VIA = visible implant, alphanumeric; CAL = Calcein immersion; VIE = visible implant elastomer; FLOY = floy tag; VIEAC = visible implant elastomer and anal clip; DYE = MetaJet Dye; PIT = PIT tag; VPP = VIE tag, PIT tag, and ultrasonic pinger; PTC = PIT tag and Carlin tag; VPT = VIE tag and PIT tag; ANL = anal clip/punch; HI-Z = HI-Z Turb'N tag

Table 9.2. Grand Summary of Atlantic Salmon marking data for New England; marked fish released in 2005.

Origin	Total External Marks	Total Adipose Clips	Total Marked
Hatchery Adult	2,083		3,657
Hatchery Juvenile	643,752	330,270	644,076
Wild Adult			12
Wild Juvenile	453		513

Table 10. Documented Atlantic salmon returns to New England rivers in 2005

	1SW		2SW		3SW		Repeat			2001-2005
	Hatchery	Wild	Hatchery	Wild	Hatchery	Wild	Hatchery	Wild	Total	Average
Androscoggin	2	0	8	0	0	0	0	0	10	6
Connecticut	0	23	4	159	0	0	0	0	186	76
Merrimack	8	0	25	1	0	0	0	0	34	89
Narraguagus	0	1	0	12	0	0	0	0	13	17
Pawcatuck	0	0	0	2	0	0	0	0	2	1
Penobscot	269	6	678	22	0	0	8	2	985	997
Saco	5	1	12	7	0	0	0	0	25	40
Total	284	31	727	203	0	0	8	2	1,255	1,227

Table 11. Summary of Atlantic salmon green egg production in Hatcheries for New England rivers in 2005.

Source River	Origin	Females Spawned	Total Egg Production
Connecticut	Domestic	1382	9,050,000
Merrimack	Domestic	191	691,000
Penobscot	Domestic	359	1,314,000
Dennys	Captive	85	386,000
East Machias	Captive	88	281,000
Machias	Captive	160	677,000
Narraguagus	Captive	146	449,000
Pleasant	Captive	99	304,000
Sheepscot	Captive	70	251,000
Total	**Captive/Domestic**	**2,580**	**13,403,000**
Connecticut	Kelt	37	384,000
Merrimack	Kelt	65	697,000
Total	**Kelt**	**102**	**1,081,000**
Connecticut	Sea Run	102	758,000
Merrimack	Sea Run	13	111,000
Penobscot	Sea Run	296	2,458,000
Total	**Sea Run**	**411**	**3,327,000**
Grand Total for Year 2005		**3,093**	**17,811,000**

Captive refers to adults produced from wild parr that were captured and reared to maturity in the hatchery.

Table 12. Summary of Atlantic salmon egg production in New England facilities.

	Sea-Run			**Domestic**			**Captive**			**Kelt**			**TOTAL**		
Year	No. females	Egg production	Eggs/ female	No. females	Egg production	Eggs/ female	No. females	Egg production	Eggs/ female	No. females	Egg production	Eggs/ female	No. females	Egg production	Eggs/ female
Cocheco															
1993-1995	3	21,000	7,100	0	0		0	0		0	0		3	21,000	7,100
Total Cocheco	3	21,000	7,100	0	0	0	0	0		0	0		3	21,000	7,100
Connecticut															
1977-1995	817	11,901,000	8,500	4,779	42,750,000	6,000	0	0		760	12,402,000	10,500	6,356	67,053,000	6,900
1996	115	938,000	8,200	1,732	11,845,000	6,800	0	0		206	2,221,000	10,800	2,053	15,004,000	7,300
1997	110	771,000	7,000	1,809	11,602,000	6,400	0	0		188	2,003,000	10,700	2,107	14,376,000	6,800
1998	185	1,452,000	7,900	1,140	7,030,000	6,200	0	0		156	1,494,000	9,600	1,481	9,976,000	6,700
1999	83	622,000	7,500	1,862	11,173,000	6,000	0	0		193	1,813,000	9,400	2,138	13,608,000	6,400
2000	49	300,000	6,100	2,471	12,200,000	4,900	0	0		142	1,350,000	9,500	2,662	13,850,000	5,200
2001	20	162,000	8,100	1,955	9,870,000	5,000	0	0		102	1,003,000	9,800	2,077	11,036,000	5,300
2002	25	181,000	7,300	1,974	10,826,000	5,500	0	0		83	827,000	10,000	2,082	11,835,000	5,700
2003	34	245,000	7,200	2,152	11,600,000	5,400	0	0		67	660,000	9,800	2,253	12,505,000	5,600
2004	37	280,000	7,600	1,875	11,750,000	6,300	0	0		53	489,000	9,200	1,965	12,519,000	6,400
2005	102	758,000	7,400	1,382	9,050,000	6,500	0	0		37	384,000	10,400	1,521	10,192,000	6,700
Total Connecticut	1,577	17,610,000	7,500	23,131	149,696,000	5,900	0	0		1,987	24,646,000	10,000	26,695	191,954,000	6,300
Dennys															
1939-1995	22	185,000	7,700	0	0		161	414,000	2,400	13	73,000	5,400	196	673,000	5,600
1996	4	29,000	7,200	0	0		86	311,000	3,600	3	29,000	9,700	93	369,000	4,000
1997	0	0		0	0		113	430,000	3,800	7	64,000	9,200	120	494,000	4,100
1998	0	0		0	0		79	338,000	4,300	10	106,000	10,600	89	443,000	5,000
1999	0	0		0	0		48	249,000	5,200	7	58,000	8,200	55	306,000	5,600

Captive refers to adults produced from wild parr that were captured and reared to maturity in the hatchery.

Note: Totals of eggs/female includes only the years for which information on number of females is available. It is a simple ratio of eggs/female and should not be used as an age specific fecundity measure because this can vary with age composition and broodstock type.

Note: Connecticut data are preliminary prior to 1990.

Year	Sea-Run No. females	Sea-Run Egg production	Sea-Run Eggs/ female	Domestic No. females	Domestic Egg production	Domestic Eggs/ female	Captive No. females	Captive Egg production	Captive Eggs/ female	Kelt No. females	Kelt Egg production	Kelt Eggs/ female	TOTAL No. females	TOTAL Egg production	TOTAL Eggs/ female
2000	0	0		0	0		64	283,000	4,400	0	0		64	283,000	4,400
2001	0	0		0	0		82	359,000	4,400	0	0		82	359,000	4,400
2002	0	0		0	0		68	352,000	5,200	0	0		68	352,000	5,200
2003	0	0		0	0		79	438,000	5,500	0	0		79	438,000	5,500
2004	0	0		0	0		88	380,000	4,300	0	0		88	380,000	4,300
2005	0	0		0	0		85	386,000	4,500	0	0		85	386,000	4,500
Total Dennys	26	214,000	7,400	0	0	0	953	3,940,000	4,327	40	330,000	8,600	1,019	4,483,000	4,800
East Machias															
1995	0	0		0	0		65	144,000	2,200	0	0		65	144,000	2,200
1996	0	0		0	0		96	221,000	2,300	0	0		96	221,000	2,300
1997	0	0		0	0		111	394,000	3,500	0	0		111	394,000	3,500
1998	0	0		0	0		103	362,000	3,500	0	0		103	362,000	3,500
1999	0	0		0	0		57	296,000	5,200	0	0		57	296,000	5,200
2000	0	0		0	0		68	394,000	5,800	0	0		68	394,000	5,800
2001	0	0		0	0		67	400,000	6,000	0	0		67	400,000	6,000
2002	0	0		0	0		92	466,000	5,100	0	0		92	466,000	5,100
2003	0	0		0	0		93	456,000	4,900	0	0		93	456,000	4,900
2004	0	0		0	0		65	252,000	3,900	0	0		65	252,000	3,900
2005	0	0		0	0		88	281,000	3,200	0	0		88	281,000	3,200
Total East Machias	0	0		0	0	0	905	3,666,000	4,145	0	0		905	3,666,000	4,100
Kennebec															
1979-1995	5	50,000	10,000	0	0		0	0		0	0		5	50,000	10,000
Total Kennebec	5	50,000	10,000	0	0	0	0	0		0	0		5	50,000	10,000

Captive refers to adults produced from wild parr that were captured and reared to maturity in the hatchery.

Note: Totals of eggs/female includes only the years for which information on number of females is available. It is a simple ratio of eggs/female and should not be used as an age specific fecundity measure because this can vary with age composition and broodstock type.

Note: Connecticut data are preliminary prior to 1990.

