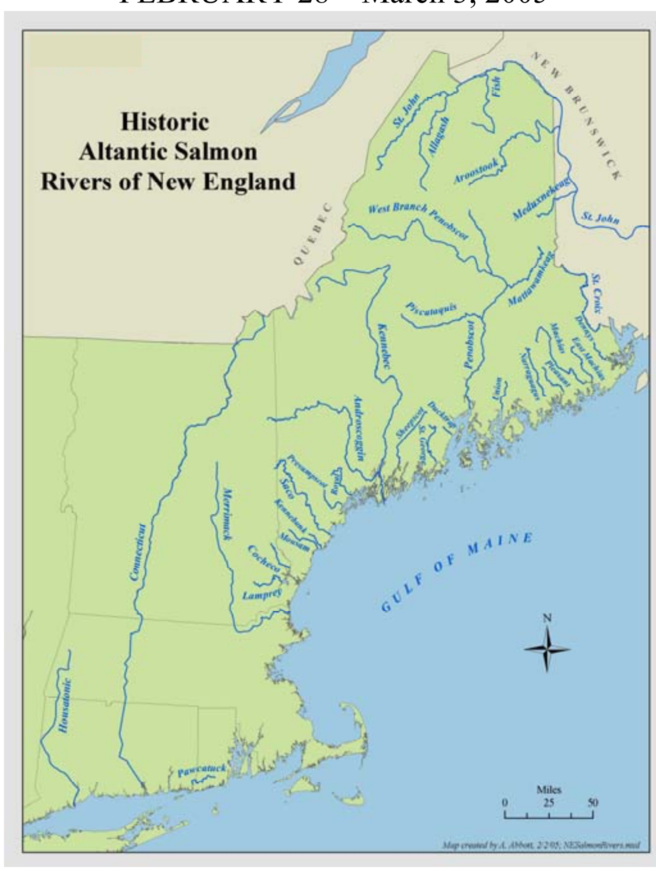
U.S. ATLANTIC SALMON ASSESSMENT COMMITTEE **ANNUAL REPORT 2005/17**

ANNUAL REPORT OF THE U.S. ATLANTIC

SALMON ASSESSMENT COMMITTEE

REPORT NO. 17 - 2004 ACTIVITIES

WOODS HOLE, MASSACHUSETTS
FEBRUARY 28 – March 3, 2005



PREPARED FOR
U.S. SECTION TO NASCO

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1.0 EXECUTIVE SUMMARY

Total return to USA rivers was 1,635; this is the sum of documented returns to traps and returns estimated using redd counts on selected Maine rivers. Adult salmon returns to USA rivers with traps or weirs totaled 1,566 fish in 2004, 12% more than observed in 2003. Eighty-two adult (90% CI = 60 - 113) fish were estimated to return to the rivers with Endangered populations, the 4th lowest for the 1991-2004 time-series. Most returns occurred in Maine, with the Penobscot River accounting for 81% of the total return. Overall, 19% of the adult returns to the USA were 1SW salmon and 81% were MSW salmon. Most (89%) returns were of hatchery smolt origin and the balance (11%) originated from either natural reproduction or hatchery fry. A total of 15,176,100 juvenile salmon (fry, parr, and smolts) and 4,311 mature adults were stocked. Eggs for USA hatchery programs were taken from 449 sea-run females, 3,074 captive/domestic females, and 95 female kelts. The number of females (3,618) contributing was less than in 2003 (3,705); and total egg take (20,486,000) was greater than that of 2003 (19,564,000). About 574,560 salmon carrying a variety of marks and/or tags (e.g., PIT tags, visual implant elastomer tags, Petersen disc tags, fin clips etc.) were released in USA waters in 2004. Production of farmed salmon in Maine was 9,121 metric tonnes in 2004.

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 Woods Hole, Massachusetts from February 28 to March 3, 2005 to address the following Terms of Reference.

1.2 Terms of Reference for Report No. 17 - 2004 Activities

From U.S. Commissioners to NASCO

(1) provide recommendations/feedback on the Future of NASCO;
(2) review SALSEA project and provide recommendations for integration of North American salmon into this project;

With respect to Stocking Guidelines:

(3) prepare a review of US compliance with the Stocking Guidelines annexed to the Williamsburg Resolution;
(4) provide any appropriate changes to the Stocking Guidelines on the basis of new scientific information;

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

(5) develop an inventory of which US stocks do and do not have rebuilding programs in place (as described in the NASCO Guidelines for the Use of Stock Rebuilding Programs);
(6) identify where existing stock rebuilding plans can be obtained and evaluate those programs against the NASCO Guidelines for the Use of Stock Rebuilding Programs;
(7) for stocks that do not have rebuilding programs, provide any available information on the planned development of such programs in the future;
(8) provide any appropriate 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:

(9) provide examples of measures taken to protect habitat and to restore degraded habitat;
(10) review information already in NASCO rivers database to ensure accuracy;
(11) populate the NASCO rivers database with habitat specific information

From ICES

1. provide an overview of salmon catches and landings, including unreported catches and catch and release, and production of farmed and ranched Atlantic salmon in 2004;
2. provide a compilation of tag releases by country in 2004;
3. describe the 2004 fisheries and the status of the stocks;
4. update age-specific stock conservation limits based on new information as available;

5. provide an analysis of any new biological and/or tag return data to identify the origin and biological characteristics of Atlantic salmon caught at St Pierre and Miquelon.

These Terms of Reference will be addressed in this report or in Working Papers (Appendix 5.2) that will be forwarded 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 1,521 fish, to support the fishery in the main stem of the Merrimack River and small reach of the Pemigewasset River, both in New Hampshire.

2.2 Adult Returns

Total return to USA rivers was 1,635 (Table 1), a 14% increase from returns in 2003 (Table 2). Changes from 2003 by river were: Connecticut (+38%), Merrimack (-13%), Penobscot (+16%), Saco (-185%), and Narraguagus (-91%). In addition to catches at traps and weirs (1,566), returns were estimated using redd counts for the eight rivers that comprise the federally endangered Gulf of Maine Distinct Population Segment (DPS). Data on adult returns and redd counts collected from 1991-2004 on the Narraguagus, Pleasant, and Dennys rivers from 2000 to 2004 were used to develop a return-redd model using a linear regression of the natural log of both values [ln (returns) = 0.5699 ln(redd count) + 1.3945]. This model and its associated error were used to simulate the most probable adult returns on a river-by-river basis (Table 3). Total estimated return for the DPS was 82 (90% CI = 60 - 113). 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 based on redds were only 4.4 % of the 2SW conservation spawner requirements for USA, with individual river returns ranging from 0.0 to 14.8 % of spawner requirements (Table 4).

Most returns occurred in Maine, with the Penobscot River accounting for 81% of the total return. Overall, 19% of the adult returns to the USA were 1SW salmon (319) and 81% were MSW salmon (1,283). Returns of both 1SW and MSW salmon in 2004 were greater than those in 2003. Most (89%) returns were of hatchery smolt origin and the balance (11%) 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 0.21%, with the 2SW fish return rate 0.17% (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 calculated in recent years have mirrored those for the Penobscot, but were between five and ten fold higher.

2.3 Stock Enhancement Programs

During 2004, about 15,173,300 juvenile salmon (91.9% fry) were released into 16 river systems (Table 5). The number of fish released was greater than that in 2003. Fry were stocked in the Connecticut, Merrimack, Saco, Penobscot, and six rivers containing the listed DPS in Maine. The 441,000 parr released in 2004 were by-products of smolt production programs and included ages 0 and 1 fish. Smolts were stocked in the Penobscot (566,000), Merrimack (50,000), Connecticut (96,400), Saco (5,400), Dennys (56,300), Pleasant (8,800), and Pawcatuck (6,100) rivers. In addition to juveniles, 4,311 adult salmon were released into USA rivers (Table 6). Most were spent broodstock or broodstock excess to hatchery capacity. October releases of broodstock to the Dennys and Machias rivers included small numbers of gravid females and males. In the Merrimack River excess broodstock were released to support a recreational fishery and to enhance spawning in the watershed.

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 572,000 salmon released into USA waters in 2004 was marked or tagged. Tags used on parr, smolts and adults included: Floy, Carlin, PIT, radio and acoustic, fin clips, and visual implant elastomer. About 17% of the marked fish were released into the Connecticut River watershed, 1% into the Merrimack River watershed, 62% into the Penobscot River, and 20% into other Maine Rivers (Tables 7).

2.5 Farm Production

Production of farmed salmon in Maine was 9,121 metric tonnes in 2004, an increase from the 6,435 metric tonnes produced in 2003. Production in each of the last three years has been less than the 13,154 tonnes produced in 2001. Production has declined due to ISAv outbreaks and changes in the industry.

2.6 Special topics

2.6.1 Contaminants

A January 4, 2004 report in *Science*, and the media releases associated with the report, documented elevated contaminant concentrations, including polychlorinated biphenyls (PCBs) and dioxins, in farm-raised salmon. The likely source for the contaminants was the fish oil used in commercial feed (Hites et al. 2004). The U.S. Fish and Wildlife Service evaluated Atlantic salmon broodstock levels of PCBs, dioxins, and/or heavy metals. Many of the National Fish Hatchery (NFH) Atlantic salmon broodstock had higher levels of total PCBs than reported by Hites et al. (2004) for farm-raised salmon sampled from east Canada and Maine (0.039 ppm and 0.026 ppm). The sea-run salmon, age-4 fish in Nashua NFH, had total PCBs body burdens of 0.089 ppm. The mean PCB level in NFH Atlantic salmon (0.0335 ppm) seemed to be consistent with the levels reported by Hites et al. (2004) for farmed salmon (primarily Atlantic salmon *Salmo salar*) around the world (Millard et al. 2004).

Contaminant levels in hatchery fish were generally 10-100 times lower than those been reported to cause sublethal effects in salmonids (Giesy et al. 2002; Meador et al. 2002; Berntssen et al. 2003; Cook et al. 2003; Carvalho et al. 2004a; Carvalho et al. 2004b). This could be interpreted to mean residues in hatchery fish are unlikely to affect performance. However, for Atlantic salmon, there are no universally accepted threshold concentrations for tissue, diet, or eggs that can be used as no adverse effects benchmarks. Wild caught and hatchery fish contain mixtures of these chemicals that can cause additive, synergistic or antagonistic effects. Virtually nothing is known about the effects of most mixtures on fish. The interactions of contaminant mixtures and the timing of exposure are also important. For example, damage sustained during development is irreversible, and can lead to permanent changes in hormone function, neural development, and vision among other features. Because of these complexities, contaminant body burdens alone cannot be used to predict performance effects. Rather, the functional deficits associated with these contaminants identified in laboratory studies with salmonids (survival, behavior, and visual acuity) are more reliable indicators of performance.

Body burden analyses require fillets. Concerns for reducing the number of lethal samples of endangered and restoration populations have prompted a search for non-lethal indicators of exposure to contaminants. Rees et al. (2003) determined that the expression of cytochrome P450 1A (CYP1A) could be used as a biomarker for possible exposure in contaminants such as PCB's and dioxins in Atlantic salmon, and further research has validated using a non-lethal gill biopsy for CYP1A mRNA. Levels of CYP1A mRNA expression in Atlantic salmon were directly related to contaminant exposure and will be a valuable tool in environmental assessment of wild Atlantic salmon populations.

Further information on contaminants is included in Section 4.1.

2.6.2 Downstream Passage

Studies of downstream migration of Atlantic salmon adults, kelts, and smolts have been conducted during the past 30 years. These have included migration on undammed streams and around dams, both with and without special downstream passage facilities. A compilation of studies at 36 different hydroelectric dams on 13 rivers in four New England states produced information from 72 studies. However, compilation may not be complete because studies of salmon migrations down free-flowing streams were underrepresented. All of these studies except one focused on Atlantic salmon smolts. The one exception included salmon kelts. Effectiveness estimates (expressed in percentage of total fish approaching the dam) vary greatly by dam. Each hydroelectric plant is unique in design, location of turbine intakes, the nature of the approach to these intakes, flow characteristics, turbine types, fish bypass design, and river hydrology. Therefore the effectiveness of downstream passage is site-specific. The most common downstream bypass device employed for salmon smolt migrations is a surface spill gate or weir that discharges into a plume or sluice conveying water and fish to the tailwater. Other techniques studied included spillway spill and passage through turbines. Auxiliary devices included louvers, guide fences or angled racks, and flashboards or inflatable dams. Passage effectiveness has been defined as the percentage of fish approaching dam that use the downstream passage device, thus avoiding the turbines. Fish may also pass over the dam or spillway. Most studies report both high and low effectiveness estimates. Within the Connecticut River basin the range of effectiveness reported over all facilities studies was 4% to 94%. On the Merrimack the range was 6% to 100%, with the range on the Penobscot the range reported was 8% to 59%. Successful downstream passage is critical to maximizing smolt survival to the estuary because juvenile rearing habitat in the headwaters on these large rivers.

Further information on downstream passage is included in Section 4.2.

Table 1. Documented Atlantic salmon returns to USA rivers, 2004. "Natural" includes fish originating from natural spawning and hatchery fry. Returns to traps are compared to five-year averages in Table 10.

	NUMBER OF RETURNS BY SEA AGE AND ORIGIN[1]								
	1SW		2SW		3SW		Repeat Spawner		
RIVER	Hatchery	Natural	Hatchery	Natural	Hatchery	Natural	Hatchery	Natural	TOTAL
Androscoggin	3	0	7	1	0	0	0	0	11
Connecticut	0	5	0	64	0	0	0	0	69
Dennys	0	0	1	0	0	0	0	0	1
Merrimack	17	2	92	15	2	0	0	0	128
Narraguagus	0	1	1	9	0	0	0	0	11
Pawcatuck	0	0	0	1	0	0	0	0	1
Penobscot	276	5	952	59	10	3	16	2	1,323
Pleasant	0	0	0	1	0	0	0	0	1
Saco	3	2	10	4	0	0	0	0	19
Union	0	0	1	1	0	0	0	0	2
Other DPS[3]	0	5	0	64	0	0	0	0	69
TOTAL	299	20	1,064	219	12	3	16	2	1,635

[1] Includes origins and ages determined from scale samples, fin deformities, marks and tags.
[2] Ages and origins are pro-rated based upon distributions for randomly selected sample days at ASC trapping facilities
[3] 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, 1967-2004. "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[1]	237	1,192	3	4	1,436	1,242	194
2004	319	1,283	15	18	1,635	1,391	244

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

Table 3. Estimated returns in 2004 to rivers within the Gulf of Maine Distinct Population Segment, based on documented returns and redd based estimates.

River	**Type**	**Estimate**	**90% CL Low**	**90% CL High**
Cove Brook	redd	0	0	1
Ducktrap River	redd	15	7	26
East Machias River	redd	24	10	49
Machias River	redd	16	8	28
Sheepscot River	redd	14	7	25
Dennys River	trap	1	1	1
Narraguagus River	trap	11	11	11
Pleasant River	trap	1	1	1
2004			**60**	**113**

Table 4. Two sea winter (2SW) returns for 2004 in relation to spawner requirements for USA rivers

River	Spawner Requirement	2SW spawners-2004	Percentage of Requirement
Penobscot	6,838	1011	14.79
Connecticut	9,727	64	0.66
Paucatuck	367	1	0.27
Merrimack	2,599	107	4.12
Dennys	161	1	0.62
Narraguagus	401	10	2.49
Pleasant	81	1	1.23
Other Maine rivers	9025	88	0.98
Total	29,199	1283	4.39

Table 5. Number of juvenile Atlantic salmon stocked in USA, 2004.

River	Fry	0 Parr	1 Parr	1 Smolt	2 Smolt	Total
Connecticut	7,683,000	3,100	2,500	0	96,400	7,785,000
Androscoggin	2,000	0	0	0	0	2,000
Aroostook	169,000	0	0	0	0	169,000
Dennys	219,000	44,000	0	56,300	0	319,300
East Machias	319,000	0	0	0	0	319,000
Kennebec	52,000	0	0	0	0	52,000
Machias	379,000	3,100	0	0	0	382,100
Narraguagus	468,000	0	0	0	0	468,000
Penobscot	1,812,000	369,200	0	566,000	0	2,747,200
Pleasant	47,000	0	0	0	8,800	55,800
Saco	375,000	0	0	5,400	0	380,400
Sheepscot	298,000	15,600	0	0	0	313,600
St Croix	0	0	0	4,100	0	4,100
Union	3,000	0	0	0	0	3,000
Merrimack	1,556,000	3,700	0	50,000	0	1,609,700
Pawcatuck	557,000	0	0	6,100	0	563,100
Total for United States	13,939,000	438,700	2,500	687,900	105,200	15,173,300

Table 6. Captive and domestic adult Atlantic salmon stocking summary for USA in 2004 by river, season and year class[1].

	NUMBER RELEASED BY SEASON AND YEAR CLASS											
	Spring / Summer				Autumn							
	2001	2002	2003	2004	1998	1999	2000	2001	2002	2003	2004	Total
Connecticut	0	0	0	0	0	0	0	110	0	0	0	110
Dennys	0	0	0	0	0	60	36	0	101	127	0	324
East Machias	0	0	0	0	0	0	97	0	0	0	0	97
Machias	0	0	0	0	0	0	193	0	100	116	0	409
Narraguagus	0	0	0	0	0	0	195	96	0	0	0	291
Pleasant	0	0	0	0	0	0	101	0	0	0	0	101
Penobscot	0	0	0	0	0	0	579	383	0	0	530	1,492
Sheepscot	0	0	0	0	0	0	116	0	0	0	0	116
Merrimack	0	724	0	0	0	0	0	297	350	0	0	1,371
Total United States	**0**	**724**	**0**	**0**	**0**	**60**	**1,317**	**886**	**551**	**243**	**530**	**4,311**

Table 7. Summary of tagged and marked Atlantic salmon released in USA, 2004. Additional details in Table 9.1.

		Stock Origin							
MarkCode	LifeHistory	Connecticut	Dennys	Merrimack	Narraguagus	Penobscot	Pleasant	Other Maine	Grand Total
AD	Smolt	94,971							94,971
AP	Adult					962			962
FLOY	Adult			1,021					1,021
FLOY	Smolt	1,242							1,242
LV	Parr					112,000			112,000
LV	Smolt					2,700			2,700
PING	Smolt		159		74		124		198
PIT	Adult		298		291	1,239	101	506	2,435
PIT	Parr	926	69						995
RAD	Adult	6							6
RAD	Smolt	214				83			297
RV	Parr		44,000			27,000			71,000
RV	Smolt					2,700			2,700
VIE	Parr		173						173
VIE	Smolt		60,000			212,060	9,000		281,060
Grand Total		97,359	104,699	1,021	365	358,744	9,225	506	571,760

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

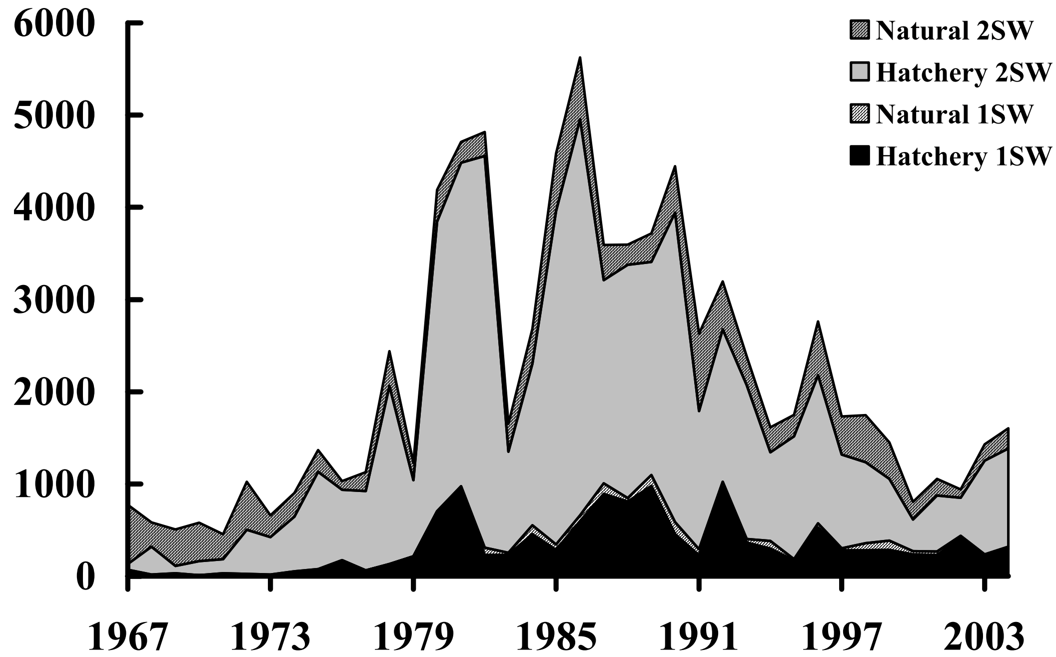
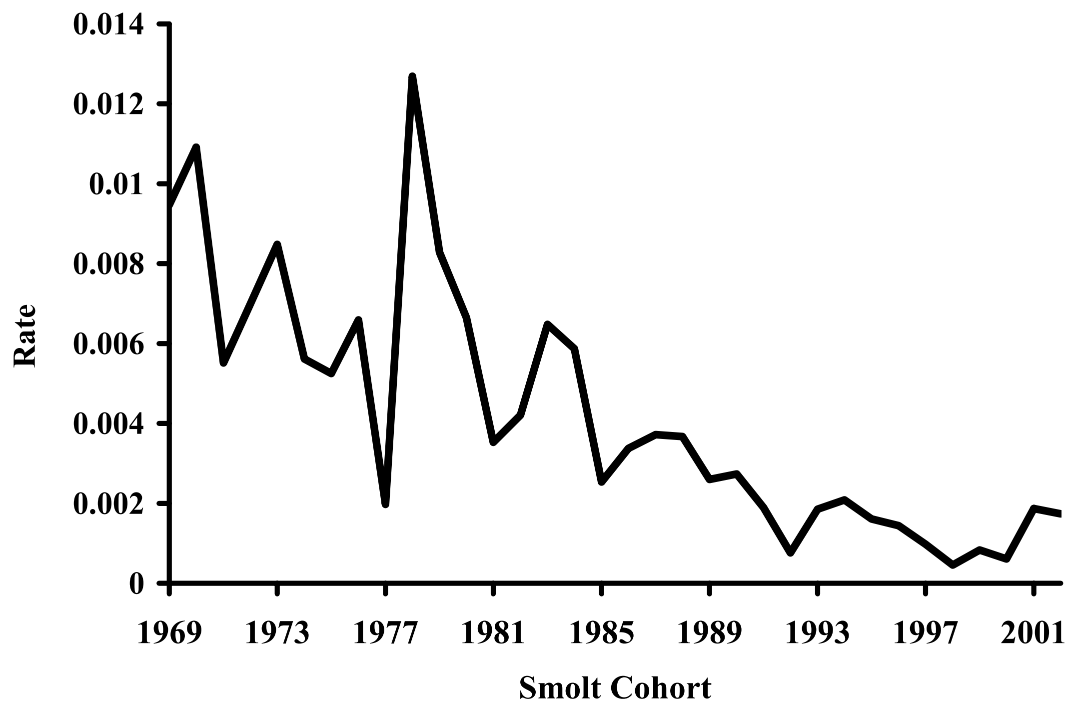


Figure 2. Return rate of 2SW adults by cohort of hatchery-reared Atlantic salmon smolts released into the Penobscot River (PN), Maine, USA.



2.10. Historical Data

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

2.10.1. Egg Production

Total egg production for Atlantic salmon restoration and recovery programs in New England for the 2004 was 20,486,000 (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 66,100 female Atlantic salmon have produced an estimated 444 million eggs for programs throughout the history of salmon enhancement, restoration, and recovery efforts.

2.10.2 Stocking

Approximately 216 million juvenile salmon have been released into the rivers of New England during the period, 1967 – 2003 (Table 14). About 80% of the total have been fry (Table 15). The majority of the juvenile releases have occurred in the Connecticut River (> 103 million), the Penobscot River (> 36 million), and the Merrimack River (> 35 million).

2.10.3. Adult Returns

The number and age structure of returns to New England rivers has varied from 1967 through 2004 (Table 16). The majority of the returns have occurred in Maine rivers (91%), followed by the returns to the Connecticut River (6.0%), and the Merrimack River (3.0%). Adult returns to the Penbscot River represent 72% of the total (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 69 sea-run Atlantic salmon adults was observed returning to the Connecticut River watershed: 45 at the Holyoke fishway on the Connecticut River, 13 at the Rainbow fishway on the Farmington River, and 11 at the Decorative Specialties International (DSI) fishway on the Westfield River. The run lasted from May 2 to June 20. A total of 63 salmon was retained for brood stock at RCNSS.

Six salmon were radio-tagged and released above the Holyoke fishway. One tag failed immediately after release. One salmon passed downstream and was captured at the DSI fishway and was released to the upper Westfield River. Three salmon were monitored in the Deerfield River. One salmon migrated approximately 160 km and through four fishways in five days from below Turners Falls to the mouth of the White River. It then passed Wilder fishway and was monitored near the mouths of the Ammonoosuc and Wells rivers.

All of the salmon observed were of wild (fry-stocked) origin. Sea-age distribution was five grilse and 64 2SW. Freshwater age distribution was 1+ (N=5), 2^+(N=56) and 3^+(N=6) and one 4+ with one unknown.

No poaching was documented but one angler reported a salmon caught and released.

3.1.2. Hatchery Operations

The program achieved 83% of egg production goals, 77% of fry stocking goals, and 97% of smolt stocking goals in 2004.

Currently, a total of 75,000 1+ pre-smolts are in production at the Pittsford NFH. They were again marked with an adipose fin clip and vaccinated with a multi-valent vaccine for *Vibrio* and furunculosis in preparation for spring stocking.

The Warren SFH (NHFG) produced 214,000 fed fry but encountered heavy mortality and poor fry condition due to lack of control of incubation temperatures. Future production at this facility is contingent on installing a chiller, which should be operational for fall, 2005.

Egg Collection

A total of 12.5 million green eggs was produced at five state and federal hatcheries within the program. Sea-runs produced 280,000 eggs from 37 females held at the RCNSS. A sample of the fertilized eggs from all sea-run crosses was egg-banked at the WRNFH for disease screening and subsequent production of future domestic brood stock. Domestics produced 11.7 million eggs from 1,875 females held at RCNSS, WRNFH, RRSFH, and KSSH. Kelts produced 489,000 eggs from 53 females held at the NANFH and RCNSS.

3.1.3. Stocking

Juvenile Atlantic Salmon Releases
A total of 7.8 million juvenile Atlantic salmon was stocked into the Connecticut River watershed in 2004. A total of 1 million fed fry and 6.7 million unfed fry were stocked into 41 tributary systems with the assistance of hundreds of volunteers. A total of 97,000 smolts was released into the lower Connecticut River mainstem and the Farmington River.

Pre-spawn Adult Salmon Releases
CTDEP released 110 pre-spawn domestic broodstock into State of Connecticut tributaries as an experiment to evaluate their spawning success because USFWS initially planned to limit incubation at WRNFH and would not have taken any eggs from KSSH. Ultimately, incubation was not limited and the remainder of eggs surplus to KSSH needs were sent to WRNFH for incubation for fry production. Surveys located numerous redds.

Egg plants
A total of 36,000 green eggs was planted in stream gravel in the Salmon 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 2004. This was the twelfth consecutive year that a study has been conducted on the river mainstem by marking smolts at the Cabot Station bypass facility and recapturing them at the bypass facility in the Holyoke Canal. The population estimate was 78,000 (+/- of 41,000 95% confidence limits).

Based on expanded electrofishing data from index stations and assumed overwinter mortality, it was estimated that 250,000 smolts were produced in tributaries basin wide, of which 183,000 (73%) were produced above Holyoke in 2004. 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 nearly 200 index stations throughout the watershed. Sampling was conducted by CTDEP, MAFW, NHFG, USFS, and VTFW. Data are used to evaluate fry stocking, estimate survival rates, and estimate smolt production. All of the data have not been analyzed yet. Preliminary information indicates that while densities and growth of parr varied widely throughout the watershed as usual, it was generally an average survival year with above average growth. Most smolts

produced are again expected to be two year olds, with some yearlings and three year olds. Preliminary analysis suggests that basin wide smolt production in 2005 will be slightly lower than last year. Electrofishing data from 2004 and previous years was added to the juvenile database for the Assessment Committee.

3.1.5. Fish Passage

Program cooperators continued to work to improve upstream passage and downstream passage at dams as well as to remove dams.

Holyoke Dam - The City of Holyoke Gas and Electric Department continued to implement new license requirements for upstream and downstream passage including construction of a full depth louver for downstream passage and two new lift towers, a redesigned spillway entrance, an expanded exit flume, and a second counting window and trap for upstream passage. Future actions include downstream fish passage improvements at the main powerhouse.

Fifteen Mile Falls Project – Studies were conducted at the upper and lower dams of this three dam project on the upper Connecticut River. The McIndoes bypass was evaluated with hatchery smolts. Past study results indicated significant turbine passage and poor bypass effectiveness. We are awaiting this year's results. USGen installed a smolt sampling device at Moore to collect data on seasonal and diurnal timing and smolt abundance as a precursor to passage facility development at Moore and Comerford. The sampler was not completed until the smolt run was underway, but 240 wild smolts were captured and trucked below McIndoes for release. Bypass efficiency of study hatchery smolts was extremely low. Further evaluation is needed in 2005.

Homestead Dam (West Swanzey Dam)- A feasibility study of removing this Ashuelot River dam has been completed and a final report is forthcoming. The dam is in severe disrepair but there are historical issues related to the dam, a covered bridge over the impoundment and a Native American fishing weir.

Fiske Mill Dam – A new owner purchased this dam on the Ashuelot River, which had been planned for removal. A denil ladder will be built for upstream passage; downstream passage is already in place.

Vermont Yankee Nuclear Power Plant- Entergy has proposed increases to thermal discharge limits. Concerns for salmon include river warming during smolt migration and impacts of the discharge plume on smolt behavior. The proposal is under review by several agencies.

3.1.6. Genetics

The U.S. Geological Survey - Biological Resources Division, through the Conte Anadromous Fish Research Center, again sampled tissue from all sea-run brood stock for genetic monitoring (microsatellite analysis). The 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.

The objective is to use a minimum of 50 pairs of sea-run adults for the egg taking operation, but since a total of 69 salmon returned to the river in 2004, kelts and parr were added to the spawning population. Parr were collected from the Williams River. Mating utilized a 4 male: 1 female breeding matrix in which one unique cross was sent to the the egg bank for future broodstock production and the other three 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 (160,000) and Sawmill Rivers (61,000) in spring of 2004 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 salmon 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. The 2004 smolt migration was the first with marked domestics contributing. Partial fin clips were taken from 1,300 smolts sampled at Cabot Station and will be analyzed at Conte Lab.

3.1.7. General Program Information

The Connecticut River Atlantic Salmon Commission was provided with $250,000 by Congress for migratory fish restoration in the Connecticut River basin in FY04. This is the first time that the Commission has ever received direct federal funding. In addition to work on other migratory species, the funding was used to address budget gaps in salmon production, to continue genetic monitoring and evaluation, to continue index station assessments, to monitor fishways, and to maintain capabilities in adult transport, handling and spawning. Unfortunately, no funding was provided to CRASC for FY05. The lack of CRASC funding combined with ongoing budget difficulties faced by cooperators, particularly the USFWS, has hampered restoration efforts. Without additional funding further cutbacks to program operations seem inevitable.

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 (CRSA) 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 and the Vermont Institute of Natural Science in Vermont. Schools in New Hampshire also participated.

3.1.8. Salmon Habitat Enhancement and Conservation

Program cooperators continued their habitat protection efforts in 2004. The USFWS and VTANR signed an agreement with the USACOE to provide natural flow regimes at their five flood control dams on tributaries in Vermont except when they are conducting flood control operations. The USFS continued their habitat restoration program. 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 2004, 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 semi-permanent weirs on the Dennys and Pleasant rivers. The summer of 2004 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, yet allowed good conditions for redd counting.

Because there was no rod catch, the number of spawners was assumed to equal returns. In 2004, pre-spawn captive broodstock were stocked in the Dennys and Machias Rivers. However, these fish will not be included in spawner numbers forwarded to ICES because less than 20 females stocked in each river were mature and their reproductive capacity and success will probably not be comparable to returning 2SW females.

Rivers with Native Atlantic Salmon
Dennys River
One two-sea winter salmon, stocked as an age 0+ fall parr, was captured at a weir located at the head of tide in Dennysville. The trapping operation started 25 May 2004, slightly later than usual, because the weir was damaged by unusually high flows in 2003. Operations continued through 12 November. Capturing one fish this year was discouraging, given that approximately 50,000 smolts from Green Lake National Fish Hatchery (GLNFH) were stocked two year before.

