ANNUAL REPORT OF THE U.S ATLANTIC SALMON ASSESSMENT COMMITTEE

REPORT NO. 28 - 2015 ACTIVITIES

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PREPARED FOR
U.S. SECTION TO NASCO

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1 Executive Summary

Abstract

Total return to USA rivers was 921; this is the sum of documented returns to traps and returns estimated by redd counts on selected Maine rivers, this is the fourth lowest for the 1991-2015 time series, 204% increase over 2014 (the lowest in the time series) and only 22% of the recent high return number in 2011. Adult salmon returns to USA rivers with traps or weirs totaled 803 in 2015. Estimated return to Gulf of Maine small coastal rivers was 118 adult salmon. Most returns occurred to the Gulf of Maine Distinct Population Segment, which includes the Penobscot River and eastern Maine coastal rivers, accounting for 96% of the total return. Overall, 16% of the adult returns to the USA were 1SW salmon, 83% were 2SW salmon and 1% were 3SW or repeat spawners. Most (80%) returns were of hatchery smolt origin and the balance (20%) originated from either natural reproduction or hatchery fry and eggs. A total of 4,044,000 juvenile salmon (eggs, fry, parr, and smolts), and 4,271 adults were stocked in 2015. Of those fish 328,792 juveniles carried a variety of marks and/or tags. Eggs for USA hatchery programs were taken from 348 sea-run females and 1,243 captive/domestic and domestic females. The total number of females (1,591) contributing was similar to 2013 (1,577); and the total egg take (6,962,000) was similar to 2014 (6,520,000). Production of farmed salmon in Maine was not available, due to regulation concerning privacy.

Description of Fisheries

Commercial and recreational fisheries for sea-run Atlantic salmon are closed in USA waters (including coastal waters). Estimated catch and unreported catch are zero (metric tonne), there was zero estimated discard from US marine commercial fisheries.

Adult Returns

Total return to USA rivers was 921; (Table 1.3.1), a 204% increase from 2014 returns and a 78% decrease from 2011 returns (Table 1.3.2). Returns are reported for three meta-population areas (Figure 1.3.1); Long Island Sound (LIS), Central New England (CNE), and Gulf of Maine (GOM). Changes from 2014 within areas were: LIS (-31%), CNE (-58%), GOM (+130%). The ratio of sea ages for fish sampled at trap and weir within other coastal GOM rivers was used to estimate the number of 2SW spawners for the estimated returns. In 2015 and into the future CNE rivers' sea ages were based on estimation from previous years, as fish are no longer handled on the trap.

Most returns occurred in the Gulf of Maine area, with the Penobscot River accounting for 79% of the total return. Overall, 16% of the adult returns to the USA were 1SW salmon and 84% were MSW salmon. Most (80%) returns were of hatchery smolt origin and the balance (20%) originated from natural reproduction, planted eggs, or hatchery fry (Figure 1.3.2). The adult return rate (1SW plus 2SW) of hatchery smolts released in the Penobscot River in

2013 was 0.11%, with the 2SW fish return rate 0.10% (Figure 1.3.3). The estimated return rate for 2SW adults from the 2013 cohort of wild smolts on the Narraguagus was 1.91% (Figure 1.3.3).

In the USA, returns are well below conservation spawner requirements. Returns of 2SW fish from traps, weirs, and estimated returns were only 2.6% of the 2SW conservation spawner requirements for USA, with returns to the three areas ranging from 0.2 to 4.6 % of spawner requirements (Table 1.3.3).

Stock Enhancement Programs

During 2015 about 4,040,00 juvenile salmon (65% fry) were released and 531,000 eggs were planted into 13 river systems (Table 1.4.1). The number of juveniles released was less than that in 2014. Fry were stocked in the Connecticut, Merrimack, Saco, Penobscot, and five coastal rivers within the GOM area Maine. The majority of smolts were stocked in one river into the GOM. In addition to juveniles, 4,271 adult salmon were released into USA rivers (Table 1.4.2). A total of 1,205 of these were pre-spawn adults released into sub-drainages of the Merrimack River; this is a result of the continued closure of the Merrimack Program.

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 328,792 salmon released into USA waters in 2015 were marked or tagged. Tags and marks for parr, smolts, and adults included: Floy, PIT, radio, acoustical, visual implant elastomer and fin clips. Nearly all of the tagging occurred in the GOM area (Table 1.5.1).

Farm Production

Production of farmed salmon in Maine was not available. As only one company is currently in production we are unable to release information based on privacy concerns. Zero aquaculture escapees were captured at fishways in the USA.

Table 1.3.1 Estimated Atlantic salmon returns to USA by geographic area, 2015. "Natural" includes fish originating from natural spawning and hatchery fry or eggs. Some numbers are based on redds. Ages and origins are prorated where fish are not available for handling.

Area	1SW		2SW		3SW		Repeat Spawners		TOTAL
	Hatchery	Natural	Hatchery	Natural	Hatchery	Natural	Hatchery	Natural	
LIS	0	4	0	18	0	0	0	0	22
CNE	1	0	12	3	1	1	0	0	18
GOM	120	25	597	131	7	0	1	0	881
Total	121	29	609	152	8	1	1	0	921

Table 1.3.2 Estimated Atlantic salmon returns to the USA, 1967-2015. "Natural" includes fish originating from natural spawning and hatchery fry or eggs. Starting in 2003 estimated returns based on redds are included.

Year	Sea age					Origin	
	1 SW	2SW	3SW	Repeat	Total	Hatchery	Natural
1967	75	574	39	93	781	114	667
1968	18	498	12	56	584	314	270
1969	32	430	16	34	512	108	404
1970	9	539	15	17	580	162	418
1971	31	407	11	5	454	177	277
1972	24	946	38	17	1,025	495	530
1973	18	623	8	13	662	422	240
1974	52	791	35	25	903	639	264
1975	77	1,250	14	30	1,371	1,126	245
1976	172	836	6	16	1,030	933	97
1977	63	1,027	7	33	1,130	921	209
1978	145	2,269	17	33	2,464	2,082	382
1979	225	972	6	21	1,224	1,039	185
1980	707	3,437	11	57	4,212	3,870	342
1981	789	3,738	43	84	4,654	4,428	226
1982	294	4,388	19	42	4,743	4,489	254
1983	239	1,255	18	14	1,526	1,270	256
1984	387	1,969	21	52	2,429	1,988	441
1985	302	3,913	13	21	4,249	3,594	655
1986	582	4,688	28	13	5,311	4,597	714
1987	807	2,191	96	132	3,226	2,896	330
1988	755	2,386	10	67	3,218	3,015	203
1989	992	2,461	11	43	3,507	3,157	350
1990	575	3,744	18	38	4,375	3,785	590
1991	255	2,289	5	62	2,611	1,602	1,009
1992	1,056	2,255	6	20	3,337	2,678	659
1993	405	1,953	11	37	2,406	1,971	435
1994	342	1,266	2	25	1,635	1,228	407
1995	168	1,582	7	23	1,780	1,484	296
1996	574	2,168	13	43	2,798	2,092	706
1997	278	1,492	8	36	1,814	1,296	518
1998	340	1,477	3	42	1,862	1,146	716
1999	402	1,136	3	26	1,567	959	608
2000	292	535	0	20	847	562	285
2001	269	804	7	4	1,084	833	251
2002	437	505	2	23	967	832	135
2003	233	1,185	3	6	1,427	1,238	189
2004	319	1,266	21	24	1,630	1,395	235
2005	317	945	0	10	1,272	1,019	253
2006	442	1,007	2	5	1,456	1,167	289
2007	299	958	3	1	1,261	940	321
2008	812	1,758	12	23	2,605	2,191	414
2009	243	2,065	16	16	2,340	2,017	323
2010	552	1,081	2	16	1,651	1,468	183
2011	1,084	3,053	26	15	4,178	3,560	618
2012	26	879	31	5	941	731	210
2013	78	525	3	5	611	413	198
2014	110	334	3	3	450	304	146
2015	150	761	9	1	921	739	182

Table 1.3.3 Two sea winter (2SW) returns for 2015 in relation to spawner requirements for USA rivers.

Area		Spawner Requirement	2SW returns 2013	Percentage of Requirement
Long Island Sound	LIS	10,094	18	0.2%
Central New England	CNE	3,435	15	0.4%
Gulf of Maine	GOM	15,670	728	4.6%
Total		29,199	761	2.6%

Table 1.4.1 Number of juvenile Atlantic salmon stocked in USA, 2015. Numbers are rounded to nearest 100.

Area	N	Rivers	Eyed Egg	Fry	0 Parr	1 Parr	1 Smolt	2 Smolt	Total
LIS	2	Connecticut, Pawcatuck		391,000					391,000
CNE	2	Merrimack, Saco		702,000	25,000		11,700		738,700
GOM	8	Androscoggin to Dennys	531,000	1,538,000	464,500		375,600		2,909,100
OBF	1	Aroostook		1,000					1,000
Total	13		531,000	2,632,000	489,500		387,300		4,039,800

Table 1.4.2 Stocking summary for sea-run, captive, and domestic adult Atlantic salmon and egg planting summary for the USA in 2015 by geographic area.

Area		Purpose	Captive Reared Domestic		Sea Run		Total
			Pre-spawn	Post-spawn	Pre-spawn	Post-spawn	
Central New England	CNE	Recreation	1,205				1,205
Gulf of Maine	GOM	Restoration	741	1,737	7	581	3,066
Total for USA			1,946	1,737	7	581	4,271

Table 1.5.1 Summary of tagged and marked Atlantic salmon released in USA, 2015. Includes hatchery and wild origin fish.

Mark Code	Life History	GOM
AD	Parr	206,182
AD	Adult	696
PING	Smolt	225
PIT	Adult	2,421
PIT	Parr	562
VIE	Smolt	117,628
RAD	Adult	58
RAD	Smolt	1,020
Total		328,792

AD = Adipose clip
PIT = Passive integrated transponder
PING = ultrasonic acoustic tag
RAD = radio tag
VIE = Visual Implant Elastomer

Table 1.6.1 Aquaculture production (metric tonnes) in New England from 1997 to 2015. Production for 2011-2015 are unknown.

Year	MT
1997	13,222
1998	13,222
1999	12,246
2000	16,461
2001	13,202
2002	6,798
2003	6,007
2004	8,515
2005	5,263
2006	4,674
2007	2,715
2008	9,014
2009	6,028
2010	11,127
2011	*
2012	*
2013	*
2014	*
2015	*

* not available for distribution

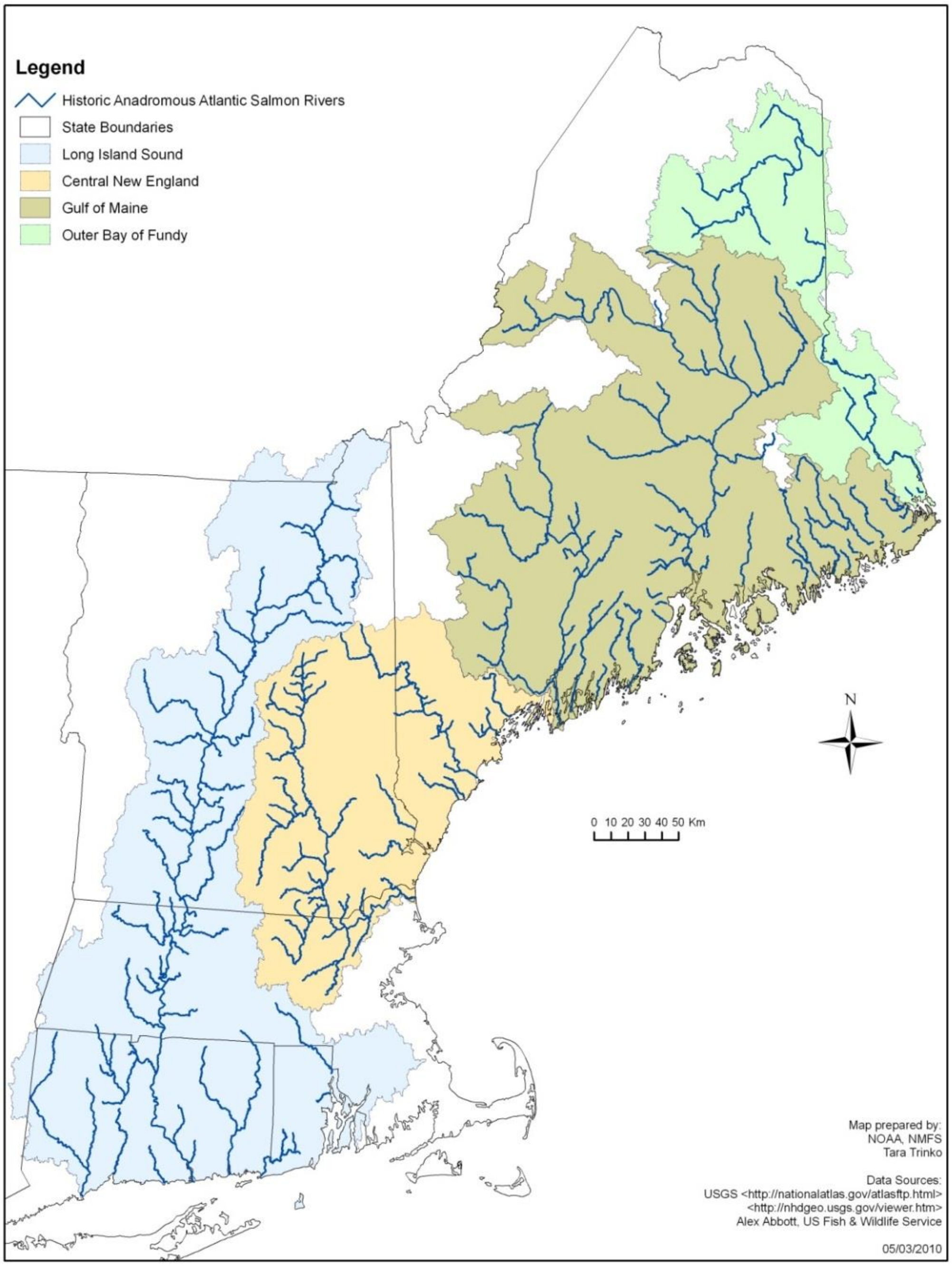

Figure 1.3.1 Map of geographic areas used in summaries of USA data for returns, stocking, and marking in 2015.

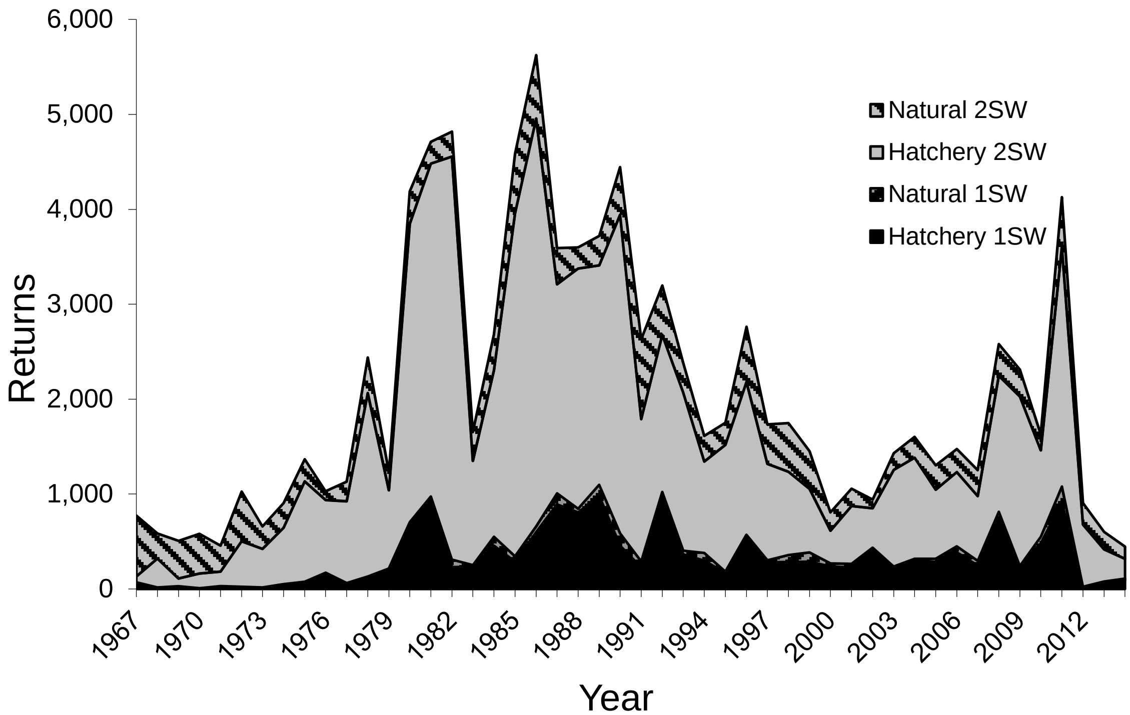

Figure 1.3.2 Origin and sea age of Atlantic salmon returning to USA rivers, 1967 to 2015.

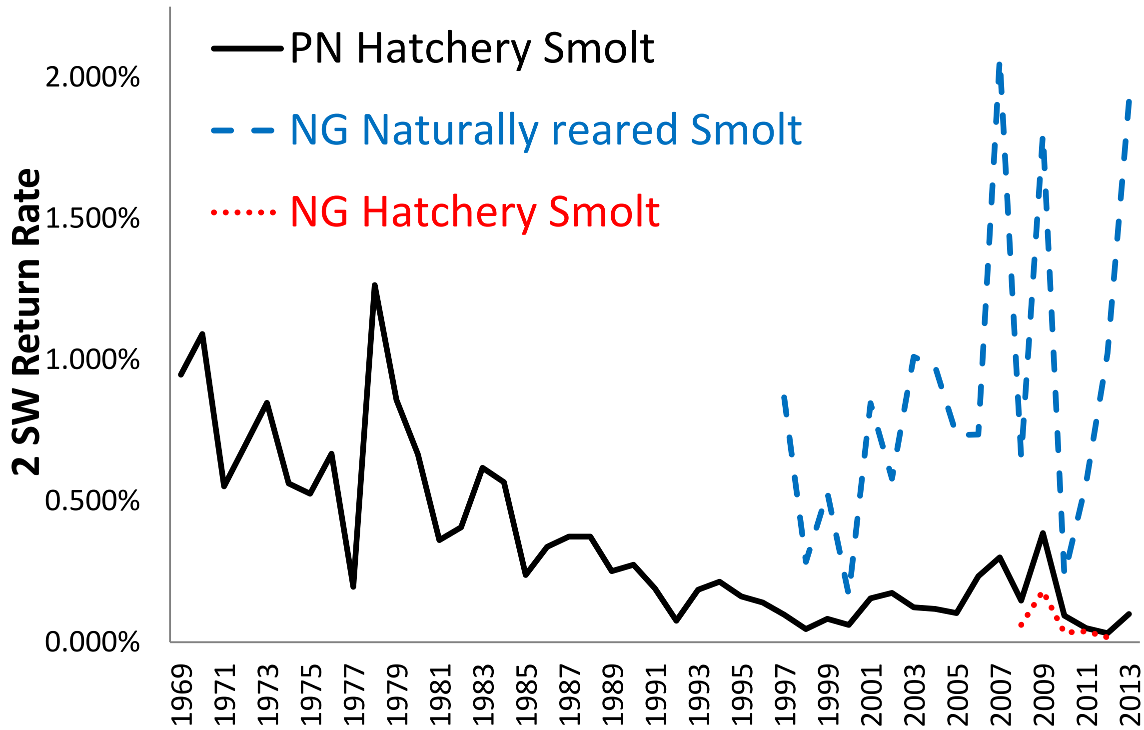

Figure 1.3.3 Return rate of 2SW adults to Gulf of Maine area rivers by smolt cohort year of hatchery-reared Atlantic salmon smolts (Penobscot River solid line) and estimated wild smolt emigration (Narraguagus River blue dashed line), and hatchery-reared salmon smolts (Narraguagus River red dotted line) USA.

2 Status of Stocks

2.1 Distribution, Biology and Management

Atlantic salmon, *Salmo salar*, is a highly prized game and food fish with a circumpolar distribution. In North America, the species originally ranged from the Ungava Bay southward to Long Island Sound, encompassing most coastal New England river basins (2.1.1). As a consequence of human development, many native New England populations were extirpated (Fay et al. 2006). Salmon life history is complex because fish use both headwater streams and distant marine habitats (2.1.2). The life cycle for US Atlantic salmon begins with spawning in rivers during autumn, and eggs remain in the gravel and hatch during winter. Fry emerge from the gravel in spring. Juvenile salmon (parr) remain in rivers 1–3 years. When parr exceed 13 cm (5 in) in the autumn, they typically develop into smolts, overwinter, and then migrate to the ocean in spring. Tagging data indicates that US salmon commonly migrate as far north as West Greenland. After their first winter at sea, a portion (~20%) of the cohort, typically males, become sexually mature and return to spawn as 1 sea-winter (1SW) fish (grilse). Non-maturing adults remain at sea, feeding in the coastal waters of West Greenland, Newfoundland, and Labrador. Historically, gillnet fisheries for salmon occurred in coastal waters. After their second winter at sea (2SW), most US salmon return to spawn, with 3 sea-winter and repeat-spawning salmon life history patterns being less common and becoming rarer (<3%) with declining stock size.

Strong homing capabilities of Atlantic salmon foster the formation and maintenance of local breeding groups or stocks (National Research Council 2002; Verspoor et al. 2002; Spidle et. al. 2003). These stocks exhibit heritable adaptations to their home range in rivers and likely at sea. The importance of maintaining local adaptations has demonstrated utility in salmon conservation (National Research Council 2004). Because of significant declines in Atlantic salmon populations in the US, an analyses of population structure was conducted, and some populations are managed under the Endangered Species Act (ESA, 74 Federal Register 29346, June 19, 2009). The Act required that subgroups must be separable from the remainder of, and significant to, the species to which it belongs to warrant ESA protection.

Assessing population structure required broad scale consideration of geologic and climatic features that shape population structure through natural selection. For Atlantic salmon, factors such as climate, soil type, and hydrology were particularly important because these factors influence ecosystem structure and function, including transfer of energy in aquatic food chains (Fay et al. 2006). Numerous ecological classification systems were examined, which integrated the many factors necessary to discern historic structure. Biologists then delineated US Atlantic salmon populations into four discrete stock complexes that are managed discretely: (i) **Long Island Sound** complex; (ii) **Central New England** complex; (iii) **Gulf of Maine** distinct population segment (DPS), and (iv) the **Outer Bay of Fundy** designatable unit (DU; Figure 2.1.1).

Restoration Areas. Native stocks in both the **Long Island Sound** and **Central New England** areas were extirpated in the 1800s (Parrish et al. 1998; Fay et. al 2006). Remnant native populations of Atlantic salmon in the US now persist only in Maine. Atlantic salmon stocks from the Penobscot River in Maine were primary donor stocks used to initiate restoration programs in the Connecticut and Pawcatuck rivers (Long Island Sound DPS) and in the Merrimack and Saco rivers (Central New England DPS). The Connecticut River program became independent of stocks from Maine and was able to sustain genetic diversity and facilitate local adaptation (Spidle et. al. 2004). All of these populations were managed under coordinated federal and interstate restoration efforts, in the form of stocking and fish-passage construction and protected from harvest by state laws and the New England Fishery Management Council Fishery Management Plan. However, USFWS curtailed large hatchery programs in the Long Island Sound DPS 2013, but the State of Connecticut agency will continue a Legacy Program in selected portions of the Connecticut River watershed within its state. Likewise, large programs were curtailed in the Merrimack in 2014. The public-private restoration program in the Saco River will represent the only stocking effort in the Central New England DPS. It is expected that remnant naturally-occurring populations may persist in the immediate future in both restoration areas.

The **Gulf of Maine DPS** represents the last naturally spawning stocks of Atlantic salmon in the US and is managed under an ESA recovery program (Anon 2005). There are several extant stocks in the DPS that are divided into three geographic Salmon Habitat Recovery Units (SHRUs): (i) Downeast Coastal; (ii) Penobscot Bay and (iii) Merrymeeting Bay. Five Downeast Coastal stocks (Dennys, East Machias, Machias, Pleasant, Narraguagus), one Penobscot Bay stock (Penobscot), and one Merrymeeting Bay stock (Sheepscot) have ongoing hatchery-supplementation programs that use river-specific broodstock. ESA recovery programs using donor stocks are ongoing in the Union, Kennebec, and Androscoggin Rivers. The Ducktrap River stock has no hatchery component but a small wild run persists. Like the restoration programs, fry stocking makes up the majority of conservation hatchery inputs to these systems, but in the Penobscot and selected river systems, smolt stocking is a major contributor that results in returns for broodstock collection and natural spawning. In addition, these extant stocks represent potential donor populations for other watersheds. While at low levels, natural reproduction still represents an important element of the management system, and redd surveys both document this contribution and facilitate management of stocked fish to protect naturally spawned offspring.

US watersheds in the **Outer Bay of Fundy** DU are supplemented by St. John River Atlantic salmon broodstock, and the core populations of this management unit have freshwater nursery areas, primarily in Canadian watersheds. The St. John River population is the largest in this region, and fish in the Aroostook River are part of this stock. In addition, the St. Croix River is in this Canadian management unit. Within Canada, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assesses population structure and status and designates which wildlife species are in peril. COSEWIC completed a species-level assessment of Atlantic salmon in eastern Canada in November 2010. The COSEWIC assessment identified 16 designatable units (DUs—equivalent to a DPS/ESU) and the two closest to the US- the outer Bay of Fundy DU (including Aroostook and St. Croix) and inner Bay of Fundy DU, were listed as endangered and recovery planning is ongoing.

2.2 The Fishery

Atlantic salmon were documented as being utilized by Native Americans in Maine approximately 7,000–6,500 calendar years BP (Robinson et al. 2009). US commercial fisheries started in Maine during the 1600s, with records of catch by various methods. Around the time of the American Revolution, weirs became the gear of choice and were modified when more effective materials and designs became available (Baum 1997). Weirs remained the primary commercial gear, with catches in Maine exceeding 90 metric tonnes (mt) in the late 1800s and 45 mt in some years during the early 1900s (Baum 1997). Penobscot River and Bay were the primary landing areas, but when the homewater fishery was finally closed in 1948, only 40 fish were harvested in this region.

Recreational angling for Atlantic salmon was historically important. The first US Atlantic salmon reportedly caught on rod and reel was captured in the Dennys River, Maine in 1832 by an unknown angler (Baum 1997). The dynamics of Atlantic salmon fishing are very ritualistic, with fly-fishing being the most generally acceptable method of angling, and the advent of salmon clubs among many US rivers creating an important and unique cultural and historical record (Beland and Bielak 2002). Recreational angling has been closed in the US for decades, with the exception of Maine, where regulations became more restrictive and harvest was discontinued in the early 1990's in all Maine Rivers but a catch-and-release fishery remained open. However, in 1999, when low salmon returns threatened sustainability of even hatchery populations, the remaining catch-and-release fishery was closed. In Maine, an experimental Penobscot River autumn (2006 and 2007) and spring (2008) catch-and-release fishery was authorized, but then closed again until populations rebuild. There remains a unique fishery for Atlantic salmon in New Hampshire, where fish retired from hatchery broodstock are reconditioned and released for angling in tributaries to the Merrimack River, which historically contained sea-run populations. License sales for this fishery are stable at about 1,300 per year.

According to the Atlantic salmon fishery management plan of the New England Fishery Management Council, the management unit for the Atlantic salmon FMP is intended to encompass the entire range of the species of U.S. origin while recognizing the jurisdictional authority of the signatory nations to NASCO. Accordingly, the management unit for this FMP is: "All anadromous Atlantic salmon of U.S. origin in the North Atlantic area through their migratory ranges except while they are found within any foreign nation's territorial sea or fishery conservation zone (or the equivalent), to the extent that such sea or zone is recognized by the United States." Presently, there is a prohibition on the possession of salmon in the EEZ. This effectively protects the entire US population complex in US marine waters and is complementary to management practiced by the states and Federal Managers for ESA listed stocks in riverine and coastal waters. However, distant-water fisheries must be managed as well to conserve and restore US salmon populations. Commercial fisheries for Atlantic salmon in Canada and Greenland are managed under the auspices of the North Atlantic Salmon Conservation Organization (NASCO), of which the US is a member. The mixed-stock fisheries in Canada were historically managed by time-area closures and quotas. However, all commercial fisheries for Atlantic salmon in Canada thought to intercept US salmon have been closed since 2000. The Greenland fishery has been managed by a quota system since 1972. In 1993, a modified quota system was agreed to, which provided a framework for quotas based on a forecast model of salmon abundance. From 1993 to 1994, quotas were bought out through a private initiative, but the fishery resumed in 1995 under forecast-modeling-based quotas. In 2002, salmon conservationists and the Organization of Fishermen and Hunters in Greenland signed a five-year, annually renewable agreement, which suspended all commercial salmon fishing within Greenland territorial waters, while allowing for an annual internal use only fishery. In 2007, a similar agreement was signed and was to be in in effect through 2013 fishing season.

The scientific advice from ICES has recommended no commercial harvest because of continued low spawner abundance since 2002. Starting in 2003, the annual regulatory measures agreed to at NASCO have restricted the annual harvest to the amount used for internal consumption in Greenland, which in the past has been estimated at 20 mt annually, with no commercial export of salmon allowed. Similar annual regulatory measures were adopted in 2004 and 2005. In 2006, multiannual regulatory measures covering the 2006-2008 fishing seasons were adopted assuming that the Framework of Indicators used in those interim years showed that there was no significant change in the previously provided multiannual catch advice. The Framework of Indicators allows for an interim check on the stock status of the West Greenland salmon complex, based on a variety of production measures, such as adult abundance and marine survival rates measured at monitoring facilities in rivers across the range of the species. Similar multiannual regulatory measures have been adopted to cover the 2009–2011 and the 2012-2014 fishing seasons. In 2012, the Government of Greenland unilaterally set a quota for factory landings of Atlantic salmon at 35 mt. A total harvest of 34 mt was reported for the 2012 fishing season, of which 14 mt were reported as factory landings. Parties to the West Greenland Commission of NASCO raised concerns that the option of landing to a factory may result in the increased harvest of Atlantic salmon beyond historical internal use levels. The Government of Greenland maintains that the option for landing to a factory falls within the current regulatory measure adopted within NASCO and that there will be no incentive for increased harvest. A quota for factory landings was again set to 35 mt for the 2013 fishery. Negotiations on this issue are continuing both within and outside of NASCO.

2.2.1 Aquaculture

Despite declining natural populations, the Atlantic salmon mariculture industry continues to develop worldwide. In eastern Maine and Maritime Canada, companies typically rear fish to smolt stage in private freshwater facilities, transfer them into anchored net pens or sea cages, feed them, and harvest the fish when they reach market size. In the Northwest Atlantic, 66% of production is based in Canada, with 99.4% of Canadian production in the Maritimes and 0.6% in Newfoundland. The balance (44%) of Northwest Atlantic production is in eastern Maine. US production trends for Maine facilities and areas occupied by marine cages have grown exponentially for two decades. By 1998, there were at least 35 freshwater smolt-rearing facilities and 124 marine production facilities in eastern North America. Since the first experimental harvest of Atlantic salmon in 1979 of 6 mt, the mariculture industry in eastern North America has grown to produce greater than 32,000 mt annually since 1997. In Maine, production increased rapidly and peaked at about 16,500 mt in 2000, but abruptly declined to below 6,000 mt in 2005 because of a disease outbreak (infectious salmon anemia) that forced the destruction of large numbers of fish. Production practices also had to change due to a federal judge fining producers for violating the federal Clean Water Act through fouling the sea floor with excess feed, medications, feces, and other pollutants. With improved regulations targeting sustainable best management practices with innovative bay-area management creating fallowing areas, farmers have increased sustainability and production, and production has rebuilt (Figure 2.2.1.1). Maine production in 2010 was over 11,000 mt, the 6th highest in the 27-year time series and valued at $73.6M. With one company in production since 2011, confidentiality policies preclude detailed reporting. The Industry projects that with new practices of fallowing production areas and rotations, annual production will vary depending upon areas occupied but should average about 6,000 mt.

Current management efforts focus on the recovery of natural populations and support of sustainable aquaculture to ensure both resource components are managed in a manner that protects both wild stocks and marine habitats.

2.3 Research Vessel Survey Indices

Atlantic salmon in the ocean are pelagic, highly surface–oriented, and of relatively limited abundance within a large expansive area; therefore, they are not typically caught in standard NEFSC bottom trawl surveys or midwater trawls used to calibrate hydroacoustic surveys. However, researchers in Canada and Norway have successfully sampled Atlantic salmon postsmolts using surface trawls. The NEFSC has been experimenting with these techniques to test them in US waters while learning more of the distribution and ecology of Atlantic salmon in the marine environment. Between 2001 and 2005, NEFSC surface trawls sampled over 4,000 postsmolts; all postsmolts were counted, weighed, and measured. The presence of any marks and clips was also recorded, as well as the fish's external appearance, degree of smoltification and fin condition and deformities, which aided in origin determination. These assessments provided novel information on US salmon postsmolt ecology and status at sea (Sheehan et al. 2011).

2.4 Stock Assessment

2.4.1 Hatchery Inputs

A unique element of Atlantic salmon populations in New England is the dependence on hatcheries. Since most US salmon are products of stocking, it is important to understand the magnitude of these inputs to understand salmon assessment results. US Atlantic salmon hatcheries are run by the US Fish and Wildlife Service and state agencies. Hatchery programs in the US take two forms: (i) conservation hatcheries that produce fish from remnant local stocks within a DPS and stock them into that DPS, or (ii) restoration hatcheries that produce salmon from broodstock originally established from donor populations outside their native DPS. Hatchery programs for the Gulf of Maine DPS are conservation hatcheries. All other New England hatcheries that operated in 2013 were restoration hatcheries. These restoration hatcheries developed broodstock primarily from original donor stocks from the Penobscot River population.

For information on the numbers of hatchery fish stocked into each US system, see Appendix 7 for current year totals and Appendix 14 for historic time series. Hatchery inputs are important to understand since hatchery-reared smolts consistently produce over 75% of the adult salmon returns to the US. Cost and hatchery capacity issues prevent more extensive use of smolts. However, fry stocking is an important tool because it minimizes selection for hatchery traits at the juvenile stage, and naturally reared smolts typically have a higher marine survival rate than hatchery smolts. From a management perspective, rebuilding Atlantic salmon populations in the US will require increasing natural production of smolts in US river systems that successfully reach the ocean and using hatchery production to optimally maintain population diversity, distribution, and abundance. However, survival at sea is a dominant factor constraining stock rebuilding across all river systems. Building sustainable Atlantic salmon populations in the US will require increasing natural production of smolts in US river systems and using hatchery production to optimally maintain population diversity and effective population sizes.

2.4.2 Stock Abundance Metrics

US Atlantic salmon populations are assessed by the US Atlantic Salmon Assessment Committee (USASAC), a team of state and federal biologists tasked with compiling data on the species throughout New England and reporting population status. Currently, population status of salmon is determined by counting returning adults either directly (traps and weirs) or indirectly (redd surveys). Total returns also include retained fish from angling in other regions, and historical US time-series (pre 1996) also include these data. Some mortality can and does occur between trap counts and actual spawning—the actual number of spawners is termed “spawning escapement” and is not estimated for many US populations. However, redd counts provide a reasonable proxy for rivers with populations surveyed with that method. Fisheries could impact escapement as well, but since the mid-1990s, most open fisheries were limited to catch and release because this mortality is lower than retention-fisheries impacts on returns or escapement would be lower. The USASAC is continuing its efforts to develop metrics to examine juvenile production of large parr (pre-smolts) and emigrating smolts.

The modern time-series of salmon returns to US rivers began in 1967. From 1967 to the present, the median annual Atlantic salmon return to US Rivers was about 1,630. The time-series of data clearly shows the rebuilding of US populations from critically low levels of abundance in the early part of the 20th century (Figures 2.2.1.1). Because many of the populations in Southern New England were extirpated and the Penobscot River was at very low levels, the salmon-returns graph illustrates the sequential rebuilding of the populations through restoration efforts in the 1970s, with increased abundance first in the Penobscot River and then in the Merrimack and Connecticut rivers. Reduction in stocking programs starting in 2014 will reduce future Long Island Sound and Central New England contributions to total US returns.

The remnant populations of the smaller rivers in the Gulf of Maine DPS and the Penobscot River were the donor material for all rebuilding programs during this time. Smolt stocking drives much of the overall total adult returns and in 1977, smolt stocking exceeded a half million and has stayed above that level since then. From 1977 to 1990, the median US returns was 3,824 and recovery and restoration appeared within reach. Unfortunately, the trajectory of this recovery did not continue due to a phase shift circa 1991 in marine survival, and an overall reduction in marine survival occurred in most southern North American populations (Chaput et al. 2005). Median annual Atlantic salmon returns to US rivers from 1991 to the present is 1,630 fish, less than 43% of the1977-1990 time-series median. There has been a downward trend in the production of salmon on both sides of the Atlantic (particularly populations dominated by 2SW fish), that has affected US populations. In addition, recovery from historical impacts was never sufficient, so US populations were at low absolute abundance when the current period of lower marine survival began.

Returns to US waters in 2015 were only 921 fish, which ranks the 39th in the 48 year time-series. Likewise, relative to the abundance in the current marine phase (1991–present), returns were 22nd in the 25 year time-series. This is in stark contrast to 2011 returns that were the highest in the modern period. Returns the last five years suggest high interannual variability in marine survival with some of the widest differences in interannual returns in the time-series despite relatively consistent smolt production.

Overall stock health can be measured by comparing abundance relative to target spawning escapements. Because juvenile rearing habitat can be measured or estimated efficiently, these data can be used to calculate target spawning requirements from required egg deposition. The number of returning Atlantic salmon needed to fully utilize all juvenile rearing habitats is termed “conservation spawning escapement” (CSE). These values have been calculated for US populations, and total 29,199 spawners (Table 2.4.2.1). The average percent of the CSE target for the time-series was less than 8%, and 2015 was only 2.6% of the CSE. In the last decade, total returns have accounted for less than 2% of this target for the Long Island Sound and Central New England stock complexes. However, salmon returns to the Gulf of Maine DPS have been as high as 20% of the CSE during this period, largely because of hatchery smolt returns to the Penobscot River. In smaller rivers of the Gulf of Maine stock complex, the CSE ranged from 3 to 15%. The Outer Bay of Fundy DU is assessed by the Department of Fisheries and Oceans Canada.

CSE levels are minimal recovery targets because they are based on spawning escapement that could fully seed juvenile habitat. In self-sustaining populations, the number of returns would frequently exceed this amount by 50–100%, allowing for sustainable harvests and buffers against losses between return and spawning. As such, the status of US Atlantic salmon populations is critically low for all stocks, and the remnant populations of the Gulf of Maine stock complex remain endangered.

Over the past 5 years, the contributions of each stock complex to the total US returns averaged 86% for the Gulf of Maine, 8% for Central New England, and 6% for Long Island Sound. Returns in 2015 were skewed, in that the Gulf of Maine’s returns made up close to 96% of total US returns. We expect this will continue as the other programs continue the ceasing of their restoration programs. Penobscot River population accounted for largest percentage of the total return (79%) from a single river.

Return rates provide a consistent indicator of marine survival. Previous studies have shown that most of the US stock complexes track each other over longer time-series for return rates (strongest index of marine survival). For a comprehensive look at return rates throughout New England, a cursory examination of returns from smolt stocked cohorts provides the most informative comprehensive assessment of all regions. While some subtleties, such as age structure of hatchery smolts, and subsidies from other larger juvenile stocking, such as parr, need further analysis, this is an informative metric.

Maine return-rate assessments provide both an index for naturally produced fish (fry stocked or wild spawned) in the Narraguagus River and for Penobscot River hatchery smolts—the longest and least variable in release methods and location (Figure 2.4.2.3). Penobscot average return rates per 10,000 smolts (SAR) for the last five years was 3.8 for 1SW salmon and 13.2 for 2SW fish. Starting in 1997, NOAA began a program to estimate production of naturally-reared smolts in the Narraguagus River, Maine. The average 2SW cohort SAR for naturally reared Narraguagus River smolt for the past five years was 111, 8 times higher than the Penobscot 2SW hatchery cohort average for the same time-period.

In 2015, the SAR for 2SW hatchery smolts released in the Penobscot River was 10.0, ranking 35th in the 45-year record, while the 2015 return rate for 1SW hatchery grilse was 2.0 ranking 36th in the 46-year record. The 2SW SAR in the Narraguagus River in 2015 was 191 (14 fold higher than the Penobscot). This metric points out a challenge to modern salmon recovery: naturally-reared smolts typically have better marine survival than hatchery fish, but the capacity of rivers to produce adequate numbers of smolts at present is generally well below replacement rates, under current marine survival rates. This indicates that the capacity of freshwater habitat to rear smolts must be increased through habitat restoration and enhancement for long-term recovery.

2.4.3 Juvenile Abundance Metrics

The USASAC used databases to develop regional-scale stock assessment products that assess various life history stages and artificial hatchery production and wild production in streams. This type of analysis and graphical summary has been used to summarize return rates across New England for hatchery smolts. Examination of these data in further detail for such a long time-series is providing insights into program-specific challenges and more general regional trends. The incorporation of more juvenile data across regions, especially the progression made in importing Maine juvenile data, is facilitating the development and exploration of juvenile indices and development of new metrics. The development of these indices will take time and thoughtful evaluation, given the broad geographic area (186,500 km^2), with variable climates and salmon habitat at near sea level to higher elevations of the Appalachian Mountains. The impact of development is also varied in this region of 14.3 million people, with salmon habitat in cities and remote wilderness. However, taken over a long time–series, this variable climate and environment could provide analytical opportunities that will enhance our understanding of juvenile production dynamics and factors that influence both capacity and variability.

Since 2009, USASAC has consolidated datasets across New England for juvenile production since at least the 1980's (some Maine data dates back > 50 years). Investigations of the juvenile production trends over time and more detailed assessments were initiated with the 2009 assessment. The first step towards investigating juvenile data trends was a graphical comparison of large parr densities throughout the region. Densities were calculated for sites with at least 10 years of estimates that are a product of electrofishing surveys throughout New England. For the model, large parr densities were ln+0.1 transformed then were analyzed with a mixed random effects model (years were fixed effects, 10 digit USGS hydrologic unit code within years were random effects, sites within 10 digit USGS hydrologic unit codes were random effects, and a "no intercept" model specification). For the Gulf of Maine DPS, data included density estimates from CPUE estimates as well as depletion-sampled estimates. The predicted year effects were then back-transformed to density units (Figure 2.4.3.1).

An examination of average densities (# per 100 m^2 habitat units) from 2008 to 2012 showed generally higher densities in Gulf of Maine DPS (3.7) estimates, relative to the Central New England (1.7) and Long Island Sound (1.6) but with substantial inter-annual variability. However, densities in the Gulf of Maine, while still variable, are higher in the past five years and may be trending upward. While insightful, a more thorough examination of these data relative to other factors, such as elevation, temperature, and stocking practices, may provide additional insights into best management practices and environmental factors. Although this index of parr density from the mixed random effects model was useful in examining trends in parr density through time, this index was not calculated for 2013 parr production. Changes in the overall Connecticut River and Merrimack River programs resulted in many fewer sites being electrofished by state and federal agencies. Also, sampling in the Gulf of Maine DPS has shifted to a Generalized Random Tessellated Stratified (GRTS) design. This design does not sample fixed sites annually as was typically done in the past, but rather samples sites that are randomly selected each year based upon stratification according to stream width categories. The GRTS design also samples using a single electrofishing pass which decreases the time spent at each site and allows a greater number of sites to be sampled within a given year. The advantage of this design over historic sampling methods is that greater spatial coverage is achieved in a more statistically valid sampling design and allows better generalization of trends in parr abundance for the GOM DPS as a whole. In future assessments, abundance indices generated from the GRTS design will be used to evaluate tends in parr abundance.

Another juvenile metric that provides a composite view of freshwater rearing is indices of smolt production. These estimates are limited in New England, but two longer time-series of data were available and provided a good contrast: the Connecticut River basinwide estimate and the Narraguagus River smolt assessment (see USASAC 2013; Connecticut monitoring ceased). Smolt production metrics are now limited to two longer time series in Maine – the Narraguagus River started in 1997 and Sheepscot River initiated in 2005 (Figure 2.4.3.2). These mark–recapture estimates using rotary-screw traps monitor production of stocked fish and naturally-reared fish. However, data presented are for naturally reared fish only as these are most comparable and longest time-series. Estimates suggest these rivers are producing less than the expected 2-3 smolts per unit of rearing habitat. Smolt estimates for other rivers supplement these longer time series and typically track the two primary metrics. Further analysis of smolt population dynamics is ongoing and examines other abundance indices, size and age distributions, and run timing. Because these indices track natural production of smolts, the general coherency in trends indicated that environmental factors may influence smolt recruitment on a regional basis in many years. Identification of these factors and when smaller scale differences occur would enhance the ability to predict and understand smolt production dynamics.

2.5 Biological Reference Points

Biological reference points for Atlantic salmon vary from other managed species in the region because they are managed in numbers, not biomass, and also because they are a protected species with limited fisheries targets. Fisheries targets (MSY, B_{MSY}, F_{MSY}, F_{TARGET}) have not been developed because current populations are so low relative even to sustainable conservation levels. A proxy for minimum biomass threshold for US Atlantic salmon would be conservation spawning escapement (CSE), because this provides the minimum population number needed to fully utilize available freshwater nursery habitat. This number is based on a single spawning cohort (2SW adults), not the standing stock of all age groups. As defined above, the CSE for New England is set at 29,199. The strongest populations in the Gulf of Maine are at less than 20% of their target of 15,670 and almost all these fish are hatchery origin while recovery goals target wild spawners. Natural mortality of Atlantic salmon in the marine environment is estimated to be 0.03 per month, resulting in an annual natural mortality rate (M) of 0.36.

2.6 Summary

Historic Atlantic salmon abundance in New England exceeded 100,000 returns annually (National Research Council 2004). Habitat changes and overfishing resulted in a severely depressed US population that, by 1950, was restricted to Maine, with adult returns of just a few hundred fish in a handful of rivers. Hatchery-based stock rebuilding occurred from 1970 to 1990, reaching a peak of nearly 6,000 fish in 1986. A North American collapse of Atlantic salmon abundance started around 1991. Since 1991, median US salmon returns were 1,640 fish, returns in 2014 were only 450 fish, and returns in 2015 were 921 fish. All stocks are at very low levels; only the Penobscot River population has been near 10% of its conservation spawning escapement and only because of an intensive smolt stocking program. Naturally-reared returns in the Penobscot are proportionally low. Most populations are still dependent on hatchery production and marine survival regimes since have been low, compromising the long-term prospects of even hatchery-supplemented populations. Returns for the past decade suggested a potential shift to higher ocean productivity until 2011. Since this point, return rates have decreased to record lows for hatchery smolts and are variable for other Maine populations. The last 10 years can best be characterized as the most variable since the regime shift of 1991. Despite low wild salmon abundance in the US, mariculture is increasing worldwide and New England production should be around 6,000 mt in the next decade. As such, Atlantic salmon remains common in the marketplace despite its precarious status is US rivers.

Table 2.4.2.1. Most current two-sea winter (2SW) conservation spawning escapement requirements for US river populations and 2SW returns (with % of CSE).

Area		Spawner Requirement	2SW returns 2013	Percentage of Requirement
Long Island Sound	LIS	10,094	18	0.2%
Central New England	CNE	3,435	15	0.4%
Gulf of Maine	GOM	15,670	728	4.6%
Total		29,199	761	2.6%

For further information

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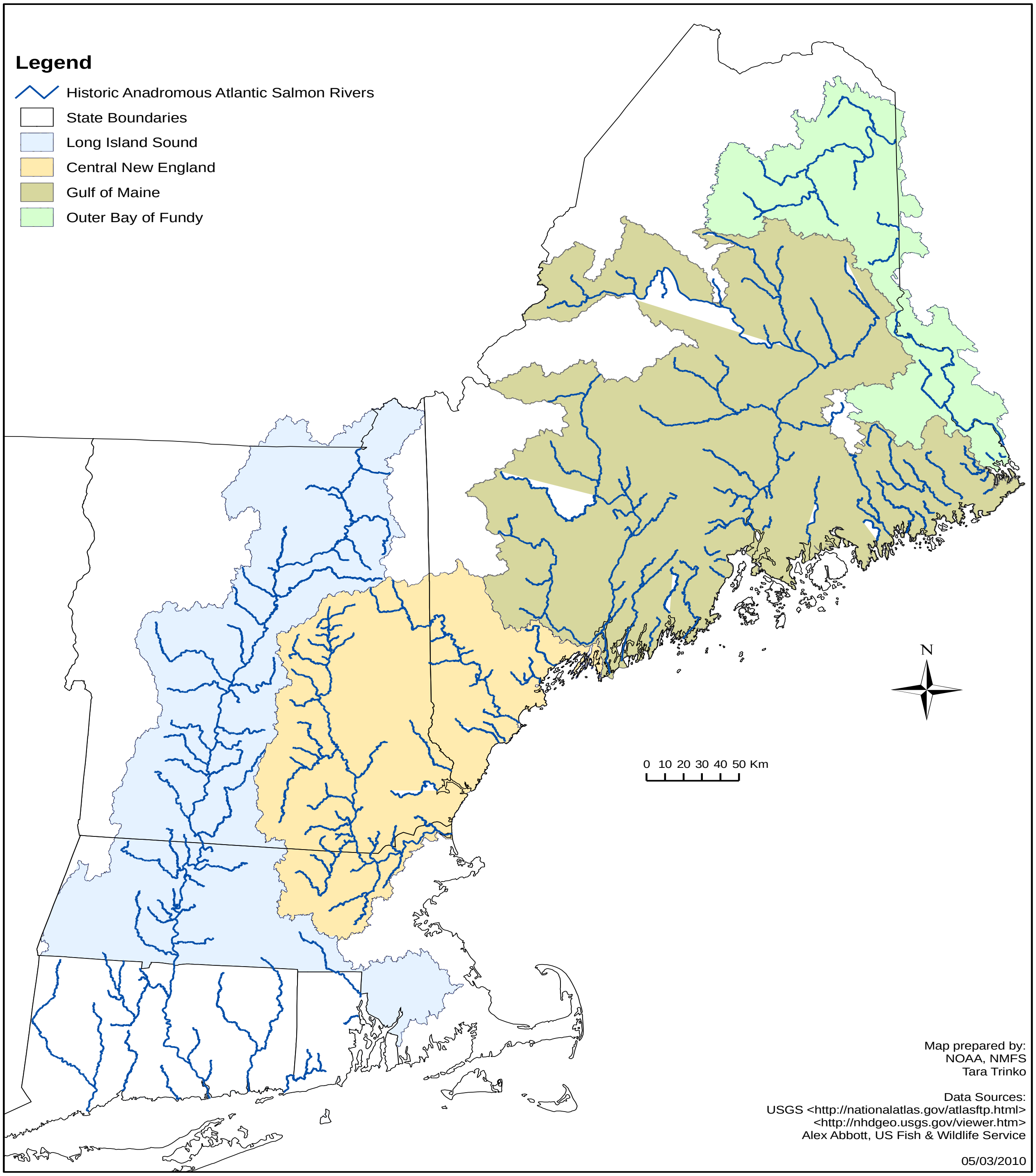


Figure 2.1.1 Map of New England Atlantic salmon management area by region from north to south: outer Bay of Fundy (OBF), Gulf of Maine DPS (GoM), central New England (CNE), and Long Island Sound (LIS) regions.

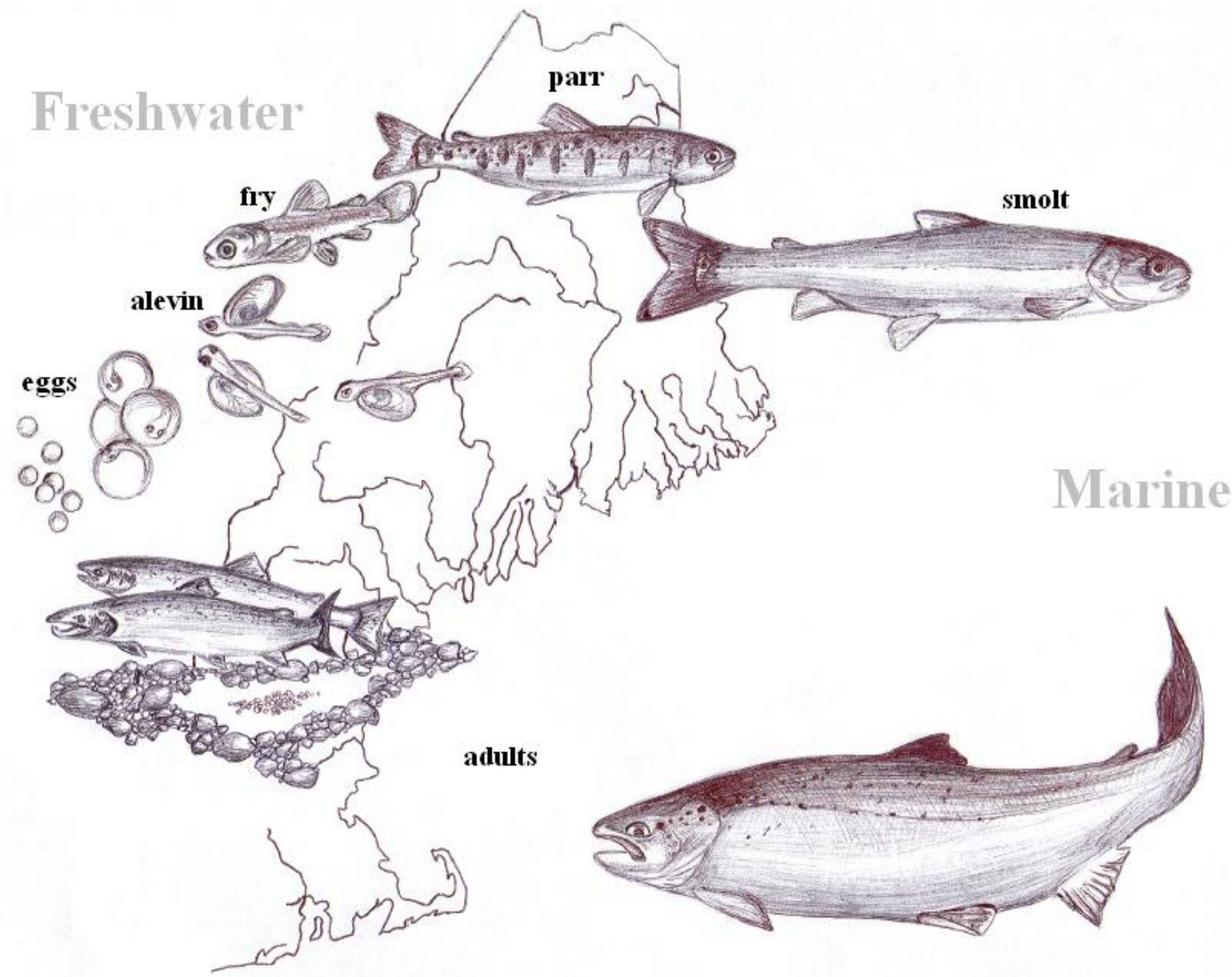


Figure 2.1.2 Life cycle of US Atlantic salmon illustrating marine and freshwater stages (Artwork by Katrina Mueller).