Year	Sea-Run			Domestic			Captive			Kelt			TOTAL		
	No. females	Egg production	Eggs/ female	No. females	Egg production	Eggs/ female	No. females	Egg production	Eggs/ female	No. females	Egg production	Eggs/ female	No. females	Egg production	Eggs/ female
Lamprey															
1992-1995	6	32,000	4,800	0	0		0	0		0	0		6	32,000	4,800
Total Lamprey	6	32,000	4,800	0	0	0	0	0		0	0		6	32,000	4,800
Machias															
1941-1995	456	3,263,000	7,300	0	0		259	680,000	2,500	6	39,000	6,400	721	3,982,000	6,900
1996	0	0		0	0		141	513,000	3,600	2	13,000	6,400	143	526,000	3,700
1997	0	0		0	0		176	603,000	3,400	0	0		176	603,000	3,400
1998	0	0		0	0		166	548,000	3,300	0	0		166	548,000	3,300
1999	0	0		0	0		121	550,000	4,500	0	0		121	550,000	4,500
2000	0	0		0	0		110	417,000	3,800	0	0		110	417,000	3,800
2001	0	0		0	0		108	672,000	6,200	0	0		108	672,000	6,200
2002	0	0		0	0		111	533,000	4,800	0	0		111	533,000	4,800
2003	0	0		0	0		121	763,000	6,300	0	0		121	763,000	6,300
2004	0	0		0	0		120	613,000	5,100	0	0		120	613,000	5,100
2005	0	0		0	0		160	677,000	4,200	0	0		160	677,000	4,200
Total Machias	456	3,263,000	7,300	0	0	0	1,593	6,569,000	4,336	8	52,000	6,400	2,057	9,884,000	4,700
Merrimack															
1983-1995	743	5,352,000	7,200	3,838	22,171,000	5,600	0	0		0	0		4,581	27,524,000	6,800
1996	31	212,000	6,900	912	5,469,000	6,000	0	0		0	0		943	5,682,000	6,000
1997	31	284,000	9,200	754	4,642,000	6,200	0	0		0	0		785	4,926,000	6,300
1998	63	518,000	8,200	560	2,669,000	4,800	0	0		5	64,000	12,900	628	3,252,000	5,200
1999	88	737,000	8,400	520	2,659,000	5,100	0	0		50	540,000	10,800	658	3,935,000	6,000
2000	38	311,000	8,200	596	2,625,000	4,400	0	0		62	748,000	12,100	696	3,683,000	5,300
2001	37	296,000	8,000	726	2,585,000	3,600	0	0		22	294,000	13,400	785	3,176,000	4,000

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Note: Totals of eggs/female includes only the years for which information on number of females is available. It is a simple ratio of eggs/female and should not be used as an age specific fecundity measure because this can vary with age composition and broodstock type.

Note: Connecticut data are preliminary prior to 1990.

	Sea-Run			Domestic			Captive			Kelt			TOTAL		
Year	No. females	Egg production	Eggs/ female	No. females	Egg production	Eggs/ female	No. females	Egg production	Eggs/ female	No. females	Egg production	Eggs/ female	No. females	Egg production	Eggs/ female
2002	16	232,000	14,500	361	1,816,000	5,000	0	0		21	232,000	11,000	398	2,279,000	5,700
2003	60	499,000	8,300	489	1,914,000	3,900	0	0		20	236,000	11,800	569	2,649,000	4,700
2004	59	494,000	8,400	229	811,000	3,500	0	0		42	48,000	1,200	330	1,353,000	4,100
2005	13	111,000	8,500	191	691,000	3,600	0	0		65	697,000	10,700	269	1,499,000	5,600
Total Merrimack	1,179	9,046,000	8,700	9,176	48,052,000	4,700	0	0		287	2,859,000	10,500	10,642	59,958,000	5,400
Narraguagus															
1962-1995	0	1,303,000		0	0		174	540,000	2,900	0	0		174	1,843,000	2,900
1996	0	0		0	0		117	434,000	3,700	0	0		117	434,000	3,700
1997	0	0		0	0		172	517,000	3,000	0	0		172	517,000	3,000
1998	0	0		0	0		186	490,000	2,600	0	0		186	490,000	2,600
1999	0	0		0	0		134	542,000	4,000	0	0		134	542,000	4,000
2000	0	0		0	0		137	432,000	3,200	0	0		137	432,000	3,200
2001	0	0		0	0		93	404,000	4,300	0	0		93	404,000	4,300
2002	0	0		0	0		159	704,000	4,400	0	0		159	704,000	4,400
2003	0	0		0	0		120	624,000	5,200	0	0		120	624,000	5,200
2004	0	0		0	0		119	453,000	3,800	0	0		119	453,000	3,800
2005	0	0		0	0		146	449,000	3,100	0	0		146	449,000	3,100
Total Narraguagus	0	1,303,000		0	0	0	1,557	5,589,000	3,655	0	0		1,557	6,892,000	3,700
Orland															
1967-1995	39	270,000	7,300	0	0		0	0		0	0		39	270,000	7,300
Total Orland	39	270,000	7,300	0	0	0	0	0		0	0		39	270,000	7,300
Pawcatuck															
1992-1995	6	50,000	7,900	0	0		0	0		0	0		6	50,000	7,900

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Note: Totals of eggs/female includes only the years for which information on number of females is available. It is a simple ratio of eggs/female and should not be used as an age specific fecundity measure because this can vary with age composition and broodstock type.

Note: Connecticut data are preliminary prior to 1990.

Year	Sea-Run No. females	Sea-Run Egg production	Sea-Run Eggs/ female	Domestic No. females	Domestic Egg production	Domestic Eggs/ female	Captive No. females	Captive Egg production	Captive Eggs/ female	Kelt No. females	Kelt Egg production	Kelt Eggs/ female	TOTAL No. females	TOTAL Egg production	TOTAL Eggs/ female
1996	1	17,000	16,900	0	0		0	0		0	0		1	17,000	16,900
1997	1	8,000	8,200	0	0		0	0		0	0		1	8,000	8,200
1999	6	61,000	10,200	0	0		0	0		0	0		6	61,000	10,200
2000	0	0		0	0		0	0		5	43,000	8,600	5	43,000	8,600
2001	0	0		2	2,000	1,100	0	0		1	8,000	7,800	3	10,000	3,300
2002	0	0		0	0		0	0		3	10,000	3,300	3	10,000	3,300
2003	2	6,000	3,100	0	0		0	0		0	0		2	6,000	3,100
Total Pawcatuck	16	142,000	9,300	2	2,000	1,100	0	0		9	61,000	6,600	27	205,000	7,700
Penobscot															
1871-1995	15,500	134,369,000	7,800	2,145	5,465,000	2,500	0	0		0	0		17,645	139,834,000	7,700
1996	380	2,635,000	6,900	0	0		0	0		0	0		380	2,635,000	6,900
1997	313	2,225,000	7,100	639	1,381,000	2,200	0	0		0	0		952	3,606,000	3,800
1998	392	2,804,000	7,200	560	1,456,000	2,600	0	0		0	0		952	4,260,000	4,500
1999	286	2,418,000	8,500	371	1,300,000	3,500	0	0		0	0		657	3,719,000	5,700
2000	196	1,559,000	8,000	540	1,334,000	2,500	0	0		0	0		736	2,893,000	3,900
2001	282	2,451,000	8,700	453	1,206,000	2,700	0	0		0	0		735	3,657,000	5,000
2002	218	2,001,000	9,200	484	1,300,000	2,700	0	0		0	0		702	3,301,000	4,700
2003	362	3,194,000	8,800	0	0		0	0		0	0		362	3,194,000	8,800
2004	353	3,229,000	9,100	477	1,200,000	2,500	0	0		0	0		830	4,429,000	5,300
2005	296	2,458,000	8,300	359	1,314,000	3,700	0	0		0	0		655	3,772,000	5,800
Total Penobscot	18,578	159,343,000	8,100	6,028	15,956,000	2,800	0	0		0	0		24,606	175,300,000	5,600
Pleasant															
2001	0	0		0	0		13	46,000	3,500	0	0		13	46,000	3,500
2002	0	0		0	0		19	84,000	4,400	0	0		19	84,000	4,400

Captive refers to adults produced from wild parr that were captured and reared to maturity in the hatchery.

Note: Totals of eggs/female includes only the years for which information on number of females is available. It is a simple ratio of eggs/female and should not be used as an age specific fecundity measure because this can vary with age composition and broodstock type.

Note: Connecticut data are preliminary prior to 1990.

Year	Sea-Run			Domestic			Captive			Kelt			TOTAL		
	No. females	Egg production	Eggs/ female	No. females	Egg production	Eggs/ female	No. females	Egg production	Eggs/ female	No. females	Egg production	Eggs/ female	No. females	Egg production	Eggs/ female
2003	0	0		0	0		11	92,000	8,300	0	0		11	92,000	8,300
2004	0	0		0	0		23	179,000	7,800	0	0		23	179,000	7,800
2005	0	0		0	0		99	304,000	3,100	0	0		99	304,000	3,100
Total Pleasant	0	0		0	0	0	165	705,000	5,420	0	0		165	705,000	5,400
Sheepscot															
1995	11	78,000	7,100	0	0		22	44,000	2,000	0	0		33	123,000	3,700
1996	7	47,000	6,700	0	0		36	66,000	1,800	7	66,000	9,400	50	179,000	3,600
1997	0	0		0	0		75	257,000	3,400	13	118,000	9,100	88	376,000	4,300
1998	0	0		0	0		98	343,000	3,500	17	162,000	9,500	115	505,000	4,400
1999	0	0		0	0		49	218,000	4,500	8	92,000	11,500	57	310,000	5,400
2000	0	0		0	0		60	246,000	4,100	0	0		60	246,000	4,100
2001	0	0		0	0		56	351,000	6,300	0	0		56	351,000	6,300
2002	0	0		0	0		100	455,000	4,600	0	0		100	455,000	4,600
2003	0	0		0	0		92	433,000	4,700	0	0		92	433,000	4,700
2004	0	0		0	0		78	308,000	3,900	0	0		78	308,000	3,900
2005	0	0		0	0		70	251,000	3,600	0	0		70	251,000	3,600
Total Sheepscot	18	125,000	6,900	0	0	0	736	2,972,000	3,855	45	438,000	9,900	799	3,537,000	4,400
St Croix															
1993-1995	36	271,000	7,500	0	0		0	0		0	0		36	271,000	7,500
2003	3	21,000	6,900	0	0		0	0		0	0		3	21,000	6,900
Total St Croix	39	292,000	7,200	0	0	0	0	0		0	0		39	292,000	7,200
Union															
1974-1995	600	4,611,000	7,900	0	0		0	0		0	0		600	4,611,000	7,900

Captive refers to adults produced from wild parr that were captured and reared to maturity in the hatchery.