ASC counted 51 redds in the Dennys River ranging throughout much of the spawning habitat in the mainstem. Although we had only one adult salmon return this year, 101 pre-spawn adult broodstock from CBNFH were stocked in the vicinity of the Dennys River Sportsman's Club, in the lower river. A small portion of these fish was expected to spawn in the river because hatchery personnel identified only 13 gravid females and 34 mature males at the time of stocking. Redds observed in the Dennys may almost entirely be attributed to the stocked fish. However, escapement past the weir cannot be entirely rule out. Of the redds counted, 38 were within 3 to 4 kilometers of the stocking location. Some movement farther upstream occurred as well, with 13 redds observed in the middle reaches of the river (Stoddard Rips). This number of redds exceeded our expectations for these fish and may indicate that more were sexually mature than predicted. ASC will attempt to evaluate the reproductive success of these fish by trapping some redds for emergent fry, as well as electrofishing later in the year.

East Machias River

Surveys in fall 2004 on the East Machias River located 10 redds in the watershed. Because in 2003, extremely high water prevented surveying many areas for redds effectively, an additional survey was conducted during spring fry stocking, however, no additional redds from 2003 were seen.

Machias River

A total of 59 redds were counted during trips that covered the majority of the spawning habitat in the Machias drainage. The redds counted were created by both wild and stocked adult salmon. ASC and USFWS released 100 adult captive reared broodstock from CBNFH in the West Branch Machias River at the outlet of Sabao Lake. At the time of stocking hatchery personnel determined that there were 15 gravid females, 37 mature males, and 48 immature fish. The West Branch Machias River was chosen as a release area because distance and a number of beaver dams isolate it from the rest of the drainage, wild escapement was unlikely, and spawning activity could be monitored effectively. However, the salmon stocked at the outlet of Sabao Lake apparently moved down the entire length of the West Branch Machias River and into the mainstem of the Machias River to construct a number of redds. In all, 40 redds were counted between the confluence of the West Branch Machias River and the end of spawning habitat below Route 9. Wild fish were also in the system because preliminary spawning activity in the lower West Branch Machias River was documented before the adults were stocked and redds were found in parts of the drainage where stocked fish were unlikely to have moved. It seems reasonable to attributing the following redds to wild escapement: 12 redds in Old Stream, two in Chain Lakes Stream, and one redd in Mopang Stream. We counted four redds in the West Branch in the general areas where we had seen test pits before the captive broodstock were stocked.

Pleasant River

A weir, located upstream of the Route 1 bridge, was operated from May 19 to November 01, 2004. Two salmon were trapped: one multi-sea winter male, that was released upstream; one short-absence hatchery smolt, stocked in May, also released upstream. Weir operation was interrupted during August 14 and 15 due to unusually high river levels and debris. It is possible adult fish could have passed over the weir during this time. However, no redds were found in the Pleasant River in 2004.

Narraguagus River

The fishway trap at the Cherryfield ice control dam was operated from May 3 through November 1, 2004. A total of 10 adults were captured, none of these were suspected to be of aquaculture origin. Under certain river flow conditions, adult salmon are able to leap the ice control dam and bypass the trap. Conditions were favorable for fish to bypass the fishway in 2004. A video camera monitors the spillway of the Cherryfield Dam during daylight hours to document fish leaping the dam. Tape analysis is complete, with one adult salmon passing over the spillway on 17 June. Videotapes from May, June, and from the latter half of August through November have been viewed. The video system sustained damage, probably from a lightening strike in early July, causing VCR, battery charger, and camera failures. No tapes were recorded from July 2 through August 17. Based upon river flows and temperatures, it is likely that some salmon were able to jump the dam during the early part of this time period.

The eleven returns accounted for (captured or viewed) on the Narraguagus River are fewer than expected based on the ensuing autumn 2004 redd survey conducted on the Narraguagus River mainstem and three of its tributaries, Sinclair, Baker, and Gould brooks. The West Branch Narraguagus River, a major tributary to the Narraguagus River was not surveyed as it contains relatively little spawning habitat and is logistically impractical for redd counts. In total, 23 redds and ten test pits were counted on the mainstem during the 2004 surveys. No redds or test pits were observed in the three tributaries surveyed. It is likely that salmon leaped the dam instead of ascending via the fishway, thus explaining the discrepancy between the redd count and trap catch.

Ducktrap River

There was one attempt to document spawning in the Ducktrap River in the fall of 2004 (November 22), during which nine redds and five test digs were observed, primarily in the Kendall Brook area. Summer flows in the Ducktrap River averaged nearly 10 cfs (cubic feet per second) during 2004, compared to an average flow of one cfs or less during the summer of 2003. Good flow conditions most likely provided better passage to upriver spawning areas.

Sheepscot River

One survey of the spawning habitat throughout the entire river was conducted. A total of eight redds were located: six between the Palermo Hatchery and Coopers Mills in the mainstem; one between Kings Mills and Headtide; and one in West Branch Sheepscot River.

Cove Brook

During three attempts to find redds in Cove Brook in 2004 (November 1, 9, and 23), no spawning activity was found. An extended period of low flows throughout the summer and early fall most likely limited access for adult salmon to upriver spawning grounds. Because juvenile Atlantic salmon were not found during the summer of 2004, the previous year's redd counts were reevaluated. ASC believes that suspected Atlantic salmon redds seen in 2003 were probably created by large brook trout superimposing redds. In 2004, ASC observed a congregation of large brook trout digging in the same area at nearly the same time as in 2003 indicating that the 2003 counts were most likely inaccurate.

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. The new regression was used for estimating the 2004 returns and retrospectively updating historical returns (Table 3.2.1.1). The 90% probability estimate for returns to the DPS in 2004 ranged from 60 to 113.

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 current simulation model above provides data for 9 generations of Atlantic salmon starting with returns in 1996 from the 1991 spawning cohort. The replacement rate averaged 0.6 during this time and the mean replacement rate has not exceeded 1 during this time period. However, in 3 of the 9 years the upper bound of the 90% confidence limits did exceed 1. The replacement rate for 2004 was 0.48 (0.32 - 0.70) and was the fourth lowest in the time series. Contributions of captive reared spawners at CBNFH are not accounted for in this calculation.

Table 3.2.1.1. Redd based estimates of adult Atlantic salmon in the DPS rivers for 2004, with estimates from 2003, 2002, 2001 and 2000.

River	Type	Estimate	90% CL Low	90% CL High
Cove Brook	redd	0	0	1
Ducktrap River	redd	15	7	26
East Machias River	redd	24	10	49
Machias River	redd	16	8	28
Sheepscot River	redd	14	7	25
Dennys River	trap	1	1	1
Narraguagus River	trap	11	11	11
Pleasant River	trap	1	1	1
		82	**60**	**113**
2003	New (Old)	76 (72)	62 (61)	96 (86)
			28 (26)	48 (41)
2001	New (Old)	103 (99)	90(87)	120 (115)
2000	New (Old)	100 (91)	79 (75)	127 (111)

Other Maine Atlantic Salmon Rivers

Penobscot River

ASC captured 1,323 sea-run salmon during 2004, releasing 714 salmon back to the Penobscot River. Thirty-five salmon were recaptured once after dropping downstream over the dam and ascending the fishway for a second time with four fish recaptured twice and two of these fish being recaptured a third time. All salmon released to the river were marked with an adipose fin punch (AP), or an upper caudal fin punch (tail punch, UCP) and most (709) were implanted with a Passive Integrated Transponder (PIT) tag to provide identification of recaptured salmon and prevent double counting. This year’s total catch represents an increase of 211 fish from the 2003 total catch of 1,112 sea-run salmon.

Of the 1,323 sea-run salmon returning to the trap in 2004, 281 were 1 sea winter (1SW) fish representing 21% of the total run. The percentage of 1SW fish (grilse) in the total run fluctuates yearly, and while this year's rate is below the mean of approximately 25% for the previous 17 years, it does fall within the normal range observed over this time period (11% - 48%). No suspected aquaculture escapees were captured, but ASC did capture three domestic broodstock released from GLNFH in previous years, based upon the mark observed (healed adipose fin punch), scale circuli patterns, and body morphology. Two of the GLNFH broodstock were returning from one-year at sea and are reported as "new sea-run fish". The third appeared to be released in fall of 2003 with no detectable sea growth based on scale analysis and was not recorded as part of this year's adult catch.

Great Lakes Hydro America, LLC (GLHA) continued operation of an Atlantic salmon trap at the fishway at Weldon Dam. 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 2004 trap catch (183 total salmon) consisted of 80 MSW salmon and 103 1SW. This catch represents a 357% increase over the previous year (40 salmon). All trapped fish were counted and permitted to swim from the trap without additional handling.

Surveys to locate and count redds were conducted on three tributaries to the Penobscot estuary. There were two surveys conducted to find redds in Souadabscook Stream in 2004. During the first, three salmon redds and two test digs were found. One additional redd was found on the second survey. No redds were found on the Passagassawakeag River or in the three reaches surveyed on the mainstem of Kenduskeag Stream in 2004.

St. Croix River

The St. Croix International Waterway Commission (SCIWC) operated a fishway trap located near the head of tide at the Milltown Dam, St. Stephens, New Brunswick, Canada. Trapping operations ran from 20 April to 29 October 2004 to capture and enumerate upstream migrating adult sea-run salmon, collect broodstock, screen for infectious salmon anemia virus (ISAV), and intercept suspected escaped aquaculture salmon. The Milltown trap captured 14 salmon in 2004, compared to 15 in 2003. One was a river-origin male, nine were hatchery origin restoration fish (6 male, 3 female), and four were suspected aquaculture escapees that were sacrificed. One of the three female hatchery-origin restoration salmon was misidentified as an aquaculture fish and killed. All other salmon were retained for broodstock and moved to Mactaquac Hatchery for spawning. The four suspected aquaculture escapees captured in 2004 is less than half of the nine escapees captured in 2003 (Table 3.2.1.2.).

Androscoggin River

Maine Department of Marine Resources operates a fishway trap on the Androscoggin River. In 2004, a total of eleven 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 operate 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, eight 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 11 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 17 salmon from this facility.

Union River
The Ellsworth dam is not equipped with an upstream fishway, however there are trapping facilities, owned by ASC, below the dam. The current dam owners, Pennsylvania Power and Light (PPL), provide fish passage by trapping fish below the dam and transporting them in tank trucks to upriver release sites. Two salmon were captured during 2004. Based on scale growth patterns, one fish, stocked in either the Penobscot or Dennys rivers as a hatchery smolt, had strayed as an adult into the Union River trap. The second fish was a wild salmon returning to the Union River and was trucked upriver and released near suitable spawning habitat. No aquaculture escapees were observed in the Union River in 2004.

Kennebec River
Redd counts undertaken by foot on tributaries of the Kennebec River in November located no redds. Bond Brook, Sevenmile and Togus streams were surveyed. No survey was completed on Messalonskee Stream due to high water. In addition, approximately 60% of the spawning habitat below Waterville on the mainstem Kennebec was surveyed by watercraft. Two redds were found with dimensions indicative of Atlantic salmon.

St. George River
One redd survey was conducted on the middle and lower portions of the river. A total of three redds with dimensions indicative of Atlantic salmon were located: two above Sennebec Pond and one below. Atlantic salmon spawning in the upper part of the system would have successfully passed the site where Sennebec Dam once stood and the rock ramp. The dam removal and rock ramp were completed in 2002.

Aroostook River
The Tinker Dam, located five kilometers upstream of the confluence with the St. John River, is the gateway to the Aroostook River. PDI Canada, Inc. operates a fish trapping and sorting facility as part of the Tinker Dam Hydro Project under an agreement with Atlantic Salmon for Northern Maine (ASNM). The Tinker trap catch improved to eight salmon (1 MSW and 7 1SW) in 2004. The 5-year mean trap catch at the Tinker dam is 22 salmon (10 1SW and 12MSW).

3.2.2. Hatchery Operations

Egg Production
Sea-run, captive and domestic broodstock produced 6.6 million green eggs for the Maine program in 2004: 3.2 million eggs (49%) from Penobscot sea-run broodstock; 2.2 million eggs

(33%) from six captive broodstock populations; 1.2 million eggs (18%) from Penobscot domestic broodstock.

Progeny produced from captive broodstock are released into their rivers of origin, as fry, parr, and smolt.

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

All three egg sources were used for the Salmon-in-Schools (FWS) and Atlantic Salmon Federation Fish Friends programs. Domestic eggs from GLNFH were transferred to the Saco River Hatchery (operated by volunteers from the Saco River Salmon Club) for rearing and release and, in addition, were utilized for a streamside incubation study in the Kennebec River drainage.

Nate Wilke, M.S. candidate at University of Maine in Orono, worked closely with CBNFH and Maine Fishery Resources Office (MEFRO) staff during the spawning season in a third 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.

Program personnel continued to refine spawning protocols for captive broodstock at CBNFH in 2004 by implementing optimization 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 paired matings between sub-samples of up to ten females and ten males based on frequency of shared alleles. Lower percentages of shared alleles between pairs of fish indicate the most appropriate matings to maximize genetic diversity. This software was used for all matings at CBNFH in 2004, with the optimization aspect used in the East Machias only, for trial purposes. It is anticipated that the software will be more widely implemented in 2005.

Broodstock Collection

Collection of juvenile Atlantic salmon from six DPS rivers for the captive broodstock program at CBNFH continued in 2004. 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 2004, a total of 1,076 parr was collected from the following rivers: 151 from the Dennys; 158 from the East Machias; 246 from the Machias; 102 from the Pleasant; 245 from the Narraguagus; and 174 from the Sheepscot.

Parr collected for broodstock in 1999 (N = 914) and 2000 (N = 1080) were tagged with Passive Integrated Transponder tags in the body cavity at the time of capture. During spawning in 2001 and 2002, approximately 70% of females spawned expelled their tags along with their eggs. No tags were lost from mature males, or from broodstock previously tagged in the dorsal musculature (Buckley, 2002). In many cases, the tags were recovered and reinserted into the dorsal musculature. This trend, although not quantified, continued during spawning of these broodstock to a lesser extent in 2003 and 2004. 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. All remaining 1999 and 2000 capture-year broodstock were released in December of 2004; all other broodstock at CBNFH are tagged intramuscularly, with a typical retention rate of 97% or higher. In October 2004, 1,092 DPS broodstock (collected in 2003) were PIT tagged, sampled for future genetic characterization, and moved from the CBNFH Receiving Building to broodstock modules.

In September of 2004, GLNFH produced 1,000 fish from the 2003 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 606 sea-run adult salmon were collected from the Penobscot River and brought to CBNFH as broodstock in 2004 (compared to 605 in 2003). 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.

3.2.3. Stocking

During 2004, approximately five million Atlantic salmon were stocked into the rivers of Maine. Of this total, 1.7 million river-specific fry were stocked into six DPS rivers, 1.7 million salmon fry were stocked into the Penobscot River drainage, and 566,000 age-1 smolts were released into the Penobscot River drainage. In addition to fry, 56,300 age-1 smolts and 44,000 parr were stocked into the Dennys River. A complete summary of stocking efforts by lifestage and river can be found in Table14.

Several privately owned, volunteer operated hatcheries were involved in releasing Atlantic salmon into Maine waters. Approximately 12,000 Pleasant River-origin fry, obtained from eggs produced by Pleasant River broodstock at CBNFH, were reared and distributed into the Pleasant River and its tributaries by volunteers from the Wild Salmon Resource Center. The Saco River Hatchery, operated by volunteers from the Saco River Salmon Club, reared and released approximately 370,000 fry. The Saco River Hatchery annually receives domestic-origin eyed eggs produced at GLNFH. The Dug Brook Hatchery, operated by Atlantic Salmon for Northern

Maine Inc., released 168,000 Saint John-origin fry into the Aroostook River and it's tributaries.

In addition to Atlantic salmon reared at federal and private hatcheries, 90 schools and businesses participated in the FWS Salmon-in-Schools and Atlantic Salmon Federation Fish Friends programs. Through these programs, participants receive approximately 200 DPS or Penobscot (sea-run or domestic) origin eyed eggs and a suggested curriculum to help educate students and the public about Atlantic salmon. Participants generally released fry produced from the 200 eggs in May and June, stocking approximately 17,000 fry into designated segments of appropriate river as permitted by the ASC.

Smolts produced from Penobscot River sea-run broodstock were also stocked in the Merrimack River (50,000) and St. Croix River (4,000) in 2004.

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 the fry population, and the need to maintain the correct number of broodstock to meet fry production needs but not exceed them. In 2004, excess broodstock were released to the Sheepscot (116), Dennys (323), East Machias (97), Machias (409), and Narraguagus (291) in October and December. October releases of broodstock to the Dennys and Machias rivers included small numbers of gravid females and males. During redd counts, unusually high numbers of redds were detected indicating that released broodstock may have spawned (see Section 3.2.1.).

Following spawning in 2004, 530 Penobscot sea-run broodstock were released; an additional 60 were retained for annual fish health screening conducted by the FWS Lamar Fish Health Unit. A summary of adult stocking is found in Table 6.

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.

ASC sampled juvenile salmon at 39 Narraguagus River locations in 2004, which is similar to effort in previous years. Eleven sites were located in tributaries and 28 sites were located on the mainstem. Parr densities were variable among the sites sampled in the mainstem in 2004, with an absence of parr at some low quality sites, to a high of 7.91 parr/unit. Parr densities in tributaries were also variable among the sites sampled, ranging from an absence of parr to 21.64 parr/unit in Shorey Brook. Parr densities tend to be highest in riffle areas with small boulder and cobble substrates. YOY densities were variable in mainstem sites, ranging from an absence of YOY to 18.20/unit. YOY densities in tributaries of the Narraguagus River ranged from 1.18/unit in Spring River to 24.37/unit at Shorey Brook.

The Sheepscot River continues to have a great deal of variability in parr densities. In 2004, six sites contained no parr and of the sites with parr, we found densities as high as 10.05 parr/unit. The average density of parr from sites that contained parr was 1.86 per/unit (Table 3.2.4.1) and the median was 0.47 parr/unit for all sites. This variability is consistent with densities in 2003.

Parr densities in the Dennys River ranged from 0.0 to 6.43 parr/unit in 2004, with a median of 1.8 parr/unit (Table 3.2.4.1). In 2004, approximately 10% of the parr captured were fall parr or residualized smolts. Fall parr releases include many fish destined to remain in the river for approximately 18 months after their release, as well as fish that may emigrate as smolts in the year following their release.

We expanded the number of index sites to be monitored with multiple-pass depletion population estimate sites in the East Machias, Machias, Pleasant, and Ducktrap rivers and Cove Brook in 2003 and 2004. This set of index sites will provide a time series for juvenile salmon abundance in significant rearing habitats in these rivers (Table 3.2.4.1). This time series will also provide an opportunity to track long-term changes in production of juvenile salmon in these habitats.

Penobscot River electrofishing surveys undertaken on three tributaries to the Mattawamkeag River (Big Gordon Brook, Little Gordon Brook, Mattakeunk Stream) and five tributaries of the mainstem Penobscot River (Mattaceunk Stream, Pollard Brook, Hoyt Brook, Hemlock Stream, Salmon Stream). Juvenile salmon were found in Big Gordon Brook, Hemlock Stream, and at two sites on Mattakeunk Stream.

Table 3.2.4.1. Juvenile Atlantic salmon population densities (fish/100m^2) in Maine Rivers, 2004.

	Young-of-the -Year				Parr			
River	Minimum	Median	Maximum	Sites	Minimum	Median	Maximum	Sites
Dennys	0	3.88	17.25	25	0	1.8	6.43	25
East Machias	0	16.72	117.51	9	0	3.21	8.62	9
Narraguagus	0	7.44	24.37	39	0	3.21	21.64	39
Machias	1.6	15.34	45.58	11	0.75	3.25	12.11	11
Pleasant	0	20.81	45.94	3	0.49	5.53	22.7	3
Ducktrap	1.46	4.7	5.73	5	0	0	0	5
Sheepscot	0	3.85	39.4	27	0	0.47	10.95	27
Cove Brook	0	0	0	5	0	0	0	5
Penobscot Tributaries	0	2.76	20.9	8	0	1.5	2.05	8

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 (1991-2004), the Dennys River (2001-2004), and the Sheepscot River (2003 - 2004). 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
On the Penobscot River, approximately 554,000 hatchery-reared smolts were released into the system. One-third (204,000) of these smolts were batch-marked with Visual Implant Elastomer (VIE) Tags. Colors and location of marks (left/right eye) were dependant on release time and location. A total of 1614 smolts were captured during RST operations in 2004, 14 of which were captured twice. Smolts averaged 185.6 +/- 0.9 mm (95% c.i.) fork length (n = 1597) and 64.5 +/- 0.9 g wet weight (n = 1473)(Table 3.2.4.2). Genetic samples, gill biopsies, and blood plasma samples were collected from fish trapped during field operations and are being analyzed by USGS.

Of the 1614 smolts collected, 598 (37%) were hatchery-marked smolts, 17 (1%) were marked hatchery fish, which were released as fall parr in 2003, and 2 were marked hatchery fish which were released as fall parr in 2002. Approximately 1.7% (28) were naturally reared (wild origin or fry-stocked) and were of age class 2+ or 3+ (Table 3.2.4.3). Smolt age and origin were determined by analyzing scale samples that were taken from a sub-sample of smolts.

Sheepscot River
The operation of two RSTs below Head of Tide Dam on the Sheepscot River resumed in 2004, after a one year hiatus. A total of 163 smolts was captured. Scale analysis showed that all of the smolts caught in the RSTs were naturally reared. Smolts averaged 183.3 +/- 2.7 mm (95% c.i.) fork length (n = 163) and 63.2 +/- 2.7 g wet weight (n = 163)(Table 3.2.4.2).

Narraguagus River
Emigration of Atlantic salmon smolts was monitored in the Narraguagus River using four RSTs in 2004. Two traps were located at river km 7.65 (Crane Camp) and two were located at river km 11.65 (Little Falls). Smolts were fin-clipped at the Little Falls site and recaptured downstream at the Crane Camp site in order to perform a stratified population estimate. Using a Darroch maximum likelihood model, we were able to derive a population estimate of 1344 +/- 487 (Table 3.2.4.4; Figure 3.2.4.1).

A total of 582 smolts was captured. Smolts averaged 172.1 +/- 1.2 mm fork length and 51.0 +/- 1.2 g wet weight (Table 3.2.4.2). Scale, genetic, and gill biopsy samples were collected from a sub-sample of the fish trapped during field operations. Scale analysis revealed that all trapped fish that were scale sampled were naturally reared. Most were from age class 2 (83%), with the remainder from age class 3 (15%) (Table 3.2.4.3).

Pleasant River
On the Pleasant River, 8811 age 1+ smolts were stocked in 2004. These fish were marked with a purple VIE tag behind the left eye. One RST was operated on the Pleasant River beneath the Addison Road bridge (river km 0.07). In 2004, 947 fish were trapped in the RST. Of the fish collected, 708 were VIE-marked stocked hatchery smolts and 214 were naturally reared smolts

(Table 3.2.4.3). Smolts averaged 174.9+/- 3.6 mm fork length and 49.3 +/- 3.6 g wet weight (Table 3.2.4.2).

Dennys River
Approximately 56,300 hatchery-reared smolts were released into the Dennys River in 2004. These smolts were batch-marked with VIE tags. Colors and location of marks (left/right eye) were dependant on release time and location. Of the 1,056 smolts captured in the RST in 2004, 873 were VIE marked, 83 were naturally reared, 25 were from fall parr stocked in 2002, and 75 were from fall parr stocked in 2003 (Table 3.2.4.3). 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 69,520 smolts, 5,573 of which were naturally reared (Table 3.2.4.5). A measure of dispersion has not yet been developed for this estimation technique.

St. Croix River
In 2004, 4,097 hatchery smolts were released into the St. Croix River, all of which were VIE marked. Smolt trapping was conducted at the Milltown Dam downstream fish passage from 3 May to 31 May. A total of 49 smolts was trapped in the RST. Forty-two of the smolts were marked hatchery smolts; 18 Penobscot strain smolts stocked from GLNFH ; 24 stocked as fall parr from Mactaquac Biodiversity Facility. Seven smolts will be classified after scale analysis (Table 3.2.4.3), but are presumed to be naturally reared due to the absence of marks.

Table 3.2.4.2. Mean length and weights of smolts collected in Maine , 2004

River	Fork Length (mm) +/- 95% C.I.	Wet Weight (g) +/- 95% C.I.
Dennys	175.2 +/- 1.6	54.6 +/- 1.5
Narraguagus	172.1 +/- 1.2	51.0 +/- 1.2
Penobscot	185.6 +/- 0.9	64.5 +/- 0.9
Pleasant	174.9 +/- 3.6	49.3 +/- 3.6
Sheepscot	183.3 +/- 2.7	63.2 +/- 2.7

Table 3.2.4.3. Age class and origin of smolts collected in Maine, 2004

	Penobscot n = 1600		Sheepscot n = 160	Narraguagus n = 164	Pleasant n = 944		Dennys n = 1056		St Croix n = 49	
Age	Naturally Reared	Hatchery	Naturally Reared	Naturally Reared	Naturally Reared	Hatchery	Naturally Reared	Hatchery	Naturally Reared	Hatchery
1+		1563	1		3	708		948		42
2+	21	2	157	137	211			25		
3+	7		1	25						
4+										
Unk	2		1	2	22		83		7	

Table 3.2.4.4. Estimates of the number of emigrating smolts in the Narraguagus River, 2003 and 2004.

Year	Total Emigration Estimate	95% C.I.
2003	1,368	619
2004	1,344	487

Table 3.2.4.5. Estimates of the number of emigrating smolts in the Dennys River, 2003 and 2004.

Year	# of Smolts Stocked	Total Emigration Estimate	95% C.I.	Estimated % of Naturally Reared Smolts
2003	55,800	64,728	N/A	2.0%
2004	56,339	69,520	N/A	8.0%

Figure 3.2.4.1. Estimated number of emigrating smolts, Narraguagus River, 1997-2004.

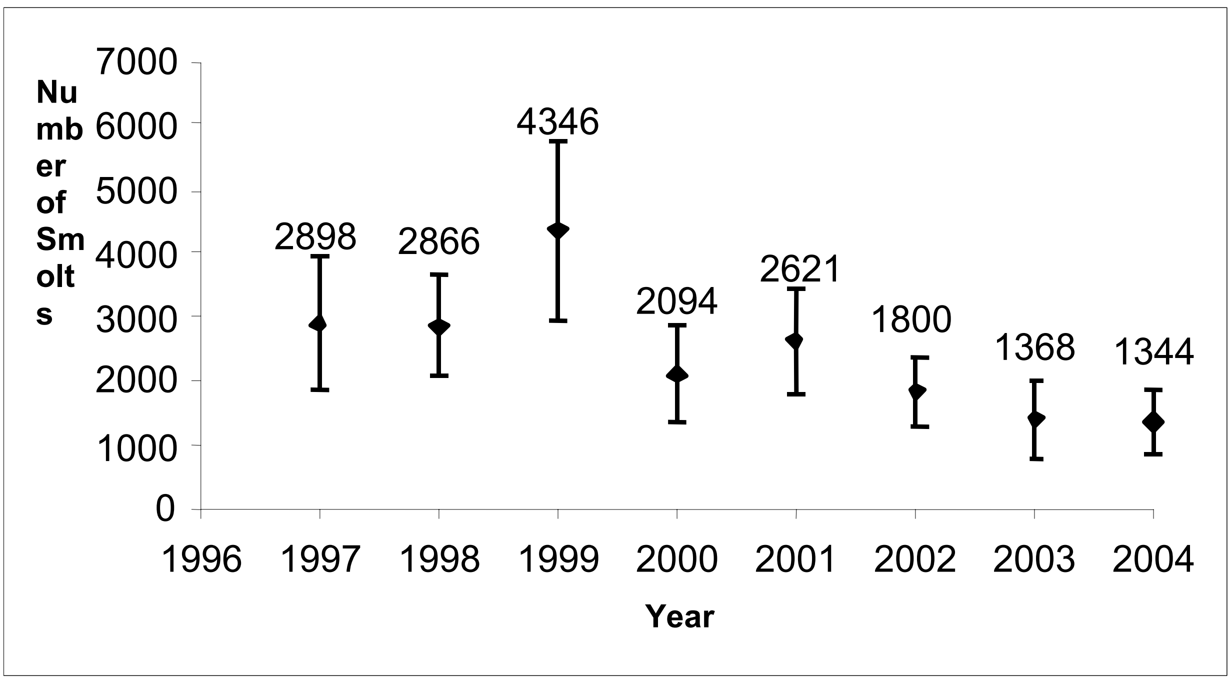
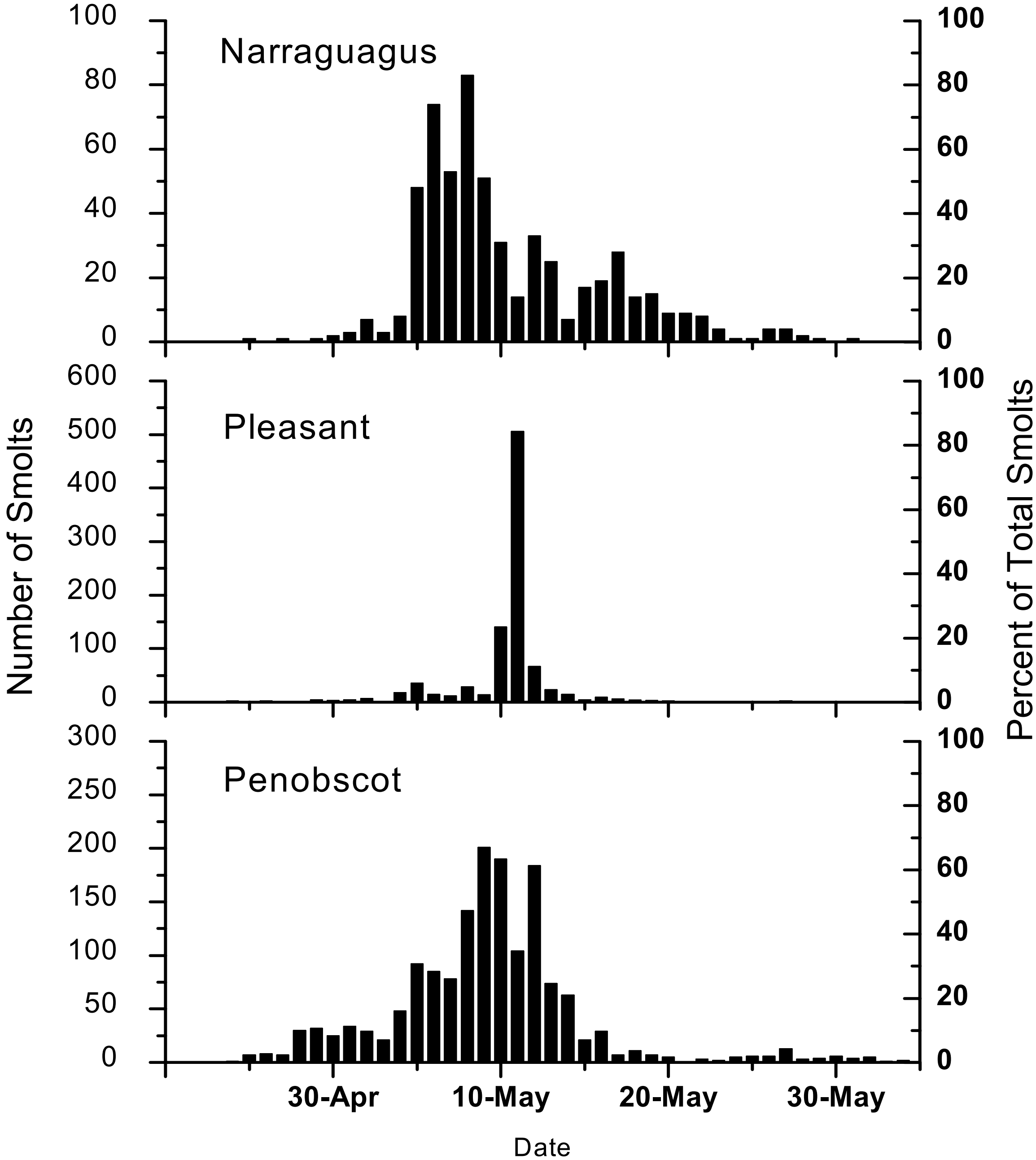


Figure 3.2.4.2 Number of smolts captured by date on the Narraguagus, Pleasant, and Penobscot Rivers in 2004.