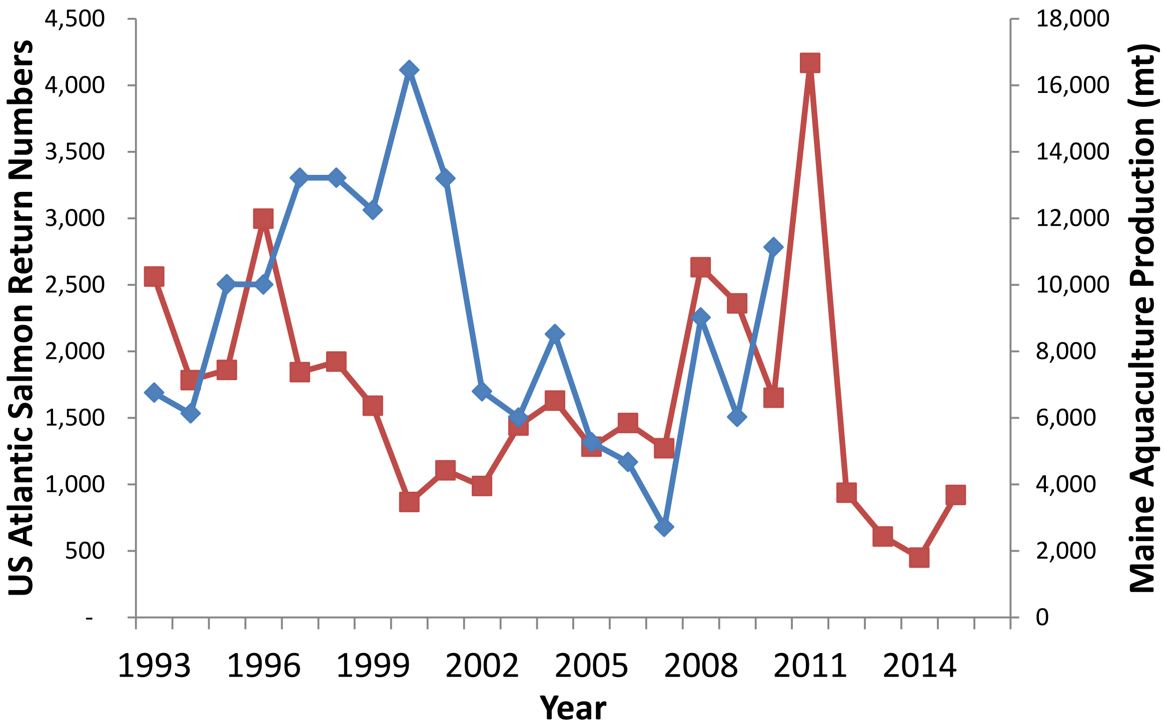


Figure 2.2.1.1 Time-series of New England Atlantic salmon returns (number of adults) and commercial Atlantic salmon aquaculture production (metric tons), with only one company reporting since 2010, confidentiality laws limit industry reporting.

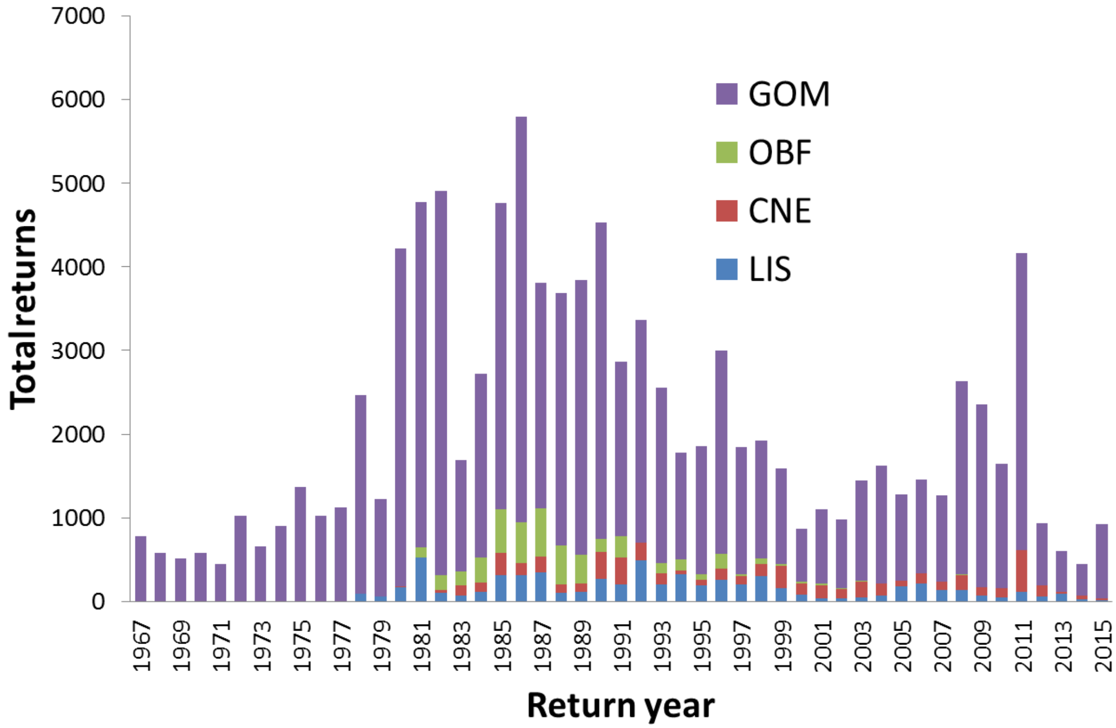


Figure 2.4.2.1 Time series of estimated total returns to New England from USASAC databases for outer Bay of Fundy (OBF) Designatable Unit, Gulf of Maine (GoM) Distinct Population Segment, central New England complex (CNE), and Long Island Sound (LIS) complex from 1967 to present year.

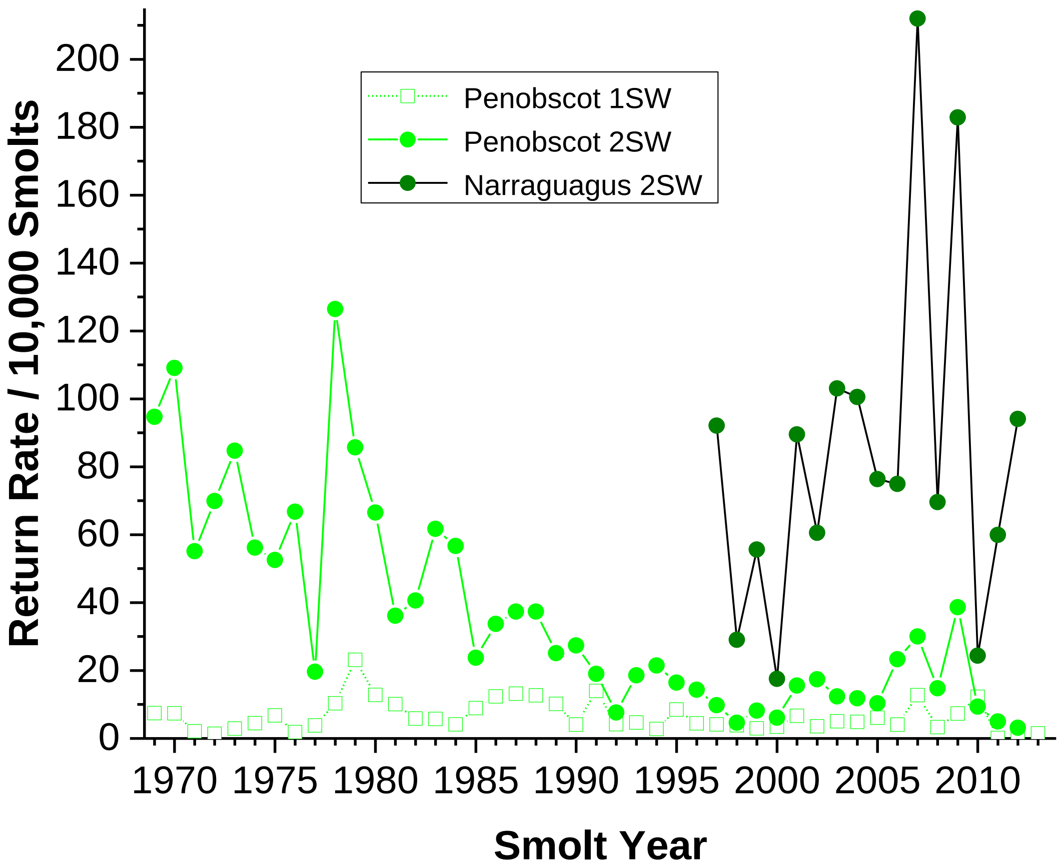


Figure 2.4.2.3 Return rates of Atlantic salmon per 10,000 smolts from the Narraguagus and Penobscot populations estimated from numbers of stocked smolts for the Penobscot and from estimated smolt emigration from the Narraguagus River population.

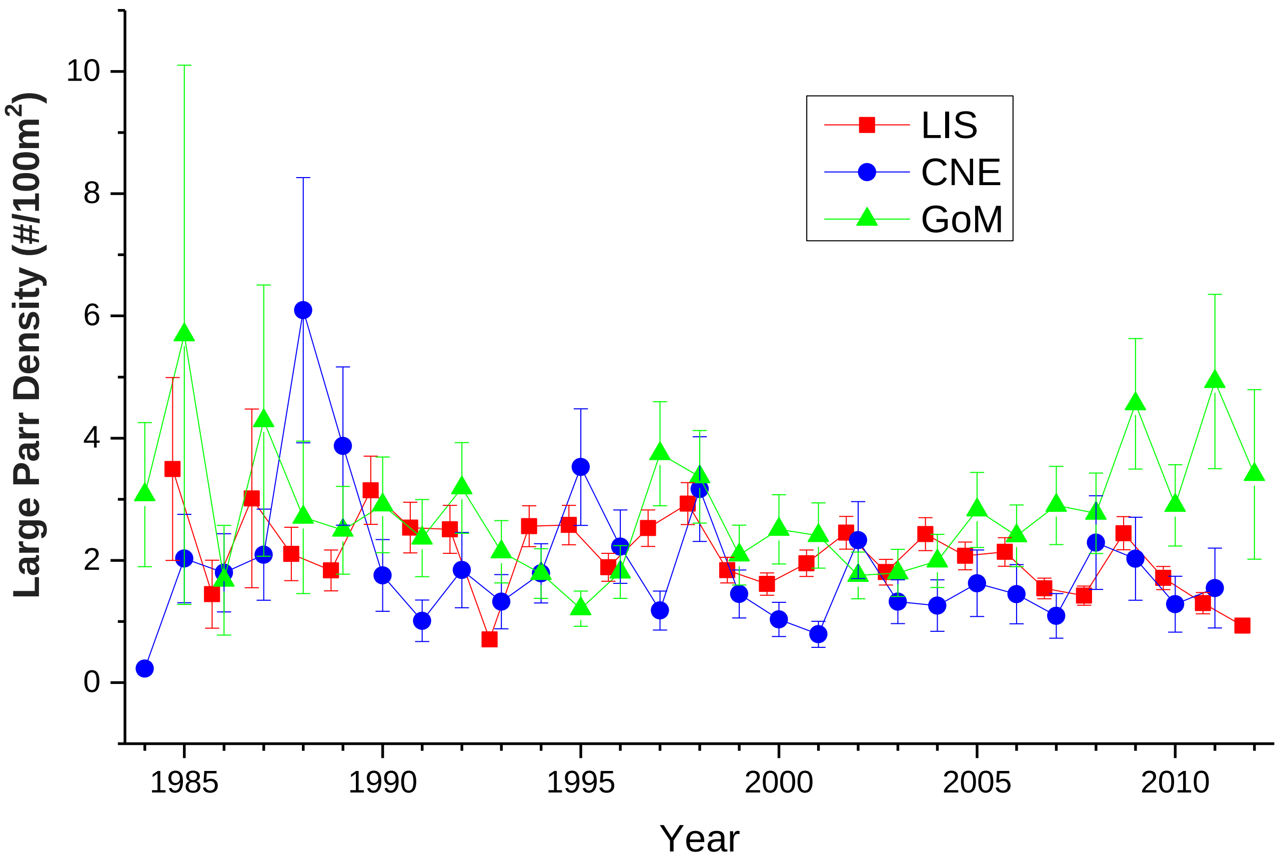


Figure 2.4.3.1 Index of large parr density from a mixed random effects model using electrofishing data from sites with > 10 years of data from 1984 through 2012 from USASAC databases for three stock complexes: Long Island Sound, Central New England, and in the Gulf of Maine DPS.

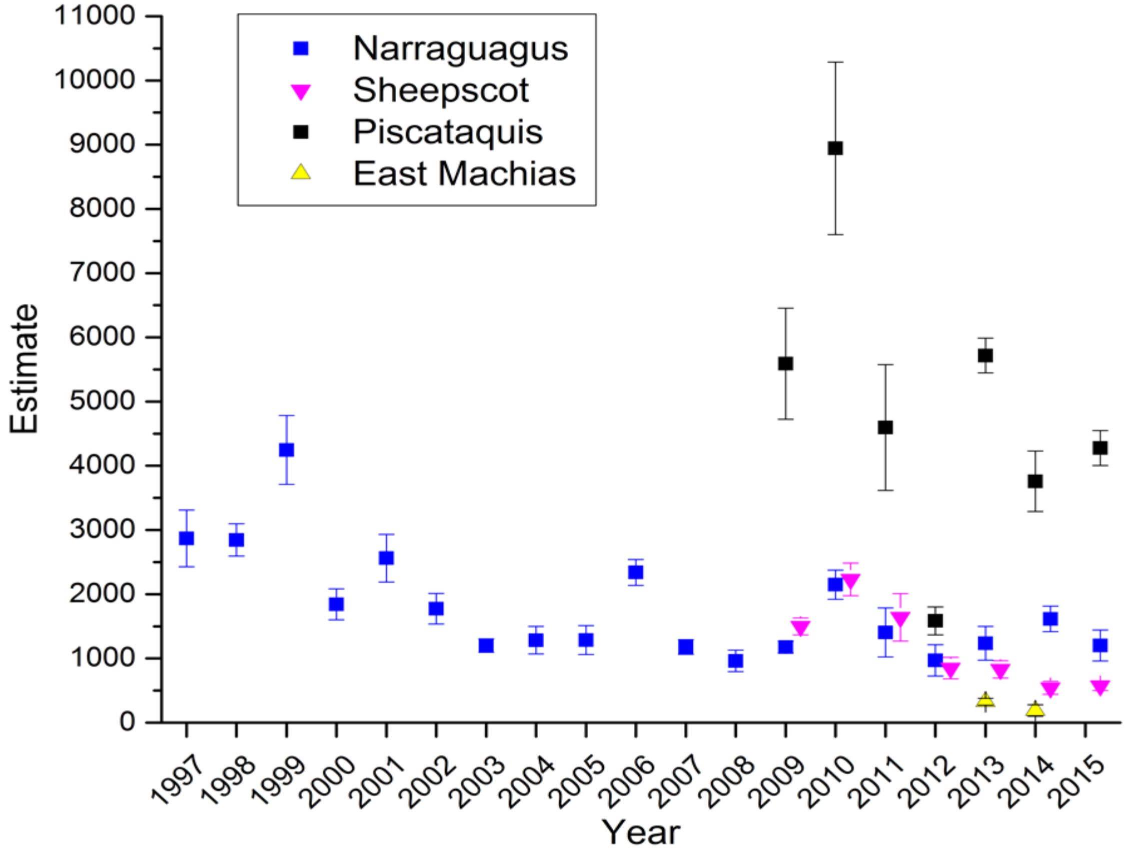


Figure 2.4.3.2 Mark-recapture population estimates of numbers of Atlantic salmon smolts emigrating from the Narraguagus, Piscatiquis, Sheepscot, and East Machias Rivers, Maine. See text for details of estimation methods.

3 Long Island Sound

Long Island Sound: Connecticut River

The Connecticut River Atlantic Salmon Restoration formally ceased in 2013 and in 2014 the new Atlantic Salmon Legacy Program was initiated by the Connecticut Department of Energy and Environmental Protection (CTDEEP). The Connecticut River Atlantic Salmon Commission (CRASC) maintained an Atlantic Salmon Sub-committee to deal with lingering issues of salmon throughout the watershed. Partner agencies other than the CTDEEP focused on operating fish passage facilities to allow upstream and downstream migrants to continue to access habitat but no further field work was conducted by other agencies. CRASC and its partners continued to work on other diadromous fish restoration in 2015. The following is a summary of work on Atlantic salmon.

3.1.1. Adult Returns

A total of 22 sea-run Atlantic salmon adults was observed returning to the Connecticut River watershed: 13 on the Connecticut River mainstem, five in the Farmington River, one in the Eightmile River, and three in the Westfield River. No sea-run salmon were retained for broodstock at any facility. Eight salmon trapped at the Holyoke Fishlift were trucked to the Conte Lab for experimental trials prior to release (see section 3.1.7). Three salmon captured at West Springfield Fishway (Westfield River) were transported by truck to suitable upstream habitat. All other returning salmon were released at the fishways. The intent was to handle, scale sample, and Floy-tag all salmon but several fish passed through a fishway while staff were not present and documented only by video.

None of the adult salmon were of hatchery (smolt-stocked) origin. All were of wild (fry-stocked) origin. One grilse was documented in 2015; all other returns were determined to be two sea-winter age fish. Not sampled fish (and fish with no readable scales) were assigned to age groups on a proportional basis. Including these assignments, the fresh-water age distribution of adult salmon was 1^{+} (13%), 2^{+} (87%) and 3^{+} (0%).

3.1.2. Hatchery Operations

Egg Collection

A total of 534,072 green eggs was produced in 2015, resulting in 448,350 eyed eggs (49% rate). Only the Kensington State Fish Hatchery (KSFH) in CT maintained domestic broodstock. Contributing broodstock included 60 females and 82 males, all 3+ year-old. Those eggs will be used for fry stocking for the Connecticut Legacy Program including the Salmon in Schools program.

3.1.3. Stocking

Juvenile Atlantic Salmon Releases

A total of 390,667 juvenile Atlantic Salmon was stocked into the Connecticut River watershed in 2015. Selected stream reaches in the Farmington River received 268,961 fry and selected reaches in the Salmon River received 121,706 fry with the assistance of many volunteers. Totals of 229,799 fed fry and 160,868 unfed fry were stocked into these tributary systems. Stocking was conducted out of KSFH and Tripps Streamside Incubation Facility (TSIF). Eggs were transferred from KSFH to TSIF as eyed eggs. In addition, an estimated 13,600 fry were stocked in various approved locations within the Salmon and Farmington rivers by schools participating in the Salmon in Schools programs, in which they incubate eggs for educational purposes and stock surviving fry.

Surplus Adult Salmon Releases

Domestic broodstock surplus to program needs from the KSFH were stocked into the Shetucket and Naugatuck rivers and two selected lakes in Connecticut to create sport fishing opportunities outside the Connecticut River basin.

3.1.4. Juvenile Population Status

Smolt Monitoring

TransCanada continued sampling of smolts at the Moore Dam on the mainstem river at Littleton, NH. The trap operated from 5 May to 26 June, collecting 202 smolts, lowest number in 12 year program time-series. The highest daily collection occurred on 18 May (N=21). Over 80% of the catch was collected between 5 May and 14 June, and 95% was collected by 22 June. All smolts were captured and transported for release immediately downstream of the Vernon Dam, due to an agreement with the agencies. Mortality from the trap was 5.4% and resulted in a total of 191 smolts released. No other monitoring of smolts was conducted in 2015.

Index Station Electrofishing Surveys

Juvenile salmon populations were assessed by electrofishing in late summer and fall at index stations in Connecticut by CTDEEP. Electrofishing surveys in other states were not conducted in 2015. Data are used to evaluate fry stocking, estimate survival rates, and estimate smolt production.

3.1.5. Fish Passage

<u>Hydropower Relicensing</u>- The licenses of five large hydropower projects (four main stem dams) will expire in 2018. These projects are Turners Falls, Vernon, Bellows Falls, and Wilder dams as well as the Northfield Mountain Pumped Storage facility, a project area spanning 175 river miles. State and Federal resource agencies have spent considerable time on FERC-related processes for these re-licensings. Numerous fish population, habitat, and fish passage studies were implemented in 2015 with results pending as of this report. In 2015, the smolt barrier/guidance net at the intake of NMPS was not installed at the request of CRASC in order to reduce impacts to FERC studies including shad migration studies. Due to the termination of the salmon restoration program, none of these requested studies involved Atlantic Salmon.

Fish Passage Monitoring- Salmonsoft® computer software was again used with lighting and video cameras to monitor passage at Turners Falls, Vernon, Bellows Falls, Wilder, Rainbow and Moulson Pond fishways. The software captures and stores video frames only when there is movement in the observation window, which greatly decreases review time while allowing 24h/d passage and monitoring.

New Fishways – No new fishways were constructed in 2015.

Dam Removals- One dam was removed in the watershed, the Ed Bills Pond Dam on the East Branch of the Eightmile River. This dam formerly had a steeppass fishway, which was disassembled and saved for a future project. The Eightmile River watershed was formerly stocked with salmon fry but that was discontinued after 2011. However, an adult salmon returned to this watershed in 2015.

Planning continued for the removal of the Norton Mill Dam (Jeremy River/Salmon River watershed), the removal of the Blackledge River Dam (Blackledge River/Salmon River watershed), the design of a fishlift at the Rainbow Dam (Farmington River), and fish passage at part of a hydro development at the Collinsville dams (Farmington River). All of these will benefit salmon as part of the Legacy Program.

Culvert Fish Passage Projects- There were many undertaken in the Basin but not of them will benefit Atlantic Salmon and therefore will not be listed here.

3.1.6. Genetics

The genetics program previously developed for the Connecticut River program has been terminated. A 1:1 spawning ratio was used for domestic broodstock spawned at the KSFH.

No further results from the Atlantic Salmon Marking Study were made available in 2015.

3.1.7. General Program Information

The use of salmon egg incubators in schools as a tool to teach about salmon continued in Connecticut. The Connecticut River Salmon Association, in cooperation with CTDEEP, maintained its Salmon-in-Schools program, providing 17,000 eggs for 85 tanks in 62 schools in Connecticut.

Dr. Ted Castro-Santos (USGS) performed a study on the sprinting performance and kinematics of adult Atlantic Salmon at the Silvio Conte Anadromous Fish Research Center in Turners Falls, MA in 2015. Eight salmon captured at Holyoke were taken to the lab and introduced into a test burst flume at the lab. After testing, and within two to seven days of capture, the fish were released back into the Connecticut River below the Turners Falls dam to resume their migration. Some of the fish were subsequently documented ascending upstream fishways. More tests are anticipated in 2016.

3.1.8. Migratory Fish Habitat Enhancement and Conservation

There were many stream restoration projects in 2015 throughout the basin in 2015 but since most of them no longer impact Atlantic Salmon habitat, they will not be listed here.

3.1 Pawcatuck River

3.2.1. Adult Returns

Zero (0) adult salmon returned to the Pawcatuck River this year.

3.2.2. Stocking

Juvenile Atlantic Salmon Releases

The Salmon in the Classroom program was responsible for stocking approximately 7000 fry into the Pawcatuck River and its tributaries. No other Atlantic salmon fry were stocked into the Pawcatuck River in 2015. No smolts were stocked in the Pawcatuck River in 2015

3.2.3. Juvenile Population Status

Index Station Electrofishing Surveys

Parr assessments were not conducted in 2015 due to lack of personnel.

3.2.4. Smolt Monitoring

No work was conducted on this topic during 2015.

3.2.5. Tagging

In Rhode Island, all smolts are released with adipose fin clips, however, no smolts were released in 2015.

3.2.6. Fish Passage

Problems with upstream fish passage exist at Potter Hill Dam, the first Denil fishway on the Pawcatuck River. Although the existing fish ladder seems to work well at normal and low flows, extremely high water levels in early spring can completely flood the ladder, and making access difficult. 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 in 2006 the owner applied for a FERC permit to develop hydropower at this location and reapplied in 2009 to continue the process. A third successive permit was denied by FERC. A new initiative to assess fish passage needs at the three lower Pawcatuck River dams is currently underway by the Army Corps of Engineers. The denil fishway construction at the Horseshoe Falls Dam has been completed. This is the fourth obstruction on the river.

3.2.7. Genetics

No genetics samples were collected in 2015.

3.2.8. General Program Information

Lack of personnel is currently the primary issue in Rhode Island's Atlantic salmon restoration program.

3.2.9. Migratory Fish Habitat Enhancement and Conservation

No habitat enhancement or conservation projects directed solely towards Atlantic salmon were conducted in the watershed during 2015.

4 Central New England

Central New England: Merrimack River

4.1.1 Adult Returns

Thirteen (13) Atlantic salmon were counted in the Merrimack River at the Essex Dam, Lawrence, MA. Unlike past years, no salmon were transported to the Nashua National Fish Hatchery (NNFH), NH. Instead all fish were allowed to run the river. Sixteen (16) fish were observed passing the Pawtucket Dam, Lowell, MA via a fish lift, with others were known to pass an unmonitored fishway at the dam. The fish could have been domestics stocking in the river or may have been sea-run fish. No morphometric data was collected, so all size and age estimations are based on stocking history and previous year's returns.

4.1.2 Hatchery Operations

The reduction of effort for the Merrimack Program has focus primary effort of Nashua National Fish Hatchery to the Saco River program. In 2015, the fish in the domestic broodstock were recorded as "Merrimack Stock". This nomenclature will continue when referring to fish stocked into the Saco River and recorded in the Merrimack River section of the report.

Egg Collection

Spawners provided an estimated 760,750 green eggs.

Sea-Run Broodstock

No sea-run fish were retained for broodstock.

Domestic Broodstock

A total of 234 female and over 240 male captive (F1 from sea-runs) broodstock spawned at Nashua NFH; 298 fish were non-spawners. Of the 234 females, 63 were two years old, and 171 were three years old. The captive broodstock spawning season began on November 19, 2015 and ended December 15, 2015, and included 7 spawning events to reach target egg production. All eggs were retained at NNFH for incubation and eventual release to the Saco River watershed and the Adopt-A-Salmon educational programs

Stocking

Juvenile stocking is limited to educational salmon in schools program at about 4,000 eggs provided to schools to rear and release in the Merrimack River watershed. We report those eggs are stocked at fry with zero loss.

4.1.3 Juvenile Population Status

Yearling Fry / Parr Assessment

In 2015, no parr assessment was conducted. Parr were occasionally collected in electrofishing surveys focused on other species, but are not reported here.

4.1.4 General Program

The U.S. Fish and Wildlife Service determined that it would end its collaborative effort to restore Atlantic salmon in the Merrimack River watershed if the number of sea-run salmon returning to the river did not increase substantially during the May/June 2013 spring migration. Primary causes that have limited the return of salmon to the river are: poor survival of salmon in the marine environment, severely reduced population abundance from in-river habitat alteration and degradation, dams resulting in migration impediments, and an inability of fish to access spawning habitat and exit the river without impairment.

Sea-run salmon and gravid hatchery broodstock had been transported to and released in the Souhegan River, and adult spawning and juvenile production had been documented; however, the number of juvenile salmon produced from natural spawning is likely not enough to substantially increase future returns. In addition, the numbers of salmon that return to the river will likely decrease given continued poor marine survival, a decrease in hatchery origin fry and smolt stocked annually from federal and state hatcheries, and an expected low rate of return of salmon.

Fish have continued to be stocked that have restoration value. These include excess gravid broodstock (in excess of the need under the Saco River agreement) and small amounts of fry stocked as part of the salmon in schools program. Some natural reproduction is likely occurring where fish can access suitable spawning habitat.

Atlantic Salmon Broodstock Sport Fishery

NHFG had their last planned stocking of Adult Atlantic salmon for their broodstock fishery in the spring of 2014. Additional adult fish were stocked In May, 2015, NHFG released 1,205 2+ and 3+ fish into the Merrimack.

Adopt-A-Salmon Family

The 2015 school year marked the twenty-third year of the Adopt-A-Salmon Family Program in central New England. In January and February, an estimated 4,000 salmon eggs were distributed from the NNFH to about 14 participating schools in New Hampshire and Massachusetts. These schools then incubated eggs in the classroom and released fry into tributaries in late spring and early summer. Schools that received eggs also participated in an educational program at the Piscataquog River Park in west Manchester, NH. The program culminated with students releasing fry into the Piscataquog River. The program was conducted by a core group of dedicated volunteers with assistance from USFWS staff.

Central New England - Integrated ME/NH Hatchery Production

The FWS, Eastern New England Fishery Resources Complex has developed an agreement with MDMR to engage in planning and implementing an Atlantic salmon restoration and enhancement project in the Saco River watershed (see section 4.2.3). The agreement provides that NNFH and/or NANFH will produce juvenile Atlantic salmon for continued Saco River Salmon Club (Club) “grow-out” or release to the Saco River.

4.2 Central New England: Saco River

4.2.1 Adult Returns

Brookfield Renewable Energy Group operated three fish passage-monitoring facilities on the Saco River. The Cataract fish lift, located on the East Channel in Saco and the Denil fishway-sorting facility located on the West Channel in Saco and Biddeford, operated from 30 April to 30 October, 2015. Five Atlantic salmon were observed moving upriver through these facilities. Only visual observations are recorded at Cataract, as the fish are never handled. One Atlantic salmon was captured at a third passage facility upriver at Skelton Dam, which operated from 30 April to 30 October, 2015. A total of five Atlantic salmon returned to the Saco River for the 2015 trapping season. However, the count could exceed five due to the possibility of adults ascending Cataract without passing through one of the counting facilities.

4.2.2 Hatchery Operations

Egg Collection

In 2015, 761,000 green eggs from Merrimack River origin broodstock were transferred for the Nashua National Fish Hatchery to the Saco River Salmon Hatchery. A portion of these were distributed to school programs (Fish Friends) and the remaining reared at the hatchery for release as fry.

Stocking

Juvenile Atlantic Salmon Releases

A total of 11,700 smolts raised at North Attleboro National Fish Hatchery (NANFH) were released to the river. In addition 25,000 age 0 parr raised at NANFH were stocked in to the Saco. Approximately 702,000 fry, reared at the Saco River Salmon Club Hatchery, were released into one mainstem reach and 28 tributaries of the Saco River.

Adult Salmon Releases

No adult Atlantic salmon were stocked into the Saco River.

4.2.3 Juvenile Population Status

Index Station Electrofishing Surveys

No electrofishing surveys directed at assessing juvenile Atlantic salmon populations were conducted in the Saco River watershed in 2015.

Smolt Monitoring

No smolt monitoring was conducted in 2015.

Tagging

No salmon out planted into the Saco were tagged or marked in 2015.

4.2.4 Fish Passage

No fish passage improvements were made during 2015.

4.2.5 Genetics

No genetic samples were collected in 2015.

4.2.6 General Program Information

The US Fish and Wildlife Service and the Maine Department of Marine Resources continue to work with Saco River Salmon Club Hatchery to adaptively manage Atlantic salmon in the Saco River.

Migratory Fish Habitat Enhancement and Conservation

No habitat enhancement or conservation projects directed solely towards Atlantic salmon were conducted in the watershed during 2015.

5 Gulf of Maine

5.1 Adult Returns

A more detailed discussion of the following is provided in Working paper WP-2016-06. Documented adult Atlantic salmon returns to rivers in the geographic area of the Gulf of Maine DPS (73 FR 51415-51436) in were 881. Returns are the sum of counts at fishways and weirs (763) and estimates from redd surveys (118). No fish returned “to the rod”, because angling for Atlantic salmon is closed statewide. Counts were obtained at fishway trapping facilities on the Androscoggin, Narraguagus, Penobscot, Kennebec, and Union rivers. Fall conditions were suitable for adult dispersal throughout the rivers, and conditions allowed redd counting.

Escapement to these same rivers in 2015 was 663; (545 Penobscot [731 return – (660 broodstock + 5 DOA) + 7 broodstock returned to the river by CBNFH + 4 captive reared freshwater CBNFH origin+ 468 gravid domestics outplanted in Mattamiscontis Stream] + 118 other DPS). Because there was no rod catch, the escapement to the GOM DPS area was assumed to equal returns (estimated or released after capture) plus released pre-spawn captive broodstock (adults used as hatchery broodstock are not included).

Estimated replacement (adult to adult) of naturally reared returns to the DPS has varied since 1990 although the rate has been somewhat consistent since 1997 at or below 1 (Figure 5.1.1). Most of these were 2SW salmon that emigrated as 2 year old smolt, thus, cohort replacement rates were calculated assuming a five year lag. These were used to calculate the geometric mean replacement rate for the previous ten years (e.g. for 2000: 1991 to 2000) for the naturally reared component of the DPS overall and in each of three Salmon Habitat Recovery Units (SHRU). Despite an apparent increase in replacement rate since 2008, naturally reared returns are still well below 500 (Fig. 5.1.2).

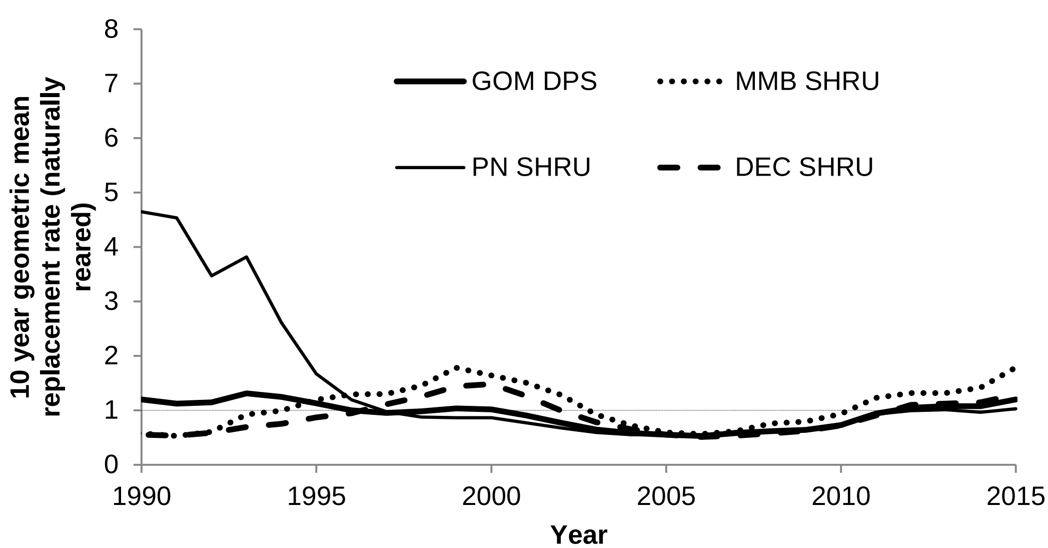


Figure 5.1.1. Ten year geometric mean of replacement rate for returning naturally reared Atlantic salmon in the GOM DPS and the three Salmon Habitat Recovery Units (SHRU).

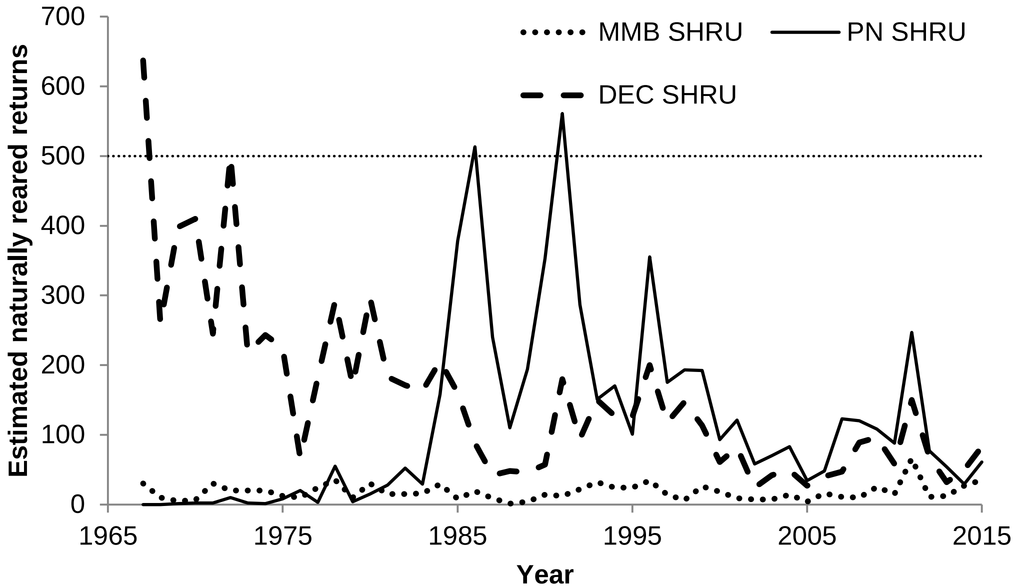


Figure 5.1.2 Estimated Naturally Reared Returns to the GOM

Small Coastal Rivers

Downeast Coastal SHRU

Dennys River
There were 16 redds surveyed in the Dennys River in 2015. This was unexpected due to recent low return rates. Although, when put alongside the Narraguagus (below), it indicates estuarine survivals was higher for that smolt cohort (2013).

East Machias River
Nine (9) redds attributed to wild returns were counted during the 2015 redd surveys in the East Machias River that included approximately 100% of known spawning habitat. No captive reared gravid adults were released into the East Machias because they were needed for egg production.

Machias River
A total of 18 redds were counted, covering only 61% of the known spawning habitat in the Machias drainage. The number of redds was less than expected; 59,000 hatchery smolts were released in 2013 and it was expected that numbers of returning adult might be as high as 106 fish based on recent SAR in the Penobscot and Narraguagus Rivers (average 0.18%). The approximate return rate was 0.03%.

The majority of the redds surveyed were observed in the West Branch of the Machias River (9) which received ½ the smolts released in 2013. The mainstem reaches adjacent to the West Branch contained 5 more redds with the remaining 4 redds split between the Old Stream (2) and Mopang Stream (2). Incidentally, the second ½ of the stocked smolts were placed into Mopang Stream.

Pleasant River
To evaluate adult returns to the Pleasant River above Saco Falls, DMR staff operated the Saco Falls fishway trap on the Pleasant River again in 2015 but for a short period from 4 May to June 17th, 2015. Since the trap was never a 100% capture device it was removed to allow time to work on other projects. There were 28 redd observed in the Pleasant River all in the upper reaches above the smolt stocking location. Unlike the Machias, the SAR was higher to Pleasant. From 62,000 smolts 28 adults returned at a SAR of 0.05%. In both this and the Machias River SAR, the return rate is conservative and doesn't account for multiple year classes and assumes 2SW returns.

Narraguagus River
Returns to the fishway trap in 2015 (3) declined even from last season (4) and remained far below the previous 10-year average (40 returns). It is important to note that high water conditions allow salmon to ascend Stillwater Dam in Cherryfield, bypassing the fishway trap. Of the three returns, all were two sea-winter (2SW) adults. In 2015, 31 redds were observed in the mainstem of the Narraguagus River. 74.2% of known spawning habitat was surveyed. Like in the Dennys, increased estuarine survival may have played a part in surveyed escapement within the drainage. However, this spawning cohort is tied to the 2010 return year where 76 adults returned. Of these 65 were hatchery smolt origin fish. The 2015 adult cohort are likely freshwater reared from 2010 natural spawning. The coarse adult to adult return rate is 40.8%.

Union River
The fish trap at Ellsworth Dam on the Union River is operated by the dam owners, Brookfield Renewable Energy Group, under protocols established by the DMR. The trap was operated from 1 May to 31 October 2015. No salmon were captured during this period.

Penobscot SHRU

Ducktrap River
There were no redds observed during surveys in late November that encompassed 54.4% of the spawning habitat area in the Ducktrap River watershed.

Cove Brook
65.3% of spawning habitat in Cove Brook was surveyed. Zero redds were observed.

Mattamiscontis Stream
468 gravid domestic broodstock were outplanted into Mattamiscontis Stream in the fall of 2015. Redd surveys conducted by the Penobscot Indian Nation observed 4 redds in a

tributary to Mattamiscontis Stream, Sam Ayers Stream. No estimate of total spawning habitat is available.

Merrymeeting Bay SHRU

Sheepscot River
There were 7 total redds observed in the Sheepscot River in 2015, all of which were in the West Branch and. 78% of known spawning habitat was surveyed. The number of redds observed was a decrease from previous years.

Sandy River (Kennebec Drainage)
The Sandy River is a tributary to the Kennebec River. In 2015, 52% of known spawning habitat was surveyed and 31 redds were observed. Origin of the redds observed in the Sandy River are from adult salmon trapped at the Lockwood fish lift (31) that were transported and placed in the Sandy River. All adults returning to the Kennebec River are likely from the Sandy since only the Sandy is were fish are placed. The Sandy is also where eyed eggs have been planted since 2006.

Redd Based Returns to Small Coastal Rivers

Scientists estimate the total number of returning salmon to small coastal rivers using capture data on rivers with trapping facilities (Pleasant, Narraguagus and Union rivers) combined with redd count data from the Dennys, East Machias, Machias, Pleasant, Narraguagus, Ducktrap, and Sheepscot Rivers. Estimated returns are extrapolated from redd count data using a return-redd regression [ln (returns) = 0.5594 ln (redd count) + 1.2893] based on redd and adult counts from 2005-2010 on the Narraguagus River, Dennys River and Pleasant River (USASAC 2010). Total estimated return based on redd counts for the small coastal rivers was 118 (95% CI = 83 - 161) (Table 5.1.1). Estimates include returns to the Union River. It should also be noted that the estimate for 2014 has changed from 92 to 95. Due to spring redd surveys in the Narraguagus River, six more redds were recorded. This particular reach had been inaccessible in 2014 due to ice formation.

Table 5.1.1 Regression estimates and confidence intervals (90% CI) of adult Atlantic salmon in the small coastal GOM DPS rivers from 1991 to 2015. Estimates include the Union River.

Year	LCI	Mean	UCI
1991	243	302	374
1992	204	251	311
1993	222	261	315
1994	154	192	239
1995	131	162	200
1996	298	353	417
1997	139	172	215
1998	167	213	272
1999	147	184	231
2000	81	109	129
2001	90	103	120
2002	33	42	53
2003	63	77	97
2004	62	84	115
2005	44	71	111
2006	49	79	122
2007	39	59	72
2008	106	138	178
2009	114	160	217
2010	118	164	329
2011	248	323	551
2012	76	115	167
2013	68	101	148
2014	65	95	133
2015	83	118	161

5.1.3 Large Rivers

Penobscot River
The fish lift at the Milford Hydro-Project owned by Brookfield Renewable Energy Group was operated daily by MDMR staff from 27 April through 13 November, 2015. The fish lift was also used to collect adult sea-run Atlantic salmon broodstock for the U.S. Fish and Wildlife Service (USFWS).

A total of 731 sea-run Atlantic salmon were captured during the 2015 season (Table 5.1.2). Scale samples were collected from 665 salmon captured at the Milford fish lift and analyzed to characterize the age and origin structure of the run. The origins of the 66 Atlantic salmon not scale sampled were prorated based on the observed proportions, taking into account the presence of tags or marks observed and dorsal fin deformity. The majority of returning salmon were age 2SW (604; 83%), along with 119 1SW salmon (16%), seven (7) 3SW fish, and one (1) repeat spawners. Approximately 92% (670) of the salmon that returned were of hatchery origin and the remaining 8% (61) were of wild or naturally reared origin.

Additional data collected at the Milford fish lift included counts of species other than Atlantic salmon present during each tending day. River herring (*Alosa spp.)*, American shad (*Alosa sapidissima*), smallmouth bass (*Micropterus dolomieu*), and sea lamprey (*Petromyzon marinus*) were the most abundant species observed in 2015.

Androscoggin River
The Brunswick fishway trap was operated from 15 April to 13 November, 2015 (Table 5.1.2). Two adult Atlantic salmon were captured at the Brunswick fishway trap; however, one Atlantic salmon left the Androscoggin River and was captured at the Lockwood fish lift facility at a later date and transported to the Sandy River. Biological data was collected from all returning Atlantic salmon in accordance with MDMR protocols, and the presence of marks and tags observed were recorded. The other Atlantic salmon was observed through the viewing window at the Brunswick fishway and never handled. Based on the length of the Atlantic salmon it was prorated as a two sea-winter return. Based on historical return trends to the Androscoggin River the origin was most likely to be hatchery.

Table 5.1.2. Counts of sea-run, Atlantic salmon returns to Maine rivers in 2015 by gender and sea-age (One sea-winter, 1SW; two sea-winter, 2SW; three sea-winter, 3SW; multi sea-winter, MSW; and repeat spawner, RPT). Also included are counts of aquaculture (AQS) and captive reared freshwater (CRF) adult captures.

				Male				Female				Unknown		Adult Counts		
SHRU and River	Trap Open Date	Median Catch Date	Trap Close Date	1SW	2SW	3SW	RPT	1SW	2SW	3SW	RPT	1SW	MSW	Sea-run	AQS	CRF
Downeast Coastal																
Narraguagus River	29 Apr	04 Jul	29 Oct	0	1	0	0	0	2	0	0	0	0	3	0	0
Pleasant River	04 May	--	17 Jun	0	0	0	0	0	0	0	0	0	0	0	0	0
Union River	01 May	--	31 Oct	0	0	0	0	0	0	0	0	0	0	0	0	0
Penobscot Bay																
Penobscot River	27 Apr	18 Jun	13 Nov	116	242	4	1	3	355	3	0	0	7	731	0	4
Merrymeeting Bay																
Lower Kennebec River	01 May	28 Jun	04 Nov	3	10	0	0	0	18	0	0	0	0	31	0	0
Lower Androscoggin R.	15 Apr	01 Jul	13 Nov	0	0	0	0	0	1	0	0	0	0	1	0	0
Sebasticook River	04 May	--	31 Oct	0	0	0	0	0	0	0	0	0	0	0	0	0
Non-GoM DPS rivers																
Aroostook River	09 Jul	07 Aug	06 Nov	1	0	0	0	5	0	0	0	0	0	6	0	0
Saco River	30 Apr	11 Jun	30 Oct	1	1	0	0	0	3	0	0	0	0	5	0	0
St. Croix River	30 Apr	--	18 Jul	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	--	--	--	121	254	4	1	8	379	3	0	0	7	777	0	4

Kennebec River

The Lockwood fish lift was operated by Brookfield staff from 1 May to 4 November, 2015 (Table 5.1.2). Thirty-one adult Atlantic salmon were captured at the Lockwood fish lift facility in 2015. Biological data was collected from all returning Atlantic salmon in accordance with MDMR protocols, and the presence of marks and tags observed were recorded. Of the thirty-one returning Atlantic salmon, twenty-eight were 2SW and three were grilse (1SW) (Table 5.2.1). Twenty-nine were determined to be of wild origin and two were of hatchery origin. Thirty adult Atlantic salmon were trucked and released to the Sandy River. The one remaining Atlantic salmon was released back to the Kennebec River below the Lockwood fish lift facility. At the time of capture the fish was thought to be a large landlocked salmon due to its appearance and scale growth. It was later determined to be an Atlantic salmon.

Sebasticook River

The Benton Falls fish lift facility was operated by MDMR staff from 4 May to 31 October, 2015. No Atlantic salmon were captured at the Benton Fall fish lift in 2015 (Table 5.1.2).

Survival Estimates

Atlantic salmon survival rates were calculated for marked hatchery stocks and naturally reared stocks for the Narraguagus and Penobscot Rivers (Table 5.1. 3). Calculations were based on known numbers of stocked salmon, smolt estimates, and adult returns. Smolt-to-adult (SAR) survival rates varied by origin; naturally reared smolts on the Narraguagus River had the highest average SAR survival (1.253%). Penobscot SAR rates of hatchery smolt are slightly higher, (0.178%) compared to the Narraguagus hatchery smolts (0.109%) but not significant (p > 0.05).

Table 5.1.3. Summary table of Atlantic salmon survival rates from the Penobscot and Narraguagus Rivers. All rates for stocked origin stocks were based on marked groups. Data represent cohorts where all 2 sea-winter adult returns have been accounted for. Therefore, in some cases some 3 sea-winter adults may still be at large. There were no smolts stocked in the Narraguagus for the 2013 cohort year.

Cohort Year	Origin of Smolt Number	Number of Smolts	Number of Survivors	% Survival
Narraguagus River Naturally Reared SAR				
2008	Estimate	962	8	0.872%
2009	Estimate	1,176	25	2.144%
2010	Estimate	2,149	25	1.183%
2011	Estimate	1,404	11	0.885%
2012	Estimate	969	9	1.023%
2013	Estimate	1,237	25	1.914%
			Mean	**1.337%**
Narraguagus River Hatchery Reared SAR				
2008	Stocked	54,100	47	0.087%
2009	Stocked	52,800	129	0.244%
2010	Stocked	62,400	78	0.125%
2011	Stocked	64,000	37	0.058%
2012	Stocked	59,100	17	0.029%
			Mean	**0.109%**
Penobscot River Hatchery Reared SAR				
2008	Stocked	554,600	1,007	0.182%
2009	Stocked	561,100	2,583	0.460%
2010	Stocked	567,100	1,230	0.217%
2011	Stocked	554,000	285	0.051%
2012	Stocked	555,200	235	0.043%
2013	Stocked	553,000	635	0.100%
			Mean	**0.180%**

5.2 Hatchery Operations

Egg Production

Sea-run, captive and domestic broodstock reared at Craig Brook National Fish Hatchery (CBNFH) and Green Lake National Fish Hatchery (GLNFH) produced 5,666,000 eggs for the Maine program in 2015: 2,640,000 from Penobscot sea-run broodstock; 779,500 eggs from one domestic broodstock population; 2,246,500 eggs from six captive broodstock populations.

Spawning protocols for domestic and captive broodstock at CBNFH and GLNFH give priority to first time spawners and utilize 1:1 paired matings. Spawning protocols for Penobscot sea run broodstock also utilize 1:1 paired matings. In 2015 CBNFH used year class crosses as well as spawning optimization software to avoid spawning closely related individuals within captive broodstock populations.

A total of 348 Penobscot sea-run origin females and 568 captive females were spawned at CBNFH between the 2^{nd} and 24^{th} of November. At GLNFH, 381 domestic females were spawned to provide eggs for in-stream egg planting.

Egg Transfers

CBNFH eyed-egg transfers from the 2014 spawn year included: 352K Penobscot eggs to GLNFH; 587K eggs to two facilities operated by the Downeast Salmon Federation (Pleasant: 216K and East Machias: 345K); 58K Penobscot eggs to DMR for planting; 87K Sheepscot eggs to DMR for planting; 113K Narraguagus eggs to GLNFH; 26K Machias eggs to DMR for planting

GLNFH transferred 275K eyed, Penobscot domestic origin eggs to DMR for egg planting in the Sandy River (1.15M) and to PIN for the Penobscot River (30K).

In addition, all three egg sources (sea-run, captive, and domestic) from the two federal hatcheries were used to support the USFWS' Salmon-in- Schools and Atlantic Salmon Federation Fish Friends programs in 2015.

Wild Broodstock Collection and Domestic Broodstock Production

A total of 660 adult sea-run Atlantic salmon captured at the Milford Dam, on the Penobscot River, was transported to CBNFH for use as broodstock.

Parr collection targets for the Dennys, East Machias, Machias, Narraguagus, and Sheepscot populations were increased by 50 each in 2013 to address concerns of diminishing genetic diversity and low re-capture rates of hatchery-origin parr. This increase was carried over in 2015.
In addition to increasing the parr collection targets for each population, greater attention was given to ensuring parr were collected in a manner that equalized the distribution of hatchery-origin products and wild reproduction.

In 2015, 1,504 wild parr (245, Dennys; 215, East Machias; 309, Machias; 304, Narraguagus; 208, Pleasant; 223, Sheepscot) were collected by CBNFH and DMR personnel. All parr were transported to CBNFH for captive rearing.

GLNFH retained approximately 1,200 fish from the 2014 year class of sea-run Penobscot-strain Atlantic salmon. These fish will be used for F2 domestic egg production at GLNFH for 2-3 years.

Disease Monitoring and Control

Disease monitoring and control was conducted at both hatcheries in accordance with hatchery broodstock management protocols and biosecurity plans. All incidental mortalities of future or adult broodstock reared at CBNFH were necropsied for disease monitoring. Analysis, conducted at the Lamar Fish Health Unit (LFHU), indicated that incidental mortalities were not caused by infectious pathogens. All lots of fish to be released from either facility were sampled in accordance with fish health protocols at least 30 days prior to release. At CBNFH, samples of reproductive fluids are collected from each female and male spawned; at GLNFH ovarian fluid is collected from 150 females. All reproductive fluids are analyzed at LFHU.

All Penobscot sea run broodstock retained at CBNFH were tested for Infectious Salmonid Anemia (ISA) as they were brought to the station in 2015. Incoming adults were isolated in the screening facility to undergo sampling procedures and await the results of PCR testing. Seven suspects were identified in 2015 and were released to the Penobscot River.

Stocking

Stocking activities in Maine resulted in the release of approximately 3.5M Atlantic salmon in 2015. These releases included Atlantic salmon from all lifestages and were initiated by Federal and State agencies, NGO's, researchers and educational programs.

Juvenile Stocking

Age-1 smolts reared at GLNFH were stocked into the Penobscot Basin (376K). Of the 376K, 118K were marked with adipose clips and visual implant elastomer (VIE) tags. Age 0 parr reared at GLNFH were stocked into the Penobscot Basin (258K); 562 of the parr were released with PIT tags as part of a DOT research project. North Attleboro National Fish Hatchery (NANFH) released 10K age 1 smolts into the Saco River. The Saco River also received 1300 age 1 smolts and 25K parr from Nashua National Fish Hatchery (NNFH).

Ambient age 0 parr reared at CBNFH released into the Sheepscot River totaled 14K. In addition CBNFH released 459 age 2 parr of the Penobscot 2014 captive year class; all CBNFH origin parr were marked with adipose fin clips. The Downeast Salmon Federation released 192K ambient age 0 parr reared at the East Machias Atlantic Salmon Resource Center; East Machias parr were adipose fin clipped.

The two federally operated hatcheries, CBNFH and GLNFH produced approximately 1.3 million fry [Penobscot, 518K; Dennys, 110K; Machias, 503K; Narraguagus, 165K; Sheepscot, 19K; Union, 23K], for release throughout the Distinct Population Segment (DPS).

Several privately operated hatcheries continued to support Atlantic salmon stocking efforts in 2015. Two hatcheries operated by the Downeast Salmon Federation released fry and age 0 parr into both the Pleasant (183K fry) and East Machias (10K fry and 192K 0 parr). The Dug Brook Hatchery operated by Atlantic Salmon for Northern Maine, released fry into the

Aroostook River drainage, however we currently do not know the number stocked. The Saco River Salmon Club hatchery released 701K fry into the Saco River drainage.

Adults

In the spring of 2015 CBNFH released 273 of the Penobscot 2013 captive year class. All but two of the 273 had been identified via genetic analysis as either originating from known parentage or were duplicative of the remaining Penobscot 2013s. Two additional 2013s were released due to their poor condition. The entire lot was PIT tagged and received double adipose punches prior to release.

GLNFH released 468 gravid domestic broodstock into Mattamiscontis Stream in 2015. Following spawning, 581 Penobscot sea-run broodstock were released by CBNFH back into the Penobscot River in 2015; an additional 55 post-spawn sea-runs were released by the University of Maine. No sea-run adults were specifically sacrificed for health screening purposes because requirements were met through incidental mortalities and subsequent routine necropsies as well as sampling of ovarian fluid and milt during spawning. CBNFH released the remaining Penobscot 2013 captive brood (145) as they had failed to successfully spawn by the end of November. These fish were released at a lower river location.

Spent captive broodstock from CBNFH were released into their natal rivers: Dennys (96); East Machias (181); Machias (199), Narraguagus (204); Pleasant (142); Sheepscot (114). GLNFH released 656 excess adults, comprised of age 3 and 4 domestic broodstock, into the Penobscot River.

5.2.3 General Program Information

U. S. Fish & Wildlife Service Schools Programs

2015 marked the twenty-first year of FWS' outreach and education program, Salmon-in-Schools, which focuses on endangered Atlantic salmon populations and habitats in Maine rivers. Student participants are provided the opportunity to raise river-specific Atlantic salmon eggs and fry in classrooms and release the fry into their natal river in early May. Classroom instruction involves the life cycle of Atlantic salmon and other diadromous fish, habitat requirements and human impacts which can affect their survival. The program contributes fry to many rivers within the DPS. In addition to educational facilities, annually a local business is annually invited to participate in the program to broaden exposure to the general public.

CBNFH and GLNFH provide Atlantic salmon eggs for the Atlantic Salmon Federation [Maine Council] program "Fish Friends". Fish Friends offers educational opportunities in Maine schools reaching thousands of students, cooperating teachers and parents annually. The two programs, working in partnership, reach over 3,600 people each school year.

Egg Take at CBNFH

CBNFH continued the photoperiod treatment conducted since 2010 on Penobscot sea run broodstock to delay the onset of spawning in 2015. As CBNFH relies solely on ambient water sources, eggs taken in October may be exposed to water temperatures above optimal levels for spawning and egg incubation [6 – 10 °C]. Above-optimal water temperatures during early egg development affect egg survival, embryonic deformities and fry survival. In addition, accelerated early egg development results in fry that biologically require feeding, but are unable to do so due to cold ambient process water.