Note: Totals of eggs/female includes only the years for which information on number of females is available. It is a simple ratio of eggs/female and should not be used as an age specific fecundity measure because this can vary with age composition and broodstock type.

Note: Connecticut data are preliminary prior to 1990.

Year	Sea-Run			Domestic			Captive			Kelt			TOTAL		
	No. females	Egg production	Eggs/ female	No. females	Egg production	Eggs/ female	No. females	Egg production	Eggs/ female	No. females	Egg production	Eggs/ female	No. females	Egg production	Eggs/ female
Total Union	600	4,611,000	7,900	0	0	0	0	0		0	0		600	4,611,000	7,900

Captive refers to adults produced from wild parr that were captured and reared to maturity in the hatchery.

Note: Totals of eggs/female includes only the years for which information on number of females is available. It is a simple ratio of eggs/female and should not be used as an age specific fecundity measure because this can vary with age composition and broodstock type.

Note: Connecticut data are preliminary prior to 1990.

Table 13. Summary of all historical Atlantic salmon egg production in hatcheries for New England rivers.

	Sea-Run			Domestic			Captive			Kelt			TOTAL		
	No. females	Egg production	Eggs/ female	No. females	Egg production	Eggs/ female	No. females	Egg production	Eggs/ female	No. females	Egg production	Eggs/ female	No. females	Egg production	Eggs/ female
Cocheco	3	21,000	7,100	0	0		0	0		0	0		3	21,000	7,100
Connecticut	1,577	17,611,000	11,200	23,131	149,696,000	6,500	0	0		1,987	24,646,000	12,400	26,695	191,953,000	7,200
Dennys	26	214,000	8,200	0	0		953	3,938,000	4,100	40	330,000	8,300	1,019	4,482,000	4,400
East Machias	0	0		0	0		905	3,666,000	4,100	0	0		905	3,666,000	4,100
Kennebec	5	50,000	10,000	0	0		0	0		0	0		5	50,000	10,000
Lamprey	6	32,000	5,300	0	0		0	0		0	0		6	32,000	5,300
Machias	456	3,263,000	7,200	0	0		1,593	6,567,000	4,100	8	52,000	6,500	2,057	9,882,000	4,800
Merrimack	1,179	9,046,000	7,700	9,176	48,052,000	5,200	0	0		287	2,859,000	10,000	10,642	59,957,000	5,600
Narraguagus	0	1,303,000		0	0		1,557	5,589,000	3,600	0	0		1,557	6,892,000	4,400
Orland	39	270,000	6,900	0	0		0	0		0	0		39	270,000	6,900
Pawcatuck	16	143,000	8,900	2	2,000	1,100	0	0		9	61,000	6,800	27	206,000	7,600
Penobscot	18,578	159,343,000	8,600	6,028	15,956,000	2,600	0	0		0	0		24,606	175,300,000	7,100
Pleasant	0	0		0	0		165	705,000	4,300	0	0		165	705,000	4,300
Sheepscot	18	125,000	7,000	0	0		736	2,972,000	4,000	45	438,000	9,700	799	3,536,000	4,400
St Croix	39	291,000	7,500	0	0		0	0		0	0		39	291,000	7,500
Union	600	4,611,000	7,700	0	0		0	0		0	0		600	4,611,000	7,700
Grand Total	**22,542**	**196,323,000**	**8,700**	**38,337**	**213,706,000**	**5,600**	**5,909**	**23,437,000**	**4,000**	**2,376**	**28,386,000**	**11,900**	**69,164**	**461,854,000**	**6,700**

Table 14. Atlantic salmon stocking summary for New England, by river.

	Number of fish stocked by life stage					
	Fry	**0 Parr**	**1 Parr**	**1 Smolt**	**2 Smolt**	**Total**
Androscoggin						
2001	3,000	0	0	0	0	3,000
2002	0	0	0	0	0	0
2003	1,000	0	0	0	0	1,000
2004	2,000	0	0	0	0	2,000
2005	0	0	0	0	0	0
Totals:Androscoggin	**6,000**	**0**	**0**	**0**	**0**	**6,000**
Aroostook						
1978-1995	628,000	317,100	38,600	32,600	29,800	1,046,100
1996	0	0	0	0	0	0
1997	578,000	0	0	0	0	578,000
1998	142,000	0	0	0	0	142,000
1999	163,000	0	0	0	0	163,000
2000	0	0	0	0	0	0
2001	182,000	300	0	0	0	182,300
2002	122,000	0	0	0	0	122,000
2003	138,000	0	0	0	0	138,000
2004	169,000	0	0	0	0	169,000
2005	133,000	0	0	0	0	133,000
Totals:Aroostook	**2,255,000**	**317,400**	**38,600**	**32,600**	**29,800**	**2,673,400**
Cocheco						
1988-1995	796,000	50,000	10,500	5,300	0	861,800
1996	126,000	0	0	0	0	126,000
1997	128,000	0	0	0	0	128,000
1998	96,000	0	0	0	0	96,000
1999	157,000	0	0	0	0	157,000
2000	146,000	0	0	0	0	146,000
2001	165,000	0	0	0	0	165,000
2002	181,000	0	0	0	0	181,000
2003	163,000	0	0	0	0	163,000
Totals:Cocheco	**1,958,000**	**50,000**	**10,500**	**5,300**	**0**	**2,023,800**
Connecticut						
1967-1995	28,732,000	2,799,400	1,799,000	3,730,600	963,200	38,024,200
1996	6,677,000	12,400	3,600	11,500	0	6,704,500
1997	8,526,000	8,800	0	1,400	0	8,536,200
1998	9,119,000	3,000	7,700	1,700	0	9,131,400
1999	6,428,000	1,000	0	22,600	0	6,451,600
2000	9,325,000	600	0	700	48,200	9,374,500
2001	9,591,000	1,600	0	700	0	9,593,300
2002	7,283,000	700	0	500	0	7,284,200
2003	7,038,000	0	0	0	90,100	7,128,100
2004	7,683,000	3,100	2,500	0	96,400	7,785,000
2005	7,805,000	0	0	0	85,100	7,890,100
Totals:Connecticut	**108,207,000**	**2,830,600**	**1,812,800**	**3,769,700**	**1,283,000**	**117,903,100**
Dennys						

	Number of fish stocked by life stage					
	Fry	0 Parr	1 Parr	1 Smolt	2 Smolt	Total
1975-1995	268,000	8,300	3,400	143,100	28,300	451,100
1996	142,000	0	0	0	900	142,900
1997	213,000	0	0	0	0	213,000
1998	233,000	10,400	0	9,600	0	253,000
1999	172,000	3,000	0	0	0	175,000
2000	96,000	30,500	0	0	0	126,500
2001	59,000	16,500	1,400	49,800	0	126,700
2002	84,000	33,000	1,900	49,000	0	167,900
2003	133,000	30,400	600	55,200	0	219,200
2004	219,000	44,000	0	56,300	0	319,300
2005	215,000	21,700	0	56,700	0	293,400
Totals:Dennys	**1,834,000**	**197,800**	**7,300**	**419,700**	**29,200**	**2,488,000**
Ducktrap						
1986-1995	68,000	0	0	0	0	68,000
1996	0	0	0	0	0	0
1997	0	0	0	0	0	0
1998	0	0	0	0	0	0
1999	0	0	0	0	0	0
2000	0	0	0	0	0	0
2001	0	0	0	0	0	0
2002	0	0	0	0	0	0
2003	0	0	0	0	0	0
2004	0	0	0	0	0	0
2005	0	0	0	0	0	0
Totals:Ducktrap	**68,000**	**0**	**0**	**0**	**0**	**68,000**
East Machias						
1973-1995	140,000	6,500	42,600	97,600	30,400	317,100
1996	115,000	0	0	0	0	115,000
1997	113,000	0	0	0	0	113,000
1998	190,000	0	0	10,800	0	200,800
1999	210,000	1,000	0	0	0	211,000
2000	197,000	0	0	0	0	197,000
2001	242,000	0	0	0	0	242,000
2002	236,000	0	0	0	0	236,000
2003	314,000	0	0	0	0	314,000
2004	319,000	0	0	0	0	319,000
2005	216,000	0	0	0	0	216,000
Totals:East Machias	**2,292,000**	**7,500**	**42,600**	**108,400**	**30,400**	**2,480,900**
Kennebec						
2001	3,000	0	0	0	0	3,000
2002	7,000	0	0	0	0	7,000
2003	42,000	0	0	0	0	42,000
2004	52,000	0	0	0	0	52,000
2005	30,000	0	0	0	0	30,000
Totals:Kennebec	**134,000**	**0**	**0**	**0**	**0**	**134,000**
Lamprey						
1978-1995	690,000	337,800	49,100	138,100	32,800	1,247,800
1996	115,000	37,000	9,400	0	0	161,400