Pleasant River, Penobscot River Tributary
Two rotary screw smolt traps were deployed in the Pleasant River in the Brownville. A five-foot diameter trap was installed on April 30 and removed on May 18. A second smaller trap, four feet in diameter, was installed on May 11 and removed on May 24. We anticipated catching downstream migrating smolts from fall parr stockings of 91,338 fish in 2002 and 83,419 fish in

2003. All parr stocked were reared at GLNFH and marked with a fin-clip prior to released to the river (right ventral fin in 2002; left ventral fin in 2003). In addition, approximately 270,500 fry were stocked in the West Branch Pleasant River and 44,850 in the Pleasant River in 2002, so capturing unmarked smolts was also likely.

Over the nearly three and half weeks the traps operated, a total of 495 smolts were captured. Of these, 206 (41.6%) were unmarked; 240 (48.5%) had a right ventral fin-clip indicating a hatchery parr released in 2003; and 49 (9.9%) originated from 2002 GLNFH parr releases. Unmarked smolts averaged 164 mm in length and weighed 42.0 g. Average length of smolts from the 2002 hatchery parr was 159 mm and they weighed an average of 37.2 g. Smolts from the 2003 stocking averaged 138 mm and 23.9 g.

Smolt Telemetry Studies

NOAA-Fisheries Service has assessed Atlantic salmon smolt migration using ultrasonic telemetry since 1997. In 2004, three different studies were conducted. On the Narraguagus (n = 74) and Pleasant (n = 24) Rivers, a total of 98, 2+ naturally reared smolts were tagged. A total of 256 smolts of hatchery origin were tagged on the Pleasant River (n = 100 age 2+) and Dennys River (n = 156 age 1+). Smolt movement was monitored from the rivers through the estuaries ou to near-shore marine environments. Sequential detections at series of receivers allowed calculations of migration speed and duration emigration for smolts. Survival of smolts to the furthest quantitative marine array was variable. The Dennys estuary stocked smolts had the lowest survival (19.23%), survival of Narraguagus smolts was 42.86%, and the Pleasant River smolts had the highest observed survivals; 60.00% for hatchery fish and 61.56% for those naturally reared.

Juvenile Tagging

Since 2000, NOAA Fisheries Service has coordinated an Atlantic salmon hatchery smolt and parr marking program. Annually, identifiable lots of these life stages were marked for the Penobscot and Dennys River to evaluate the role of hatchery enhancement in Atlantic salmon restoration. The smolt lots were release at different locations and times to identify the effects of release time and location on survival. From 2000 – 2004, a total 926,092 smolts were marked for the Penobscot River and 212,533 smolts were marked for release on the Dennys River. Marked smolt releases in 2004 for the Penobscot and Dennys River were 203,700 and 55,877, respectively. Along with the Penobscot and the Dennys, smolts were marked for the St. Croix (2001 – 04: 19,575 smolts marked), Saco (2002 – 03: 7,333 smolts marked) and Pleasant Rivers (2003 – 04: 11,629 smolts marked). To help evaluate to what extent fall parr were contributing to the smolt emigration and subsequent spawning escapement on the Dennys and Penobscot Rivers, a fall parr marking program was initiated in 2001 and 2002, respectively. In 2004, 44,033 marked fall parr (100%) were released in the Dennys River and 158,479 in the Penobscot River.

3.2.5. Fish Passage

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. Effective fishway operation is essential for returning salmon to pass dams and access headwater spawning areas. Fishways on the Penobscot River were inspected on a routine basis in 2004 in conjunction with a PIT tag study, which required biologists to visit fishways twice each week to download data and maintain equipment. Fishways were inspected on a routine basis in order to ensure proper operation and confirm operator compliance with appropriate maintenance procedures. Inspections were routinely conducted at four dams on the Piscataquis River (Howland, Browns Mill, Moosehead Manufacturing, and Guilford Industries), the Lowell Tannery Dam on the Passadumkeag River, and five mainstem Penobscot River dams (Veazie, Great Works, Milford, West Enfield, and Weldon). Less frequent inspections were conducted at fishways on other rivers.

Maine and US fisheries agency staff participated in several meetings and consultation reviews involving the following projects on the Penobscot River: Weldon, Medway, West Enfield, Howland, Milford, Stillwater, Orono, Great Works, and Veazie. With the exception of the Weldon Dam Project (Mattaceunk), all projects are included in the Penobscot River Restoration Project, either through proposed project decommissioning (Veazie, Great Works, Howland) or project modification to enhance hydropower production (Medway, West Enfield, Milford, Stillwater, Orono). ASC staff also attended the annual meeting of the Mattagamon Lake Association as part of yearly consultation on Mattagamon Lake level management and minimum flows into the East Branch Penobscot River. In addition, Maine and U.S. fisheries agency staff attended numerous meetings and field events associated with the hydro relicensings and or passage facility construction in the Kennebec drainage including: Lockwood (Florida Power and Light); Sandy River (Town of Madison); Benton Falls (Benton Falls Hydro Associates); Burnham (Ridgewood Maine Hydro Partners); Anson and Abenaki (Madison Paper Industries); Fort Halifax (Florida Power and Light) Projects.

GLHA, owners of the Weldon Dam, conducted radio telemetry studies in 2004 to evaluate a smolt downstream bypass system at the dam. Preliminary results suggest 40% bypass passage efficiency for smolts through the bypass facility. In addition, GLHA reported capturing 6,000 wild smolts utilizing the bypass system during a two-week trapping period.

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 cost estimate and is exploring funding sources. The most affordable plan is to line the wood fishway with aluminum. The FWS and the Pleasant River Watershed Council patched a hole in the wall of the fishway, did other minor concrete work, and installed new baffles on fishway at Saco Falls on the Pleasant River. ASC removed a coffer dam placed in fishway to do the work. Marion Falls on Cathance Stream has a fishway associated with a highway bridge. Associated with a MDOT and Federal Highway Administration (FHA), a project to replace the bridge, rehabilitate the fishway, and eliminate the hydraulic restriction at the existing bridge over Cathance Stream will be initiated. This project requires a Section 7 consultation, and FWS is preparing a Biological Opinion.

The FWS, in consultation with ASC, is exploring options to have the Loring Development Agency, current owner of a dam on the Little Madawaska River, install a fishway.

Sites where removal is one option
The ASC is working with Maine Department of Marine Resources (DMR), Inland Fish & Wildlife (IFW), FWS, NOAA, Trout Unlimited, the Sheepscot River Watershed Council to address native fish species passage issues at the Coopers Mills Dam. Removal is one of the options being considered.

A multi-agency project involving the ASC, NOAA, FWS and the Downeast Salmon Federation to remove a dam sill at Saco Falls on the Pleasant River is pending. Removal was scheduled for 2004, but high water prevented its start.

Another dam removal, in final stages of planning and funding, is the Sandy River Project Dam on the Sandy River in the Kennebec drainage. The principal objectives are to restore free-swim fish passage for all native fish species, including Atlantic salmon, American Shad, alewife, blueback herring, American eel, and lamprey. Partners in this project include Madison Electric Company, Trout Unlimited, ASC, DMR, USDA/NRCS, and NOAA.

The FWS and ASC are working with the owner of West Winterport Dam and the Town of Winterport to explore options to provide fish passage at the site on the Marsh River, a tributary to the Penobscot River estuary. The dam is not producing power and in its current state does not have fish passage. The system upstream of the dam contains approximately 1,629 units of Atlantic salmon habitat. The FERC exemption for the dam has been surrendered and FERC has issued an order to maintain the dam “as is”. That order does not require fish passage or removal.

3.2.6. Genetics

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 fingerprinting of broodstock prior to spawning also allows program managers an opportunity to eliminate undesirable genes from the spawning population.

Fin samples were collected during tagging operations in 2004 from all parr broodstock captured in 2003 and currently reared at CBNFH: Dennys, 150; East Machias, 157; Machias, 250; Pleasant, 114; Narraguagus, 259; and Sheepscot, 162. In 2004, genetic samples were collected at the rotary screw traps (RST) by taking fin clips from smolts from the following rivers: St. Croix (31), Dennys (536), Pleasant (222), Narraguagus (507), Sheepscot (159), Pleasant [Penobscot River drainage] (367), and Penobscot below Veazie (393). Further, adipose fin punches for DNA analysis were collected and archived from 1,317 of the 1,323 salmon captured at the Veazie trap.

3.2.7. General Program Information

Penobscot PIT Tag Project

This was the third and final year for a cooperative research project among the ASC, USGS (Conte Anadromous Fish Research Center), FWS, NOAA, and the Penobscot Indian Nation (PIN). The study is investigating the temporal and spatial movements of Atlantic salmon during their upstream migration in the Penobscot River basin using PIT (Passive Integrated Transponder) tags. PIT tag antenna arrays and data loggers were installed at the entrance and exit of fishways at five mainstem dams (Veazie, Great Works, Milford, West Enfield, and Mattaceunk) and three Piscataquis River drainage dams (Howland, Dover-Foxcroft, and Browns Mills). In 2003, we released 506 salmon to the Penobscot River marked with PIT tags injected into the dorsal musculature. ASC contract personnel downloaded remote fishway PIT tag antenna data loggers twice weekly, imported data into a database, and will be actively auditing and analyzing data for fish movement patterns during the winter months. Fish passage will be related to season timing, photoperiod, river flow, and temperature, along with final destinations of tagged fish. The project results have exceeded our expectations, and have yielded valuable data on the movements and distribution of salmon in the Penobscot drainage after they pass upstream of the Veazie Dam.

Habitat Connectivity

In 2004, the MEFRO of the FWS, in cooperation with the PIN, continued work initiated in 2003 to examine fish passage, habitat connectivity, and non-point source pollution in Maine's rivers.

Staff biologists conducted surveys at 150 sites within the Piscatquis River watershed to evaluate the condition and effectiveness of bridge and culvert design in terms of overall river health, and passage of Atlantic salmon and other native fish species. Each site was inventoried for design, condition, and function. The current survey protocol is based on similar projects initiated by the Vermont Agency of Natural Resources and the US Forest Service, San Dimas Technology and Development Center. Data collected on habitat conditions of representative reaches upstream, within, and downstream of each road crossing were analyzed to determine the structure's effect on flow, passage, and habitat connectivity. This information was input into a database for future management use. The database and accompanying report were distributed to the PIN, Project SHARE and other interested parties.

In a continuation of work initiated on the Kenduskeag Stream in 2003, MEFRO developed an atlas of surveyed sites on Kenduskeag Stream, and reviewed the survey protocol and data collection techniques used in 2003. This should increase the efficiency of future surveys. It is the goal of the MEFRO to establish a survey protocol that is applicable throughout Maine and New England, and can be used by both staff and volunteers. Staff is currently facilitating this process through contact with various federal, state, and local government agencies, as well as local and national non-profit and non-government environmental organizations.

Water Chemistry Monitoring

The year 2004 was the second and final year of the ASC pH Survey. The objective of the survey is to create seasonal snapshots of pH related water chemistry in Maine salmon rivers. This sample scheme allows for comparisons of water chemistry both within and among watersheds under similar flow and precipitation conditions.

In 2003 and 2004, water samples were collected on the same day in spring, summer, and fall from approximately 70 sites across 13 Downeast and central Maine river systems, including all eight drainages within the DPS. Samples from both years were analyzed for closed-cell pH (ClpH), air-equilibrated pH (EqpH), acid neutralizing (buffering) capacity (ANC), apparent color, and conductivity. In addition, the 2004 samples underwent full ion chemistry analysis, including calcium (Ca), total aluminum (Al), and inorganic aluminum (Ali).

All rivers sampled: 1) have depressed pH and ANC values associated with high flow events; 2) watersheds east of the Penobscot River (Union, Tunk, Narraguagus, Pleasant, Machias, E. Machias, Dennys rivers) generally have lower pH and ANC values than the rivers west of the Penobscot River (Ducktrap, Sheepscot, and Sandy rivers; Marsh and Kenduskeag streams; Cove Brook); 3) the decline in pH and ANC during high flow events was much more pronounced in the eastern watersheds; 4) tributaries tend to have lower pH than do mainstem sites, especially during high flow events; and, 5) summer base-flow sampling showed that all the rivers, except Tunk Stream, had pH values favorable for salmon health at that time of year.

Calcium (Ca) data from 2004 shows similar results to the pH data, essentially that rivers east of the Penobscot River have lower Ca concentrations than do the rivers to the west. Calcium is an important component of the water chemistry to freshwater ecosystems, fish health and nutrition, and because of its ability to ameliorate the affects of toxic forms of aluminum (monomeric, labile) to juvenile salmon. Waters with calcium concentrations below 2.5 mg/L may be deficient in their ability to ameliorate the deleterious affects of monomeric aluminum associated with low pH.

The spring 2004 samples were taken during a small hydrologic event, results included: 1) calcium concentrations for eight DPS rivers were generally below 3.0 mg/L, except for the Sheepscot River and Cove Brook; 2) all the Downeast rivers experienced Ca levels below 2.5 mg/L at one or more sites; and, 3) the Narraguagus, Pleasant and Machias rivers did not have any sites above 2.5 mg/L calcium in the spring sample. The 2004 summer and fall samples were taken at normal base flow for each respective time of year and calcium levels were generally good with regard to salmon health, with the majority having calcium concentrations above 2.5 mg/L.

Hydrologic Catalog and Watershed Model Evaluations

The Maine Atlantic Salmon Commission worked with Kleinschmidt Energy and Water Resource Engineering of Pittsfield Maine (Kleinschmidt), and Sevee and Maher Engineers, Inc. of Cumberland Center Maine (Seevee and Maher) to develop a better understanding of stream basin hydrology and its effects of on salmon habitat in the Narraguagus, Pleasant, and Machias Rivers. The study brought together these two Maine firms to catalog and assess existing ground and surface water, geologic, habitat, and climatic data within these watersheds. Now completed, the study serves as the beginning of efforts to develop linked surface-water and ground-water (SW-GW) watershed models as tools to assess the effects of surface-water and groundwater withdrawals, and land use/land cover changes on river flows, groundwater, and Atlantic salmon habitat.

3.2.8. Salmon Habitat Enhancement and Conservation

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 2004. 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 2004 based on priority criteria established by the SHARE Restoration Working group in cooperation with the landowners. In addition, this process resulted in the Rt. 1 Bridge crossing the Machias River being nominated for restoration by the Maine Department of Transportation.

3.3. Merrimack River

3.3.1 Adult Returns

One hundred and twenty-eight sea-run Atlantic salmon returned to the Essex Dam Fish Lift in the Merrimack River during 2004.Volunteers from New Hampshire Trout Unlimited and Manchester Fly Fishers assisted MADFW and USFWS personnel in trapping and counting returning fish at the Essex Dam fish lift this year. One hundred and twenty salmon were captured and transported to the Nashua National Fish Hatchery (NNFH), four salmon escaped to the river, and four salmon died in transit to the hatchery or prior to spawning. Of the 18 captured adult returns, readable scale samples were collected from 125. Of the one hundred and twenty-eight salmon captured, all returned in spring. Forty-nine percent (49%) of returning adults were females and 51% were males. Furunculosis (*Aeromonas salmonicida*) was detected in deceased post-spawn sea run adults in December 2004. Due to the egg disinfection protocols adhered to at NNFH, progeny from these adults have tested negative for the pathogen subsequent to sampling of adults. Central New England Fishery Resources Complex personnel consulted with Lamar FHU personnel in arriving at a conservative approach to pathogen management. All surviving sea run adults were destroyed per USFWS Lamar FHU directives.

Scales from one hundred and twenty-five Atlantic salmon adult returns were analyzed to determine age and origin of the fish. This analysis determined one hundred and eight fish to be of hatchery smolt origin (87.7%) and sixteen to be of stocked fry origin (12.9%). Seventeen of the one hundred and eight smolt origin fish (15.7%) were determined to be grilse (1SW), eighty-nine of the one hundred and eight were two sea-winter fish (82.4%) and two were three sea-winter fish (1.9%) Two of the stocked fry origin adults were grilse (12.5%) and the remaining fourteen were two sea-winter fish (87.5%).

The current rate of return for the 2000 fry cohort is 0.050 (all eleven fish being from W2.2 sea run returns captured in 2004 from the 2,217,000 fry stocked in 2000. The rate of return (adults produced per 10,000 fry stocked) remains low (below 0.1) when compared to levels observed from the late 1980's to the mid 1990's (0.1 to 0.6), and very low when compared with return rates observed from the mid 1970's to late 1980's (greater than 1.0). The return rates have increased marginally over the past four years. Available data suggests it required 201,545 fry stocked in year 2000 to produce one adult return in 2004. In contrast it required 219,500 fry stocked in 1999 to produce one adult return and 323,625 fry stocked in 1998 provided one adult return. Table 3.3.1.1 and 3.3.1.2 provide summary data for sea run returns in recent years.

Table 3.3.1.1. Adult Atlantic salmon of fry stocked origin, Merrimack River, Year 2004.

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	0.192
1995	19	63	0	5	0	87	2,827,000	0.308
1996	4	23	0	0	0	27	1,795,000	0.150
1997	1	3	0	0	0	4	2,000,000	0.020
1998	2	6	0	0	0	8	2,589,000	0.031
1999	1	4	0	0	3	8	1,756,000	0.046
2000	0	11	NA	0	NA	11 (est.)	2,217,000	0.050 (est.)
2001	2	-	-	-	-	-	1,708,000	NA
2002	-	-	-	-	-	-	1,414,000	NA
2003	-	-	-	-	-	-	1,335,000	NA
2004	-	-	-	-	-	-	1,541,500	NA

Table 3.3.1.2. Adult Atlantic salmon of hatchery smolt stocked origin, Merrimack River, Year 2004.

Stocking Year	Adult Sea Run Returns				Number of Smolts Stocked	Return Rate[1]
	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	NA	101 (est.)	50,000	2.02 (est.)
2003	17	NA	NA	NA	49,600	NA
2004	NA	NA	NA	NA	----	NA

[1] Return Rate = (Number of Adult Sea Run Returns/Number of Smolts Stocked) X 1000

3.3.2. Hatchery Operations

The majority of Atlantic salmon fry produced for release in the watershed was provided by the NANFH (45%, 499,765) and the WSFH (55%, 1056735). The parentage of fry stocked in 2004 was primarily domestic broodstock (68%, 1,056,735), followed by sea-run broodstock (21%, 323,918), and kelts (11%, 175,847). All fry of sea-run and kelt parentage are part of a genetic characterization study. Survival of fry for the 2004 year class (sea-run broodstock) was low. Periods of increased mortality occurred during the incubation stage especially for eggs received from fish that were spawned later in the season (November). Smolts produced for stocking in 2004 were provided by the GLNFH and were of Penobscot River sea-run parentage.

Egg Collection
Sea-Run Broodstock
One hundred twenty-eight sea run Atlantic salmon were trapped at the Essex Dam in Lawrence, MA in 2004. Fifty-nine females and 60 males were spawned during fall, 2004 spawning operations. The sea run spawning season began on 21 October and ended by 9 November. The 59 females spawned yielded 494,059 eggs, resulting in an average fecundity of 8,374 eggs/female. The majority of the eggs were transported to the NANFH to be hatched and released as fry. About 11,800 sea-run eggs, approximately 2 %, were retained at the NNFH as future broodstock aliquots. Additional eggs were kept for program development. Initial figures indicate 95% eye-up rates for the 2004 sea run eggs (F1).

Captive/Domestic Broodstock
A total of 229 female domestic broodstock reared at the NNFH provided an estimated 1,914,326 eggs during 2004 spawning operations. The domestic spawning season began on 9 November and ended 13 January, encompassing twelve spawn events. Delayed maturation of Merrimack River domestic broodstock has been observed over the last four years resulting in a protracted spawning season. During the period 1999-2005 domestic spawning commenced later each successive year, and this temporal shift has resulted in delaying the transfer of spent broodstock to the state of NH. Furthermore, delayed maturation has slowed the process of moving broodstock on station to maintain proper rearing densities. Study is needed to determine the cause of delayed maturation in order to maintain annual production schedules. Efforts will be aimed at eliminating the need for application of gonadotropic hormones. Eggs produced in the last three spawn sessions were directly transferred to RIFW, Arcadia SFH, eliminating the need to incubate Rhode Island eggs at NANFH.

The majority of domestic eggs were transported to the NANFH and WSFH to be held for fry stocking within the Merrimack River watershed. During the fall of 2004, 42 female kelts were spawned with 35 male kelts at the NANFH to produce a total of 428,325 eggs. Both the 2001 and 2002 year classes were spawned and most male kelts were from the 2002 year class. All fish were genetically marked and part of a genetic characterization program.

3.3.3. Stocking

Approximately 1.6 million juvenile Atlantic salmon were released in the Merrimack River watershed during the period April - June of 2004. The release included approximately 1.55 million unfed fry (NANFH), 3,661 (age 0) 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 therefore used to differentiate between fish stocked as fry 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 watershed, 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 in Lawrence, MA in early April. Smolt stocking has been timed to reduce the potential impacts of predation by striped bass that typically arrive in the estuary and near shore coastal environment in mid to late April. Approximately 500 smolts (83 radio tagged) were released in the Merrimack River (NH) as part of a downstream fish passage study at a hydroelectric site

Yearling Fry / Parr Assessment

Seven sites, one in each of the seven rivers, were sampled in 2004. 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 has 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 (age 1) 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 sample sites included a total of approximately 165.4 units (one unit = 100 m^2) of juvenile habitat. The "index 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 2004.

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. Data are currently being compiled for the complete time series with study results to be available in 2005.

Table 3.3.4.1 Estimates for age 1 parr per habitat unit at sample sites in the Merrimack River watershed, 1994 to 2004.

Table 3.3.4.1 Estimates for age 1 parr per habitat unit at sample sites in the Merrimack River watershed, 1994 - 2004.

Sample Site	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	Mean	SD	CV
Hubbard		14.1	0.8	3.6	12.8	11.8	2.8	4.9	12.3			7.9	5.4	68
Needleshop			6.1	13.6	5.2	6.4	1.2	1.5	7.6			5.9	4.2	70
Blood								4.8	4.8			4.8	0.0	0
Mid Mad	3.3	2.5					6.7	1.9	7.1			4.3	2.4	57
Smith*	*3.3*	*6.5*	*7.1*	*0.9*	*9.2*	*4.7*	*0.9*	*0.7*	*2.8*	*1.0*	*1.8*	3.5	3.0	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*	3.3	2.3	70
U. S.B. Baker*	*5.5*	*3.7*	*2.5*	*1.2*	*4.0*	*3.7*	*0.5*	*1.5*	*4.9*			3.1	1.7	56
Stirrup								1.1	4.4			2.8	2.4	85
Stoney*	*1.0*	*3.3*	*6.7*	*1.2*	*8.0*	*1.2*	*0.2*	*0.3*	*3.0*			2.8	2.8	102
Souhegan*	*3.1*	*1.8*	*4.5*	*0.1*	*11.7*	*0.3*	*0.5*	*0.1*	*1.8*	*0.9*	*1.5*	2.4	3.4	141
Pemi Wood.		4.3	1.4	1.6	2.1	2.6	3.0	0.5	5.3			2.6	1.6	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*	2.8	2.5	89
Eastman		2.0	1.3	0.8	4.4	1.8	4.6	2.8	2.8			2.5	1.4	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
Beebe*	*1.3*	*1.8*	*1.8*	*2.7*	*3.9*	*3.0*	*2.7*	*1.7*	*2.1*			2.3	0.8	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
Baker*	*1.0*	*3.2*	*2.0*	*1.4*	*4.3*	*1.4*	*0.7*	*0.8*	*4.2*	*1.5*	*1.3*	2.0	1.3	66
Mid Pemi		5.2	0.7	1.8	1.8	2.6	1.6	1.0	2.3			2.1	1.4	66
Upper Pemi*	*2.7*	*3.3*	*0.9*	*0.5*	*1.6*	*7.2*	*0.2*	*0.2*	*2.0*			2.1	2.2	106
L. S.B. Baker*	*3.4*	*3.4*	*2.0*	*1.1*	*1.7*	*1.5*	*0.5*	*2.0*	*2.6*			2.0	1.0	48
Mad*	*1.8*	*2.9*	*0.8*	*1.2*	*2.4*	*0.7*	*3.0*	*0.9*	*2.0*	*2.2*	*2.1*	1.8	0.8	45
Lower Pemi		3.5	0.3	0.6	1.0	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	0.0	4.2	0.3	0.0	0.3				1.2	1.7	143
Black	0.5	1.6	1.4	0.5	3.8	1.6	0.0		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			1.0	1.1	108
Punch								0.3	1.3			0.8	0.7	85
E.B Pemi*	*1.6*	*3.4*	*0.1*	*0.0*	*0.1*	*0.5*	*0.5*	*0.0*	*1.0*	*1.4*	*0.3*	0.8	1.0	128
Academy		0.3	0.0									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			
SD*	*1.4*	*1.9*	*2.7*	*1.0*	*3.3*	*1.9*	*1.2*	*0.8*	*1.1*	0.9	1.4			
CV*	*63*	*48*	*92*	*75*	*79*	*82*	*90*	*72*	*38*	63	76			
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 six mainstem generating facilities with the most recent studies continuing in 2004. 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 studies to date has been compiled and has been made available for this stock assessment meeting addressing year 2004 activities.

Studies and evaluations of fish passage efficiency and effectiveness at most mainstem and a numerous tributary dams have occurred, and these studies have demonstrated that smolt mortality occurs at dams due to a variety of reasons (turbine entrainment, spill, predation) and that seaward migration is impeded or delayed at dams. Water flow regimes, also altered during the period of seaward migration due to the presence of dams 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 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, and 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 to require construction of additional fish passage facilities, they have not been reached to trigger the need for construction of upstream fish passage facilities. Fishery resource agencies will continue to consult and coordinate with hydroelectric facility owner/operators and water resource users to construct and improve upstream and downstream fish passage facilities and to 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 will minimize delays in upstream migration of numerous fish species including Atlantic salmon. Older (original) 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 will be fully operational in spring 2005.

Public Service Company of New Hampshire (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 2004 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 juvenile clupeids. 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 ladder entrance on the west side of the river.

Studies were conducted in spring of 2004 to determine the effectiveness of the Amoskeag Dam bypass at passing smolts using attraction flows of 125 cfs and 289 cfs (5% maximum turbine flow). Radio-tagged smolts were released upstream of the project during minimal spill and with project flashboards fully installed. A total of 83 radio-tagged smolts was released upstream of the project between 21 - 31 May. Sixty-six (79.5%) smolts were detected passing the project; forty (70%) used the bypass; seventeen (30%) passed through the turbines; nine (14%) spilled over the dam; two were detected in the headpond and 15 did not enter the study area. Operating the units in the order of Units 3 (nearest the bypass/crestgate), 2, and 1 appeared to have increased passage effectiveness. Overall passage was greater at 125 cfs (76%) as compared to 289 cfs (67%). The results of this spring 2004 study were similar to those observed in spring 2001, and at this time fishery resource agencies have indicated that no further studies are required.

3.3.6. Genetics

In 2002, funding was secured for genetic analyses of domestic broodstock, sea-runs, and kelts. 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 2004 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 (domestics parentage fry).

Sea-run fry develop at an earlier date due to their time of spawning, which subsequently leads to targeting lower watershed tributaries for this group in early spring. A primary question of interest is if fry-origin adult returns are from areas in proportion to stocking rates or if other mechanisms (improved fitness of sea-run fry) or impacts (more barriers 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 now underway and it is anticipated that results will guide culture and management measures to be implemented in fall of 2005.

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 October 1 to March 31. In spring of 2004, 724 (age 2) domestic broodstock were released for the fishery. In fall of 2004 an additional 797 (age 2 and age 3) broodstock were released for a combined total release of 1,521 fish to support the fishery in the main stem of the Merrimack River and small reach of the Pemigewasset River.

Broodstock were released for the fishery later in spring than in previous years due to concerns related to unknown body burdens of contaminants in hatchery reared fished. 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 exceeded consumption advisory criteria identified by the State of New Hampshire, Department of Environmental Services.

There is a lag time in reporting from angler diaries which results in this summary characterizing the 2003 fishery. There were 1,959 salmon stocked and 1,337 permits sold in 2003 from which an estimated 751 anglers actually fished for salmon. The majority of the anglers were NH residents, 12% were nonresidents. Anglers fished an estimated 11,387 hours during 4,686 fishing trips. They caught an estimated 1,156 fish, released 991, and kept 165 salmon. Catch per unit effort was 0.10 salmon per hour (anglers fished approximately 9.8 hours before catching a salmon). The average angler spent about $158 in 2003, and estimated total expenditure by anglers in the 2003 season was approximately $119,000.

Education / Outreach
Adopt-A-Salmon Family
The 2004-2005 school year marks a dozen years in which the Adopt-A-Salmon Family Program has been providing outreach and education to school groups in three states (Maine, New Hampshire and Massachusetts in which recovery and/or restoration efforts are in place for Atlantic salmon. A core group of volunteers continues to be a major ingredient in program success. The program continues to have a diversified approach which that offers participating students an educational experience with Atlantic salmon, and also provides a watershed approach emphasizing such topic as water quality and river connectivity, aspects of river health important to all species of fish and aquatic life in general.

In November 2004 greater than 1,200 students as well as teachers and parents arrived in busses an educational program that included a tour of the Nashua National Fish Hatchery and a spawning demonstration. These students came from 21 school located in three different states. In February 2005, 31 schools received over 10,000 salmon eggs to be reared in classroom incubators. Throughout the winter and spring students monitor the progress of their eggs and release their fry into many tributaries of the Merrimack River watershed later in the summer. The volunteers that assist in all aspects of the program will be honored at our third annual "Volunteer Appreciation Day" reception to be held in March.

Central New England Fishery Resources Office staff submitted an application to the EPA for a grant for the next school year that, if awarded, would provide for a part time coordinator for the program. Coordinator responsibilities would be to provide teachers' with training and resources to more fully implement the program in their school.

The Amoskeag Fishways Partnership
The Merrimack River Anadromous Fish Restoration Program continued to be represented in The Amoskeag Fishways 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 year round, 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 2004 exceeded 20,000 people with approximately12,000 students and 8,000 adults involved. 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. Planning for a ten (10) year Fishways anniversary is now occurring and an event is scheduled for April 2005 to celebrate the success and continuation of the partnership.

3.3.8. Salmon Habitat Enhancement and Conservation

Habitat Restoration

In 2004 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. Public hearings to address removal issues pertaining to the Merrimack Village Dam, Souhegan River (Merrimack, NH) have been scheduled with outcomes anticipated in 2005. 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 habitat.

3.4. Pawcatuck River

3.4.1. Adult Returns

One female sea-run Atlantic salmon was captured in the fish ladder at Potter Hill in 2004. She was a 4 year old salmon that was stocked in the Pawcatuck River system as a fry.

3.4.2. Hatchery Operations

Egg Collection

Sea-Run Broodstock
A total of approximately 4,140 eggs were collected from the single female Atlantic salmon. The eggs were fertilized with pooled milt obtained from Richard Cronin National Salmon Station and from kelts at North Attleboro National Fish Hatchery, which was taken from a total of nine Connecticut River returns. All of the eggs will be retained for subsequent release as age 1 smolts in 2006.

Between 17,000 and 20,000 fry from sea-run salmon were acquired from the Nashua National Fish Hatchery in early 2004. These fish are being raised at the Arcadia Research Hatchery and the Perryville Hatchery. About 5000 of the largest of these parr were graded out, adipose fin clipped and placed in a pond at Arcadia for over wintering. The remaining 13,000 will be raised at the Perryville Hatchery. The majority of these fish will be raised to the smolt stage and released into the Pawcatuck River in the spring of 2005.

The Arcadia Warm Water Hatchery is also housing approximately 6000 parr from our sea-run salmon from 2003, which will also be released into the Pawcatuck River in the spring of 2005. All of the fish raised as smolts have had their adipose fins clipped.

Captive/Domestic Broodstock
The North Attleboro National Fish Hatchery (NANFH) incubated 500,000 eggs for stocking in the Pawcatuck River in spring 2003, and gave an additional 52,000 eggs to Rhode Island's salmon program for incubation at the Arcadia Research Hatchery (ARH) for stocking as fed fry in May 2003.

A small number (~100) of the fry acquired from Nashua will be retained in the hatchery to build up our newly begun broodstock program. Additionally, 52 of the 6109 smolts that were raised at Arcadia and released into the Pawcatuck River in 2004 were also retained for our broodstock program

About 200 adult broodstock (ages 4-5 years) were acquired from Nashua National Fish Hatchery in the summer of 2004. An additional 500 broodstock (2-3 years old) were acquired in October 2004. The older of these fish will be spawned and stocked out into various land locked ponds as was done in 2003. The remaining fish will be spawned and continued to be housed at the Perryville Hatchery, in Wakefield, Rhode Island.