The photoperiod treatment re-sets the biological clock in the sea-run broodstock, delaying maturation and the onset of spawning, using artificial light. Filtered ambient light is still available; extra light is administered via overhead lighting using a predetermined schedule and time clocks. The 2015 treatment extended the light available during the summer solstice [June 21] for ten days.

Juvenile Population Status

Juvenile abundance estimates

ME-DMR conducted electrofishing surveys to monitor spatial and temporal abundance of Atlantic salmon juveniles at 235 sites in 2015. One hundred ninety five sites were directed at several projects including a juvenile abundance index, egg planting assessment, and large woody debris. Additionally, ME-DMR assisted the USFWS Craig Brook crew in collecting parr broodstock at 40 sites. DMR collected 384 scale samples and 622 fork length measurements from juvenile salmon in 2015.

2015 was the fifth year that a Generalized Random Tessellated Stratified (GRTS) design with unequal probability of selection was used for establishing sampling locations for juvenile Atlantic salmon population assessment. For 2015, a reduction in effort focused on the Narraguagus River (10) and the East Machias River (21) in the Downeast SHRU; The Piscataquis River (15) in the Penobscot SHRU; and the Sandy River (30) and the Sheepscot River (8) in the Merrymeeting Bay SHRU. A total of 100 sites were sampled under the GRTS selection. Electrofishing effort was not limited to GRTS selected sites and an additional 95 sites were sampled for objectives ranging from egg planting evaluation to wild spawning assessment not including parr brood collections.

Median parr and YOY CPUE are presented in Tables 5.3.1 and 5.3.2. Median parr CPUE appears to have remained the same for the Penobscot SHRU but slightly increased for the Merrymeeting and Downeast SHRUs (Table 3.5.2). This may indicate inter-annual variation and not be indicative of any overall change in the status of the stock. With many different factors including, variations in stocking rates, lifestages, regional climates, etc. it would be difficult to point to one cause.

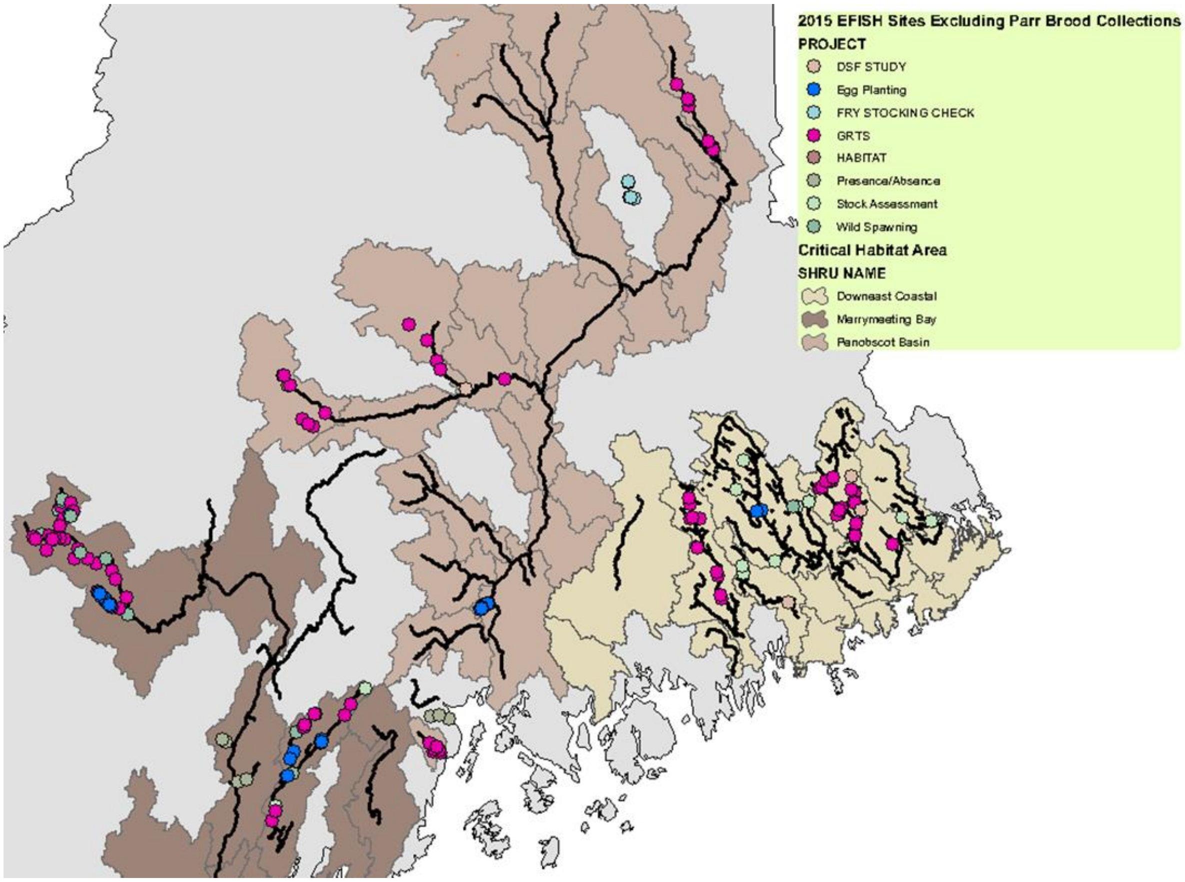


Figure 5.3.1. Distribution of electrofishing survey sites throughout the GOM DPS in 2015. Survey objectives are noted by project color. Purple dots are GRTS sites.

Table 5.3.1. Minimum (min), median, and maximum (max) relative abundance of juvenile Atlantic salmon population (fish/minute) based on timed single pass catch per unit effort (CPUE) sampling in selected Maine Rivers, 2014. Drainages are grouped by Salmon Habitat Recovery Unit (line).

		Parr				YOY			
Drainage	**Year**	**n**	**Min**	**Median**	**Max**	**n**	**Min**	**Median**	**Max**
East Machias	2015	21	0	1.4	4.39	21	0	0	8.97
Machias	2015	3	1.17	2.31	3.04	3	9.38	11.92	12.15
Narraguagus	2015	10	0	0.68	2.6	10	0	0	1.19
Pleasant	2015	3	0	0.79	2.35	3	1.58	2.08	9.77
Lower Androscoggin	2015	3	0	0	0.6	3	0	0.59	4.39
Lower Kennebec	2015	53	0	0.4	4.4	53	0	0.2	5.4
Sheepscot	2015	22	0	0.4	3	22	0	0.5	6.8
Saco	2015	3	0.2	0.4	0.4	3	1.2	3.58	7.15
Ducktrap	2015	7	0	0	0	7	0	0	3.42
Mattawamkeag	2015	16	0	0.36	1.28	16	0	0.92	2.73
Penobscot	2015	31	0	2.12	4.23	31	0	1.1	6.27
Piscataquis	2015	13	0	0.19	3.78	13	0	0	8.47

Table 5.3.2. Minimum (min), median, and maximum (max) density (fish/100m^2) and relative abundance (fish/minute) of Atlantic salmon juveniles. Data from sampled rivers were aggregated by Salmon Habitat Recovery Unit (SHRU), 2007 to 2015. No multi-pass depletion surveys were completed in 2015 for the Downeast and Merrymeeting Bay SHRUs.

		Density (fish / 100m^2)								CPUE (fish / minute)							
		Parr				YOY				Parr				YOY			
SHRU	**Year**	**N**	**Min**	**Median**	**Max**	**N**	**Min**	**Median**	**Max**	**N**	**Min**	**Median**	**Max**	**N**	**Min**	**Median**	**Max**
Downeast Coastal	2007	55	0	2.88	22.32	53	0.42	7.33	58.85	139	0	0.56	5.05	139	0	1.79	15.31
	2008	43	0	3.55	20.15	43	0	7.02	73.83	20	0	0	2.4	20	0	0.59	8.75
	2009	56	0	3.75	32.53	56	0	7.66	36.54	58	0	0.75	5.45	58	0	1.62	15.37
	2010	29	0.54	5.17	28	29	0	8.03	89.09	109	0	1	8.84	109	0	1.4	15.54
	2011	19	0	2.83	94.58	19	0	3.41	65.74	162	0	0.8	8.74	162	0	0.6	6.32
	2012	9	0.56	2.75	11.36	9	0	0.72	19.88	73	0	0.44	3.19	73	0	0.37	5.4
	2013	6	0	1.48	2.49	6	0	1.17	13.59	85	0	0.6	8	85	0	0	8.4
	2014	10	0	1.63	16.69	10	0	2.02	16.57	84	0	0.6	5.4	84	0	0.88	12.98
	2015	0				0				37	0	1	4.39	37	0	0	12.15
		Density (fish / 100m^2)								CPUE (fish / minute)							
		Parr				YOY				Parr				YOY			
SHRU	**Year**	**N**	**Min**	**Median**	**Max**	**N**	**Min**	**Median**	**Max**	**N**	**Min**	**Median**	**Max**	**N**	**Min**	**Median**	**Max**
Merrymeeting Bay	2007	33	0	0.28	50.27	33	0	4.03	69.76	34	0	0	2.6	34	0	0.23	5.03
	2008	26	0	1.64	21.65	27	0	2.17	38.85	20	0	0.36	0.77	20	0	0	1.4
	2009	17	0	6.01	21.74	17	0	3.12	28.07	48	0	0	3.27	48	0	0.19	9.35
	2010	22	0	2.14	16.57	21	0	3.03	109.94	112	0	0	2.94	112	0	0.8	29.4
	2011	17	0	8.65	44.45	17	0	1.89	43.26	56	0	0.2	4.37	56	0	0.2	9.8
	2012	20	0	2.25	16	20	0	6.65	77.48	108	0	0.2	4.92	108	0	0.4	12.97
	2013	15	0	4.92	41.11	15	0	8.86	61.68	103	0	0.2	2.8	103	0	0.4	6.6
	2014	11	0	4.76	34.96	11	0	8.83	60.64	95	0	0.4	2.8	95	0	0.4	7.5
	2015	0				0				78	0	0.4	4.4	78	0	0.2	6.8
		Density (fish / 100m^2)								CPUE (fish / minute)							
		Parr				YOY				Parr				YOY			
SHRU	**Year**	**N**	**Min**	**Median**	**Max**	**N**	**Min**	**Median**	**Max**	**N**	**Min**	**Median**	**Max**	**N**	**Min**	**Median**	**Max**
Penobscot	2007	49	0	0	33.73	25	0	0	66.78	50	0	0.38	2.51	50	0	0	1.8
	2008	11	0	6.69	17.75	11	0	19.94	47.08	74	0	0	0.95	74	0	0	0.38
	2009	10	0	7.89	20.39	10	4.07	29.8	39.74	119	0	0	2.93	119	0	0.75	7.79
	2010	11	0	11.5	22.07	12	0	10.68	92.68	112	0	0	3.91	112	0	0.77	15.95
	2011	5	0	6.99	14.9	5	0	4.06	49.8	87	0	0	3.82	87	0	0	5.72
	2012	13	0	1.47	12.99	13	0	21.9	69.88	85	0	0	3.05	85	0	0.4	13.96
	2013	10	0	10.61	25	12	0	6.54	105.14	85	0	0.53	4.53	85	0	0.19	12.2
	2014	7	0	7.39	16.37	7	0	16.25	79.32	58	0	0.79	3.73	58	0	0.54	10.06
	2015	7	0	15.08	40.12	7	0	51.3	115.08	67	0	0.87	4.23	67	0	0.75	8.47

The following is a summary of activities intended to obtain an abundance of smolt out-migration at several sites within the GOM. A more detailed report on smolt population enumeration and dynamics is included in Working Paper WP16-02- Smolts Update.

NOAA-National Marine Fisheries Service (NOAA) and the Maine Bureau of Sea Run Fisheries and Habitat (BSRFH), conducted seasonal field activities enumerating smolt populations using Rotary Screw Traps (RSTs) in several of Maine’s coastal rivers.

Maine MDMR captured Atlantic salmon smolts using rotary screw traps (RST) in four Maine rivers; East Machias, Narraguagus, Piscataquis, and Sheepscot, to estimate smolt production and monitor migration timing in spring 2015. The East Machias River site was operated in partnership with the Downeast Salmon Federation (DSF). A total of 2,374 smolts of hatchery and wild origin were captured in Maine rivers in 2015 (Table 5.3.3).

Table 5.3.3. Atlantic salmon smolt trap deployments, total captures, and capture timing by origin in Maine rivers, 2015.

River	Dates Deployed		Origin	Total Captures	First Capture	Median Capture Date	Last Capture
East Machias	27-Apr	16-Jun	H	67	4-May	21-May	11-Jun
			W	7	2-May	15-May	11-Jun
Narraguagus	28-Apr	1-Jun	W	379	2-May	15-May	27-May
Piscataquis	1-May	29-May	W	1,533	6-May	13-May	28-May
Sheepscot	2-May	3-Jun	H	218	2-May	17-May	3-Jun
			W	170	2-May	12-May	29-May
Total				2,374			

Smolt Abundance

A subsample of captured smolts undergo biological sampling including measurement of length (mm) and live weight (0.1g), observation of marks, fin condition, relative smolt development, and notation of any injury or mortality. Depending on site specific sampling plans, smolts were differentially marked or tagged to aide in mark and recapture or tracking. MDMR marked 1,481 smolts with a caudal punch in 2015. Scale samples and genetic tissue were collected for analysis from all rivers. No PIT tags were applied to smolts in 2015.

Scale analysis documented wild origin smolts were predominately age-2 in the Narraguagus and Sheepscot River (Table 5.3.4). The East Machias and Piscataquis River had a higher proportion of age-3 smolts. In the East Machias River, the demographic shift is expected to remain similar in coming years due to the elimination of drainage-wide unfed fry stocking while transitioning to 0+ parr stocking. Piscataquis River age-3 smolts were more prevalent due to a strong year class produced by increased spawning escapement in 2011 followed by reduced escapement in 2012. Sheepscot River hatchery origin smolts were predominately age-1 (p8). Age-2 Sheepscot River smolts of both origins (W2 and p20) were larger compared to all rivers (Table 5.3.5). Both age-2 and age-3 wild smolts captured in the Piscataquis River were smaller than smolts in all rivers. In a rare occurrence, Sheepscot River wild smolts were smaller at age-3 than age-2; however age-3 sample size was low.

Table 5.3.4 Freshwater age of naturally-reared smolts captured in smolt traps in Maine rivers.

	2015				5 year average (2010-2014)			
River	1	2	3	4	1	2	3	4
Narraguagus	1.2%	74.1%	24.7%	0%	0.2%	84.5%	15.0%	0.3%
Sheepscot	0%	96.7%	3.3%	0%	0.5%	89.2%	10.0%	0.3%
Piscataquis	0%	39.8%	60.2%	0%	0%	79.8%	19.9%	0.3%
East Machias	0%	42.9%	57.1%	0%	N/A	N/A	N/A	N/A
Sandy	0%	86.4%	13.0%	0.6%	0%	79.9%	20.1%	0%

Table 5.3.5. Mean fork length (mm) ± S.D. by origin of smolts captured in smolt traps in Maine rivers.

	Age-1 (p8) Hatchery-origin				Age-2 Naturally-reared			
			5 year average				5 year average	
River	n	2015	n	('10-'14)	n	2015	n	('10-'14)
Narraguagus	0	N/A	0	N/A	72	165±13	477	172±16
Sheepscot	110	165±9	579	163±10	117	190±15	741	187±19
Piscataquis	0	N/A	0	N/A	269	158±13	2407	146±11
East Machias	19	168±16	0	N/A	3	161±11	N/A	N/A
Sandy	0	N/A	0	N/A	132	153±12	215	156±15

Maine DMR scientists calculated population estimates using Darroch Analysis with Rank Reduction (DARR) 2.0.2 for program R (Bjorkstedt 2005; Bjorkstedt 2010) for each RST site (Table 5.3.6). The East Machias, Piscataquis and Sheepscot River population estimates are based on a one site mark-recapture design. The total population estimate for all smolts exiting the East Machias River (hatchery 0+ parr origin and wild/naturally reared origin) was 263 ± 51. The hatchery population estimate was calculated 228 ± 46. Insufficient recaptures prohibited calculation of the wild origin population estimate. The population estimate of smolts exiting the Piscataquis River was 4,278 ± 272. The total population estimate for all smolts exiting the Sheepscot River (hatchery 0+ parr origin and wild/naturally reared origin) was 1,558 ± 186. The hatchery population estimate was calculated 1,055 ± 220. The wild population estimate was 572 ± 72. The hatchery and wild population estimates were not comparable to the total population estimate when summed (1,627 vs 1,558). A two site mark-recapture design was used on the Narraguagus River to estimate the number smolts exiting the system for an eighteenth year. The Narraguagus River smolt population was estimated 1,201 ± 241.

Table 5.3.5. Mean fork length (mm) ± S.D. by origin of smolts captured in smolt traps in Maine rivers.

	Age-1 (p8) Hatchery-origin				Age-2 Naturally-reared			
			5 year average				5 year average	
River	n	2015	n	('10-'14)	n	2015	n	('10-'14)
Narraguagus	0	N/A	0	N/A	72	165±13	477	172±16
Sheepscot	110	165±9	579	163±10	117	190±15	741	187±19
Piscataquis East	0	N/A	0	N/A	269	158±13	2407	146±11
Machias	19	168±16	0	N/A	3	161±11	N/A	N/A
Sandy	0	N/A	0	N/A	132	153±12	215	156±15

Table 5.3.6. Maximum likelihood mark-recapture population estimates for wild and hatchery origin
Atlantic salmon smolts emigrating from Maine rivers, 2015.

River	Estimate Type	Origin	Population Estimate
East Machias	One site	Hatchery	228 ± 46
		Wild	n/a
		Both	263 ± 51
Narraguagus	Two site	Wild	1,201 ± 241
Piscataquis	One site	Wild	4,261 ± 270
Sheepscot	One site	Hatchery	1,055 ± 220
		Wild	572 ± 72
		Both	1,558 ± 186

Fish Passage

Penobscot River PIT Network

Starting in 2011, a cooperative effort between the MDMR, the University of Maine (UM), and the United States Geological Survey's Maine Cooperative Fish and Wildlife Research Unit (CFWRU), led to the installation of antennas to monitor movement of fish marked with passive integrated transponder (PIT) tags in the Penobscot River system. The following are unpublished abstracts of recent work in the Penobscot River. Contact information is made available for corresponding authors.

Upstream Movements of Atlantic Salmon in the Lower Penobscot River, Maine Following Two Dam Removals and Fish Passage Modifications

Lisa K. Izzo (*lisa.izzo@maine.edu)*, George Maynard, and Joseph Zydlewski

As part of the Penobscot River Restoration Project (PRRP), Great Works (rkm 59) and Veazie (rkm 46) Dams were removed, making Milford Dam (rkm 61) the first impediment to federally endangered Atlantic Salmon *Salmo salar*. Upstream habitat access for Atlantic salmon is dependent upon successful and timely passage at a newly constructed fish lift at Milford Dam, as nearly all suitable spawning habitat is located upstream. In 2014 and 2015, a total of 73 adult salmon were captured at Milford Dam, radio and PIT tagged, and displaced downstream to track their upstream movements through the lower Penobscot River to assess potential delays at 1) the dam remnants, 2) the modified but impassable Orono Dam on the Stillwater Branch, and 3) the new Milford fish lift. Additionally, transit times of adult Atlantic salmon in the lower Penobscot River before and after changes to the system were compared. Movement rates through the dam remnants were rapid and comparable to open river reaches. Passage efficiency of the new fish lift was high, with 95 and 100% of fish passing in each of the two study years. However, fish experienced long delays at Milford Dam, with approximately 1/3 of fish taking over a week to pass in each year, well below the FERC passage standard of 95% within 48 hours. Telemetry indicates most fish locate the fishway entrance within 5 hours of arrival and were observed at the entrance at all hours of the day. These data indicate that overall transit times through the lower river were comparable to reported movement rates prior to river modifications due to the substantial delays seen at Milford Dam. The results of this study show that while adult Atlantic Salmon locate the new fish lift entrance quickly, passage of these fish is significantly delayed under current operations.

Size Matters: Fish-ways can Exert Size Selective Pressure on Migrating Atlantic Salmon

George A. Maynard (george.maynard@maine.edu), Michael T. Kinnison, Joseph D. Zydlewski

Humans can exert selective forces on phenotypes in populations of domestic and wild animals. The evolutionary effects of lethal selective pressures (i.e. harvest) on wild fish populations have been well documented. Sub-lethal selective pressures can also cause evolutionary changes in phenotypes. For migratory fishes, passage facilities may represent such a non-lethal selective pressure. Our analysis of six years of passage data suggests that certain fish passage facilities at hydroelectric dams on the Penobscot River have been exerting selective pressure against large-bodied, anadromous Atlantic salmon (*Salmo salar*). At the second and third dams in the river, a 91 cm salmon was 21%-27% and 11.9%-16.2% less likely to pass than a 45 cm salmon, respectively. Given that size at maturity is a heritable trait in salmonids, in a wild-reproducing population of Atlantic Salmon, exclusion of large, productive fish from spawning areas would be expected to have population-level impacts. Due to conservation efforts, in the Penobscot River most (>95%) returning fish originate from hatchery programs and thus, from parents that are not subjected to the selective pressures of fish-way passage. Analysis of fork lengths of Atlantic salmon returning to the Penobscot River from 1978-2012 did not indicate any evolutionary impact of size-selection on mean size, though variation in length decreased significantly during this time. Additionally, slow maturing (three sea-winter) adults and iteroparous individuals were essentially lost from the population during that time. We hypothesize that size selection at fish-ways may compromise populations of migrating Atlantic salmon over several generations.

Genetics

Tissue samples were collected from salmon handled at the Androscoggin River fishway in Brunswick (1), the Lockwood fish lift on the Kennebec River (30), the Narraguagus River

(3), and the Penobscot River (709). In total 741 genetic samples were collected in 2015 from adult trapping facilities. All tissue samples were preserved in 95% ethanol.

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

To reduce handling stress, tag loss, and tagging-related mortality, juvenile broodstock are currently tagged one year post-capture at CBNFH. This allows the fish to reach an appropriate size to allow for intramuscular insertion of PIT tags. In October 2015, DPS broodstock (collected in 2014) were PIT tagged, sampled for future genetic characterization, and moved from the CBNFH Receiving Building to broodstock modules.

General Program Information

GOM DPS Recovery Plan

A draft of the First Revision to the Recovery Plan for the Gulf of Maine Distinct Population Segment of Atlantic Salmon has been completed by the U.S. Fish and Wildlife Service (Service) and National Oceanographic and Atmospheric Administration - National Marine Fisheries Service (NMFS), in close collaboration with Maine Department of Marine Resources and the Penobscot Indian Nation. The draft was reviewed by the Department of Interior Office of the Regional Solicitor in late fall of 2012. Revisions are nearly complete to the draft plan in response to issues raised by the Regional Solicitor's Office. The Service and NMFS target date for publishing a notice of availability for public review in the Federal Register, in late spring of 2016. Once the document is under public review, the agencies will convene several public meetings across the DPS to allow direct discussions between stakeholders and the agencies; formal comments will be accepted through electronic means and via surface mail.

Migratory Fish Habitat Enhancement and Conservation

Habitat Assessment

MDMR staff conducted habitat surveys in seven streams in 2015 (Table 5.7.1). Staff surveyed approximately 39km of stream length documenting over 5,740 units of rearing habitat. Additionally, staff documented 5 units of spawning habitat. Data are currently being entered in the DMR Habitat database for use in GIS. The new dataset will be appended to the current habitat database and a new GIS dataset will be issued in March 2016. Surveys in the Downeast Coastal SHRU focused on streams that received recent connectivity improvements and/or potential expanded stocking. New surveys occurred in the Merrymeeting Bay SHRU in 2015.

Table 5.7.1 List of streams surveyed by MEDMR Staff in 2015.

SHRU	Drainage	Stream	Survey Length (km)	Rearing Units (100m²)	Spawning Units (100m²)	Comments
Downeast Coastal						
	Machias	Lanpher Brook	1.66	37.1	-	Survey extension
	Narraguagus	Humpback Brook	0.57	22.9	-	Survey extension
	Union	Indian Camp Brook	3.80	182.2	-	New survey
	Union	Smith Brook	0.89	22.0	-	New survey
	Union	Spring Brook	1.25	27.6	-	New survey
	Union	Warm Brook	0.97	28.9	-	New survey
Merrymeeting Bay						
	Carrabassett	Carrabassett River	29.89	5419.8	5.4	New survey
		TOTAL	**39.0**	**5740.5**	**5.4**	

Habitat Connectivity

Numerous studies have identified how stream barriers can disrupt ecological processes, including hydrology, passage of large woody debris and movement of organisms. Thousands of barriers exist in Maine streams that block the movement of diadromous fish, other aquatic and terrestrial species, sediment, nutrients and woody debris. These barriers include dams and road-stream crossings. All dams interrupt stream systems, but are highly variable in their effects on the physical, biological, and chemical characteristics of rivers. Improperly sized and placed culverts can drastically alter physical and ecological stream conditions. Undersized culverts can restrict stream flows, cause scouring and erosion and restrict animal passage. Perched culverts usually scour the stream bottom at the downstream end and can eliminate or restrict animal passage. Culverts that are too small, or have been difficult to maintain or install are also at increased risk of catastrophic failure during larger than average storm events. Emergency replacements are more dangerous, more costly economically and more environmentally damaging than replacements planned ahead of disaster.

Barrier Surveys: A coordinated effort is underway in Maine to identify aquatic connectivity issues across the state. Since 2006, state and federal agencies and non-governmental organizations have been working together to inventory and assess fish passage barriers in Maine and to develop barrier removal priorities. Partners include The Nature Conservancy, Maine Audubon, USDA Natural Resources Conservation Service (NRCS), U.S. Fish and Wildlife Service (USFWS), the Maine Department of Inland Fisheries and Wildlife (MDIFW), Maine Department of Marine Resources (MDMR), Maine Forest Service (MFS), Maine Department of Transportation (MDOT), Maine Natural Areas Program (MNAP), Maine Coastal Program, Trout Unlimited, Atlantic Salmon Federation, Maine Rivers, National Oceanic and Atmospheric Agency (NOAA), and the Androscoggin Valley and Oxford County Soil and Water Conservation Districts.

After 9 years of fieldwork, about two-thirds of the state's perennial stream crossings have been assessed (see Map 1). About 10,000 stream crossings have been assessed within the Gulf of Maine DPS. A wide variety of private owners, municipalities, and agencies are using survey information to prioritize road-stream crossing improvement projects. Many local, state, and private road managers have requested data showing where problems are so they can include them in long-term budget and repair schedules. In 2016, stream barrier surveys will be completed in the Kennebec, West Branch Penobscot, Androscoggin, St. John, and small coastal Maine watersheds.

Maine Barrier Survey Status Map

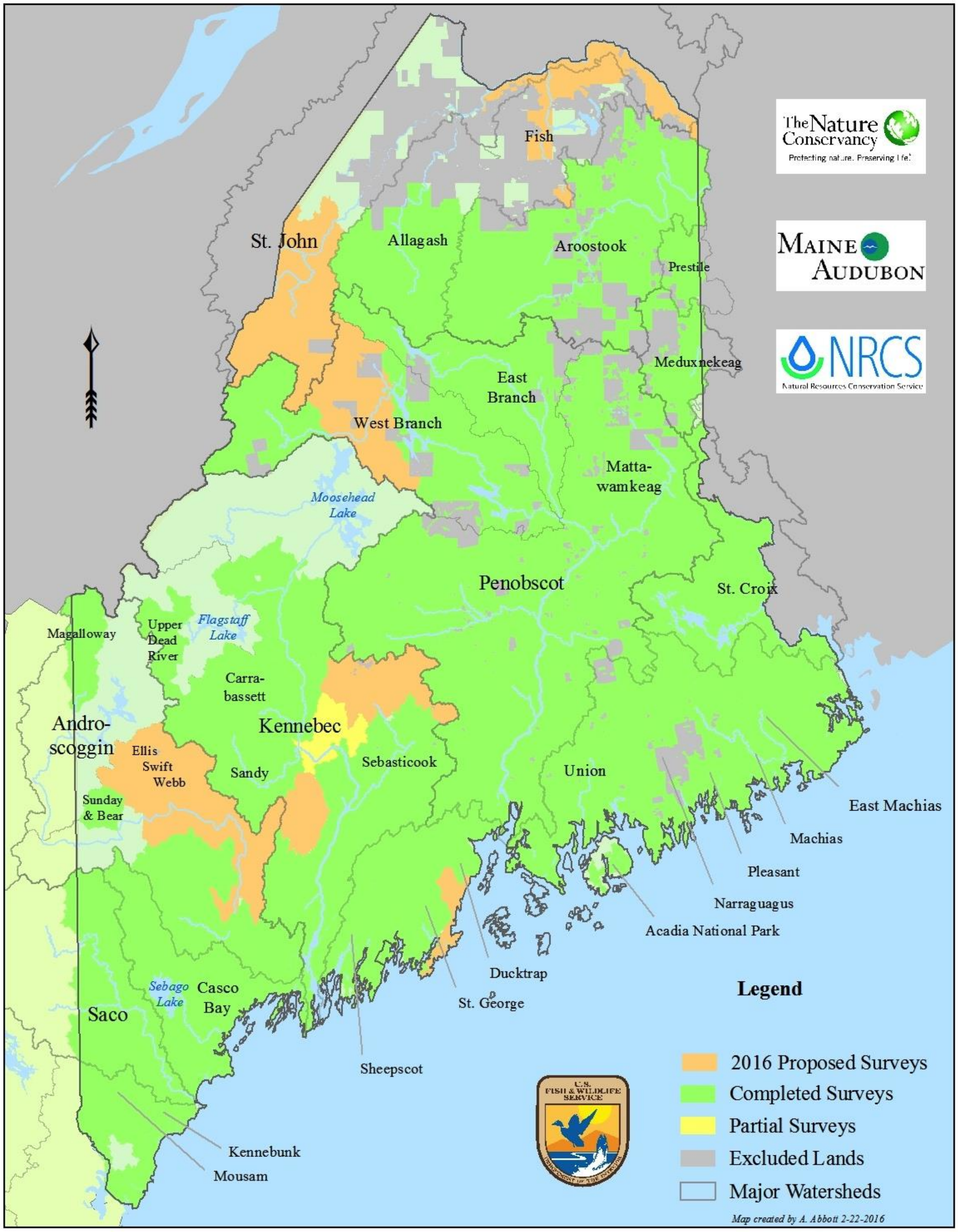


Figure 5.7.1 Extent of barrier surveys conducted in Maine to present. Almost 10,000 road-stream crossings have been assessed within the Gulf of Maine DPS since 2006.

As part of the NOAA-funded Penobscot Habitat Blueprint effort The Nature Conservancy (TNC) is developing a stream barrier prioritization and an associated custom analysis tool. This prioritization will help planners and managers identify the stream barriers (culverts, dams) where fish passage improvements, via upgrades or other mitigation efforts, can have the greatest ecological impact.

Following similar methodologies to TNC's Northeast Aquatic Connectivity project (https://tnc.box.com/s/l50rfnkeztmcvqa53ikr), Chesapeake Fish Passage Prioritization (http://maps.tnc.org/EROF_ChesapeakeFPP), and Southeast Aquatic Connectivity Assessment Project (http://maps.tnc.org/seacap), a suite metrics are calculated for each stream barrier in a GIS. Each metric assesses a quality that is relevant to understanding the impacts of a barrier on aquatic organism passage. The can include metrics that are derived from the river network (e.g. upstream miles that would be opened by the mitigation of a barrier), habitat data (e.g. salmon parr productivity in a barriers upstream connected network), or any number of other data types and sources (e.g. invasive species presence, geology, alewife spawning ponds, etc). These metrics can then be subset and weighted to develop a prioritized result that is reflective of a user's objective. For example, a prioritization that seeks to identify barriers whose mitigation would most benefit salmon might heavily weight metrics which assess the length of habitat that would be opened by each barrier's mitigation and the parr productivity of that habitat. Conversely, a prioritization that seeks to identify priority barriers for brook trout might most heavily weight whether each barrier is within an Eastern Brook Trout Joint Venture (EBTJV) Wild Brook Trout Patch, and how much of the reconnected habitat is considered 'High' or 'Very High' quality brook trout habitat by Maine's Department of Inland Fish and Wildlife.

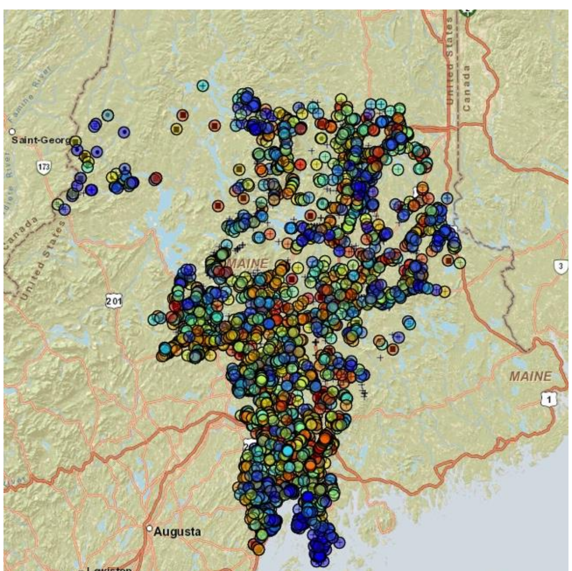


Figure 5.7.2 Diadromous fish consensus prioritization. Warm colors are higher priorities, cool colors are lower priorities.

TNC is working with the Penobscot Habitat Blueprint Workgroup to identify two "consensus scenarios." This multi-stakeholder group includes representatives from state and federal agencies and other NGOs which are active in fish passage issues in Maine. The consensus scenarios, developed by weighting a subset of metrics as described above, will reflect the Workgroup's priority barriers for diadromous fish and resident fish, respectively, and will provide a clear set of priorities that can be used by partners to inform planning decisions. Additionally, a custom-prioritization tool will be available so users can develop their own prioritizations based on a user-defined subset of metrics and weights. This tool, which will be hosted in a web map along with the consensus scenarios, will provide a "menu" of the universe of metrics which are available for use in the prioritization. Beyond the ability to prioritize barriers, the tool will also allow users to model the removal or mitigation of a barrier and assess the impacts of that removal on the remaining priorities. For example, if a given barrier is potentially slated for removal / upgrade, the prioritization tool can be run as if that barrier were no longer a barrier thereby revealing, perhaps, that the next upstream barrier which had previously been a low priority has become a higher priority. An intermediate step to running the "barrier removal" functionality is a re-calculation of all of the metrics for the barriers surrounding the removed barrier. Thus, in addition to a prioritization run as if the barrier did not exist, the tool produces metric values which, in and of themselves, may be of interest to the user. As of February 8, 2016, an initial draft of the geoprocessing service that underlies the prioritization tool is functional, including the barrier removal functionality and summary statistics functionality. Further, a development version of the web map and tool is operational. The map interface and functionality will continue to be built out from the core functionality that is currently operational.

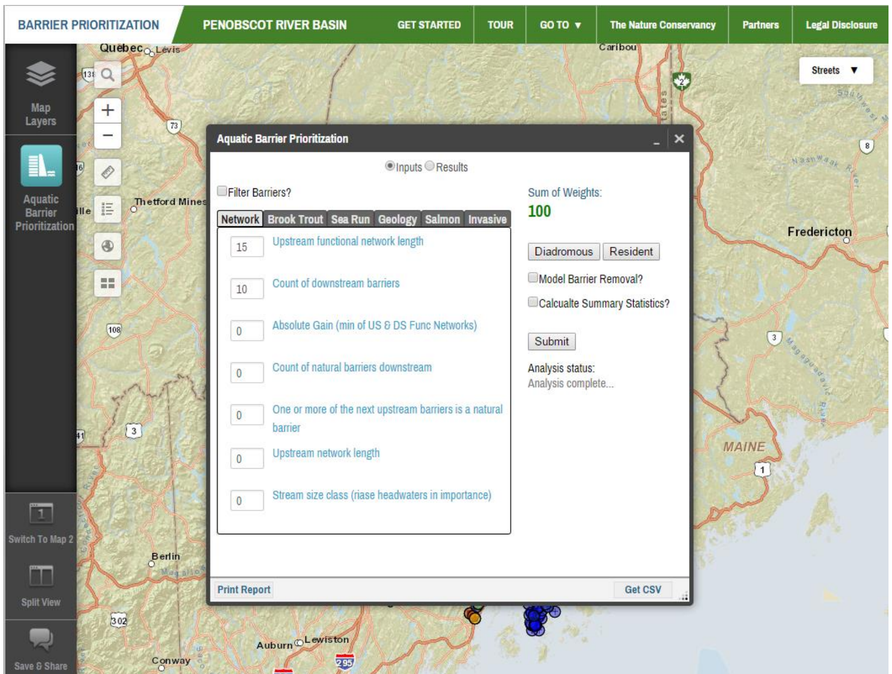


Figure 5.7.3 User interface for the Penobscot Habitat Blueprint Barrier Prioritization Tool

Stream Smart training: In 2015, Maine Audubon continued to lead a statewide partnership to educate professionals responsible for road-stream crossings on how to improve stream habitat by creating better crossings. The partnership hosted 8 workshops around the state (in southern, central, and northern Maine) with 195 attendees. Since 2012, 800 people representing 111 towns have attended Stream Smart workshops. Workshops inform public and private road owners about opportunities to replace aging and undersized culverts with designs that last longer, improve stream habitat, save money on maintenance, and can reduce flooding. Participants in the workshops included town road commissioners, public works directors, contractors, forest landowners, foresters, loggers, engineers, conservation commissions, watershed groups and land trusts. Additional project partners include the Maine Coastal Program, Maine Department of Environmental Protection, NOAA, US Fish

& Wildlife Service, USDA NRCS, Maine Forest Service, Maine Rivers, Casco Bay Estuary Partnership, Project Share, Sustainable Forestry Initiative, the Nature Conservancy, and US Army Corps.

Figure 5.7.4 Stream Smart training provides instruction on culvert assessment and design methodologies.

Four of the workshops were Stream Assessment Field trainings targeting but not limited to prior Stream Smart workshop attendees. The focus of the field trainings provides an introduction to stream survey techniques and approaches for developing initial recommendations for road-stream crossings. The training provided information to allow participants to:

- Understand stream survey tools and techniques including longitudinal profiles, cross sections and bed characterization
- Learn approaches to understand specific site conditions at road-stream crossing
- Collect data from road-stream crossing sites and input into spreadsheets
- Develop recommendations for properly sized and installed structures

Online data viewer – Online data viewer – The Maine Stream Habitat Viewer provides easy access to habitat and barrier datasets (http://mapserver.maine.gov/streamviewer/streamdocHome.html), and was being completely revised in 2015. The viewer now hosted by the Maine Office of GIS will shift to its new Maine Department of Agriculture, Conservation and Forestry host in early 2016. The Viewer contains Atlantic salmon spawning and rearing habitat, and modeled rearing datasets along with dams, natural barriers and public road-stream crossings. The Viewer was created to enhance statewide stream restoration and conservation efforts, and provides a starting point for towns, private landowners, and others to learn more about stream habitats across the state. The Viewer allows you to:

- Display habitats of conservation and restoration interest, like alewife, Atlantic salmon, sea-run rainbow smelt, wild eastern brook trout and tidal marshes.
- Display locations of dams and surveyed public road crossings that are barriers.
- Click on habitats and barriers to learn about their characteristics.
- Perform queries based on areas of interest.
- Contact experts for technical assistance and funding information.

2015 Highlighted Connectivity Projects

Stream Connectivity Projects

In 2015, 21 additional aquatic connectivity projects were completed across the Gulf of Maine DPS (Table 1) with the primary goal of restoring aquatic organism connectivity and ecological stream processes by allowing the natural flow of materials (water, wood, sediment). A total of over 51 miles of stream were made accessible as a result of these projects. These efforts were made possible due to strong partnerships including Natural Resource Conservation Service, Penobscot Indian Nation, Project SHARE, Maine Dept. Inland Fisheries and Wildlife, Maine Dept. of Marine Resources, Maine Dept. of Conservation, Maine Forest Service, NOAA Fisheries, Atlantic Salmon Federation, U.S. Fish and Wildlife Service, The Nature Conservancy, Downeast Lakes Land Trust, municipalities, lake associations, towns, and numerous private landowners.

Project Type	Watershed	Stream	KM
Removal	East Machias	Beaverdam Stream	21.7
Waste block bridge	Penobscot	Sebec	1.3
Waste block bridge	Penobscot	West Branch Penobscot	0.9
Decommission	Penobscot	West Branch Pleasant	1.3
Bridge	Penobscot	Blackstone Brook	16.1
Box culvert	Penobscot	Bradford Brook	1.4
Box culvert	Penobscot	Seams Brook	2.7
Arch	Androscoggin	Hodgkins Brook	3.1
Arch	Union	Winkumpaugh Brook	3.2
Waste block bridge	Penobscot	South Branch Lake Inlet Stream	3.4
3 Arch	Penobscot	Mattamiscontis Stream	2.6
Arch	East Machias	Northern Stream	0.8
Arch	East Machias	Northern Stream	2.4
4 Remnant dam removals	Narraguagus	35 Brook	14.5
Arch	Narraguagus	W. Branch Brook	0.8
Arch	Narraguagus	Burnam Brook	0.8
Total			**77.0**

Table 5.7.2: Projects restoring stream connectivity in Maine Atlantic salmon watersheds, indicating project type, stream and watershed name and kilometers of stream habitat access.

Figure 5.7.5. Stream Simulation design replacement culvert in Penobscot River watershed (credit Ben Naumann USDA-NRCS).

Figure 5.7.6. Crossing decommissioning in West Branch Pleasant (credit Ben Naumann USDA-NRCS).

Habitat Complexity

<u>Narraguagus Focus Area Restoration</u>

Project SHARE has identified the Upper Narraguagus Watershed as a high-priority focus area for salmonid habitat restoration. The Narraguagus River is located in Maine's Downeast, region within the geographic range of the federally listed-endangered Atlantic salmon. Other native fish species include Eastern brook trout (identified in steep decline throughout its range by the Eastern Brook Trout Joint Venture), American eel, alewife, shad, and sea lamprey.

Over the last thirteen years SHARE, in collaboration with state and federal agencies, landowners, and nonprofit organizations, has developed a habitat restoration program with principal focus on the five Downeast Maine Atlantic salmon watersheds. The group has identified threats to habitat connectivity and function and opportunities to restore coldwater refugia and rearing habitat, and conducted cooperative projects that have removed those threats and/or restored connectivity and natural stream function. Watershed-scale threat assessments of the Narraguagus River have documented summer water temperatures in main stem river reaches above sub-lethal stress levels, approaching acute lethal levels. Remnant dams and associated legacy reservoirs are identified heat sinks contributing to warmer temperatures. Undersized culverts at road/stream crossings present stream connectivity threats and are barriers to upstream coldwater refugia.

Climate change predictions present threats in addition to legacy effects of past land use. Stream temperatures are expected to rise in most rivers; the threat to salmon recovery is high where temperatures are near sub-lethal or lethal thresholds for salmon (Beechie et al. 2013). Average air temperatures across the Northeast have risen 1.5˚ F since 1970, with winter temperatures rising most rapidly, 4˚ between 1970 and 2000 (NECIA 2007). However, increased water temperature is not the only threat associated with climate change. Precipitation and timing of significant aquatic events (intense rain, ice-out, spring flooding, and drought, among them) are "master variables" that influence freshwater ecosystems and are predicted to change, according to all climate model predictions. Jacobson et. al. (2009) provide a preliminary assessment summarizing impacts to Maine's freshwater ecosystems, predicting a wetter future, with more winter precipitation in the form of rain and increased precipitation intensity. Although it is not possible to predict specific changes at a given location, several 100- to 500-year precipitation events have occurred in recent years. Climate change will affect the inputs of water to aquatic systems in Maine, and temperature changes will affect freezing dates and evaporation rates, with earlier spring runoff and decreased snow depth. Stream gauges in Maine show a shift in peak flows to earlier in spring, with lower flows later in the season. New England lake ice-out dates have advanced by up to two weeks since the 1800s. Water levels and temperatures cue migration of sea-run fish such as alewives, shad, and Atlantic salmon into our rivers, and the arrival or concentration of birds that feed on these fish. Lower summer flows will reduce aquatic habitats like coldwater holding pools and spawning beds. This complex interplay of climate effects, restoration opportunities, and potential salmonid responses poses a considerable challenge for effectively restoring salmon populations in a changing climate (Beechie et al. 2013). However, past land use practices often have degraded habitats to a greater degree than that predicted from climate change, presenting substantial opportunities to improve salmon habitats more than enough to compensate for expected climate change over the next several decades (Battin et al., 2007).

Process-based habitat restoration provides a holistic approach to river restoration practices that better addresses primary causes of ecosystem degradation (Roni et al., 2008). Historically, habitat restoration actions focused on site-specific habitat characteristics designed to meet perceived "good" habitat conditions (Beechie et al. 2010). These actions favored engineering solutions that created artificial and unnaturally static habitats, and attempted to control process and dynamics rather than restore them. By contrast, efforts to reestablish system process promote recovery of habitat and biological diversity. Process restoration focuses on critical drivers and functions that are the means by which the ecosystem and the target species within it can be better able to adapt to future events, such as those predicted associated with climate change.
SHARE is collaborating in this project with a team of scientists in a 5- to 7-year applied science project taking a holistic, natural process-based, approach to river and stream restoration in an 80-square-mile area in Hancock and Washington Counties. The vision, from the perspective of restoration of Atlantic salmon as an endangered species, is to restore the return of spawning adult Atlantic salmon from the sea to the Upper Narraguagus River sub-watershed to escapement levels that are self-sustaining. The work will be guided by a

team of scientists and restoration actions will be based on the four principles of process-based restoration of river systems:

- Restoration actions should address the root causes of degradation;
- Actions should be consistent with the physical and biological potential of the site;
- Actions should be at a scale commensurate with environmental problems; and
- Actions should have clearly articulated expectations for ecosystem dynamics.

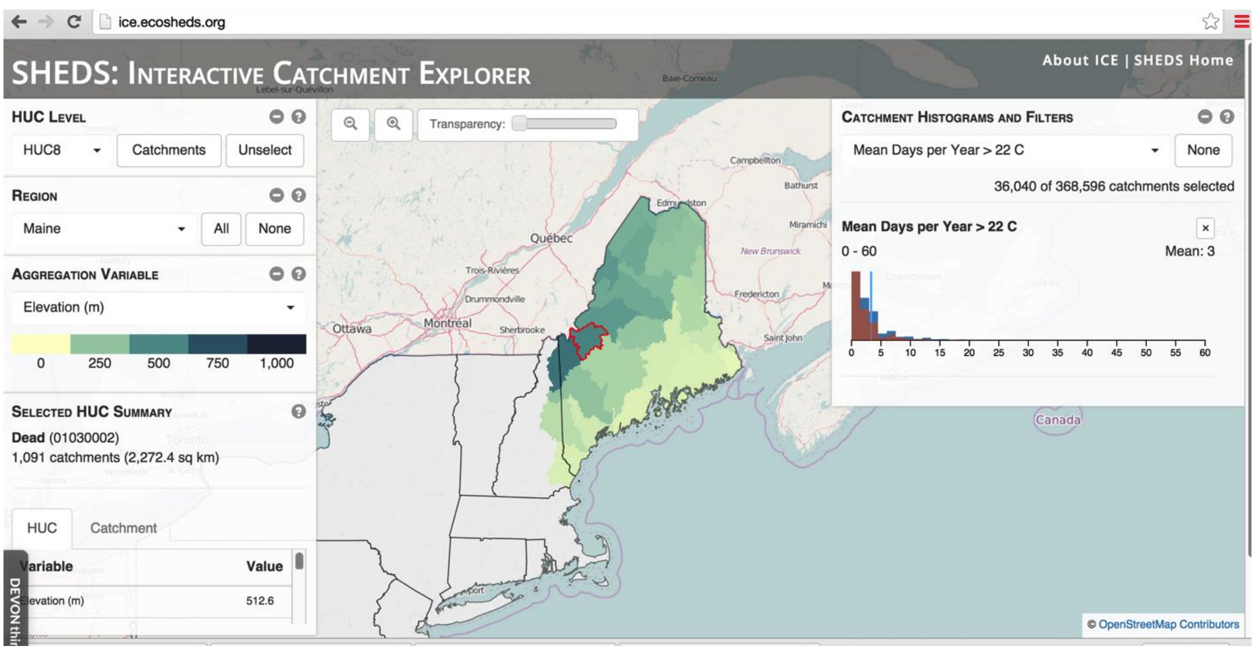
This project, a collaboration with the National Oceanographic and Atmospheric Administration, the U.S. Fish and Wildlife Service, the University of Maine, Maine's Department of Marine Resources, Boston College, Connecticut College, and the Canadian Rivers Institute, will test the hypothesis that reconnecting river and stream habitat, improving habitat suitability, and reintroducing salmon to unoccupied habitat, will increase the number of salmon smolts leaving the sub-watershed en route to the ocean.
In 2015, two pilot wood placement projects were implemented in the mainstem Narraguagus. Crews placed wood jams in the mainstem of the river in order to force development of more complex multiple thread (anabranching) channels. It is hoped that

such channels will provide greater riparian shading, greater edge effects and be more productive for juvenile Atlantic salmon. The structures were surveyed using CHaMP (https://www.champmonitoring.org/) protocols. Unfortunately, the wood became mobile under high flows soon after placement. The group is now investigating alternative placement techniques.

Water Temperature

The Maine Stream Temperature Monitoring Network was developed in 2014 to facilitate a coordinated stream temperature monitoring effort in Maine that will be integrated with regional and national efforts. The Network is being implemented by the Stream Temperature Working Group (STWG), composed of multiple state agencies, academic institutions, NGOs, tribes and federal agencies.

In 2015, the STWG collected historical temperature data from more than 1200 locations and deployed over 220 stream temperature sensors in every watershed, with many more to come in the following seasons. The group held a protocol workshop in early spring to teach logger deployment methods and continue to build capacity throughout the state. The web-based database, SHEDS, is now operational and organizations across the state are uploading their continuous stream temperature data into one, centralized repository. Additionally, the public may view and download any stream temperature data in the database not flagged as "private." SHEDS also hosts a module for predictive catchment modeling, as well as other stream temperature modeling tools. Researchers and fisheries managers plan to use this robust data repository for fish occupancy modeling, habitat restoration prioritization, and regional climate studies.



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6 Outer Bay of Fundy

The rivers in this group are boundary waters with Canada. Further the majority of the watershed area for both watersheds is in Canada. As such, the Department of Fisheries and Oceans conducts assessments and reports status of stock information to ICES and NASCO.

6.1 Adult Returns

The Tinker fishway trap on the Aroostook River was operated by Algonquin Power Company from 15 April to 13 November, 2015. Six Atlantic salmon were captured and released upstream in 2015. All six salmon (1 male and 5 female) were reported as wild origin.

6.2 Hatchery Operations

Stocking

Atlantic Salmon for Northern Maine. Inc. (ASNM) owns and operates the Dug Brook Hatchery in Sheridan, Maine to produce Atlantic salmon fry for stocking in the Aroostook River. The hatchery imports and incubates “St. John River strain” salmon eggs produced by captive-reared broodstock at the Mactaquac Biodiversity Facility. Broodstock and eggs are subject to U.S. Title 50 fish health certification. In 2015 the ASNM stocked over 569,000 unfed fry.

Adult Salmon Releases

No adults were stocked in 2015.

6.3 Juvenile Population Status

Electrofishing Surveys

There were no population assessments in the Aroostook River watershed in 2015.

Smolt Monitoring

No smolt monitoring was conducted for the Aroostook River program.

6.4 Tagging

No tagging occurred in the Aroostook River program.

6.5 Fish Passage

No projects or updates.

6.6 Genetics

No tissue samples were collected.

6.7 General Program Information

No updates or information.

7 Terms of Reference and Emerging Issues in New England Salmon

To be proactive to requests from ICES and NASCO, this section is developed to report on and bring into focus emerging issues and terms of reference beyond scope of standard stock assessment updates that are typically included in earlier sections. The purpose of this section is to provide some additional overview of information presented or developed at the meeting that identifies emerging issues or new science or management activities important to Atlantic salmon in New England. These sections review select working papers and the ensuing discussions to provide information on emerging issues.

The focus topics identified at this meeting were limited and most time was spent on improved stock assessment work sessions and a theme session on stream temperature modeling. This information is highlighted in the following four sections: 7.1) NASCO US Management Objectives Update; 7.2) USASAC Regional Assessment Product Progress Update. Finally, based on actions and discussions at the meeting draft terms of reference for next year's meeting were developed (7.3).

7.1 NASCO Management US Objectives Update and Program Classification Terminology

The existing NASCO management objective for considering a fishery at West Greenland includes an arbitrary criterion of a 25% increase in adult returns to the US from the average returns, 1992-1996. A working paper by Rory Saunders, Tim Sheehan, and Steve Gephard explained how this was established many years ago. The criterion was almost satisfied in 2011 when the Penobscot River experienced the best run in many years. However, this would have represented only 8.7% of the established Conservation Limit (CL) for the U.S. and could have allowed fishing of the GOM DPS (endangered) and would not have been consistent with the Precautionary Approach, ICES advice, and previous agreements of NASCO. There is a need to establish a more useful CL for the US. This need is amplified by the recent changes in the Connecticut River program.

Many alternative approaches to determining a new CL were considered. The paper recommended, and the USASAC concurred, that the US CL should be consistent with the draft recovery plan for the GOM DPS. This equates to roughly 6,000 MSW adults equally distributed across each of the three recovery units (Figure 7.1.1) for a sustained period of time (at least 10 years).

Figure 7.1.1 Recovery units for the Gulf of Maine DPS.

Such a CL would not consider Conservation Spawning Escapement (CSE) needs for other river basins that are managed by programs of varying natures and would deflect any criticism from other Parties that the US was 'padding' realistic requirements. No one can deny the need for the CSEs for the GOM DPS. So instead of an arbitrary fraction of all habitat in all basins, including some with uncertain management objectives, the proposed CL will include 100% of all habitat in the basins included in the listed GOM DPS. This CL is higher and therefore more protective (in regards to a future potential fishery) to the fish in the basins that are not included than the current CL for which those basins were included. Moreover, since this CL would be used only for ICES catch advice to NASCO, it carries no constraints or mandates for local authorities managing programs in the basins that are not included. A more precise calculation of the CL will be provided by NOAA after further analyses. Much of the discussion at the 2015 meeting was around the history of the development of the CSE for the Rivers. Work will be ongoing to be able to clearly articulate how those CSE were developed.

7.2 USASAC Regional Assessment Product Progress Update

The USASC moved forward on improving and enhancing assessment products. As noted last year, the USASAC felt that this large undertaking should be accomplished over the course of several intercession meetings. Intercession meetings were limited in 2015 but email information exchange and work at the meeting advanced progress on recovery metrics for Gulf of Maine DPS that can be used throughout New England. In addition, the structure of the 2014 meeting was such that it was a working meeting and some enhancements to regional assessment were done at the meeting, 2015 meeting focused on juvenile abundance methods and tying in the Assessment and Recovery criteria. USASAC suggested that this annual meeting format continue and that the Chair should follow-up with leads of terms-of-reference during summer to encourage intercession meetings to accelerate this effort. Some considerations that the USASAC believed were essential to moving forward were 1) making sure that the core needs of the ICES working group are met since that is mission essential, 2) making sure that the document continues to deliver programmatic data since it has become the one stop shopping venue for New England and NASCO managers for US data, 3) working towards providing data for the Gulf of Maine for each individual Salmon Habitat Recovery Unit with associated metrics of progress, and 4) making sure that as more data is developed and analyzed it is used as a tool to rebuild Atlantic salmon stocks. To this last point, the USASAC recognizes it needs to provide core stock assessment information (provide a yardstick of progress) but understands the need to better communicate information to managers as opportunities and threats are recognized (provide rebuilding tools). These needs are especially urgent as habitat connectivity and in-stream improvements are increasing regionally and the scope and impact of stocking programs is decreasing.

7.3 USASAC Draft Terms of Reference 2017 Meeting

The purpose of this section is to outline potential terms of reference identified at the USASAC annual meeting in March and to start an outline for refinement at our summer teleconference tentatively scheduled for mid-July 2016. and will be refined further prior to 2016 Assessment Meeting.