	Number of fish stocked by life stage					
	Fry	**0 Parr**	**1 Parr**	**1 Smolt**	**2 Smolt**	**Total**
1997	141,000	52,900	0	0	0	193,900
1998	95,000	0	0	3,300	0	98,300
1999	127,000	0	0	0	0	127,000
2000	104,000	0	0	0	0	104,000
2001	111,000	0	300	0	0	111,300
2002	103,000	0	0	60,000	0	163,000
2003	106,000	0	0	0	0	106,000
Totals:Lamprey	**1,592,000**	**427,700**	**58,800**	**201,400**	**32,800**	**2,312,700**
Machias						
1970-1995	389,000	86,900	117,800	180,500	42,200	816,400
1996	233,000	0	0	0	1,900	234,900
1997	236,000	0	0	0	0	236,000
1998	300,000	5,900	0	10,800	0	316,700
1999	169,000	1,000	0	0	0	170,000
2000	209,000	0	0	0	0	209,000
2001	267,000	0	0	0	0	267,000
2002	327,000	0	0	0	0	327,000
2003	341,000	0	300	0	0	341,300
2004	379,000	3,100	0	0	0	382,100
2005	476,000	0	200	0	0	476,200
Totals:Machias	**3,326,000**	**96,900**	**118,300**	**191,300**	**44,100**	**3,776,600**
Merrimack						
1975-1995	15,939,000	222,500	568,800	1,006,600	630,500	18,367,400
1996	1,795,000	0	4,900	50,000	0	1,849,900
1997	2,000,000	5,000	10,000	52,500	5,400	2,072,900
1998	2,589,000	0	6,800	51,900	0	2,647,700
1999	1,756,000	0	4,400	56,400	0	1,816,800
2000	2,217,000	0	0	52,500	0	2,269,500
2001	1,708,000	0	0	49,500	0	1,757,500
2002	1,414,000	0	1,900	50,000	1,200	1,467,100
2003	1,335,000	0	900	49,600	1,000	1,386,500
2004	1,556,000	3,700	0	50,000	0	1,609,700
2005	962,000	1,400	400	50,000	0	1,013,800
Totals:Merrimack	**33,271,000**	**232,600**	**598,100**	**1,519,000**	**638,100**	**36,258,800**
Narraguagus						
1970-1995	179,000	30,300	12,600	106,100	84,000	412,000
1996	196,000	0	0	0	0	196,000
1997	209,000	0	2,000	700	0	211,700
1998	274,000	14,400	0	0	0	288,400
1999	155,000	18,200	0	1,000	0	174,200
2000	252,000	0	0	0	0	252,000
2001	353,000	0	0	0	0	353,000
2002	261,000	0	0	0	0	261,000
2003	491,000	0	0	0	0	491,000
2004	468,000	0	0	0	0	468,000
2005	352,000	0	0	0	0	352,000
Totals:Narraguagus	**3,190,000**	**62,900**	**14,600**	**107,800**	**84,000**	**3,459,300**
Pawcatuck						

	Number of fish stocked by life stage					
	Fry	**0 Parr**	**1 Parr**	**1 Smolt**	**2 Smolt**	**Total**
1979-1995	1,470,000	1,073,100	234,500	30,500	500	2,808,600
1996	289,000	136,100	0	5,000	0	430,100
1997	100,000	0	14,000	11,500	0	125,500
1998	910,000	0	14,700	5,700	0	930,400
1999	591,000	0	0	3,900	0	594,900
2000	326,000	0	0	0	0	326,000
2001	423,000	0	0	8,500	0	431,500
2002	403,000	0	0	0	0	403,000
2003	313,000	0	0	5,200	0	318,200
2004	557,000	0	0	6,100	0	563,100
2005	5,000	0	0	16,600	0	21,600
Totals:Pawcatuck	**5,387,000**	**1,209,200**	**263,200**	**93,000**	**500**	**6,952,900**
Penobscot						
1970-1995	6,429,000	1,557,700	1,351,100	7,667,500	2,508,200	19,513,500
1996	1,242,000	226,000	17,500	552,200	0	2,037,700
1997	1,472,000	310,900	4,200	580,200	0	2,367,300
1998	930,000	337,400	13,400	571,800	0	1,852,600
1999	1,498,000	229,600	1,500	567,300	0	2,296,400
2000	513,000	288,800	700	563,200	0	1,365,700
2001	364,000	235,800	2,100	454,000	0	1,055,900
2002	746,000	396,700	1,800	547,000	0	1,691,500
2003	741,000	320,700	2,100	547,300	0	1,611,100
2004	1,812,000	369,200	0	566,000	0	2,747,200
2005	1,899,000	295,400	0	530,600	0	2,725,000
Totals:Penobscot	**17,646,000**	**4,568,200**	**1,394,400**	**13,147,100**	**2,508,200**	**39,263,900**
Pleasant						
1975-1995	187,000	2,500	1,800	54,700	18,100	264,100
1996	0	0	0	0	0	0
1997	0	0	0	0	0	0
1998	0	0	0	0	0	0
1999	0	0	0	0	0	0
2000	0	0	0	0	0	0
2001	0	0	0	0	0	0
2002	0	13,500	0	0	0	13,500
2003	82,000	0	0	2,800	0	84,800
2004	47,000	0	0	0	8,800	55,800
2005	76,000	0	0	5,900	0	81,900
Totals:Pleasant	**392,000**	**16,000**	**1,800**	**63,400**	**26,900**	**500,100**
Saco						
1975-1995	1,045,000	165,200	201,200	223,200	9,500	1,644,100
1996	0	45,000	0	20,000	0	65,000
1997	97,000	63,300	0	20,200	0	180,500
1998	429,000	50,000	0	21,300	0	500,300
1999	688,000	47,000	0	20,100	0	755,100
2000	599,000	48,200	0	22,600	0	669,800
2001	479,000	0	0	400	0	479,400
2002	597,000	0	0	4,100	0	601,100
2003	501,000	20,000	0	3,200	0	524,200

	Number of fish stocked by life stage					
	Fry	**0 Parr**	**1 Parr**	**1 Smolt**	**2 Smolt**	**Total**
2004	375,000	0	0	5,400	0	380,400
2005	340,000	0	18,000	1,700	0	359,700
Totals:Saco	**5,150,000**	**438,700**	**219,200**	**342,200**	**9,500**	**6,159,600**
Sheepscot						
1971-1995	159,000	70,800	20,600	92,200	7,100	349,700
1996	102,000	0	0	0	0	102,000
1997	64,000	0	0	0	0	64,000
1998	256,000	9,300	0	0	0	265,300
1999	302,000	4,700	0	0	0	306,700
2000	211,000	0	0	0	0	211,000
2001	171,000	0	0	0	0	171,000
2002	172,000	0	0	0	0	172,000
2003	323,000	0	0	0	0	323,000
2004	298,000	15,600	0	0	0	313,600
2005	201,000	15,900	0	0	0	216,900
Totals:Sheepscot	**2,259,000**	**116,300**	**20,600**	**92,200**	**7,100**	**2,495,200**
St Croix						
1981-1995	1,260,000	303,400	158,100	731,600	20,100	2,473,200
1996	0	52,100	0	15,600	0	67,700
1997	1,000	400	0	0	0	1,400
1998	2,000	31,700	200	0	0	33,900
1999	1,000	22,500	0	21,300	0	44,800
2000	1,000	19,000	0	20,000	0	40,000
2001	1,000	6,300	0	8,100	0	15,400
2002	1,000	15,400	0	4,100	0	20,500
2003	1,000	16,800	0	3,200	0	21,000
2004	0	2,800	0	4,100	0	6,900
2005	0	0	0	0	0	0
Totals:St Croix	**1,268,000**	**470,400**	**158,300**	**808,000**	**20,100**	**2,724,800**
Union						
1971-1995	81,000	166,500	0	379,700	251,000	878,200
1996	0	53,500	0	0	0	53,500
1997	12,000	69,300	0	0	0	81,300
1998	165,000	0	0	0	0	165,000
1999	165,000	82,100	0	0	0	247,100
2000	0	0	0	0	0	0
2001	2,000	0	0	0	0	2,000
2002	5,000	0	0	0	0	5,000
2003	3,000	0	0	0	0	3,000
2004	3,000	0	0	0	0	3,000
2005	2,000	0	0	0	0	2,000
Totals:Union	**438,000**	**371,400**	**0**	**379,700**	**251,000**	**1,440,100**
Upper StJohn						
1979-1995	2,165,000	1,456,700	14,700	5,100	27,700	3,669,200
1996	0	0	0	0	0	0
1997	0	0	0	0	0	0
1998	0	0	0	0	0	0
1999	0	0	0	0	0	0

	Number of fish stocked by life stage					
	Fry	**0 Parr**	**1 Parr**	**1 Smolt**	**2 Smolt**	**Total**
2000	0	0	0	0	0	0
2001	0	0	0	0	0	0
2002	0	0	0	0	0	0
2003	0	0	0	0	0	0
2004	0	0	0	0	0	0
2005	0	0	0	0	0	0
Totals:Upper StJohn	**2,165,000**	**1,456,700**	**14,700**	**5,100**	**27,700**	**3,669,200**

Table 15. Overall summary of Atlantic salmon stocking for New England, by river.