Approximately 200,000 eggs usually raised by the North Attleboro National Fish Hatchery for our fry stocking program will be raised at the Arcadia Research Hatchery and stocked in May 2005. These eggs were acquired from Nashua National Fish Hatchery.

Hatchery Improvements. It was found that the production of well water had decreased markedly to 12 gallons per minute in early 2004. The recommendation was to perform a zonal hydro fracture in order to increase the flow. The zonal hydro fracture was conducted in late July and the result was an increase in production to 43 gallons per minute. This improvement has enabled us to expand the number of fish raised at the hatchery as described above.

3.4.3. Stocking

Rhode Island Division of Fish and Wildlife (RIDFW) personnel stocked fry throughout the Pawcatuck River watershed. In addition, fourteen local schools participated in the Salmon in the Classroom program and each stocked approximately 200 fry, which were hatched in their classroom.

Juvenile Atlantic Salmon Releases
A total of 556,732 fry were released into the Pawcatuck River watershed in 2004 for a density of approximately 166 fry/habitat unit. On May 12, 2003 245,910 fry provided by NANFH were stocked in 27 locations in the Pawcatuck River and its tributaries. On May 13, 2003, 248,021 fry were stocked in 34 locations in the Pawcatuck River and its tributaries. About 50,000 fed fry, raised at the ARH were also stocked in the Pawcatuck River on June 2, 2004.

Additionally, 6057 age 1 smolts also raised at ARH were released in the Pawcatuck River at several locations downstream of the Potter Hill dam and at Shannock. On February 17, 2004, 1,300 smolts were released at Shannock on the Mainstem of the Pawcatuck River. Approximately 2,400 smolts were released at several locations downstream of the Potter Hill Dam on March 22, 2004, and the remaining 2,400 were released at the same locations on May 6, 2004. This latter group was held back because of their smaller size and was allowed to gain in weight and length before being released.

Adult Salmon Releases
Approximately 200 adult broodstock acquired from the Nashua National Fish Hatchery in theEQ summer of 2004 were released in December 2004. The Atlantic salmon broodstock were stocked in four locations in Rhode Island. These locations included Stafford Pond, Barber Pond, Carbunkle Pond and Meadowbrook Pond.

3.4.4. Juvenile Population Status

Index Station Electrofishing Surveys
Parr were collected by electrofishing at 13 sites in the Pawcatuck River in the fall of 2004. The 13 sites included a total of 66 units (one unit = 100 m2) of juvenile habitat. Units sampled represent about 1.3% of the 4792 total habitat units available. Age 0 parr (2004 cohort) ranged in length from 38 mm to 98 mm, with an average of 68.2 mm, and age 1 parr (2003 cohort)

ranged in length from 101 mm to 215 mm, averaging 152.8 mm. Mean lengths in 2003 were higher than those found in 2003. Mean densities of age 0 parr and age 1 parr were 13.0 and 3.7 per 100 m^2, respectively. These densities represent an increase in densities of 0 parr and 1 parr from 2003.

Smolt Monitoring
No work was conducted on this topic during 2004.

Tagging
No work was conducted on this topic during 2004.

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 drops. 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 2004.

3.4.7. General Program Information

No dam removal or fishway construction work was conducted during 2004.

3.4.8. Salmon Habitat Enhancement and Conservation

No habitat enhancement or conservation projects directed solely at Atlantic salmon were conducted in the watershed during 2004.

4.0 DEVELOPMENTS IN THE MANAGEMENT OF ATLANTIC SALMON

4.1 Contaminants

4.1.1 Study of hatchery-reared Atlantic salmon contaminants

Presentation by Timothy Kubiak (timothy_kubiak@fws.gov) and Adria Elskus (aelskus@usgs.gov)

A January 4, 2004 report in *Science*, and the media releases associated with the report, raised consumer safety concerns regarding farm-raised salmon and fish consumption in general. The report documented elevated contaminant concentrations, including polychlorinated biphenyls (PCBs) and dioxins, in farm-raised salmon, and cited the likely source for the contaminants as the fish oil used in the commercial feed manufacturing process which the salmon subsequently bioaccumulate (Hites et al. 2004). U.S. Fish and Wildlife Region 5 fisheries program administrators decided to evaluate whether these broodstock contain levels of PCBs, dioxins, and/or heavy metals that exceeded existing Federal consumption advisory safety limits. The concern was borne from the fact that surplus broodstock from the Service's hatcheries are released to various States for stocking for recreational fisheries, and subsequently may be consumed by people (Excerpted from Millard et al. 2004).

A total of 138 fish were sampled from the R5 National Fish Hatchery system: 90 Atlantic salmon, 24 lake trout, and 24 rainbow trout. These 138 fish comprised the 22 composite skin-on fillet samples, grouped by species, age, and sex, that were analyzed by the Fish and Wildlife Service contract laboratory (Millard et al. 2004). Hites et al. (Hites et al. 2004) reported that farm-raised salmon sampled from east Canada and Maine showed total PCB levels of approximately 0.039 ppm and 0.026 ppm, respectively. Many of the National Fish Hatchery Atlantic salmon broodstock had higher levels. The sea-run salmon, age-4 fish in Nashua NFH, were higher in total PCBs (0.089 ppm) than many of the European pen-reared fish (0.040-0.050 ppm) reported by Hites et al. (2004). The mean PCB level in R5 NFH Atlantic salmon (0.0335 ppm) appeared to be consistent with the levels reported by Hites et al. (2004) for farmed salmon (primarily Atlantic salmon *Salmo salar*) around the world (Millard et al. 2004).

When using EPA human risk values as the default (reported as total dioxin toxicity equivalents or TCDD TEQs, the sum of dioxins, furans and dioxin-like PCBs) from its Consumption Advisory Guidance, dioxin levels (as TCDD TEQ) in composite samples from the Region 5 NFH broodstock were generally as restrictive, or more so, than were the total PCB levels in these fish. The TCDD TEQ levels caused 6 of 14 Atlantic salmon samples to fall within the restrictive 0.5 meals per month category. TCDD TEQ levels in the sea-run salmon in Nashua triggered the only "do not eat" advisory (although, if the one hexa-chlorinated furan was not included, because it was an estimated concentration, the risk based sea-run sample would be less restrictive at the 0.5 meal per month category). PCB levels only caused 2 samples to fall within the 0.5 meals/month category. Mercury, dieldrin, and endrin levels were far less restrictive than either TCDD TEQs or PCBs. For the reasons stated above, the TCDD TEQ data can reasonably be viewed as the "limiting factor" when considering the ultimate fate of these fish for human consumption (Millard et al. 2004).

Published results in the last few years suggest feeds contaminated with dioxins and PCBs may have adverse effects on salmonids (Giesy et al. 2002; Carvalho et al. 2004a; Carvalho et al. 2004b). Since PCBs also were the significant contributor to Atlantic salmon contaminant residues identified in R5 hatchery samples (Millard et al., 2004), these fish could be functionally compromised if diet or eggs contain sufficient contamination.

Because we had residue data for these contaminants in hatchery fish, the question becomes: do these levels of contaminants affect the performance of hatchery-reared salmon? Contaminant levels in hatchery fish were generally 10-100 times lower than those that have been reported to cause sublethal effects in salmonids (Meador et al. 2002; Berntssen et al. 2003; Cook et al. 2003; Carvalho et al. 2004b). At first glance, this could be interpreted to mean residues in hatchery fish are unlikely to affect performance. However, this cannot be concluded for several reasons: (1) toxicity data on these contaminants are based on laboratory studies of the effects of single compounds; wild caught and hatchery fish contain mixtures of these chemicals; (2) mixtures of chemicals can cause additive, synergistic or antagonistic effects, and we know virtually nothing about the effects of most mixtures on fish, or any organism; (3) most toxicity data are based on water exposure, not dietary studies or body burdens, making it difficult to predict potential effects based on body burden or diet data; (4) timing of exposure (e.g. during critical life history events) is likely to have a greater effect on fish performance than the amount of exposure (e.g. damage sustained during development is irreversible, and can lead to permanent changes in hormone function, neural development, and vision among other features); (5) the majority of toxicity studies have been conducted on non-salmonids, and because of the dramatic differences among species in sensitivity to toxicants, these data cannot be extrapolated to salmon. Finally, we cannot rule out the possible significance of low-level contamination. In studies with dioxin-like chemicals, even very low levels of dioxin in the diet (1.8 ng TCDD/kg body weight) of adult rainbow trout females significantly reduced survival in both adults and offspring (Giesy et al. 2002). For Atlantic salmon, there are no universally accepted threshold concentrations for tissue, diet or eggs that can be used as no adverse effects benchmarks.

Based on the complexities briefly outlined above, it is clear that body burdens alone cannot be used to predict performance effects. Rather, the functional deficits associated with these contaminants, as identified in laboratory studies with salmonids (e.g. survival, behavior, and visual acuity), are more reliable indicators of performance and may prove useful tools for determining the quality of hatchery reared Atlantic salmon prior to stocking.

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4.1.2 Screening-level contaminant assessment of Maine's DPS Atlantic salmon rivers using white suckers – 2004 Status Report.

Presentation by Steve Mierzykowski (steve_mierzykowski@fws.gov), Joan Trial, and Don Tillitt

For decades, Atlantic salmon (*Salmo salar*) have been declining in Maine and Canadian Maritimes rivers and no single cause has been identified. In a review of water quality issues potentially affecting Atlantic salmon in Maine (Haines 2002), it was apparent that, except for the Dennys River, and East Machias River, contaminant data to illustrate uptake or residues in resident fish was lacking in five of the Distinct Population Segment rivers. Because of their endangered species protection and population status, it is impracticable to collect and kill wild Atlantic salmon from rivers within the DPS for tissue residue analyses. However, white suckers exist in all of Maine's rivers and are extremely useful as stream-resident sentinels of contaminant exposure and effects. Residue studies with white suckers have been used in Maine, regional and national biomonitoring programs to illustrate contaminant exposure (Mower 2004, Yeardley *et al*. 1998, Schmitt and Brumbaugh 1990).

Wholebody composite samples of stream-resident white suckers from rivers within the DPS with Atlantic salmon populations are being analyzed for trace element and organochlorine compounds. In four of the eight DPS rivers examined to date, only one (p,p'-DDE) of 22 organochlorine compounds included in the scan was found above the detection limit. The DDE levels (≤ 5 ppb, wet weight) in DPS river white sucker samples were considerably lower the geometric mean reported in a national biomonitoring program (190 ppb, Schmitt et al. 1990). Trace element levels in sucker composite samples were similar to concentrations reported in other biomonitoring programs (Mower 2004, Yeardley *et al*. 1998, Schmitt and Brumbaugh 1990). However, arsenic in Cove Brook (0.20 ppm), and chromium (2.20 ppm) and selenium (0.57 ppm) in the Narraguagus River were elevated compared to these other monitoring programs. In 2005, blood plasma from white suckers in the eight rivers will be examined for biomarkers of xenoestrogen exposure (i.e., 17 beta estradiol, 11-ketotestoterone, vitellogenin).

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4.1.3 Endocrine disruption in Atlantic salmon (*Salmo salar*) exposed to pesticides

Abstract by Benjamin W. Spaulding (Benjamin_Spaulding@umint.maine.edu).
Terry A. Haines, Rebecca Holberton, and Rebecca Van Beneden.

Since the early 1980's, the numbers of Atlantic salmon (*Salmo salar*) returning to Maine's rivers have been in general decline. In addition, estimates of parr, freshwater smolt and emigrating smolt populations indicate low overwinter survival rates. Overall, these low numbers, along with several other factors, resulted in the Atlantic salmon in eight rivers in Maine being classified as a distinct population segment under the Endangered Species Act. Because many of the listed rivers are found near lowbush blueberry barrens, we investigated the endocrine disrupting potential and effects of selected blueberry pesticides on Atlantic salmon. An E-SCREEN assay was conducted to determine the relative estrogen mimicking properties, measured by a relative proliferative effect, of the most commonly used pesticides registered for use on lowbush blueberry.

Atlantic salmon pre-smolts of hatchery origin were subjected to pulsed exposures of a mixture of pesticides at environmentally realistic concentrations. For each of the two years of this study, pre-smolts were subjected to a total of five weekly, 24h pesticide exposures. In Year One, Velpar (hexazinone), Orbit (propiconazole), and Super BK (2,4 Dichlorophenoxy acetic acid) were tested. In Year Two, Orbit, Sinbar (terbacil), and Imidan (phosmet) were tested. To evaluate the effects of the pesticides on smoltification, the fish were periodically exposed to 24h saltwater challenge tests (SWCT) to examine the osmoregulatory ability of the pre-smolts. We measured gill Na^+ / K^+ ATPase activity, plasma chloride concentration, hematocrit, vitellogenin presence, and plasma steroid concentrations (estrogen/androgen) of randomly selected smolts after the pesticide exposures and saltwater challenges.

Control group Atlantic salmon pre-smolts did undergo smoltification as indicated by increased gill Na^+ / K^+ ATPase activity and low mortality rates in SWCT. Body length and weight of smolts was not affected by pesticide exposure in either year. Significantly lower gill Na^+ / K^+ ATPase activity was detected in smolts during Year Two only after the second SWCT. Plasma chloride levels were significantly different between control and exposed groups for both years, but values in each treatment remained in expected ranges for freshwater and saltwater portions of the study. Hematocrit values were within normal range in Year One, but in Year Two exposed fish had significantly higher values than control fish after each pesticide exposure. Plasma steroid concentrations did not significantly differ between groups for either year. Therefore, in spite of multiple pulsed exposures to mixtures of blueberry pesticides calculated to be above expected concentrations found in the environment, the results do not support the hypothesis that the observed overwinter mortality of smolts and reduced adult returns of Atlantic salmon are due to endocrine disruption by the pesticides utilized in this study.

4.1.4 A non-lethal method to estimate CYP1A expression in laboratory and wild Atlantic salmon (*Salmo salar*)

Abstract by Christopher B. Rees, Stephen D. McCormick and Weiming Li (liweim@msu.edu)

Expression of cytochrome P450 1A (CYP1A) has been used as a biomarker for possible exposure in contaminants such as PCB's and dioxins in teleost fish. Using a quantitative reverse transcription-polymerase chain reaction (Q-RT-PCR) and a non-lethal gill biopsy, we estimated levels of CYP1A mRNA expression in Atlantic salmon. Groups of ten Atlantic salmon juveniles (48-76 g) received an intraperitoneal injection of 50 ug g^{-1} β-naphthoflavone (BNF) or vehicle. Their gill tissues were repeatedly sampled by non-lethal biopsies on day 0, 1, 2, and 7. Control fish showed static levels of CYP1A over the course of sampling. BNF treated salmon demonstrated similar levels of CYP1A to control fish at day 0 and higher levels over the course of each additional sampling unit. Gill biopsies from wild salmon sampled from Millers River (South Royalston, Worcester County, MA, USA), known to contain PCBs, showed significantly higher CYP1A levels over a pristine stream, Fourmile Brook (Northfield, Franklin County, MA, USA). We conclude that gill biopsies coupled with Q-RT-PCR analysis is a valuable tool in environmental assessment of wild Atlantic salmon populations and many other populations as well.

4.2 Compilation of quantitative studies of downstream migration and fish passage

This section contains a table (Table 4.2), and references and summaries of the studies reviewed in Section 2.6.

Table 4.2 Downstream Passage Efficiency Studies by State.

	River	*Stream*	*Project*	*Species*	*Year*	*Study*	*% Efficiency*	*COMMENTS*
Maine								
	PENOBSCOT	PENOBSCOT R	MATTACEUNK(WELD/2520A	ATS	1990	BE	20	
				ATS	1990	BE	54	
				ATS	1993	BE	59	
				ATS	1993	BE	59	radiotracking study
				ATS	1994	BE	45	
				ATS	1994	BE	45	radiotracking study
				ATS	1995	BE	52	
				ATS	1995	BE	52	radiotracking study
				ATS	1997	BE	41	radiotracking study
				ATS	1998	BE	22	radiotracking study
				ATS	1999	BE	17	radiotracking study
			WEST ENFIELD(ST/2600A	ATS	1993	BE	8	
				ATS	1993	TM	4	radio telemetry study
				ATS	1994	BE	50	
	SACO	SACO R	CATARACT(EAST CHANNEL)/2528A	ATS	1994	BE	30	
Massachusetts								
	CONNECTICUT	CONNECTICUT R	CABOT STATION/1889A	ATS	1991	BE	66	
				ATS	1992	BE	38	
				ATS	1993	BE	32	
				ATS	1994	BE	55-75	
				ATS	1995	BE	57	
				ATS	1997	BE	68-73	
			HOLYOKE (H.FALLS)/2004A	ATS	1982	TM	6.3	radio telemetry
				ATS	1990	BE	24	at 326 cfs w/ 8' deep floating louvers

Study Types: BE = Bypass Efficiency
TM = Turbine Mortality

River	Stream	Project	Species	Year	Study	% Efficiency	COMMENTS
CONNECTICUT	CONNECTICUT R	HOLYOKE (H.FALLS)/2004A	ATS	1991	BE	36	at 500 cfs w/ bascule gate insert & no structure at intake
			ATS	1991	BE	88	at 1200 cfs w/ bascule gate insert & no structure at intake
			ATS	1992	BE	68	at 326 cfs w/ floating boom & insert at bypass
			ATS	1992	BE	75	at 326 cfs w/ floating boom & insert at bypass
			ATS	1994		63	overall non-turbine passage
			ATS	1994	BE	43	at 326 cfs w/ trashrack overlay & weir at bypass
			ATS	1995	BE	63	at 326 cfs w/ same set-up as 1994 studies
	DEERFIELD R	DEERFIELD 2/2323A	ATS	1999	BE	20	radiotracking study
			ATS	2000	BE	15	Radiotracking study
			ATS	2002	BE	44	Radiotracking study
			ATS	2003	BE	60	radiotracking study
		DEERFIELD 3/2323B	ATS	1999	BE	78	radiotracking study
			ATS	2000	BE	41	radiotracking study
			ATS	2002	BE	77	radiotracking study
			ATS	2003	BE	73	radiotracking study
		DEERFIELD 4/2323C	ATS	1999	BE	59	radiotracking study
			ATS	2000	BE	28	radiotracking study
			ATS	2002	BE	57	radiotracking study
			ATS	2003	BE	57	radiotracking study
		GARDNER FALLS/2334A	ATS	1999	BE	72	radiotracking study
			ATS	2000	BE	28	radiotracking study
MERRIMACK	MERRIMACK R	LOWELL/2790A	ATS	1992	TM	11.5	radio telemetry study
New Hampshire							
CONNECTICUT	ASHUELOT R	LOWER ROBERTSON/8235A	ATS		BE	7	floy tagged; tested inducers; videotaped fish
	CONNECTICUT R	WILDER/1892A	ATS	1991	BE	91	AT 200 CFS
			ATS	1991	BE	94	AT 324 CFS
			ATS	1991	BE	96	AT 550 CFS
			ATS	1994	BE	69	AT 200 CFS

Study Types: BE = Bypass Efficiency
TM = Turbine Mortality

River	Stream	Project	Species	Year	Study	% Efficiency	COMMENTS
CONNECTICUT	CONNECTICUT R	WILDER/1892A	ATS	1994	BE	71	AT 324 CFS
			ATS	1994	BE	88	AT 550 CFS
			ATS	1994	TM	4	Turb'N Tag study
	SUGAR R	LOWER VILLAGE/9088A	ATS		BE	81.5	
MERRIMACK	PEMIGEWASSET R	AYERS ISLAND #2/2456A	ATS	1992	BE	54	radiotracking study
			ATS	1993	BE	61	radiotracking study
			ATS	1999	BE	100	radiotracking study
	SOUHEGAN R	PINE VALLEY(WIL/9282A	ATS	1993	BE	96	
Vermont							
CONNECTICUT	BLACK R	CAVENDISH/2489A	TROUT	1998	BE	46	tested 1-2 hp flow inducer; used trout as surrogate for ATS
			TROUT	1999	BE	56	mark-recapture study
			TROUT	2000	BE	17	mark-recapture study
			TROUT	2001	BE	63	mark-recapture study
	CONNECTICUT R	BELLOWS FALLS/1855A	ATS	1995	BE	94	
		VERNON/1904A	ATS	1994	BE	76	
			ATS	1995	BE	73	
			ATS	1996	BE	75	
			ATS	1996	TM	15	at unit #4 (small unit)
			ATS	1996	TM	5	at unit #10 (large unit)
LAKE CHAMPLAIN	WINOOSKI R	ESSEX 19/2513A	ATS (LL)	1996	BE	27	radiotracking study
			ATS (LL)	1997	BE	6	radiotracking study

Study Types: BE = Bypass Efficiency
TM = Turbine Mortality

4.2.1 Connecticut River Program

Compiled by Jan Rowan. References of studies and highlights of results:

Melissa Grader. 2004. Summary of Downstream Fish Passage Effectiveness Studies at Dams in the Connecticut River Basin. New England Field Office database (personal communication).

- Deerfield #2 on the Deerfield River: 21% effective from sluice.
- Deerfield #2 on the Deerfield River: 60% effective bypass.
- Deerfield #3 on the Deerfield River: 73% effective bypass.
- Deerfield #3 on the Deerfield River: surface collection of radio-tagged fish was 77.6% effective.
- Deerfield #4 on the Deerfield River: 57% effective bypass.
- Deerfield #4 on the Deerfield River: surface collection of radio-tagged fish was 59 % effective.
- Gardner Falls on the Deerfield River: louvers were 28-72% effective depending on flows; 72% effective at generation flows <600 cfs and 25% effective at generating flows >900 cfs.
- Lower Village dam on Sugar River: overlay on racks (½" mesh) 81-82% effective.
- Lower Robertson dam on the Ashuelot River :7% efficiency for smolts from 2-inch spaced racks with flow inducers (otherwise inconclusive results).
- Cavendish dam on Black River : 63% (49-72%) effective for trout from 1-1/2" spaced racks.
- Bellows Falls on Connecticut River: bypass 94% effective.
- Cabot Station on Connecticut River: bypass 68-73% effective.
- Wilder on Connecticut River: bypass 69-91% effective.
- Vernon on Connecticut River: bypass 73-76% effective.
- Hadley Falls Station (Holyoke) on Connecticut River: bypass 43-63% effective.

These studies are referenced in a publication entitled:

FERC Division of Hydropower Administration and Compliance – Office of Energy Products. September 2004. Evaluation of Mitigation Effectiveness at Hydropower Projects: Fish Passage.

(These data are also available in the FERC eLibrary. The eLibrary can be accessed from the FERC website: www.ferc.gov)

Brian Adams. 2004. Data for the 2004 Evaluation of the production of Atlantic salmon (*Salmo salar*) and stocked Atlantic salmon fry in the upper Connecticut River basin. Northeast Generating Services.

- 1,312 smolts were captured, marked and released at Cabot Station,
- 22 marked smolts were recaptured out of a total of 1,802 smolts at Holyoke,

- Capturing smolts at Cabot was most productive in the evening while it was most productive at Holyoke at mid-day,
- The total smolt emigration estimate calculated from this data is 77,548 +/- 40,749 smolts. This compares to a past average of about 51,000 smolts (Bob Stira, personal communication).

Normandeau Associates, Inc. May 1996. The Vernon bypass fishtube: evaluation of survival and injuries of Atlantic salmon smolts. New England Power Company. Westborough, MA.

- Used White River NFH salmon smolts and HI-Z Turb'N Tag recapture technique
- 75 smolts were passed through the fishtube and 25 smolts were controls released directly into the tailrace
- Study conducted at water temperatures ranging from 16^o-17.5^{o}C (60.8^o-63.5^{o}F)
- Discharge through fishtube was 40 cfs
- Discharge through the turbines ranged from 1,795-10,235 cfs but was > 9,000 cfs for 13 of the 15 test hours
- 93.3% short and long-term survival of fish passed through fishtube
- Low observed injury rate

Normandeau Associates, Inc. May 1996. Efficiency of the louver system to facilitate passage of emigrating Atlantic salmon smolts at Vernon Hydroelectric Station, Spring 1995. New England Power Company. Westborough, MA.

- A louver system was built to guide smolts to the fishpipe
- The louver system is only effective for smolts which approach the Vernon station along the east shoreline or mid-river
- Most smolts approach the station from the east shoreline or mid-river
- The louver system excluded 42.1% of the smolts which approached the dam from the east and mid-river, the remainder moved west in the forebay beyond the louver
- The west fishtube passed 61.8% of the smolts which passed the station from the western forebay (or 39.3% of all smolts passing Vernon)
- A total of 173 radio tagged smolts passed Vernon station: 23.7% passed through the fishpipe, 39.3% passed through the west fishtube, 34.7% passed through the turbines

W. Peter Saunders, Jr., International Science & Technology, Inc. October 1987. Assessment of the frequency of worst case flow conditions during downstream migration of salmon smolts at Bellows Falls dam. New England Power Service Company. Westborough, MA.

- Worst case conditions include river flows of < 11,000 cfs when all river flow is diverted through the power canal during the likely period of smolt migration
- The likely period of annual smolt migration is at river temperatures from 10^o-20^{o}C (50^o-68^{o}F) and between April 27 through June 14
- Peak smolt migration occurs early in this defined period when worst case conditions are least likely
- Analysis based on historical daily water temperature and daily river discharge data for Bellows Falls dam

- There is a 41% chance of worst case conditions during smolt migration

Normandeau Associates, Inc. July 2004. Evaluation of downstream fishway effectiveness for Atlantic salmon smolts at the McIndoes development, Connecticut River, Spring 2003. USGen New England Inc. Concord, NH.

- Downstream smolt passage is provided by a skimmer gate next to the turbine intakes near the middle of the dam
- 200 age-2 smolts were radio tagged and released from May 20-May 28 at water temperatures ranging from 8°-12°C (46.4°-53.6°F)
- Fishway effectiveness was calculated to be 33.3% with 64 smolts using the fishway and 122 passing the project through the turbine intakes
- 5 of the tagged salmon did not pass downstream during the 22 day study period and 1 passed by an unknown route
- 75.9% of the smolts passed at night between 8 pm and 6 am.

Normandeau Associates, Inc. November 2000. Atlantic salmon smolt migration through the Moore and Comerford reservoirs, spring 2000. PG&E Generating. Lebanon, NH.

- A total of 148 smolts were radio tagged and released at water temperatures that ranged from 11°-12.5°C (51.8°-54.5°F)
- Five groups of smolts (108) were released in Moore reservoir from May 6 – May 27; 10 smolts from the first release passed the dam (9 in spill, 1 in turbines) and the 9 live smolts reached the Comerford dam; the remainder stayed in the vicinity of the dam or moved upstream
- Two groups of smolts (40) were released in Comerford reservoir on May 17 & May 22; none of the Comerford releases passed the dam, but 4 of the 9 smolts that passed Moore passed Comerford via the spillway
- Travel time and residency varied widely among the smolts
- Unusually high flows resulted in spill conditions at both dams during the study period
- The only passage of tagged smolts at either dam occurred during the spill events

Gomez and Sullivan Engineers, P.C. December 1998. West Springfield Hydroelectric Project – Fish passage monitoring final report. Rexam DSI.

- The 18' high timber crib Rexam DSI dam is the first barrier on the Westfield River
- In 1995, the dam was equipped with a Denil fishway for upstream passage of Atlantic salmon and American shad and other migratory and resident species
- Spill is the primary means of downstream passage from April through May for smolts
- Spill also occurs in the summer and fall and may pass post-spawning salmon
- Continuous spill in the bypass through a zone of passage provides an alternate downstream passage route in all flow conditions
- Downstream migrants may also pass via the power canal which is equipped with bypass racks (one inch clear spacing) that guide fish to the bypass weir has a coarse trash rack (with removable vertical bars on one foot centers)
- Evaluation of smolt emigration was hampered by high flows in 1996 and 1997 and it was assumed that most passed via spill during mid-April when water temperature

- reached 10°C (50°F) – none were observed delayed above the project as at other facilities upstream
- Evaluation of post-spawning adult emigration in 1997 revealed that 8 of 8 live salmon moved downstream in the fall after spawning; Five of these adults passed the DSI dam in late fall/early winter either via spill or through minimum flow weirs and one passed in the spring via spill or the power canal and downstream fishway (2 died in the winter)
- Evaluation of post-spawning adult emigration in 1998 revealed that 5 of 8 live salmon moved downstream in the fall after spawning (3 died upstream); Two passed via the power canal and downstream fishway in December

HARZA Engineering Company. November 1990. Report on downstream fish passage facilities for Hadley Falls Station. Northeast Utilities Service Company.

- Hadley Falls Station consists of the Holyoke dam, and the Hadley Falls Station which is a 3-level, 4.5 mile long canal system and 5 generating stations in the canal system
- This was an economic pre-feasibility study of various downstream fish passage alternatives including a floating skirted boom and stationary screens, floating louvers, full depth louvers, Eicher screens, and Hadley Falls Station shutdown during migration

Stephen Gephard, Tim Wildman, Joseph Ravita, Bruce Williams and David Ellis. 2003. Anadromous fish enhancement and restoration 2003: Federal Aid in Sport Fish Restoration F-50-D-24 performance report. State of Connecticut Department of Environmental Protection.

- Smolt emigration on the Farmington River was monitored at the Rainbow fishway and bypass using real-time counts and videography; 5,266 smolts were observed (compared to 7,504 in 2003)
- Smolts sampled at the Rainbow dam fishway and bypass were comprised of 36.7% hatchery smolts and 63.3% stream-reared smolts

Donald Pugh and Boyd Kynard. May 2001. Westfield River adult salmon report: Westfield River, Massachusetts 1996-1998. Conte Anadromous Fish Research Center, USGS/BRD, Turners Falls, MA.

- From 1996-1998, sea-run Atlantic salmon were trapped in the spring at the DSI dam, radio tagged, and released above the Knightville dam on the East Branch of the Westfield River; In 1997 and 1998 domestic broodstock were tagged and released in East and West branches of the Westfield River
- Habitat use, behavior and movement of the tagged adults was monitored manually and with fixed data loggers
- In 1996, 9 sea runs were tagged; 4 died after release – 1 or 2 of which was likely poached; the five living fish spent the summer in pools and moved upstream only at spawning and then held in riffles and runs; movement occurred in the day – 4 of the 5 salmon spawned; all 5 survived spawning; 1 moved downstream in fall, 3 moved down in spring, and 1 was poached

- In 1997, 11 sea runs were tagged; 6 moved downstream, 4 moved upstream and 1 held where released; 2 were poached soon after release; 9 fish survived until fall; In the East Branch, fish moved upstream just prior to spawning and 3 or 4 of these fish spawned; Ultimately, those fish that moved downstream initially did not spawn; 9 fish emigrated – 8 passed Crescent Mills dam (7 in fall and 1 in spring) via the fish bypass; the 7 fish emigrating in the fall passed the Woronoco dam via spill and the spring and via the bypass in the fall; Of the 8 fish that made it to DSI, 5 passed downstream, 2 died at the project, and I died above in the impoundment
- In 1997, 16 domestic brood stock were tagged and released in the East and West Branches; After release, 2 fish died (maybe poached) near the release site in the West Branch, 6 moved downstream in the West Branch with 2 passing DSI, and the remainder died in the vicinity of the downstream dams; In the East Branch, 3 may have spawned, 5 moved downriver and never spawned; 5 fish passed DSI and 2 died neared Woronoco
- In 1998, 12 sea runs were tagged; 1 fish moved downstream and died at Crescent Mills; 1 fish moved downstream and passed DSI but was later recaptured at DSI and re-released upstream; 9 fish survived until fall; 3 fish died or were poached; 4 of the remaining fish spawned; River discharge was unusually low in the fall; 4 fish emigrated past DSI in the fall and 1 left in winter
- In 1998, 16 domestic brood stock were tagged and released in the East and West Branches; In both Branches, fish released in summer did not spawn,1 emigrated in the fall and the remainder died; 1 fall released fish in the West Branch spawned and all moved downstream past DSI either in the fall or spring; East Branch releases all moved downstream, none spawned; 3 successfully emigrated past DSI in late fall or early spring

Stephen D. McCormick, Gayle Barbin Zydlewski, Kevin G. Whalen, Alex J. Haro, Darren T. Lerner, Michael F. O'Dea and Amy M. Moeckel. Smolt migration demography and overwinter survival of Atlantic salmon in a restoration stream of the Connecticut River, USA. Conte Anadromous Fish Research Center, USGS/BRD, Turners Falls, MA.

- 5-20% of PIT tagged 1+ and 2+ parr (autumn-stocked salmon fry) moved downstream in Smith Brook (VT)
- Fish migrating as smolts the following spring were those >11.5 cm FL (4.5") the previous fall
- 90% of smolt migration occurs between April 20 and May 12 though migration begins as early as mid-March and ends as late as mid-May
- Most of the smolt migration occurs at night
- Smolt migration is not keyed to flow
- Overwinter survival ranged from 28-68% for parr >11.5 cm
- Smolt recruitment ranged from 19-42%

Stephen D. McCormick, Alex J. Haro, Michael F. O'Dea, Darren T. Lerner, and Amy M. Moeckel. Migratory patterns of wild and hatchery-reared Atlantic salmon in the Connecticut River. Conte Anadromous Fish Research Center, USGS/BRD, Turners Falls, MA.