1) Escapement- stocking database integration – include midterm meeting report on SOD - hatchery (July 2016 in Nashua) – Domina, Atkinson, Lamothe, Saunders, Kocik, Bailey, Sheehan, FWS PL-GL.

Special session trends in hatchery production

- age structures
- egg planting
- what are stocking targets
- other changes to hatchery protocols

2) Integration USASAC (dbase) and Recovery Criteria (intersection between hatchery #s and stock assessment). Atkinson, Lamothe, Saunders, Kircheis, FWS PL-ES.

Conservation Limits and Escapement (Atkinson, Kircheis, Saunders, Kocik, Sheehan).

3) Lower PN redd counts- and how to integrate into PN SHRU – using redd counts (maybe integrate CV, DT, Kenduskeag). Simpson, Kocik, Atkinson.

4) Review of 5-year stock status report from NOAA in VSP –type format- it is possible this will be done intercessional to get USASAC review prior to publication.
(Kircheis, Kocik- SAAT,GDAT).

5) CSL needed for this ICES meeting- number on a by river basis should be published as a table with documentation. Monitored rivers and proportion of CL met is what goes through ICES. Short term- of 43 US rivers reported to NASCO how many monitored and how many meeting CL). All, See #2 above.

8 List of Attendees, Working Papers, and Glossaries

List of Attendees

First Name	Last Name	Primary Email	Agency	Location
Ernie	Atkinson	Ernie.Atkinson@maine.gov	ME	Jonesboro, ME
John	Kocik	John.Kocik@noaa.gov	NOAA	Orono, ME
Christine	Lipsky	Christine.Lipsky@noaa.gov	NOAA	Orono, ME
Rory	Saunders	Rory.Saunders@noaa.gov	NOAA	Orono, ME
John	Sweka	John_Sweka@fws.gov	FWS	Via Phone
Peter	Lamothe	Peter_Lamothe@fws.gov	FWS	East Orland, ME
Colby	Bruchs	Colby.W.B.Bruchs@maine.gov	ME	Jonesboro, ME
Mitch	Simpson	Mitch.Simpson@maine.gov	ME	Bangor, ME
Tim	Sheehan	Tim.Sheehan@noaa.gov	NOAA	Woods Hole, MA
James	Hawkes	james.hawkes@noaa.gov	NOAA	Orono, ME
Jason	Overlock	jason.overlock@maine.gov	ME	Hallowell, ME
Paul	Christman	paul.christman@maine.gov	ME	Hallowell, ME
Michael	Bailey	michael_bailey@fws.gov	FWS	Nashua, NH
Steve	Gephard	Steve.Gephard@po.state.ct.us	CT	Old Lyme, CT
Oliver	Cox	Oliver.N.Cox@maine.gov	ME	Bangor, ME
Seth	Ricker	Seth.Ricker@wildlife.ca.gov	CA	Via Webinar
Justin	Garwood	Justin.Garwood@wildlife.ca.gov	CA	Via Webinar
Mariska	Obedzinski	mobedzinski@ucsd.edu	UCSD	Via Webinar
Joan	Trial	trial@midmaine.com	Private	Via Webinar
Gregg	Horton	gregg.horton@scwa.ca.gov	CA	Via Webinar

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

Number	Authors	Title
PS16-01	Christine Dudley	Pawcatuck River Update (email)
PS16-02	Steve Gephard	Connecticut River Update (PPT)
PS16-03	Michael Bailey	Merrimack River Update (PPT)
PS16-04	Ernie Atkinson	Saco, DPS, OBF Updates (PPT)
PS16-05	John Sweka	Database Update
PS16-06	Rory Saunders	NASCO (PPT)
PS16-07	Tim Sheehan	ICES (PPT)
PS16-08	Ernie Atkinson	Atlantic salmon Juvenile Abundance and Distribution within the Gulf of Maine DPS (PPT)
PS16-09	Justin Garwood and Seth Ricker	Estimation of Juvenile Coho Salmon Occurrence, Abundance, and Detection Using N-mixture Models Across Multiple Spatial Scales to Define Population Spatial Structure (PPT - WEBINAR)
PS16-10	Mariska Obedzinki and Gregg Horton	Led Discussion of Intergration of PS16-08 and PS16-09
WP16-01	Graham S. Goulette, James P. Hawkes, and Paul Christman	Update on Coastal Maine Atlantic Salmon Smolt Telemetry Studies: 2015
WP16-02	Colby W.B. Bruchs, James P. Hawkes, Ernest J. Atkinson, Christine A. Lipsky, Ruth Haas-Castro, Randy Spencer, Paul Christman, Kyle Winslow, and Justin Stevens	Update on Maine River Atlantic Salmon Smolt Studies: 2015
WP16-03	David Bean	Maine and neighboring Canadian Commercial Aquaculture Activities and Production
WP16-04	John F. Kocik, Susan E. Wigley, Christopher Tholke, and Daniel Kircheis	Annual Bycatch Update Atlantic Salmon though May 2015
WP16-05	Ruth E. Haas-Castro, Graham S. Goulette, James P. Hawkes, and Christine A. Lipsky	Review of Image Analysis Studies: 2015 (PART 1) and Work Plan for 2016 (PART 2)
WP16-06	Colby W.B. Bruchs, Mitch Simpson, Ernest J. Atkinson, Jason Overlock, Peter Ruksznis, and Paul Christman	Update on Maine River Adult Salmon Stock Assessment: 2015

8.2.1 PS16 08-10 discussion overview.

E. Atkinson led a discussion on the current method used to estimate juvenile abundance and distribution within the Gulf of Maine DPS. The GRTs is employed via electrofishing and has replaced past methodologies. The design allows for stratified unequal sampling using habitat and stream size as strata to choose sampling sites. J. Garwood and S. Ricker discussed the development of methods to aid in estimation of juvenile Coho Salmon occurrence, abundance, and detection using N-mixture models across multiple spatial scales. The discussions were in terms of sampling wild non-stocked populations over wife geographic space via snorkeling. Many of the questions with Coho overlap with Atlantic salmon. M. Obedzinki and G. Horton led a discussion of the ability on bringing the methods together to best answer the questions considering habitat and sampling differences between the two species. Some of the modeling for the N-Mixture modeling is still in process, but the USASAC will continue to look at new and innovative methods to collect the most appropriate data for our assessment needs.

8.3 Glossary of Abbreviations

Glossary of Abbreviations

Adopt-A-Salmon Family	AASF
Arcadia Research Hatchery	ARH
Division of Sea Run Fisheries and Habitat	DSRFH
Central New England Fisheries Resource Office	CNEFRO
Connecticut River Atlantic Salmon Association	CRASA
Connecticut Department of Environmental Protection	CTDEP
Connecticut Department of Energy and Environmental Protection	CTDEEP
Connecticut River Atlantic Salmon Commission	CRASC
Craig Brook National Fish Hatchery	CBNFH
Decorative Specialities International	DSI
Developmental Index	DI
Dwight D. Eisenhower National Fish Hatchery	DDENFH
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 Aquaculture Association	MAA
Maine Atlantic Salmon Commission	MASC
Maine Department of Marine Resources	MDMR
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 Hydrologic Dataset	NHD
National Oceanic and Atmospheric Administration	NOAA
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 Fisheries Science Center	NEFSC
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

8.4 Glossary of Definitions

8.4.1 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 culture 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. This can refer to a number or just as a group of fish.
Egg Deposition	Salmon eggs that are deposited in gravelly reaches of the river. This can refer to the action of depositing eggs by the fish, a group of unspecified number of eggs per event, or a specific number of eggs.
Fecundity	The reproductive rate of salmon represented by 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	Adults produced from naturally reared 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.

8.4.2 Life History related

Green Egg	Life stage from spawning until faint eyes appear.
Eyed Egg	Life stage from the appearance of faint eyes until hatching.
Sac Fry	Life stage from the end of the primary dependence on the yolk sac (initiation of feeding) to June 30 of the same year.
Feeding Fry	Life stage from the end of the primary dependence on the yolk sac (initiation of feeding) to June 30 of the same year.
Fed Fry	Fry subsequent to being fed an artificial or natural diet. Often used interchangeably with the term "feeding fry" and most often associated with stocking activities.
Unfed Fry	Fry that have not been fed an artificial diet or natural diet. Most often associated with stocking activities.
Parr	Life stage immediately following the fry stage until the commencement of migration to the sea as smolts.
Age 0 Parr	Life stage occurring during the period from August 15 to December 31 of the year of hatching, often referring to fish that are stocked from a hatchery during this time. The two most common hatchery stocking products are (1) parr that have been removed from an accelerated growth program for smolts and are stocked at lengths >10 cm and (2) parr that have been raised to deliberately produce more natural size-at-age fish and are stocked at lengths ≤10 cm.
Age 1 Parr	Life stage occurring during the period from January 1 to December 31 one year after hatching.
Age 2 Parr	Life stage occurring during the period from January 1 to December 31 two years after hatching.
Parr 8	A parr stocked at age 0 that migrates as 1 Smolt (8 months spent in freshwater).
Parr 20	A parr stocked at age 0 that migrates as 2 Smolt (20 months spent in freshwater).

Smolt	An actively migrating young salmon that has undergone the physiological changes to survive the transition from freshwater to saltwater.
1 Smolt	Life stage occurring during the period from January 1 to June 30 of the year of migration. The migration year is one year after hatch.
2 Smolt	Life stage occurring during the period from January 1 to June 30 of the year of migration. The migration year is two years after hatch.
3 Smolt	Life stage occurring during the period from January 1 to June 30 of the year of migration. The migration year is three years after hatch.
Post Smolt	Life stage occurring during the period from July 1 to December 31 of the year the salmon became a smolt. Typically encountered in the ocean.
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 (MSW) 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	Life stage after a salmon spawns. For domestic salmon, this stage lasts until death. For wild fish, this stage lasts until it returns to home waters to spawn again.
Reconditioned Kelt	A kelt that has been restored to a feeding condition in captivity.
Repeat Spawner	A salmon that returns numerous times to the river for the purpose of reproducing. Previous spawner.

Appendices

Appendix 1. Estimated Atlantic salmon returns to the USA, 1967-2015. "Natural" includes fish originating from natural spawning and hatchery fry. Starting in 2003 estimated returns based on redds are included.

Year	Sea age					Origin	
	1 SW	2SW	3SW	Repeat	Total	Hatchery	Natural
1967	75	574	39	93	781	114	667
1968	18	498	12	56	584	314	270
1969	32	430	16	34	512	108	404
1970	9	539	15	17	580	162	418
1971	31	407	11	5	454	177	277
1972	24	946	38	17	1,025	495	530
1973	18	623	8	13	662	422	240
1974	52	791	35	25	903	639	264
1975	77	1,250	14	30	1,371	1,126	245
1976	172	836	6	16	1,030	933	97
1977	63	1,027	7	33	1,130	921	209
1978	145	2,269	17	33	2,464	2,082	382
1979	225	972	6	21	1,224	1,039	185
1980	707	3,437	11	57	4,212	3,870	342
1981	789	3,738	43	84	4,654	4,428	226
1982	294	4,388	19	42	4,743	4,489	254
1983	239	1,255	18	14	1,526	1,270	256
1984	387	1,969	21	52	2,429	1,988	441
1985	302	3,913	13	21	4,249	3,594	655
1986	582	4,688	28	13	5,311	4,597	714
1987	807	2,191	96	132	3,226	2,896	330
1988	755	2,386	10	67	3,218	3,015	203
1989	992	2,461	11	43	3,507	3,157	350
1990	575	3,744	18	38	4,375	3,785	590
1991	255	2,289	5	62	2,611	1,602	1,009
1992	1,056	2,255	6	20	3,337	2,678	659
1993	405	1,953	11	37	2,406	1,971	435
1994	342	1,266	2	25	1,635	1,228	407
1995	168	1,582	7	23	1,780	1,484	296
1996	574	2,168	13	43	2,798	2,092	706
1997	278	1,492	8	36	1,814	1,296	518
1998	340	1,477	3	42	1,862	1,146	716
1999	402	1,136	3	26	1,567	959	608
2000	292	535	0	20	847	562	285
2001	269	804	7	4	1,084	833	251
2002	437	505	2	23	967	832	135
2003	233	1,185	3	6	1,427	1,238	189
2004	319	1,266	21	24	1,630	1,395	235
2005	317	945	0	10	1,272	1,019	253
2006	442	1,007	2	5	1,456	1,167	289
2007	299	958	3	1	1,261	940	321
2008	812	1,758	12	23	2,605	2,191	414
2009	243	2,065	16	16	2,340	2,017	323
2010	552	1,081	2	16	1,651	1,468	183
2011	1,084	3,053	26	15	4,178	3,560	618
2012	26	879	31	5	941	731	210
2013	78	525	3	5	611	413	198
2014	110	334	3	3	450	304	146
2015	150	761	9	1	921	739	182

Appendix 2. Two sea winter (2SW) returns for 2014 in relation to spawner requirements for USA rivers.

Area	1SW		2SW		3SW		Repeat Spawners		TOTAL
	Hatchery	Natural	Hatchery	Natural	Hatchery	Natural	Hatchery	Natural	
LIS	0	4	0	18	0	0	0	0	22
CNE	1	0	12	3	1	1	0	0	18
GOM	120	25	597	131	7	0	1	0	881
Total	121	29	609	152	8	1	1	0	921

Appendix 3. Number of juvenile Atlantic salmon stocked in USA, 2015. Numbers are rounded to 100.

Area	N	Rivers	Eyed Egg	Fry	0 Parr	1 Parr	1 Smolt	2 Smolt	Total
LIS	2	Connecticut, Pawcatuck		391,000					391,000
CNE	2	Merrimack, Saco		702,000	25,000		11,700		738,700
GOM	8	Androscoggin to Dennys	531,000	1,538,000	464,500		375,600		2,909,100
OBF	1	Aroostook		1,000					1,000
Total	13		531,000	2,632,000	489,500		387,300		4,039,800

Appendix 4. Stocking summary for sea-run, captive, and domestic adult Atlantic salmon and egg planting summary for the USA in 2015 by geographic area.

Area		Purpose	Captive Reared Domestic		Sea Run		Total
			Pre-spawn	Post-spawn	Pre-spawn	Post-spawn	
Central New England	CNE	Recreation	1,205				1,205
Gulf of Maine	GOM	Restoration	741	1,737	7	581	3,066
Total for USA			1,946	1,737	7	581	4,271

Appendix 5. Summary of tagged and marked Atlantic salmon released in USA, 2015. Includes hatchery and wild origin fish.

Mark Code	Life History	GOM
AD	Parr	206,182
AD	Adult	696
PING	Smolt	225
PIT	Adult	2,421
PIT	Parr	562
VIE	Smolt	117,628
RAD	Adult	58
RAD	Smolt	1,020
Total		328,792

AD = Adipose clip
PIT = Passive integrated transponder
PING = ultrasonic acoustic tag
RAD = radio tag
VIE = Visual Implant Elastomer

Appendix 6. Aquaculture production (metric tonnes) in New England from 1997 to 2015. Production for 2011-2015 are unknown.

Year	MT
1997	13,222
1998	13,222
1999	12,246
2000	16,461
2001	13,202
2002	6,798
2003	6,007
2004	8,515
2005	5,263
2006	4,674
2007	2,715
2008	9,014
2009	6,028
2010	11,127
2011	*
2012	*
2013	*
2014	*
2015	*

* not available for distribution

Appendix 7. Juvenile Atlantic salmon stocking summary for New England in 2015.

United States

No. of fish stocked by lifestage

River	Egg	Fry	0 Parr	1 Parr	2 Parr	1 Smolt	2 Smolt	Total
Connecticut	0	391,000	0	0	0	0	0	391,000
Total for Connecticut Program								**391,000**
Androscoggin	0	2,000	0	0	0	0	0	2,000
Aroostook	0	1,000	0	0	0	0	0	1,000
Dennys	0	110,000	0	0	0	0	0	110,000
East Machias	0	11,000	192,000	0	0	0	0	203,000
Kennebec	275,000	2,000	0	0	0	0	0	277,000
Machias	49,000	503,000	500	0	0	0	0	552,500
Narraguagus	0	165,000	0	0	0	0	0	165,000
Penobscot	89,000	518,000	257,800	0	0	375,600	0	1,240,400
Pleasant	0	183,000	0	0	0	0	0	183,000
Saco	0	702,000	25,000	0	0	11,700	0	738,700
Sheepscot	118,000	19,000	14,200	0	0	0	0	151,200
Union	0	25,000	0	0	0	0	0	25,000
Total for Maine Program								**3,648,800**
Total for United States								**4,039,800**
Grand Total								**4,039,800**

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

Appendix 8. Number of adult Atlantic salmon stocked in New England rivers in 2015.

Drainage	Purpose	Captive/Domestic Pre-Spawn	Captive/Domestic Post-Spawn	Sea Run Pre-Spawn	Sea Run Post-Spawn	Total
Dennys	Restoration	0	96	0	0	96
East Machias	Restoration	0	181	0	0	181
Machias	Restoration	0	199	0	0	199
Merrimack	Recreation	1,205	0	0	0	1,205
Narraguagus	Restoration	0	204	0	0	204
Penobscot	Restoration	741	801	7	581	2,130
Pleasant	Restoration	0	142	0	0	142
Sheepscot	Restoration	0	114	0	0	114
Total		1,946	1,737	7	581	4,271

Pre-spawn refers to adults that are stocked prior to spawning of that year. Post-spawn refers to fish that are stocked after they have been spawned in the hatchery.

Appendix 9.1. Atlantic salmon marking database for New England; marked fish released in ***2015***.

Marking Agency	Age	Life Stage	H/W	Stock Origin	Primary Mark or Tag	Number Marked	Secondary Mark or Tag	Release Date	Release Location
USFWS	5	Adult	H		PIT	37	PUNCH	Nov	
USFWS	4	Adult	H		PIT	37	PUNCH	Nov	
USFWS	3	Adult	H		PIT	40	PUNCH	Nov	
USFWS	0	Parr	H		AD	14,150		Sept	
CONTE	3	Adult	W	Connecticut	PIT	1	FLOY	June	Connecticut
CONTE	4	Adult	W	Connecticut	PIT	3	FLOY	May	Connecticut
CONTE	4	Adult	W	Connecticut	PIT	4	FLOY	June	Connecticut
CTDEEP	3	Adult	W	Connecticut	FLOY	1	FLOY	June	Connecticut
CTDEEP	4	Adult	W	Connecticut	FLOY	2	FLOY	May	Connecticut
HE	3	Adult	W	Connecticut	FLOY	1		May	Connecticut
HE	4	Adult	W	Connecticut	FLOY	1		June	Connecticut
HE	4	Adult	W	Connecticut	FLOY	3		May	Connecticut
MADFW	2	Adult	W	Connecticut	FLOY	1		May	Connecticut
MADFW	3	Adult	W	Connecticut	FLOY	1		June	Connecticut
MADFW	4	Adult	W	Connecticut	FLOY	1		June	Connecticut
USFWS	4	Adult	H	Dennys	PIT	31	PUNCH	Dec	Dennys
USFWS	5	Adult	H	Dennys	PIT	65	PUNCH	Dec	Dennys
EMARC	0	Parr	H	East Machias	AD	192,032		Oct	East Machias
USFWS	3	Adult	H	East Machias	PIT	18	PUNCH	Dec	East Machias
USFWS	6	Adult	H	East Machias	PIT	1	PUNCH	Nov	East Machias
USFWS	5	Adult	H	East Machias	PIT	71	PUNCH	Nov	East Machias
USFWS	5	Adult	H	East Machias	PIT	2	PUNCH	Dec	East Machias
USFWS	4	Adult	H	East Machias	PIT	30	PUNCH	Nov	East Machias
USFWS	3	Adult	H	East Machias	PIT	49	PUNCH	Nov	East Machias
USFWS	4	Adult	H	East Machias	PIT	10	PUNCH	Dec	East Machias

Marking Agency	Age	Life Stage	H/W	Stock Origin	Primary Mark or Tag	Number Marked	Secondary Mark or Tag	Release Date	Release Location
USFWS	3	Adult	H	Machias	PIT	42	PUNCH	Dec	Machias
USFWS	3	Adult	H	Machias	PIT	35	PUNCH	Nov	Machias
USFWS	4	Adult	H	Machias	PIT	40	PUNCH	Dec	Machias
USFWS	4	Adult	H	Machias	PIT	2	PUNCH	Nov	Machias
USFWS	5	Adult	H	Machias	PIT	2	PUNCH	Dec	Machias
USFWS	5	Adult	H	Machias	PIT	78	PUNCH	Nov	Machias
USFWS	4	Adult	H	Narraguagus	PIT	49	PUNCH	Nov	Narraguagus
USFWS	5	Adult	H	Narraguagus	PIT	74	PUNCH	Nov	Narraguagus
USFWS	3	Adult	H	Narraguagus	PIT	81	PUNCH	Nov	Narraguagus
Brookfield		Adult	H	Penobscot	RAD	3	PIT	May	Penobscot
Brookfield	1	Smolt	H	Penobscot	RAD	22		June	Penobscot
Brookfield	1	Smolt	H	Penobscot	RAD	359		May	Androscoggin
Brookfield	1	Smolt	H	Penobscot	RAD	488		May	
Brookfield	1	Smolt	H	Penobscot	RAD	713		May	Penobscot
DMR		Adult	H	Penobscot	PIT	2		Sept	Penobscot
DMR		Adult	H	Penobscot	PIT	2		Oct	Penobscot
DMR		Adult	H	Penobscot	PIT	1		June	Penobscot
DMR		Adult	H	Penobscot	PIT	36		July	Penobscot
Miller Hydro	1	Smolt	H	Penobscot	RAD	161		May	Androscoggin
NOAA	1	Smolt	H	Penobscot	PING	100		May	Penobscot
NOAA	4	Smolt	W	Penobscot	PING	1		May	
NOAA	2	Smolt	W	Penobscot	PING	43		May	
NOAA	3	Smolt	W	Penobscot	PING	6		May	
USFWS	4	Adult	H	Penobscot	PIT	130	PUNCH	Nov	Penobscot
USFWS	4	Adult	H	Penobscot	AD	358		Dec	Penobscot
USFWS	3	Adult	H	Penobscot	AD	338		Nov	Penobscot
USFWS	3	Adult	H	Penobscot	PIT	273	PUNCH	May	Penobscot

Marking Agency	Age	Life Stage	H/W	Stock Origin	Primary Mark or Tag	Number Marked	Secondary Mark or Tag	Release Date	Release Location
USFWS	3	Adult	H	Penobscot	PIT	443	PUNCH	Dec	Penobscot
USFWS		Adult	H	Penobscot	PIT	7	PUNCH	July	Penobscot
USFWS		Adult	H	Penobscot	PIT	591	PUNCH	Nov	Penobscot
USFWS	0	Parr	H	Penobscot	PIT	562		Oct	Penobscot
USFWS	1	Smolt	H	Penobscot	VIE	54,918	AD	April	Penobscot
USFWS	1	Smolt	H	Penobscot	VIE	62,710	AD	May	Penobscot
USGS		Adult	H	Penobscot	RAD	55	PIT	Nov	Penobscot
USGS	1	Smolt	H	Penobscot	PING	75		May	Penobscot
USFWS	5	Adult	H	Pleasant	PIT	78	PUNCH	Nov	Pleasant
USFWS	4	Adult	H	Pleasant	PIT	39	PUNCH	Nov	Pleasant
USFWS	3	Adult	H	Pleasant	PIT	25	PUNCH	Nov	Pleasant

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; TEMP = temperature mark on otolith or other hard part; VPT = VIE tag and PIT tag; ANL = anal clip/punch; HI-Z = HI-Z Turb'N tag; DUCP = Double upper caudal punch; PUNCH = Double adipose or upper caudal punch

Appendix 9.2. Grand Summary of Atlantic Salmon marking data for New England; marked fish released in ***2015****.*

Origin	Total External Marks	Total Adipose Clips	Total Marked
Hatchery Adult	3,076	696	3,175
Hatchery Juvenile	323,810	323,810	326,290
Wild Adult	19		19
Wild Juvenile			50
Total			**329,534**

Appendix 10. Documented Atlantic salmon returns to New England rivers in 2015.

	1SW		2SW		3SW		Repeat			2011-2015
	Hatchery	Wild	Hatchery	Wild	Hatchery	Wild	Hatchery	Wild	Total	Average
Androscoggin	0	0	0	1	0	0	0	0	**1**	13
Connecticut	0	4	0	18	0	0	0	0	**22**	62
Kennebec	0	3	2	26	0	0	0	0	**31**	25
Merrimack	2	0	7	2	1	1	0	0	**13**	121
Narraguagus	0	0	0	3	0	0	0	0	**3**	48
Penobscot	110	9	552	52	7	0	1	0	**731**	1,024
Saco	1	0	4	0	0	0	0	0	**5**	23
Total	**113**	**16**	**565**	**102**	**8**	**1**	**1**	**0**	**806**	**1,317**

Note: The origin/age distribution for returns to the Merrimack River in 2014 were based on observed distributions over the previous 10 years because fish were not handled in 2014.

Appendix 11. Summary of Atlantic salmon green egg production in Hatcheries for New England rivers in 2015.

Source River	Origin	Females Spawned	Total Egg Production
Connecticut	Domestic	60	534,000
Merrimack	Domestic	234	761,000
Penobscot	Domestic	381	
Dennys	Captive	78	447,000
East Machias	Captive	110	468,000
Machias	Captive	108	354,000
Narraguagus	Captive	124	447,000
Pleasant	Captive	63	214,000
Sheepscot	Captive	85	317,000
Total	**Captive/Domestic**	**1,243**	**3,542,000**
Penobscot	Sea Run	348	
Total	**Sea Run**	**348**	
Grand Total for Year	**2015**	**1,591**	**3,542,000**

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

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

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
Cocheco															
1993-2005	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															
1977-2005	1,577	17,611,000	7,800	23,131	149,696,000	5,900	0	0		1,987	24,646,000	10,100	26,695	191,953,000	6,500
2006	116	896,000	7,700	1,782	10,020,000	5,600	0	0		47	460,000	9,800	1,945	11,376,000	5,800
2007	95	723,000	7,600	1,598	9,390,000	5,900	0	0		113	1,190,000	10,500	1,806	11,303,000	6,300
2008	85	602,000	7,100	1,633	8,980,000	5,500	0	0		101	1,190,000	11,800	1,819	10,772,000	5,900
2009	46	317,000	6,900	1,975	9,906,000	5,000	0	0		62	642,000	10,400	2,083	10,865,000	5,200
2010	26	180,000	6,900	1,935	10,021,000	5,200	0	0		55	593,000	10,800	2,016	10,794,000	5,400
2011	47	376,000	8,000	707	4,389,000	6,200	0	0		24	176,000	7,300	778	4,941,000	6,400
2012	33	234,000	7,100	721	4,564,000	6,300	0	0		6	37,000	6,200	760	4,835,000	6,400
2013	46	325,000	7,100	77	556,000	7,200	0	0		0	0		123	881,000	7,200
2014	0	0		103	830,000	8,100	0	0		0	0		103	830,000	8,100
2015	0	0		60	534,000	8,900	0	0		0	0		60	534,000	8,900
Total Connecticut	2,071	21,264,000	7,400	33,722	208,886,000	6,300	0	0		2,395	28,934,000	9,600	38,188	259,084,000	6,600
Dennys															
1939-2005	26	214,000	7,600	0	0		953	3,938,000	4,200	40	330,000	7,700	1,019	4,482,000	5,000
2006	0	0		0	0		96	400,000	4,200	0	0		96	400,000	4,200
2007	0	0		0	0		84	425,000	5,100	0	0		84	425,000	5,100
2008	0	0		0	0		105	450,000	4,300	0	0		105	450,000	4,300
2009	0	0		38	91,000	2,400	61	360,000	5,900	0	0		99	451,000	4,600

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

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

Note: Connecticut data are preliminary prior to 1990.

Year	Sea-Run No. females	Sea-Run Egg production	Sea-Run Eggs/ female	Domestic No. females	Domestic Egg production	Domestic Eggs/ female	Captive No. females	Captive Egg production	Captive Eggs/ female	Kelt No. females	Kelt Egg production	Kelt Eggs/ female	TOTAL No. females	TOTAL Egg production	TOTAL Eggs/ female
2010	0	0		87	596,000	6,900	25	105,000	4,200	0	0		112	701,000	6,300
2011	0	0		0	0		0	0		0	0		0	0	
2012	0	0		0	0		0	0		0	0		0	0	
2013	0	0		0	0		46	111,000	2,400	0	0		46	111,000	2,400
2014	0	0		0	0		40	148,000	3,700	0	0		40	148,000	3,700
2015	0	0		0	0		78	447,000	5,700	0	0		78	447,000	5,700
Total Dennys	26	214,000	7,600	125	687,000	4,600	1,488	6,384,000	4,411	40	330,000	7,700	1,679	7,615,000	4,600
East Machias															
1995-2005	0	0		0	0		905	3,666,000	4,100	0	0		905	3,666,000	4,100
2006	0	0		0	0		82	328,000	4,000	0	0		82	328,000	4,000
2007	0	0		0	0		78	456,000	5,800	0	0		78	456,000	5,800
2008	0	0		0	0		85	350,000	4,100	0	0		85	350,000	4,100
2009	0	0		0	0		81	311,000	3,800	0	0		81	311,000	3,800
2010	0	0		0	0		48	228,000	4,800	0	0		48	228,000	4,800
2011	0	0		0	0		52	210,000	4,000	0	0		52	210,000	4,000
2012	0	0		0	0		65	160,000	2,500	0	0		65	160,000	2,500
2013	0	0		0	0		70	252,000	3,600	0	0		70	252,000	3,600
2014	0	0		0	0		99	452,000	4,600	0	0		99	452,000	4,600
2015	0	0		0	0		110	468,000	4,300	0	0		110	468,000	4,300
Total East Machias	0	0		0	0	0	1,675	6,881,000	4,145	0	0		1,675	6,881,000	4,100
Kennebec															
1979-2005	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
1992-2005	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															
1941-2005	456	3,263,000	7,300	0	0		1,593	6,567,000	4,200	8	52,000	6,400	2,057	9,882,000	6,100
2006	0	0		0	0		160	720,000	4,500	0	0		160	720,000	4,500
2007	0	0		0	0		150	714,000	4,800	0	0		150	714,000	4,800
2008	0	0		0	0		141	650,000	4,600	0	0		141	650,000	4,600
2009	0	0		0	0		144	557,000	3,900	0	0		144	557,000	3,900
2010	0	0		0	0		108	480,000	4,400	0	0		108	480,000	4,400
2011	0	0		0	0		100	361,000	3,600	0	0		100	361,000	3,600
2012	0	0		0	0		113	288,000	2,500	0	0		113	288,000	2,500
2013	0	0		0	0		114	342,000	3,000	0	0		114	342,000	3,000
2014	0	0		0	0		141	640,000	4,500	0	0		141	640,000	4,500
2015	0	0		0	0		108	354,000	3,300	0	0		108	354,000	3,300
Total Machias	456	3,263,000	7,300	0	0	0	2,872	11,673,000	3,936	8	52,000	6,400	3,336	14,988,000	4,100
Merrimack															
1983-2005	1,179	9,046,000	7,900	9,176	48,052,000	4,900	0	0		287	2,859,000	10,500	10,642	59,957,000	6,100
2006	42	377,000	9,000	269	1,097,000	4,100	0	0		49	582,000	11,900	360	2,056,000	5,700
2007	35	299,000	8,600	687	2,587,000	3,800	0	0		45	511,000	11,400	767	3,398,000	4,400
2008	66	533,000	8,100	275	1,018,000	3,700	0	0		47	511,000	10,900	388	2,062,000	5,300
2009	48	369,000	7,700	516	2,380,000	4,600	0	0		55	577,000	10,500	619	3,326,000	5,400
2010	28	201,000	7,200	135	721,000	5,300	0	0		57	669,000	11,700	220	1,591,000	7,200
2011	107	935,000	8,700	103	408,000	4,000	0	0		0	0		210	1,343,000	6,400
2012	72	510,000	7,100	231	746,000	3,200	0	0		0	0		303	1,255,000	4,100

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
2013	5	36,000	7,200	295	853,000	2,900	0	0		0	0		300	889,000	3,000
2014	0	0		293	1,244,000	4,200	0	0		0	0		293	1,244,000	4,200
2015	0	0		234	761,000	3,300	0	0		0	0		234	761,000	3,300
Total Merrimack	1,582	12,306,000	7,900	12,214	59,867,000	4,000	0	0		540	5,709,000	11,200	14,336	77,882,000	5,000
Narraguagus															
1962-2005	0	1,303,000		0	0		1,557	5,589,000	3,600	0	0		1,557	6,892,000	3,600
2006	0	0		0	0		165	702,000	4,300	0	0		165	702,000	4,300
2007	0	0		0	0		186	854,000	4,600	0	0		186	854,000	4,600
2008	0	0		0	0		169	820,000	4,900	0	0		169	820,000	4,900
2009	0	0		0	0		178	848,000	4,800	0	0		178	848,000	4,800
2010	0	0		0	0		97	694,000	7,200	0	0		97	694,000	7,200
2011	0	0		0	0		124	485,000	3,900	0	0		124	485,000	3,900
2012	0	0		0	0		145	433,000	3,000	0	0		145	433,000	3,000
2013	0	0		0	0		118	279,000	2,400	0	0		118	279,000	2,400
2014	0	0		0	0		112	355,000	3,200	0	0		112	355,000	3,200
2015	0	0		0	0		124	447,000	3,600	0	0		124	447,000	3,600
Total Narraguagus	0	1,303,000		0	0	0	2,975	11,506,000	4,136	0	0		2,975	12,809,000	4,100
Orland															
1967-2005	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															
1992-2005	16	143,000	8,900	2	2,000	1,100	0	0		9	61,000	6,600	27	206,000	7,700
2006	0	0		4	4,000	1,000	0	0		0	0		4	4,000	1,000
2007	2	9,000	4,500	0	0		0	0		0	0		2	9,000	4,500

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
2008	0	0		0	0		0	0		2	10,000	5,000	2	10,000	5,000
2009	0	0		0	0		0	0		2	5,000	2,500	2	5,000	2,500
2012	2	5,000	2,500	550	2,000	0	0	0		0	0		552	7,000	0
Total Pawcatuck	20	157,000	5,300	556	8,000	700	0	0		13	76,000	4,700	589	241,000	3,400
Penobscot															
1871-2005	18,578	159,343,000	7,900	6,571	17,283,000	2,700	0	0		0	0		25,149	176,627,000	7,400
2006	325	3,034,000	9,300	0	0		329	1,400,000	4,300	0	0		654	4,434,000	6,800
2007	315	2,697,000	8,600	394	1,595,000	4,000	0	0		0	0		709	4,292,000	6,100
2008	297	2,500,000	8,400	352	1,420,000	4,000	0	0		0	0		649	3,920,000	6,000
2009	283	2,433,000	8,600	312	1,040,000	3,300	0	0		0	0		595	3,473,000	5,800
2010	289	2,091,000	7,200	314	1,269,000	4,000	0	0		0	0		603	3,360,000	5,600
2011	313	2,626,000	8,400	351	1,216,000	3,500	0	0		0	0		664	3,842,000	5,800
2012	259	1,950,000	7,500	373	1,101,000	3,000	0	0		0	0		632	3,051,000	4,800
2013	174	1,258,000	7,200	517	1,713,000	3,300	0	0		0	0		691	2,971,000	4,300
2014	102	775,000	7,600	557	1,653,000	3,000	0	0		0	0		659	2,428,000	3,700
2015	348	0	0	381	0	0	0	0		0	0		729	0	0
Total Penobscot	21,283	178,707,000	7,300	10,122	28,290,000	3,100	329	1,400,000	4,300	0	0		31,734	208,398,000	5,100
Pleasant															
2001-2005	0	0		0	0		165	705,000	5,400	0	0		165	705,000	5,400
2006	0	0		0	0		54	240,000	4,400	0	0		54	240,000	4,400
2007	0	0		0	0		77	275,000	3,600	0	0		77	275,000	3,600
2008	0	0		14	66,000	4,700	47	139,000	3,000	0	0		61	205,000	3,400
2009	0	0		3	20,000	6,500	54	230,000	4,200	0	0		57	249,000	4,400
2010	0	0		30	186,000	6,200	12	42,000	3,500	0	0		42	228,000	5,400

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

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

Note: Connecticut data are preliminary prior to 1990.

Year	Sea-Run 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
2011	0	0		4	35,000	8,800	26	124,000	4,800	0	0		30	159,000	5,300
2012	0	0		68	133,000	2,000	55	145,000	2,600	0	0		123	278,000	2,300
2013	0	0		4	29,000	7,300	78	262,000	3,400	0	0		82	291,000	3,500
2014	0	0		0	0		74	259,000	3,500	0	0		74	259,000	3,500
2015	0	0		0	0		63	214,000	3,400	0	0		63	214,000	3,400
Total Pleasant	0	0		123	469,000	5,900	705	2,635,000	3,800	0	0		828	3,103,000	4,100
Sheepscot															
1995-2005	18	125,000	6,900	0	0		736	2,972,000	3,900	45	438,000	9,900	799	3,536,000	4,400
2006	0	0		0	0		83	277,000	3,300	0	0		83	277,000	3,300
2007	0	0		0	0		81	349,000	4,300	0	0		81	349,000	4,300
2008	0	0		0	0		75	340,000	4,500	0	0		75	340,000	4,500
2009	0	0		0	0		86	329,000	3,800	0	0		86	329,000	3,800
2010	0	0		0	0		68	264,000	3,900	0	0		68	264,000	3,900
2011	0	0		0	0		72	253,000	3,500	0	0		72	253,000	3,500
2012	0	0		0	0		89	231,000	2,600	0	0		89	231,000	2,600
2013	0	0		0	0		81	230,000	2,800	0	0		81	230,000	2,800
2014	0	0		0	0		56	164,000	2,900	0	0		56	164,000	2,900
2015	0	0		0	0		85	317,000	3,700	0	0		85	317,000	3,700
Total Sheepscot	18	125,000	6,900	0	0	0	1,512	5,726,000	3,564	45	438,000	9,900	1,575	6,290,000	3,600
St Croix															
1993-2005	39	291,000	7,400	0	0		0	0		0	0		39	291,000	7,400
Total St Croix	39	291,000	7,400	0	0	0	0	0		0	0		39	291,000	7,400
Union															
1974-2005	600	4,611,000	7,900	0	0		0	0		0	0		600	4,611,000	7,900

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

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

Note: Connecticut data are preliminary prior to 1990.

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

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

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

Note: Connecticut data are preliminary prior to 1990.

Appendix 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	2,071	21,264,000	7,400	33,722	208,885,000	6,400	0	0		2,395	28,935,000	9,600	38,188	259,084,000	6,500
Dennys	26	214,000	7,600	125	687,000	4,600	1,488	6,384,000	4,400	40	330,000	7,700	1,679	7,615,000	4,600
East Machias	0	0		0	0		1,675	6,881,000	4,100	0	0		1,675	6,881,000	4,100
Kennebec	5	50,000	10,000	0	0		0	0		0	0		5	50,000	10,000
Lamprey	6	32,000	4,800	0	0		0	0		0	0		6	32,000	4,800
Machias	456	3,263,000	7,300	0	0		2,872	11,673,000	3,900	8	52,000	6,400	3,336	14,988,000	4,100
Merrimack	1,582	12,306,000	7,900	12,214	59,866,000	4,000	0	0		540	5,709,000	11,100	14,336	77,881,000	5,000
Narraguagus	0	1,303,000		0	0		2,975	11,506,000	4,100	0	0		2,975	12,809,000	4,100
Orland	39	270,000	7,300	0	0		0	0		0	0		39	270,000	7,300
Pawcatuck	20	157,000	5,300	556	8,000	700	0	0		13	76,000	4,700	589	241,000	3,500
Penobscot	21,283	178,707,000	7,300	10,122	28,290,000	3,100	329	1,400,000	4,300	0	0		31,734	208,398,000	5,100
Pleasant	0	0		123	468,000	5,900	705	2,634,000	3,800	0	0		828	3,102,000	4,100
Sheepscot	18	125,000	6,900	0	0		1,512	5,726,000	3,600	45	438,000	9,900	1,575	6,290,000	3,600
St Croix	39	291,000	7,400	0	0		0	0		0	0		39	291,000	7,400
Union	600	4,611,000	7,900	0	0		0	0		0	0		600	4,611,000	7,900
Grand Total	**26,148**	**222,614,000**	**8,500**	**56,862**	**298,204,000**	**5,200**	**11,556**	**46,204,000**	**4,000**	**3,041**	**35,540,000**	**11,700**	**97,607**	**602,564,000**	**6,200**

Note: Eggs/female represents the overall average number of eggs produced per female and includes only years for which information on the number of females is available.

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

	Number of fish stocked by life stage							
	Egg	**Fry**	**0 Parr**	**1 Parr**	**2 Parr**	**1 Smolt**	**2 Smolt**	**Total**
Androscoggin								
2001-2005	0	6,000	0	0	0	0	0	6,000
2006	0	1,000	0	0	0	0	0	1,000
2007	0	1,000	0	0	0	0	0	1,000
2008	0	1,000	0	0	0	0	0	1,000
2009	0	2,000	0	0	0	0	0	2,000
2010	0	1,000	0	0	0	0	0	1,000
2011	0	1,000	0	0	0	0	0	1,000
2012	0	1,000	0	0	0	0	0	1,000
2013	0	1,000	0	0	0	500	0	1,500
2014	0	1,000	0	0	0	0	0	1,000
2015	0	2,000	0	0	0	0	0	2,000
Totals:Androscoggin	**0**	**18,000**	**0**	**0**	**0**	**500**	**0**	**18,500**
Aroostook								
1978-2005	0	2,255,000	317,400	38,600	0	32,600	29,800	2,673,400
2006	0	324,000	0	0	0	0	0	324,000
2007	0	854,000	0	0	0	0	0	854,000
2008	0	365,000	0	0	0	0	0	365,000
2009	0	458,000	0	0	0	0	0	458,000
2010	0	527,000	0	0	0	0	0	527,000
2011	0	237,000	0	0	0	0	0	237,000
2012	0	731,000	0	0	0	0	0	731,000
2013	0	580,000	0	0	0	0	0	580,000
2014	0	569,000	0	0	0	0	0	569,000
2015	0	1,000	0	0	0	0	0	1,000
Totals:Aroostook	**0**	**6,901,000**	**317,400**	**38,600**	**0**	**32,600**	**29,800**	**7,319,400**
Cocheco								
1988-2005	0	1,958,000	50,000	10,500	0	5,300	0	2,023,800
Totals:Cocheco	**0**	**1,958,000**	**50,000**	**10,500**	**0**	**5,300**	**0**	**2,023,800**
Connecticut								
1967-2005	0	108,207,000	2,830,600	1,812,800	0	3,769,700	1,283,000	117,903,100
2006	0	5,848,000	3,700	0	12,600	1,000	52,100	5,917,400
2007	0	6,345,000	0	600	2,300	600	99,000	6,447,500
2008	0	6,041,000	0	0	2,400	0	50,000	6,093,400
2009	0	6,476,000	3,900	0	14,400	0	49,100	6,543,400
2010	0	6,009,000	0	6,300	19,000	0	42,700	6,077,000
2011	0	6,010,000	5,200	9,500	10,000	0	81,700	6,116,400
2012	0	1,733,000	3,100	7,500	4,000	0	71,000	1,818,600
2013	0	1,857,000	3,200	0	0	600	99,500	1,960,300
2014	0	199,000	0	0	0	0	0	199,000
2015	0	391,000	0	0	0	0	0	391,000
Totals:Connecticut	**0**	**149,116,000**	**2,849,700**	**1,836,700**	**64,700**	**3,771,900**	**1,828,100**	**159,467,100**

	Number of fish stocked by life stage							
	Egg	**Fry**	**0 Parr**	**1 Parr**	**2 Parr**	**1 Smolt**	**2 Smolt**	**Total**
Dennys								
1975-2005	0	1,834,000	197,800	7,300	0	419,700	29,200	2,488,000
2006	0	295,000	27,600	0	0	56,500	0	379,100
2007	0	257,000	0	0	0	56,500	0	313,500
2008	0	292,000	0	0	0	0	200	292,200
2009	0	317,000	0	0	0	0	600	317,600
2010	0	430,000	0	0	0	0	0	430,000
2011	0	539,000	0	0	0	0	0	539,000
2014	0	84,000	0	0	0	0	0	84,000
2015	0	110,000	0	0	0	0	0	110,000
Totals:Dennys	**0**	**4,158,000**	**225,400**	**7,300**	**0**	**532,700**	**30,000**	**4,953,400**
Ducktrap								
1986-2005	0	68,000	0	0	0	0	0	68,000
Totals:Ducktrap	**0**	**68,000**	**0**	**0**	**0**	**0**	**0**	**68,000**
East Machias								
1973-2005	0	2,292,000	7,500	42,600	0	108,400	30,400	2,480,900
2006	0	199,000	0	0	0	0	0	199,000
2007	0	245,000	0	0	0	0	0	245,000
2008	0	261,000	0	0	0	0	0	261,000
2009	0	186,000	0	0	0	0	0	186,000
2010	0	266,000	0	0	0	0	0	266,000
2011	0	180,000	0	0	0	0	0	180,000
2012	0	88,000	53,200	0	0	0	0	141,200
2013	0	20,000	77,600	0	0	0	0	97,600
2014	0	16,000	149,800	0	0	0	0	165,800
2015	0	11,000	192,000	0	0	0	0	203,000
Totals:East Machias	**0**	**3,764,000**	**480,100**	**42,600**	**0**	**108,400**	**30,400**	**4,425,500**
Kennebec								
2001-2005	0	138,000	0	0	0	0	0	138,000
2006	40000	8,000	0	0	0	0	0	47,598
2007	34000	20,000	0	0	0	0	0	53,878
2008	246000	3,000	0	0	0	0	0	249,331
2009	159000	2,000	0	0	0	200	0	161,609
2010	600000	147,000	0	0	0	0	0	746,849
2011	810000	2,000	0	0	0	0	0	811,500
2012	921000	2,000	0	0	0	0	0	922,888
2013	654000	2,000	0	0	0	600	0	656,682
2014	1151000	2,000	0	0	0	0	0	1,153,330
2015	275000	2,000	0	0	0	0	0	276,587
Totals:Kennebec	**4,890,000**	**328,000**	**0**	**0**	**0**	**800**	**0**	**5,218,252**
Lamprey								
1978-2005	0	1,592,000	427,700	58,800	0	201,400	32,800	2,312,700
Totals:Lamprey	**0**	**1,592,000**	**427,700**	**58,800**	**0**	**201,400**	**32,800**	**2,312,700**

	Number of fish stocked by life stage							
	Egg	**Fry**	**0 Parr**	**1 Parr**	**2 Parr**	**1 Smolt**	**2 Smolt**	**Total**
Machias								
1970-2005	0	3,326,000	96,900	118,300	0	191,300	44,100	3,776,600
2006	0	638,000	2,000	1,500	0	0	0	641,500
2007	0	470,000	0	2,200	0	0	0	472,200
2008	0	585,000	100	400	0	0	0	585,500
2009	0	291,000	300	0	0	0	0	291,300
2010	0	510,000	0	0	0	0	0	510,000
2011	0	347,000	0	500	0	0	0	347,500
2012	0	231,000	0	1,400	0	0	0	232,400
2013	0	172,000	800	1,400	0	59,100	0	233,300
2014	27000	210,000	400	0	0	0	0	237,387
2015	49000	503,000	500	0	0	0	0	552,732
Totals:Machias	**76,000**	**7,283,000**	**101,000**	**125,700**	**0**	**250,400**	**44,100**	**7,880,419**
Merrimack								
1975-2005	0	33,307,000	232,600	598,100	0	1,519,000	638,100	36,294,800
2006	0	1,011,000	0	0	0	50,000	0	1,061,000
2007	0	1,140,000	0	0	0	50,000	0	1,190,000
2008	0	1,766,000	3,400	9,600	0	88,900	0	1,867,900
2009	0	1,051,000	0	0	0	91,100	0	1,142,100
2010	0	1,481,000	80,000	9,300	0	72,900	0	1,643,200
2011	0	892,000	93,800	0	0	34,900	0	1,020,700
2012	0	1,016,000	22,000	0	0	33,800	0	1,071,800
2013	0	111,000	0	41,200	0	40,900	0	193,100
2014	0	12,000	0	0	0	0	0	12,000
Totals:Merrimack	**0**	**41,787,000**	**431,800**	**658,200**	**0**	**1,981,500**	**638,100**	**45,496,600**
Narraguagus								
1970-2005	0	3,322,000	62,900	14,600	0	107,800	84,000	3,591,300
2006	0	478,000	17,500	0	0	0	0	495,500
2007	0	346,000	15,700	0	0	0	0	361,700
2008	0	485,000	21,000	0	0	54,100	0	560,100
2009	0	449,000	0	0	0	52,800	0	501,800
2010	0	698,000	0	0	0	62,400	0	760,400
2011	0	465,000	0	0	0	64,000	0	529,000
2012	0	389,000	0	0	0	59,100	0	448,100
2013	0	288,000	0	0	0	0	0	288,000
2014	79000	263,000	0	0	0	0	0	342,145
2015	0	165,000	0	0	0	0	0	165,000
Totals:Narraguagus	**79,000**	**7,348,000**	**117,100**	**14,600**	**0**	**400,200**	**84,000**	**8,043,045**
Pawcatuck								
1979-2005	0	5,387,000	1,209,200	263,200	0	93,000	500	6,952,900
2006	0	85,000	0	0	0	12,800	0	97,800
2007	0	115,000	0	4,900	0	6,400	0	126,300
2008	0	313,000	0	0	0	6,000	0	319,000
2009	0	86,000	0	0	0	5,400	0	91,400
2010	0	290,000	0	0	0	3,900	0	293,900

	Number of fish stocked by life stage							
	Egg	**Fry**	**0 Parr**	**1 Parr**	**2 Parr**	**1 Smolt**	**2 Smolt**	**Total**
2011	0	6,000	0	0	0	0	0	6,000
2012	0	6,000	0	0	0	0	0	6,000
2013	0	8,000	0	0	0	0	0	8,000
2014	0	5,000	0	0	0	0	0	5,000
Totals:Pawcatuck	**0**	**6,301,000**	**1,209,200**	**268,100**	**0**	**127,500**	**500**	**7,906,300**
Penobscot								
1970-2005	0	17,646,000	4,568,200	1,394,400	0	13,265,700	2,508,200	39,382,500
2006	0	1,509,000	293,500	0	0	555,200	0	2,357,700
2007	0	1,606,000	337,800	0	0	559,900	0	2,503,700
2008	0	1,248,000	216,600	0	0	554,600	0	2,019,200
2009	0	1,023,000	172,200	0	0	561,100	0	1,756,300
2010	0	999,000	258,800	0	0	567,100	0	1,824,900
2011	0	952,000	298,000	0	0	554,000	0	1,804,000
2012	353000	1,073,000	325,700	0	0	555,200	0	2,306,679
2013	233000	722,000	214,000	0	0	553,000	0	1,722,193
2014	89000	815,000	0	0	0	557,700	0	1,461,360
2015	89000	518,000	257,800	0	0	375,600	0	1,240,580
Totals:Penobscot	**764,000**	**28,111,000**	**6,942,600**	**1,394,400**	**0**	**18,659,100**	**2,508,200**	**58,379,112**
Pleasant								
1975-2005	0	363,000	16,000	1,800	0	63,400	26,900	471,100
2006	0	284,000	0	0	0	0	15,200	299,200
2007	0	177,000	0	0	0	0	0	177,000
2008	0	171,000	0	0	0	0	0	171,000
2009	0	97,000	0	0	0	0	300	97,300
2010	0	142,000	0	0	0	0	0	142,000
2011	0	124,000	0	0	0	61,000	0	185,000
2012	0	40,000	0	0	0	60,200	0	100,200
2013	0	180,000	0	0	0	62,300	0	242,300
2014	46000	114,000	0	0	0	0	0	159,500
2015	0	183,000	0	0	0	0	0	183,000
Totals:Pleasant	**46,000**	**1,875,000**	**16,000**	**1,800**	**0**	**246,900**	**42,400**	**2,227,600**
Saco								
1975-2005	0	5,150,000	438,700	219,200	0	345,800	9,500	6,163,200
2006	0	106,000	0	0	0	0	0	106,000
2007	0	576,000	0	0	0	0	0	576,000
2008	0	358,000	9,100	0	0	0	0	367,100
2009	0	1,000	0	0	0	0	0	1,000
2010	0	302,000	0	0	0	26,500	0	328,500
2011	0	238,000	16,000	0	0	12,000	0	266,000
2012	0	396,000	0	12,800	0	11,900	0	420,700
2013	0	319,000	10,100	0	0	12,100	0	341,200
2014	0	366,000	16,000	0	0	12,100	0	394,100
2015	0	702,000	25,000	0	0	11,700	0	738,700
Totals:Saco	**0**	**8,514,000**	**514,900**	**232,000**	**0**	**432,100**	**9,500**	**9,702,500**

	Number of fish stocked by life stage							
	Egg	**Fry**	**0 Parr**	**1 Parr**	**2 Parr**	**1 Smolt**	**2 Smolt**	**Total**
Sheepscot								
1971-2005	9000	2,259,000	116,300	20,600	0	92,200	7,100	2,504,000
2006	9000	151,000	16,600	0	0	0	0	176,600
2007	0	198,000	0	0	0	0	0	198,000
2008	0	218,000	13,000	0	0	0	0	231,000
2009	0	185,000	17,900	0	0	0	0	202,900
2010	9000	114,000	14,500	0	0	0	0	137,500
2011	0	129,000	15,000	0	0	0	0	144,000
2012	70000	50,000	15,700	0	0	0	0	136,069
2013	122000	18,000	14,000	0	0	0	0	154,476
2014	118000	23,000	15,000	0	0	0	0	155,668
2015	118000	19,000	14,200	0	0	0	0	150,868
Totals:Sheepscot	**455,000**	**3,364,000**	**252,200**	**20,600**	**0**	**92,200**	**7,100**	**4,191,081**
St Croix								
1981-2005	0	1,268,000	470,400	158,300	0	808,000	20,100	2,724,800
2006	0	0	27,600	0	0	0	0	27,600
2007	0	0	0	0	0	0	0	0
2008	0	0	0	0	0	0	0	0
2010	0	0	0	0	0	0	0	0
2014	0	0	0	0	0	0	0	0
2015	0	0	0	0	0	0	0	0
Totals:St Croix	**0**	**1,268,000**	**498,000**	**158,300**	**0**	**808,000**	**20,100**	**2,752,400**
Union								
1971-2005	0	438,000	371,400	0	0	379,700	251,000	1,440,100
2006	0	2,000	0	0	0	0	0	2,000
2007	0	22,000	0	0	0	0	0	22,000
2008	0	23,000	0	0	0	0	0	23,000
2009	0	28,000	0	0	0	0	0	28,000
2010	0	19,000	0	0	0	0	0	19,000
2011	0	19,000	0	0	0	0	0	19,000
2012	0	1,000	0	0	0	0	0	1,000
2013	0	2,000	0	0	0	0	0	2,000
2014	0	24,000	0	0	0	0	0	24,000
2015	0	25,000	0	0	0	0	0	25,000
Totals:Union	**0**	**603,000**	**371,400**	**0**	**0**	**379,700**	**251,000**	**1,605,100**
Upper StJohn								
1979-2005	0	2,165,000	1,456,700	14,700	0	5,100	27,700	3,669,200
Totals:Upper StJohn	**0**	**2,165,000**	**1,456,700**	**14,700**	**0**	**5,100**	**27,700**	**3,669,200**

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

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

	Egg	Fry	0 Parr	1 Parr	2 Parr	1 Smolt	2 Smolt	Total
Androscoggin	0	17,000	0	0	0	500	0	**17,900**
Aroostook	0	6,901,000	317,400	38,600	0	32,600	29,800	**7,319,400**
Cocheco	0	1,958,000	50,000	10,500	0	5,300	0	**2,024,200**
Connecticut	0	149,115,000	2,849,700	1,836,700	64,800	3,771,900	1,828,200	**159,401,100**
Dennys	0	4,158,000	225,400	7,300	0	532,800	30,000	**4,953,800**
Ducktrap	0	68,000	0	0	0	0	0	**68,000**
East Machias	0	3,762,000	480,100	42,600	0	108,400	30,400	**4,424,000**
Kennebec	4,889,000	328,000	0	0	0	900	0	**5,218,500**
Lamprey	0	1,593,000	427,700	58,800	0	201,400	32,800	**2,313,700**
Machias	76,000	7,283,000	100,900	125,600	0	250,400	44,100	**7,880,700**
Merrimack	0	41,787,000	431,700	658,100	0	1,981,400	638,100	**45,496,500**
Narraguagus	79,000	7,349,000	117,100	14,600	0	400,300	84,000	**8,043,700**
Pawcatuck	0	6,300,000	1,209,200	268,100	0	127,500	500	**7,905,500**
Penobscot	764,000	28,110,000	6,942,600	1,394,400	0	18,659,100	2,508,200	**58,378,200**
Pleasant	46,000	1,875,000	16,000	1,800	0	247,000	42,400	**2,228,200**
Saco	0	8,514,000	514,800	232,000	0	432,000	9,500	**9,702,500**
Sheepscot	455,000	3,365,000	252,100	20,600	0	92,200	7,100	**4,191,700**
St Croix	0	1,270,000	498,000	158,300	0	808,000	20,100	**2,754,200**
Union	0	602,000	371,400	0	0	379,700	251,000	**1,604,400**
Upper StJohn	0	2,165,000	1,456,700	14,700	0	5,100	27,700	**3,669,200**
TOTALS	**276,522,000**	**16,261,000**	**4,882,800**	**64,800**	**28,036,500**	**5,583,900**		**337,595,400**

Summaries for each river vary by length of time series.