Totals reflect the entirety of the historical time series for each river.

	Fry	0 Parr	1 Parr	1 Smolt	2 Smolt	Total
Androscoggin	6,000	0	0	0	0	**5,700**
Aroostook	2,255,000	317,400	38,600	32,600	29,800	**2,673,800**
Cocheco	1,958,000	50,000	10,500	5,300	0	**2,024,200**
Connecticut	108,206,000	2,830,600	1,812,800	3,769,700	1,283,100	**117,901,900**
Dennys	1,834,000	197,800	7,300	419,800	29,200	**2,488,200**
Ducktrap	68,000	0	0	0	0	**68,000**
East Machias	2,292,000	7,500	42,600	108,400	30,400	**2,480,800**
Kennebec	134,000	0	0	0	0	**134,300**
Lamprey	1,593,000	427,700	58,800	201,400	32,800	**2,313,700**
Machias	3,326,000	96,900	118,200	191,300	44,100	**3,776,300**
Merrimack	33,271,000	232,500	598,100	1,519,000	638,100	**36,258,800**
Narraguagus	3,190,000	62,900	14,600	107,800	84,000	**3,459,700**
Pawcatuck	5,387,000	1,209,200	263,200	93,000	500	**6,952,800**
Penobscot	17,645,000	4,568,200	1,394,400	13,147,100	2,508,200	**39,263,000**
Pleasant	393,000	16,000	1,800	63,400	26,900	**500,700**
Saco	5,150,000	438,700	219,200	342,200	9,500	**6,159,300**
Sheepscot	2,259,000	116,300	20,600	92,200	7,100	**2,495,400**
St Croix	1,268,000	470,400	158,300	808,000	20,100	**2,725,100**
Union	437,000	371,400	0	379,700	251,000	**1,439,000**
Upper StJohn	2,165,000	1,456,700	14,700	5,100	27,700	**3,669,200**
TOTALS	**192,837,000**	**12,870,200**	**4,773,800**	**21,286,000**	**5,022,500**	**236,789,900**

Summaries for each river vary by length of time series.

Table 16. Documented Atlantic salmon returns to New England rivers.

Documented returns include rod and trap caught fish. Returns are unknown where blanks occur.
Returns from juveniles of hatchery origin include age 0 and 1 parr, and age 1 and 2 smolt releases.
Returns of wild origin include adults produced from natural reproduction and adults produced from fry releases.

	HATCHERY ORIGIN				WILD ORIGIN				
	1SW	2SW	3SW	REPEAT	1SW	2SW	3SW	REPEAT	Total
Androscoggin									
1983-1995	24	480	5	2	4	63	0	1	**579**
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**
2001	1	4	0	0	0	0	0	0	**5**
2002	0	2	0	0	0	0	0	0	**2**
2003	0	3	0	0	0	0	0	0	**3**
2004	3	7	0	0	0	1	0	0	**11**
2005	2	8	0	0	0	0	0	0	**10**
Total for Androscoggin	32	531	6	2	6	84	0	1	**662**
Cocheco									
1990-1995	0	0	1	1	1	4	0	0	**7**
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**
2001	0	0	0	0	0	0	0	0	**0**
2002	0	0	0	0	0	0	0	0	**0**
2003	0	0	0	0	1	3	0	0	**4**
Total for Cocheco	0	0	1	1	6	10	0	0	**18**
Connecticut									
1969-1995	35	3,357	28	1	8	485	8	0	**3,922**
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**
2001	1	0	0	0	4	34	1	0	**40**
2002	0	3	0	0	2	38	1	0	**44**
2003	0	0	0	0	0	42	1	0	**43**

	HATCHERY ORIGIN				WILD ORIGIN				
	1SW	2SW	3SW	REPEAT	1SW	2SW	3SW	REPEAT	Total
2004	0	0	0	0	5	64	0	0	**69**
2005	0	4	0	0	23	159	0	0	**186**
Total for Connecticut	36	3,507	28	2	75	1630	12	4	**5,294**
Dennys									
1967-1995	18	304	0	1	21	726	3	10	**1,083**
1996	0	0	0	0	1	7	0	0	**8**
1997	0	0	0	0	0	0	0	0	**0**
1998	1	0	0	0	0	0	0	0	**1**
1999	0	0	0	0	0	0	0	0	**0**
2000	0	1	0	0	0	1	0	0	**2**
2001	9	2	0	0	1	9	0	0	**21**
2002	2	0	0	0	0	0	0	0	**2**
2003	4	5	0	0	0	1	0	0	**10**
2004	0	1	0	0	0	0	0	0	**1**
2005									
Total for Dennys	34	313	0	1	23	744	3	10	**1,128**
Ducktrap									
1985-1995	0	0	0	0	3	30	0	0	**33**
1996									
1997									
1998									
1999									
2000									
2001									
2002									
2003									
2004									
2005									
Total for Ducktrap	0	0	0	0	3	30	0	0	**33**
East Machias									
1967-1995	21	250	1	2	12	329	1	10	**626**
1996									
1997									
1998									
1999									
2000									
2001									
2002									
2003									

	HATCHERY ORIGIN				WILD ORIGIN				
	1SW	2SW	3SW	REPEAT	1SW	2SW	3SW	REPEAT	Total
2004									
2005									
Total for East Machias	21	250	1	2	12	329	1	10	**626**
Kennebec									
1975-1995	12	189	5	1	0	9	0	0	**216**
1996									
1997									
1998									
1999									
2000									
2001									
2002									
2003									
2004									
2005									
Total for Kennebec	12	189	5	1	0	9	0	0	**216**
Lamprey									
1979-1995	10	17	1	0	1	13	0	0	**42**
1996	0	0	0	0	0	1	0	0	**1**
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	6	0	0	0	**6**
2000	0	0	0	0	2	2	0	0	**4**
2001	0	0	0	0	0	0	0	0	**0**
2002	0	0	0	0	0	0	0	0	**0**
2003	0	0	0	0	2	0	0	0	**2**
Total for Lamprey	10	17	1	0	11	16	0	0	**55**
Machias									
1967-1995	32	329	9	2	33	1,592	41	131	**2,169**
1996									
1997									
1998									
1999									
2000									
2001									
2002									
2003									
2004									
2005									

	HATCHERY ORIGIN				WILD ORIGIN				
	1SW	2SW	3SW	REPEAT	1SW	2SW	3SW	REPEAT	Total
Total for Machias	32	329	9	2	33	1592	41	131	**2,169**
Merrimack									
1978-1995	139	671	17	1	77	823	23	0	**1,751**
1996	11	44	0	3	3	13	0	2	**76**
1997	9	43	0	4	9	5	0	1	**71**
1998	11	45	1	0	19	47	0	0	**123**
1999	46	65	1	0	9	64	0	0	**185**
2000	26	32	0	0	1	23	0	0	**82**
2001	5	73	0	0	2	3	0	0	**83**
2002	31	17	0	0	1	6	0	0	**55**
2003	12	129	0	0	0	4	0	0	**145**
2004	17	92	2	0	2	15	0	0	**128**
2005	8	25	0	0	0	1	0	0	**34**
Total for Merrimack	315	1,236	21	8	123	1004	23	3	**2,733**
Narraguagus									
1967-1995	91	637	19	52	49	2,220	68	140	**3,276**
1996	1	6	0	0	9	43	0	5	**64**
1997	0	2	0	0	1	30	0	4	**37**
1998	0	0	0	1	1	18	0	2	**22**
1999	0	2	0	0	6	23	0	1	**32**
2000	0	1	0	0	13	8	0	1	**23**
2001	0	2	0	0	5	22	2	1	**32**
2002	0	0	0	1	4	3	0	0	**8**
2003	0	0	0	0	0	21	0	0	**21**
2004	0	0	0	0	1	10	0	1	**12**
2005	0	0	0	0	1	12	0	0	**13**
Total for Narraguagus	92	650	19	54	90	2410	70	155	**3,540**
Pawcatuck									
1981-1995	1	139	1	0	0	1	0	0	**142**
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**
2001	0	0	0	0	0	0	0	0	**0**
2002	0	0	0	0	0	0	0	0	**0**
2003	0	0	0	0	0	1	1	0	**2**
2004	0	0	0	0	0	1	0	0	**1**
2005	0	0	0	0	0	2	0	0	**2**