- Early release hatchery salmon smolts are detected downstream at about the same time as smolts released up to 3 weeks later
- Smolts from northern tributaries arrive at the mouth of the river later than fish from the southern tributaries
- Detection of hatchery-reared and stream-reared PIT tagged smolts were greater for southern tributaries suggesting lower survival for smolts in northern tributaries

Kevin G. Whalen, Donna L. Parrish, and Stephen D. McCormick. 1999. Migration timing of Atlantic salmon smolts relative to environmental and physiological factors. Transactions of the American Fisheries Society 128: 289-301, 1999.

- Smolt migration in the West River begins in late April and early May when the river temperature reaches 5^{o}C (41^{o}F)
- Peak movement occurs in early and mid-May at temperatures >8^{o}C (46.4^{o}F)
- Migration is completed by early June
- Smolts in the warmest tributary tended to migrate earlier and show greater Na^{+}, K^{+} - ATPase activity
- The period between onset of migration and loss of smolt characteristics may be brief suggested a need to minimize delays in downstream passage to maximize successful smolt recruitment

4.2.2 Merrimack River Program

Compiled by Joe McKeon. References of studies and highlights of results:

Public Service Company of New Hampshire, Merrimack River Project (Amoskeag, Hooksett & Garvins Falls (FERC No. 1893) 2004. Response Attachments to Additional Information Requests, Volume 1 December 2004. Evaluation of the effectiveness of the Amoskeag crest gate to pass Atlantic salmon *(Salmo salar)* smolts.

- A total of 83 radio-tagged smolts was released during study conducted between 15 May and 21 May, 2004 with water temperatures ranging between 17^{o}C and 20^{o}C.
- Bypass test flows of 289 cfs and 125 cfs were evaluated.
- Sixty-six (79.5%) smolts were detected passing the project; 40 (70%) used the bypass; 17 (30%) passed through the turbines; nine (14%) spilled over the dam; two detected in the headpond, and 15 did not enter the study area.
- Operating units in the order of unit 3, unit 2, and unit 1seems to have increased passage effectiveness with unit 3 nearest the crest gate.
- Overall passage was higher at 125 cfs (76%) than at 289 cfs (67%).
- Results of 2004 study were similar to those obtained in 2001.
- Agencies have indicated that the Amoskeag Dam crest gate is an effective passage route.

Normandeau Associates (NAI). 2003. Downstream Passage of Atlantic Salmon Smolts at the Amoskeag Hydroelectric Project, Spring 2003 (FERC No. 1893) Draft Report, September 2003.

- A total of 108 radio-tagged Atlantic salmon smolts (Green Lake National Fish Hatchery one-year old smolts) was released above the project in 7 separate groups (9 - 22 fish) between 21 May and 31 May, 2003.
- Bypass test flow of 285 cfs was evaluated.
- 107 smolts (96.3%) were detected with manual and/or stationary receivers, 103 (96.3%) passed the project and 4 (3.7%) did not pass.
- 23 (22%) of 103 smolts passing project exited via the bypass; 59 (57%) passed through the turbines; 11 (11%) spilled over the dam; and 10 (10%) passed through undetermined routes.
- Flow levels of 557 cfs, 285 cfs, and 125 cfs were tested at the Amoskeag Dam bypass in 2003.
- Combined bypass efficiency of 22% in 2003 (2001 study= 71% efficiency).
- 71% of smolts were successful in passing with bypass attraction flows of 110 to 125 cfs (4 -12% of turbine flow, which are low to moderate levels).

Normandeau Associates (NAI). 2003. Downstream Passage of Atlantic Salmon Smolts at the Amoskeag Hydroelectric Project, Spring 2001 (FERC No. 1893) Final Report, August 2003.

- A total of 109 radio-tagged Atlantic salmon smolts (Green Lake National Fish Hatchery one-year old smolts) was released above the project in 11 separate groups between 15 May and 25 May, 2001.
- Overall bypass efficiency was 71%.
- 74 % of released smolts used the bypass at a bypass flow of 100 cfs and 64% used the bypass when bypass flow was 125 cfs.
- 30% of bypassed smolts became stationary after passage.
- 36% of turbine-passed smolts remained in the tailrace.
- 25% of bypassed smolts reached downstream monitor Station 6 (4.3 miles downstream).
- 27% of turbine passed smolts continued downstream past Station 6.
- 25% of all released smolts continued downstream past Station 6.
- Movement of many radiotags back upstream to the tailrace suggests substantial predation.
- Evidence of large numbers of broodstock salmon above and below the project, and evidence from fish ladder monitoring all suggest that broodstock salmon are the major predator on study fish.

Normandeau Associates (NAI). 2001. Radio-Telemetry Study of the Garvins Falls Hydroelectric Project Downstream Fish Bypass System, Merrimack River, New Hampshire, Spring 2000.

- A total of 74 radio tagged smolts was released with a full pond (all flashboards up) and normal canal level between 13 May and 25 May, 2000.

- Water temperature ranged from 11.6^{o}C to 13.0^{o}C; total hydraulic capacity for plant is 6,045 cfs.
- Fifty-six (76%) smolts were detected entering the power canal; 49 (88%) were detected passing through the fish bypass; and 7 (12%) were detected behind the louvers.
- The presence of 150-300 Atlantic salmon broodstock in the canal may have adversely affected the percentages of smolts using the bypass; radio-telemetry results indicated possible predation on smolts by broodstock.

Bradley F. Blackwell, G. Gries, F. Juanes, K.D. Friedland, L.W. Stolte, and J.F. McKeon. 1998. Simulating migration mortality of Atlantic salmon smolts in the Merrimack River. North American Journal of Fisheries Management 18: 31-45. 1998.

- In-river survival of smolts was modeled and ranged from 0.7-23.5%
- Estimated transit times generally increased in migration scenarios in which smolts began migration later in the season.
- Beginning migration later in the season resulted in lower in-river survival.
- The model was evaluated by comparing records of returns of two-seawinter adults to the Merrimack River to a likely range of marine survival rates.
- The model may have application in population assessment, river management and salmon restoration.

Charles Ritzi Associates. 1993. Report of Results of a study of the effectiveness of downstream fish passage facilities at the Pine Valley Hydroelectric Project (FERC No. 9282) Souhegan River, New Hampshire, July 1993.

- Scope of study to assess smolt passage via the downstream fishway consisting of a 3-foot-wide surface inlet weir at the downstream end of the penstock intake trash wrack; a bypass inlet box; and a 24 inch diameter bypass pipe (operation at 24 – 30 cfs) to carry fish to a bypass channel.
- Six hundred and sixteen (616) smolts released 10 May with 595 (97%) captured in holding tank at end of bypass pipe.
- Eighty-six (14%) of captures died in holding tank.
- A total of 1,120 wild smolts captured in this study, with movement of wild smolts well underway by 29 April.
- Ninety (8%) of wild smolts died in the holding tank.
- Heavy fishing pressure observed upstream and downstream of the study site and hooking mortality was evident for both wild and hatchery smolts.

Lakeside Engineering, Inc. 1996. Summary of results of the fifth year of study of the effectiveness of fish passage facilities at the Rolfe Canal Hydroelectric Project (FERC No. 3240) Contoocook River, New Hampshire, September 1996.

- Scope of study involved release of 240 smolts upstream of Rolfe (Outlet) Canal and York Dam for mark/recapture study; installation of a sound generation system [SDS (sound deterrent system)] at head of Rolfe Canal; provide 5-foot-wide surface weir (bypass) at York Dam and trap system.

- York Dam bypass operation from 21 May through June 27 with a total of 11 (4.5%) of released fish were recaptured; monitoring at a downstream dam continued from 22 May through 24 June.
- River water temperature was 16^{o}C to 17^{o}C.
- SDS testing showed that smolts generally moved to approximately 25 feet or more from the sound source unless confined by the pen, and proponents of system indicated that the SDS sound generating spacing of 6.5 M (21.3 feet) should be adequate to provide a continuous sound deterrent for smolts at the entrance of Rolfe Canal.

Normandeau Associates, Inc. 2001. Passage Route Selection and Survival of Atlantic salmon smolts passed through the Lowell Hydroelectric Project, Merrimack River, Massachusetts, FERC Project No. 2790-MA, November 2001.

- Passage route study using 60 radio-tagged smolts and turbine survival study on 75 (50 treatment, 25 control) fish using the HI-Z Turb'N Tag recapture method.
- Conducted during peak out-migration period on or about 5 May with water temperature between 10^{o} C and 18^{o} C with facility at typical operating levels.
- Three bypass flows targeted for testing for bypass study: 2%, 3.5%, and 4.5% of turbine flow.
- Twenty radio-tagged smolts to test each of three bypass flows with efficiency averaging 32% with a range of 15% passage at 25 of turbine flow to 42% passage with about 4% bypass flow.
- Smolts released for turbine survival study suggested that immediate and delayed survival after passage approached 100%.
- Predatory fish (primarily resident striped bass) in the tailrace and downstream of the project have a substantial impact on the survival rates of smolts emigrating past the project.

Normandeau Associates, Inc. 1996. Downstream Passage of Radio-Tagged Atlantic salmon smolts at the Lowell and Lawrence Hydroelectric Projects on the Merrimack River, February 1996.

- Downstream passage routes used by salmon smolts at the Lowell and Lawrence Projects was assessed using 49 smolts released upstream of Lowell and 47 release upstream of Lawrence.
- Majority of smolts passed both projects through the turbines. At Lawrence 21 passed through the turbine and 1 (5%) used the bypass.
- Of the 22 fish that passed the Lawrence Project, 77% continued downstream movement 2 miles below the project.
- Most fish passed the project at night; questions arose about whether study fish were functional smolts; wild smolts observed moving past project as well.

Normandeau Associates (NAI). 2001. Survival of hatchery-reared Atlantic salmon smolts through the fish bypass at the Ayers Island Hydroelectric Project, Pemigewasset River, Spring 2001.

- A total of 33 Atlantic salmon smolts (Green Lake National Fish Hatchery one- year old smolts) was released in three separate groups (9-12 smolts) into the bypass flow at Ayers Island Hydroelectric Project between 21 May and 23 May 2001.

- Thirty-two (32) fish detected after release with 29 (91%) reaching the Bristol Bridge downstream monitoring station (approx. 1.6 miles downstream); one (3%) became stationary at the bridge; one (3%) became stationary 0.7 miles downstream of dam; and two (6%) became stationary in lower plunge pool below dam.
- One signal (3%) presumed to malfunction and lost.
- Bypass flows during the study were approximately 225 cfs and river temperatures during study ranged from 14.9^{o}C to 16.0^{o}C.
- Twenty-eight radio-tagged smolts passed the Bristol Bridge; 11 passed within 24 hours, 10 passed within 36 hours and 7 passed more than 36 hours after release.
- Average passage time was 33 h: 48 min, ranging between 2 h: 42 min and 216 h: 33min.
- Survival of 91%, lower than what USFWS routinely finds acceptable, reported however the agency accepts that the bypass sluice provides a safe egress route for salmon smolts and that further testing of the bypass for smolt survival is not needed at this time.

FERC Division of Hydropower Administration and Compliance – Office of Energy Products. September 2004. Evaluation of Mitigation Effectiveness at Hydropower Projects: Fish Passage.

The report includes a study at the Ayers Island Dam Hydroelectric Project, Pemigewasset River that occurred previous to the study reported above. Highlights include:

- Downstream Passage of Atlantic salmon smolts at the Ayers Island Dam plunge pool and fish sampler constructed in 1996. Plunge pool modified and new fish passage flashboard installed in 1998 to smooth flows entering fish spillway.
- Fish passage effectiveness: 1992 – 54 %; 19934 – 61%; 1999 – 100%.

(These data are also available in the FERC eLibrary. The eLibrary can be accessed from the FERC website: www.ferc.gov)

4.2.3 Saco River Program

These are references for studies conducted at hydropower dams on the Saco River, Maine, 1995-2004, as compiled by Norm Dube and Kevin Dunham.

Normandeau Associates, Inc. and FPL Energy Maine Hydro, LLC. 2004. Evaluation of Atlantic Salmon Smolt Bypass Guidance at the Bar Mills Project, Saco River, Maine. Normandeau Project Number 18953. 9 pp + Appendices.

Normandeau Associates. 2002. Atlantic Salmon Smolt Passage Route Usage and Survival at the Bar Mills Project, Saco River, Maine. Normandeau Project Number 18916. Report Prepared for FPL Energy Maine Hydro, LLC, Portland, Maine. 13 pp. + Appendices.

Normandeau Associates. 2000. Atlantic Salmon Smolt Passage Routes and Survival at the West Buxton Project Saco River, Maine. Normandeau Project Number 17960. Report prepared for FPL Energy Maine Hydro, LLC, Portland, Maine.

Normandeau Associates, Inc. and Central Maine Power. 1998. Draft Report Movement and Behavior of Atlantic Salmon (*Salmo salar*) Smolts at the Bonny Eagle (FERC Project No. 2529), West Buxton (FERC Project No. 2531), Bar Mills (FERC Project No. 2194), and Skelton (FERC Project No. 2527) Hydroelectric Projects, Saco River, Maine. Report Prepared for Central Maine Power Company. 28 pp. + Appendices.

RMC Environmental Services. 1995. Final Report on Movement and Behavior of Atlantic Salmon Smolts, American Shad, and River Herring at the Cataract Fishways, Saco River, Maine. Report Prepared for Central Maine Power Company. 53 pp.

Bonny Eagle **(FERC No. 2529)** **River mile 26**

Project Description

Project Works: 784’ long earth and concrete Main River dam (including a 67’ high, 164’ long concrete intake structure protected by trash racks, a 12’ high, 370’ long east earth dike, and a 12’ high, 250’ long west earth dike), and the 13’ high, 350’ long concrete gravity New River dam.

Turbines: 6 **Turbine Type:** Horizontal Francis type

Generating Capacity: 7.2 MW

Hydraulic Capacity: 4,632 cfs

Downstream Passage System

Year Studied: 1998 **Life Stages Studied:** smolts

Permanent Bypass System: A log/trash sluice adjacent to the powerhouse serves as an interim bypass.

Study Methods: Radio telemetry

Collection Efficiency: 1.) spill conditions: 31% turbines, 42% bypass sluice, 27% spillway.
2.) flashboards up, 200 cfs in bypass: 7% turbines, 93% bypass sluice.
3.) flashboards up, 250 cfs in bypass: 9% turbines, 91% bypass sluice.

Turbine Survival: N/A

West Buxton **(FERC No. 2531)** **River mile 24**

Project Description

Project Works: 585’ long, 30’ high concrete gravity dam consisting of two overflow sections with a total crest length of 333’ (topped with 4’ high pintype flashboards), a gated section containing a 20’ wide vertical lift gate, two 40’ wide stanchion sections, an 11’ wide log sluice section, two gates regulating the flow of water to the lower powerhouse, five gate openings (two sealed by stop logs) admitting water to the upper powerhouse, and a 241’ long concrete conduit leading from the intake structure to a surge chamber and then to the lower powerhouse.

Turbines: 6

Turbine Type: 5 horizontal Francis type
1 Kaplan type

Generating Capacity: 7.9 MW

Hydraulic Capacity: 5,000 cfs

Downstream Passage System

Year Studied: 2000

Life Stages Studied: smolts

Permanent Bypass System: Fish in the forebay area enter a series of openings located at the top of units 1 through 5 trash racks. Fish enter these openings and then are sluiced to the existing trash sluice and into the tailrace.

Study Methods: Radio telemetry (efficiency), Balloon tags (survival)

Collection Efficiency: 1.) sluice open to 100 cfs discharge and flow induction devices operating at 3’ deep: 95% turbines, 5% sluice
2.) sluice open to 200 cfs discharge and flow induction devices operating at the surface: 36% turbines, 64% sluice
3.) sluice open to 200 cfs discharge and flow induction devices off: 60% turbines, 40% sluice
4.) sluice open to 100 cfs discharge and flow induction devices operating at the surface: 45% turbines, 55% sluice

Turbine Survival: 85% Francis type, 97% Kaplan type

Bar Mills **(FERC No. 2194) River mile 20**

Project Description

Project Works: 296' x 7' high concrete gravity spillway plus 6.75' hinged steel flashboards and a 14' wide log sluice in center of dam; 94' long canal headworks; 735' long canal including a 311' long non-overflow section, a 376' long overflow section, and 6'wide sluice. Bypass reach is 1,500' long.

Turbines: 2 **Turbine Type:** Vertical fixed blade propeller type Leffel turbines

Generating Capacity: 4.0 MW

Hydraulic Capacity: 3,120 cfs

Downstream Passage System

Years Studied: 2001- present **Life Stages Studied:** smolts

Permanent Bypass System: System constructed in 2000. A six-foot wide overflow weir gate (existing trash sluice) leads to a metal flume that deposits downstream migrating fish into a permanently watered plunge pool in the bypass reach. Conveyance flow is 120 cfs (4% of turbine flow). Four-foot deep and eight-foot deep-weighted booms were tested in 2003 to provide additional guidance of smolts to flume. Booms measured 250 feet long and were angled at 29 degrees.

Study Methods: Radio telemetry (RT) and PIT tags

Collection Efficiency: 1a) 4-ft deep unweighted boom: RT - 38% turbines, 62% bypass sluice; 1b) PIT – 26% turbines, 71% bypass sluice.
2a) 4-ft deep weighted boom: RT - 23% turbines, 77% bypass sluice; 2b) PIT - 49% bypass (failed antenna).
3a) 8-ft deep weighted boom: RT – 21% turbines, 77% bypass sluice; 3b) PIT – 4 tests: 34%, 62%, 92% and 94% bypass sluice.

Turbine Survival: 88% - one-year study (Normandeau Associates 2002).

Skelton **(FERC No. 2527) River mile 17**

Project Description

Project Works: 1,695' long concrete gravity and earth embankment dam topped with a roadway, consisting of: a 1,200' long earthen embankment section 59' high, a west bulkhead and spillway gate section 170' long by 75' high holding four Taintor gates each 32.5' wide by 20' tall, an intake structure 107' long by 146' wide with two openings protected by trash racks, a fishway and sluice section 30’ long, an east bulkhead and spillway gate section 188’ long by 75’ high with four Taintor gates each 32.5’ wide by 20’ high, a concrete retaining wall traversing along the western embankment 763’ long, and an excavated tailrace 150’ long.

Turbines: 2 **Turbine Type:** vertical Kaplan

Generating Capacity: 16.8 MW

Hydraulic Capacity: 3,200 cfs

Downstream Passage System

Years Studied: 1998 **Life Stages Studied:** smolts

Permanent Bypass System:

Study Methods: Radio telemetry

Collection Efficiency: 1.) spill conditions: 3% turbines, 11% bypass, 86% spillway.
2.) flashboards up, 200 cfs in bypass: 36% turbines, 64% bypass.
3.) flashboards up, 250 cfs in bypass: 100% bypass.

Turbine Survival: N/A

Cataract (FERC No. 2528) Head of tide

Project Description

Project Works: Includes Cataract (East Channel) Dam with a nonoverflow concrete section 116’ long and 52’ high, a concrete powerhouse intake section 49’ wide with two openings, a vertical lift Broome type gate section 20’ wide and 15’ high, an overflow spillway 90’ long and 30’ high with 4’ high hinged-type flashboards. The West Channel dam consists of a stone masonry dam section 238’ long and 7’ high with 4’ high pin-type flashboards, an orifice fishway section 17’ wide, a Taintor gate section 20’ wide and 15’ high, a spillway 36’ long and 17’ high with 4’ high pin-type flashboards, and a sluice gate about 15’ wide.

Turbines: 1 – East channel **Turbine Type:** vertical Kaplan type
Generating Capacity: 6.5 MW

Hydraulic Capacity: 3,100 cfs

Downstream Passage System

Years Studied: 1995 **Life Stages Studied:** smolts

Permanent Bypass System: East Channel – curtain wall in front of trash racks extending 10 ft below minimum pool level, and a bypass opening located on the east side of the trash racks leading to a flume that discharges into the tailrace.
West Channel – existing trash sluice modified by the addition of a flume extension, discharge from the sluice into a 6 ft deep plunge pool that leads into a concrete channel through Lower York Dam, then over a weir into a second tidal plunge pool adjacent to the entrance of the West Channel fishway.

Study Methods: Radio telemetry

Collection Efficiency: 1.) spill conditions; flashboards down on West Channel (W.C.) dam and up on East Channel (E.C.) dam: 12% E.C. turbines, 81% W.C. spillway, 7% E.C. bypass.
2.) flashboards up at both dams: 71% E.C. turbine, 29% E.C. bypass.

Turbine Survival: N/A

4.2.4 Penobscot River

These are references for studies conducted at hydropower dams on the Penobscot River, Maine, 1987-1999, as compiled by Norm Dube.

Bangor-Pacific Hydro Associates. 1993. 1992 Evaluation of Downstream Fish Passage Facilities at the West Enfield Project (FERC No. 2600). 11 pp. + Appendices.

Bangor-Pacific Hydro Associates. 1993. 1993 Evaluation of Downstream Fish Passage Facilities at the West Enfield Project (FERC No. 2600). 20 pp. + Appendices.

Bangor-Pacific Hydro Associates. 1994. 1994 Evaluation of Downstream Fish Passage Facilities at the West Enfield Project (FERC No. 2600). 18 pp. + Appendices.

Great Northern Paper, Inc. 1987. 1987 Report on Downstream Passage of Atlantic Salmon Smolts and Kelts at Weldon Dam. Mattaceunk Project, FERC No. 2520. Great Northern Paper, Inc., Millinocket, Maine. 32 pp. + Appendices.

Great Northern Paper, Inc. 1988. 1988 Report on Downstream Passage of Atlantic Salmon Smolts and Kelts at Weldon Dam. Great Northern Paper, Inc., Millinocket, Maine. x + 90 pp. + Appendices.

Great Northern Paper, Inc. 1989. 1989 Report on Downstream Passage of Atlantic Salmon Smolts and Kelts at Weldon Dam. Great Northern Paper, Inc., Millinocket, Maine. xi + 94 pp. + Appendices.

Great Northern Paper, Inc. 1990. 1990 Report on Downstream Passage of Atlantic Salmon Smolts and Kelts at Weldon Dam. Great Northern Paper, Inc., Millinocket, Maine. 10 pp. + Appendices.

Great Northern Paper, Inc. 1992. 1991-1992 Report on the Effectiveness of Interim Downstream Passage Facilities for Atlantic Salmon Smolts and Kelts at Weldon Dam. Mattaceunk Project. FERC No. 2520. Great Northern Paper, Inc., Millinocket, Maine. vi + 22 pp. + Appendices.

Great Northern Paper, Inc. 1993. 1993 Report on the Effectiveness of Permanent Downstream Passage Facilities for Atlantic Salmon at Weldon Dam. Mattaceunk Project. FERC No. 2520. Great Northern Paper, Inc., Millinocket, Maine. ii + 54 pp. + Appendices.

Great Northern Paper, Inc. 1994. 1994 Report on the Effectiveness of Permanent Downstream Passage Facilities for Atlantic Salmon at Weldon Dam. Mattaceunk Project. FERC No. 2520. Great Northern Paper, Inc., Millinocket, Maine. ii + 61 pp. + Appendices.

Great Northern Paper, Inc. 1995. 1995 Report on the Effectiveness of the Permanent Downstream Passage System for Atlantic Salmon Weldon Dam. Mattaceunk Project. FERC No. 2520. Great Northern Paper, Inc., Millinocket, Maine. ii + 78 pp. + Appendices.

Great Northern Paper, Inc. 1997. 1997 Report on the Effectiveness of the Permanent Downstream Passage System for Atlantic Salmon at Weldon Dam. Mattaceunk Project. FERC No. 2520. Great Northern Paper, Inc., Millinocket, Maine. ii + 61 pp. + Appendices.

Great Northern Paper, Inc. 1998. 1998 Report on the Effectiveness of the Permanent Downstream Passage System for Atlantic Salmon at Weldon Dam. Great Northern Paper, Inc., Millinocket, Maine. iii + 36 pp. + Appendices.

Great Northern Paper, Inc. 1999. 1999 Report on the Effectiveness of Permanent Downstream Passage Facilities for Atlantic Salmon Weldon Dam. Mattaceunk Project, FERC No. 2520. Great Northern Paper, Inc., Millinocket, Maine. 32 pp. + Appendices.

Hall, S.D. and S.L. Shepard. 1990a. 1989 Progress Report of Atlantic Salmon Kelt Radio Telemetry Investigations on the Lower Penobscot River. Bangor Hydro-Electric Co., Bangor, Maine. 30 pp.

Hall, S.D. and S.L. Shepard. 1990b. Report for 1989 Evaluation Studies of Upstream and Downstream Facilities at the West Enfield Project (FERC No. 2600). Bangor-Pacific Hydro Associates. 17 pp. + Appendices.

Shepard, S.L. 1989a. 1988 Progress Report: Atlantic Salmon Kelt Radio Telemetry Investigations in the Lower Penobscot River. Bangor Hydro-Electric Co., 32 pp. + Appendices

Shepard, S.L. 1991a. Report on Radio Telemetry Investigations of Atlantic Salmon Smolt Migration in the Penobscot River. Bangor Hydro-Electric Co., 38 pp. + Appendices.

Shepard, S.L. 1991b. Evaluation of Upstream and Downstream Fish Passage Facilities at the West Enfield Project (FERC No. 2600). Bangor-Pacific Hydro Associates, 25 pp. + Appendices. (Note: fall 1989 and spring 1990 studies).

Shepard, S.L. 1991c. Evaluation of Upstream and Downstream Fish Passage Facilities at the West Enfield Project (FERC No. 2600). Bangor-Pacific Hydro Associates, 27 pp. + Appendices. (Note: spring and fall 1991 studies).

Shepard, S.L. 1993. Survival and Timing of Atlantic Salmon Smolts Passing the West Enfield Hydroelectric Project. Bangor-Pacific Hydro Associates. 27 pp.

Shepard, S.L. and S.D. Hall. 1991. Final Report: Adult Atlantic Salmon Radio Telemetry Studies in the Penobscot River. Bangor Hydro-Electric Co., 49 pp. + Appendices.

Mattaceuk **(WELDON) (FERC No. 2520)**

Project Description

Project Works: 657' long x 40' high ogee spillway including 4' high flashboards; roller gate 90' long x 19' high to control spills and headpond levels.

Turbines: 4 **Turbine Type:** 2 fixed blade, 2 Kaplan

Generating Capacity: 19.2 MW

Hydraulic Capacity: 7,000 cfs

Downstream Passage System

Years Studied: 1987 – 1999 **Life Stages Studied:** smolts, kelts

Permanent Bypass System: 1) single surface inlets integral with trashracks on two of four turbine forebays for fish collection; 2) strobe lights in remaining two forebays for fish repulsion; 3) one-inch clear spacing overlay trashracks to depth of 16 feet at full pond at all four turbine intakes to discourage fish entrainment; 4) a 42-inch underground fish passage pipe for transport of collected fish to the tailrace area. System installed in 1992.

Study Methods: Radio telemetry; in-line monitoring facility at passage pipe

Collection Efficiency: Smolts -17% - 59%; six years combined – 38% (N = 155)
Kelts – 63% (fall studies, three years, N = 8)
Kelts – 76% (spring studies, three years, N = 25)

Turbine Survival: Not studied; estimated at 1) 95% for smolts (Truebe, J. and M. Drooker. 1985. A Summary of State of the Art Methods for Passage of Downstream Migrating Salmon With Application to the Great Northern Paper Weldon Station, Mattaceunk Project, Penobscot River, Maine. FERC No. 2520), and 2) 90% (acute mortality 10%, smolts, ASAL Model).

Downstream Passage Routes: spillway, roll gate, log sluice, fixed blade propeller turbines (2), Kaplan turbines (2), downstream passage system.

West Enfield **(FERC No. 2600)**

Project Description

Project Works: 363' long x 39' high ogee spillway plus 6' high flashboards; 45' long non-overflow spillway; 107' long gated spillway.

Turbines: 2 **Turbine Type:** Pit Type (horizontal Kaplan turbines)

Generating Capacity: 13 MW

Hydraulic Capacity: 9,000 cfs

Downstream Passage System

Years Studied: 1990 – 1994 (smolts) **Life Stages Studied:** smolts; kelts
1990 (kelts)

Permanent Bypass System: weirs (5) plus transport flume; system installed when project redeveloped in 1988.

Study Methods: radio telemetry

Collection Efficiency: Smolts -2% - 36%; five years combined – 17% (N = 259)
Kelts – 4% (spring study, N = 23)

Turbine Survival: 97.7% (acute mortality 2.3%, smolts, Shepard 1993); estimated at 95% (acute mortality 5%, smolts, ASAL Model).

Downstream Passage Routes: turbines, downstream passage system, spillway, and gates

Milford **(FERC No. 2534)**

Project Description

Project Works: 1,159' long x 20' high concrete gravity spillway plus 4.5' high flashboards; 25' wide concrete sluiceway and gate.

Turbines: 4 **Turbine Type:** Kaplan (3); fixed blade (1)

Generating Capacity: 6.4 MW

Hydraulic Capacity: 5,200 cfs

Downstream Passage System

Years Studied: 1989 – 1990 (smolts)
1988 – 1989 (kelts)

Life Stages Studied: smolts; kelts

Permanent Bypass System: No dedicated downstream bypass system at time of studies; angled rack guidance system to direct downstream migrants to and through an empty turbine pit has since been deployed. System has not been studied.

Study Methods: radio telemetry

Collection Efficiency: Smolts – N/A; 41% turbine passage; 59% spillway passage; (N = 68)
Kelts – N/A; 100% spillway passage; spring studies only, (N = 30)

Turbine Survival: Not studied; estimated at 91% (acute mortality 9%, smolts, ASAL Model).

Downstream Passage Routes: turbines, spillway, gates, and downstream passage system

Veazie **(FERC No. 2403)**

Project Description

Project Works: 902' long x 25' high concrete buttress spillway including 6.5' Obermeyer inflatable flashboard system; approximately 240' long x 25' high concrete forebay including 3.5' (approximate) high fixed flashboards.

Turbines: 15 (Station A); 2 (Station B)

Turbine Type: Station A: vertical Francis (15); Station B: vertical fixed blade (2)

Generating Capacity: 5.4 MW (Station A); 3.0 MW (Station B)

Hydraulic Capacity: 7,525 cfs

Downstream Passage System

Years Studied: 1989 – 1990 (smolts)
1988 – 1989 (kelts)

Life Stages Studied: smolts; kelts

Permanent Bypass System: No dedicated downstream bypass system; attempts have been made to utilize trash gate/ice sluice as downstream bypass route for smolts with limited success. Studies were undertaken when main spillway had 6.5' hinged wooden flashboards (i.e. prior to installation of Obermeyer system).

Study Methods: radio telemetry

Collection Efficiency: Smolts – N/A; 29% turbine passage; 71% spillway/ice sluice passage; (N = 42)
Kelts – N/A; 100% spillway passage; spring studies only (N = 30)

Turbine Survival: Not studied; estimated at 91% (acute mortality 9%, smolts, ASAL Model).

Downstream Passage Routes: turbines, spillway, forebay, trash gate, and ice sluice

Note: Downstream passage data were collected for other projects in the lower Penobscot system (Stillwater, Orono, Great Works) but did not study specific downstream passage routes, rather only monitored passage by the projects.

4.3 Recommendations to U.S. Delegation regarding ICES and NASCO

ICES WGNAS

The US Atlantic Salmon Assessment Committee (USASAC) recommends that NASCO changes its practice of asking the ICES Working Group on North Atlantic Salmon (WGNAS) for catch advice each year to providing catch advice every two years. Such catch advice should cover two year periods. During the years when catch advice is not requested, the USASAC recommends that the WGNAS meets and works on scientific issues other than catch advice, such as North Atlantic Ocean ecosystem considerations and sources of marine mortality of Atlantic salmon.

The USASAC notes that current overall Atlantic salmon stock levels are so far below conservation limits that there is essentially zero chance of the population increasing sufficiently within a one year time frame to allow a commercial fishery in West Greenland, while meeting the 75% probability of achievement standard. The current models used by the WGNAS can be used to provide the multi-year catch advice as well as generate probabilities of catch that could be foregone in the second year of a multi-year catch quota. This arrangement allows application of the Precautionary Approach when setting catch quotas by considering both the status of the stock as well as the potential yield to the fishery. If necessary, the US delegation could request a more detailed explanation from US scientists of why catch advice covering two year periods is unlikely to miss significant stock recoveries.