Appendix 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									
1983-2005	32	531	6	2	6	84	0	1	**662**
2006	5	1	0	0	0	0	0	0	**6**
2007	6	11	0	0	1	2	0	0	**20**
2008	8	5	0	0	2	1	0	0	**16**
2009	2	19	0	0	0	3	0	0	**24**
2010	2	5	0	0	0	2	0	0	**9**
2011	2	27	0	0	1	14	0	0	**44**
2013	0	1	0	0	0	1	0	0	**2**
2014	0	2	0	0	0	1	0	0	**3**
2015	0	0	0	0	0	1	0	0	**1**
Total for Androscoggin	57	602	6	2	10	109	0	1	**787**
Cocheco									
1992-2005	0	0	1	1	6	10	0	0	**18**
Total for Cocheco	0	0	1	1	6	10	0	0	**18**
Connecticut									
1974-2005	36	3,507	28	2	75	1,630	12	0	**5,290**
2006	13	33	0	0	20	147	0	1	**214**
2007	0	19	0	0	1	120	1	0	**141**
2008	7	10	0	0	3	118	1	2	**141**
2009	0	18	0	0	0	57	0	0	**75**
2010	0	3	0	0	1	47	0	0	**51**
2011	2	17	0	0	31	61	0	0	**111**
2012	0	1	0	0	0	53	0	0	**54**
2013	0	4	0	0	3	85	0	0	**92**
2014	0	0	0	0	2	30	0	0	**32**
2015	0	0	0	0	4	18	0	0	**22**
Total for Connecticut	58	3,612	28	2	140	2366	14	3	**6,223**
Dennys									
1967-2005	35	314	0	1	31	744	3	31	**1,159**
2006	2	2	0	0	1	1	0	0	**6**
2007	1	1	0	0	0	1	0	0	**3**
2008	0	1	0	0	1	3	0	3	**8**
2009	0	0	0	0	0	6	1	1	**8**

	HATCHERY ORIGIN				WILD ORIGIN				
	1SW	2SW	3SW	Repeat	1SW	2SW	3SW	Repeat	Total
2010	1	1	0	0	0	4	0	0	**6**
2011	0	1	0	0	2	5	1	0	**9**
Total for Dennys	39	320	0	1	35	764	5	35	**1,199**
Ducktrap									
1985-2005	0	0	0	0	3	30	0	0	**33**
Total for Ducktrap	0	0	0	0	3	30	0	0	**33**
East Machias									
1967-2005	21	250	1	2	12	329	1	10	**626**
Total for East Machias	21	250	1	2	12	329	1	10	**626**
Kennebec									
1975-2005	12	189	5	1	0	9	0	0	**216**
2006	4	6	0	0	3	2	0	0	**15**
2007	2	5	1	0	2	6	0	0	**16**
2008	6	15	0	0	0	0	0	0	**21**
2009	0	16	0	6	1	10	0	0	**33**
2010	0	2	0	0	1	2	0	0	**5**
2011	0	21	0	0	2	41	0	0	**64**
2012	0	1	0	0	0	4	0	0	**5**
2013	0	1	0	0	0	7	0	0	**8**
2014	0	2	0	0	3	13	0	0	**18**
2015	0	2	0	0	3	26	0	0	**31**
Total for Kennebec	24	260	6	7	15	120	0	0	**432**
Lamprey									
1979-2005	10	17	1	0	11	16	0	0	**55**
2006	0	0	0	0	2	0	0	0	**2**
Total for Lamprey	10	17	1	0	13	16	0	0	**57**
Machias									
1967-2005	32	329	9	2	33	1,592	41	131	**2,169**
Total for Machias	32	329	9	2	33	1592	41	131	**2,169**
Merrimack									
1982-2005	315	1,236	21	8	121	990	26	0	**2,717**
2006	9	64	1	0	6	9	0	0	**89**
2007	8	52	0	0	1	12	1	0	**74**
2008	6	77	0	0	5	29	1	0	**118**
2009	4	41	2	0	1	28	2	0	**78**
2010	29	40	0	0	7	7	1	0	**84**
2011	128	155	12	1	11	90	5	0	**402**
2012	0	81	15	0	1	27	3	0	**127**

	HATCHERY ORIGIN				WILD ORIGIN				
	1SW	2SW	3SW	Repeat	1SW	2SW	3SW	Repeat	Total
2013	0	6	0	3	0	12	0	0	**21**
2014	4	25	1	0	0	10	0	0	**40**
2015	2	7	1	0	0	2	1	0	**13**
Total for Merrimack	505	1,784	53	12	153	1216	40	0	**3,763**
Narraguagus									
1967-2005	92	650	19	54	90	2,408	71	155	**3,539**
2006	0	0	0	0	3	12	0	0	**15**
2007	0	0	0	0	2	9	0	0	**11**
2008	0	0	0	0	4	18	1	1	**24**
2009	3	0	0	0	1	5	0	0	**9**
2010	30	33	1	1	3	6	0	2	**76**
2011	55	96	2	1	20	21	0	1	**196**
2012	2	9	1	0	0	5	0	0	**17**
2013	3	14	0	0	0	4	0	0	**21**
2014	0	2	0	0	0	1	0	1	**4**
2015	0	0	0	0	0	3	0	0	**3**
Total for Narraguagus	185	804	23	56	123	2492	72	160	**3,915**
Pawcatuck									
1982-2005	2	148	1	0	1	17	1	0	**170**
2006	0	0	0	0	0	0	0	0	**0**
2007	0	2	0	0	0	0	0	0	**2**
2008	0	0	0	0	0	0	0	0	**0**
2009	0	0	0	0	0	0	0	0	**0**
2010	0	0	0	0	0	1	0	0	**1**
2011	0	1	0	0	0	3	0	0	**4**
2012	0	0	0	0	0	2	0	0	**2**
2013	0	0	0	0	0	2	0	0	**2**
2014	0	0	0	0	0	0	0	0	**0**
Total for Pawcatuck	2	151	1	0	1	25	1	0	**181**
Penobscot									
1968-2005	10,732	43,185	287	705	676	3,721	35	99	**59,440**
2006	338	653	1	4	15	33	0	0	**1,044**
2007	226	575	0	1	35	88	0	0	**925**
2008	713	1,295	0	4	23	80	0	0	**2,115**
2009	185	1,683	2	1	12	74	1	0	**1,958**
2010	410	819	0	11	23	53	0	0	**1,316**
2011	696	2,167	3	12	45	201	1	0	**3,125**
2012	8	531	6	2	5	69	0	3	**624**
2013	54	275	3	2	3	44	0	0	**381**

	HATCHERY ORIGIN				WILD ORIGIN				
	1SW	**2SW**	**3SW**	**Repeat**	**1SW**	**2SW**	**3SW**	**Repeat**	**Total**
2014	82	153	2	2	1	21	0	0	**261**
2015	110	552	7	1	9	52	0	0	**731**
Total for Penobscot	13,554	51,888	311	745	847	4436	37	102	**71,920**
Pleasant									
1967-2005	5	12	0	0	14	228	3	2	**264**
2012	0	0	0	0	0	2	0	0	**2**
2013	0	1	0	0	0	0	0	0	**1**
2014	2	0	0	0	0	1	0	0	**3**
Total for Pleasant	7	13	0	0	14	231	3	2	**270**
Saco									
1985-2005	117	583	3	7	24	74	3	0	**811**
2006	8	15	0	0	4	3	0	0	**30**
2007	4	16	0	0	0	4	0	0	**24**
2008	11	26	2	0	8	12	3	0	**62**
2009	1	9	0	0	0	4	0	0	**14**
2010	8	5	0	0	3	4	0	0	**20**
2011	30	36	0	0	11	17	0	0	**94**
2012	0	12	0	0	0	0	0	0	**12**
2013	0	2	0	0	0	1	0	0	**3**
2014	0	3	0	0	0	0	0	0	**3**
2015	1	4	0	0	0	0	0	0	**5**
Total for Saco	180	711	5	7	50	119	6	0	**1,078**
Sheepscot									
1967-2005	6	38	0	0	30	358	10	0	**442**
Total for Sheepscot	6	38	0	0	30	358	10	0	**442**
Union									
1973-2005	274	1,841	9	28	1	16	0	0	**2,169**
2006	0	0	0	0	0	0	0	0	**0**
2007	0	0	0	0	0	0	0	0	**0**
2008	0	0	0	0	0	0	0	0	**0**
2009	0	0	0	0	0	0	0	0	**0**
2010	0	0	0	0	0	0	0	0	**0**
2013	0	0	0	0	0	1	0	0	**1**
2014	0	1	0	0	0	1	0	0	**2**
Total for Union	274	1,842	9	28	1	18	0	0	**2,172**

Appendix 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	57	602	6	2	10	109	0	1	**787**
Cocheco	0	0	1	1	6	10	0	0	**18**
Connecticut	58	3,612	28	2	140	2,366	14	3	**6,223**
Dennys	39	320	0	1	35	764	5	35	**1,199**
Ducktrap	0	0	0	0	3	30	0	0	**33**
East Machias	21	250	1	2	12	329	1	10	**626**
Kennebec	24	260	6	7	15	120	0	0	**432**
Lamprey	10	17	1	0	13	16	0	0	**57**
Machias	32	329	9	2	33	1,592	41	131	**2,169**
Merrimack	505	1,784	53	12	153	1,216	40	0	**3,763**
Narraguagus	185	804	23	56	123	2,492	72	160	**3,915**
Pawcatuck	2	151	1	0	1	25	1	0	**181**
Penobscot	13,554	51,888	311	745	847	4,436	37	102	**71,920**
Pleasant	7	13	0	0	14	231	3	2	**270**
Saco	180	711	5	7	50	119	6	0	**1,078**
Sheepscot	6	38	0	0	30	358	10	0	**442**
Union	274	1,842	9	28	1	18	0	0	**2,172**

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

Year	Total Fry (10,000s)	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	2	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1975	3	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1976	3	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	5	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	5	7	1.400	0	0	0	0	100	0	0	0	0	0	0	0	100	0	0
1979	2	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1980	9	18	2.022	0	0	0	0	100	0	0	0	0	0	0	0	100	0	0
1981	15	19	1.261	0	0	0	11	89	0	0	0	0	0	0	11	89	0	0
1982	13	31	2.429	0	0	0	0	90	10	0	0	0	0	0	0	90	10	0
1983	7	1	0.143	0	100	0	0	0	0	0	0	0	0	0	100	0	0	0
1984	46	1	0.022	0	0	0	0	0	100	0	0	0	0	0	0	0	100	0
1985	29	35	1.224	0	0	0	0	100	0	0	0	0	0	0	0	100	0	0
1986	10	27	2.791	0	0	0	4	96	0	0	0	0	0	0	4	96	0	0
1987	98	44	0.449	0	16	0	0	68	2	0	14	0	0	0	16	68	16	0
1988	93	92	0.992	0	0	0	0	97	1	0	2	0	0	0	0	97	3	0
1989	75	47	0.629	0	6	0	6	85	0	0	2	0	0	0	12	85	2	0
1990	76	53	0.693	0	13	0	0	87	0	0	0	0	0	0	13	87	0	0
1991	98	25	0.255	0	20	0	0	64	0	0	16	0	0	0	20	64	16	0
1992	93	84	0.904	0	1	0	0	85	1	0	13	0	0	0	1	85	14	0
1993	261	94	0.361	0	0	0	2	87	0	0	11	0	0	0	2	87	11	0
1994	393	197	0.502	0	0	0	1	93	0	0	6	0	0	0	1	93	6	0

Means includes year classes with complete return data (year classes of 2010 and later).

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

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

1995	451	83	0.184	0	2	0	6	89	0	0	2	0	0	0	8	89	2	0
1996	478	55	0.115	0	4	0	5	89	2	0	0	0	0	0	9	89	2	0
1997	589	24	0.041	0	0	0	4	88	4	0	4	0	0	0	4	88	8	0
1998	661	33	0.050	0	0	0	6	88	0	0	3	0	3	0	6	88	3	3
1999	456	33	0.072	0	0	3	6	79	0	0	12	0	0	0	6	82	12	0
2000	693	43	0.062	0	0	0	0	86	0	0	14	0	0	0	0	86	14	0
2001	699	115	0.165	0	2	0	1	89	0	2	7	0	0	0	3	91	7	0
2002	490	88	0.179	0	10	0	11	69	1	2	6	0	0	0	21	71	7	0
2003	482	102	0.211	0	7	0	12	75	1	0	5	0	0	0	19	75	6	0
2004	526	74	0.141	1	9	0	0	86	0	0	3	0	0	1	9	86	3	0
2005	542	48	0.089	2	2	0	2	92	0	0	2	0	0	2	4	92	2	0
2006	397	37	0.093	0	0	0	0	97	0	0	3	0	0	0	0	97	3	0
2007	455	43	0.095	0	2	0	2	93	0	2	0	0	0	0	4	95	0	0
2008	424	44	0.104	0	7	0	32	59	0	0	2	0	0	0	39	59	2	0
2009	472	61	0.129	0	3	0	0	97	0	0	0	0	0	0	3	97	0	0
2010	425	20	0.047	0	25	0	5	70	0	0	0			0	30	70	0	
2011	438	12	0.027	0	83	0	17	0		0				0	100	0		
2012	85	0	0.000	0	0		0							0	0			
2013	62	0	0.000	0										0				
Total	**10,161**	**1,690**																
Mean			**0.495**	**0**	**6**	**0**	**3**	**70**	**3**	**0**	**4**	**0**	**0**	**0**	**9**	**70**	**7**	**0**

Means includes year classes with complete return data (year classes of 2010 and later).

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

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

Year	Total Fry (10,000s)	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	2	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1975	3	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1976	3	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	5	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	5	7	1.400	0	0	0	0	100	0	0	0	0	0	0	0	100	0	0
1979	5	3	0.561	0	100	0	0	0	0	0	0	0	0	0	100	0	0	0
1980	29	18	0.630	0	0	0	0	100	0	0	0	0	0	0	0	100	0	0
1981	17	19	1.129	0	0	0	11	89	0	0	0	0	0	0	11	89	0	0
1982	29	46	1.565	0	0	0	0	89	11	0	0	0	0	0	0	89	11	0
1983	19	2	0.108	0	100	0	0	0	0	0	0	0	0	0	100	0	0	0
1984	58	3	0.051	0	0	0	0	33	33	0	33	0	0	0	0	33	66	0
1985	42	47	1.113	0	0	0	0	100	0	0	0	0	0	0	0	100	0	0
1986	18	28	1.592	0	0	0	4	96	0	0	0	0	0	0	4	96	0	0
1987	117	51	0.436	0	18	0	0	67	2	0	14	0	0	0	18	67	16	0
1988	131	108	0.825	0	0	0	0	97	1	0	2	0	0	0	0	97	3	0
1989	124	67	0.539	0	22	0	7	69	0	0	1	0	0	0	29	69	1	0
1990	135	68	0.505	0	19	0	0	79	0	0	1	0	0	0	19	79	1	0
1991	221	35	0.159	0	17	0	0	63	0	0	20	0	0	0	17	63	20	0
1992	201	118	0.587	0	5	0	0	82	1	0	12	0	0	0	5	82	13	0
1993	415	185	0.446	0	4	0	3	87	0	0	6	0	0	0	7	87	6	0
1994	598	294	0.492	0	5	0	2	88	0	0	5	0	0	0	7	88	5	0

Means includes year classes with complete return data (year classes of 2010 and later).

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

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

1995	682	143	0.210	1	13	0	7	78	0	0	2	0	0	1	20	78	2	0
1996	668	101	0.151	0	16	0	11	71	1	0	1	0	0	0	27	71	2	0
1997	853	37	0.043	0	3	0	3	89	3	0	3	0	0	0	6	89	6	0
1998	912	44	0.048	0	0	0	9	84	0	0	5	0	2	0	9	84	5	2
1999	643	45	0.070	0	0	2	4	80	0	0	13	0	0	0	4	82	13	0
2000	933	66	0.071	0	6	0	0	80	0	0	14	0	0	0	6	80	14	0
2001	959	151	0.157	0	3	0	3	88	0	1	5	0	0	0	6	89	5	0
2002	728	165	0.227	1	10	0	12	72	1	1	3	0	0	1	22	73	4	0
2003	704	147	0.209	1	14	0	12	69	1	0	4	0	0	1	26	69	5	0
2004	768	121	0.157	1	11	0	0	86	0	0	2	0	0	1	11	86	2	0
2005	781	63	0.081	2	13	0	5	79	0	0	2	0	0	2	18	79	2	0
2006	585	50	0.085	0	8	0	0	88	0	0	4	0	0	0	8	88	4	0
2007	634	62	0.098	0	3	0	2	90	0	3	2	0	0	0	5	93	2	0
2008	604	83	0.137	0	4	0	35	59	0	0	2	0	0	0	39	59	2	0
2009	648	79	0.122	0	4	0	0	95	0	0	1	0	0	0	4	95	1	0
2010	601	29	0.048	0	28	0	7	66	0	0	0			0	35	66	0	
2011	601	29	0.048	3	34	0	7	55		0				3	41	55		
2012	173	5	0.029	0	40		60							0	100			
2013	186	1	0.005	100										100				
Total	**14,840**	**2,520**																
Mean			**0.389**	**0**	**11**	**0**	**4**	**68**	**2**	**0**	**4**	**0**	**0**	**0**	**15**	**68**	**6**	**0**

Means includes year classes with complete return data (year classes of 2010 and later).

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

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

Year	Total Fry (10,000s)	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	3	3	1.034	0	100	0	0	0	0	0	0	0	0	0	100	0	0	0
1980	20	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1981	2	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	17	15	0.902	0	0	0	0	87	13	0	0	0	0	0	0	87	13	0
1983	16	1	0.064	0	100	0	0	0	0	0	0	0	0	0	100	0	0	0
1984	13	2	0.156	0	0	0	0	50	0	0	50	0	0	0	0	50	50	0
1985	14	12	0.881	0	0	0	0	100	0	0	0	0	0	0	0	100	0	0
1986	8	1	0.126	0	0	0	0	100	0	0	0	0	0	0	0	100	0	0
1987	7	5	0.740	0	0	0	0	80	0	0	20	0	0	0	0	80	20	0
1988	33	13	0.391	0	0	0	0	100	0	0	0	0	0	0	0	100	0	0
1989	28	19	0.680	0	63	0	11	26	0	0	0	0	0	0	74	26	0	0
1990	27	11	0.407	0	45	0	0	45	0	0	9	0	0	0	45	45	9	0
1991	37	2	0.054	0	50	0	0	0	0	0	50	0	0	0	50	0	50	0
1992	55	15	0.271	0	20	0	0	67	0	0	13	0	0	0	20	67	13	0
1993	77	52	0.673	0	13	0	6	77	0	0	4	0	0	0	19	77	4	0
1994	110	49	0.447	0	31	0	4	63	0	0	2	0	0	0	35	63	2	0
1995	115	42	0.367	2	38	0	5	52	0	0	2	0	0	2	43	52	2	0
1996	91	19	0.208	0	58	0	11	26	0	0	5	0	0	0	69	26	5	0
1997	148	4	0.027	0	0	0	0	100	0	0	0	0	0	0	0	100	0	0
1998	119	2	0.017	0	0	0	0	100	0	0	0	0	0	0	0	100	0	0
1999	99	2	0.020	0	0	0	0	50	0	0	50	0	0	0	0	50	50	0

Means includes year classes with complete return data (year classes of 2010 and later).

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

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

2000	125	9	0.072	0	0	0	0	89	0	0	11	0	0	0	0	89	11	0
2001	125	12	0.096	0	8	0	17	75	0	0	0	0	0	0	25	75	0	0
2002	119	22	0.185	5	5	0	14	77	0	0	0	0	0	5	19	77	0	0
2003	112	8	0.071	0	38	0	25	38	0	0	0	0	0	0	63	38	0	0
2004	118	11	0.093	0	18	0	0	82	0	0	0	0	0	0	18	82	0	0
2005	124	12	0.097	0	58	0	8	33	0	0	0	0	0	0	66	33	0	0
2006	86	5	0.058	0	60	0	0	40	0	0	0	0	0	0	60	40	0	0
2007	91	9	0.099	0	11	0	0	78	0	11	0	0	0	0	11	89	0	0
2008	88	8	0.091	0	0	0	38	62	0	0	0	0	0	0	38	62	0	0
2009	82	4	0.049	0	0	0	0	100	0	0	0	0	0	0	0	100	0	0
2010	85	4	0.047	0	25	0	0	75	0	0	0			0	25	75	0	
2011	76	0	0.000	0	0	0	0	0		0				0	0	0		
2012	35	0	0.000	0	0		0							0	0			
2013	56	0	0.000	0										0				
Total	**2,361**	**373**																
Mean			**0.270**	**0**	**23**	**0**	**4**	**58**	**0**	**0**	**7**	**0**	**0**	**0**	**28**	**58**	**7**	**0**

Means includes year classes with complete return data (year classes of 2010 and later).

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

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

Year	Total Fry (10,000s)	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	4	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1976	6	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	7	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	11	18	1.698	0	0	0	0	11	33	22	28	6	0	0	0	33	61	6
1979	8	43	5.584	0	0	0	0	84	5	2	9	0	0	0	0	86	14	0
1980	13	42	3.333	0	0	0	0	19	5	19	52	5	0	0	0	38	57	5
1981	6	78	13.684	0	0	0	6	81	0	5	8	0	0	0	6	86	8	0
1982	5	48	9.600	0	0	2	2	77	8	0	10	0	0	0	2	79	18	0
1983	1	23	27.479	0	4	4	17	65	4	0	4	0	0	0	21	69	8	0
1984	53	47	0.894	0	13	0	4	77	2	0	4	0	0	0	17	77	6	0
1985	15	59	3.986	0	2	0	7	69	2	0	20	0	0	0	9	69	22	0
1986	52	111	2.114	0	11	0	0	77	1	0	9	0	2	0	11	77	10	2
1987	108	264	2.449	0	2	0	9	85	0	0	4	0	0	0	11	85	4	0
1988	172	93	0.541	1	5	0	0	90	0	0	3	0	0	1	5	90	3	0
1989	103	45	0.435	2	7	0	31	60	0	0	0	0	0	2	38	60	0	0
1990	98	21	0.215	5	0	0	10	81	0	0	5	0	0	5	10	81	5	0
1991	146	17	0.117	0	6	0	6	76	12	0	0	0	0	0	12	76	12	0
1992	112	15	0.134	0	0	0	0	93	7	0	0	0	0	0	0	93	7	0
1993	116	11	0.095	0	0	0	27	45	0	9	18	0	0	0	27	54	18	0
1994	282	53	0.188	0	0	0	13	85	0	0	2	0	0	0	13	85	2	0
1995	283	87	0.308	0	0	0	22	72	0	6	0	0	0	0	22	78	0	0

Means includes year classes with complete return data (year classes of 2010 and later).

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

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

1996	180	27	0.150	0	0	0	15	85	0	0	0	0	0	0	15	85	0	0
1997	200	4	0.020	0	0	0	25	75	0	0	0	0	0	0	25	75	0	0
1998	259	8	0.031	0	0	0	25	75	0	0	0	0	0	0	25	75	0	0
1999	176	8	0.046	0	0	0	12	50	0	0	38	0	0	0	12	50	38	0
2000	222	12	0.054	0	0	0	0	100	0	0	0	0	0	0	0	100	0	0
2001	171	5	0.029	0	0	0	40	20	0	0	40	0	0	0	40	20	40	0
2002	141	8	0.057	0	0	0	0	88	12	0	0	0	0	0	0	88	12	0
2003	133	20	0.150	0	0	0	30	60	5	0	0	5	0	0	30	60	5	5
2004	156	35	0.225	0	0	0	3	83	3	6	6	0	0	0	3	89	9	0
2005	96	33	0.343	0	0	0	9	79	3	0	6	0	3	0	9	79	9	3
2006	101	16	0.158	0	0	0	6	25	31	0	31	0	0	0	6	25	68	0
2007	114	100	0.877	0	1	0	7	84	3	3	2	0	0	0	8	87	5	0
2008	177	32	0.181	0	0	0	22	78	0	0	0	0	0	0	22	78	0	0
2009	105	13	0.124	0	0	0	8	92	0	0	0	0	0	0	8	92	0	0
2010	148	8	0.054	0	0	0	0	88	12	0	0			0	0	88	12	
2011	89	5	0.056	0	60	0	0	40		0				0	60	40		
2012	102	0	0.000	0	0		0							0	0			
2013	11	0	0.000	0										0				
Total	**4,182**	**1,409**																
Mean			**2.151**	**0**	**1**	**0**	**10**	**64**	**4**	**2**	**9**	**0**	**0**	**0**	**12**	**66**	**13**	**1**

Means includes year classes with complete return data (year classes of 2010 and later).

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

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

Year	Total Fry (10,000s)	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
1982	0	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	1	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	15	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	38	3	0.078	0	0	0	0	100	0	0	0	0	0	0	0	100	0	0
1994	56	2	0.036	0	0	0	0	100	0	0	0	0	0	0	0	100	0	0
1995	37	5	0.136	0	0	0	20	80	0	0	0	0	0	0	20	80	0	0
1996	29	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1997	10	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1998	91	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1999	59	5	0.085	0	0	20	0	80	0	0	0	0	0	0	0	100	0	0
2000	33	2	0.061	0	50	0	0	50	0	0	0	0	0	0	50	50	0	0
2001	42	2	0.047	0	0	0	0	100	0	0	0	0	0	0	0	100	0	0
2002	40	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2003	31	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2004	56	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2005	1	1	1.923	0	0	0	0	0	0	0	100	0	0	0	0	0	100	0
2006	8	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2007	12	2	0.173	0	0	0	0	100	0	0	0	0	0	0	0	100	0	0
2008	31	3	0.096	0	33	0	0	67	0	0	0	0	0	0	33	67	0	0
2009	9	2	0.234	0	0	0	0	100	0	0	0	0	0	0	0	100	0	0

Means includes year classes with complete return data (year classes of 2010 and later).

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

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

2010	29	0	0.000	0	0	0	0	0	0	0	0			0	0	0	0	
2011	1	0	0.000	0	0	0	0	0		0				0	0	0		
2012	1	0	0.000	0	0		0							0	0			
2013	1	0	0.000	0										0				
Total	**631**	**27**																
Mean			**0.137**	**0**	**4**	**1**	**1**	**37**	**0**	**0**	**5**	**0**	**0**	**0**	**5**	**38**	**5**	**0**

Means includes year classes with complete return data (year classes of 2010 and later).

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

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

Year	Total Fry (10,000s)	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
1987	12	2	0.165	0	100	0	0	0	0	0	0	0	0	0	100	0	0	0
1988	4	3	0.693	0	0	0	0	100	0	0	0	0	0	0	0	100	0	0
1989	11	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	4	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	5	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	12	4	0.322	0	50	0	0	50	0	0	0	0	0	0	50	50	0	0
1993	11	2	0.190	0	0	0	0	100	0	0	0	0	0	0	0	100	0	0
1994	24	4	0.166	0	25	0	0	75	0	0	0	0	0	0	25	75	0	0
1995	24	1	0.041	0	0	0	0	100	0	0	0	0	0	0	0	100	0	0
1996	25	15	0.607	0	20	0	33	47	0	0	0	0	0	0	53	47	0	0
1997	22	3	0.134	0	33	0	0	67	0	0	0	0	0	0	33	67	0	0
1998	26	1	0.039	0	0	0	0	100	0	0	0	0	0	0	0	100	0	0
1999	13	6	0.454	0	0	0	0	100	0	0	0	0	0	0	0	100	0	0
2000	28	3	0.108	0	100	0	0	0	0	0	0	0	0	0	100	0	0	0
2001	25	4	0.160	0	0	0	0	100	0	0	0	0	0	0	0	100	0	0
2002	26	21	0.799	0	10	0	24	67	0	0	0	0	0	0	34	67	0	0
2003	25	13	0.526	8	38	0	8	46	0	0	0	0	0	8	46	46	0	0
2004	28	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2005	26	2	0.076	0	0	0	0	100	0	0	0	0	0	0	0	100	0	0
2006	25	3	0.119	0	33	0	0	67	0	0	0	0	0	0	33	67	0	0
2007	28	5	0.178	0	0	0	0	100	0	0	0	0	0	0	0	100	0	0

Means includes year classes with complete return data (year classes of 2010 and later).

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

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

2008	27	22	0.821	0	0	0	36	64	0	0	0	0	0	0	36	64	0	0
2009	24	2	0.085	0	0	0	0	100	0	0	0	0	0	0	0	100	0	0
2010	28	4	0.143	0	50	0	25	25	0	0	0			0	75	25	0	
2011	24	0	0.000	0	0	0	0	0		0				0	0	0		
2012	15	0	0.000	0	0		0							0	0			
2013	21	0	0.000	0										0				
Total	**543**	**120**																
Mean			**0.247**	**0**	**18**	**0**	**4**	**60**	**0**	**0**	**0**	**0**	**0**	**0**	**22**	**60**	**0**	**0**

Means includes year classes with complete return data (year classes of 2010 and later).

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

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

Year	Total Fry (10,000s)	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	1	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	11	1	0.095	0	0	0	0	100	0	0	0	0	0	0	0	100	0	0
1990	27	4	0.146	0	25	0	0	75	0	0	0	0	0	0	25	75	0	0
1991	81	8	0.099	0	0	0	0	75	0	0	25	0	0	0	0	75	25	0
1992	40	15	0.373	0	0	0	0	93	0	0	7	0	0	0	0	93	7	0
1993	66	37	0.559	0	0	0	0	100	0	0	0	0	0	0	0	100	0	0
1994	67	44	0.652	0	0	0	2	91	0	0	7	0	0	0	2	91	7	0
1995	88	17	0.192	0	0	0	18	82	0	0	0	0	0	0	18	82	0	0
1996	71	12	0.170	0	0	0	8	92	0	0	0	0	0	0	8	92	0	0
1997	91	6	0.066	0	0	0	0	100	0	0	0	0	0	0	0	100	0	0
1998	102	8	0.078	0	0	0	25	62	0	0	12	0	0	0	25	62	12	0
1999	71	4	0.056	0	0	0	0	75	0	0	25	0	0	0	0	75	25	0
2000	84	11	0.131	0	9	0	0	73	0	0	18	0	0	0	9	73	18	0
2001	107	20	0.188	0	5	0	5	90	0	0	0	0	0	0	10	90	0	0
2002	89	34	0.381	0	15	0	6	79	0	0	0	0	0	0	21	79	0	0
2003	81	23	0.284	0	17	0	9	70	0	0	4	0	0	0	26	70	4	0
2004	93	36	0.389	0	11	0	0	86	0	0	3	0	0	0	11	86	3	0
2005	84	1	0.012	0	0	0	100	0	0	0	0	0	0	0	100	0	0	0
2006	73	5	0.069	0	0	0	0	80	0	0	20	0	0	0	0	80	20	0
2007	57	5	0.088	0	0	0	0	80	0	0	20	0	0	0	0	80	20	0
2008	63	9	0.143	0	0	0	44	44	0	0	11	0	0	0	44	44	11	0

Means includes year classes with complete return data (year classes of 2010 and later).

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

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

2009	65	11	0.170	0	9	0	0	82	0	0	9	0	0	0	9	82	9	0
2010	60	2	0.033	0	0	0	0	100	0	0	0			0	0	100	0	
2011	59	1	0.017	100	0	0	0	0		0				100	0	0		
2012	39	0	0.000	0	0		0							0	0			
2013	47	0	0.000	0										0				
Total	**1,717**	**314**																
Mean			**0.197**	**0**	**4**	**0**	**10**	**74**	**0**	**0**	**7**	**0**	**0**	**0**	**14**	**74**	**7**	**0**

Means includes year classes with complete return data (year classes of 2010 and later).

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

Appendix 18.8: Return rates for Atlantic salmon that were stocked as fry in the Penobscot River .

Year	Total Fry (10,000s)	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	10	76	8.000	0	0	0	39	33	7	1	20	0	0	0	39	34	27	0
1981	20	410	20.297	0	0	0	6	79	1	2	11	0	0	0	6	81	12	0
1982	25	478	19.274	0	0	0	4	89	1	2	5	0	0	0	4	91	6	0
1984	8	103	12.875	0	0	0	24	64	1	5	3	0	0	0	24	69	7	0
1985	20	171	8.680	0	0	0	11	62	2	6	19	0	0	0	11	68	21	0
1986	23	332	14.690	0	0	0	20	62	0	5	13	0	0	0	20	67	13	0
1987	33	603	18.108	0	0	0	15	72	0	2	12	0	0	0	15	74	12	0
1988	43	219	5.081	0	0	0	16	78	0	0	6	0	0	0	16	78	6	0
1989	8	112	14.545	0	0	0	20	75	0	3	3	0	0	0	20	78	3	0
1990	32	118	3.722	0	0	0	19	76	0	3	3	0	0	0	19	79	3	0
1991	40	126	3.166	0	0	0	30	59	2	0	9	0	0	0	30	59	11	0
1992	92	315	3.405	0	0	0	2	93	1	1	4	0	0	0	2	94	5	0
1993	132	158	1.197	0	0	0	5	89	0	1	4	0	0	0	5	90	4	0
1994	95	153	1.612	0	0	0	1	82	0	4	12	0	0	0	1	86	12	0
1995	50	132	2.629	0	0	0	19	67	0	5	8	0	0	0	19	72	8	0
1996	124	117	0.942	0	0	0	36	50	2	7	6	0	0	0	36	57	8	0
1997	147	115	0.781	0	0	0	7	79	1	8	5	0	0	0	7	87	6	0
1998	93	49	0.527	0	0	0	24	71	0	0	2	2	0	0	24	71	2	2
1999	150	79	0.527	0	0	0	18	70	3	0	10	0	0	0	18	70	13	0
2000	51	63	1.228	0	0	0	10	81	0	2	8	0	0	0	10	83	8	0
2001	36	24	0.659	0	0	0	17	71	0	8	4	0	0	0	17	79	4	0

Means includes year classes with complete return data (year classes of 2010 and later).

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

Appendix 18.8: Return rates for Atlantic salmon that were stocked as fry in the Penobscot River .

2002	75	40	0.536	0	0	0	10	80	0	0	10	0	0	0	10	80	10	0
2003	74	106	1.430	0	0	0	14	79	0	2	5	0	0	0	14	81	5	0
2004	181	117	0.646	0	0	0	28	64	1	0	7	0	0	0	28	64	8	0
2005	190	91	0.479	0	0	0	25	73	0	2	0	0	0	0	25	75	0	0
2006	151	78	0.517	0	0	0	13	68	1	4	14	0	0	0	13	72	15	0
2007	161	220	1.370	0	0	0	9	86	0	0	4	0	0	0	9	86	4	0
2008	125	104	0.834	0	0	0	42	58	0	0	0	0	0	0	42	58	0	0
2009	102	50	0.489	0	0	0	10	88	0	0	2	0	0	0	10	88	2	0
2010	100	27	0.270	0	0	0	11	74	0	4	11			0	11	78	11	
2011	95	51	0.536	0	0	0	0	96		4				0	0	100		
2012	107	7	0.065	0	0		100							0	100			
2013	72	0	0.000	0										0				
Total	**2,665**	**4,844**																
Mean			**5.112**	**0**	**0**	**0**	**17**	**72**	**1**	**3**	**7**	**0**	**0**	**0**	**17**	**75**	**8**	**0**

Means includes year classes with complete return data (year classes of 2010 and later).

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

Appendix 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							
	MK	PW	CT	CTAH	SAL	FAR	WE	PN
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		8.000
1980	3.333		0.630	2.022		0.000		
1981	13.684		1.129	1.261		0.000		20.297
1982	9.600	0.000	1.565	2.429		0.902		19.274
1983	27.479		0.108	0.143		0.064		
1984	0.894		0.051	0.022		0.156		12.875
1985	3.986	0.000	1.113	1.224		0.881		8.680
1986	2.114		1.592	2.791		0.126		14.690
1987	2.449	0.000	0.436	0.449	0.165	0.740		18.108
1988	0.541	0.000	0.825	0.992	0.693	0.391	0.000	5.081
1989	0.435		0.539	0.629	0.000	0.680	0.095	14.545
1990	0.215		0.505	0.693	0.000	0.407	0.146	3.722
1991	0.117		0.159	0.255	0.000	0.054	0.099	3.166
1992	0.134		0.587	0.904	0.322	0.271	0.373	3.405
1993	0.095	0.078	0.446	0.361	0.190	0.673	0.559	1.197
1994	0.188	0.036	0.492	0.502	0.166	0.447	0.652	1.612
1995	0.308	0.136	0.210	0.184	0.041	0.367	0.192	2.629
1996	0.150	0.000	0.151	0.115	0.607	0.208	0.170	0.942
1997	0.020	0.000	0.043	0.041	0.134	0.027	0.066	0.781
1998	0.031	0.000	0.048	0.050	0.039	0.017	0.078	0.527
1999	0.046	0.085	0.070	0.072	0.454	0.020	0.056	0.527
2000	0.054	0.061	0.071	0.062	0.108	0.072	0.131	1.228
2001	0.029	0.047	0.157	0.165	0.160	0.096	0.188	0.659
2002	0.057	0.000	0.227	0.179	0.799	0.185	0.381	0.536
2003	0.150	0.000	0.209	0.211	0.526	0.071	0.284	1.430
2004	0.225	0.000	0.157	0.141	0.000	0.093	0.389	0.646
2005	0.343	1.923	0.081	0.089	0.076	0.097	0.012	0.479
2006	0.158	0.000	0.085	0.093	0.119	0.058	0.069	0.517
2007	0.877	0.173	0.098	0.095	0.178	0.099	0.088	1.370
2008	0.181	0.096	0.137	0.104	0.821	0.091	0.143	0.834

Year Stocked	Number of adult returns per 10,000 fry stocked							
	MK	**PW**	**CT**	**CTAH**	**SAL**	**FAR**	**WE**	**PN**
2009	0.124	0.234	0.122	0.129	0.085	0.049	0.170	0.489
2010	0.054	0.000	0.048	0.047	0.143	0.047	0.033	0.270
2011	0.056	0.000	0.048	0.027	0.000	0.000	0.017	0.536
2012	0.000	0.000	0.029	0.000	0.000	0.000	0.000	0.065
2013	0.000	0.000	0.005	0.000	0.000	0.000	0.000	0.000
Mean	**2.211**	**0.132**	**0.397**	**0.505**	**0.254**	**0.278**	**0.199**	**5.277**
StDev	**5.344**	**0.425**	**0.459**	**0.717**	**0.269**	**0.306**	**0.178**	**6.515**

Note: MK = Merrimack, PW = Pawcatuck, CT = Connecticut (basin), CTAH = Connecticut (above Holyoke), SAL = Salmon, FAR = Farmington, WE = Westfield, PN = Penobscot. Fry return rates for the Penobscot River are likely an over estimate because they include returns produced from spawning in the wild. Other Maine rivers are not included in this table until adult returns from natural reproduction and fry stocking can be distinguished. Return rates (returns/10,000 fry) are calculated from stocked fry numbers and do not include any natural fry production.

Note: Summary mean and standard deviation computations only include year classes with complete return data (2006 and earlier).

Appendix 20. Summary of age distributions of adult Atlantic salmon that were stocked in 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	9	0	4	78	4	0	4	0	0	0	13	79	8	0
Connecticut (basin)	3	14	0	6	76	2	0	5	0	0	3	20	76	6	0
Farmington	0	25	0	5	62	0	0	7	0	0	0	29	63	8	0
Merrimack	0	3	0	10	70	4	2	9	1	0	0	14	72	14	1
Pawcatuck	0	8	2	2	78	0	0	10	0	0	0	10	80	10	0
Penobscot	0	0	0	19	73	1	3	7	0	0	0	19	76	8	0
Salmon	0	23	0	6	70	0	0	0	0	0	0	29	70	0	0
Westfield	4	4	0	9	75	0	0	7	0	0	4	13	75	7	0
Overall Mean:	**1**	**11**	**0**	**8**	**73**	**1**	**1**	**6**	**0**	**0**	**1**	**19**	**74**	**8**	**0**

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

Update on Coastal Maine
Atlantic Salmon Smolt Telemetry Studies: 2015

Graham S. Goulette[1], James P. Hawkes[1], and Paul Christman[2]

[1]NOAA Fisheries Service
NEFSC/Maine Field Station
17 Godfrey Drive Suite #1
Orono, ME 04473

[2]Department of Marine Resources
Division of Sea Run Fisheries and Habitat
21 State House Station
Augusta, ME 04333

Abstract
In 2015, we tagged naturally-reared smolts (n = 50) collected in the Sandy River (a Kennebec River tributary) and released them into the Kennebec River from May 9 to May 22. Movements were monitored via a moored acoustic receiver network through the non-hydro freshwater portion, Merrymeeting Bay, and estuarine environments. Median fork length was 160 mm and median weight was 38.7 g. Preliminary estimates of smolt survival to the Gulf of Maine were 0.32 (95% CL 0.23-0.42). Smolt emigration averaged 5.5 days from release to the outermost array - a distance of about 92 km. Freshwater movements were predominantly nocturnal while movements lower in the system appeared to have been influenced by tidal stage.

INTRODUCTION

NOAA's National Marine Fisheries Service (NOAA) has been evaluating emigrating smolt dynamics via acoustic telemetry since 1997 (Kocik et al. 2009). Initial studies were of native populations in the Narraguagus River and have since expanded to other rivers and varying age classes of both naturally-reared and hatchery-origin smolts. After surgically implanting acoustic transmitters into smolts, NOAA biologists monitor smolt movements throughout river, estuary, and near shore systems using a stationary receiver network and mobile tracking receivers to confirm fates. Specific to the Kennebec telemetry study, we evaluated survival and performance of smolts from egg-planted (naturally-reared) origin. This is the first evaluation of lower-river and estuary ecology of smolts reared from this recovery strategy. This method is the primary conservation hatchery restoration strategy in the Kennebec and has been successful in producing relatively high densities of Atlantic salmon parr. The project also provides us with novel information in the Kennebec system in regards to smolt movements – especially within the estuary.

TELEMETRY STUDY OBJECTIVES 2014-2015

1) Describe biometrics of tagged smolts relative to overall population.

2) Quantify migration success and identify areas of high mortality of these smolts.
3) Describe migration behavior of smolts through the Kennebec Estuary.

METHODS

STUDY AREA -
The Sandy River is one of the largest tributaries within the Kennebec River watershed and contributes 1,528 sq. km of drainage to the system. The entire Kennebec watershed drains an area of 15,358 sq. km (Maine Basin Report 2007). The mainstem originates from Moosehead Lake and travels 233 km to Merrymeeting Bay. The portion of estuary that includes Merrymeeting Bay is almost entirely freshwater (during low flows and high tides, the salt wedge may intrude into the bay). Below Merrymeeting Bay the remainder of the Kennebec Estuary is brackish with salt wedge intrusion dependent on flows and tide height (Hayden 1998). We categorized our study area into four segments; 1) non-tidal freshwater (river km 99 – 72), tidal freshwater (river km 72 – 49), Merrymeeting Bay (river km 49 – 31), and lower Kennebec Estuary (river km 31 – 7) (Figure 1).

ARRAY DESIGN
Kennebec River/Estuary Telemetry Network
Twenty-eight VEMCO VR2W receivers were deployed throughout the Kennebec River, Merrymeeting Bay, and Kennebec Estuary as part of a collaborative effort between the Maine Department of Marine Resources (ME-DMR) and NOAA (Figure 1). ME-DMR deployed 17 receivers in the freshwater portions of the Kennebec River and lower Kennebec Esutary. We deployed 2 receivers below the release site and 9 receivers in Merrymeeting Bay, around the Chops and lower Kennebec Estuary.

We deployed all receivers in the Kennebec system on 6 May (ME-DMR deployed all their receivers between 28 April and 11 May). We first tended and downloaded all units in the NOAA array on 20 May and again 4 June. We retrieved the majority of our receivers on 25 June. All remaining receivers (ME-DMR and NOAA) were retrieved in the fall.

TAGGING
We surgically implanted V9-6L 69 kHz (A69-1601) serial coded acoustic VEMCO transmitters into study smolts (NOAA Field Protocols, 2006). The V9-6L transmitters were 21mm x 9mm and had air/water weights of 2.9g/1.6g (VEMCO, 2015). Each transmitter was programmed to emit a unique coded electronic pulse every 20 to 40 seconds for the first 35 days and switch to 60 to 80 seconds for the remainder of the battery life with a minimum projection of 147 total days. To ensure transmitters were functioning properly, we conducted a 24h water submersion test prior to surgery. We also confirmed transmitters were functioning post-surgery using a VR100 receiver during post-surgery fish recovery.

Smolts were collected using a 2.4 m rotary screw trap on the Sandy River – supplied by NOAA Fisheries and operated by Brookfield Renewable Energy staff. Surgeries were conducted streamside to implant tags then smolts were trucked to Waterville and released below Lockwood Dam, the last hydro project on the Kennebec, allowing assessment of fish migration to the sea without dam impediments.

We tagged smolts greater than 145 mm fork length (FL) following standard operating procedures (NOAA Field Protocols, 2006). Prior to surgery, we collected scale samples and genetic tissue and measured fork length (mm) and wet weight (g) from all smolts. Once we completed surgeries, tagged smolts were held in an aerated 170 l cooler for 1.0 to 3.5 hours before we released them at the Waterville boat ramp in the Kennebec River 1.9 km downstream of Lockwood Dam (Figure 1). At completion of this study phase, a more comprehensive evaluation of group and individual performance and migration ecology will be synthesized in a manuscript.

ANALYSIS

We calculated descriptive statistics on fork length, weight, condition factor, and percent transmitter to body weight (in air, g) of groups. Age data from scale samples were assigned at the image analysis lab in Woods Hole, MA.

We modeled survivorship (Φ) and detection efficiency (ρ) probabilities between monitoring sites using the Cormack-Jolly-Seber (CJS) release-recapture model (Seber 1982). Parameters were estimated from complete capture histories at multiple sites, without removals in Program MARK (White et al. 1982). In this interim report, the efficiency of the outer array (terminal capture location) is assumed to be equal to survival as a standard output (Seber 1982). The cumulative survival from the Sidney site (river km 86.8) to the outer array (and entry into the Gulf of Maine) was simulated for a standard population of 10,000 smolts using survival at each receiver or array benchmark downstream within the program @Risk. We then modeled the site-specific mortality of the group using a PERT distribution of survival estimates with the associated 95% confidence limits for each location derived from MARK. The simulation took a random draw from each site-specific survival parameter to estimate fish alive at that site and the entire model sequence was repeated 10,000 times to generate the estimates and error bounds.

We calculated swim speeds (body lengths per second -bl^{-sec}) by taking a total distance value and dividing by individual smolt length then dividing the product by travel time for each defined distance. We calculated total migration time (days) for successful smolts by subtracting the first detection at the outermost array (Mill Cove – river km 7.38) from the release date and time. We summarized diurnal movement patterns using the first detection at each VR unit or array and identifying the time of day that corresponds with sunrise/sunset data taken from http://aa.usno.navy.mil/. We summarized tidal use patterns by first detection data at each VR unit or array and the corresponding tidal stage of each detection taken from http://tbone.biol.sc.edu/tide/sitesel.html. Diurnal and tidal movements are collected from smolts traveling downstream only (i.e. smolt movements during reversals were not analyzed).

RESULTS

TAGGING AND RELEASE

We performed surgeries and released smolts between 9 May and 22 May. Naturally-reared smolts (n = 50) had a median fork length of 160 (Min 145 – Max 184) mm, median wet weight of 38.7 (Min 28.0 – Max 60.1) g and a median condition factor of 0.97 (Min 0.83 – Max 1.09). The median proportion of tag weight to smolt body weight (in air) was 7.5 (Min 4.8 – Max 10.4) %. Tagged smolt ages were 86% two year olds, 12% three year olds and 2% four year olds. The age frequency of tagged smolts was representative of the total number of smolts captured (85% 2 year olds, 14% 3 year olds, <1% 4 year olds and <1% unknown.

SURVIVORSHIP AND ARRAY EFFICENCY

We summarized survival and array efficiencies calculated in MARK in Table 1. To account for surgical effects and delayed mortality, our assessment of survival starts at the Sidney site (river km 86.8). This may be revised in final models as we evaluate post-surgical dynamics. From the Sidney site, our initial estimates of cumulative survival of smolts to the outer Mill Cove Array was estimated to be 0.32 (95% CL 0.23 - 0.42). Survival rates at each site, as measured by the PERT distribution are described in Table1c. These estimates should be considered preliminary. However, these reported survival rates are slightly lower than those reported for naturally-reared smolts in the Narraguagus River (Kocik et al. 2009) and Penobscot River across most years (NOAA unpublished data).

SWIM SPEED AND MIGRATION TIME

Median swim speeds, by river reach, of successful migrants in 2015 ranged between 0.7 and 5.4 bl^{-sec} (Figure 2). Upon initial migration, swim speeds were rapid through the non-tidal freshwater section (river km 86.8 – 71.5) at 3.7 bl^{-sec}. Swim speeds dropped to ~ 2.8 bl^{-sec} for the first freshwater tidal section (river km 71.5 – 58.2) but increased in the next section to 5.4 bl^{-sec} (river km 58.2 – 49.8) before decreasing back to 2.7 bl^{-sec} for the last freshwater tidal section prior to entering the Merrymeeting Bay area (river km 49.8 – 35.5). In the first Merrymeeting Bay section just before the Chops (river km 32.5) swim speed decreased to 0.7 bl^{-sec}. Through the Chops, only one individual swim speed was calculated due to detection efficiency. After passing the Chops, median swim speeds were 1.2 and 2.2 bl^{-sec} for the remaining two sections in the lower Kennebec Estuary (river km 31.0 – 7.4).

Total mean migration time (from release to the outermost array at Mill Cove - river km 7.38) was 5.5 days (SE = 0.7). This rate equates to 16.7 km/day.

DIURNAL MOVEMENT

Smolts migrated throughout the 24h diel period but exhibited different use patterns between the upper freshwater river portions and lower reaches In the upper freshwater portion, from release to river km 58.2 most of the movement (59 -100%) was during the nighttime or low light conditions. From river km 58.2 and beyond, through the lower river, Merrymeeting Bay and lower Kennebec Estuary, daylight dominated the movements averaging 64% of the movements (33% – 82%). During this time period, daylight accounted for ~ 55% of each 24 hour period.

TIDAL MOVEMENT

Smolts utilized the slack and ebb tides through the tidal portion of the study array. In the freshwater portions above Hallowell (river km 67) flood tide movements accounted for 5 – 33% of all movements where tidal influence would have the least impact. Several river kms prior to and through the Chops (river km 54.6 – 25.4) flood tides made up 0 – 6% of the total movements with the exception of river km 32.25 being at 33%. In the remaining portion of the lower estuary (river km 25.4 – 7.38), slack and ebb tides accounted for the majority of smolt movements (50 – 73%).

ADDITIONAL REPORTING – Telemetry Tidbits

PENOBSCOT SMOLTS – SPECIES INTERACTIONS (See Hawkes et al. report)

We concluded the second year of a two year study (2013 & 2015) to investigate the interactions (spatial and temporal overlap) of acoustically tagged salmon smolts and river herring abundance and distribution during hydroacoustic surveys. This investigation was focused on specifics of migration ecology that are not used in general telemetry reporting, therefore, we have provided a brief summary of survival from that study here.

Penobscot River hatchery reared smolts (n = 100) were tagged and released on two dates during 2015, we found 90% of tagged smolts (after accounting for surgical effects and delayed mortality) successfully emigrated the estuary and reached Penobscot Bay. Median migration time from release to the outer array was 4.4 days (1.4 – 11.7).

OTN – HALIFAX LINE

Preliminary findings indicate 29% of the Kennebec smolts reached the Ocean Tracking Network's Halifax line off the coast of Nova Scotia, Canada in 2015. This number would represent about 77% of the smolts that successfully exited the Kennebec Estuary. Median timing from the last KN array to Halifax was 25.5 days (18.8 - 37.7). The numbers and timing will be analyzed further.

For the Penobscot smolts, 38% of the total number released in 2015 reached the Halifax line. These smolts represent approximately 47% of the smolts reaching Penobscot Bay. Their median migration time from last PN array to Halifax was 26.8 days (16.3 – 69.5).

ACKNOWLEDGMENTS

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Table 1. MARK estimates of survival (1a) and array efficiency (1b) for emigrating smolts. Estimates (1c) of simulated release of 10,000 smolts to estuary extent (simulated survival).