	HATCHERY ORIGIN				WILD ORIGIN				
	1SW	2SW	3SW	REPEAT	1SW	2SW	3SW	REPEAT	Total
Total for Pawcatuck	2	148	1	0	1	14	1	0	**167**
Penobscot									
1967-1995	8,078	36,120	266	591	513	2,679	23	74	**48,344**
1996	484	1,218	6	18	11	303	3	1	**2,044**
1997	243	934	4	14	4	153	2	1	**1,355**
1998	238	793	0	10	31	133	1	4	**1,210**
1999	223	568	0	11	49	108	0	9	**968**
2000	167	265	0	15	16	69	0	2	**534**
2001	195	466	0	3	21	98	2	0	**785**
2002	363	344	0	15	14	41	1	2	**780**
2003	196	847	1	4	6	56	0	2	**1,112**
2004	276	952	10	16	5	59	3	2	**1,323**
2005	269	678	0	8	6	22	0	2	**985**
Total for Penobscot	10,732	43,185	287	705	676	3721	35	99	**59,440**
Pleasant									
1967-1995	5	12	0	0	11	214	2	2	**246**
1996									
1997	0	0	0	0	0	1	0	0	**1**
1998									
1999									
2000	0	0	0	0	1	2	0	0	**3**
2001	0	0	0	0	1	9	1	0	**11**
2002	0	0	0	0	0	0	0	0	**0**
2003	0	0	0	0	1	1	0	0	**2**
2004	0	0	0	0	0	1	0	0	**1**
2005									
Total for Pleasant	5	12	0	0	14	228	3	2	**264**
Saco									
1977-1995	23	358	2	2	0	2	0	0	**387**
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**
2001	15	49	0	0	0	5	0	0	**69**
2002	3	37	0	2	3	2	0	0	**47**
2003	2	23	0	0	2	12	0	0	**39**
2004	3	10	0	0	2	4	0	0	**19**
2005	5	12	0	0	1	7	0	0	**25**

	HATCHERY ORIGIN				WILD ORIGIN				
	1SW	2SW	3SW	REPEAT	1SW	2SW	3SW	REPEAT	Total
Total for Saco	117	583	3	7	24	74	3	0	**811**
Sheepscot									
1967-1995	6	38	0	0	30	350	10	0	**434**
1996	0	0	0	0	0	8	0	0	**8**
1997	0	0	0	0	0	0	0	0	**0**
1998									
1999									
2000									
2001									
2002									
2003									
2004									
2005									
Total for Sheepscot	6	38	0	0	30	358	10	0	**442**
St Croix									
1981-1995	612	1,002	38	12	411	629	39	17	**2,760**
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**
2001	13	7	0	0	0	0	0	0	**20**
2002	14	6	0	0	0	0	0	0	**20**
2003	6	9	0	0	0	0	0	0	**15**
2005	3	4	0	0	0	0	0	0	**7**
Total for St Croix	718	1,122	38	12	440	670	39	17	**3,056**
Union									
1973-1995	290	1,734	9	24	1	11	0	0	**2,069**
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**
2001	0	0	0	0	0	0	0	0	**0**
2002	0	5	0	0	0	0	0	0	**5**
2003	1	0	0	0	0	0	0	0	**1**
2004	0	1	0	0	0	1	0	0	**2**
Total for Union	303	1,821	9	28	1	16	0	0	**2,178**

Table 17. Summary of documented Atlantic salmon returns to New England rivers.

Totals reflect the entirety of the available historical time series for each river. Earliest year of data for Penobscot, Narraguagus, Machias, East Machias, Dennys, and Sheepscot rivers is 1967.

	Grand Total by River								
	HATCHERY ORIGIN				WILD ORIGIN				
	1SW	2SW	3SW	REPEAT	1SW	2SW	3SW	REPEAT	Total
Androscoggin	32	531	6	2	6	84	0	1	662
Cocheco	0	0	1	1	6	10	0	0	18
Connecticut	36	3,507	28	2	75	1,630	12	4	5,294
Dennys	34	313	0	1	23	744	3	10	1,128
Ducktrap	0	0	0	0	3	30	0	0	33
East Machias	21	250	1	2	12	329	1	10	626
Kennebec	12	189	5	1	0	9	0	0	216
Lamprey	10	17	1	0	11	16	0	0	55
Machias	32	329	9	2	33	1,592	41	131	2,169
Merrimack	315	1,236	21	8	123	1,004	23	3	2,733
Narraguagus	92	650	19	54	90	2,410	70	155	3,540
Pawcatuck	2	148	1	0	1	14	1	0	167
Penobscot	10,732	43,185	287	705	676	3,721	35	99	59,440
Pleasant	5	12	0	0	14	228	3	2	264
Saco	117	583	3	7	24	74	3	0	811
Sheepscot	6	38	0	0	30	358	10	0	442
St Croix	718	1,122	38	12	440	670	39	17	3,056
Union	303	1,821	9	28	1	16	0	0	2,178

Table 18.1: Return rates for Atlantic salmon that were stocked as fry in the Connecticut (above Holyoke) River .

Year	Total Fry (1000s)	Total Returns	Returns (per 10,000)	Age class (smolt age.sea age) distribution (%) 1.1	1.2	1.3	2.1	2.2	2.3	3.1	3.2	3.3	4.2	Age (years) dist'n (%) 2	3	4	5	6
1974	16	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1975	32	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1976	27	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	50	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	50	7	1.400	0	0	0	0	100	0	0	0	0	0	0	0	100	0	0
1979	24	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1980	89	18	2.022	0	0	0	0	100	0	0	0	0	0	0	0	100	0	0
1981	151	19	1.261	0	0	0	11	89	0	0	0	0	0	0	11	89	0	0
1982	128	31	2.429	0	0	0	0	90	10	0	0	0	0	0	0	90	10	0
1983	70	1	0.143	0	100	0	0	0	0	0	0	0	0	0	100	0	0	0
1984	455	1	0.022	0	0	0	0	0	100	0	0	0	0	0	0	0	100	0
1985	286	35	1.224	0	0	0	0	100	0	0	0	0	0	0	0	100	0	0
1986	97	27	2.791	0	0	0	4	96	0	0	0	0	0	0	4	96	0	0
1987	981	44	0.449	0	16	0	0	68	2	0	14	0	0	0	16	68	16	0
1988	928	92	0.992	0	0	0	0	97	1	0	2	0	0	0	0	97	3	0
1989	747	47	0.629	0	6	0	6	85	0	0	2	0	0	0	13	85	2	0
1990	765	53	0.693	0	13	0	0	87	0	0	0	0	0	0	13	87	0	0
1991	982	25	0.255	0	20	0	0	64	0	0	16	0	0	0	20	64	16	0
1992	929	84	0.904	0	1	0	0	85	1	0	13	0	0	0	1	85	14	0
1993	2,607	94	0.361	0	0	0	2	87	0	0	11	0	0	0	2	87	11	0
1994	3,925	197	0.502	0	0	0	1	93	0	0	6	0	0	0	1	93	6	0

Mean return rate computation includes incomplete return rates for 2000 - 2003 year class fish.

NOTE: Return rates (returns/10,000 fry) are calculated from stocked fry numbers and do not include any natural fry production.

Table 18.1: Return rates for Atlantic salmon that were stocked as fry in the Connecticut (above Holyoke) River .

1995	4,507	83	0.184	0	2	0	6	89	0	0	2	0	0	0	8	89	2	0
1996	4,780	55	0.115	0	4	0	5	89	2	0	0	0	0	0	9	89	2	0
1997	5,885	24	0.041	0	0	0	4	88	4	0	4	0	0	0	4	88	8	0
1998	6,614	33	0.050	0	0	0	6	88	0	0	3	0	3	0	6	88	3	3
1999	4,565	33	0.072	0	0	3	6	79	0	0	12	0	0	0	6	82	12	0
2000	6,928	43	0.062	0	0	0	0	86	0	0	14			0	0	86	14	
2001	6,989	107	0.153	0	2	0	1	95		2				0	3	97		
2002	4,903	19	0.039	0	47		53							0	100			
2003	4,823	0	0.000	0										0				
Total	**63,333**	**1,172**																
Mean			**0.560**	**0**	**7**	**0**	**4**	**66**	**4**	**0**	**4**	**0**	**0**	**0**	**11**	**66**	**8**	**0**

Mean return rate computation includes incomplete return rates for 2000 - 2003 year class fish.

NOTE: Return rates (returns/10,000 fry) are calculated from stocked fry numbers and do not include any natural fry production.

Table 18.2: Return rates for Atlantic salmon that were stocked as fry in the Connecticut (basin) River .

Year	Total Fry (1000s)	Total Returns	Returns (per 10,000)	Age class (smolt age.sea age) distribution (%)										Age (years) dist'n (%)				
				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
1974	16	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1975	32	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1976	27	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	50	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	50	7	1.400	0	0	0	0	100	0	0	0	0	0	0	0	100	0	0
1979	54	3	0.561	0	100	0	0	0	0	0	0	0	0	0	100	0	0	100
1980	286	18	0.630	0	0	0	0	100	0	0	0	0	0	0	0	100	0	0
1981	168	19	1.129	0	0	0	11	89	0	0	0	0	0	0	11	89	0	11
1982	294	46	1.565	0	0	0	0	89	11	0	0	0	0	0	0	89	11	0
1983	226	2	0.088	0	100	0	0	0	0	0	0	0	0	0	100	0	0	100
1984	584	3	0.051	0	0	0	0	33	33	0	33	0	0	0	0	33	67	0
1985	422	47	1.113	0	0	0	0	100	0	0	0	0	0	0	0	100	0	0
1986	176	28	1.592	0	0	0	4	96	0	0	0	0	0	0	4	96	0	4
1987	1,169	51	0.436	0	18	0	0	67	2	0	14	0	0	0	18	67	16	18
1988	1,310	108	0.825	0	0	0	0	97	1	0	2	0	0	0	0	97	3	0
1989	1,243	67	0.539	0	22	0	7	69	0	0	1	0	0	0	30	69	1	30
1990	1,346	68	0.505	0	19	0	0	79	0	0	1	0	0	0	19	79	1	19
1991	2,208	35	0.159	0	17	0	0	63	0	0	20	0	0	0	17	63	20	17
1992	2,009	118	0.587	0	5	0	0	82	1	0	12	0	0	0	5	82	13	5
1993	4,147	185	0.446	0	4	0	3	87	0	0	6	0	0	0	6	87	6	6
1994	5,938	294	0.495	0	5	0	2	88	0	0	5	0	0	0	7	88	5	7

Mean return rate computation includes incomplete return rates for 2000 - 2003 year class fish.