The WGNAS meetings during years when catch advice is not provided could include scientists who have expertise with other species, fisheries, or issues in the North Atlantic Ocean. Their participation would assist the group to examine issues that may be preventing stock rebuilding other than fishing. The benefit to NASCO would be additional information that could be used to open dialog with other groups that manage resources that impact Atlantic salmon. For example, if the WGNAS concluded that the population abundance of prey was limiting salmon production in the Atlantic Ocean, NASCO could initiate a dialog with the ICES ACFM regarding the management of the fisheries for these prey species.

Next Steps for NASCO

The US Atlantic Salmon Assessment Committee (USASAC) recommends that NASCO considers contracting ICES for catch advice on a schedule of every two years. The USASAC suggests that this opportunity could provide the possibility for NASCO to increase its role as an international coordinator and facilitator for Atlantic salmon by initiating a Standing Scientific Committee to more thoroughly evaluate the hypothesized cause of increased salmon mortality at sea. Scientists from NASCO contracting parties would constitute this standing committee although membership could be dynamic, thereby allowing experts from many different fields to contribute to the knowledge base investigating these marine related issues. The meeting would operate in the ICES working group model and the schedule would be determined by the needs of the committee. However, the USASAC envisions that this group would meet frequently to ensure continued progress towards investigating the mechanisms related to the increased marine mortality as documented in recent years.

4.4 Stocking Guidelines

Compliance with NASCO Stocking Guidelines found in Document CNL(03)55

Programs for rebuilding and recovering Atlantic salmon populations in the U.S. (which include the Connecticut River, Maine Rivers, Merrimack River, and Pawcatuck River Programs) are in compliance with the NASCO guidelines for stocking Atlantic salmon as found in document CNL (03)55. The term stocking is defined in the guidelines as “the deliberate release of Atlantic salmon at any stage of their life cycle into the wild for enhancement, mitigation, restoration, rehabilitation or ranching purposes.” For the purposes of stocking guidance, the North American Commission (NAC) classifies rivers into three types: Class 1 (Pristine), Class II (Habitat alterations, non-indigenous wild or hatchery-reared Atlantic salmon populations), and Class III (Habitat alterations, non-indigenous fish species). Class I rivers do not exist in each of the four stated programs. Whereas the Maine Rivers program includes both Class II and III rivers, only Class III rivers are represented in other programs. All programs enlist active participation of partners and stakeholders, and culture and management actions and measures are identified and prioritized in planning documents available to all interested parties. No salmon of European origin are cultured or released in US waters. Fish health inspections and best management practices are established and maintained at all culture facilities, and fish transfers among facilities are in compliance with all national and state regulations. Restoration and recovery plans are adaptive, culture programs implement best management practices in consultation with geneticists and conservation biologists, and proponents and agencies responsible for salmon stocking and managing populations evaluate programs and compile and maintain summary and accomplishment reports. The Committee has not identified any necessary changes to the existing Stocking Guidelines.

4.4.1. Connecticut River

B. Guidelines applicable to all rivers:

1. No salmon of European origin are released.
2. Fish health inspections are maintained at all facilities and no ‘emergency diseases’ were detected in any fish.
3. All transfers between facilities within the basin are in compliance with all national and State regulations. There are no transfers across the basin boundaries.
4. Considerable consultation with geneticists and conservation biologists has occurred throughout the 37-year history of the program and a Genetics Subcommittee has developed management protocols and monitors implementation.
    a. Eggs of wild, sea-return fish are used in the program but are augmented with eggs from reconditioned kelts and captive broodstock that are F1 generation of wild parents.
    b. The removal of wild spawners does not have a negative impact on the population because the nascent population has always been maintained in hatcheries and does not rely on natural reproduction.

c. Over 90% of wild returning salmon is retained for spawning and the selection of these fish (as opposed to the other 10%) is random and includes all components of the populations.
d. For much of the history of the program, more than 50 random pairs have been used in spawning. In recent years, the number of returning adults has dipped below 100 fish and the balance of the 50 females (when needed) were made up with captive kelts (females that were sea-returns during a previous year) and the balance of the 50 males were made up with mature parr from streams stocked with fry that had wild, sea-return parents. Although these mature parr had not been to sea, the reasoning has been that the fish spent minimal time in a hatchery and had been subjected to natural selection in the stream and therefore these fish were preferable over domestic broodstock that had spent their entire life in a hatchery.
e. Milt is never mixed in breeding, with mating schemes of 1 to 1.
f. Early in the history of the program, eggs from a number of different North American rivers were used in the stocking program. The full extent of the contribution of some of these stocks to subsequent generations is unknown but it is known that Maine salmon stocks have made major contributions to the development of the Connecticut River stock.
g. The major stocking strategy is fry stocking with sporadic and relative small stockings of hatchery-reared smolts and very minor stockings of eggs and parr.

5. It is assumed that the large Connecticut River watershed historically supported multiple Atlantic salmon stocks and ideally when salmon is re-established to the river, the population will be managed in a manner that will allow the development of separate sub-populations in large tributaries or portions of the watershed. However, at this point in the restoration program, all fish are being managed as one population. Due to low numbers of returns and the need to maintain a minimum effective breeding population, management for separate sub-populations (stocks) is premature.

E. Guidelines applicable to Class III rivers (the Connecticut River is a class III river):

1. There are no remaining native stocks of Atlantic salmon in the Connecticut River watershed or within 300 miles of the mouth of the Connecticut River so the stocking of salmon in this watershed may proceed without the need for “careful ecological impact evaluations”.
2. Rehabilitation
   (a) The key strategies are to improve degraded habitat, restore fish passage, and generate sea-returns through stocking. However, at this point in the program, a very small true spawning escapement is allowed. Most returning adults are captured for captive broodstock spawning to produce fry for stocking. Eventually, as returns increase, more sea-returns will be released for a true spawning escapement.
   (b) The stocking of cultured salmon is a major tool for rehabilitation.
3. Restoration of salmon in a river where there are no salmon (this is the case for the entire Connecticut River watershed)

(a) All tributaries to the Connecticut River as well as most rivers in New England have lost their native salmon populations and it has not been useful to evaluate “genetic and ecological characteristics” of these streams.
(b) The restoration program has relied on the use of the nearest salmon river: the Penobscot River.
(c) Consideration has been given to impacts on the existing fish community and fisheries. No deleterious impacts are expected. Existing parr populations seem to be coexisting with other stream species and existing fisheries.

4. No commercial ranching of Atlantic salmon currently exists in or around the Connecticut River.

IV. Guidelines for Authorizing Stocking

A. All stockings are conducted by State or federal agencies that are partners of the restoration program.

B. Proponent of stocking
1. All agencies that stock salmon must have the approval of the Connecticut River Atlantic Salmon Commission and the information provided is consistent with that in Box 1.
2. justifications are not necessary since the stockings are all part of the restoration program.
3. Not applicable.
4. All stockings are reported back to the Commission.

C. Responsibility of the Commission, which issues permits
a. Not applicable- no existing wild salmon populations.
b. All proponents are members of the Commission and understand the guidelines.
c. A permit system and inventory for all stockings has been established and is maintained.
d. Each State within the watershed has enacted regulations that control the stocking of salmon.
e. Formal evaluation of the stockings occurs annually.
f. Not applicable- no existing wild salmon populations.
g. No comment.
h. Can be provided upon request.

4.4.2. Maine Rivers

Rationale for stocking:

The current Atlantic salmon stocking program in Maine is focused on five populations listed as endangered under the Endangered Species Act, the Penobscot River, and several other rivers. All rivers contain populations that are at very low levels, and most if not all populations would be extinct if not for the stocking program.

Our goal is to restore salmon to Maine rivers. To this end, we have followed a program of stocking salmon that would not adversely affect the wild populations or have negative impacts on the ecological systems.

A. River Classes in Maine:

Maine has only Class II and III rivers.

B. Guidelines applicable for all rivers:

1. Maine uses only native strains of salmon for stocking. We actively genetically screen fish for European ancestry and remove them from the population if identified.
2. All fish and eggs are screened for disease and pathogens before they are moved to another facility or stocked into the wild.
3. All fish moved or stocked comply with national, state, and provincial (border waters) regulations for restricted diseases.
4. All broodstock has been derived from wild collected salmon. Whenever possible, all hatchery populations are derived from natal populations specific to a river to maintain the uniqueness of the stocks. Broodstock has been derived from various age classes including adults, young of the year, parr, and smolts. Parr are the primary source of broodstock, except on the Penobscot where sea-run adults are the source of broodstock. Removal of donor broodstock generally has little negative impact on the number of naturally reared returning adults. In cases where the population is at high risk, removing fish for broodstock may be the only method to maintain the population until recovery becomes successful. All broodstock populations are managed for as robust an effective population size as possible. While this can be challenging with very small populations, we strive to maintain minimum numbers of parents per generation. We also generally follow a one:one mating scheme. However, we will deviate from this to optimize genetic diversity in very small populations.
5. Our current system does not attempt to manage subpopulations within drainages. Most rivers are small and likely had only one population. In larger rivers with diverse habitat (Penobscot, Machias), there may have been more than one population. However, it is not clear if these populations were extant when the stocking program was implemented.

D. Class II Guidelines

1. Maine does not use non-indigenous populations in any rivers for any type of stocking. We do restoration activities in the freshwater and marine environments of some rivers.

2. Maine is attempting to restore and protect habitat, as well as increase the numbers of spawning adults by numerous fisheries management approaches. The extremely small size of some of our populations, as well as the endangered status under ESA, have also necessitated using river-specific populations for restoration. In cases where the natal population is no longer extant or too small to be viable, we will seek the ecologically and genetically best population(s) for restoration. We predominantly stock fry in rivers, many of which do not have any, or very few spawning adults. We have also stocked pre-spawn adults, and continue to evaluate this as a

restoration approach. In the Penobscot, and other rivers at times, we stock smolts. This is done when too few fry are available, or demographics require returning adults annually.

3. In cases where the river is devoid of natal salmon we would stock the river with fry or eggs from a nearby river with genetically and ecologically compatible fish.

4. Maine does not sea ranch salmon for population restoration or recreational fishing. However, commercial aquaculture operations rear salmon in marine net pens.

E. Class III guidelines

1. For class III rivers Maine would follow the guidelines outlined for Class II rivers.

Guidelines for Administering Stocking

All Atlantic salmon stocking in Maine is permitted through the Maine Atlantic Salmon Commission. This agency follows the guidelines for proponents. All stocking proposals are reviewed by a Technical Advisory Committee (TAC) before being permitted. All stocking is reported by this agency. Evaluation of the effectiveness of the stocking program is ongoing, led by the Maine Atlantic Salmon Commission in collaboration with NOAA Fisheries and the United States Fish and Wildlife Service. Results of this evaluation process will be used to modify and improve the stocking program and its effectiveness towards the goals of achieving self-sustaining populations of Atlantic salmon in Maine rivers.

4.4.3. Merrimack River

B. Guidelines applicable to all rivers:

1. No salmon of European origin released.
2. Fish health inspections maintained at all facilities.
3. All transfers among facilities supporting the program were in compliance with all national and State regulations.
4. Consultation with geneticists and conservation biologists has occurred throughout the history of the Merrimack River program and the results of a recent genetic characterization of sea run returns, kelts, and domestic broodstock at the Nashua and North Attleboro National Fish Hatcheries will now be used to refine hatchery mating protocols and management measures.
    a. Eggs of wild, sea-return fish are used in the program but are augmented with eggs from reconditioned kelts and captive broodstock that are F1 generation of wild parents.
    b. The nascent population is maintained in hatcheries and has not relied on natural reproduction.
    c. All sea-returning salmon are retained for spawning, and donor stocks of age 1 hatchery smolts of Penobscot River origin are released annually in the watershed.

d. For much of the history of the program, about 50 random pairs have been used in spawning. Throughout the last decade, donor stocks of age 1 hatchery smolts (Penobstock River, 50,000) have been released in the watershed and time series suggest that approximately 80% of sea-returning adults typically originate from these smolt donor stocks each year. Captive kelts (females that were sea-returns during a previous year) and domestic broodstock are also used to produce gametes to meet fry production targets for the program.
e. The program has strived to achieve mating schemes of 1 to 1, and the results of recent genetic characterization of adult spawners will provide opportunities to implement refined spawning protocols.
f. Early in the history of the program, eggs from a number of different North American rivers were used in the stocking program. The full extent of the contribution of some of these stocks to subsequent generations is unknown but it is likely that Maine salmon stocks have made major contributions to the development of the Merrimack River stock.
g. The major stocking strategy is fry stocking (unfed fry), and age 1 smolt stocking.

5. It is assumed that the Merrimack River watershed historically supported multiple Atlantic salmon stocks and ideally when a run of salmon is re-established, the population will be managed in a manner that will allow the development of separate sub-populations in large tributaries or portions of the watershed. At this time all fish are being managed as one population. Due to low numbers of returns and the need to maintain a minimum effective breeding population, management for separate sub-populations (stocks) is premature.

E. Guidelines applicable to Class III rivers (the Merrimack River is a Class III river):

5. There are no native stocks of Atlantic salmon in the Merrimack River watershed or within 200 miles of the mouth of the Merrimack River so the stocking of salmon in this watershed may proceed without the need for "careful ecological impact evaluations".
6. Rehabilitation
   (a) The key strategy is to improve degraded habitat, restore fish passage, and generate sea-returns through stocking. At this point no spawning escapement occurs. All returning adults are captured for captive broodstock spawning to produce fry for stocking. As returns increase, sea-returns will be released for spawning escapement.
   (b) The stocking of cultured salmon is a major tool for rehabilitation.
7. Restoration of salmon in a river where there are no salmon (this is the case for the entire Merrimack River watershed)
   (a) All tributaries to the Merrimack River as well as most rivers in New England have lost their native salmon populations and it has not been useful to evaluate "genetic and ecological characteristics" of these streams.
   (b) The restoration program has relied on the use of the nearest salmon river: the Penobscot River.
   (c) Consideration has been given to impacts on the existing fish community and fisheries. No deleterious impacts are expected. Existing parr populations seem to be coexisting with other native stream species and existing fisheries.

8. No commercial ranching of Atlantic salmon currently exists in or around the Merrimack River.

IV. Guidelines for Authorizing/Administering Stocking

A. All life stages of fish are released by State or federal agencies that are partners in the restoration program.

B. Proponent of stocking

5. All agencies that stock salmon must have the approval of the Merrimack River Policy Committee (Policy Committee) and the information provided is consistent with that in Box 1.
6. Justifications are not necessary since the stockings are all part of the restoration program.
7. Not applicable.
8. All stockings are reported back to the Policy Committee.

C. Responsibility of the Commission, which issues permits

1. Not applicable- no existing wild salmon populations.
2. All proponents are members of the Policy Committee and understand the guidelines.
3. A permit system and inventory for all stockings has been established and is maintained.
4. Each State within the watershed has enacted regulations that control the stocking of salmon.
5. Formal evaluation of the stockings occurs annually.
6. Not applicable- no existing wild salmon populations.
7. Can be provided upon request.

4.4.4. Pawcatuck River

B. Guidelines applicable to all rivers:

1. No salmon of European origin released.
2. Fish health inspections maintained at all facilities.
3. All transfers among facilities supporting the program were in compliance with all national and State regulations.
4. Consultation with geneticists and conservation biologists has occurred throughout the history of the Pawcatuck River program and the results of a recent genetic characterization of sea run returns, kelts, and domestic broodstock at the Nashua and North Attleboro National Fish Hatcheries will now be used to refine hatchery mating protocols and management measures.
    h. Eggs from captive broodstock that are F1 generation of wild parents are used in the program.

i. The nascent population is maintained in hatcheries and has not relied on natural reproduction.
j. All sea-returning salmon are retained for spawning, and donor stocks of fry from Merrimack River captive broodstock that are F1 generation of wild parents are used in the program.
k. For much of the history of the program donor stocks of fry from Merrimack River captive broodstock that are F1 generation of wild parents have been used in the program. Donor stocks of age 1 hatchery smolts (Penobstock River, 50,000) have been released in the Merrimack River watershed and time series suggest that approximately 80% of sea-returning adults typically originate each year from these smolt donor stocks.
l. The program has strived to achieve mating schemes of 1 to 1, and the results of recent genetic characterization of adult spawners will provide opportunities to implement refined spawning protocols.
m. Early in the history of the program, eggs from a number of different North American rivers were used in the stocking program. The full extent of the contribution of some of these stocks to subsequent generations is unknown but it is likely that Maine salmon stocks have made major contributions to the development of the Merrimack River stock.
n. The major stocking strategy is fry stocking (unfed fry), and occasionally age 1 smolt stocking.

5. It is assumed that the Pawcatuck River watershed historically supported multiple Atlantic salmon stocks and ideally when a run of salmon is re-established, the population will be managed in a manner that will allow the development of separate sub-populations in large tributaries or portions of the watershed. At this time all fish are being managed as one population. Due to low numbers of returns and the need to maintain a minimum effective breeding population, management for separate sub-populations (stocks) is premature.

E. Guidelines applicable to Class III rivers (the Pawcatuck River is a class III river):

1. There are no native stocks of Atlantic salmon in the Pawcatuck River watershed or within 200 miles of the mouth of the Pawcatuck River so the stocking of salmon in this watershed may proceed without the need for “careful ecological impact evaluations”.
2. Rehabilitation
   (b) The key strategy is to improve degraded habitat, restore fish passage, and generate sea-returns through stocking. At this point no spawning escapement occurs. All returning adults are captured for captive broodstock spawning to produce fry for stocking. As returns increase, sea-returns will be released for spawning escapement.
   (c) The stocking of cultured salmon is a major tool for rehabilitation.
3. Restoration of salmon in a river where there are no salmon (this is the case for the entire Pawcatuck River watershed)
   (d) All tributaries to the Pawcatuck River as well as most rivers in New England have lost their native salmon populations and it has not been useful to evaluate “genetic and ecological characteristics” of these streams.

(e) The restoration program has relied on the use of the nearest salmon river: the Penobscot River.
(f) Consideration has been given to impacts on the existing fish community and fisheries. No deleterious impacts are expected. Existing parr populations seem to be coexisting with other native stream species and existing fisheries.

4. No commercial ranching of Atlantic salmon currently exists in or around the Pawcatuck River.

IV. Guidelines for Authorizing/Administering Stocking

A. All life stages of fish are released by State or federal agencies that are partners in the restoration program.

B. Proponent of stocking

1. All agencies that stock salmon must have the approval of the Rhode Division of Fish and Wildlife (Division) that is consistent with that in Box 1.
2. Justifications are not necessary since the stockings are all part of the restoration program.
3. Not applicable.
4. All stockings are reported back to the Division.

C. Responsibility of the Commission, which issues permits

1. Not applicable- no existing wild salmon populations.
2. All proponents coordinate with the Division and understand the guidelines.
3. A permit system and inventory for all stockings has been established and is maintained.
4. Each State within the watershed has enacted regulations that control the stocking of salmon.
5. Formal evaluation of the stockings occurs annually.
6. Not applicable- no existing wild salmon populations.
7. Can be provided upon request.

4.5 Stock Rebuilding

Adherence to NASCO Guidelines on the Use of Stock Rebuilding Programmes in the Context of the Precautionary Management of Salmon Stocks (CNL(04)55)

The status and stock rebuilding programs for Atlantic salmon populations in the U.S. (which include the Connecticut, Maine, Merrimack, and Pawcatuck River Programs) continue to be evaluated in relation to conservation limits, exploitation, stock history and diversity indices, uncertainty in data and estimation procedures, and the reasons for declines and population losses. With the exception of the Pawcatuck River, each Program has established a Technical Advisory Committee to guide the implementation of management measures designed to restore or recover salmon stocks above conservation limits. Factors that contribute to depressed population levels (e.g. environmental changes, habitat losses, subsistence harvest, etc.) are also being evaluated. In addition, genetics and pathology are assessed, research and management actions prioritized for restoration and recovery, and strategies developed to protect and restore critical habitats. Stakeholders have been identified and included in theses processes. In Maine, the river-specific stocking already established is consistent with NASCO Stocking Guidelines. Threat assessments are also underway in Maine to identify risks as part of the Endangered Species Act listing and the recovery planning process.

4.5.1. Connecticut River

1. Background: The Connecticut River population is below its Conservation Limit and a stock rebuilding program has been developed.

2. A Technical Advisory Committee is in place to guide the implementation of management measures designed to restore or recover this stock above conservation limits.

3. An evaluation of the stock's status has been conducted. The native stock(s) is extinct. A restoration population is far below the Conservation Limit for the watershed.

4. An evaluation of stock decline and threats has been conducted.

   A) Natural environmental change - changes have occurred since the extirpation of the native stocks but environmental conditions still appear to fall within the range of acceptability for Atlantic salmon.

   B) Habitat degradation - considerable habitat degradation has occurred since the extirpation of the native stocks, particularly in terms of sedimentation, water quality and migratory barriers. However, and with remedial actions, it is believed that the condition of the existing habitat will support Atlantic salmon.

   C) Species interactions - There are many interactions with native species that are not worrisome, but there are many non-native species in the basin (some of these non-natives may have negative impacts on Atlantic salmon populations).

   D) Exploitation - There is no exploitation, commercial or recreational, of salmon in the basin.

   E) Differential effects on stock components - Very few grilse return to the Connecticut River. New England grilse tend to return in late summer, when Long Island is too warm for salmon.

5. Stakeholders and partners in the Connecticut River Program have been identified and are fully involved in the program.

6. Management actions have been planned and prioritized with the development of a strategic plan (Anonymous. 1998). The plan includes research needs, environmental management, fishery management, and gene banking.

7. Interim measures have been identified and implemented. These include stocking of juveniles, capture of returning adults for breeding, and the prohibition of all salmon exploitation. Interim reference points are provided in the Strategic Plan.

8. Social and economic factors have been considered in the program. A new socio-economic study is proposed for the program.

9. Population sizes and responses to management activities are monitored, and management activities are regularly evaluated.

4.5.2. Maine Rivers

1. In Maine, a stock-rebuilding program is in place, partly as a result of the listing of the Gulf of Maine Distinct Population Segment (DPS) as endangered under the United States Endangered Species Act (ESA), and partly because of general efforts to restore salmon to Maine waters.

2. A Technical Advisory Committee is in place to guide the implementation of management measures designed to restore or recover DPS and Penobscot-strain stocks above conservation limits.

3. The status of salmon stocks in Maine continues to be evaluated in relation to conservation limits, exploitation, and uncertainty in data and estimation procedures, history of the stocks, stock diversity, and the reasons for the declines and loss of populations in Maine.

4. Factors that may contribute to the depressed levels of Maine's salmon stocks are currently being evaluated. These include environmental change (such as hydrology and water temperature alterations); habitat degradation and habitat loss; species interactions (including exotic species, aquaculture, and indigenous species); exploitation (salmon fishing in Maine is not permitted), including Greenland ocean harvest; and demographic and genetic factors and susceptibilities.

5. The Maine Program has identified, included, and involved stakeholders from federal, state, tribal, and local governments and their agencies; commercial interests (such as aquaculture, forestry, and agriculture); various local and broader non-profit environmental groups; academic institutions; and the general public.

6. The process of identifying threats, prioritizing rivers and populations, and prioritizing management actions and research to best manage and restore salmon in Maine is part of the ESA listing process, but is also being pursued independently of this process. The Maine Program has been protecting critical habitat, restoring habitat, and attempting to

evaluate various factors, both natural and anthropogenic, that may be causing the decline in salmon. Currently the harvest strategy is no harvest. A captive broodstock program for six populations that serves as a protective gene bank in case of full loss in the wild has been established (Draft, 2005).

7. The Maine Program is currently establishing recovery goals, including interim measures. A risk assessment process has been initiated in tandem with recovery planning. In addition, we have already established a stocking program (based on river-specific culture and stocking protocols) that follows NASCO Stocking Guidelines.

8. The Maine Program continues to assess and adapt our management based on social and economic factors. Biological factors are the primary decision-making tools, but social and economic factors are considered and evaluated in decision-making.

9. The Maine Program will continually monitor, evaluate progress and assess the effectiveness of our management activities.

4.5.3. Merrimack River

1. Background: The Merrimack River population is below its Conservation Limit and a stock rebuilding program has been developed.

2. A Technical Advisory Committee is in place to guide the implementation of management measures designed to restore or recover this population above conservation limits.

3. The native stock(s) is extinct. The restoration population is far below the Conservation Limit for the watershed.

4. An evaluation of stock decline and threats has been conducted.

    A) Natural environmental change - changes have occurred since the extirpation of the native stocks but environmental conditions still appear to fall within the range of acceptability for Atlantic salmon.

    B) Habitat degradation - considerable habitat degradation has occurred since the extirpation of the native stocks, particularly in terms of sedimentation, water quality and migratory barriers. However, there have been remedial actions and it is believed that the condition of the existing habitat will support Atlantic salmon.

    C) Species interactions - There are many interactions with native species that are not worrisome but there are many non-native species in the basin (some of these non-natives may have negative impacts on Atlantic salmon populations).

    D) Exploitation - There is no exploitation, commercial or recreation, of wild sea-returning salmon in the watershed.

E) Differential effects on stock components - Few grilse return to the Merrimack River, and the majority of sea-returning fish of fry origin are identified as age 4 fish (W2.2) and as age 1 smolt-origin fish (H1.2).

5. Stakeholders and partners involved in the Merrimack River Anadromous Fish Restoration Program are fully engaged in activities, and roles and responsibilities are defined.

6. Management actions and measures have been planned and prioritized with the development of a Strategic Plan (Technical Committee for Anadromous Fishery Management of the Merrimack River Basin and Advisors to the Technical Committee. 1997). The plan includes research needs, environmental and fishery management measures, hatchery production targets, and overall goals and objectives.

7. Interim measures are identified in the Strategic Plan and many have been implemented. Measures include stocking of various life stages, capture of returning adults for breeding, and a prohibition of the exploitation of sea-run salmon.

8. Social and economic factors have been considered in the program.

9. Population sizes and responses to management activities are monitored, and management activities are regularly evaluated.

4.5.4. Pawcatuck River

1. Background: The Pawcatuck River population is below its Conservation Limit and a stock rebuilding program has been developed.

2. A Technical Advisory Committee will be re-established to guide the implementation of management measures designed to restore or recover this population above conservation limits.

3. An evaluation of the stock status has been conducted. The native stock(s) is extinct. A restoration population is far below the Conservation Limit for the watershed.

4. An evaluation of stock decline and threats has been conducted.

    F) Natural environmental change - changes have occurred since the extirpation of the native stocks but environmental conditions still appear to fall within the range of acceptability for Atlantic salmon.

    G) Habitat degradation - considerable habitat degradation has occurred since the extirpation of the native stocks, particularly in terms of sedimentation, water quality and migratory barriers. However, there have been remedial actions and it is believed that the condition of the existing habitat will support Atlantic salmon.

H) Species interactions - There are many interactions with native species that are not worrisome but there are many non-native species in the basin (some of these non-natives may have negative impacts on Atlantic salmon populations).

I) Exploitation - There is no exploitation, commercial or recreation, of wild sea-returning salmon in the watershed.

J) Differential effects on stock components - Very few grilse return to the Pawcatuck River.

5. Stakeholders involved in the Pawcatuck River Anadromous Fish Restoration Program are fully engaged in activities, with roles and responsibilities well defined.

6. Management actions and measures have been planned and prioritized with the development of a Strategic Plan (Technical Committee for Anadromous Fishery Management of the Pawcatuck River Basin. 1997). The plan includes research needs, environmental and fishery management measures, hatchery production targets, and overall goals and objectives.

7. Interim measures are identified in the Strategic Plan and many have been implemented. Measures include stocking of various life stages, capture of returning adults for breeding, and a prohibition of the exploitation of sea-run salmon.

8. Social and economic factors have been considered in the program.

9. Population responses to management activities are monitored and management activities are evaluated.

References

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Draft 2005. Captive Broodstock Management Plan for Atlantic Salmon at Craig Brook National Fish Hatchery, East Orland, Maine. 2005. Maine Broodstock Management Plan Committee.

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4.6 NASCO Habitat Database

Progress in entering data in this database varies by program. Within the Connecticut River Program, the states of CT, NH, and VT have entered most of the required data for 35 rivers. The decision was made to enter data for only the mainstem of the Connecticut River and the major tributaries that drain directly to the mainstem. Data for streams that flow into those major tributaries will be lumped with data for those major tributaries. The Committee agreed to follow that protocol for all New England river systems. Data are entered for the Pawcatuck River Program but more work is needed. The Maine and Merrimack River programs have explored the database but have not made significant data entries. The Committee discussed several frustrations with web based data entry. In particular, both the USASAC database and the State of Maine database include data on adult returns and juvenile densities that could be exported in bulk format to the NASCO database. Similarly, Maine maintains habitat data in a database that could be exported to the NASCO database. However, due to the way the NASCO database is now set up, each of these numbers would need to be entered individually. Another frustration was that users are not able to track previous entries of environmental impacts as new entries are made. Ed Baum was present and asked the group to send him a note when they encountered problems with data entry. He also entertained the possibility of importing data for a program as tables rather than requiring single river data entry.

4.7 Research

Research abstracts were compiled into a single Microsoft Word Document this year instead of using Procite software due to the inability to export the data to a Microsoft Access database as intended. The goal remains to place abstracts into a common database accessible through the Website both for submission as well as key word searching and subsequent use. This would be maintained as a continuing database over the years.

In reviewing the current format of abstracts, a recommendation was made in 2004 to categorize the abstracts by the source of information, e.g. peer review paper, abstract of current work, poster presentation, etc. It was agreed that this would be incorporated into the database.

Efforts will continue to design and implement a Website enabled database with appropriate fields including the source of the abstract as noted above. The prototype database would first be circulated to the Committee for review.

4.7.1 Conservation Or Management

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

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The goal of this study is to determine factors influencing inter-stage survival of juvenile Atlantic salmon in the Sheepscot River Watershed, Maine. This project will begin with batching family groups from spawning in the fall 2004, and stocking into specific river sections in the spring 2005. Unique genetic batches will be stocked into separate river sections, concordant with current stocking densities used for the Sheepscot River. Survival from fry to age-1 parr will be assessed during electrofishing surveys in > 25 sites in the early fall 2006. Apparent survival and growth at each site will be correlated with macrohabitat features such as watershed area, stream temperature, pH, stream gradient, and surrounding land use. Survival will also be correlated with abundance of non-salmon and predatory species. Tissue samples will be obtained from a subsample of parr collected at each site for genetic analysis to determine parentage and assess relative survival of family groups stocked in a specific site. During the spring 2007 smolt outmigration, smolts will be captured in the rotary screw trap operated by NOAA-Fisheries near Head Tide Dam. Tissue samples will be obtained from emigrating smolts throughout the smolt run, and parentage analysis will be used to determine which river section the fish were originally stocked as fry. Relative survival to the smolt stage will then be compared among river sections. Also, relative survival to the smolt stage will be correlated to survival to age-1 parr in a river section. This analysis will identify which river sections result in the highest survival to the smolt stage and will help to identify impediments to smolt outmigration. For example, a particular river section may have high survival to the age-1 parr stage, but contribute a small proportion to the outmigrating smolt population due to barriers (e.g. predation, thermal regimes, etc.) to outmigration. The results of this study 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.

Long-term changes in migration timing of adult Atlantic salmon at the southern edge of the North American species distribution: local adaptation or a coast-wide response to environmental change?

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The Connecticut River historically represented the southernmost extent of the North American range of Atlantic salmon, but the native population was extirpated 200 years ago by dam construction. An extensive restoration effort has relied upon stock transfers from more northern rivers, especially the Penobscot River (Maine). Long-term success depends on the donor stocks adapting to the new river. Recent genetic work has shown differences between donor and derivative populations but life history traits have not been quantitatively compared. Here we focus on the timing of the adult migration. Based on data from other salmon stocks we expect that many native salmon migrated in March/April compared to May/June in more northerly stocks. We examined 23 years of migration timing data collected at two capture locations in the Connecticut drainage and found that both date of first capture and median capture date shifted significantly earlier by about 0.5 days/year. In order to conclude whether this is an adaptive change or a coast-wide effect we also quantified changes in migration timing of more northerly stocks (in Maine and Canada). We found a latitudinal pattern in the average returns dates as well as coherent patterns in the shifts towards earlier peak migration dates across the systems. These consistent shifts are correlated with long-term changes in temperature and flow, and may represent a response to global climate change.