1a) Survivorship (Φ)

		Release Group 1		
Site/Array	Km Travel	Estimate	95%low	95%high
South Release	0.00	0.70	0.56	0.81
Vassalboro	5.00	1.00	1.00	1.00
Sidney	10.74	1.00	1.00	1.00
North Augusta	21.30	0.83	0.67	0.92
Augusta	23.82	0.86	0.69	0.95
Augusta Lower	25.96	1.00	1.00	1.00
Hallowell Upper	27.47	1.00	1.00	1.00
Hallowell Lower	30.50	0.97	0.70	1.00
Brown's Island	32.47	0.91	0.70	0.98
Rolling Dam	39.26	0.86	0.65	0.96
Nehumkeag	42.87	0.95	0.71	0.99
Courthouse Point	47.75	0.89	0.65	0.97
Gleasons	55.35	0.88	0.61	0.97
Abby Point	62.01	1.00	1.00	1.00
Above Chops	65.25	1.00	1.00	1.00
Below Chops	66.47	1.00	1.00	1.00
Thorne Head	69.40	1.00	1.00	1.00
Winslow Rocks	72.11	1.00	1.00	1.00
Doubling Point	76.88	1.00	1.00	1.00
Phippsburg	79.80	1.00	1.00	1.00
Ram Island	83.00	1.00	1.00	1.00
Mill Cove	90.12	0.99	0.99	0.99

1b) Efficiency (ρ)

		Release Group 1		
Site/Array	Km Travel	Estimate	95%low	95%high
South Release	0.00	0.857	0.700	0.939
Vassalboro	5.00	1.000	1.000	1.000
Sidney	10.74	1.000	1.000	1.000
North Augusta	21.30	1.000	1.000	1.000
Augusta	23.82	1.000	1.000	1.000
Augusta Lower	25.96	1.000	1.000	1.000
Hallowell Upper	27.47	1.000	1.000	1.000
Hallowell Lower	30.50	0.909	0.700	0.977
Brown's Island	32.47	1.000	1.000	1.000
Rolling Dam	39.26	1.000	1.000	1.000
Nehumkeag	42.87	1.000	1.000	1.000
Courthouse Point	47.75	1.000	1.000	1.000
Gleasons	55.35	0.786	0.506	0.929
Abby Point	62.01	1.000	1.000	1.000
Above Chops	65.25	0.429	0.206	0.684
Below Chops	66.47	0.357	0.157	0.624
Thorne Head	69.40	0.429	0.206	0.684
Winslow Rocks	72.11	0.500	0.260	0.740
Doubling Point	76.88	0.571	0.316	0.794
Phippsburg	79.80	0.714	0.439	0.889
Ram Island	83.00	0.714	0.439	0.889
Mill Cove	90.12	0.792	0.792	0.792

1c) Simulated Survival of a Release of 10,000 Smolts

		Release Group 1		
Site/Array	Km Travel	Estimate	95%low	95%high
Sidney	0.00	10,000	10,000	10,000
North Augusta	5.00	10,000	10,000	10,000
Augusta	10.74	10,000	10,000	10,000
Augusta Lower	21.30	8,171	7,351	8,897
Hallowell Upper	23.82	6,919	5,980	7,838
Hallowell Lower	25.96	6,919	5,980	7,838
Brown's Island	27.47	6,919	5,980	7,838
Rolling Dam	30.50	6,425	5,404	7,427
Nehumkeag	32.47	5,690	4,665	6,748
Courthouse Point	39.26	4,801	3,800	5,851
Gleasons	42.87	4,392	3,404	5,441
Abby Point	47.75	3,787	2,855	4,798
Above Chops	55.35	3,208	2,343	4,169
Below Chops	62.01	3,208	2,343	4,169
Thorne Head	65.25	3,208	2,343	4,169
Winslow Rocks	66.47	3,208	2,343	4,169
Doubling Point	69.40	3,208	2,343	4,169
Phippsburg	72.11	3,208	2,343	4,169
Ram Island	76.88	3,208	2,343	4,169
Mill Cove	79.80	3,208	2,343	4,169

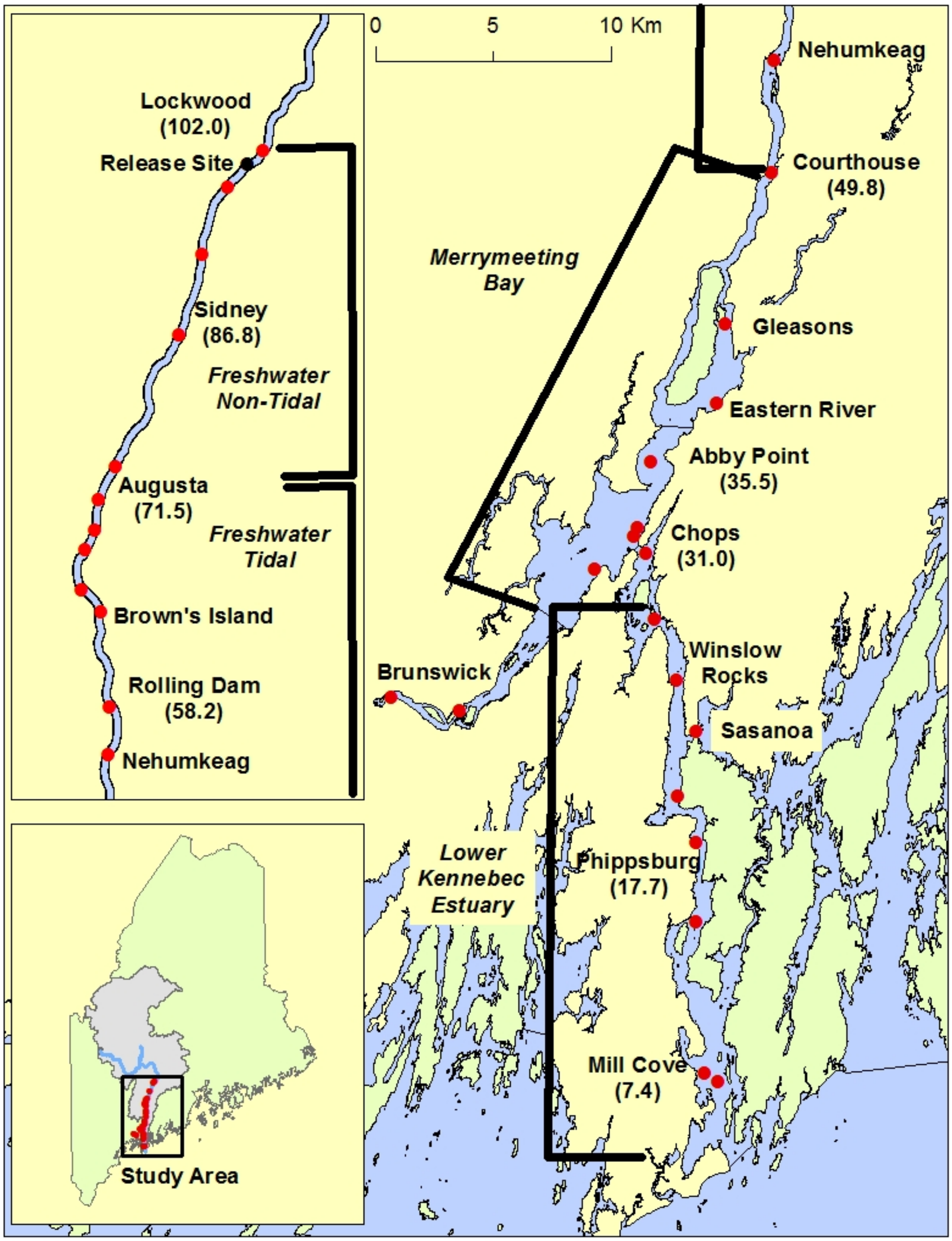

Figure 1. 2015 Kennebec telemetry array split into four sections; 1) freshwater non-tidal – release site to Augusta 2) freshwater tidal – Augusta to Courthouse Point 3) Merrymeeting Bay – Courthouse Point to Below Chops 4) lower Kennebec Estuary - below Chops to Mill Cove

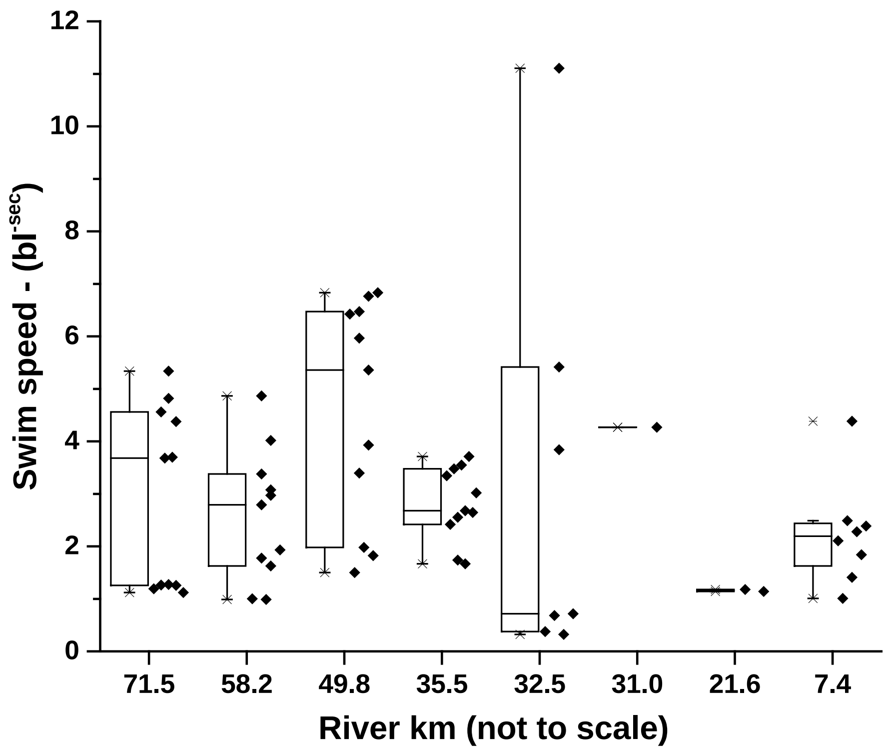

Figure 2. Swim speeds (bl^{-sec}) of successful smolts by river km. Each box-n-whisker plot represents swim speed between the river kms. The box represent 25th – 75th and whiskers represent 5th – 95th percentiles for swim speed. The horizontal lines represent median swim speeds. The diamonds to the right of the boxes represent the individual swim speed data points from detected smolts at each river km.

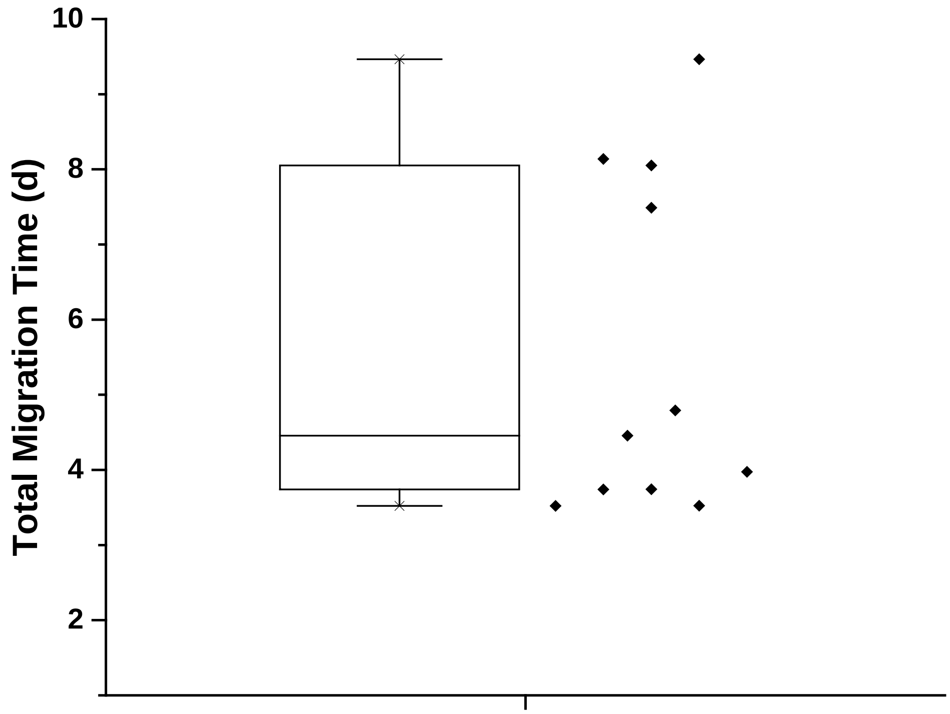

Figure 3. Total migration times of successful migrants in days (d). The box represent 25th – 75th and whiskers represent 5th – 95th percentiles of total migration times. The horizontal lines represent median times. Diamonds to the right of the box represent individual total migration time of tagged smolts in days.

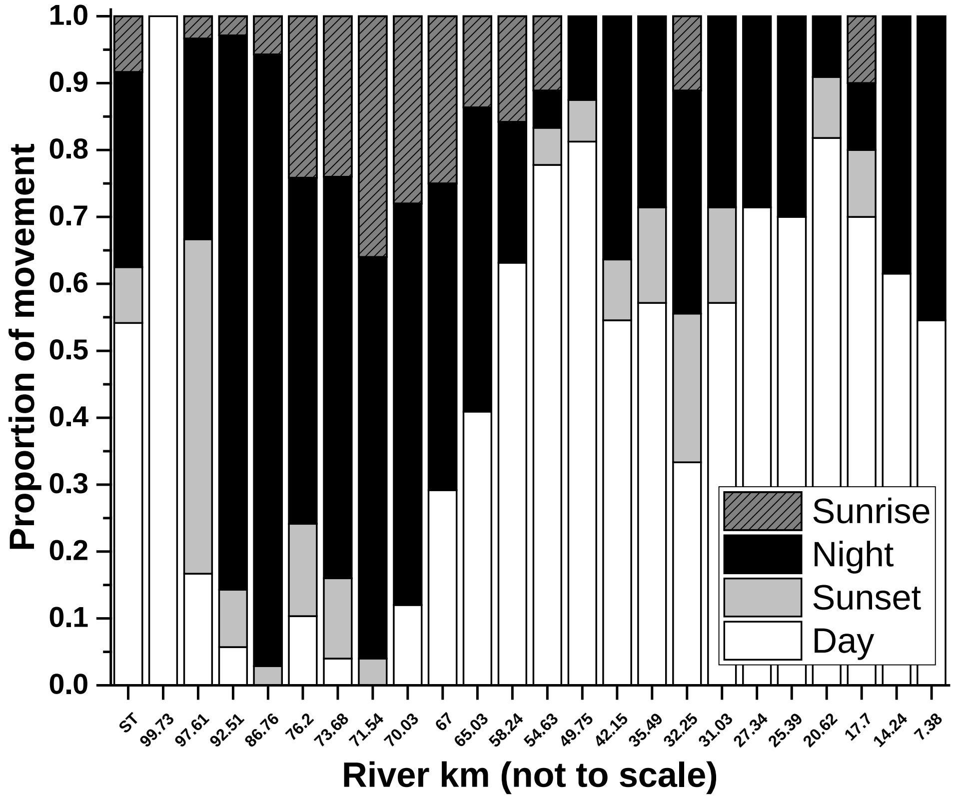

Figure 4. Diurnal data, by site, at time of initial detection of out-migrating smolts at VR locations. ST = light standard for amount of time each diurnal phase persists in a given day.

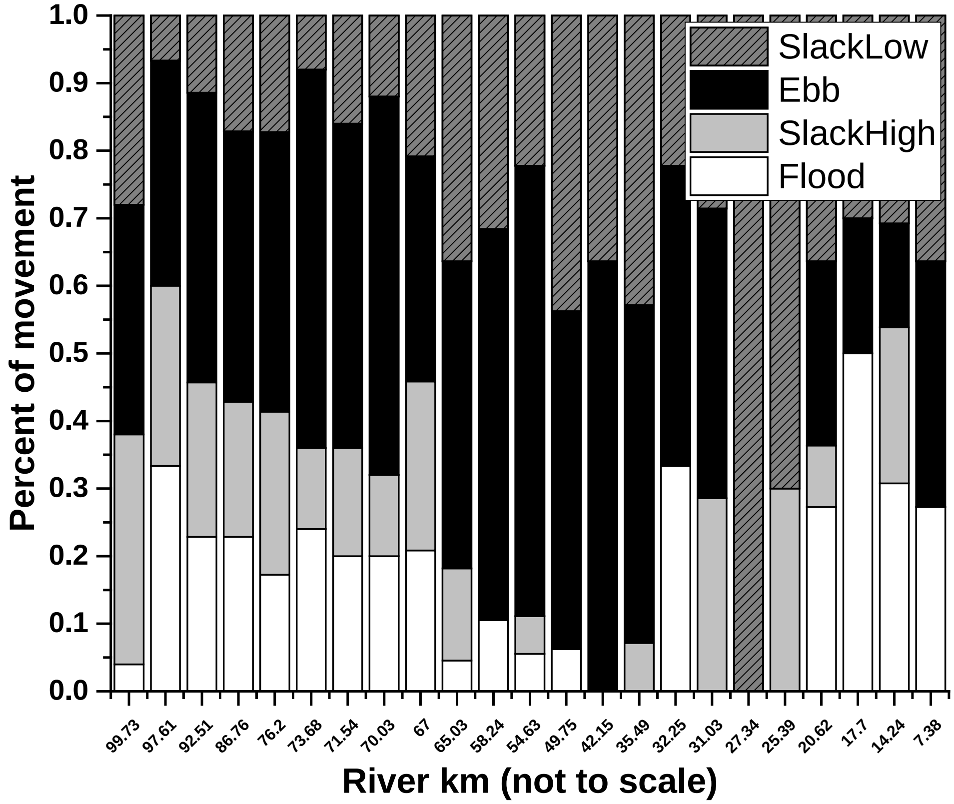

Figure 5. Tidal data, by site, at time of initial downstream detection of out-migrating smolts at VR locations.

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Update on Maine River Atlantic Salmon Smolt Studies: 2015

Colby W.B. Bruchs[1], James P. Hawkes[2], Ernest J. Atkinson[1], Christine A. Lipsky[2], Ruth Haas-Castro[3], Randy Spencer[4], Paul Christman[5] Kyle Winslow[6], and Justin Stevens[2]

[1]Department of Marine Resources
Division of Sea Run Fisheries and Habitat
317 Whitneyville Road
P.O. Box 178
Jonesboro, ME 04648

[2]NOAA's National Marine Fisheries Service
Atlantic Salmon Research Conservation Task
Maine Field Station
17 Godfrey Drive, Suite 1
Orono, Maine 04473

[3]NOAA's National Marine Fisheries Service
Atlantic Salmon Research and Conservation Task
166 Water St.
Woods Hole, MA 02543

[4]Department of Marine Resources
Division of Sea Run Fisheries and Habitat
650 State Street
Bangor, ME 04401

[5]Department of Marine Resources
Division of Sea Run Fisheries and Habitat
32 Blossom Lane
Augusta, ME 04333

[6]Downeast Salmon Federation
East Machias Aquatic Research Center
13 Willow Street
East Machias, ME 04630

Abstract. *NOAA's National Marine Fisheries Service (NOAA) and the Maine Department of Marine Resources (DMR) have conducted seasonal field activities assessing Atlantic salmon smolt populations using Rotary Screw Traps (RSTs) in selected Maine rivers since 1996. This working paper updates smolt population assessment activities conducted in 2015 and provides abundance estimates using a Darroch maximum likelihood model where mark-recapture techniques are used. DMR captured smolts using RSTs at two sites on the Narraguagus River from 28 April to 1 June. Three* *hundred and seventy-nine (379) smolts of naturally-reared (product of natural spawning, egg planting, or fry stocking) origin were handled. DMR generated a basin-wide estimate for naturally-reared smolts exiting the Narraguagus River of 1,201 ± 241, continuing the 18-year time series of estimates at the Crane Camp trapping site. DMR operated three RSTs at one site on the Sheepscot River from 2 May to 3 June, capturing 388 smolts from naturally- and hatchery-reared origins. The Sheepscot River population estimate was comprised of 572 ± 72 naturally-reared smolts and 1,055 ± 220 smolts that were the result of parr stocking. DMR operated two RSTs at one site on the Piscataquis River from 1 May to 29 May. All smolts captured (1,533) were naturally-reared resulting in an estimated emigrating population of 4,278 ± 272. In partnership with the Downeast Salmon Federation (DSF), DMR operated two RSTs at one site on the East Machias River from 27 April to 16 June. Staff captured 74 smolts resulting in a population estimate of 263 ± 51 smolts that were product of naturally-reared and parr stocked origins. Brookfield Renewable Energy Partners operated one RST on the Sandy River from 9 May to 8 June capturing 161 naturally-reared smolts.*

INTRODUCTION

Rotary Screw Traps (RSTs) are passive fish collection devices that are current-propelled, relying on spiral panels built into a screen-covered cone suspended between two pontoons. The large end of the upstream-facing cone captures oncoming flow with the lower half of the cone submerged in the water. Water pressure on the spiral panels forces the cone to turn on a central shaft. Fish migrating downstream that enter the cone are trapped by the rotating screw and are forced into a live-car (holding box) at the end of the trap (Figure 1) (E.G. Solutions 2002; Music et al. 2010). Scientists use RSTs to monitor out-migrating juvenile salmon, develop population estimates, and provide fish for related projects. A better understanding of smolt growth and survival may provide valuable information for restoration and modeling efforts used to assess Atlantic salmon populations. These data may also help researchers differentiate between mortality occurring in riverine habitats and mortality occurring in estuarine and open ocean habitats.

NOAA's National Marine Fisheries Service (NOAA) and the Maine Department of Marine Resources (DMR) have undertaken several research initiatives to identify and quantify factors that limit survival and recruitment of Atlantic salmon in Maine to determine the best strategies to recover salmon stocks. Atlantic salmon smolt studies in Maine began with the deployment of a single RST on the Narraguagus River in 1996. In 2015, DMR monitored the emigration of Atlantic salmon smolts within four watersheds. A variety of sampling designs and goals exist on each of the rivers studied. The 2015 study design consisted of four traps on the Narraguagus River, two traps on the East Machias River, two traps in the Penobscot basin, and three traps on the Sheepscot River. Brookfield Renewable Energy Partners operated one trap on the Sandy River in the Kennebec basin.

ROTARY SCREW TRAPPING STUDY OBJECTIVES:

1) Generate population estimates based on mark-recapture techniques, or enumerate out-migrating individuals.
2) Describe the biometrics (length, weight, and condition), origin, age structure, and timing of the out-migrating population.
3) Identify trends and make comparisons of biological data and samples between rivers and through the time series.

METHODS

Smolt traps were deployed shortly after ice out, usually by the second week in April, and continued fishing until five consecutive days of no capture, which is usually the first week of June (Music et al 2010). In 2015, DMR deployed nine 1.52 m (5 foot) RSTs at four sites on three Maine rivers, and two 2.44 m (8 foot) RSTs at one site on the East Machias River. One 2.44 m RST was deployed by Brookfield Renewable Energy Partners at one site on the Sandy River. All smolt traps were tended at least once daily in the morning.

During daily tends, captured smolts undergo biological sampling and measurement. Biological sample collection included measurement of length (mm) and live weight (0.1g), observation of marks, fin condition, relative smolt development, and notation of any injury or mortality. Scale samples were collected to determine age and origin. Smolt origin is defined naturally-reared (smolts produced by natural spawning, egg planting, or fry stocking) or hatchery (smolts produced by stocking age 0 parr that were raised as a directed product). Scale samples were analyzed by DMR and/or NOAA staff. Tissue samples were collected from a subset of smolts for genetic analysis. Depending on site-specific sampling plans, smolts were differentially marked or tagged to aide in mark-recapture or tracking. DMR scientists generated population estimates using program DARR 2.0.2 for R (Bjorkstedt 2005; Bjorkstedt 2010).

Assessments on the Narraguagus River were conducted using four RSTs operated by DMR at two sites (river km 11.16 and 7.65). In 2015, the upstream site operated from 29 April to 1 June and the lower site operated from 28 April to 1 June. Mark-recapture techniques were used to generate a stratified population estimate on the Narraguagus River. Smolts were marked at the upstream trapping site and released. Smolts with and without marks were then collected, enumerated and released at the lower trapping site. Mark-recapture estimates were calculated using four-day strata.

In the Sheepscot River, DMR operated three RSTs below Head of Tide Dam (river km 10.46), from 2 May to 3 June. Population estimates were obtained using mark-recapture techniques to generate a stratified population estimate. Smolts captured in the RSTs were marked, transported five kilometers upstream and released. Four-day strata were used to generate mark-recapture estimates.

DMR operated two traps on the Piscataquis River (river km 89.26) in the Penobscot basin from 1 May to 29 May. The site was operated to evaluate smolt production from natural spawning. Up to 75 smolts per day were marked, transported and released 3.2 km upriver from the RST site. Smolts not transported up river were counted, received biological sampling, and released ≥100m downstream of the traps. One-day strata were used to generate mark-recapture estimates.

DMR scientists, in partnership with the Downeast Salmon Federation (DSF), operated two 2.44 m (8 foot) RSTs at one site (river km 4.60) on the East Machias River from 27 April to 16 June. The site was operated to continue monitoring smolt production from drainage-wide stocking of age 0 parr. Population estimates were made by marking and transporting smolts approximately one kilometer upstream, where they were released. Four-day strata were used to generate mark-recapture estimates.

Brookfield Renewable Energy Partners deployed and tended one 2.44 m (8 foot) RST on the Sandy River (river km 23.80) in the Kennebec basin from 9 May to 8 June. NOAA staff collected smolt data and samples, and obtained smolts for acoustic tagging studies related to estuary and marine migration ecology (see 2015 USASAC Maine Telemetry Update). No population estimate was attempted.

RESULTS

Narraguagus River. DMR captured 379 smolts in 2015. A subset of smolts were scale sampled (n=98) and all unmarked smolts were tissue sampled (n=231). The observed age distribution of naturally-reared smolts was: 1.2% age-1, 74.1% age-2, and 24.7% age-3 (Table 5.4.5). Age 2 smolts (n=72) averaged (± S.D.) 165 ± 13 mm fork length and 42.9 ± 11.3 g live weight (Tables 5.4.6 and 5.4.7 and Figures 5.4.1 and 5.4.2). The two-site method population estimate for the total number of naturally-reared smolts was 1,201 ± 241 (Figure 5.4.3).

Sheepscot River. DMR captured 388 smolts at the Sheepscot River site. A subset of scales (n=335) and all unmarked smolts were tissue sampled (n=159). Scientists observed 218 smolts marked with an adipose clip, indicating they were of hatchery-origin stocked as age 0 parr in 2013 or 2014. Scale analysis determined fourteen smolts observed without an adipose clip were of hatchery-origin. The age distribution of naturally-reared smolts was: 96.7% age-2 and 3.3% age-3 (Table 5.4.5). Age-2 naturally-reared smolts (n=117) averaged 190 ± 15 mm fork length and 70.7 ± 16.6 g live weight (Tables 5.4.6 and 5.4.7, Figures 5.4.1 and 5.4.2). The population estimate of naturally-reared smolts was 572 ± 72. The estimate resulting from parr stocking was 1,055 ± 220. The population estimate for all smolts exiting the system was 1,558 ± 186 (Figure 5.4.3).

Piscataquis River. DMR captured 1,533 naturally-reared smolts in the Piscataquis River. A subset of scales (n=676) and no tissue samples were collected. The age distribution of naturally-reared smolts was: 39.8% age-2 and 60.2% age-3 (Table 5.4.5).

Age-2 smolts (n=269) averaged 158 ± 13 mm fork length and 37.8 ± 9.5 g live weight (Tables 5.4.6 and 5.4.7, Figures 5.4.1 and 5.4.2). The population estimate of emigrating smolts was 4,278 ± 272 (Figure 5.4.3).

East Machias River. DMR and DSF scientists captured 74 smolts in the East Machias River. All smolts were scale sampled and tissue sampled for genetics. Scientists observed 66 smolts marked with an adipose clip, indicating they were of hatchery-origin stocked as age 0 parr in 2012, 2013, or 2014. Scale analysis determined one smolt observed without an adipose clip was of hatchery-origin. The age distribution of naturally-reared smolts was: 42.9% age-2 and 57.1% age-3 (Table 5.4.5). Age-2 smolts (n=3) averaged 161 ± 11 mm fork length and 39.2 ± 8.0 g live weight (Tables 5.4.6 and 5.4.7 and Figures 5.4.1 and 5.4.2). The population estimate of naturally-reared smolts was unable to be determined due to low numbers. The estimate of smolts from parr stocking was 228 ± 46. The population estimate for all smolts exiting the system was 263 ± 51 (Figure 5.4.3).

Sandy River. Staff from Brookfield Renewable Energy Partners captured 161 naturally-reared smolts in the Sandy River in 2015. Nearly all smolts were scale sampled (n=155) and a subset was tissue sampled (n=96). The age distribution of smolts was: 86.4% age-2, 13.0% age-3 and 0.6% age-4 (Table 5.4.5). Age-2 smolts (n=132) averaged 153 ± 12 mm fork length and 35.8 ± 9.1 g live weight (Tables 5.4.6 and 5.4.7 and Figures 5.4.1 and 5.4.2).

Smolt Run Timing. In 2015, the median capture date of naturally-reared smolts on the Narraguagus and East Machias was 15 May. Sheepscot River naturally-reared median capture date was 12 May. Median capture date on the East Machias and Piscataquis River was 13 May. Smolt run duration ranged from 23 days on the Piscataquis River to 41 days on the East Machias River. Run duration was 21 days on the Narraguagus River (as measured at the upstream site) and 33 days on the Sheepscot River (Figures 5.4.4. and 5.4.5.).

DISCUSSION

The population estimate of naturally-reared smolts in the Narraguagus River was lower than 2014 (1,590) and below the previous 10-year average (1,461). The Sheepscot River estimate was similar to the previous year (542) remaining near the lowest in the river's time-series (2009-present). The estimate generated for the Piscataquis River increased compared to the previous year (4,278 vs 3,464). The population estimate for all smolts emigrating from the East Machias River was lower than the previous year (263 vs 1,019).

The Narraguagus River population was produced primarily by natural spawning and fry stocking. Sea-run adult returns declined in 2012 (86 redds vs. 263 redds) subsequently leading to increased fry stocking in 2013. Approximately 240,000 fry were released in 2013, lower than the previous 5-year average (~365,000 fry). The resulting smolt population estimate was below the previous 10-year average (1,201 vs 1,461). Similar levels of natural spawning and fry stocking will contribute to the naturally-reared smolt population in 2016.

Smolts produced in the Sheepscot River were produced by egg planting, fry stocking, and stocking age 0 parr as a directed product. Naturally-reared smolt production resulted primarily from eyed-egg planting and reduced fry stocking. Production of naturally-reared smolts was similar to 2014, remaining 57% lower than the previous 5-year average. Below average age-3 smolt production was observed. Results are further evidence of the relative weakness of the naturally-reared smolt cohort in the previous year. Smolt production from parr stocking declined for the second consecutive year; 60% lower than the previous 5-year average.

Smolts produced in the Piscataquis River resulted from fry stocking and natural spawning by the most recent cohort of translocated sea-run adults. The estimated population of 4,278 ± 272 smolts resulted in production greater than 1 smolt/100m^2 of habitat. The Piscataquis River continued to outperform all other rivers sampled when comparing naturally-reared smolt production per unit of habitat (range: 0.03 – 0.24/unit). The Piscataquis River RST site will be discontinued in 2016 due to funding constraints.

Scale analysis results indicated naturally-reared smolts were predominately age-2. Results were consistent with sample data collected on Maine rivers during the previous two decades. However, the Piscataquis River had a higher proportion of age-3 smolts indicating continued strong cohort performance produced by natural spawning in 2011. Comparing populations produced by stocking age 0 parr, Sheepscot River hatchery-origin smolts were predominately age-1 (p8). This demographic result is consistent across river-specific populations of the GoM DPS when stocking 0+ parr as a directed product. However, older age-class hatchery-origin smolts (p20 and p32) were proportionally greater in the East Machias River, indicating poor overwinter survival of the 2014 0+ parr cohort (Bruchs et al. 2016).

Median capture date of naturally-reared smolts was variable compared to the previous year on most rivers: Sheepscot smolts were 1 day later while East Machias and Piscataquis smolts were 4 days earlier. Median capture date on the Narraguagus River was the same as the previous year; however the duration of the run was nearly 2 weeks shorter than in 2014. Duration of the run was similar between the Narraguagus and Piscataquis River, while the East Machias River run was again prolonged compared to all other rivers.

Mean fork length and mean live weight of age-2 naturally reared smolts emigrating from the Narraguagus and Sandy rivers were lower than previous years. Sandy River age-2 smolts were smaller than smolts from all other rivers. Sheepscot and Piscataquis River smolts were observed larger than previous years. Naturally-reared smolts emigrating from the Sheepscot were larger than smolts from the other rivers. Sheepscot and East Machias age-1 (p8) hatchery-origin smolts were of similar size in 2015.

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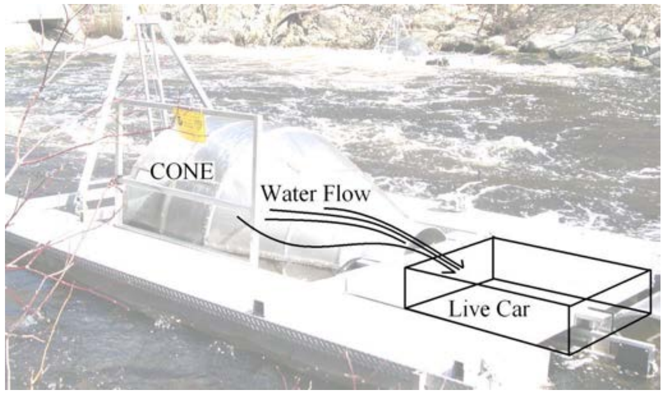

Figure 1. Schematic of Rotary Screw Trap. Image from NOAA Archives.

Table 5.4.5. Freshwater age of naturally-reared smolts captured in smolt traps in Maine rivers.

	2015				5 year average (2010-2014)			
River	1	2	3	4	1	2	3	4
Narraguagus	1.2%	74.1%	24.7%	0%	0.2%	84.5%	15.0%	0.3%
Sheepscot	0%	96.7%	3.3%	0%	0.5%	89.2%	10.0%	0.3%
Piscataquis	0%	39.8%	60.2%	0%	0%	79.8%	19.9%	0.3%
East Machias	0%	42.9%	57.1%	0%	N/A	N/A	N/A	N/A
Sandy	0%	86.4%	13.0%	0.6%	0%	79.9%	20.1%	0%

Table 5.4.6. Mean fork length (mm) ± S.D. by origin of smolts captured in smolt traps in Maine rivers.

	Age-1 (p8) Hatchery-origin				Age-2 Naturally-reared			
				5 year average				5 year average
River	n	2015	n	('10-'14)	n	2015	n	('10-'14)
Narraguagus	0	N/A	0	N/A	72	165±13	477	172±16
Sheepscot	110	165±9	579	163±10	117	190±15	741	187±19
Piscataquis	0	N/A	0	N/A	269	158±13	2407	146±11
East Machias	19	168±16	0	N/A	3	161±11	N/A	N/A
Sandy	0	N/A	0	N/A	132	153±12	215	156±15

Table 5.4.7. Mean smolt live weight (g) ± S.D. by origin of smolts captured in smolt traps in Maine rivers.

	Age-1 (p8) Hatchery-origin				Age-2 Naturally-reared			
				5 year average				5 year average
River	n	2015	n	('10-'14)	n	2015	n	('10-'14)
Narraguagus	0	N/A	0	N/A	72	42.9±11.3	471	51.6±15.2
Sheepscot	110	50.6±8.8	551	47.3±9.8	117	70.7±16.6	736	67.4±21.2
Piscataquis	0	N/A	0	N/A	269	37.8±9.5	2355	29.7±7.3
East Machias	18	46.1±11.3	0	N/A	3	39.2±8.0	0	N/A
Sandy	0	N/A	0	N/A	132	35.8±9.1	212	40.1±11.3

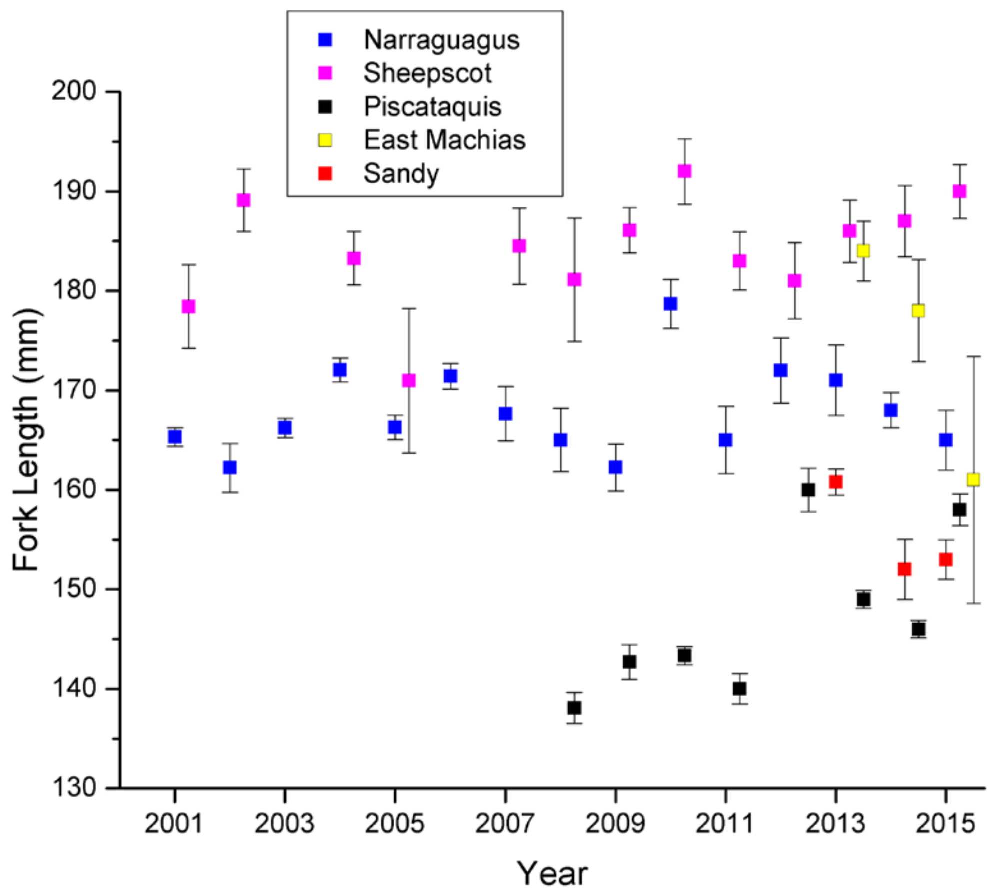

Figure 5.4.1. Mean fork length (mm) ± 95% C.I. of age-2 smolts captured in Maine rivers (2001-2015).

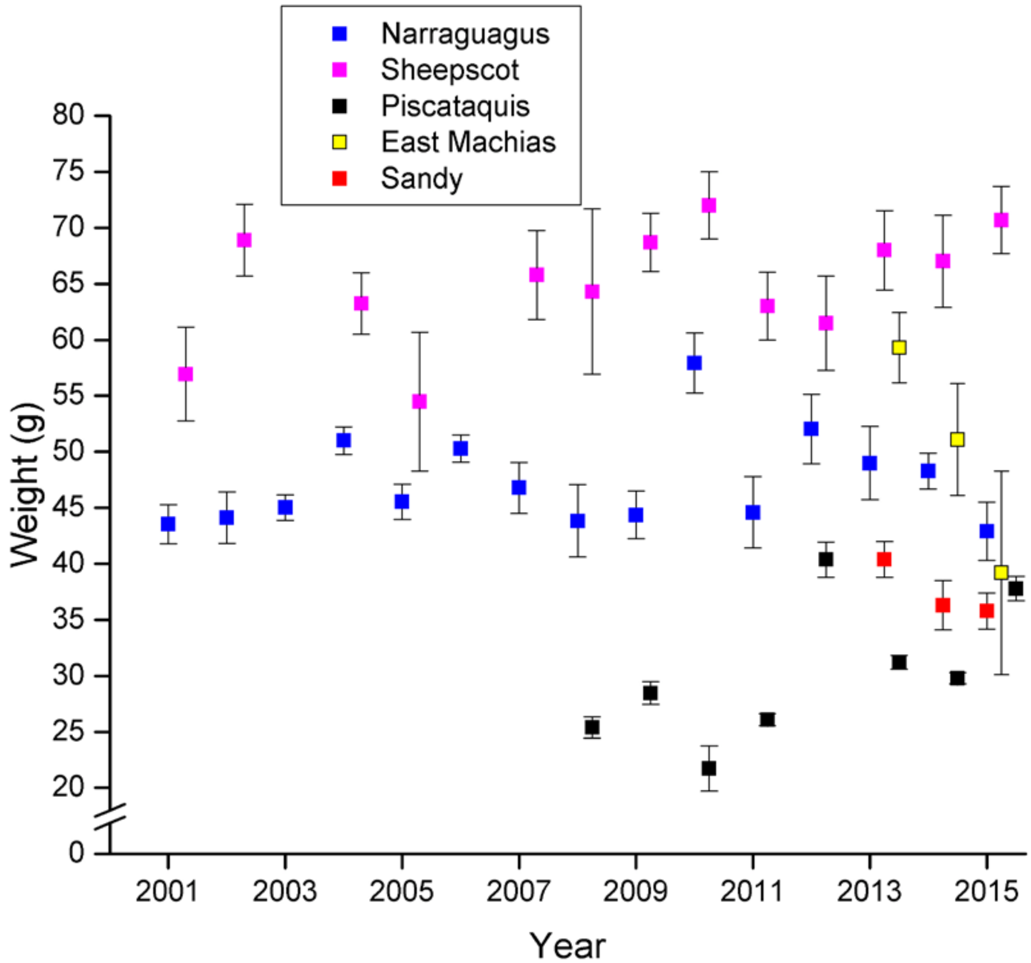

Figure 5.4.2. Mean live weight (g) ± 95% C.I. of age-2 smolts captured in Maine rivers (2001-2015).

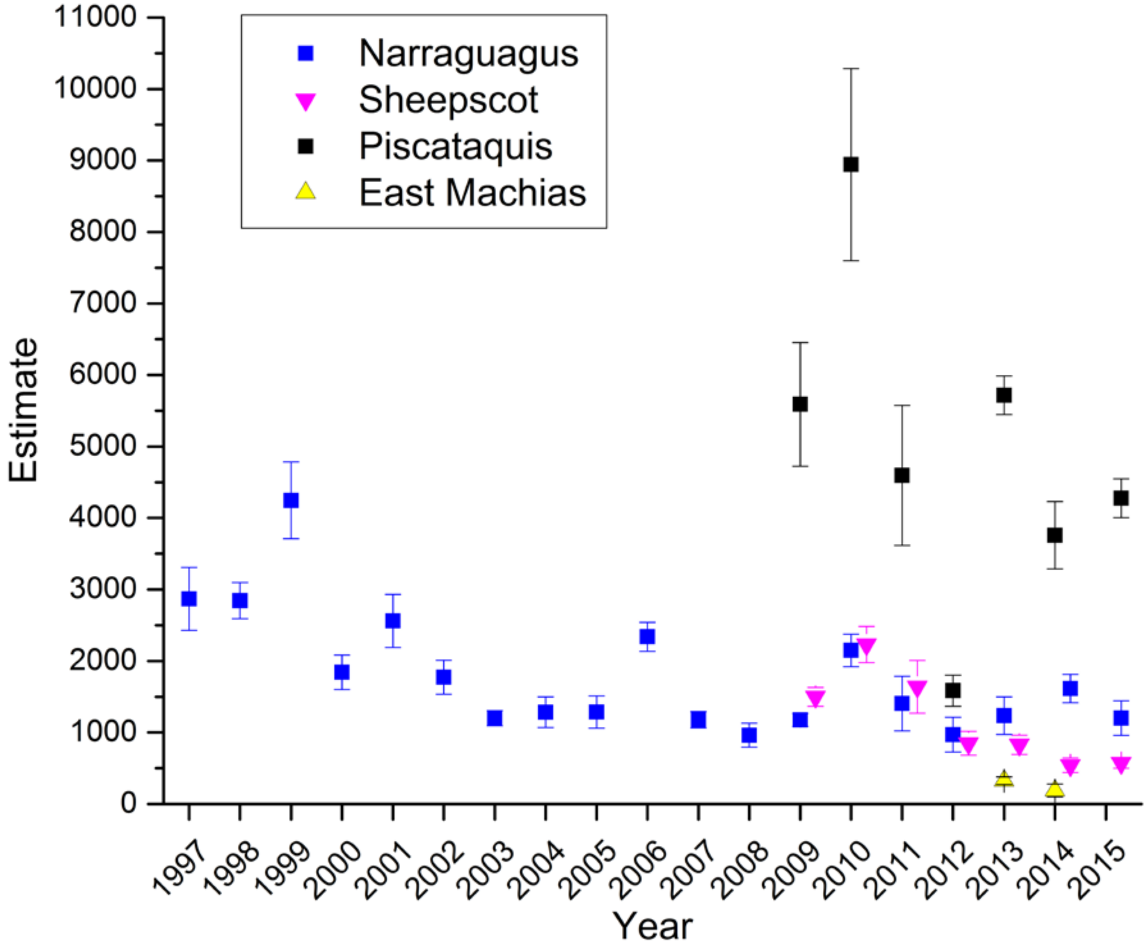

Figure 5.4.3. Population Estimates (± Std. Error) of emigrating naturally-reared smolts in the Narraguagus, Sheepscot, Piscataquis, and East Machias rivers, Maine (1997-2015), using DARR 2.0.2.

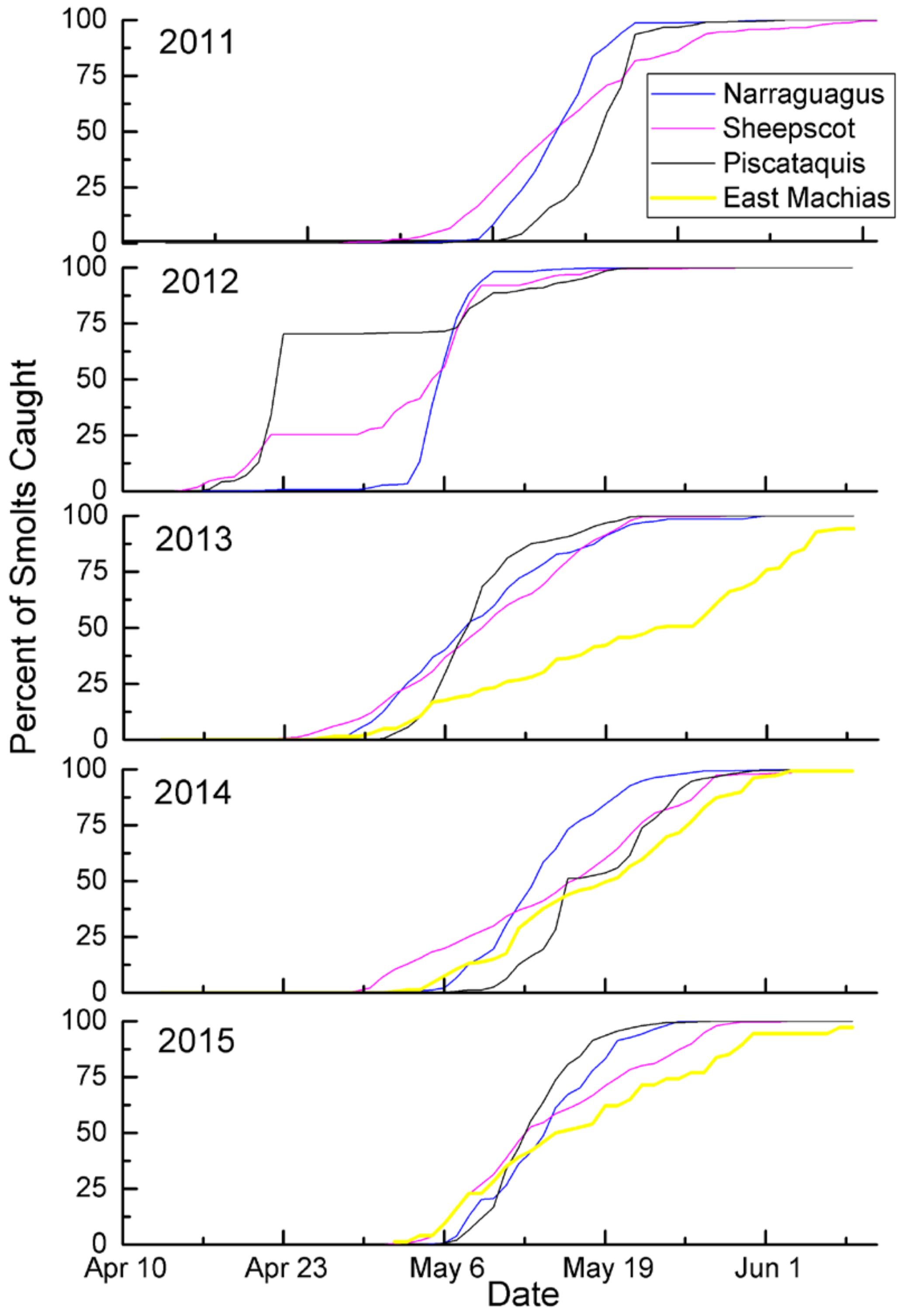

Figure 5.4.4. Cumulative percent smolt capture of all origins by date (run timing) on the Narraguagus (blue line), Sheepscot (pink line), Piscataquis (black line), and East Machias (yellow line) rivers, Maine (2011-2015).

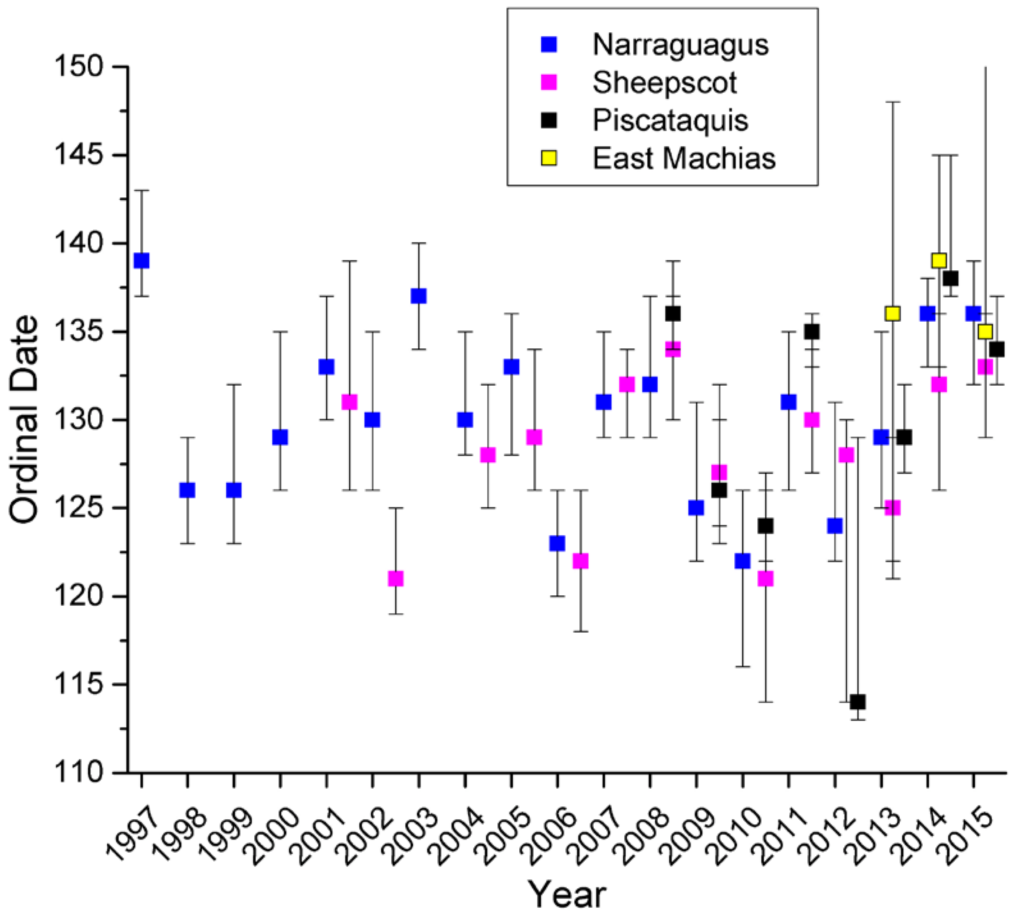

Figure 5.4.5. Ordinal day (days from January 1) of median smolt capture of naturally-reared smolts on the Narraguagus, Sheepscot, Piscataquis, and East Machias rivers, Maine (1997-2015). Error bars represent 25th and 75th percentiles of median run dates.

Maine and neighboring Canadian Commercial Aquaculture Activities and Production

David Bean

National Marine Fisheries Service, Maine Field Station, Orono, Maine 04473

Atlantic salmon farming operations in the northeastern United States (U.S.) are concentrated in large bays and interspersed among the many islands characteristic of the Maine coast. In addition, commercial Atlantic salmon hatcheries and juvenile rearing facilities supporting the U.S. industry are located on rivers within the geographic range of the federally endangered Gulf of Maine Distinct Population Segment of Atlantic salmon (GOM DPS). In 2015, no aquaculture origin fish were reported captured in Maine rivers and production of farmed Atlantic salmon is slightly down compared with previous years, although an increase in spring stocking in 2014 should result in more fish harvested in 2016 (Table 1).

Table 1 Atlantic salmon stocked into marine net pens for commercial aquaculture as reported pursuant to Army Corps of Engineers permit requirements
*1 dead aquaculture origin adult was found in the St. Croix River ***Estimated data.

Year	Total Salmon Stocked (smolts + fall parr + clips)	RV clipped fish stocked	Harvest total (metric tons)	Suspect aquaculture origin captures (Maine DPS Rivers)
2000	4,511,361		16,460.936	31
2001	4,205,161		13,202.049	65
2002	3,952,076		6,798.368	14
2003	2,660,620		6,007.113	2
2004	1,580,725		8,514.717	0
2005	294,544		5,262.776	12
2006	3,030,492	252,875	4,673.790	6
2007	2,172,690	154,850	2,715.268	0*
2008	1,470,690		9,014.387	0
2009	2,790,428		6,027.774	0
2010	2,156,381	128,716	11,127.047	0
2011	1,838,642	45,188	6,031.228***	3
2012	1,947,799	137,207	5,397***	7
2013	1,329,371	170,024	5,079***	0
2014	2,285,000	0	5,189***	0
2015	1,983,850	446,129	4,570***	0

Recent NOAA efforts to facilitate permitting offshore aquaculture

Recently, there has been increased interest in developing aquaculture within the EEZ and with this expansion into new territory, comes uncertainty surrounding the potential risk for interactions with protected species. Accordingly, NOAA Fisheries Protected Resource Division held a workshop in September 2015 with industry, the scientific community, and other stakeholder communities to better understand the potential for interactions between protected species and offshore aquaculture gear in order to support the NOAA Aquaculture program goals. By involving scientists, biologists, engineers and stakeholders in early dialogue with the applicants, we can better understand potential impacts and, as needed, work to develop ways to minimize any potential impacts. This multi-stakeholder approach is critical to developing measures that address all the important issues in mollusk production, and are practical to implement on farms. Initiating this dialogue as projects begin to expand into these new waters will also allow us to gather information during the permitting and consultation process with the ACOE. Our goal is to provide technical guidance and eventually develop best management practices which can help minimize impacts to protected resources, expedite the reviews of these offshore projects, as well as provide the necessary information to inform decision making and effectively streamline the required Endangered Species Act and Marine Mammal Protection Act consultations. Further coordination between regulators and managers of active sites will allow refinements in gear deployment which could reduce the severity of interactions with protected species. A final report, due out soon, will capture the meeting notes during breakout sessions along with summaries of the work presented.

Genetically Engineered Atlantic salmon

The United States Food and Drug Administration (FDA) have recently (November 2015) approved a New Animal Drug Application (NADA:141-454) for AquaBounty Technologies (ABT) of Maynard, Massachusetts. The approval is for a single copy of the α-form of the *opAFP-GHc2* recombinant DNA (rDNA) construct at the α-locus in the EO-1α lineage of triploid hemizygous, all-female Atlantic salmon (*Salmo salar*) known as AquAdvantage Salmon (AAS) under the conditions of use specified in the application. This rDNA construct at this specific site in the genome is the new animal drug (“the article”) that is the subject of the NADA, review and approval process under the authority of the Federal Food, Drug and Cosmetic Act. The FDA reviewed this application in regards to food safety issues focusing on consumption hazards and associated risks posed to the public. The approved NADA has conditions of use specified in the approved application, which includes; 1) production of eyed eggs in Prince Edward Island (PEI), Canada; 2) shipment of eyed eggs to Panama; and 3) grow-out of fish in the highlands of Panama. An FDA approval letter and appendix can be found on their website (http://www.fda.gov/AnimalVeterinary/DevelopmentApprovalProcess/GeneticEngineering/GeneticallyEngineeredAnimals/ucm466214.htm). Here you can find documents which describe certain provisions specified in the approved application (NADA 141-454) for use of the new animal drug described above, as well as applicable post-market requirements for records and reports of adverse events and other experiences.

Sea Lice studies in Cobscook Bay

A recent publication on work conducted by University of Maine (UM) graduate students investigating lice loads on wild fish in Cobscook Bay (Jensen *et. al.,* 2015) found that 10 different species captured in their survey gear were infested with *Caligus elongatus* with at least 1 louse per fish, but overall, among all of the fish sampled, a very low prevalence rate (approximately <5%). Fish collection was conducted monthly between March and November (with the exception of July) in 2012 with sites distributed among inner, outer and middle bays using stationary and mobile gear types such as beach seines, fyke nets, pelagic trawl, and benthic trawl, sampling over 6,000 fish. No Atlantic salmon were captured in any gear type throughout the study period. Researchers used DNA sequencing on 175 individual lice (34% of the total number of sea lice collected) to confirm sea lice species and verify visual observations, overall, only *Caligus elongatus* was found, no individuals were identified as *Lepeophtheirus salmonis* for all fish species collected. These results were in contrast to another study being conducted with sentinel cages in Cobscook bay where the PI had reported observing high levels of infestation by *L. salmonis* in late summer and fall during peak water temperatures (I. R. Bricknell, University of Maine, personal communication in Jensen *et al* 2015). The authors have a few explanations for this in light of having an active salmon farming industry within Cobscook Bay. One supporting fact was the bay received a 30 day fallow period in 2012, immediately prior to conducting the study, typically the bay would support up to 14 active sites (Maine Department of Marine Resources 2012). In this paper, the authors had theorized “by removing all cultured Atlantic salmon from the bay, the fallowing may have disturbed L. salmonis dynamics associated with the pens, with the cultured fish subsequently having minimal influence on infestations among the wild fish assemblage (Jensen *et. al.,* 2015).” This would certainly be the intent of the fallow period and this study may provide some data supporting the effectiveness of bay-wide fallowing as a way to reduce lice loads on the wild fish assemblages inhabiting the bay.