NOTE: Return rates (returns/10,000 fry) are calculated from stocked fry numbers and do not include any natural fry production.

Table 18.2: Return rates for Atlantic salmon that were stocked as fry in the Connecticut (basin) River .

1995	6,780	143	0.211	1	13	0	7	78	0	0	2	0	0	1	20	78	2	20
1996	6,645	101	0.152	0	16	0	11	71	1	0	1	0	0	0	27	71	2	27
1997	8,498	37	0.044	0	3	0	3	89	3	0	3	0	0	0	5	89	5	5
1998	9,085	44	0.048	0	0	0	9	84	0	0	5	0	2	0	9	84	5	9
1999	6,395	45	0.070	0	0	0	4	80	0	0	13	0	0	0	4	82	13	4
2000	9,292	66	0.071	0	6	0	0	80	0	0	14			0	6	80	14	
2001	9,557	143	0.150	0	3	0	3	93		1				0	6	94		
2002	7,249	38	0.052	3	45		53							3	97			
2003	7,004	1	0.001	100										100				
Total	**92,260**	**1,717**																
Mean			**0.431**	**3**	**13**	**0**	**4**	**65**	**2**	**0**	**5**	**0**	**0**	**3**	**17**	**65**	**7**	**15**

Mean return rate computation includes incomplete return rates for 2000 - 2003 year class fish.

NOTE: Return rates (returns/10,000 fry) are calculated from stocked fry numbers and do not include any natural fry production.

Table 18.3: Return rates for Atlantic salmon that were stocked as fry in the Farmington River .

Year	Total Fry (1000s)	Total Returns	Returns (per 10,000)	Age class (smolt age.sea age) distribution (%)										Age (years) dist'n (%)				
				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	3	1.034	0	100	0	0	0	0	0	0	0	0	0	100	0	0	0
1980	197	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1981	18	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	166	15	0.902	0	0	0	0	87	13	0	0	0	0	0	0	87	13	0
1983	157	1	0.064	0	100	0	0	0	0	0	0	0	0	0	100	0	0	0
1984	128	2	0.156	0	0	0	0	50	0	0	50	0	0	0	0	50	50	0
1985	136	12	0.881	0	0	0	0	100	0	0	0	0	0	0	0	100	0	0
1986	79	1	0.126	0	0	0	0	100	0	0	0	0	0	0	0	100	0	0
1987	68	5	0.740	0	0	0	0	80	0	0	20	0	0	0	0	80	20	0
1988	333	13	0.391	0	0	0	0	100	0	0	0	0	0	0	0	100	0	0
1989	279	19	0.680	0	63	0	11	26	0	0	0	0	0	0	74	26	0	0
1990	270	11	0.407	0	45	0	0	45	0	0	9	0	0	0	45	45	9	0
1991	371	2	0.054	0	50	0	0	0	0	0	50	0	0	0	50	0	50	0
1992	553	15	0.271	0	20	0	0	67	0	0	13	0	0	0	20	67	13	0
1993	772	52	0.673	0	13	0	6	77	0	0	4	0	0	0	19	77	4	0
1994	1,097	49	0.447	0	31	0	4	63	0	0	2	0	0	0	35	63	2	0
1995	1,146	42	0.367	2	38	0	5	52	0	0	2	0	0	2	43	52	2	0
1996	912	19	0.208	0	58	0	11	26	0	0	5	0	0	0	68	26	5	0
1997	1,480	4	0.027	0	0	0	0	100	0	0	0	0	0	0	0	100	0	0
1998	1,191	2	0.017	0	0	0	0	100	0	0	0	0	0	0	0	100	0	0
1999	986	2	0.020	0	0	0	0	50	0	0	50	0	0	0	0	50	50	0

Mean return rate computation includes incomplete return rates for 2000 - 2003 year class fish.

NOTE: Return rates (returns/10,000 fry) are calculated from stocked fry numbers and do not include any natural fry production.

Table 18.3: Return rates for Atlantic salmon that were stocked as fry in the Farmington River .

2000	1,247	9	0.072	0	0	0	0	89	0	0	11			0	0	89	11	
2001	1,252	12	0.096	0	8	0	17	75		0				0	25	75		
2002	1,192	5	0.042	20	20		60							20	80			
2003	1,123	0	0.000	0										0				
Total	**15,182**	**295**																
Mean			**0.307**	**1**	**23**	**0**	**5**	**56**	**1**	**0**	**10**	**0**	**0**	**1**	**27**	**56**	**10**	**0**

Mean return rate computation includes incomplete return rates for 2000 - 2003 year class fish.

NOTE: Return rates (returns/10,000 fry) are calculated from stocked fry numbers and do not include any natural fry production.

Table 18.4: Return rates for Atlantic salmon that were stocked as fry in the Merrimack River .

Year	Total Fry (1000s)	Total Returns	Returns (per 10,000)	Age class (smolt age.sea age) distribution (%) 1.1	1.2	1.3	2.1	2.2	2.3	3.1	3.2	3.3	4.2	Age (years) dist'n (%) 2	3	4	5	6
1975	36	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1976	63	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	72	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	106	18	1.698	0	0	0	0	11	33	22	28	6	0	0	0	33	61	6
1979	77	43	5.584	0	0	0	0	84	5	2	9	0	0	0	0	86	14	0
1980	126	43	3.413	0	0	0	0	19	5	21	51	5	0	0	0	40	56	5
1981	57	81	14.211	0	0	0	10	78	0	5	7	0	0	0	10	83	7	0
1982	50	48	9.600	0	0	2	2	77	8	0	10	0	0	0	2	79	19	0
1983	8	23	27.479	0	4	4	17	65	4	0	4	0	0	0	22	70	9	0
1984	526	47	0.894	0	13	0	4	77	2	0	4	0	0	0	17	77	6	0
1985	148	59	3.986	0	2	0	7	69	2	0	20	0	0	0	8	69	22	0
1986	525	110	2.095	0	11	0	0	78	1	0	8	0	2	0	11	78	9	2
1987	1,078	278	2.579	0	2	0	8	86	0	0	4	0	0	0	10	86	4	0
1988	1,718	95	0.553	1	5	0	0	91	0	0	3	0	0	1	5	91	3	0
1989	1,034	43	0.416	0	7	0	30	63	0	0	0	0	0	0	37	63	0	0
1990	975	21	0.215	5	0	0	10	81	0	0	5	0	0	5	10	81	5	0
1991	1,458	17	0.117	0	6	0	6	76	12	0	0	0	0	0	12	76	12	0
1992	1,118	14	0.125	0	0	0	0	93	7	0	0	0	0	0	0	93	7	0
1993	1,157	11	0.095	0	0	0	27	45	0	9	18	0	0	0	27	55	18	0
1994	2,816	54	0.192	0	0	0	15	83	0	0	2	0	0	0	15	83	2	0
1995	2,827	87	0.308	0	0	0	22	72	0	6	0	0	0	0	22	78	0	0

Mean return rate computation includes incomplete return rates for 2000 - 2003 year class fish.

NOTE: Return rates (returns/10,000 fry) are calculated from stocked fry numbers and do not include any natural fry production.

Table 18.4: Return rates for Atlantic salmon that were stocked as fry in the Merrimack River .

1996	1,795	27	0.150	0	0	0	15	85	0	0	0	0	0	0	15	85	0	0
1997	2,000	4	0.020	0	0	0	25	75	0	0	0	0	0	0	25	75	0	0
1998	2,589	8	0.031	0	0	0	25	75	0	0	0	0	0	0	25	75	0	0
1999	1,756	8	0.046	0	0	0	13	50	0	0	38	0	0	0	13	50	38	0
2000	2,217	12	0.054	0	0	0	0	100	0	0	0			0	0	100	0	
2001	1,708	3	0.018	0	0	0	67	33		0				0	67	33		
2002	1,414	0	0.000	0	0		0							0	0			
2003	1,335	0	0.000	0										0				
Total	**30,789**	**1,154**																
Mean			**2.548**	**0**	**2**	**0**	**11**	**62**	**3**	**2**	**8**	**0**	**0**	**0**	**13**	**64**	**11**	**0**

Mean return rate computation includes incomplete return rates for 2000 - 2003 year class fish.

NOTE: Return rates (returns/10,000 fry) are calculated from stocked fry numbers and do not include any natural fry production.

Table 18.5: Return rates for Atlantic salmon that were stocked as fry in the Pawcatuck River .