4.7.2 Culture Or Life History

Methanol as a cryoprotectant for Atlantic salmon spermatozoa

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The effect of four extenders on the success of cryopreservation of Atlantic salmon *Salmo salar* sperm was tested. Extenders included: (1) Cloud extender (54.04 g/L glucose and 1.7 g/L KCl) with 5% dimethyl sulfoxide (DMSO), (2) Cloud extender with 5% DMSO supplemented with 13.3% egg yolk, (3) Cloud extender with 10% methanol (4) Cloud extender with 10% methanol supplemented with 13.3% egg yolk. Fertilization rates, expressed as the percentage of eyed embryos, ranged from 52.7 to 83.5 %. Sperm cryopreserved using Cloud with 10% methanol supplemented with 13.3% egg yolk yielded significantly higher ($F3, 19 = 31.4$, $P < 0.001$) fertilization rates (83.0%) than did sperm cryopreserved with the other three extenders. Our fertilization rates compare favorably to those observed for eggs from the same year class fertilized with fresh milt (81.4%) and reared at the White River National Fish Hatchery. The presence of egg yolk added to extenders incorporating 10% methanol provided additional protection to salmonid sperm during the freezing and thawing processes and resulted in an increase in survival from 72.9 to 83.5%. However, the cryoprotective effect of egg yolk may be specific to the individual formulation of extenders. In our trials, Cloud-5% DMSO without egg yolk yielded a 66.9% fertilization rate while Cloud-5% DMSO supplemented with 13.3% egg yolk, produced only 52.7% fertilization after cryopreservation. Our results indicate cryopreservation has the potential to be successfully used as a tool for Atlantic salmon management.

Growth and Survival of Atlantic Salmon Fed a Vegetable Based Diet

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Organochlorine contaminants have been found to be higher farmed raised Atlantic salmon than in wild fish. The difference in contaminant concentrations observed between farmed and wild salmon are most likely a function of their diet. Farmed salmon are typically fed a concentrated feed high in fish oils and fish meal, which is obtained primarily from small pelagic schooling fishes. It is known that such fishes may accumulate pollutants such as organochlorines. Consumption of farmed salmon may result in exposure to a variety of persistent bioaccumulative contaminants, which may pose a risk to human health. Such findings have led fish culturists to look for means to reduce, or to eliminate entirely, the use of fish meal in aquaculture. The objective of this study was to compare the performance of Atlantic salmon fry fed a diet composed entirely of soy, gluten and plant protein versus a traditional, widely used diet comprised of fish and animal meal. Approximately 2,250 F1-generation ATS sac-fry of Connecticut River origin produced at the NEFC were used for this study. Fish were equally divided and randomly distributed among the 9 cylindrical tanks (90 L; 48 cm in diameter at the base and 38 cm tall) with flow through water at 1.5 liters per minute. Fry were stocked at a density of 250 fish per tank. Prior to the onset of feeding, triplicate tanks were randomly assigned one of the following diet regimens: 1. Corey Starter (CS) - a commercially available, fish meal-based dry diet provided to first-feeding fry by a number of federal salmon hatcheries in the northeast; 2. Freedom Feeds starter diet (FF) - a fish feed developed and manufactured by Freedom Feeds, Urbana, Ohio whose protein source is grain, grain products, plants and plant protein products; 3. Corey Starter offered for 2-3 weeks followed by a 2 week weaning to Freedom Feeds starter diet (CF). Feed was offered at 4.5% body weight/d. Mortalities were removed and recorded prior to the initial feeding each morning. Following the initial inventory, total tank biomass was measured every 14 days to assess growth and to adjust feed ration to compensate for weight gain. Rearing continued for 40 weeks. After 20 weeks of rearing, neither mean weight nor survival were significantly affected by diet regimen. Mean weight (± SD) for each of the regimens was 1.0 ± 0.1 g/fish (CS), 0.98 ± 0.1 g/fish (CF) and 0.90 ± 0.1 g/fish (FF). Mean survival was 71% (CS), 69% (CF) and 61% (FF). However, at the conclusion of the 40-week trial, fish fed a constant fish meal-based diet (CS) were significantly larger (6.3 ± 0.2 g/fish) than fish feed either the CF (4.3 ± 0.1 g/fish) or FF (3.9 ± 0.04 g/fish) diets, both of which incorporated plant protein-based diets into the feeding regimen. Final survival was also affected with fish offered CS exhibiting significantly greater survival (70%) than those offered either CF (47%) or FF (41%).

Linking hydrologic regime to summer growth of age-0 Atlantic salmon.

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Significant reductions in growth of juvenile stream salmonids associated with low summer flow have been observed, but underlying mechanisms are poorly understood, and predictive power is limited. We conducted a stage-specific analysis of the relationship between summer flow and the growth of age-0 Atlantic salmon in two rearing sites in the Upper Connecticut River basin, New Hampshire, USA. We contrasted effects of variation in foraging habitat availability and temperature on individual age-0 salmon mass during a high- and two low-flow years and from high- and low-flow sites within years. Overall age-0 salmon mass was positively correlated with the availability of model-predicted favorable foraging locations and negatively correlated with density during the summer. Individual salmon mass, and the proportion of temperature-predicted maximum mass was lowest during the two low-flow years, and in lower in the upstream vs. downstream sections. Between-year variation in growth was not closely associated with temperature-model predictions. However, some of the difference between upstream and downstream sections appeared to be associated with lower summer temperatures in the upstream section. Our case study provides a framework for combining empirical and modeling approaches to quantify the potential impact of hydrologic change on fish growth and links variation in stream discharge to juvenile salmon performance across time and space.

Interactive effects of habitat and potential predator density on abundance and size of underyearling Atlantic salmon in Connecticut River rearing tributaries

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We investigated the effects of habitat availability and abundance of potential predators on abundance and size of underyearling Atlantic salmon at 12 replicate introduction sites (3 sites per stream on 4 streams). Three thousand unfed salmon fry were stocked at each site in May 2004. Total salmon retention (number remaining in the 270 m sampled area in August / number stocked) ranged from 1-20%. Salmon retention showed a strong negative relationship to the log of total density of potential predators (all overyearling trout + adult slimy sculpin; $F_{1,10} = 130$, $P < 0.001$, $r^2 = 0.93$). Availability of suitable early-season habitat significantly predicted salmon loss only at sites with high predator density (>10 predators/100m2, $F_{1,6} = 10.9$, $P = 0.02$, $r^2 = 0.64$), suggesting that predators may mediate previously observed salmon habitat limitation. Much of the observed relationship of retention and predators in this study may be due to salmon moving out of the sampled area in response to predation risk rather than direct mortality from predators. Salmon density in August in individual 30 m sections within the 270 m sampled area did not decline with distance from the release point, suggesting that many salmon migrated out of the sampled area. Salmon growth rate was not clearly related to habitat characteristics, but was negatively related to log salmon density both across sites ($F_{1,10}$=6.1, P=0.03, r^2=0.38) and across 30 m sections within sites ($F_{1,43}$=23.5, P<0.001, r^2=0.81).

4.7.3. Fish Health

Combined Use of the ASK and SHK-1 Cell Lines Can Enhance the Detection of Infectious Salmon Anemia Virus

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Infectious salmon anemia (ISA) is a severe disease primarily affecting commercially farmed Atlantic salmon (*Salmo salar*) in seawater. The disease has been reported in portions of Canada, the United Kingdom, the Faroe Islands, and the United States. Infectious salmon anemia virus (ISAV), the causative agent of ISA, has also been isolated from several asymptomatic marine and salmonid fish species. Diagnostic assays available for the detection of ISAV include virus isolation in cell culture, reverse-transcriptase polymerase chain reaction, an enzyme-linked immunosorbent assay and an indirect fluorescent antibody test. Virus isolation is considered the gold standard and five salmonid cell lines are known to support the growth of ISAV. In this study, the relative performance of the SHK-1, ASK, and CHSE-214 cell lines in detecting ISAV was evaluated using samples from both experimentally and naturally infected Atlantic salmon. Inter-laboratory comparisons were conducted using a quality control/quality assurance ring test. Both the SHK-1 and ASK cell lines performed well in detecting ISAV, while the performance of the CHSE-214 cell line was highly variable between laboratories. Although the ASK cell line appeared to represent a good alternative to the more commonly used SHK-1 line, use of a single cell line for diagnostic assays may increase the potential for false-negative results. Thus, the SHK-1 and ASK cell lines can be used in combination to provide optimal ability to detect ISAV.

Water Quality and Atlantic Salmon Survival: Streamside Rearing Studies on the Dennys, Pleasant, and Kenduskeag Rivers.

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Exchangeable aluminum concentrations and river pH's in eastern Maine frequently reach values over 40μg/L and below pH 6. Exposure to these conditions for 48hrs has been shown to correspond with negative physiological impacts on Atlantic salmon (*Salmo salar*) smolts (McCormick, unpublished data). In 2004, streamside rearing study was initiated on the Denny's, Pleasant, and Penobscot watersheds in order to investigate the effects of episodic acid/aluminum fluxes on juvenile life stages of Atlantic salmon. During the 21 day study period (April 25th – May 14th) Penobscot strain Atlantic salmon smolts were held in ambient water conditions for 3-6 day intervals at 6 locations on the aforementioned watersheds. During this period blood and gill samples were collected from the smolts to assess gill aluminum content, plasma chloride levels, plasma glucose levels, and Na,K-ATPase activity. In addition to biological samples, water chemistry samples were taken to determine calcium (Ca), magnesium (Mg), sodium (Na), potassium (K), acid neutralizing capacity (ANC), pH, clpH, dissolved organic carbon (DOC), total aluminum (Al-tot), and organic aluminum (Al-org) levels present at the study sites. Interactions between water chemistry and smolt physiology are currently being analyzed. From this information we hope to further identify the extent in which ambient water conditions in Eastern Maine may be impacting the health and survival of juvenile Atlantic salmon.

Update on Disease Management Issues for the Restoration of Atlantic Salmon to the Connecticut River

Trish Barbash

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The speaker summarizes recent pathogens of concern to Atlantic salmon restoration, with particular emphasis on *Aeromonas salmonicida* (furunculosis) and Infectious Salmon Anemia Virus (ISAv). Management strategies in place for prevention and control of disease in cultured, wild and captive stocks, as well as ramifications of disease to the restoration program will be discussed.

4.7.4. Marking

Evaluation of Calcein-Marked and Unmarked Atlantic Salmon Fry Stocked into the West Branch Sheepscot River, Maine (Technical Information Leaflet LM-04-01)

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In May of 2001 and 2002, equivalent numbers of calcein-marked and unmarked Atlantic salmon fry produced at Craig Brook National Fish Hatchery were released at numerous sites in the West Branch Sheepscot and Narraguagas Rivers in Maine. Fish were liberated as non-feeding fry and remained at large for four months prior to recapture by electrofishing in September of the respective study year. Marked fish were visually discerned from unmarked fish non-lethally using a hand-held calcein detection device. In the 2001 study, genetic analysis of fin clips via microsatellite DNA techniques showed that 76% of unmarked fish captured could be assigned to known parentage from Craig Brook NFH matings. Using these data, G-test analysis showed that calcein-marked and unmarked fish were recovered at the expected 1:1 ratio. In the 2002 study, unmarked fish were captured in greater proportion to the expected 1:1 ratio, but tissue samples were not taken. As a result, DNA analysis and subsequent parentage assignment could not be made for the 2002 study. Analysis of total length data from both study years showed that calcein marking did not adversely affect growth. During the 2002 study, 13 fish from the 2001 study were found which had retained the calcein mark in the wild for 16 months. Likewise, during annual parr collection in 2003, seven calcein-marked fish from the 2002 study were also identified. Excluding labor, the cost of applying the calcein mark was about $0.01 per fish. The calcein marking technique has potential as a relatively inexpensive and practical way to perform hatchery product evaluations where a batch mark is adequate.

Evaluation of Calcein Marks on Juvenile Atlantic Salmon Exposed to Natural Light

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Calcein from the both Sigma-Aldrich, Inc. and Western Chemical (SE-MARK™) was used to mark Atlantic salmon young-of-year (YOY) and parr to determine whether exposure to natural light caused differential degradation of calcein marks over a 2-month period. Fish were marked via immersion bath and maintained in 2-ft-diameter circular tanks with n=50 YOY and n=20 parr. Both age groups were exposed to the following treatments: (1) full sun with bird netting only (2) semi-shaded with top screen and (3) indoors. Baseline photos were taken via epi-fluorescent microscopy to compare with subsequent calcein mark evaluations. Photos were analyzed for calcein mark brilliance using a commercially-available photo analysis softwear. At all sampling periods, calcein mark degradation was directly proportional to the natural light levels striking study tanks. Calcein marks of fish immersed in SE-MARK™ showed consistently more brilliant fluorescence values than those immersed in SIGMA calcein at all sample intervals. However, fish in all outdoor treatments lost mark brilliance after 10 days regardless of chemical brand while fish maintained indoors retained high levels of mark brilliance over the 60-day study. After 60 days, the only outdoor treatment fish which had detectable marks were those treated with SE-MARK™ in semi-shaded tanks. Exposure of fish to sunlight in all outdoor tanks was set up to be more severe than would likely occur in the wild in order to accelerate mark degradation. Full sun and semi-shaded tanks received average light intensities of 75,320 and 16, 271 LUX, respectively. In comparison, average values under a shade tree were 1,665 LUX.

4.7.5. Population Estimates Or Tracking

Assessment of Negative Bias in Removal Estimators for Fish Population Estimation at Two Spatial Scales

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Removal estimators for stream fish abundance are widely used, but can result in biased population estimates at the site level. We conducted computer simulations to examine how the Carle and Strub (1978) estimator coupled with variation in catchability influences the accuracy of population estimates at the site level. Site level population estimates were then used to examine what effect potential bias in the population estimate at a site had on basinwide abundance estimates. Historic electrofishing data obtained from the Narraguagus River was used as baseline data for the construction of these simulations (e.g. ranges of sample sizes, catchabilities, and spatial variability in parr abundance). At the site level, mean % bias of population estimates was -24% when catchability was low (0.30 – 0.40) and the true population was low (1 – 20 fish). Negative bias decreased as the true population size increased and catchability increased. When true populations exceeded 120, % bias was < 1% regardless of the simulated catchability. The negative bias at the site level affected total population estimates for the entire river basin. Under current sampling methodology in the Narraguagus River, basinwide population estimates are likely to be on average 7.70 – 13.38 % lower than the true population. Confidence intervals (95%) would be expected to cover the true population between 73 – 83% of the time. By doubling the amount of sampling, negative bias of the basinwide estimate was reduced to 0.13 – 6.51 % and 95% confidence intervals covered the true population 87 – 94% of the time. These results should serve as a reference point to gauge the effectiveness of current sampling efforts in providing reliable estimates of Atlantic salmon parr in the Narraguagus River. The methodology employed by this simulation study can also be applied to other river basins (e.g. Sheepscot & Dennys) where a basinwide estimate of parr is desired to evaluate those sampling efforts.

Atlantic salmon smolt migration in the Connecticut River: mark/recapture population estimates and migratory behavior

Bob Stira

Northeast Generation Services, 301 Hammer Mill Road, Rocky Hill, CT 06067.

Since 1993, facilities at the Turners Falls (Cabot Station) and Holyoke hydroelectric projects have been used to estimate the number of Atlantic salmon smolts migrating from the upper Connecticut River basin, using mark/recapture techniques. Estimates for six of those years ranged from about 20,000 to 80,000 smolts, with confidence intervals ranging from about 23 to 53% of the estimates. During other years estimates were either not feasible (4 yr) or needed adjustment (2 yr) because of field conditions. The two adjusted estimates were about 37,000 (2001) and about 92,000 (1998). Smolt collections usually began in late April and continued through May. About 40% of marked smolts recaptured at Holyoke (51.8 km downstream of Cabot Station) arrived there within 24 h of release at Turners Falls, and about 70% arrived within 48 h; some arrived at Holyoke up to 7 d after release. There appeared to be a negative relationship between river flow volume and time elapsed between marking and recapture. Overall length frequency distribution peaked between 165 and 190 mm (TL), with a mean of about 184 mm.

4.7.6. Smoltification And Smolt Ecology

Request to TAC for an Extension of the RNA-DNA study (or Can RNA-DNA ratios indicate feeding in outmigrating smolts?)

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RNA-DNA ratios have been used as an index of growth in fishes at various life stages. Although this technique typically requires fish sacrifice, our previous study demonstrated a reliable and accurate non-lethal sampling technique, showed strong correlation of RNA-DNA ratios with weight change over a period of one month, and was a first step in applying this technique to hatchery-released smolts to determine success at feeding during migration. Laboratory 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 individual fish. All surviving experimental smolts were released to the original designated river. Sixty-four of the experimental fish were captured from the marine environment after release (33 Marical-treated fish; 31 control fish) and were weighed and sampled for RNA-DNA assay. Marical and control fish were of similar baseline weight and length. Under laboratory conditions, no significant differences were found between Marical and control fish relative to weight loss, RNA-DNA ratios and specific growth rate after one week without food. Conversely, there was wide variation in field collected fish weights and it appears that Marical-treated fish grew while control fish did not. However, there was no significant difference in weight or in the mean of the nucleic acid ratios between field collected Marical and control fish. Tissue type and temperature may be confounding the results of field collected fish. Muscle samples of approximately two-thirds of the captured fish had a distinctly different brown tissue layer beneath the skin and above the white muscle. Assays were conducted including this tissue with the white muscle. If this tissue is a thin layer of dark muscle, 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.

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

Stephen D. McCormick[1], Gayle Barbin Zydlewski, Kevin G. Whalen, Alex J. Haro, Darren T. Lerner, Michael F. O'Dea and Amy M. Moeckel.

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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 1998-2004, 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. , whereas fish that remained were those less than 12 cm In spring 1998-2003, 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 all 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%.

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

D. F. Kircheis and R. B. Dill

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.

Thresholds for the impact of acid and aluminum on Atlantic salmon smolts and fry.

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In order to determine the levels of acid and aluminum that impact juvenile Atlantic salmon, smolts and fry were exposed to 3 pH levels (6.0, 5.6, 5.2) and four aluminum levels (0, 40, 80 and 175 µg/L total aluminum, two-thirds of which was exchangeable) for 48 hours. Following this treatment, smolts were subjected to a 24 h seawater challenge (35 ppt). All smolts died within 48 h at pH 5.2, 175 µg/L Al. There were some mortalities in fresh water at pH 5.2, 80 µg/mL Al and pH 5.6, 175 µg/L Al, and further mortalities when these fish were transferred to seawater. These mortalities were associated with decreased plasma ions in fresh water and higher plasma ions in seawater. Gill Na,K-ATPase activity decreased at pH 5.6 and 175 µg/L Al. There was no detectable increase in gill Al levels at pH 6.0 with increasing Al, but substantial increases in gill Al were observed at Al > 40 μg/L at pH 5.6 and 5.2. These elevated gill aluminum levels are likely to have long term effects on smolts. There were no mortalities of fry during the 48 h treatment, but plasma sodium losses were observed at the most severe pH and Al conditions. The results indicate that exposure to pH 5.2 and > 80 μg/L Al or pH 5.6 and 175 μg/l Al will have immediate negative impacts on smolts, and that pH < 5.6 and > 40 μg/l Al are likely to have effects for exposure periods greater than 48 h.

Physiological and behavioral effects of nonylphenol and 17□-estradiol on larval survival and smolt development of Atlantic salmon, Salmo salar

Darren T. Lerner[1] and Stephen D. McCormick[2].

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Nonylphenol (NP) is widely found in effluents from sewage treatment plants and industrial sites due to its use in detergents, plastics, cleaning products, and pesticides. A direct consequence of this widespread use is its presence in rivers and estuarine systems. In this study, we examined the effects of estradiol (E2) and environmentally relevant concentrations of aqueous NP on larval survival and smolt development of Atlantic salmon. Larvae were exposed for three weeks to 10 or 100 ppb NP, 2 ppb E2, or vehicle. Animals were maintained at ambient conditions for one year and then assessed for endocrine, osmoregulatory, and behavioral disruption of smolt development. Fifty percent of larvae treated with 100 ppb NP succumbed to mortality, with less than 5% mortality in each of the other groups. Between one and two months post-treatment E2 and 10 ppb NP treatment resulted in mortality 4 to 5 times greater than controls, indicating a delayed mortality effect. These groups also exhibited decreased gill Na^+, K^+, -ATPase activity and salinity tolerance as smolts as well as a greater stress response when challenged with a handling stressor as evidenced by increases in plasma cortisol and decreases in plasma chloride in freshwater. Seawater preference of smolts exposed to E_2 or 10 ppb NP as larvae was significantly reduced. These results indicate that E2 and environmentally relevant levels of aqueous NP can compromise smolt physiology and behavior and elicit stress hypersensitivity one-year following exposure. These impacts of early exposure suggest that NP and E2 can have long term, 'organizational' effects on life history events in Atlantic salmon.

Effect of hexazinone and atrazine on different life stages of Atlantic salmon

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Hexazinone and atrazine are highly mobile herbicides that are widely used along rivers in the United States. Exposure to these compounds can be potentially harmful to fish, including Atlantic salmon (*Salmo salar*), which have been recently listed as an endangered species. The

objective of this study was to determine the effect of environmentally relevant concentrations of hexazinone and atrazine on larvae (soon after hatching) and smolts. Atlantic salmon larvae and smolts were exposed to 100 ppb hexazinone, 10 ppb and 100 ppb atrazine for 21 days. There was no effect of either contaminant on larval survival. Exposure to 100 ppb hexazinone, 10 and 100 ppb atrazine caused an increase in opercular movement in larvae, while only 100 ppb atrazine cause a significant weight loss. There were no mortalities in fresh water or after seawater challenge in smolts exposed to hexazinone or 10 ppb of atrazine, however 9.1% of the 100 ppb atrazine fish died. Hexazinone exposure had no effect on plasma levels of cortisol, chloride, and sodium in fresh water or after seawater challenge. Fresh water smolts exposed to 100 ppb atrazine had decreased plasma sodium and chloride ions and increased cortisol. After seawater challenge, fish exposed to 100 ppb atrazine had a significant increase in hematocrit, plasma cortisol, sodium, and chloride. Hexazinone exposure resulted in decreased gill Na^+ K^+ ATPase activity, whereas atrazine had no effect. Growth rate for 2 months in seawater was not affected by prior hexazinone or atrazine exposure. We conclude that under the conditions imposed in this study, there was no effect of hexazinone on salinity tolerance of Atlantic salmon smolts. Hexazinone does appear to affect some features of larval respiration. Atrazine has a substantial impact on larval metabolism and causes ionoregulatory disturbance in smolts.

Developing a model of smolt migration in the Connecticut River

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Variation exists in Atlantic salmon life history, including specific behaviors (e.g. timing of smolt migration and movement speed). This variation is associated with success (i.e., making it out of the river alive). In this study, we are asking what types of variation might affect success in smolt migration? We are interested in 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.

4.7.7. Stock Identification Or Genetics

A watershed-scale assessment of proportional representation and migration timing of smolts stocked in known regions above Cabot Station.

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To date, it has been difficult to assess the relative production and migration timing of smolts from the many drainages in the Connecticut River basin because tagging large numbers of stocked fry has not been practical. Working with hatchery managers and personnel from the states of Vermont and Connecticut starting in 1997, we implemented a genetic marking program that allows assignment of large numbers of fry to stocking batches (locations). In 2002, 10 batches of fry were stocked into 10 drainages of the Connecticut River above the Turners Falls dam. In total, 3.6 million identifiable fry were stocked (71% of total stocked above Turners Falls). We first tested whether a subset of fry from each stocking batch could be assigned uniquely to the correct batch. Then, in the spring of 2004, 1300 smolts were sampled from the Cabot bypass at the Turners Falls dam. Our goal with this analysis was to determine 1) if smolts collected had equal contribution from all stocking locations, 2) if smolts from the different stocking locations had equal migration timing and 3) if smolts from the different stocking locations had equal sizes.

5.0 APPENDICES

5.1 List of Attendees

Joan G. Trial - Chair
Maine Atlantic Salmon Commission

Chris Legault
National Marine Fisheries Service

Denise B. Buckley
U.S. Fish and Wildlife Service – Maine Fishery Resources Office

John A. Sweka
U.S. Fish and Wildlife Service – Northeast Fishery Center

Gabe Gries
NH Fish and Game Department

Steve Mierzykowski
U.S. Fish and Wildlife Service – Maine Field Office

Joseph F. McKeon
U.S. Fish and Wildlife Service – Central New England Fishery Resources Office

Ed Baum
Atlantic Salmon Unlimited, Hermon, ME

Jay McMenemy
VT Fish and Wildlife, Springfield, VT

Adria A. Elskus,
U.S. Geologic Survey -

Timothy Kubiak
U.S. Fish and Wildlife Service - New Jersey Field Office

Carl Burger
Maine Fisheries Program Complex

John Kocik
NOAA Fisheries Service Maine Field Station

Tim Sheehan
NOAA Fisheries Service Woods Hole Lab

5.2. List of Working Papers

1. Barbash, T. and Sweka, J. 2005. Efforts Involving Infectious Salmon Anemia Virus among feral Atlantic salmon in the Northeastern USA. Working Paper 9 PPT only.
2. Dill, R. and Trial. 2005. ASC Temperature Monitoring Program, Past, Present, and Future. Working Paper 11 PPT only.
3. Elskus, A. 2005. Do Contaminants in Hatchery Salmon Compromise Performance? Working Paper 16 PPT only.
4. Hastings, E. 2005. Atlantic Salmon Smolt and Parr Marking Project Overview 2000 – 2004. Working Paper 27.
5. Hawkes, J.P., Kocik, J.F., and Sheehan, T.F. 2005. Update on Coastal Maine River Atlantic Salmon Smolt Telemetry Studies: 2004. Working Paper 22.
6. Holbrook, C. Zydlewski, J. and Kinnison, M. 2005. Assessment of downstream smolt passage in the Penobscot River. Working Paper 2.
7. Kocik, J.F. 2005. A Status of Stock Brief – How do we make it Brief? Working Paper 3 PPT Only.
8. Kocik, J.F. and Trial, J.G. 2005. Updating Redd-Based Estimates of Adult Returns to the Gulf of Maine Distinct Population Segment: 2005 Benchmark Update. Working Paper 5.
9. Kubiak, T. 2005. Results Of USFWS Contaminant Sampling In Atlantic Salmon Broodstock Conducted in 2004. Working Paper 12 PPT only
10. Legault, C. and Sheehan T.F. 2005. Bayesian Estimation of Emigration Rates. Working Paper 7 PPT only.
11. Legault, C. and Sheehan T.F. 2005. Bycatch of Atlantic Salmon at Sea. Working Paper 4 PPT only.
12. Li, Weiming, McCormick, S., and Rees, C. 2005. Assessment of Impacts of Contaminants on Atlantic Salmon Smolts Working Paper 25.
13. Lipsky, C.A., Hawkes, J.P., Kocik, J.F. and Mackey, G. 2005. Update on Maine River Atlantic Salmon Smolt Studies: 2004. Working Paper 1.
14. Mason, V. 2005. Rhode Island Program Report. Working Paper 15 PPT only.
15. McKeon, J.F. 2005. Merrimack Program Report. Working Paper 24 PPT only.
16. McMenamy, J. 2005. Connecticut Program Report. Working Paper 23 PPT only.
17. Mierzykowski, S. 2005. Contaminant Assessment of the DPS Atlantic Salmon Rivers - 2004 Status Report. Working Paper 10 PPT only.
18. Renkawitz, M. and Sheehan, T. 2005. 2004 NOAA – Fisheries Atlantic Salmon Postsmolt Trawl Survey Project Overview and Preliminary Results. Working Paper 20.
19. Sheehan, T.F. 2005. SALSEA Summary. Working Paper 26 PPT only.
20. Sheehan, T.F., Legault, C.M., King, T., and Spidel, A. 2005. Probabilistic-based Genetic Assignment model (PGA): Sub-continent of origin assignments of the West Greenland Atlantic salmon catch Working Paper 18 PPT only.
21. Sheehan, T.F., Reddin, D., King, T. and Siegstad, H. 2005. The International Sampling Program, Continent of Origin and Biological Characteristics of Atlantic Salmon Collected at West Greenland in 2004. Working Paper 19 PPT only.

22. Sheehan, T.F., Trial, J., and Legault, C.M. 2005. Redefining the US smolt age Distribution (Sheehan, Trial and Legault) Working Paper 21.
23. Sweka, J.A., Legault, C.M., Beland, K.F., Trial, J.G. and Millard, M.J. 2005. Assessment of Negative Bias in Removal Estimators for Fish Population Estimation at Two Spatial Scales. Working Paper 14. with PPT
24. Trial, J. 2005. Maine Program Report. Working Paper 17 PPT only.
25. Trial, J.G. 2005. Calculating Ocean Mortality. Working Paper 6 PPT only.
26. Trial, J.G., Legault, C. and Sheehan T.F. 2005. 2004 ICES North Atlantic Salmon Working Group Meeting Summary. Working Paper 8 PPT only.
27. Vashon, A., Butler, E., Saunders, R., Hawkes, J., Kocik, J.F., Dill, R., and Simpson, R. 2005. Managing the Impacts of Cormorant Predation on Endangered Atlantic Salmon Smolts. Working Paper 13 PPT only.

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 Tables Supporting the Document

Table 7. Juvenile Atlantic salmon stocking summary for New England in 2004.

United States

No. of fish stocked by lifestage

River	Fry	0 Parr	1 Parr	1 Smolt	2 Smolt	Total
Connecticut	7,683,000	3,100	2,500	0	96,400	7,785,000
Total for Connecticut Program						**7,785,000**
Androscoggin	2,000	0	0	0	0	2,000
Aroostook	169,000	0	0	0	0	169,000
Dennys	219,000	44,000	0	56,300	0	319,300
East Machias	319,000	0	0	0	0	319,000
Kennebec	52,000	0	0	0	0	52,000
Machias	379,000	3,100	0	0	0	382,100
Narraguagus	468,000	0	0	0	0	468,000
Penobscot	1,812,000	369,200	0	566,000	0	2,747,200
Pleasant	47,000	0	0	0	8,800	55,800
Saco	375,000	0	0	5,400	0	380,400
Sheepscot	298,000	15,600	0	0	0	313,600
St Croix	0	0	0	4,100	0	4,100
Union	3,000	0	0	0	0	3,000
Total for Maine Program						**5,215,500**
Merrimack	1,556,000	3,700	0	50,000	0	1,609,700
Total for Merrimack Program						**1,609,700**
Pawcatuck	557,000	0	0	6,100	0	563,100
Total for Pawcatuck Program						**563,100**
Total for United States						**15,173,300**

Canada

No. of fish stocked by lifestage

River	Fry	0 Parr	1 Parr	1 Smolt	2 Smolt	Total
St Croix	0	2,800	0	0	0	2,800
Total for Canada Program						**2,800**
Total for Canada						**2,800**

Grand Total **15,176,100**

Distinction between US and CAN stocking is based on source of eggs or fish.

Table 8. Captive and domestic adult Atlantic salmon stocking summary for New England in 2004 by river, season, and year class (= year of egg take or wild collection).

	NUMBER RELEASED BY SEASON AND YEAR CLASS														
	Spring / early summer							Autumn							
	1998	1999	2000	2001	2002	2003	2004	1998	1999	2000	2001	2002	2003	2004	**Total**
United States															
Connecticut	0	0	0	0	0	0	0	0	0	0	110	0	0	0	110
Total for Connecticut program :	0	0	0	0	0	0	0	0	0	0	110	0	0	0	110
Dennys	0	0	0	0	0	0	0	0	60	36	0	101	127	0	324
East Machias	0	0	0	0	0	0	0	0	0	97	0	0	0	0	97
Machias	0	0	0	0	0	0	0	0	0	193	0	100	116	0	409
Narraguagus	0	0	0	0	0	0	0	0	0	195	96	0	0	0	291
Pleasant	0	0	0	0	0	0	0	0	0	101	0	0	0	0	101
Penobscot	0	0	0	0	0	0	0	0	0	579	383	0	0	530	1,492
Sheepscot	0	0	0	0	0	0	0	0	0	116	0	0	0	0	116
Total for Maine program :	0	0	0	0	0	0	0	0	60	1,317	479	201	243	530	2,830
Merrimack	0	0	0	0	724	0	0	0	0	0	297	350	0	0	1,371
Total for Merrimack program :	0	0	0	0	724	0	0	0	0	0	297	350	0	0	1,371
Total United States	0	0	0	0	724	0	0	0	60	1,317	886	551	243	530	4,311

Table 9.1. Atlantic salmon marking database for New England; marked fish released in 2004 .