In 2015, another sea lice study being conducted by UM in which researchers are placing sentinel cages stocked with juvenile Atlantic salmon in Cobscook Bay; suffered a minor set-back when one of the cages accidentally opened and allowed all of the test fish to escape into the wild. The primary investigators for this study reported over 70 fish were lost during this incident. Unfortunately, no preliminary information is available at the time of this report.

Working together to develop consistent regulations and protective measures to minimize impacts from commercial Atlantic salmon aquaculture

In 2015, the Department Fisheries and Oceans Canada made significant progress developing new regulations for sustainable aquaculture practices referred to as the Aquaculture Activities Regulations which clarifies rules on the deposit of pesticides and drugs in water for the purposes of aquaculture, as well as impose new reporting requirements to make industry practices more transparent to Canadians. The Regulations came into effect on June 29, 2015. The Regulations also impose greater public reporting on the industry as well as specific environmental monitoring and sampling requirements. The Regulations increase the Government of Canada's oversight and ensure there are clear and consistent national rules. Following up on the national regulations, individual Provinces are also developing specific regulations in regards to reducing impacts from commercial salmon farming operations to wild Atlantic salmon populations in eastern Canada. Some of the Provinces have strict regulations in place, while others are developing more stringent permits requiring more accountability from the farms.This effort has been moving forward in Nova Scotia with discussions between the U.S. and the Province to develop consistent regulations in regards to escape reporting, marking and containment practices which are in place for Maine salmon farms.

Continuing to work on regulatory framework to minimize impacts from fish transfers

The Northeast Fish Health Committee (NEFHC, a subcommittee of the Northeast Fisheries Administrators Association) encourages state and federal fish and wildlife agencies to develop rules, regulations, and/or protocols to manage fish importation in ways that minimize the movement of pathogens. The NEFHC annually reviews the fish health status of the Northeast states and have developed regional guidelines that enable state resource agencies to prevent the importation or transfer among member states of fish infected with the listed pathogens of concern. In 2015, the NEFHC completed revisions to the existing fish health guidelines to include fish importation, movement and transfer between all states in the Northeast United States (Connecticut, Delaware, Maine, Maryland, Massachusetts New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, and Virginia). These revisions have been unanimously accepted by the Northeast Fisheries Administrators for each of the States represented above.

The United States Department of Agriculture Animal and Plant Health Inspection Service (USDA APHIS) have established a non-regulatory framework for the improvement and verification of farmed aquatic animals produced in the United States referred to as Commercial Aquaculture Health Program Standards (CAHPS). The principle components of the program should provide Federal, State and Tribal authorities with regulatory responsibilities a robust process for early disease detection, surveillance, reporting and response for the control of aquatic animal pathogens and to prevent pathogen dissemination via movement and trade of aquatic animals.

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Annual Bycatch Update Atlantic Salmon though May 2015

John F. Kocik[1], Susan E. Wigley[2], Christopher Tholke[2], and Daniel Kircheis[3]

NOAA Fisheries Service

[1] Northeast Fisheries Science Center
[3] Greater Atlantic Regional Fisheries Office
Maine Field Station
17 Godfrey Drive Suite 1
Orono, ME 04473-3693
John.Kocik@noaa.gov

[2] Northeast Fisheries Science Center
166 Water Street
Woods Hole, MA 02543

SUMMARY: Atlantic salmon, unlike other New England Fishery Management Council managed stocks, is not subject to a plan review by the National Marine Fisheries Service because the current fishery management plan prohibits their possession and any directed or incidental (bycatch) commercial fishery for Atlantic salmon in federal waters. Due primarily to significant ongoing threats from poor marine survival, dams, and the inadequacy of existing regulatory mechanism for dams, the Gulf of Maine Distinct Population Segment of Atlantic salmon was listed as endangered under the Endangered Species Act in June 2009. The other stock complexes (Long Island Sound, Central New England, trans-boundary Outer Bay of Fundy) are also well below conservation limits. Under current natural mortality regimes, US salmon stock complexes are below the minimum stock size at which rebuilding to a biomass that can support harvest of the maximum sustainable yield (Bmsy) will occur within 10 years. The highest abundances noted are less than 25% of these conservation minima and the median values are less than 10% -even with extensive hatchery support. While bycatch is uncommon, it is summarized annually. Total documented bycatch is 15 individuals observed over 7 years from 1989 through May 2015. Observed bycatch was 0 in 19 of 26 years with the highest documented catch occurring in 1992 (n=7). Fish have been observed across 7 statistical areas in the Gulf of Maine region. The most recent catch was 2 salmon in 2013. This report summarizes reports and data queries through May 2015 in support of US Atlantic Salmon Assessment Committee reporting to International Council for the Exploration of the Sea.

US Fisheries, Current Management Structures and Bycatch

The last commercial fishery for Atlantic salmon in the United States was closed after the 1948 season in the Penobscot River, Maine (Fay et al. 2006). Current Atlantic salmon abundance is low in all management areas with total U.S. returns of less than 4,000 spawners since 1986 (USASAC 2012). Although never commonly targeted in offshore waters, regulations have been in place since 1987 restricting ocean harvest. According to the Atlantic salmon fishery management plan (FMP) - "The management unit for the Atlantic salmon FMP is intended to encompass the entire range of the species of U.S.

origin while recognizing the jurisdictional authority of the signatory nations to NASCO" (NEFMC 1987). Accordingly, the management unit for this FMP is: "All anadromous Atlantic salmon of U.S. origin in the North Atlantic area through their migratory ranges except while they are found within any foreign nation's territorial sea or fishery conservation zone (or the equivalent), to the extent that such sea or zone is recognized by the United States." Presently there is a prohibition on the possession of Atlantic salmon in the US exclusive economic zone. Effectively this protects all US populations in marine waters and is complementary to management practiced by the states in riverine and coastal waters. Within US waters directed fishing for other species does have the potential to intercept salmon as bycatch. Beland (1984) reported that fewer than 100 salmon per year were caught incidental to other commercial fisheries in the coastal waters of Maine. Incidental catch, while uncommon, is not limited to a particular cohort, samplers have documented various age classes, and also aquaculture escapes. In most modern fisheries, the epipelagic distribution of Atlantic salmon would minimize encounters (Renkawitz et al. 2012).

In 1989, NOAA's National Marine Fisheries Service, Northeast Fisheries Science Center (NEFSC) implemented the Northeast Fisheries Observer Program (NEFOP). The NEFOP is a comprehensive, multi-purpose program that collects a broad range of data on all species that are encountered during a fishing trip as well as gear characteristics data, economic information and biological sampling (NEFOP 2013). In 2010, the NEFSC implemented the At-Sea Monitoring Program (ASM; NEFOP 2011) in support of Amendment 16 of the Northeast Multispecies FMP. The NEFOP and ASM employ trained sea-going observers and monitors to collect these data. The NEFSC website has detailed information on the NEFOP and ASM. These data have been analyzed from 2007 onward as part of the standardized bycatch reporting (Wigley et al. 2011, 2012a, 2012b, 2013; 2014, 2015). We analyzed these data to include all documented encounters of Atlantic salmon. In addition to these reports, in response to a standardized omnibus data request from GARFO to document endangered species bycatch and discards, the NEFSC provides a summary database that was updated through May 2015 (Tholke personal communication). This working paper includes this temporal coverage but no salmon were observed in 2014 and through May 2015.

Table 1 summarizes all Atlantic salmon encountered during 1989- May 2015, Atlantic salmon were observed in only 7 of 26 years. A total of 15 fish weighing 38.5 kg (71.8 pounds) of Atlantic salmon were reported and 67% (10) were discarded. In the 8 years with encounters, most observations were single fish (Table 1). Atlantic salmon were reported in 7 statistical areas (Figure 1). March-May encounters were in areas 514, 515, 522, and 525. June to September encounters were in areas 513 and 514 and all November encounters were in area 537.

The standardized bycatch reports document only rare occurrences of Atlantic salmon in observer databases in recent years. This working paper summarizes the entire time series of NEFOP/ASM data and confirms these findings over the past 26 years. Recent investigations also confirm the potential for Atlantic salmon bycatch to be occurring in pelagic and midwater fisheries due to an overlap in space and time of the fish and gear.

As noted above, there are few observations of it actually happening. The bycatch of Atlantic salmon in herring fisheries is not considered a significant mortality source for U.S. stocks (ICES 2004). These analyses were conducted in 2004 and with increased observer coverage in the midwater trawl fleet, the ability to detect uncommon species may increase as this time-series grows.

Discard Reporting and Extrapolation -

Wigley et al. (2014) extrapolated total discard using the standardized bycatch reporting methods was approximately 49 pounds for Atlantic salmon. While Atlantic salmon were routinely included in this report series, this report was the first time the estimated discards of Atlantic salmon were greater than zero. Wigley et al. (2015) also reported an estimated total discard (33 pounds). These two reports covered different portions of the calendar year 2013 fishery (Wigley et al. 2014, 2015). Blaylock et al. reported no discards occurred for Atlantic salmon (Salmo salar) in 2011 and 2012; however 0.04 mt (CV=0.686) of Atlantic salmon discards were estimated in the NE large mesh gillnet fleet in the 2013 calendar year (Blaylock et al. 2015).

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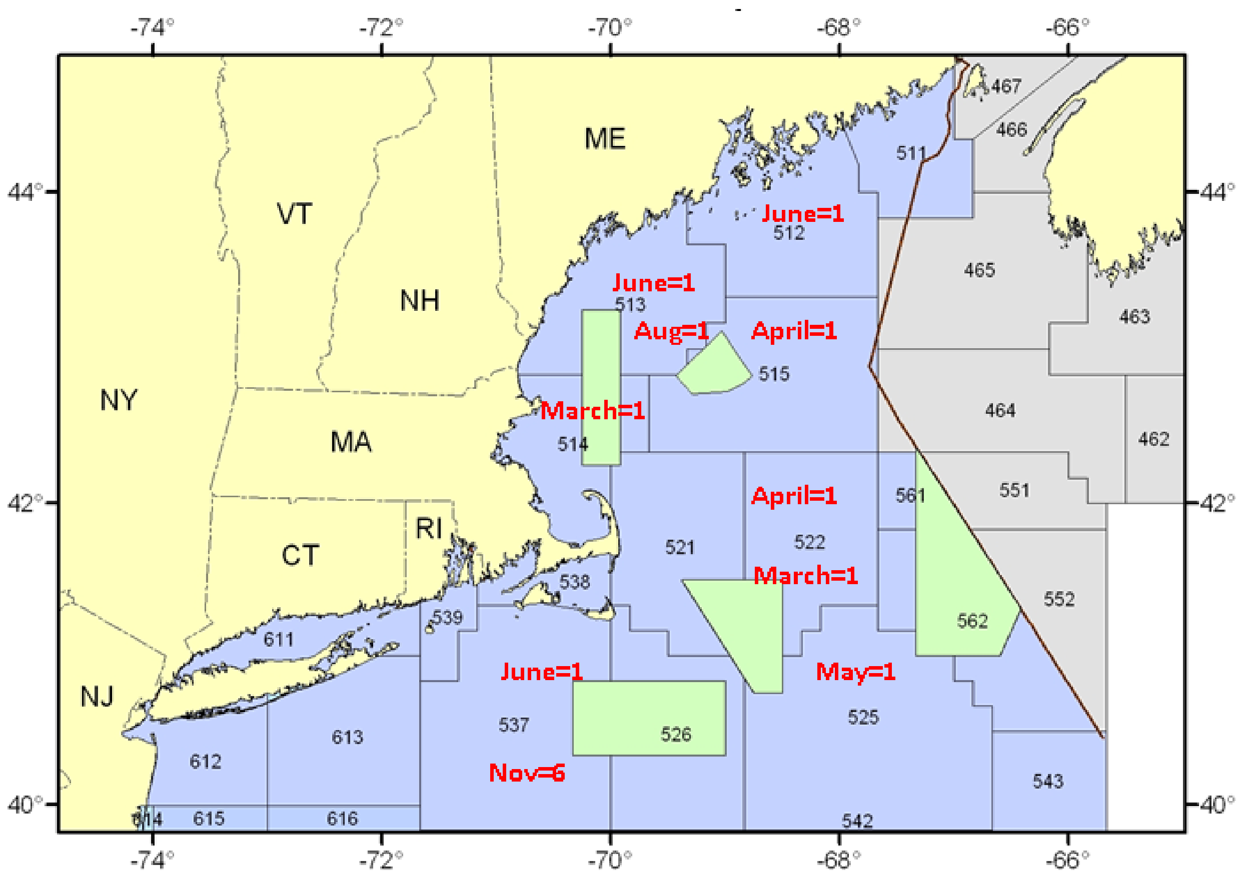
Table 1. Overview of Northeast Fisheries Observer Program and At-Sea Monitoring Program documentation of Atlantic salmon bycatch. Annual weights are average of that years catch if greater than one or represent individual fish weight. Total weight of all 15 fish reported in pounds and average in kg.

Year	Fish Count	Weight (lbs)	Weight (kg)
1990	1	1.0	0.45
1992	7	26.0	1.68
2004	1	2.0	0.91
2005	2	6.8	1.54
2009	1	9.0	4.08
2011	1	11.0	4.99
2013	2	16.0	3.63
Totals	15	71.8	Avg = 2.5

Figure 1. Map of Gulf of Maine region showing the month and number of Atlantic salmon observed (e.g., Nov=6: 6 salmon observed in this area in Nov). Location of the label within the statistical grid does not denote more specific locations. Blue polygons are USA statistical areas, grey are in Canada and green-shaded polygons represent regulated access areas.



Review of Image Analysis Studies: 2015 (PART 1) and Work Plan for 2016 (PART 2)

Ruth E. Haas-Castro[1], Graham S. Goulette[2], James P. Hawkes[2], and Christine A. Lipsky[2]

[1]NOAA's National Marine Fisheries Service
Atlantic Salmon Research and Conservation Task
166 Water St.
Woods Hole, MA 02543
Ruth.Haas-Castro@NOAA.GOV

[2]NOAA's National Marine Fisheries Service
Atlantic Salmon Research Conservation Task
Maine Field Station
17 Godfrey Drive, Suite 1
Orono, Maine 04473

Abstract. *NOAA's National Marine Fisheries Service has conducted studies on Atlantic salmon scales that were collected during annual field activities performed for assessing Atlantic salmon smolt and adult populations since 1992. Results from scale studies are used for Atlantic salmon stock assessments. This paper describes activities performed in 2015 by NOAA's Atlantic Salmon Research and Conservation Task Image Analysis Labs with regard to these scale collections and related activities (Part 1) and provides a description of activities planned for 2016 (Part 2). 2015 completed projects involved Atlantic salmon scales from 586 smolts and 465 adult fish.*

Overview

The NEFSC Image Analysis (IA) Labs processes numerous Atlantic salmon scales each year in support of population dynamics research. Most scales analyzed by NOAA's National Marine Fisheries Service's (NOAA) Atlantic Salmon Research and Conservation Task (ASRCT) are used to determine age and rearing origin while some scales are also used to extract measurements of common scale features (e.g., circuli, annuli, scale radius) to assess growth. Data are audited by re-examining a portion of the collection with special attention to outliers and difficult specimens (scales that are difficult to read because of regeneration, damage, or pigmentation attached to the scale). Both age and measurement data are stored in a common-access networked Excel electronic spreadsheet, SalmoScale.xls. Data in this spreadsheet are linked by unique fish identifiers (JoinID) to the ASRCT smolt archive database, as well as the Maine Department of Marine Resources (ME DMR) adult database. A Scale Imaging Plan (SIP) is maintained to track workloads and ensure timely delivery of IA products. IA lab tasks also include inventory control and return of samples to appropriate archiving agencies. The integration of SalmoScale.xls with other Atlantic salmon data is an essential part of many of the ASRCT projects.

Scale processing and analyses are performed in both Image Analysis Labs - at the Maine Field Station in Orono, ME, and at the Woods Hole Laboratory. Scales processed by the ASRCT IA Labs can be categorized by project type: stock assessment, special projects, and cooperative studies. Stock assessment projects occur annually and include scales collected from rotary screw traps (RSTs) operated on the rivers within the Salmon Habitat Recovery Units. Special projects are conducted when a SIP Request is submitted by ASRCT biologists, contracted staff, partners, or student interns. Complete processing of scales often involves inter-agency collaboration – either in the acquisition of the scales or in the final age/origin determination for them. For these cooperative studies, we work closely with the Maine Department of Marine Resources, NGOs, academia, and other state and provincial and federal partners within the U.S. and Canada.

Review of Image Analysis Studies: 2015 (Part I)

2015 PROJECTS

ASCRT projects are listed and prioritized in Table 1.1 along with projects that were initiated in prior years and completed in 2015. In addition to standard processing (imaging and aging), some projects also call for measurements of scale features (e.g., scale radius, distances to circuli, and annuli), which use Image Pro Plus analysis software.

IA Labs processed 650 new of 1,051 total scale samples collected from Atlantic salmon smolts and adults, as well as producing images of these samples (detail of this work is provided in Table 1.1). NOAA student interns performed initial processing of mounting and imaging of smolt scales. Images were subsequently read by them as well as NOAA biologists.

The SALSEA adult scales from 2011 had been impressed in acetate slides previously by SALSEA constituents. With the addition of 2015 smolt scales, the SalmoScale.xls database currently contains 17,081 records from Atlantic salmon scales collected from 1990 through 2015. SALSEA measurement data are not included in the SalmoScale.xls, due to their specific project-oriented data format.

COMPLETED PROJECTS

2015 Smolt Scales

Age and origin data are presented from RST-captured Narraguagus, Sheepscot, and Sandy River smolts in Tables 1.2 – 1.4. It should be noted that data reported in this paper cannot be extrapolated to the population level without consideration of the complete sampled population.

Narraguagus River samples (Table 1.2) include scales from only naturally reared smolts, with no fall age-0 parr or smolt stocked fish released into the system since 2012. Every third smolt was scale sampled resulting in a total of 98 samples from the 426 smolts captured at the Narraguagus traps. These naturally reared smolts were composed of 73% age 2s and 24% age-3s, a shift in the proportion of age-2s and 3s from last year's 83% and 15%. Although there were three age-4 smolts in 2014, there were none in 2015. Historically, i.e. in the early 1960s, it was not uncommon to see a few age-4 smolts and even an occasional age-5 smolt heading to sea (Baum 1997). Unreadable scales, assigned an age of "unknown" (unk for unmarked or p-unk for parr stocked and s-unk for smolt-stocked fish with unreadable scales), typically makeup 1-7% of the scales evaluated. Ages were initially determined without the tagging information, but final ages were assigned considering tagging data.

In the Sheepscot River (Figure 1.1, Table 1.3), age-0 parr were stocked in the fall of 2009-2014 and were adipose fin-clipped. Thus, any parr-stocked fish caught in the traps could have been from any of these cohorts, making their "origin/age" p32, p20, or p8 (p meaning parr-stocked, the number indicating the months since release). Of 486 smolts captured, 388 were new fish (not recaptures). Of these 388 smolts, 86% (n=333) were scale sampled; 63% of the scale-sampled smolts were of hatchery origin (Table 1.3d), with 53% of the hatchery smolts having been released the previous fall as parr and caught as p8s (Table 1.3b). In 2014, 84% of the parr-stocked smolts were p8s and those that remained in the river and were trapped in 2015 made up 41% of the parr-stocked captures (p20s). As usual, most of the naturally reared smolts captured were w.2; however, w.3 smolts dropped from 19 % in 2014 to only 3% in 2015.

Brookfield Renewable Energy Partners began sampling smolts in the Sandy River in 2012, to identify and describe the naturally reared smolt run timing and composition. Captured smolts are the product of egg planting activities carried out by ME DMR as a method to restore Atlantic salmon to the Kennebec watershed. NOAA researchers collected scale samples from 96.3% (155 out of 161) of the captured fish. Ages of Sandy River smolt scales are displayed in Table 4. The distribution of age-2s in 2015 was similar to previous years, which, since 2012 has ranged from 75% in 2014 to 87% in 2012 (unk ages excluded). This was, however, the first year an age-4 smolt has been captured. The Sandy River smolt scales differ from Sheepscot and Narraguagus smolt scales because the first annulus tends to be much smaller than what is seen in Narraguagus and Sheepscot smolt scales, sometimes almost absent, which makes age determination a challenge.

Smolts sampled during the emigration period in Narraguagus and Sheepscot River systems in 2015 exhibit similarities to past years' data. Sandy River smolts, in comparison, are significantly smaller at ages 2 and 3 than both the Narraguagus and Sheepscot River smolts, at least for years 2014 and 2015 (Figure 1.2 and Haas-Castro et al. 2014, and 2015). For 2015, mean fork lengths of scale-sampled smolts indicates that Narraguagus fish, age-2 and age-3, are overall smaller at age than Sheepscot smolts (Figure 1.2) although the difference is generally not statistically different ($p<0.05$). This is in keeping with past years in which the Sheepscot smolts were consistently larger at age than the Narraguagus smolts (Figure 1.3). Most of the naturally-reared emigrating smolts are age-2 (Tables 1.2 – 1.4). For smolts of all three rivers, the fork lengths of age-3 fish overlap with age-2 fish, although the mean lengths at age are greater for the older fish within each river. A comparison of fork lengths of 2015 age-2 smolts from the Narraguagus and Sheepscot rivers to fork lengths from age-2 smolts from the last 10 years, 2006-2015, show no real trends over that time frame (Figure 1.3).

Age Reader Precision

Age reader percent-agreements are provided in Tables 1.5-1.7. Initial age readings were performed with no knowledge of fish markings or clips. These initial age readings were compared to final audited readings. Audited readings were determined from the principle investigator's second readings and took into account all information from marked or clipped fish. Initial scale readings indicate a strong ability to distinguish between hatchery and naturally reared smolts. The largest difficulties occurred when distinguishing p20s from w.2s (Table 1.5). High agreement with Narraguagus scales was helped by the lack of hatchery scales (Table 1.6).

There were three readers for the Sandy River smolts (including auditor). Agreement was high for the age-2 smolts (86-87%), but age-3s and even the one age-4 presented a bit more of a challenge (Table 1.7). The table represents initial readings by age readers versus the final audit ages which were agreed upon by all readers.

Other Image Analysis Lab Activities

SALSEA

SALSEA (Salmon-at-Sea) is an international cooperative research program initiated to understand the decline of Atlantic salmon during the marine phase of their life. Detailed information about the program is available online (www.salmonatsea.com). A project carried over from its initiation in 2014, we had processed 401 SALSEA scale samples collected from the 2011 Greenland enhanced sampling program, described by the International Atlantic Salmon Research Board (2010). In 2015, the audit of these data has been completed, a process involving identifying, checking, and in many cases re-measuring scales with measurement data outliers as well as scales whose age data did not match measurement data (e.g. age indicated 3 years in a river, but only 2 freshwater annuli were recorded). Currently, the discrepancies between our ages and ages determined by Canada's Department of Fisheries and Oceans (DFO) are being investigated through sharing our images of scales with DFO's age reader. It is hoped that consensus will be reached for as many as possible. The final ages and data summaries are pending consultation with DFO.

Growth Analysis of North American Atlantic Salmon

As part of a co-operative research project with Dr. Kathy Mills of the University of Maine and Gulf of Maine Research Institute, the NEFSC IA Lab is collecting scale feature measurements from Atlantic salmon adult returns to the Penobscot River from years spanning 1979 through 2002. Dr. Mills' objective is to analyze changes in growth patterns over time in an effort to better understand factors contributing to the decline in Atlantic salmon marine survival in the mid-1990's and their inability to recover to date. The ASRCT imaged, measured, and audited 968 adult scales in 2012 and 2013 (Table 1.1, project short name is PN-Historical). Data gaps still exist for some years and therefore approximately 60 additional scales are currently being selected and processed to fill the data gaps.

SPARO Revival

In 2006, the project SPARO (scale pattern analysis by river reach rearing origin) was published in which scale pattern analysis was used to discriminate among salmon parr reared in different reaches of the Narraguagus River basin (Haas-Castro et al. 2006). Discriminant functions were able to differentiate parr from geographically grouped tributary habitats from other types of habitat. We are revisiting data from the SPARO project to determine if production of smolts above Beddington Lake in the mainstem and tributary production of smolts in the Narraguagus can be tracked using SPARO models. Original analyses were performed in SYSAT. In 2015, we transitioned these data and analyses into StatGraphics with results similar to those from SYSTAT. This effort is in support of Project SHARE's endeavor to enhance habitat in upper reaches of the watershed.

Table 1.1. Abbreviated version of current SIP (as of 1/20/2016) summarizing work completed in 2015.

Priority	Project Short Name	Drainage/ Location	Life Stage	Sample Collection Year	Target/ Completion Date	No. Scale Samples Processed
***complete pending**	SALSEA Greenland 2011	Greenland	adult	2011	1/30/2015	401
complete	NG rst-smolt studies 2015	Narraguagus River	smolt	2015	10/26/2015	98
complete	SHP rst-smolt studies 2015	Sheepscot River	smolt	2015	10/26/2015	333
complete	Sandy River rst-smolt studies 2015	Sandy River	smolt	2015	10/29/2015	155
complete	Harvard Canadian salmonids	Hudson Bay	adult	2015	6/11/2015	18
complete	ME Aquaculture Scale Archives	Aquaculture	adult	2013	3/30/2015	46
TOTAL						**1,051**

Table 1.2. Age distribution of 2015 Narraguagus scale-sampled smolts that were processed by the ASRCT Image Analysis Lab. Age assignments of “unk” were given when age could not be determined, usually due to regenerated or damaged scales.

Age	Count	Percent
unk	1	1.0%
w.1	1	1.0%
w.2	72	73.5%
w.3	24	24.5%
Grand Total	**98**	

Table 1.3a-d. Age distribution by origin of 2015 Sheepscot scale-sampled smolts that were processed by the ASRCT Image Analysis Lab. Age assignments of “p-unk” were given when smolt was known to be a parr-stocked smolt but age was not known, either due to regenerated or damaged scales or because the scale was not processed due to the large numbers of hatchery origin smolts sampled. (a) Age distribution of all Sheepscot 2015 scale samples (b) Age distribution of 2015 Hatchery Origin scale samples (c) Age distribution of 2015 naturally reared (w or “wild”) scale samples (d) 2015 distribution of hatchery and naturally reared scale samples

a.

Age	**Count**	**Percent**
unk	2	1%
*p-unk	13	4%
p20	86	26%
p8	111	33%
w.2	117	35%
w.3	4	1%
Grand Total	**333**	

b.

HatcheryAge	**Count**	**Percent**
p-unk	13	6%
p20	*86	41%
p8	*111	53%
Total	**210**	

*Of the 210 hatchery origin smolts, 15 were unmarked “suspect” hatchery origin, including 12 p8s and 3 p20s

c.

WildAge	**Count**	**Percent**
unk	2	2%
w.2	117	95%
w.3	4	3%
Total	**123**	

d.

Rearing Origin	**Count**	**Percent**
hatchery	210	63%
wild	123	37%
Total	**333**	

Table 1.4. Age distribution of Sandy River smolts trapped by Brookfield Renewable Energy Partners and collected by NOAA staff in 2015. All smolts were naturally reared.

Age	Count	%
unk	1	<1%
w.2	132	85%
w.3	21	14%
w.4	1	<1%
Total	**155**	

Table 1.5. Reader agreement, Audit Age, and Initial Reader Age, for 2015 Sheepscot Smolts. Unreadable and unread scales are not included. Light blue shading indicates correct origin by initial reader; dark blue shading indicates correct age, based on audit age. Bold red indicates the largest error in the table.

	Initial Reader Age								
Audit Age	p20	p8	unk	w.1	w.2	w.3	Grand Total	% Age Agree	% Origin Agree
p20	57	20	2		7		**86**	66%	90%
p8	24	85		1	1		**111**	77%	100%
w.2	**27**	9	1		79	1	**117**	68%	68%
w.3	2				1	1	**4**	25%	50%
Grand Total	110	114	3	1	88	2	**318**	69%	84%

Table 1.6. Reader agreement by age, Audit Age vs. Initial Reader Age, for 2015 Narraguagus smolts. Unreadable and unread scales are not included. Blue shading indicates correct age, based on audit age. Bold red indicates the largest error in the table.

	Initial Reader Age				
Audit Age	w.1	w.2	w.3	Grand Total	% Age Agree
w.1	1			**1**	100%
w.2		72		**72**	100%
w.3		**13**	11	**24**	46%
Grand Total	1	85	11	**97**	87%

Table 1.7. Reader agreement, Audit Age and (a) Initial ReaderA Age and (b) Initial ReaderB Age, for 2015 Sandy River Smolts. Shading indicates correct age, based on audit age. Uknowns are excluded from the graph.

a. **Initial ReaderA Age**

Audit Age	w.1	w.2	w.3	Grand Total	% Age Agree
w.2	1	113	18	**132**	86%
w.3		21		**21**	0%
w.4		1		**1**	0%
Grand Total	1	135	18	**154**	73%

b. **Initial ReaderB Age**

Audit Age	unk	w.2	w.3	w.4	Grand Total	% Age Agree
w.2		115	16	1	**132**	87%
w.3		17	4		**21**	19%
w.4	1				**1**	0%
Grand Total	1	132	20	**1**	**154**	77%

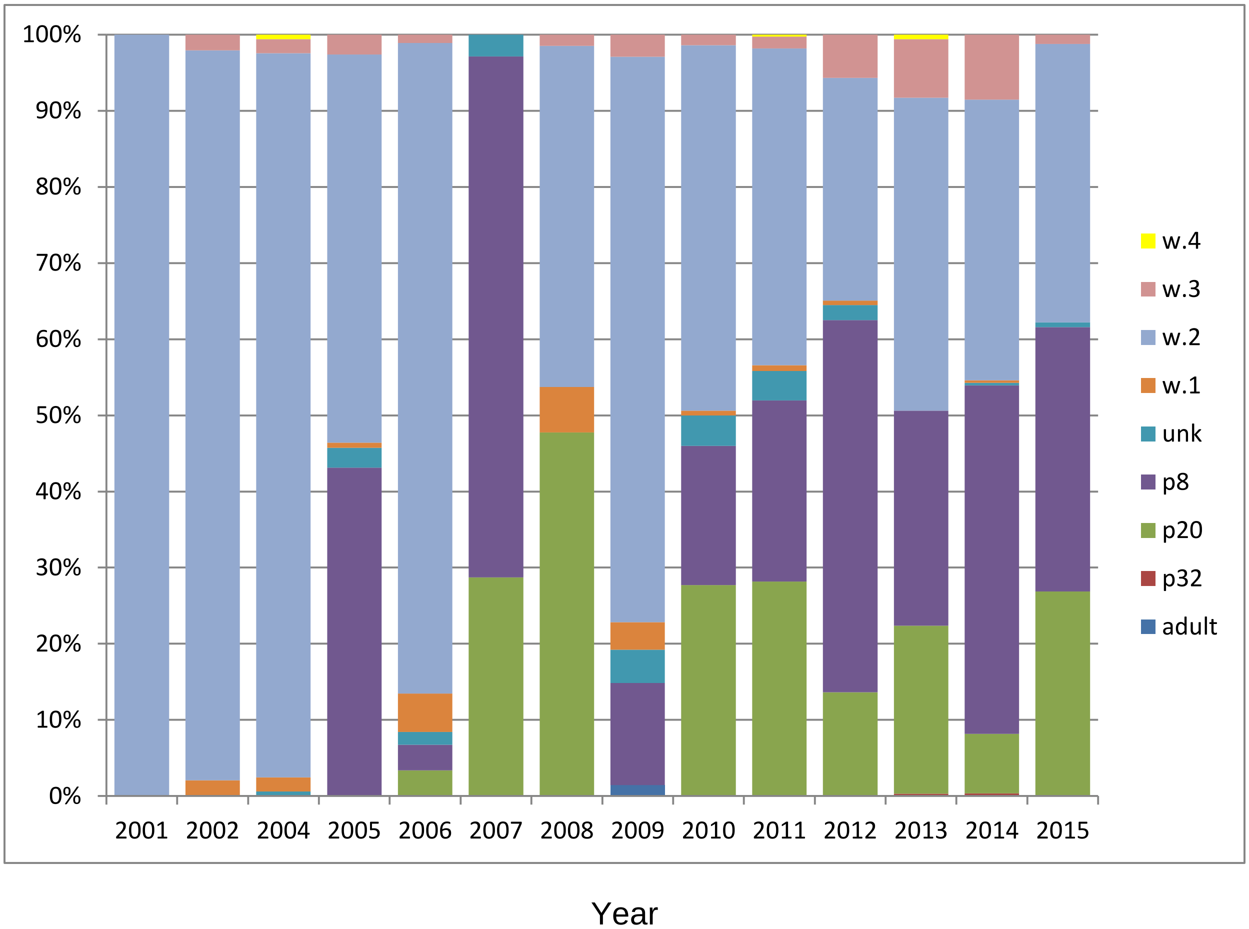


Figure 1.1. Percent composition of Atlantic salmon smolt ages captured and scale-sampled in rotary screw traps on the Sheepscot River during 2001-2015 (2003 – no trapping conducted; 2007 – all analyzed samples were of hatchery origin; 2013 – 387 parr-stocked scale samples were not processed and are not included).

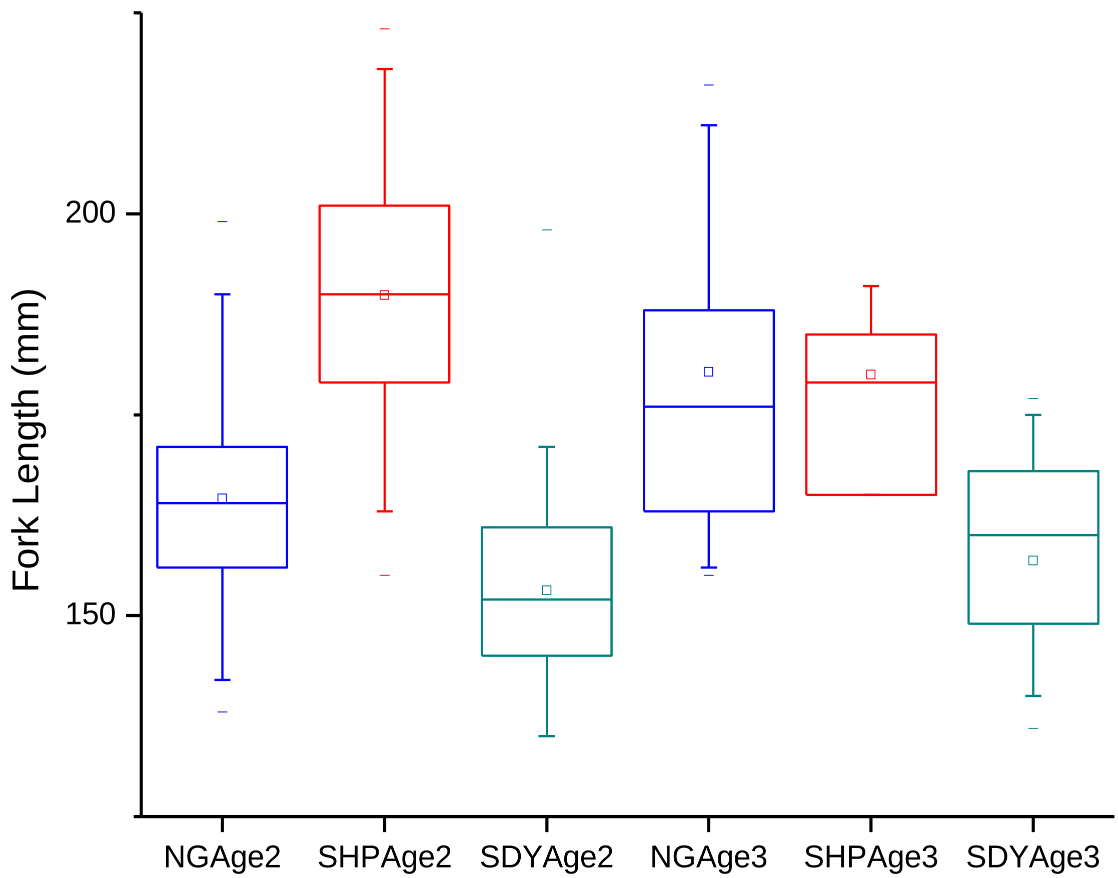


Figure 1.2. Comparison of fork lengths (mm) at age for naturally reared smolts that were scale-sampled from fish captured in rotary screw traps on the Narraguagus (NG), Sheepscot (SHP), and Sandy (SDY) Rivers in the 2015 smolt run. The boxes display the 25th to 75th interquartile range, the small square indicates the mean, the horizontal line indicates the median, the error bars show the 5th and 95th percentile, and the dashes indicate the maximum and minimum values.

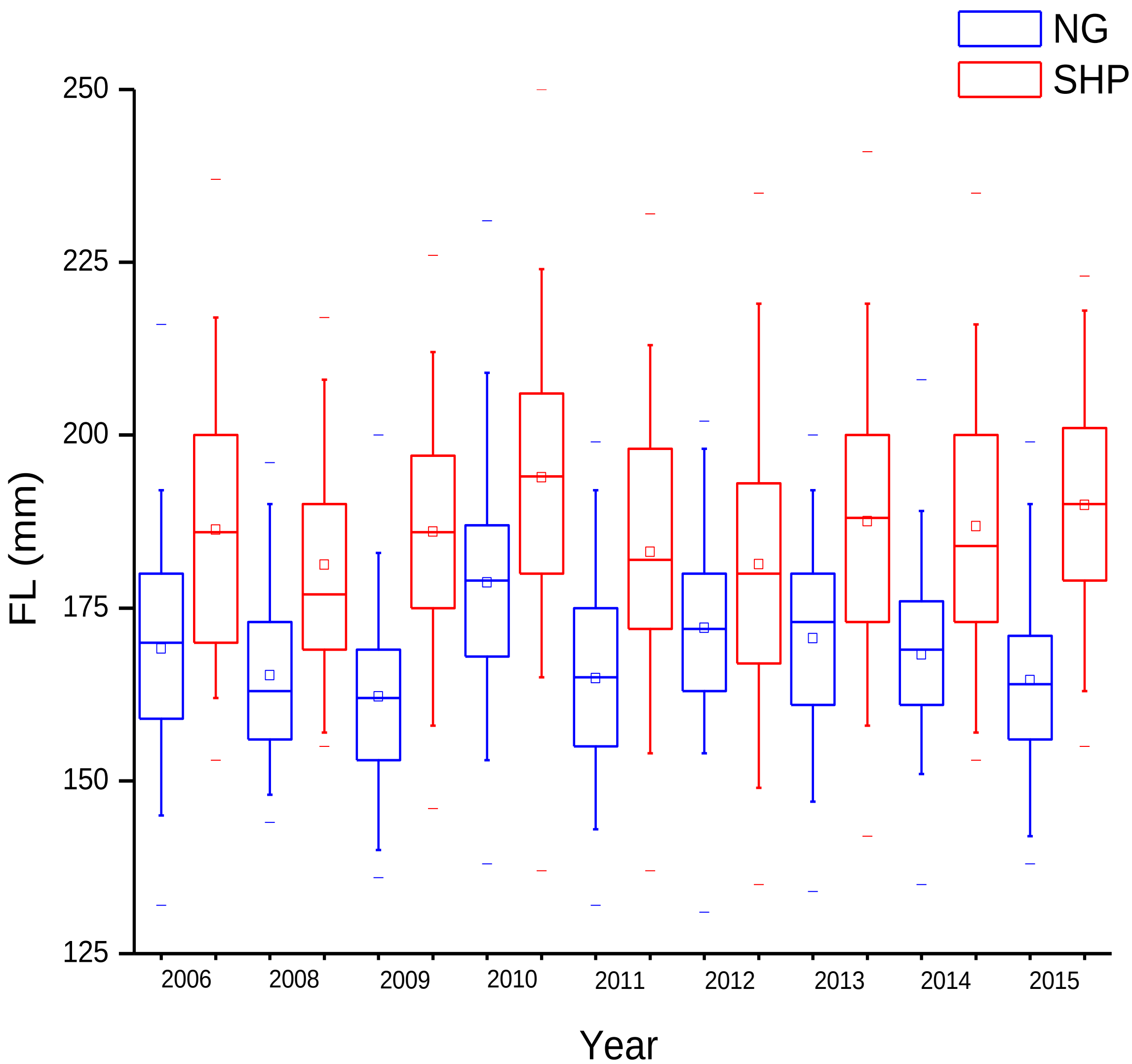


Figure 1.3. Comparison of fork lengths (mm) at age-2 for scale-sampled smolts captured in rotary screw traps on the Narraguagus and Sheepscot Rivers from 2006 through 2015. The box displays the 25^{th} to 75^{th} interquartile range, the small square indicates the mean, the horizontal line indicates the median, the error bars show the 5^{th} and 95^{th} percentile, and the dashes indicate the maximum and minimum values. (All 2007 scale samples analyzed from Sheepscot River smolts were hatchery origin; therefore 2007 data from both rivers are omitted).

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ASRCT Image Analysis Lab Work Plan for 2016 (Part 2)

Purpose: The purpose of this section is to communicate and coordinate IA Lab project goals and objectives within the Atlantic Salmon Research and Conservation Task and to provide an overview of project directions and assessment and research outputs. This summary targets FY2016 (1 October 2015 to 30 September 2016) plans. Table 2.1 is an excerpt from the current SIP, indicating scale projects planned for the year.

5 Year Vision

In the last five years, we have shifted the focus of IA Lab resources and activities away from hatchery-product evaluation towards a core objective of better understanding historical and current trends in marine ecology and survival. We are working toward this through a retrospective examination of marine growth, growth patterns, and maturity through a more detailed time-series analysis of adult scales for US stocks and those captured at West Greenland. To understand inputs to marine systems, we continue to maintain baseline processing/ageing of smolt scales for 2-3 rivers collected by Maine DMR. We anticipate that some limited hatchery-origin work may be needed to more accurately describe adult trends related to recovery plan objectives.

Overview

Image Analysis Lab projects are categorized into three operational areas – Smolt Production, Marine Ecology (adults at sea, returning adults), and Method and Technical Development. A fourth category, Hatchery Product Evaluation, is included during the transition period as we phase out this focus. The accompanying table, IA Lab Project Overviews, offers summaries of ongoing projects as well as projects projected for the next few years (Appendix 2).

Smolt Production –Baseline Aging and Task Time Series: The task will continue to analyze smolt scales for the Narraguagus and Sheepscot River populations for aging of naturally-reared smolts in order to understand the changes in smolt output over time (e.g. ratio of age 2-3 smolts, size-at-age, and in season distribution of cohorts). These samples are collected by Bureau of Sea Run Fisheries and Habitat of Maine Department of Marine Resources under the NOAA-DMR co-operative agreement 2011-2016. In addition to supporting production studies, when naturally-reared smolts are used in telemetry studies, scales will be collected and aged (<200 annually). We do not expect to receive Sandy River scales in 2016 as there will be no RST sampling.

Marine Ecology: As our research efforts focus more on marine growth and ecology of Atlantic salmon, the IA Lab will be working increasingly with postsmolt and adult scales collected in the Labrador Sea and Greenland as well as adults returning to Maine Rivers. Scale measurement data taken from both historical scale samples as well as from more recent salmon scales will be used to evaluate growth and health of the stock complex and to analyze specific cohorts sampled at different times during their marine migration. Some of these projects are being conducted with SALSEA cooperators as well as our research partners at the Maine DMR, Gulf of Maine Research Institute, and Universities.

In a project related to Growth Analysis of North American Atlantic Salmon described in Part I, Dr. Mills and NEFSC biologists are also examining marine growth of recaptured Carlin-tagged Atlantic salmon. Approximately 2000 scales collected in West Greenland and North America are being processed and measured in an effort to characterize the temporal patterns of marine growth over multiple decades. Large scale climate forcing mechanisms will be evaluated to determine if there is a relationship with the observed marine growth patterns.

Method and Technical Development: Image Analysis Lab projects with a focus on data QA/QC have the ultimate goal of improving salmon population assessment capabilities. The proximate goals for these projects are to evaluate the data that we are collecting from scales and identify methods to improve efficiency, accuracy, and precision. In FY2012, we complemented our previous analysis of within-fish scale variability with a scale reader variability study that was initiated in 2010. In 2012, we also initiated a study comparing impressed scales to scales mounted between glass slides which we are continuing in 2015. Method and study design improvements identified are incorporated in ASRCT scale collection and imaging protocols. In 2015, we are continuing attempts to apply 2006 scale pattern analysis discriminant function models to track production in Narraguagus tributaries. We will select smolts scales collected in 2001 and 2002, extract measurement data from a collection of scales, some of which will have known rearing locations, and use the 2006 parr-based discriminant functions to estimate how many come from above Beddington Lake, and how many from below the lake.

Table 2.1. Abbreviated version of current SIP (as of 1/20/2016) summarizing work planned for 2016.

Priority	Project Short Name	Drainage/ Location	Life Stage	Sample Collection Year	Target/ Completion Date	No. Scale Samples Processed
1	PN Historical, Filling Gaps	PN	adult	multi	6/1/2016	60
1	Carlin Tag Historical	Greenland/ME	adult	multi	8/30/2016	1948
2	DMR	East Machias River	smolt	2013-14	6/30/2016	293
3	NG rst-smolt studies 2016	Narraguagus River	smolt	2016	8/30/2016	200
3	SHP rst-smolt studies 2016	Sheepscot River	smolt	2016	9/15/2016	200
4	Narraguagus SPARO Revival	Narraguagus River	smolt	2001	8/30/2016	TBD
TBD	PN VIE Early Marine Growth	Penobscot River	adult	2001-2004 +	5/31/2017	500
TOTAL						**1,253+TBD**

Appendix 2. Image Analysis Lab Project Overviews FY2014-2017 Ordered by Action Date/Priority

FY2016/Current

Project Short Title	Goal (from SIP Request)	Target Date	Focus	Leader	Reference Documents
SALSEA Greenland 2011	Characterize data related to age and growth of salmon sampled at Greenland	30Jan16	Marine Ecology	Sheehan	2009 SIP Request-TS
SPARO Revival	Determine applicability of 2006 SPARO parr model to 2001 smolts	30Aug16	Methods		Haas-Castro et al. 2006
Mounted vs. Impressed Scales	Determine if measurements made using the two methods of scale processing vary significantly	30Aug16	Methods	Haas-Castro	2012 SIP Request (A.Miller)
Smolt Production 2016	Describe age and composition of smolts emigrating from the Sheepscot and Narraguagus Rivers	30Oct16	Smolt Ecology	Hawkes/Lipsky	2009 SIP Request for NG rollover-JH 2009 SIP Request-for SHP rollover-CAL
Carlin Tag Historical	Describe age structure and marine growth patterns of salmon whose Carlin tags have been recovered in WG or the PN over multi-decadal time scale	30Aug16	Marine Ecology	Sheehan	2011 Mills post-doc proposal; 2015 SIP Request-TS

Future (FY2016-17)

Project Short Title	Goal (from SIP Request)	Target Date	Focus	Leader	Reference Documents
Back-calc Validation	Determine method that most accurately back-calculates Penobscot River smolt length from adult scale measurements and adult length	FY17	Methods	Lipsky/ Haas-Castro	2010 SIP Request-CAL

Runout/Spring Smolt Growth	SIP TBD	FY16	Smolt Ecology	Haas-Castro	2009 Scale Workshop Notes
PN VIE Growth	Examine early marine growth variability across release dates and locations	FY17	Hatchery Product/Marine Ecology	Renkawitz	2009 SIP Request-MR
Greenland Historical	Describe age structure and marine growth patterns of salmon recovered in WG over multi-decadal time scale	TBD	Marine Ecology	Sheehan	2009 SIP Request-TS
PN Smolt vs. Adult Size Thresholds	SIP TBD	TBD	Smolt/ Mar Eco	Lipsky	2009 Scale Workshop Notes
NG Smolt vs. Adult Size Thresholds	SIP TBD	TBD	Smolt/ Marine Ecology	Hawkes	2009 Scale Workshop Notes
NG Smolt Stocking Lg. vs. Sm	SIP TBD	TBD	Hatchery Product	Hawkes	2009 Scale Workshop Notes
NG Smolts Hatchery Unknowns	SIP TBD	TBD	Methods	TBD	2009 Scale Workshop Notes
PN Fall Parr Contributions	SIP TBD	TBD	Hatchery Product	TBD	2009 Scale Workshop Notes

Update on Maine River Adult Salmon Stock Assessment: 2015

Colby W.B. Bruchs[1], Mitch Simpson[2], Ernest J. Atkinson[1], Jason Overlock[3], Peter Ruksznis[2] and Paul Christman[3]

[1]Department of Marine Resources
Division of Sea Run Fisheries and Habitat
317 Whitneyville Road
P.O. Box 178
Jonesboro, ME 04648

[2]Department of Marine Resources
Division of Sea Run Fisheries and Habitat
650 State Street
Bangor, ME 04401

[3]Department of Marine Resources
Division of Sea Run Fisheries and Habitat
32 Blossom Lane
Augusta, ME 04333

Abstract. *Maine Department of Marine Resources (DMR) and its authorized representatives have operated adult Atlantic salmon counting facilities on several rivers in Maine since 1948. In addition to operation of counting facilities, DMR scientists have conducted annual redd counting surveys to evaluate adult Atlantic salmon spawning escapement in several Maine rivers since 1973. This working paper updates adult Atlantic salmon stock assessment activities conducted in 2015 summarizing adult counts and spawning escapement estimates derived using a redd-return regression model. Within the Gulf of Maine Distinct Population Segment (GoM DPS) (73 FR 51415-51436), counting facilities were operated in rivers among the Downeast Coastal (three), Merrymeeting Bay (three), and Penobscot Bay (two) Salmon Habitat Recovery Units (SHRUs). Five counting facilities were operated in non-GoM DPS rivers. Redd counting surveys were also conducted in each SHRU; five Downeast Coastal SHRU drainages, three drainages within the Merrymeeting Bay SHRU, and four drainages within the Penobscot Bay SHRU were surveyed in 2015. Documented adult Atlantic salmon returns to rivers within the geographic area of the GoM DPS in 2015 totaled 881. Returns are the sum of counts at fishlifts, fishways and weirs (763) and estimates from redd surveys (118). Total escapement to these same rivers was 663. Because there was no rod catch, escapement to the GoM DPS area was assumed to equal returns (estimated or released after capture) plus released pre-spawn captive broodstock (adults used as hatchery broodstock are not included).*

INTRODUCTION

The Maine Department of Marine Resources (DMR), Division of Sea–run Fisheries and Habitat (DSRFH) and its authorized representatives have operated adult Atlantic salmon counting facilities on several rivers in Maine since 1948[1]. Counting facilities deployed to capture adult Atlantic salmon consist of fishlift and fishway traps located at dams as well as traps located at barrier weirs within and outside the Gulf of Maine Distinct Population Segment (GoM DPS) (73 FR 51415-51436). Counting facilities are primarily operated to enumerate the Atlantic salmon spawning stock, collect biological data from individual fish according to established sampling protocols, procure sea-run broodstock, and exclude suspected aquaculture Atlantic salmon for each river in which salmon are trapped. Further, DMR scientists utilize these facilities to enumerate other diadromous fish species and provide fish for related research projects. In addition to the operation of counting facilities, DMR scientists have conducted annual redd counting surveys to evaluate Atlantic salmon spawning escapement in several Maine rivers since 1973.

Counting facility operation and fall redd count survey data continue to inform researchers of trends in adult Atlantic salmon abundance and replacement. These data allow researchers to estimate marine survival of naturally-reared stocks where within river smolt abundance estimates are available. Data collected also informs managers of lifestage-specific hatchery product survival. Further, DMR scientists rely on redd abundance and location data to adaptively manage hatchery supplementation of vacant juvenile Atlantic salmon rearing habitat. In 2015, DMR operated and/or coordinated the operation of adult Atlantic salmon trapping facilities at thirteen locations to enumerate spawning stock among nine drainages in Maine. Additionally, DMR conducted redd counting surveys in twelve drainages.

[1] Maine DMR-DSRFH (formerly Maine Atlantic Salmon Commission, formerly Maine Atlantic Salmon Authority, formerly Maine Atlantic Sea Run Salmon Commission)

ADULT SALMON STOCK ASSESSMENT OBJECTIVES:

1) Operate and/or coordinate operation of adult Atlantic salmon counting facilities in Maine rivers.
2) Assess annual adult Atlantic salmon escapement in Maine rivers by conducting annual redd count surveys.
3) Collect scales, tissue samples, and biological data from returning adult Atlantic salmon enumerated at trapping facilities to describe the biometrics of the population.
4) Document marks and tags (applied prior to their release as juveniles) observed on adult Atlantic salmon enumerated at trapping facilities.
5) Identify population trends in each Salmon Habitat Recovery Unit (SHRU) and make comparisons of biological data and samples between rivers and through the time series.

METHODS

Adult Atlantic salmon returns are documented at counting facilities. Counting facilities consist of fishlift and fishway traps located at dams as well as traps located at barrier weirs. Counting facilities begin operation at varying dates depending on location. The general trapping season may occur from April 1 to November 30. Fishlifts and associated traps are tended several times each day. Fishway and weir trap tends occur at least once daily.

During daily tends, captured adults undergo biological sampling and measurement in accordance with DMR protocols (Maine DMR 2016). Biological sample collection includes measurement of fork length (cm), observation of marks and/or tags, documentation of fin condition, fin punched (adipose or caudal), and notation of any injury or mortality. Scale samples are collected to determine age and origin. Origin is defined as naturally-reared (adult returns produced by natural spawning, egg planting, or fry stocking) or hatchery (adult returns produced by stocking smolts). Scale samples are analyzed by DMR. Tissue samples were collected from a subset of returns for genetic analysis and for identification during hatchery spawning activities.

Thirteen counting facilities are utilized to enumerate adult Atlantic salmon returns in Maine. DMR operated three counting facilities during the 2015 season within the GoM DPS (Table 5.1.1). DMR coordinated operation of four counting facilities that were operated by the facility owners within the GoM DPS. Additionally, five counting facilities located in non-GoM DPS rivers were operated by the facility owners and/or their designees.

Redd count surveys are conducted from mid-October to mid-December annually. Spring redd count surveys are often used when river ice conditions limit access during the previous fall. DMR staff conduct these surveys by wading in rivers and streams and/or by traveling down rivers and streams by canoe. Redds and test pits are determined based on consistent observation criteria (Hobbs 1937; Burner 1951; and Orcutt et al. 1968). Locations and number of redds and test pits are documented and georeferenced for inclusion in the DMR Redd Survey Archive. Evaluation of spawning escapement is achieved using a model wherein estimated adult Atlantic salmon returns are extrapolated from redd count data using a return-redd regression [ln (returns) = 0.5594 ln (redd count) + 1.2893] based on redd and adult counts from 2005-2010 on the Narraguagus River, Dennys River and Pleasant River (USASAC 2010). DMR staff conducted redd counting surveys in twelve drainages in 2015 (Table 5.1.2).

GoM DPS – Downeast Coastal SHRU

Dennys: The Dennys River weir (river km 1.48) was not operated in 2015. Redd counts are utilized to evaluate spawning escapement. DMR staff conducted redd count surveys from 13 November through 23 November, 2015.

East Machias: Counting facilities are not operated on the East Machias River. Redd counts are utilized to evaluate spawning escapement. DMR and Downeast Salmon Federation (DSF) staff conducted redd count surveys from 4 November through 16 December, 2015.

Machias: Counting facilities are not operated on the Machias River. Redd counts are utilized to evaluate spawning escapement. DMR staff conducted redd count surveys from 2 November through 4 December, 2015.