Year	Total Fry (1000s)	Total Returns	Returns (per 10,000)	Age class (smolt age.sea age) distribution (%)										Age (years) dist'n (%)				
				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**
1993	383	3	0.078	0	0	0	0	100	0	0	0	0	0	0	0	100	0	0
1994	557	2	0.036	0	0	0	0	100	0	0	0	0	0	0	0	100	0	0
1995	367	5	0.136	0	0	0	20	80	0	0	0	0	0	0	20	80	0	0
1996	289	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1997	100	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1998	910	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1999	591	2	0.034	0	0	50	0	50	0	0	0	0	0	0	0	100	0	0
2000	326	2	0.061	0	50	0	0	50	0	0	0			0	50	50	0	
2001	423	2	0.047	0	0	0	0	100		0				0	0	100		
2002	403	0	0.000	0	0		0							0	0			
2003	313	0	0.000	0										0				
Total	**4,662**	**16**																
Mean			**0.036**	**0**	**5**	**6**	**2**	**53**	**0**	**0**	**0**	**0**	**0**	**0**	**7**	**59**	**0**	**0**

Mean return rate computation includes incomplete return rates for 2000 - 2003 year class fish.

NOTE: Return rates (returns/10,000 fry) are calculated from stocked fry numbers and do not include any natural fry production.

Table 18.6: Return rates for Atlantic salmon that were stocked as fry in the Salmon River .

Year	Total Fry (1000s)	Total Returns	Returns (per 10,000)	Age class (smolt age.sea age) distribution (%)										Age (years) dist'n (%)				
				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
1987	121	2	0.165	0	100	0	0	0	0	0	0	0	0	0	100	0	0	0
1988	43	3	0.693	0	0	0	0	100	0	0	0	0	0	0	0	100	0	0
1989	111	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	38	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	49	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	124	4	0.322	0	50	0	0	50	0	0	0	0	0	0	50	50	0	0
1993	105	2	0.190	0	0	0	0	100	0	0	0	0	0	0	0	100	0	0
1994	241	4	0.166	0	25	0	0	75	0	0	0	0	0	0	25	75	0	0
1995	242	1	0.041	0	0	0	0	100	0	0	0	0	0	0	0	100	0	0
1996	247	15	0.607	0	20	0	33	47	0	0	0	0	0	0	53	47	0	0
1997	223	3	0.134	0	33	0	0	67	0	0	0	0	0	0	33	67	0	0
1998	257	1	0.039	0	0	0	0	100	0	0	0	0	0	0	0	100	0	0
1999	132	6	0.454	0	0	0	0	100	0	0	0	0	0	0	0	100	0	0
2000	278	3	0.108	0	100	0	0	0	0	0	0			0	100	0	0	
2001	250	4	0.160	0	0	0	0	100		0				0	0	100		
2002	263	7	0.266	0	29		71							0	100			
2003	247	1	0.040	100										100				
Total	**2,971**	**56**																
Mean			**0.199**	**6**	**22**	**0**	**7**	**56**	**0**	**0**	**0**	**0**	**0**	**6**	**29**	**56**	**0**	**0**

Mean return rate computation includes incomplete return rates for 2000 - 2003 year class fish.

NOTE: Return rates (returns/10,000 fry) are calculated from stocked fry numbers and do not include any natural fry production.

Table 18.7: Return rates for Atlantic salmon that were stocked as fry in the Westfield River .

Year	Total Fry (1000s)	Total Returns	Returns (per 10,000)	Age class (smolt age.sea age) distribution (%)										Age (years) dist'n (%)				
				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
1988	6	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	106	1	0.095	0	0	0	0	100	0	0	0	0	0	0	0	100	0	0
1990	274	4	0.146	0	25	0	0	75	0	0	0	0	0	0	25	75	0	0
1991	806	8	0.099	0	0	0	0	75	0	0	25	0	0	0	0	75	25	0
1992	402	15	0.373	0	0	0	0	93	0	0	7	0	0	0	0	93	7	0
1993	662	37	0.559	0	0	0	0	100	0	0	0	0	0	0	0	100	0	0
1994	674	44	0.652	0	0	0	2	91	0	0	7	0	0	0	2	91	7	0
1995	885	17	0.192	0	0	0	18	82	0	0	0	0	0	0	18	82	0	0
1996	706	12	0.170	0	0	0	8	92	0	0	0	0	0	0	8	92	0	0
1997	909	6	0.066	0	0	0	0	100	0	0	0	0	0	0	0	100	0	0
1998	1,022	8	0.078	0	0	0	25	63	0	0	13	0	0	0	25	63	13	0
1999	712	4	0.056	0	0	0	0	75	0	0	25	0	0	0	0	75	25	0
2000	839	11	0.131	0	9	0	0	73	0	0	18			0	9	73	18	
2001	1,066	20	0.188	0	5	0	5	90		0				0	10	90		
2002	892	7	0.079	0	71		29							0	100			
2003	811	0	0.000	0										0				
Total	**10,772**	**194**																
Mean			**0.180**	**0**	**7**	**0**	**6**	**79**	**0**	**0**	**7**	**0**	**0**	**0**	**13**	**79**	**7**	**0**

Mean return rate computation includes incomplete return rates for 2000 - 2003 year class fish.

NOTE: Return rates (returns/10,000 fry) are calculated from stocked fry numbers and do not include any natural fry production.

Table 19. Summary return rates in southern New England for Atlantic salmon that were stocked as fry.

Year Stocked	Number of adult returns per 10,000 fry stocked						
	Merrimack	Pawcatuck	CT 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	1.698		1.400	1.400			
1979	5.584		0.561	0.000		1.034	
1980	3.413		0.630	2.022		0.000	
1981	14.211		1.129	1.261		0.000	
1982	9.600		1.565	2.429		0.902	
1983	27.479		0.088	0.143		0.064	
1984	0.894		0.051	0.022		0.156	
1985	3.986		1.113	1.224		0.881	
1986	2.095		1.592	2.791		0.126	
1987	2.579		0.436	0.449	0.165	0.740	
1988	0.553		0.825	0.992	0.693	0.391	0.000
1989	0.416		0.539	0.629	0.000	0.680	0.095
1990	0.215		0.505	0.693	0.000	0.407	0.146
1991	0.117		0.159	0.255	0.000	0.054	0.099
1992	0.125		0.587	0.904	0.322	0.271	0.373
1993	0.095	0.078	0.446	0.361	0.190	0.673	0.559
1994	0.192	0.036	0.495	0.502	0.166	0.447	0.652
1995	0.308	0.136	0.211	0.184	0.041	0.367	0.192
1996	0.150	0.000	0.152	0.115	0.607	0.208	0.170
1997	0.020	0.000	0.044	0.041	0.134	0.027	0.066

Year Stocked	Number of adult returns per 10,000 fry stocked						
	Merrimack	Pawcatuck	CT Basin	Connecticut (above Holyoke)	Salmon	Farmington	Westfield
1998	0.031	0.000	0.048	0.050	0.039	0.017	0.078
1999	0.046	0.034	0.070	0.072	0.454	0.020	0.056
2000	0.054	0.061	0.071	0.062	0.108	0.072	0.131
2001	0.018	0.047	0.150	0.153	0.160	0.096	0.188
2002	0.000	0.000	0.052	0.039	0.266	0.042	0.079
2003	0.000	0.000	0.001	0.000	0.040	0.000	0.000
Mean	**2.548**	**0.036**	**0.431**	**0.560**	**0.199**	**0.307**	**0.180**
StndDev	**5.779**	**0.044**	**0.490**	**0.763**	**0.210**	**0.329**	**0.189**

Note: Maine rivers not included in this table until adult returns from natural reproduction and fry stocking can be distinguished.

Note: Summary mean and standard deviation computations includes incomplete return rates from 1998 (5 year olds), 1999 (4 year olds), 2000 (3 year olds), and 2001(2 year olds).

Table 20. Summary of age distributions of adult Atlantic salmon that were stocked in southern New England as fry.

	Mean age class (smolt age.sea age) distribution (%)										Mean age (years) (%)				
	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**
Connecticut (above Holyoke)	0.0	3.3	0.1	2.9	87.6	0.8	0.0	0.1	0.0	0.1	0.0	6.2	87.9	5.8	0.1
Connecticut (basin)	0.2	8.0	0.1	4.1	82.1	0.6	0.0	0.0	0.0	0.1	0.2	12.1	82.3	5.4	0.1
Farmington	0.7	25.8	0.0	5.4	63.1	0.7	0.0	0.0	0.0	0.0	0.7	31.2	63.1	5.1	0.0
Salmon	1.8	25.0	0.0	17.9	55.4	0.0	0.0	0.0	0.0	0.0	1.8	42.9	55.4	0.0	0.0
Westfield	0.0	4.1	0.0	5.2	85.6	0.0	0.0	0.1	0.0	0.0	0.0	9.3	85.6	5.2	0.0
Merrimack	0.2	3.0	0.2	8.5	76.3	1.8	0.0	0.1	0.3	0.2	0.2	11.5	78.5	9.4	0.4
Overall Mean:	**0.5**	**11.5**	**0.1**	**7.3**	**75.0**	**0.7**	**0.0**	**0.0**	**0.0**	**0.1**	**0.5**	**18.9**	**75.4**	**5.1**	**0.1**

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

Note: Maine rivers not reported until adult returns from natural reproduction and fry stocking can be distinguished.