Marking Agency	Age	Life Stage	H/W	Stock Origin	Primary Mark or Tag	Number Marked	Secondary Mark or Tag	Release Date	Release Location
NAI	4	Adult	W	Connecticut	RAD	4	VIE	May	Connecticut
NAI	5	Adult	W	Connecticut	RAD	1	VIE	May	Connecticut
NAI	4	Adult	W	Connecticut	RAD	1	VIE	June	Connecticut
NAI	2	Smolt	H	Connecticut	FLOY	1,242		June	Connecticut
NAI	2	Smolt	H	Connecticut	RAD	214		June	Connecticut
USFWS	2	Smolt	H	Connecticut	AD	47,735		April	Connecticut
USFWS	2	Smolt	H	Connecticut	AD	47,236		Mar	Connecticut
USGS	0	Parr	W	Connecticut	PIT	467		Sept	Connecticut
USGS	1	Parr	W	Connecticut	PIT	459	VIE	Oct	Connecticut
ASC	1	Parr	W	Dennys	PIT	69		Various	Dennys
NOAA	0	Parr	H	Dennys	VIE	173	AD	April	Dennys
NOAA	0	Parr	H	Dennys	RV	44,000		Oct	Dennys
NOAA	1	Smolt	H	Dennys	VIE	30,000	AD	April	Dennys
NOAA	1	Smolt	H	Dennys	VIE	30,000	AD	May	Dennys
USFWS	3	Adult	H	Dennys	PIT	202		Oct	Dennys
USFWS	5	Adult	H	Dennys	PIT	36		Dec	Dennys
USFWS	6	Adult	H	Dennys	PIT	60		Dec	Dennys
USFWS	5	Adult	H	East Machias	PIT	97		Dec	East Machia
USFWS	3	Adult	H	Machias	PIT	100		Oct	Machias
USFWS	5	Adult	H	Machias	PIT	193		Dec	Machias
NHFG	3	Adult	H	Merrimack	FLOY	297		Oct	Merrimack
NHFG	2	Adult	H	Merrimack	FLOY	724		June	Merrimack
USFWS	4	Adult	H	Narraguagus	PIT	96		Dec	Narraguagu
USFWS	5	Adult	H	Narraguagus	PIT	195		Dec	Narraguagu
ASC	varied	Adult	H	Penobscot	PIT	530		Nov	Penobscot

Marking Agency	Age	Life Stage	H/W	Stock Origin	Primary Mark or Tag	Number Marked	Secondary Mark or Tag	Release Date	Release Location
ASC	varied	Adult	H	Penobscot	PIT	709	AP	Various	Penobscot
NOAA	0	Parr	H	Penobscot	LV	37,000		Sept	Penobscot
NOAA	0	Parr	H	Penobscot	LV	32,000	AD	Sept	Penobscot
NOAA	0	Parr	H	Penobscot	RV	27,000	AD	Oct	Penobscot
NOAA	0	Parr	H	Penobscot	LV	43,000		Oct	Penobscot
NOAA	1	Smolt	H	Penobscot	VIE	4,000	AD	April	St Croix
NOAA	1	Smolt	H	Penobscot	VIE	50,060	AD	May	Penobscot
NOAA	1	Smolt	H	Penobscot	VIE	158,000	AD	April	Penobscot
PSNH	1	Smolt	H	Penobscot	RAD	83		May	Merrimack
SRSC	1	Smolt	H	Penobscot	LV	2,700		Various	Saco
SRSC	1	Smolt	H	Penobscot	RV	2,700		Various	Saco
USFWS	3	Adult	H	Penobscot	AP	383		Dec	Penobscot
USFWS	4	Adult	H	Penobscot	AP	579		Dec	Penobscot
NOAA	2	Smolt	H	Pleasant	VIE	9,000	AD	May	Pleasant
USFWS	5	Adult	H	Pleasant	PIT	101		Dec	Pleasant
USFWS	5	Adult	H	Sheepscot	PIT	116		Dec	Sheepscot
SCIWC	0	Parr	H	St Croix	3RANI	3,000	AD	Oct	St Croix

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.

Table 9.2. Grand Summary of Atlantic Salmon marking data for New England; marked fish released in 2004.

Origin	Total External Marks	Total Adipose Clips	Total Marked
Hatchery Adult	2,692		4,418
Hatchery Juvenile	568,846	438,204	569,143
Wild Adult	6		6
Wild Juvenile	459		995

Table 10. Documented Atlantic salmon returns to New England rivers in 2004.

	1SW		2SW		3SW		Repeat			2000-2004
	Hatchery	Wild	Hatchery	Wild	Hatchery	Wild	Hatchery	Wild	Total	Average
Androscoggin	3	0	7	1	0	0	0	0	11	5
Connecticut	0	5	0	64	0	0	0	0	69	55
Dennys	0	0	1	0	0	0	0	0	1	7
Merrimack	17	2	92	15	2	0	0	0	128	99
Narraguagus	0	1	1	9	0	0	0	0	11	19
Pawcatuck	0	0	0	1	0	0	0	0	1	1
Penobscot	276	5	952	59	10	3	16	2	1323	907
Pleasant	0	0	0	1	0	0	0	0	1	3
Saco	3	2	10	4	0	0	0	0	19	45
Union	0	0	1	1	0	0	0	0	2	2
Total	**299**	**15**	**1,064**	**155**	**12**	**3**	**16**	**2**	**1,566**	**1,142**

Table 11. Summary of Atlantic salmon green egg production in Hatcheries for New England rivers in 2004.

Source River	Origin	Females Spawned	Total Egg Production
Connecticut	Domestic	1875	11,750,000
Merrimack	Domestic	229	811,000
Penobscot	Domestic	477	1,200,000
Dennys	Captive	88	380,000
East Machias	Captive	65	252,000
Machias	Captive	120	613,000
Narraguagus	Captive	119	453,000
Pleasant	Captive	23	179,000
Sheepscot	Captive	78	308,000
Total	**Captive/Domestic**	**3,074**	**15,946,000**
Connecticut	Kelt	53	489,000
Merrimack	Kelt	42	48,000
Total	**Kelt**	**95**	**537,000**
Connecticut	Sea Run	37	280,000
Merrimack	Sea Run	59	494,000
Penobscot	Sea Run	353	3,229,000
Total	**Sea Run**	**449**	**4,003,000**
Grand Total for Year	**2004**	**3,618**	**20,486,000**

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.

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
Cocheco															
1993-1994	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															
1977-1994	716	10,956,000	8,300	3,521	35,195,000	6,000	0	0		577	10,242,000	10,200	4,814	56,393,000	6,900
1995	101	946,000	9,400	1,258	7,555,000	6,000	0	0		183	2,159,000	11,800	1,542	10,660,000	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
Total Connecticut	1,475	16,853,000	7,700	21,749	140,646,000	5,900	0	0		1,950	24,261,000	10,100	25,174	181,762,000	6,300
Dennys															
1939-1994	22	185,000	7,700	0	0		56	110,000	2,000	8	39,000	4,700	86	334,000	6,300
1995	0	0		0	0		105	304,000	2,900	5	34,000	6,800	110	338,000	3,100
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

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
1999	0	0		0	0		48	249,000	5,200	7	58,000	8,200	55	306,000	5,600
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
Total Dennys	26	214,000	7,400	0	0	0	868	3,554,000	4,145	40	330,000	8,200	934	4,096,000	4,700
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
Total East Machias	0	0		0	0	0	817	3,385,000	4,240	0	0		817	3,385,000	4,200
Kennebec															
1979-1994	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
Lamprey															

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.

	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
1992-1994	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															
1941-1994	456	3,263,000	7,300	0	0		88	196,000	2,200	2	12,000	5,800	546	3,470,000	7,100
1995	0	0		0	0		171	484,000	2,800	4	28,000	6,900	175	512,000	2,900
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
Total Machias	456	3,263,000	7,300	0	0	0	1,433	5,892,000	4,182	8	53,000	6,400	1,897	9,207,000	4,600
Merrimack															
1983-1994	719	5,165,000	7,200	3,144	17,818,000	5,400	0	0		0	0		3,863	22,983,000	6,800
1995	24	188,000	7,800	694	4,353,000	6,300	0	0		0	0		718	4,541,000	6,300
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

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
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
Total Merrimack	1,166	8,936,000	8,600	8,985	47,361,000	4,900	0	0		222	2,162,000	10,500	10,373	58,459,000	5,500
Narraguagus															
1962-1994	0	1,303,000		0	0		59	146,000	2,500	0	0		59	1,449,000	2,500
1995	0	0		0	0		115	394,000	3,400	0	0		115	394,000	3,400
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
Total Narraguagus	0	1,303,000		0	0	0	1,411	5,140,000	3,645	0	0		1,411	6,443,000	3,600
Orland															
1967-1994	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															
1992-1994	6	50,000	7,900	0	0		0	0		0	0		6	50,000	7,900
1996	1	17,000	16,900	0	0		0	0		0	0		1	17,000	16,900

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 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
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															
1871-1994	15,120	131,633,000	7,900	2,145	5,465,000	2,500	0	0		0	0		17,265	137,098,000	7,700
1995	380	2,736,000	7,200	0	0		0	0		0	0		380	2,736,000	7,200
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
Total Penobscot	18,282	156,885,000	8,100	5,669	14,642,000	2,600	0	0		0	0		23,951	171,528,000	5,800
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
2003	0	0		0	0		11	92,000	8,300	0	0		11	92,000	8,300

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
2004	0	0		0	0		23	179,000	7,800	0	0		23	179,000	7,800
Total Pleasant	0	0		0	0	0	66	401,000	6,000	0	0		66	401,000	6,000
Presumpscot															
2004	0	0		0	0		0	0		0	0		0	0	
Total Presumpscot	0	0		0	0	0	0	0		0	0		0	0	
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
Total Sheepscot	18	125,000	6,900	0	0	0	666	2,721,000	3,880	45	438,000	9,900	729	3,286,000	4,500
St Croix															
1993-1994	26	194,000	7,400	0	0		0	0		0	0		26	194,000	7,400
1995	10	77,000	7,700	0	0		0	0		0	0		10	77,000	7,700
2003	3	21,000	6,900	0	0		0	0		0	0		3	21,000	6,900
Total St Croix	39	292,000	7,300	0	0	0	0	0		0	0		39	292,000	7,300
Union															

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
1974-1994	600	4,611,000	7,900	0	0		0	0		0	0		600	4,611,000	7,900
2003	0	0		0	0		0	0		0	0		0	0	
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	1,475	16,853,000	11,400	21,749	140,646,000	6,500	0	0		1,950	24,262,000	12,400	25,174	181,761,000	7,200
Dennys	26	214,000	8,200	0	0		868	3,552,000	4,100	40	330,000	8,300	934	4,096,000	4,400
East Machias	0	0		0	0		817	3,385,000	4,100	0	0		817	3,385,000	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		1,433	5,890,000	4,100	8	52,000	6,500	1,897	9,205,000	4,900
Merrimack	1,166	8,935,000	7,700	8,985	47,361,000	5,300	0	0		222	2,161,000	9,700	10,373	58,458,000	5,600
Narraguagus	0	1,303,000		0	0		1,411	5,140,000	3,600	0	0		1,411	6,443,000	4,600
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	18,282	156,885,000	8,600	5,669	14,643,000	2,600	0	0		0	0		23,951	171,528,000	7,200
Pleasant	0	0		0	0		66	401,000	6,100	0	0		66	401,000	6,100
Presumpscot	0	0		0	0		0	0		0	0		0	0	#Error
Sheepscot	18	125,000	7,000	0	0		666	2,722,000	4,100	45	438,000	9,700	729	3,285,000	4,500
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	**22,131**	**192,996,000**	**8,700**	**36,405**	**202,652,000**	**5,600**	**5,261**	**21,090,000**	**4,000**	**2,274**	**27,304,000**	**12,000**	**66,071**	**444,043,000**	**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
Totals:Androscoggin	**6,000**	**0**	**0**	**0**	**0**	**6,000**
Aroostook						
1978-1994	624,000	317,100	38,600	32,600	29,800	1,042,100
1995	4,000	0	0	0	0	4,000
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
Totals:Aroostook	**2,122,000**	**317,400**	**38,600**	**32,600**	**29,800**	**2,540,400**
Cocheco						
1988-1994	682,000	50,000	10,500	5,300	0	747,800
1995	114,000	0	0	0	0	114,000
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						
1967-1994	21,915,000	2,794,900	1,799,000	3,729,300	963,200	31,201,400
1995	6,817,000	4,500	0	1,300	0	6,822,800
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		90,100	
2004	7,683,000	3,100	2,500	0	96,400	7,785,000
Totals:Connecticut	**100,402,000**	**2,830,600**	**1,812,800**	**3,769,700**	**1,197,900**	**102,884,900**
Dennys						

	Number of fish stocked by life stage					
	Fry	0 Parr	1 Parr	1 Smolt	2 Smolt	Total
1975-1994	184,000	8,300	3,400	143,100	28,300	367,100
1995	84,000	0	0	0	0	84,000
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
Totals:Dennys	**1,619,000**	**176,100**	**7,300**	**363,000**	**29,200**	**2,194,600**
Ducktrap						
1986-1994	68,000	0	0	0	0	68,000
1995	0	0	0	0	0	0
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
Totals:Ducktrap	**68,000**	**0**	**0**	**0**	**0**	**68,000**
East Machias						
1973-1994	140,000	6,500	42,600	97,600	30,400	317,100
1995	0	0	0	0	0	0
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
Totals:East Machias	**2,076,000**	**7,500**	**42,600**	**108,400**	**30,400**	**2,264,900**
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
Totals:Kennebec	**104,000**	**0**	**0**	**0**	**0**	**104,000**
Lamprey						
1978-1994	599,000	280,700	49,100	133,300	32,800	1,094,900
1995	91,000	57,100	0	4,800	0	152,900
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						
1970-1994	239,000	86,900	117,800	180,500	42,200	666,400
1995	150,000	0	0	0	0	150,000
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
Totals:Machias	**2,850,000**	**96,900**	**118,100**	**191,300**	**44,100**	**3,300,400**
Merrimack						
1975-1994	13,112,000	222,500	556,100	935,800	630,500	15,456,900
1995	2,827,000	0	12,700	70,800	0	2,910,500
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
Totals:Merrimack	**32,309,000**	**231,200**	**597,700**	**1,469,000**	**638,100**	**35,245,000**
Narraguagus						
1970-1994	74,000	30,300	12,600	106,100	84,000	307,000
1995	105,000	0	0	0	0	105,000
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
Totals:Narraguagus	**2,838,000**	**62,900**	**14,600**	**107,800**	**84,000**	**3,107,300**
Pawcatuck						

	Number of fish stocked by life stage					
	Fry	**0 Parr**	**1 Parr**	**1 Smolt**	**2 Smolt**	**Total**
1979-1994	1,103,000	1,020,900	234,500	30,500	500	2,389,400
1995	367,000	52,200	0	0	0	419,200
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
Totals:Pawcatuck	**5,382,000**	**1,209,200**	**263,200**	**76,400**	**500**	**6,931,300**
Penobscot						
1970-1994	5,927,000	1,232,700	1,345,500	7,099,100	2,508,200	18,112,500
1995	502,000	325,000	5,600	568,400	0	1,401,000
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
Totals:Penobscot	**15,747,000**	**4,272,800**	**1,394,400**	**12,616,500**	**2,508,200**	**36,538,900**
Pleasant						
1975-1994	187,000	2,500	1,800	54,700	18,100	264,100
1995	0	0	0	0	0	0
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
Totals:Pleasant	**316,000**	**16,000**	**1,800**	**57,500**	**26,900**	**418,200**
Saco						
1975-1994	669,000	165,200	201,200	203,500	9,500	1,248,400
1995	376,000	0	0	19,700	0	395,700
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

	Number of fish stocked by life stage					
	Fry	**0 Parr**	**1 Parr**	**1 Smolt**	**2 Smolt**	**Total**
2003	501,000	20,000	0	3,200	0	524,200
2004	375,000	0	0	5,400	0	380,400
Totals:Saco	**4,810,000**	**438,700**	**201,200**	**340,500**	**9,500**	**5,799,900**
Sheepscot						
1971-1994	159,000	70,800	20,600	92,200	7,100	349,700
1995	0	0	0	0	0	0
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
Totals:Sheepscot	**2,058,000**	**100,400**	**20,600**	**92,200**	**7,100**	**2,278,300**
St Croix						
1981-1994	1,259,000	303,400	158,100	731,600	20,100	2,472,200
1995	1,000	0	0	0	0	1,000
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
Totals:St Croix	**1,268,000**	**470,400**	**158,300**	**808,000**	**20,100**	**2,724,800**
Union						
1971-1994	81,000	111,700	0	379,700	251,000	823,400
1995	0	54,800	0	0	0	54,800
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
Totals:Union	**436,000**	**371,400**	**0**	**379,700**	**251,000**	**1,438,100**
Upper StJohn						
1979-1994	2,165,000	1,456,700	14,700	5,100	27,700	3,669,200
1995	0	0	0	0	0	0
1996	0	0	0	0	0	0
1997	0	0	0	0	0	0
1998	0	0	0	0	0	0

	Number of fish stocked by life stage					
	Fry	**0 Parr**	**1 Parr**	**1 Smolt**	**2 Smolt**	**Total**
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
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	2,122,000	317,400	38,600	32,600	29,800	**2,540,900**
Cocheco	1,958,000	50,000	10,500	5,300	0	**2,024,200**
Connecticut	100,400,000	2,830,600	1,812,800	3,769,700	1,198,000	**102,883,300**
Dennys	1,619,000	176,100	7,300	363,000	29,200	**2,194,700**
Ducktrap	68,000	0	0	0	0	**68,000**
East Machias	2,076,000	7,500	42,600	108,400	30,400	**2,265,000**
Kennebec	104,000	0	0	0	0	**103,900**
Lamprey	1,593,000	427,700	58,800	201,400	32,800	**2,313,700**
Machias	2,850,000	96,900	118,100	191,300	44,100	**3,300,000**
Merrimack	32,309,000	231,200	597,700	1,469,000	638,100	**35,244,500**
Narraguagus	2,838,000	62,900	14,600	107,800	84,000	**3,107,400**
Pawcatuck	5,382,000	1,209,200	263,200	76,400	500	**6,931,000**
Penobscot	15,747,000	4,272,800	1,394,400	12,616,500	2,508,200	**36,538,400**
Pleasant	316,000	16,000	1,800	57,500	26,900	**418,600**
Saco	4,810,000	438,700	201,200	340,500	9,500	**5,799,900**
Sheepscot	2,058,000	100,400	20,600	92,200	7,100	**2,278,400**
St Croix	1,268,000	470,400	158,300	808,000	20,100	**2,725,100**
Union	435,000	371,400	0	379,700	251,000	**1,437,400**
Upper StJohn	2,165,000	1,456,700	14,700	5,100	27,700	**3,669,200**
TOTALS	**180,125,000**	**12,535,900**	**4,755,200**	**20,624,400**	**4,937,400**	**215,849,300**

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									
1983-1994	22	468	5	2	4	61	0	1	**563**
1995	2	12	0	0	0	2	0	0	**16**
1996	2	19	1	0	1	16	0	0	**39**
1997	0	0	0	0	0	1	0	0	**1**
1998	0	4	0	0	0	0	0	0	**4**
1999	0	1	0	0	1	3	0	0	**5**
2000	0	3	0	0	0	0	0	0	**3**
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**
Total for Androscoggin	30	523	6	2	6	84	0	1	**652**
Cocheco									
1990-1994	0	0	1	1	1	3	0	0	**6**
1995	0	0	0	0	0	1	0	0	**1**
1996	0	0	0	0	2	0	0	0	**2**
1997	0	0	0	0	0	0	0	0	**0**
1998	0	0	0	0	0	0	0	0	**0**
1999	0	0	0	0	2	1	0	0	**3**
2000	0	0	0	0	0	2	0	0	**2**
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									
1969-1994	34	3,199	28	1	8	456	8	0	**3,734**
1995	1	158	0	0	0	29	0	0	**188**
1996	0	143	0	0	5	111	0	1	**260**
1997	0	0	0	1	6	191	1	0	**199**
1998	0	0	0	0	10	288	0	2	**300**
1999	0	0	0	0	11	142	0	1	**154**
2000	0	0	0	0	1	76	0	0	**77**
2001	1	0	0	0	4	34	1	0	**40**

	HATCHERY ORIGIN				WILD ORIGIN				
	1SW	2SW	3SW	REPEAT	1SW	2SW	3SW	REPEAT	Total
2002	0	3	0	0	2	38	1	0	**44**
2003	0	0	0	0	0	42	1	0	**43**
2004	0	0	0	0	5	64	0	0	**69**
Total for Connecticut	36	3,503	28	2	52	1471	12	4	**5,108**
Dennys									
1967-1994	21	294	0	1	19	716	3	10	**1,064**
1995	0	0	0	0	0	5	0	0	**5**
1996	0	0	0	0	3	7	0	0	**10**
1997	0	0	0	0	0	0	0	0	**0**
1998	0	0	0	0	0	1	0	0	**1**
1999									
2000	1	1	0	0	0	1	0	0	**3**
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**
Total for Dennys	37	303	0	1	23	740	3	10	**1,117**
Ducktrap									
1985-1994	0	0	0	0	3	30	0	0	**33**
1995									
1996									
1997									
1998									
1999									
2000									
2001									
2002									
2003									
2004									
Total for Ducktrap	0	0	0	0	3	30	0	0	**33**
East Machias									
1967-1994	21	250	1	2	12	329	1	10	**626**
1995									
1996									
1997									
1998									
1999									
2000									
2001									

	HATCHERY ORIGIN				WILD ORIGIN				
	1SW	2SW	3SW	REPEAT	1SW	2SW	3SW	REPEAT	Total
2002									
2003									
2004									
Total for East Machias	21	250	1	2	12	329	1	10	**626**
Kennebec									
1975-1994	12	189	5	1	0	9	0	0	**216**
1995									
1996									
1997									
1998									
1999									
2000									
2001									
2002									
2003									
2004									
Total for Kennebec	12	189	5	1	0	9	0	0	**216**
Lamprey									
1979-1994	10	17	1	0	1	12	0	0	**41**
1995	0	0	0	0	0	1	0	0	**1**
1996	0	0	0	0	0	1	0	0	**1**
1997	0	0	0	0	0	0	0	0	**0**
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									
1967-1994	32	329	9	2	33	1,592	41	131	**2,169**
1995									
1996									
1997									
1998									
1999									
2000									
2001									
2002									

	HATCHERY ORIGIN				WILD ORIGIN				
	1SW	2SW	3SW	REPEAT	1SW	2SW	3SW	REPEAT	Total
2003									
2004									
Total for Machias	32	329	9	2	33	1592	41	131	**2,169**
Merrimack									
1978-1994	137	653	17	1	77	809	23	0	**1,717**
1995	2	18	0	0	0	14	0	0	**34**
1996	11	44	0	3	3	13	0	2	**76**
1997	9	43	0	4	9	5	0	1	**71**
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**
Total for Merrimack	307	1,211	21	8	123	1003	23	3	**2,699**
Narraguagus									
1967-1994	90	624	19	51	48	2,140	68	134	**3,174**
1995	0	0	0	0	0	51	0	5	**56**
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	1	0	0	1	9	0	0	**11**
Total for Narraguagus	91	638	19	53	88	2368	70	153	**3,480**
Pawcatuck									
1981-1994	1	137	1	0	0	1	0	0	**140**
1995	0	2	0	0	0	0	0	0	**2**
1996	0	2	0	0	0	0	0	0	**2**
1997	0	0	0	0	0	3	0	0	**3**
1998	0	0	0	0	1	2	0	0	**3**
1999	1	6	0	0	0	4	0	0	**11**
2000	0	1	0	0	0	0	0	0	**1**
2001	0	0	0	0	0	0	0	0	**0**
2002	0	0	0	0	0	0	0	0	**0**

	HATCHERY ORIGIN				WILD ORIGIN				
	1SW	2SW	3SW	REPEAT	1SW	2SW	3SW	REPEAT	Total
2003									
2004	0	0	0	0	0	1	0	0	**1**
Total for Pawcatuck	2	148	1	0	1	11	0	0	**163**
Penobscot									
1967-1994	7,965	35,324	201	466	415	2,326	23	65	**46,785**
1995	158	1,077	7	9	6	84	0	1	**1,342**
1996	482	1,187	6	14	13	335	3	5	**2,045**
1997	241	914	4	13	6	174	2	1	**1,355**
1998	240	796	0	10	29	130	1	4	**1,210**
1999	225	568	0	9	46	110	0	10	**968**
2000	166	265	0	15	17	70	0	2	**535**
2001	191	469	0	2	24	98	2	0	**786**
2002	362	344	1	15	14	41	0	2	**779**
2003	196	848	2	3	6	56	0	1	**1,112**
2004	276	952	10	16	5	59	3	2	**1,323**
Total for Penobscot	10,502	42,744	231	572	581	3483	34	93	**58,240**
Pleasant									
1967-1994	5	12	0	0	11	214	2	2	**246**
1995									
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**
Total for Pleasant	5	12	0	0	14	228	3	2	**264**
Saco									
1977-1994	23	324	2	2	0	2	0	0	**353**
1995	0	34	0	0	0	0	0	0	**34**
1996	11	39	1	3	0	0	0	0	**54**
1997	5	23	0	0	0	0	0	0	**28**
1998	9	7	0	0	4	7	1	0	**28**
1999	10	11	0	0	12	31	2	0	**66**
2000	31	14	0	0	0	4	0	0	**49**
2001	15	49	0	0	0	5	0	0	**69**
2002	3	37	0	2	3	2	0	0	**47**

	HATCHERY ORIGIN				WILD ORIGIN				
	1SW	2SW	3SW	REPEAT	1SW	2SW	3SW	REPEAT	Total
2003	2	23	0	0	2	12	0	0	**39**
2004	3	10	0	0	2	4	0	0	**19**
Total for Saco	112	571	3	7	23	67	3	0	**786**
Sheepscot									
1967-1994	6	36	0	0	30	328	10	0	**410**
1995	0	2	0	0	0	22	0	0	**24**
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									
Total for Sheepscot	6	38	0	0	30	358	10	0	**442**
St Croix									
1981-1994	605	987	38	12	403	613	39	17	**2,714**
1995	7	15	0	0	8	16	0	0	**46**
1996	13	77	0	0	10	32	0	0	**132**
1997	26	2	0	0	0	0	0	0	**28**
1998	20	3	0	0	12	6	0	0	**41**
1999	1	2	0	0	7	3	0	0	**13**
2000	10	10	0	0	0	0	0	0	**20**
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**
Total for St Croix	715	1,118	38	12	440	670	39	17	**3,049**
Union									
1973-1994	290	1,734	9	24	1	11	0	0	**2,069**
1995									
1996	6	62	0	0	0	1	0	0	**69**
1997	0	8	0	0	0	0	0	0	**8**
1998	2	7	0	4	0	0	0	0	**13**
1999	3	3	0	0	0	3	0	0	**9**
2000	1	1	0	0	0	0	0	0	**2**
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**

	HATCHERY ORIGIN				WILD ORIGIN				
	1SW	2SW	3SW	REPEAT	1SW	2SW	3SW	REPEAT	Total
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	30	523	6	2	6	84	0	1	**652**
Cocheco	0	0	1	1	6	10	0	0	**18**
Connecticut	36	3,503	28	2	52	1,471	12	4	**5,108**
Dennys	37	303	0	1	23	740	3	10	**1,117**
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	307	1,211	21	8	123	1,003	23	3	**2,699**
Narraguagus	91	638	19	53	88	2,368	70	153	**3,480**
Pawcatuck	2	148	1	0	1	11	0	0	**163**
Penobscot	10,502	42,744	231	572	581	3,483	34	93	**58,240**
Pleasant	5	12	0	0	14	228	3	2	**264**
Saco	112	571	3	7	23	67	3	0	**786**
Sheepscot	6	38	0	0	30	358	10	0	**442**
St Croix	715	1,118	38	12	440	670	39	17	**3,049**
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 (%)										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	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 1999 - 2002 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	6	82	12	
2000	6,928	37	0.053	0	0	0	0	100		0				0	0	100		
2001	6,989	3	0.004	0	67		33							0	100			
2002	4,903	0	0.000	0										0				
Total	**58,510**	**1,043**																
Mean			**0.572**	**0**	**8**	**0**	**3**	**66**	**5**	**0**	**3**	**0**	**0**	**0**	**11**	**66**	**8**	**0**

Mean return rate computation includes incomplete return rates for 1999 - 2002 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 (%) 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	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 1999 - 2002 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	4	82	13	
2000	9,292	57	0.061	0	7	0	0	93		0				0	7	93		
2001	9,557	8	0.008	0	50		50							0	100			
2002	7,249	1	0.001	100										100				
Total	**85,256**	**1,535**																
Mean			**0.439**	**3**	**14**	**0**	**4**	**64**	**2**	**0**	**5**	**0**	**0**	**3**	**17**	**64**	**7**	**15**

Mean return rate computation includes incomplete return rates for 1999 - 2002 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	50	50	

Mean return rate computation includes incomplete return rates for 1999 - 2002 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	8	0.064	0	0	0	0	100		0				0	0	100		
2001	1,252	3	0.024	0	33		67							0	100			
2002	1,192	1	0.008	100										100				
Total	**14,059**	**281**																
Mean			**0.315**	**4**	**24**	**0**	**4**	**56**	**1**	**0**	**10**	**0**	**0**	**4**	**28**	**56**	**10**	**0**

Mean return rate computation includes incomplete return rates for 1999 - 2002 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 (%)										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
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 1999 - 2002 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	13	50	38	
2000	2,217	12	0.054	0	0	0	0	100		0				0	0	100		
2001	1,708	2	0.012	0	0		100							0	100			
2002	1,414	0	0.000	0										0				
Total	**29,454**	**1,153**																
Mean			**2.638**	**0**	**2**	**0**	**12**	**63**	**3**	**3**	**9**	**0**	**0**	**0**	**14**	**66**	**12**	**1**

Mean return rate computation includes incomplete return rates for 1999 - 2002 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	0	0.000	0	0	0	0	0	0	0	0			0	0	0	0	
2000	326	1	0.031	0	0	0	0	100		0				0	0	100		
2001	423	0	0.000	0	0		0							0	0			
2002	403	0	0.000	0										0				
Total	**4,349**	**11**																
Mean			**0.028**	**0**	**0**	**0**	**2**	**48**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**48**	**0**	**0**

Mean return rate computation includes incomplete return rates for 1999 - 2002 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	100	0	
2000	278	3	0.108	0	100	0	0	0		0				0	100	0		
2001	250	0	0.000	0	0		0							0	0			
2002	263	0	0.000	0										0				
Total	**2,724**	**44**																
Mean			**0.182**	**0**	**22**	**0**	**2**	**53**	**0**	**0**	**0**	**0**	**0**	**0**	**24**	**53**	**0**	**0**

Mean return rate computation includes incomplete return rates for 1999 - 2002 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	75	25	
2000	839	9	0.107	0	11	0	0	89		0				0	11	89		
2001	1,066	2	0.019	0	50		50							0	100			
2002	892	0	0.000	0										0				
Total	**9,961**	**167**																
Mean			**0.174**	**0**	**6**	**0**	**7**	**80**	**0**	**0**	**6**	**0**	**0**	**0**	**14**	**80**	**6**	**0**

Mean return rate computation includes incomplete return rates for 1999 - 2002 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
1998	0.031	0.000	0.048	0.050	0.039	0.017	0.078
1999	0.046	0.000	0.070	0.072	0.454	0.020	0.056
2000	0.054	0.031	0.061	0.053	0.108	0.064	0.107
2001	0.012	0.000	0.008	0.004	0.000	0.024	0.019
2002	0.000	0.000	0.001	0.000	0.000	0.008	0.000
Mean	**2.638**	**0.028**	**0.439**	**0.572**	**0.182**	**0.315**	**0.174**
StndDev	**5.864**	**0.046**	**0.497**	**0.773**	**0.223**	**0.334**	**0.199**

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	2.9	0.1	2.3	88.7	0.9	0.0	0.1	0.0	0.1	0.0	5.2	88.8	5.9	0.1
Connecticut (basin)	0.1	7.8	0.1	3.3	83.2	0.7	0.0	0.0	0.0	0.1	0.1	11.1	83.3	5.5	0.1
Farmington	0.7	26.7	0.0	4.6	63.0	0.7	0.0	0.0	0.0	0.0	0.7	31.3	63.0	5.0	0.0
Salmon	0.0	27.3	0.0	11.4	61.4	0.0	0.0	0.0	0.0	0.0	0.0	38.6	61.4	0.0	0.0
Westfield	0.0	1.8	0.0	4.8	88.6	0.0	0.0	0.0	0.0	0.0	0.0	6.6	88.6	4.8	0.0
Merrimack	0.2	3.0	0.2	8.5	76.2	1.8	0.0	0.1	0.3	0.2	0.2	11.5	78.5	9.4	0.4
Overall Mean:	**0.2**	**11.6**	**0.1**	**5.8**	**76.8**	**0.7**	**0.0**	**0.0**	**0.0**	**0.1**	**0.2**	**17.4**	**77.3**	**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.