Narraguagus: DMR staff operated the Cherryfield Dam fishway trap (river km 1.85) in the Narraguagus River from 29 April to 29 October, 2015. Biological data and tissue samples are taken from each individual fish in accordance with DMR protocols, along with existing marks and tags. All fish enumerated at the Cherryfield Dam facility are released upstream. It is important to note that high water conditions allow salmon to ascend Cherryfield Dam, bypassing the fishway trap. Redd counts provide further evaluation of spawning escapement. DMR staff conducted redd count surveys from 5 November through 8 December, 2015.

Pleasant: DMR staff operated the Saco Falls fishway trap (river km 11.00) in the Pleasant River from 4 May to 17 June, 2015. Biological data and tissue samples are taken from each individual fish in accordance with DMR protocols, along with existing marks and tags. All fish enumerated at the Saco Falls facility are released upstream. It is important to note that high water conditions allow salmon to ascend Saco Falls, bypassing the fishway trap. Further, salmon may access spawning habitat below the trapping facility. Redd counts provide further evaluation of spawning escapement. DMR staff and Downeast Salmon Federation (DSF) staff conducted redd count surveys from 5 November through 10 December, 2015.

Union: Brookfield Renewable Energy Partners (BREP) staff operated the Ellsworth Dam fishway trap (river km 5.71) in the Union River from 1 May to 31 November, 2015. Biological data and tissue samples are taken from each individual fish in accordance with DMR protocols, along with existing marks and tags. All fish enumerated at the Ellsworth Dam facility are trucked upstream and released in the West Branch. Redd count surveys were not conducted in the Union River in 2015.

GoM DPS – Merrymeeting Bay SHRU

Androscoggin: The Brunswick fishway trap (river km 15.25) in the Androscoggin River was operated by DMR and BREP staff from 15 April to 13 November, 2015. Biological data and tissue samples are taken from each individual fish in accordance with DMR protocols, along with existing marks and tags. All fish enumerated at the Brunswick fishway facility are passed upstream. DMR staff conducted redd count surveys on 19 November, 2015.

Kennebec: The Lockwood fishlift facility (river km 101.92) in the Kennebec River was operated by BREP staff from 1 May to 4 November, 2015. Biological data and tissue samples are taken from each individual fish in accordance with DMR protocols, along with existing marks and tags. Scales are read on site to determine age and origin of the fish. All fish enumerated at the Lockwood fishlift facility are trucked to the Sandy River by DMR. The Benton Falls fishlift facility (river km 7.84) in the Sebasticook River was operated by Benton Hydro Associates staff from 4 May to 31 October, 2015. Only visual observations are recorded at the Benton Falls fishlift facility, as fish pass upstream without handling. Redd counts are utilized to evaluate spawning escapement. DMR staff conducted redd count surveys from 14 October through 12 November, 2015.

Sheepscot: Counting facilities are not operated on the Sheepscot River. Redd counts are utilized to evaluate spawning escapement. DMR staff conducted redd count surveys from 9 November through 2 December, 2015.

GoM DPS – Penobscot Bay SHRU

Ducktrap: Counting facilities are not operated on the Ducktrap River. Redd counts are utilized to evaluate spawning escapement. DMR staff conducted redd count surveys from 3 November through 1 December, 2015.

Penobscot: The Milford fishlift (river km 62.28) was operated by DMR and BREP staff in the Penobscot River beginning 27 April to 12 November, 2015. The Orono Dam fishlift was operated by BREP staff beginning 27 April to 12 November, 2015. All fish enumerated at the Orono Dam are included in the Milford fishlift count. A subset of the adult Atlantic salmon captured at both facilities are retained and transferred to the United States Fish and Wildlife Service (USWFS) Craig Brook National Fish Hatchery (CBNFH) for the sea-run broodstock program. All other fish enumerated at the Milford fishlift are released upstream or used for research. Redd counts are utilized to evaluate spawning escapement. DMR staff conducted redd count surveys from 4 November through 30 November.

Non-GoM DPS Rivers

Aroostook: Algonquin Power Company operates the Tinker Dam facility (river km 5.16) in the Aroostook River (Outer Bay of Fundy – OBoF DPS). The fishway trap was operated from 9 July to 6 November, 2015. All fish enumerated at the Tinker Dam facility are released upstream. Redd count surveys were not conducted in the Aroostook River in 2015.

Saco: BREP operates three fish passage facilities in the Saco River (Central New England – CNE DPS). The Cataract fishlift (river km 7.61), located on the East Channel in the Saco River was operated from 27 April to 30 October, 2015. The Denil fishway sorting facility (river km 0.97-SC1) on the West Channel in Saco and Biddeford was operated from 2 May to 30 October. Only visual observations are recorded at the Cataract facilities, as fish pass upstream without handling. The third passage facility upriver at the Skelton Dam (river km 25.66) was operated from 30 April to 30 October, 2015. Biological data and tissue samples are taken from each individual fish in accordance with DMR protocols, along with existing marks and tags. All fish enumerated at the Skelton Dam are trucked upstream and released in the Little Ossipee River. Redd count surveys were not conducted in the Saco River in 2015.

St. Croix: Atlantic Salmon Federation (ASF) staff operate the Milltown Dam facility on the St. Croix River (OBoF DPS). The fishway trap was operated from 30 April to18 July, 2015. Biological data and tissue samples are taken from each individual fish in accordance with DMR protocols, along with existing marks and tags. All non-aquaculture suspect (AQS) fish enumerated at the Milltown Dam facility are released upstream. Redd count surveys were not conducted in the St. Croix River in 2015.

RESULTS

GoM DPS – Downeast Coastal SHRU

Dennys: The Dennys River weir (river km 1.48) was not operated in 2015. The weir has not been operated since 2011. Reactivation of the facility is unlikely. Redd counts were utilized to evaluate spawning escapement. DMR staff documented 16 redds attributed to naturally-reared returns (Table 5.1.2). Surveys covered 78.9% of known spawning habitat (Figure 5.1.2).

East Machias: Counting facilities are not operated on the East Machias River. Redd counts were utilized to evaluate spawning escapement. DMR and Downeast Salmon Federation (DSF) staff documented 9 redds attributed to naturally-reared returns (Table 5.1.2). Surveys covered 98.8% of known spawning habitat (Figure 5.1.2).

Machias: Counting facilities are not operated on the Machias River. Redd counts were utilized to evaluate spawning escapement. DMR documented 18 redds attributed to naturally-reared returns and/or returns from smolt stocking (Table 5.1.2). Surveys covered 61.0% of known spawning habitat (Figure 5.1.2).

Narraguagus: DMR staff captured one male and two female adult Atlantic salmon in the fishway trap (Figure 5.1.1 and Table 5.1.3). Median capture date was 4 July. All captures (3) were two-sea-winter (2SW) salmon of naturally-reared origin (Table 5.1.4). Sea-age and origin were determined based on scale analysis and marks observed. Naturally-reared 2SW salmon (n=3) averaged (± S.D.) 74.7 ± 2.1 cm fork length (Table 5.1.5). All captures were observed with injuries; injury rate was 2/injured fish in 2015 (Table 5.1.6). Redd counts were also used to evaluate spawning escapement. DMR staff documented 31 redds attributed to naturally-reared returns (Table 5.1.2). Surveys covered 74.2% of known spawning habitat (Figure 5.1.2).

Pleasant: No Atlantic salmon were captured in the Saco Falls fishway trap in 2015 (Table 5.1.3). However, redd counts were also used to evaluate spawning escapement. DMR and DSF staff documented 28 redds attributed to returns from smolt stocking (Table 5.1.2). Surveys covered 85.3% of known spawning habitat (Figure 5.1.2).

Union: No Atlantic salmon were captured in the Ellsworth Dam fishway trap in 2015 (Table 5.1.2).

GoM DPS – Merrymeeting Bay SHRU

Androscoggin: DMR and BREP staff enumerated two adult Atlantic salmon at the Brunswick fishway facility in 2015 (Figure 5.1.3 and Table 5.1.3). Median capture date was 1 July. However, one adult left the Androscoggin River and was enumerated at the Lockwood fishlift facility at a later date. Sea-age and origin of the adult salmon remaining in the Androscoggin River were undetermined as the fish was observed through the viewing window at the facility and was not handled. All captures were observed with injuries; injury rate was 2/injured fish in 2015 (Table 5.1.5). Redd counts were also used to evaluate spawning escapement. No spawning activity was observed in 2015 (Figure 5.1.2. and Table 5.1.2).

Kennebec: BREP staff captured 31 adult Atlantic salmon at the Lockwood fishlift facility in 2015 (Figure 5.1.5 and Table 5.1.3). Median capture date was 28 June. The sea-age distribution of returns comprised of 28 two-sea-winter (2SW) and 3 one sea-winter (1SW) grilse. Twenty-nine salmon were determined to be of naturally-reared origin (93.6%) and two of hatchery-origin (6.5%) (Table 5.1.4). Naturally-reared 2SW salmon (n=26) averaged (± S.D.) 72.3 ± 3.7 cm fork length (Table 5.1.5). Injuries were observed on 48% of returns; injury rate was 1.5/injured fish in 2015 (Table 5.1.6). Naturally-reared returns were attributed to natural spawning and/or egg planting. Hatchery-origin returns were attributed to strays from smolt stocking. DMR trucked 30 adult Atlantic salmon upstream for release in the Sandy River. One adult Atlantic salmon was inadvertently released back to the Kennebec River below the Lockwood fishlift facility. At time of capture the fish was thought to be a large landlocked Atlantic salmon due to its appearance and irregular scale growth pattern. It was later determined after further scale analysis to be an Atlantic salmon grilse, which spent some time at sea. No Atlantic salmon were captured at the Benton Falls fishlift facility on the Sebasticook River in 2015. Redd counts were also used to evaluate spawning escapement in the Kennebec drainage. DMR staff documented 31 redds in tributaries of the Kennebec, primarily in the Sandy River (Table 5.1.2). Surveys covered 19.9% of known spawning habitat (Figure 5.1.2).

Sheepscot: Counting facilities are not operated on the Sheepscot River. Redd counts were utilized to evaluate spawning escapement. DMR staff documented six redds in 2015 (Table 5.1.2). All redds were located in the West Branch. Escapement can be attributed to naturally-reared returns, stream-side incubated fry, and egg planting. Surveys covered 77.7% of known spawning habitat (Figure 5.1.2).

GoM DPS – Penobscot Bay SHRU

Ducktrap: Counting facilities are not operated on the Ducktrap River. Redd counts were utilized to evaluate spawning escapement. No spawning activity was observed in 2015 (Table 5.1.2). Surveys covered 54.4% of known spawning habitat (Figure 5.1.2).

Penobscot: A total of 725 sea-run Atlantic salmon were captured during the 2015 season at the Milford fish lift on the Penobscot River (Figure 5.1.4 and Table 5.1.3). In addition, 6 sea-run Atlantic salmon were captured at the Orono fish lift. The total sea-run Atlantic salmon return to the Penobscot River in 2015 was 731 sea-run salmon. This year's median capture date was 18 June. Scale samples were collected from 665 salmon captured at the Milford and Orono fish lifts and analyzed to characterize the age and origin structure of the run. The origins of 66 Atlantic salmon not scale sampled were prorated based on the observed proportions, taking into account the presence of tags or marks observed and dorsal fin deformity. The majority of returning salmon were age 2SW (604; 83%), along with 119 1SW salmon (16%), seven 3SW fish, and one repeat spawner. Approximately 92% (670) of the salmon that returned were of hatchery origin and the remaining 8% (61) were of naturally-reared origin (Table 5.1.4). Naturally-reared 2SW salmon (n=52) averaged (± S.D.) 73.6 ± 3.4 cm fork length (Table 5.1.5). Hatchery-origin 2SW salmon (n=544) averaged (± S.D.) 75.1 ± 3.2 cm fork length. Injuries were observed on 35% of the returns; injury rate was 1.4/injured fish in 2015 (Table 5.1.6).

Only 1% of this year's run (8 salmon) were observed to have at least one mark applied (adipose clip and/or Visual Implant Elastomer "VIE") prior to being released as a hatchery smolt (Table 5.1.7). These eight fish marked consisted of a single 2SW male salmon with an adipose clip and no other visible mark and seven grilse (1SW) with adipose clips and VIE tags (3 left eye green, 1 right eye green, and 3 left eye red). These fish were released as smolts from Green Lake National Fish Hatchery (GLNFH) after being adipose clipped and VIE tagged as part of an ongoing study. Atlantic salmon captured in the Milford and Orono fish lifts in 2015 were tissue sampled in conjunction with MDMR collection procedures (Table 5.1.8). In 2015, the 709 tissue samples collected at Milford were delivered to USFWS Northeast Fishery Center in Lamar, PA for genetic analysis and to identify appropriate mating pairs during spawning at CBNFH.

During the 2015 trapping season, 660 adult Atlantic salmon broodstock were collected at the Milford Dam fish lift on the Penobscot River and transported to CBNFH (Table 5.1.9). All broodstock were marked with a fin punch and tagged with a PIT tag. The 660 brood salmon represent an increase of 446 fish from last year's total of 214 salmon and was 100 fish more than the broodstock target of 560. Atlantic salmon broodstock transported in 2015 consisted of 354 females, 244 males, and 62 grilse. All broodstock were collected and transported to CBNFH from 13 May through 2 August, 2015. The majority of the broodstock were collected in June (Table 5.1.10). All sea-run adult Atlantic salmon (minus mortalities) not retained for broodstock (62) were released upstream (Table 5.1.11). Further, four adults of captive-reared freshwater (CRF) origin and seven adult Atlantic salmon captured as broodstock were released upstream. Additionally, 468 gravid domestic (DOM) origin adults were released from GLNFH in Mattamiscontis Stream. Total adult Atlantic salmon escapement to the Penobscot River was 545 in 2015.

Redd count surveys were conducted by DMR staff in six watersheds within the Penobscot River drainage in 2015. Three tributaries located below the Milford Dam fishlift were surveyed to evaluate spawning escapement. Redd count surveys in Cove Brook found no evidence of spawning activity, however a grilse was found dead. This salmon return most likely resulted from recent egg planting activities. Redd count surveys in Kenduskeag Stream documented one redd (Table 5.1.2) where hatchery-origin pre-spawn 4 year old adults (from previous Penobscot parr collections) were released in the spring of 2015. Souadabscook Stream was also surveyed; no spawning activity was observed. Redd count surveys above Milford Dam fishlift occurred in the Mattawamkeag and Piscataquis drainages. No redds were found on a reach within the East Branch Mattawamkeag; surveys covered 5.2% of known spawning habitat (Figure 5.1.1). The upper Piscataquis, which receives the most intensive stocking and monitoring, was surveyed twice. No redds were documented in this reach. A lower reach was surveyed and two redds were identified. This reach was identified to have spawning activity during the recent adult translocation study. A significant proportion (77.6%) of the Pleasant River (tributary to Piscataquis) was surveyed and no redds were found. Surveys covered 32.4% of known spawning habitat in the Piscataquis drainage in 2015. Additional watersheds were surveyed by Penobscot Indian Nation (PIN) staff to assess spawning of 468 gravid domestic adults released in Mattamiscontis Stream. No evidence of spawning activity was observed in Mattamiscontis Stream. However, PIN staff documented four redds in Sam Ayer's Stream (tributary to Mattamiscontis).

Non-GoM DPS Rivers

Aroostook: Algonquin Power Company captured six adult Atlantic salmon and released all upstream (Table 5.1.3). Median capture date was 7 August. All six salmon (1 male and 5 female) were reported as wild origin (Table 5.1.4).

Saco: BREP staff observed five adult Atlantic salmon moving upstream through the Cataract fishlift and Denil fishway facilities in the Saco River (Table 5.1.3 and Table 5.1.4). Median capture date was 11 June. One Atlantic salmon was captured at the Skelton Dam facility and trucked upstream and released in the Little Ossipee River. It is important to note that the total count returning to the Saco River could exceed five salmon due to the possibility of adults ascending Cataract without passing through one of the counting facilities.

St. Croix: No Atlantic salmon were reported captured in 2015 (Table 5.1.3). Naturally-reared Atlantic salmon have not been documented at Milltown since 2006.

Redd Based Returns/Escapement to Small Coastal Rivers

Scientists estimate the total number of returning salmon to small coastal rivers using capture data on rivers with trapping facilities (Narraguagus, Pleasant, and Union rivers) combined with redd count data from the Dennys, East Machias, Machias, Pleasant, Narraguagus, Ducktrap, and Sheepscot Rivers. Estimated returns are extrapolated from redd count data using a return-redd regression [ln (returns) = 0.5594 ln (redd count) + 1.2893] based on redd and adult counts from 2005-2010 on the Narraguagus River, Dennys River and Pleasant River (USASAC 2010). Total estimated return based on redd counts for the small coastal rivers was 118 (90% CI = 83 - 161) in 2015 (Figure 5.1.6 and Table 5.1.12). Estimates include returns to the Union River.

DISCUSSION

Documented adult Atlantic salmon returns to rivers in the geographic area of the Gulf of Maine DPS (73 FR 51415-51436) in 2015 totaled 881. Returns are the sum of counts at fishlifts, fishways and weirs (763) and estimates from redd surveys (118). No fish returned "to the rod", because angling for Atlantic salmon is closed statewide. Escapement to these same rivers in 2015 was 663; (545 Penobscot [731 return – (660 broodstock + 5 DOA) + 7 broodstock returned to the river by CBNFH + 4 CRF origin + 468 gravid DOM origin in Mattamiscontis Stream] + 118 other DPS). Because there was no rod catch, the escapement to the GOM DPS area was assumed to equal returns (estimated or released after capture) plus released pre-spawn captive broodstock (adults used as hatchery broodstock are not included).

Estimated replacement (adult to adult) of naturally-reared returns to the DPS has varied since 1990 although the rate has been somewhat consistent since 1997 at or below 1 (Figure 5.1.7). Most of these were 2SW salmon that emigrated as 2 year old smolt, thus, cohort replacement rates were calculated assuming a five year lag. These were used to calculate the geometric mean replacement rate for the previous ten years (e.g. for 2000: 1991 to 2000) for the naturally-reared component of the DPS overall and in each of three Salmon Habitat Recovery Units (SHRU). Despite an apparent increase in replacement rate since 2008, naturally-reared returns are still well below 500 (Fig. 5.1.8).

Returns to the Cherryfield Dam fishway trap on the Narraguagus River (3) declined from the previous year (4) and remained below the previous 10-year average for naturally-reared returns (13) (Figure 5.1.1). It is important to note that high water conditions allow salmon to ascend Cherryfield Dam, bypassing the fishway trap. Redd counts provided further evaluation of adult returns in the Narraguagus River. Estimated escapement in 2015 (27) was higher than the previous year (21) but remained well below the previous 5-year average (77) that resulted largely from smolt stocking returns. Prior to the recent 5-year period of escapement from smolt stocking, the previous 10-year average escapement estimate was 20 (2000-2009). The escapement observed in the Narraguagus River in 2015 was attributed to below average naturally-reared smolt production observed in 2013. However, these smolts appeared to experience improved marine survival compared to recent cohorts. The smolt-to-adult return (SAR) rate for the 2013 naturally-reared smolt cohort (191/10k) was highest since 2007 and the second highest SAR rate in the time-series (Figure 5.1.9). The 2013 cohort was produced primarily by increased natural spawning of adult returns resulting from the 2008 smolt stocking and fry stocking in spring 2011.

Estimated escapement to the Machias (15) and Pleasant (26) rivers were lower than the Narraguagus (27) in 2015 despite recent smolt stocking (59,000 Machias; 62,300

Pleasant) in 2013. Results are further evidence that hatchery SAR rates are far lower than the SAR of naturally-reared Narraguagus smolts. Results were consistent with past comparison of Narraguagus naturally-reared smolt and Penobscot hatchery smolt return rates (Figure 5.1.9). However, due to consistently low naturally-reared smolt production (≤ .25/unit) in the Downeast Coastal SHRU (see WP16-02 Smolt Update), hatchery smolt stocking remains a valuable tool to provide short-term increases in adult escapement in this geographic area of the GoM DPS.

Naturally-reared returns to the Penobscot River in 2015 (61) increased from the previous year (22) and remained below the previous 10-year average (86) (Figure 5.1.4). Naturally-reared returns resulted from fry stocking and natural spawning. The proportion of naturally-reared returns in 2015 (8%) was consistent with the previous 10-year average (7%). Hatchery-origin returns to the Penobscot River in 2015 (670) increased from the previous year (239) and remained below the previous 10-year average (1,187). Hatchery-origin returns resulted from smolt stocking. Although redd counts are conducted on the Penobscot River, they are not used to estimate adult returns.

Naturally-reared returns to the Kennebec River (29) increased from the previous year (13) and were above the previous 10-year average for naturally-reared returns (13) (Figure 5.1.5). Naturally-reared returns likely resulted from eyed-egg planting and limited natural spawning. Hatchery-origin returns (2) were consistent with the previous year (2) and remained below the previous 10-year average (8). Hatchery-origin returns resulted from stray returns from the Penobscot River smolt stocking program.

The escapement observed in the Sheepscot River in 2015 is attributed to below average naturally-reared smolt production observed in 2013. The 2013 cohort was produced primarily by limited natural spawning of adult returns and stream-side incubated fry stocking. Estimated escapement in the Sheepscot River (12) decreased from the previous year (25) and was below the previous 10-year average escapement (15).

Scale analysis results indicated sea-age of naturally-reared and hatchery-origin adult salmon was predominately 2SW. Results were consistent with sample data collected on Maine rivers during the previous six decades wherein 2SW salmon typically comprise 80-90% of the returning population. Mean fork length of naturally-reared 2SW salmon returning to the Narraguagus and Penobscot rivers were greater than previous years. Androscoggin and Kennebec River naturally-reared 2SW salmon were smaller than previous years. Mean fork length of hatchery-origin 2SW salmon returning to the Penobscot River was greater than previous years and larger than 2SW salmon observed in all other rivers.

Median capture date of adult Atlantic salmon was variable compared to the previous year but was earlier on most Maine rivers: Narraguagus salmon were 15 days earlier while salmon returning to the Androscoggin were 13 days earlier. Median capture date on the Penobscot River was 11 days earlier than the previous year. Returns to the Aroostook River were four days earlier while salmon returning to the Saco were one day earlier. Median capture date was four days later on the Kennebec River.

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United States Atlantic Salmon Assessment Committee (USASAC). 2010. Annual Report of the U.S. Atlantic Salmon Assessment Committee Report No. 22 – 2009 Activities. Gloucester, MA. 179 pp. http://www.nefsc.noaa.gov/USASAC/

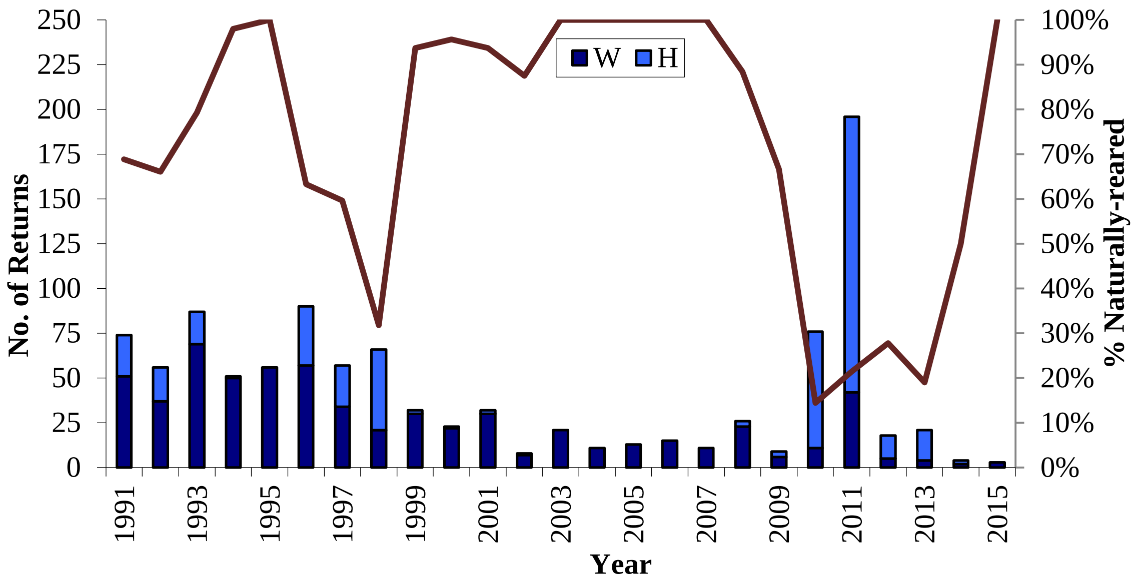

Figure 5.1.1. Cumulative adult Atlantic salmon catch by origin (bar) and proportion of naturally-reared returns (line), Cherryfield Dam fishway trap, Narraguagus River, Maine (1991-2015).

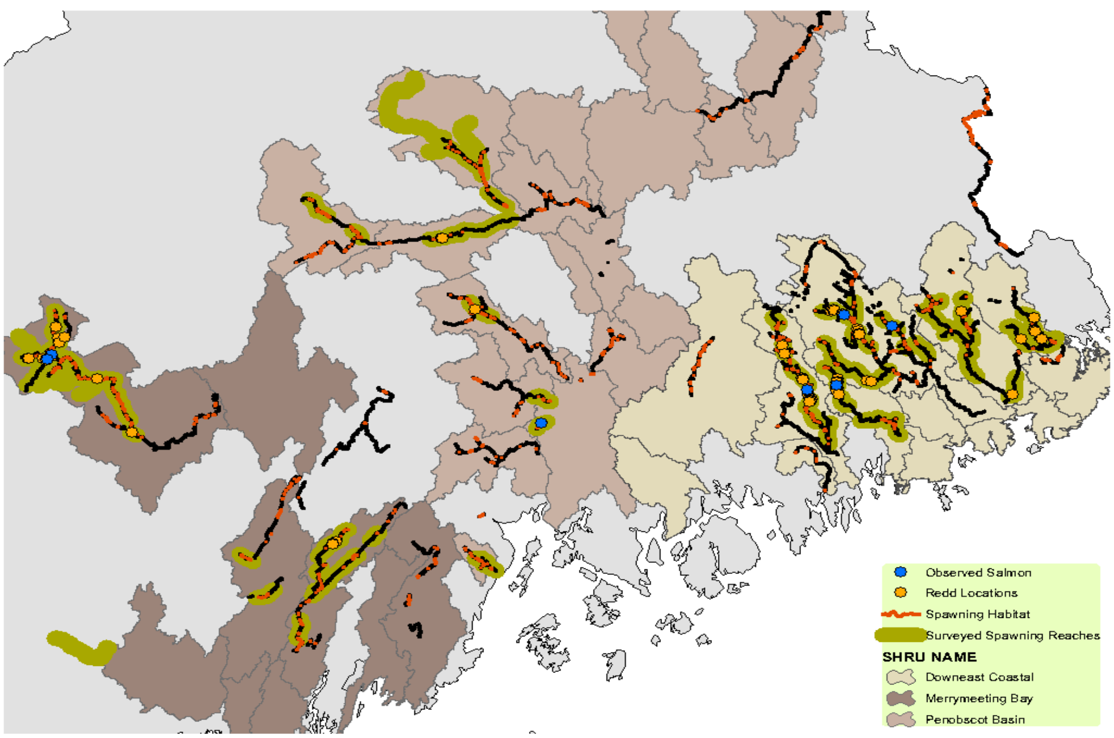

Figure 5.1.2. Survey coverage and distribution of redds observed in Maine rivers in 2015.

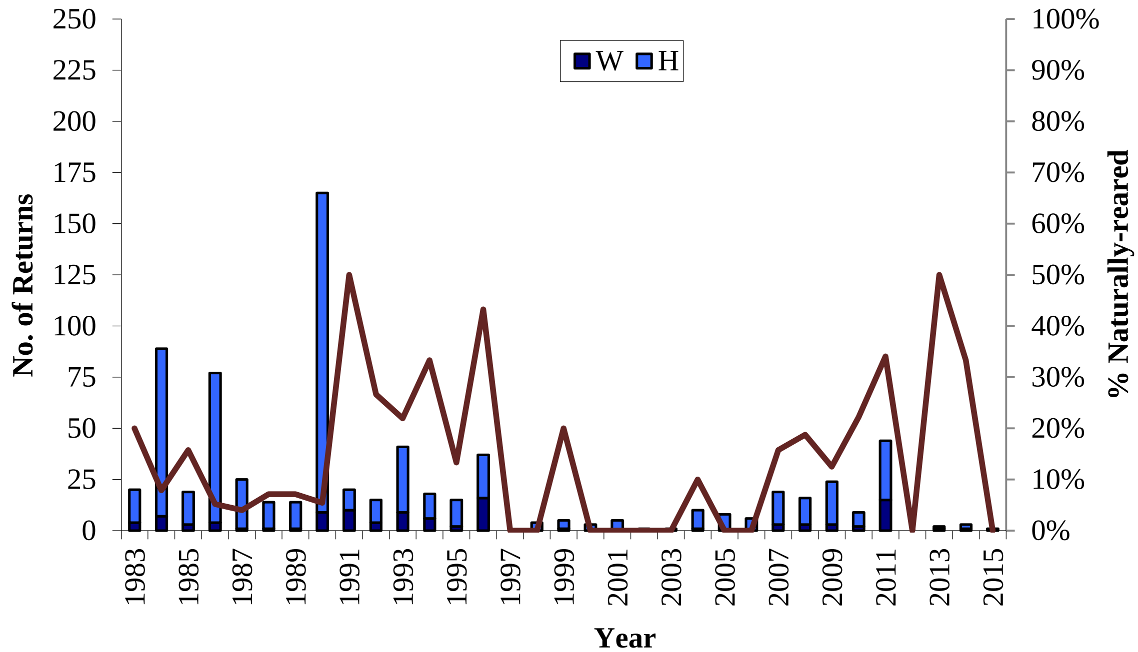

Figure 5.1.3. Cumulative adult Atlantic salmon catch by origin (bar) and proportion of naturally-reared returns (line), Brunswick Dam fishway trap, Lower Androscoggin River, Maine (1983-2015).

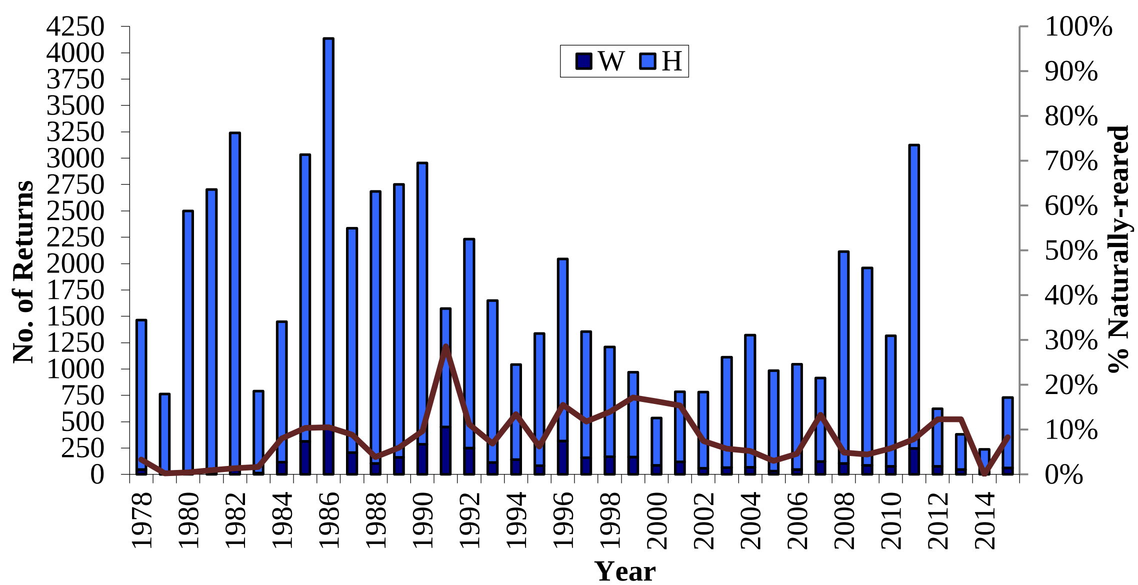

Figure 5.1.4. Cumulative adult Atlantic salmon catch by origin (bar) and proportion of naturally-reared returns (line), Veazie Dam fishway trap (1978-2013) and Milford Dam fishlift (2014-2015), Penobscot River, Maine.

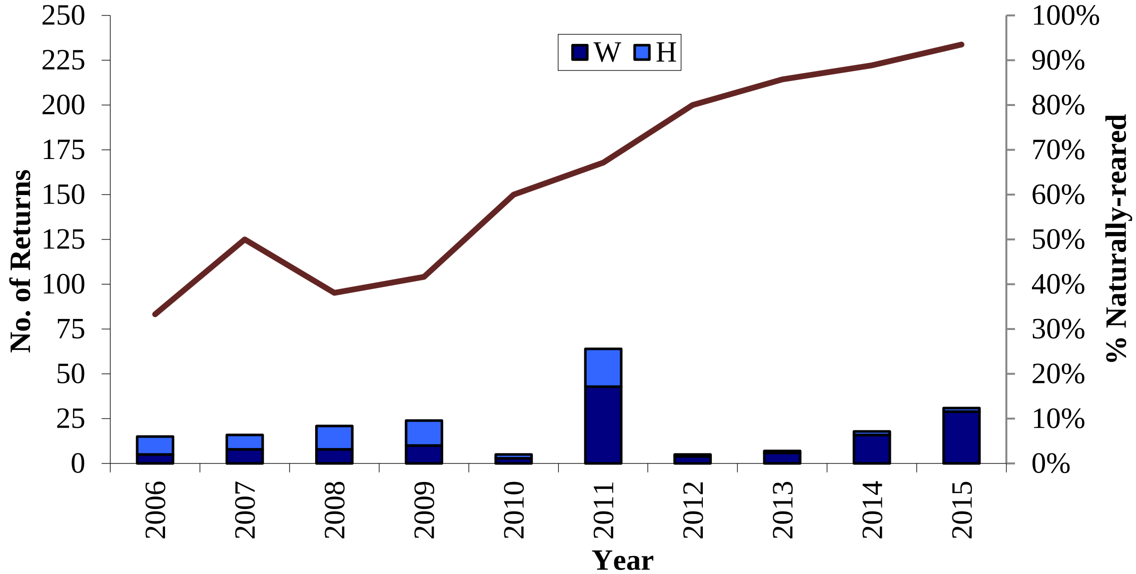

Figure 5.1.5. Cumulative adult Atlantic salmon catch by origin (bar) and proportion of naturally-reared returns (line), Lockwood Dam fishlift, Lower Kennebec River, Maine (2006-2015)

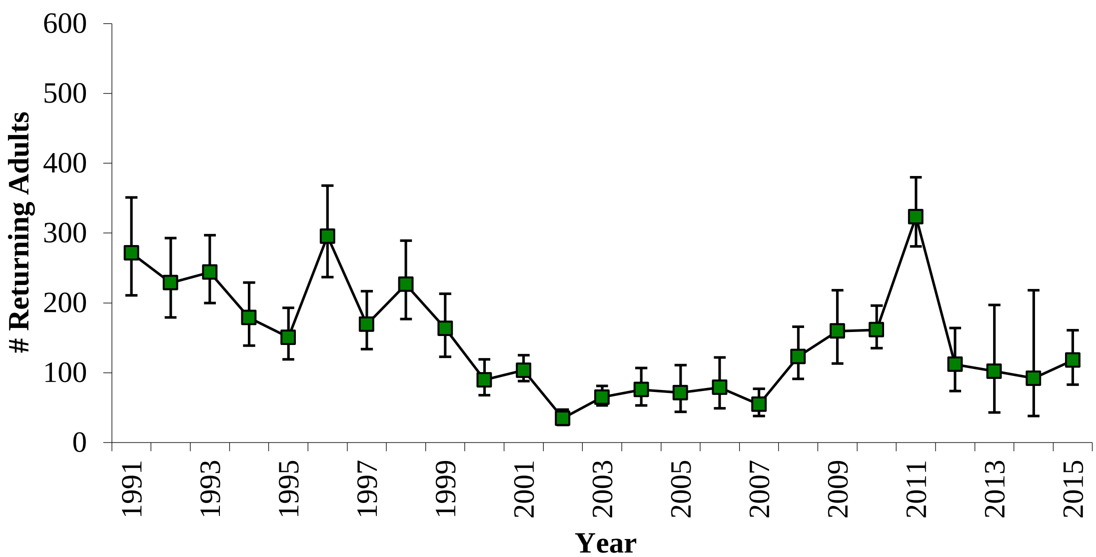

Figure 5.1.6. Regression estimates and confidence intervals (± 90% CI) of adult Atlantic salmon returns to small coastal GoM DPS rivers from 1991 to 2015. Estimates include the Union River.

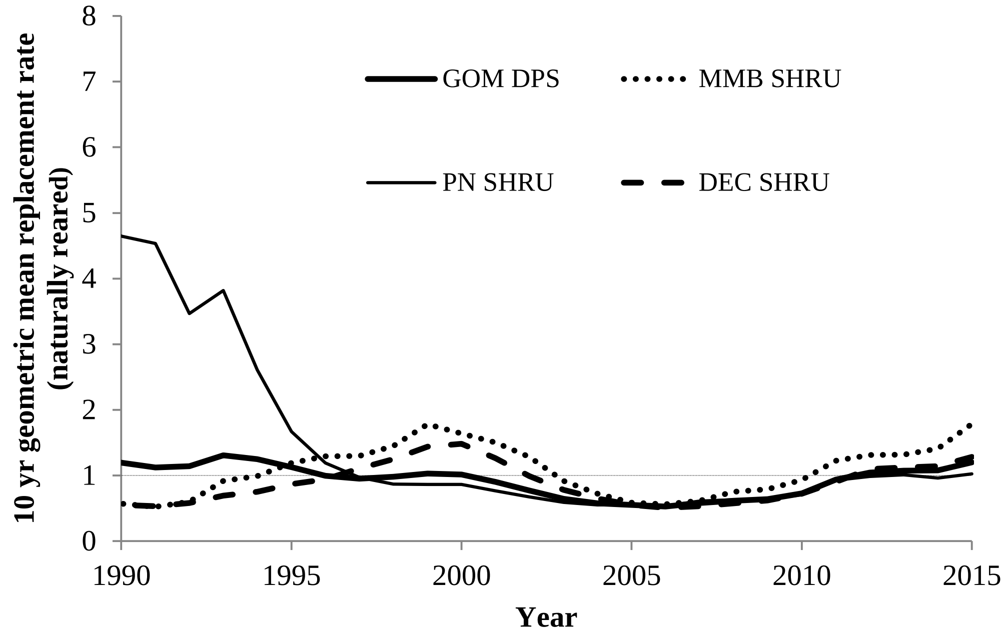

Figure 5.1.7. Ten-year geometric mean replacement rate for returning naturally-reared Atlantic salmon in the GoM DPS by Salmon Habitat Recovery Unit (SHRU) (1990-2015).

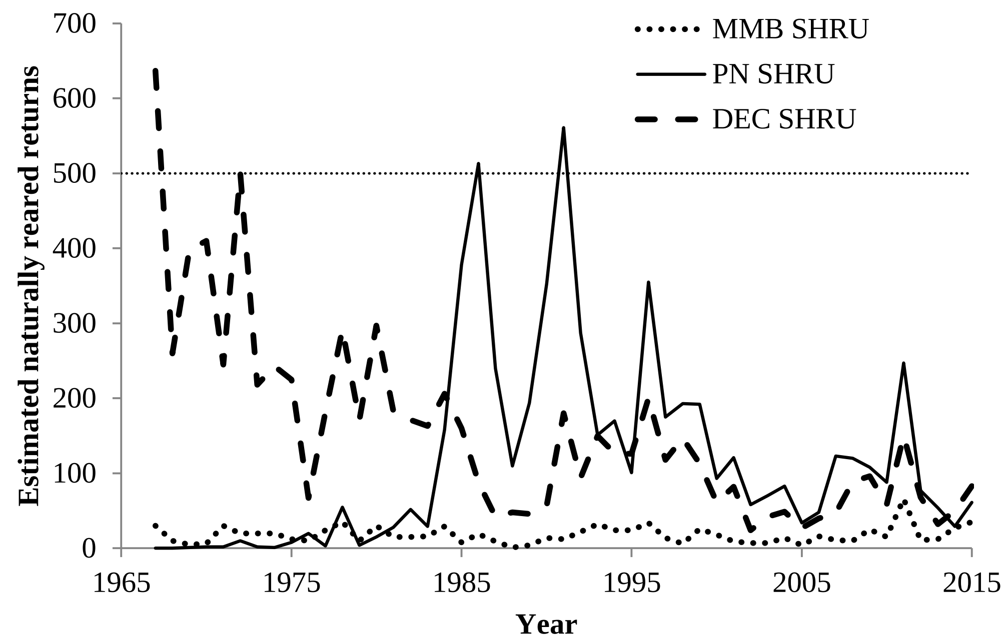

Figure 5.1.8. Estimated adult Atlantic salmon returns (naturally-reared) to the GoM DPS by Salmon Habitat Recovery Unit (SHRU) (1967-2015).

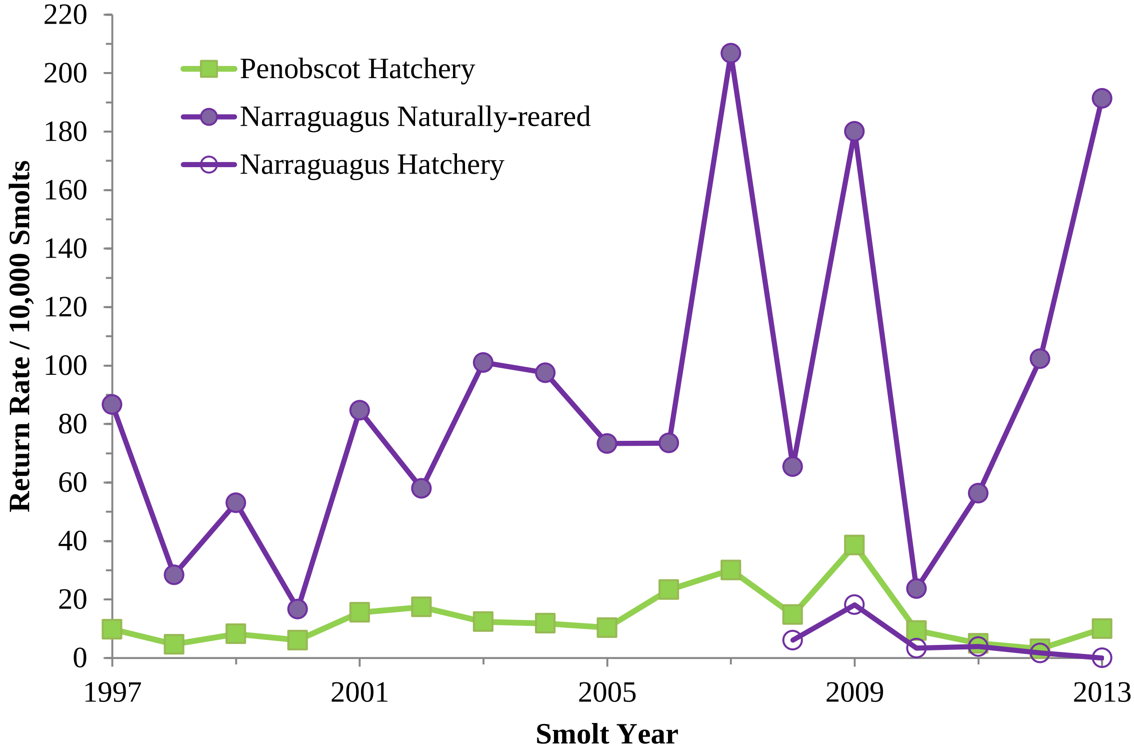

Figure 5.1.9. Return rate of 2SW adults to Gulf of Maine area rivers by cohort of hatchery-reared Atlantic salmon smolts and estimated naturally-reared smolt emigration (1997-2013).

Table 5.1.1. Counting facilities operated to enumerate adult Atlantic salmon returns to Maine rivers, 2015.

River	**Site**	**Type**	**DPS***	**SHRU****	**Operator**
Androscoggin	Brunswick	Fishway	GoM	MMB	Brookfield Renewable Energy Partners/DMR
Kennebec	Benton Falls	Fishlift	GoM	MMB	Brookfield Renewable Energy Partners/DMR
Kennebec	Lockwood	Fishlift	GoM	MMB	Brookfield Renewable Energy Partners/DMR
Penobscot	Milford	Fishlift	GoM	PB	DMR
Penobscot	Orono	Fishlift	GoM	PB	Brookfield Renewable Energy Partners/DMR
Pleasant	Saco Falls	Fishway	GoM	DC	DMR
Narraguagus	Cherryfield	Fishway	GoM	DC	DMR
Union	Ellsworth	Fishlift	GoM	DC	Brookfield Renewable Energy Partners
Aroostook	Tinker	Fishway	OBoF	-	Algonquin Power Company
St. Croix	Milltown	Fishway	OBoF	-	New Brunswick Power/Atlantic Salmon Federation
Saco	Cataract (East Channel)	Fishlift	CNE	-	Brookfield Renewable Energy Partners
Saco	Cataract (West Channel)	Fishway	CNE	-	Brookfield Renewable Energy Partners
Saco	Skelton	Fishlift	CNE	-	Brookfield Renewable Energy Partners

* DPS: GoM, Gulf of Maine; OBoF, Outer Bay of Fundy; CNE, Central New England.
** SHRU: MMB, Merrymeeting Bay; PB, Penobscot Bay; DC, Downeast Coastal.

Table 5.1.2. Redd count survey results by SHRU and drainage. Effort is shown by both total kilometers and proportion of spawning habitat surveyed.

SHRU	Drainage	# Redds Observed	% Drainage Spawning Habitat Surveyed	Total River km Surveyed
Downeast Coastal	Dennys	16	78.9	33.4
	East Machias	9	98.8	28.9
	Machias	18	61	59.8
	Narraguagus	31	74.2	50.6
	Pleasant	28	85.3	22.9
	SHRU Total	102	-	195.6
Merrymeeting Bay	Androscoggin	0	-	0.2
	Kennebec	31	19.9	62.9
	Sheepscot	7	77.7	44.7
	SHRU Total	38	-	107.8
Penobscot Bay	Ducktrap	0	54.4	4.1
	Mattawamkeag	0	1.5	4.2
	Penobscot	1	1.7	8.5
	Piscataquis	2	32.4	41.2
	SHRU Total	3	-	58.9
	GoM DPS Total	143	-	362.1

Table 5.1.3. Counts of sea-run, Atlantic salmon returns to Maine rivers in 2015 by gender and sea-age (One sea-winter, 1SW; two sea-winter, 2SW; three sea-winter, 3SW; multi sea-winter, MSW; and repeat spawner, RPT). Also included are counts of aquaculture (AQS) and captive reared freshwater (CRF) adult captures.

				Male				Female				Unknown		Adult Counts		
SHRU and River	**Trap Open Date**	**Median Catch Date**	**Trap Close Date**	**1SW**	**2SW**	**3SW**	**RPT**	**1SW**	**2SW**	**3SW**	**RPT**	**1SW**	**MSW**	**Sea-run**	**AQS**	**CRF**
Downeast Coastal																
Narraguagus River	29 Apr	04 Jul	29 Oct	0	1	0	0	0	2	0	0	0	0	3	0	0
Pleasant River	04 May	--	17 Jun	0	0	0	0	0	0	0	0	0	0	0	0	0
Union River	01 May	--	31 Oct	0	0	0	0	0	0	0	0	0	0	0	0	0
Penobscot Bay																
Penobscot River	27 Apr	18 Jun	13 Nov	116	242	4	1	3	355	3	0	0	7	731	0	4
Merrymeeting Bay																
Lower Kennebec River	01 May	28 Jun	04 Nov	3	10	0	0	0	18	0	0	0	0	31	0	0
Lower Androscoggin R.	15 Apr	01 Jul	13 Nov	0	0	0	0	0	1	0	0	0	0	1	0	0
Sebasticook River	04 May	--	31 Oct	0	0	0	0	0	0	0	0	0	0	0	0	0
Non-GoM DPS rivers																
Aroostook River	09 Jul	07 Aug	06 Nov	0	1	0	0	0	5	0	0	0	0	6	0	0
Saco River	30 Apr	11 Jun	30 Oct	1	1	0	0	0	3	0	0	0	0	5	0	0
St. Croix River	30 Apr	--	18 Jul	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	--	--	--	121	254	4	1	8	379	3	0	0	7	777	0	4

Table 5.1.4. Age and origin of sea run Atlantic salmon returns to Maine rivers in 2015.

SHRU and River	Total Sea-run Returns	Hatchery 1SW	Hatchery 2SW	Hatchery 3SW	Hatchery RPT	Hatchery Total	Wild 1SW	Wild 2SW	Wild 3SW	Wild MSW	Wild RPT	Wild Total
Downeast Coastal												
Narraguagus River	3	0	0	0	0	0	0	3	0	0	0	3
Pleasant River	0	0	0	0	0	0	0	0	0	0	0	0
Union River	0	0	0	0	0	0	0	0	0	0	0	0
Penobscot Bay												
Penobscot River	731	110	552	7	1	670	9	52	0	0	0	61
Merrymeeting Bay												
Lower Kennebec River	31	0	2	0	0	2	3	26	0	0	0	29
Lower Androscoggin R.	1	0	1	0	0	1	0	0	0	0	0	0
Sebasticook River	0	0	0	0	0	0	0	0	0	0	0	0
Non-GoM DPS rivers												
Aroostook River	6	0	0	0	0	0	0	6	0	0	0	6
Saco River	5	1	4	0	0	5	0	0	0	0	0	0
St. Croix River	0	0	0	0	0	0	0	0	0	0	0	0
Total	777	111	559	7	1	678	18	81	0	0	0	99

Table 5.1.5. Mean fork length (cm) ± S.D. by origin of sea-run Adult Atlantic salmon captured at counting facilities in Maine rivers.

	2SW Hatchery-origin				2SW Naturally-reared			
			10 year average				10 year average	
River	n	2015	n	('05-'14)	n	2015	n	('05-'14)
Androscoggin	0	N/A	71	73.7±4.9	1	71	23	73.5±4.6
Kennebec	2	72.0±1.4	60	73.5±3.7	26	72.3±3.7	93	73.2±2.6
Narraguagus	0	N/A	138	71.5±3.6	3	74.7±2.1	66	71.6±3.1
Penobscot	544	75.1±3.2	8749	73.0±3.2	52	73.6±3.4	679	72.0±3.2

Table 5.1.6. Documented injuries to sea-run Atlantic salmon returns to Maine by river in 2015.

						Injuries											
SHRU and River	**Total Sea-run Returns Handled**	**Number Injured Salmon**	**Number of Injuries Observed**	**Injuries per Injured Fish**	**Returns with Injuries (%)**	**Abrasion and Scraped up Sides**	**Banged Up Nose**	**Bird Attack**	**Hooking Wound**	**Laceration**	**Lamprey Wound**	**Net Marks**	**Puncture Wound**	**Scars**	**Seal Bite**	**Split Fin**	**Other**
Downeast Coastal																	
Narraguagus River	3	3	6	2.0	100	3	1	0	0	0	0	0	0	0	1	0	1
Pleasant River	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0
Union River	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0
Penobscot Bay																	
Penobscot River	731	257	351	1.4	35	41	35	9	0	111	78	0	0	36	16	17	9
Merrymeeting Bay																	
Lower Kennebec River	31	15	22	1.5	48	9	4	0	0	0	2	0	1	3	0	3	0
Lower Androscoggin River	1	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sebasticook River	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non-GoM DPS rivers																	
Aroostook River	6	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0
Saco River	5	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	777	276	381	1.4	36	53	40	9	0	111	80	0	1	39	17	20	10

Table 5.1.7. Marks and tags observed on Atlantic salmon in Maine, 2015. Counts are for first captures of sea-run and captive origin adult Atlantic salmon.

SHRU and River	Total Returns	Adipose Punch	Adipose Clips	Left Ventral Clip	Visible Implant Elastomer Tag	Passive Integrated Transponder Tag	Total Marks and Tags
Downeast Coastal							
Narraguagus River	3	0	0	0	0	0	0
Pleasant River	0	0	0	0	0	0	0
Union River	0	0	0	0	0	0	0
Penobscot Bay							
Penobscot River	731	0	8	0	7	4	19
Merrymeeting Bay							
Lower Kennebec River	31	1	0	0	0	0	1
Lower Androscoggin R.	1	0	0	0	0	0	0
Sebasticook River	0	0	0	0	0	0	0
Non-GoM DPS rivers							
Aroostook River	6	0	0	0	0	0	0
Saco River	5	0	0	0	0	0	0
St. Croix River	0	0	0	0	0	0	0
Total	777	1	8	0	7	4	20

Table 5.1.8. Number of scale and genetic samples collected from Atlantic salmon and the number of marks and tags applied to Atlantic salmon in Maine by river, 2015. Counts are for first and subsequent captures regardless of origin.

SHRU and River	# Scale Samples	# Genetic Samples	Adipose Punch Applied	Caudal Punch Applied	Passive Integrated Transponder Tag	Radio Tag
Downeast Coastal						
Narraguagus River	3	3	3	0	0	0
Pleasant River	0	0	0	0	0	0
Union River	0	0	0	0	0	0
Penobscot Bay						
Penobscot River	665	709	698	9	704	100
Merrymeeting Bay						
Lower Kennebec River	31	30	30	0	0	0
Lower Androscoggin R.	1	1	1	0	0	0
Sebasticook River	0	0	0	0	0	0
Non-GoM DPS rivers						
Aroostook River	0	0	0	0	0	0
Saco River	0	0	0	0	0	0
St. Croix River	0	0	0	0	0	0
Total	700	743	732	9	704	100

Table 5.1.9. Summary of Atlantic salmon sea-run broodstock targets and actual broodstock transported to Craig Brook National Fish Hatchery from the Milford Dam fishlift, Penobscot River, 2015.

Gender	Broodstock Target	Actual Broodstock
MSW Females	280	354
MSW Males	230	244
1SW Males	50	62
Total	560	660

Table 5.1.10. Monthly captures of sea-run adult Atlantic salmon retained for sea-run broodstock at the Milford Dam fishlift, Penobscot River, 2015.

	Male				Female				
Month	**1SW**	**2SW**	**3SW**	**RPT**	**1SW**	**2SW**	**3SW**	**RPT**	**Total**
May	0	23	0	0	0	12	1	0	36
June	42	195	3	1	1	281	3	0	526
July	20	22	0	0	3	52	0	0	97
August	0	0	0	0	0	1	0	0	1
Sept	0	0	0	0	0	0	0	0	0
Oct	0	0	0	0	0	0	0	0	0
								Total	660

Table 5.1.11. Monthly captures of sea-run adult Atlantic salmon released upstream (escapement) at the Milford Dam fishlift, Penobscot River, 2015.

	Male				**Female**				**Unknown**				
Month	**1SW**	**2SW**	**3SW**	**RPT**	**1SW**	**2SW**	**3SW**	**RPT**	**1SW**	**2SW**	**3SW**	**RPT**	**Total**
May	0	0	0	0	0	0	0	0	0	0	0	0	0
June	1	0	0	0	0	0	0	0	0	5	0	0	6
July	44	0	0	0	0	1	0	0	0	1	0	0	46
August	4	0	0	0	0	0	0	0	0	1	0	0	5
Sept	0	1	0	0	0	1	0	0	0	0	0	0	2
Oct	3	0	0	0	0	0	0	0	0	0	0	0	3
												Total	62

Table 5.1.12. Regression estimates and confidence intervals (± 90% CI) of adult Atlantic salmon returns to small coastal GOM DPS rivers from 1991 to 2015. Estimates include the Union River.

Year	LCI	Mean	UCI
1991	211	272	351
1992	179	229	293
1993	200	244	297
1994	139	179	229
1995	119	151	193
1996	237	295	368
1997	134	169	217
1998	177	227	289
1999	123	164	213
2000	68	90	119
2001	88	103	125
2002	25	35	47
2003	53	65	81
2004	53	76	107
2005	44	71	111
2006	49	79	122
2007	38	55	77
2008	91	123	166
2009	113	160	218
2010	135	161	196
2011	281	323	380
2012	74	112	164
2013	43	102	197
2014	65	95	133
2015	83	118	161