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

REPORT NO. 30 - 2017 ACTIVITIES

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PREPARED FOR
U.S. SECTION TO NASCO

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1 Executive Summary

1.1 Abstract

Total returns to USA rivers was 1,041; this is the sum of documented returns to traps and returns estimated by redd counts. This, year ranks 20 out of 27 years for the 1991-2017 time series. Documented returns to traps totaled 972 and returns estimated by redd counts was 69 adult salmon. Most returns were to the Gulf of Maine Distinct Population Segment, which includes the Penobscot River, Kennebec River and Eastern Maine coastal rivers, accounting for 96.8% of the total returns. Overall, 34.9% of the adult returns to the USA were 1SW salmon, 63.7% were 2SW salmon and 1.2% were 3SW or repeat spawners. Most (77.4 %) returns were of hatchery smolt origin and the balance (22.6%) originated from either natural reproduction, 0+ fall stocked parr, hatchery fry, or eggs. A total of 4,262,454 juvenile salmon (eggs, fry, parr, and smolt), and 4,849 adults were stocked into US rivers. Of those fish, 265,528 carried a mark and/or tag. Eggs for USA hatchery programs were taken from 310 sea-run females and 1,678 captive/domestic and domestic females. Total egg take (8,213,649) was much higher than the previous three years' average of 6,302,893, partially due to the increased numbers of spawners used (previous three-year average of 1,641 females). Production of farmed salmon in Maine was not available, due to regulations concerning privacy.

1.2 Description of Fisheries and By-catch in USA Waters

Commercial and recreational fisheries for sea-run Atlantic salmon are closed in USA waters. Additionally, Atlantic salmon (*Salmo salar*) are not subject to a fishery management plan review by the National Marine Fisheries Service (NMFS) because the current plan prohibits their possession as well as any directed fishery or incidental (bycatch) in federal waters. Similar prohibitions exist in state waters. Atlantic salmon bycatch in US waters of the Northeast Shelf could be from 4 primary sources: 1) Gulf of Maine Distinct Population Segment (endangered); 2) Long Island Sound or Central New England Distinct Population Segments (non-listed); 3) trans-boundary Canadian populations (many southern Canadian stocks are classified as Endangered by Canada); or 4) escaped fish from US or Canada aquaculture facilities. Bycatch and discard of Atlantic salmon is monitored annually by Northeast Fisheries Science Center (NEFSC) using the Standardized Bycatch Reporting Methodology (e.g., Wigley and Tholke 2017). While bycatch is uncommon, we summarized observed events from 1989 through September 2017 using reports and data queries (Table 1.2.1). Prior to 1993, observers recorded Atlantic salmon as an aggregate weight per haul and therefore, no individual counts are available. However, 8 observed interactions were documented suggesting that at a minimum 8 individual salmon were encountered. After 1993, observers recorded Atlantic salmon on an individual basis. Between 1993 and 2017, seven observed interactions occurred, with a total count of seven individuals. Atlantic salmon bycatch has been observed across seven statistical areas in the Gulf of Maine region, primarily in benthic fisheries (Figure 1.2.1). Four interactions were observed in bottom otter trawl gear and 11 interactions were observed in sink gillnet gear. Bycatch of Atlantic salmon is a rare event as interactions have been observed in only 7 of the 29-year time series and no Atlantic salmon have been observed since August 2013.

1.3 Adult Returns to USA Rivers

Total returns to USA rivers was 1,041 (Table 1.3.1), an increase of 166% from 2016 but only 25% of 2011 returns (Table 1.3.2). Returns are reported for three meta-population areas (Figure 1.3.1): Long Island Sound (LIS, 20 total returns), Central New England (CNE, 13 total returns), and Gulf of Maine (GOM, 1,008 total returns). Changes from 2016 within areas were: LIS +75%, CNE +46%, and GOM +39%. The ratio of sea ages for fish sampled at traps and weirs was used to estimate the number of 2SW spawners. Since 2015, CNE rivers' sea ages are based on the estimates from 2009-2014, as fish are no longer handled at the trap.

Two sea-winter smolt to adult returns (SAR) rates for the 2015 smolt cohort for the Penobscot River equaled 0.12% and for the Narraguagus River equaled 0.62% (Figure 1.3.3). These were both increases over the 2014 smolt cohort estimates. However, the naturally reared 2SW SAR for the Narraguagus was below the previous three-year average (1.15%). Likewise, the 2SW SAR for the Penobscot hatchery origin smolts was also below the previous three-year average (0.06%). The 1SW SAR for hatchery smolts in the Penobscot also increased over the 2014 estimate (Figure 1.3.4).

At the 2017 meeting of the USASAC, updated Conservation Limit (CL) numbers were presented that calculated the CL in Maine using habitat values modeled by Wright et al. 2008. Calculation of CL (Baum 1995) still uses 2.4 eggs per square meter and an average fecundity of 7,200 eggs to calculate the number of females needed. This number is doubled assuming a 1:1 female to male spawning ratio. Baum (1995) noted that habitat values were incomplete for several drainages and the CL was likely underestimated. By using the Wright et al. (2008) habitat model, estimates of Atlantic salmon habitat are available for all drainages within the Gulf of Maine DPS. Applying these updated habitat amount to the CL equation, a total of 61,355 adults is calculated as the CL for the Gulf of Maine. When added to the CL's for the Central New England and Long Island Sound the CL for US rivers totals 84,655. These updated values are summarized in Table 1.3.3 and Table 1.3.4. Further detailed is provided by USASAC (2018) and (Atkinson and Kocik 2017 Working Paper WP17-03).

With the listing of Atlantic salmon populations in Maine as endangered under the US Endangered Species Act, there was a requirement to designate habitat which is critical for the recovery of the species (Critical Habitat, CH). Not all habitat within a drainage was designated as CH, as some tributaries were excluded for economic or geographical reasons (Federal Register 74:117 (June 19, 2009):29300-29341). Citing concerns that using the total habitat amount for the Gulf of Maine may inflate the numbers above what is possible for restoration given accessibility for returning adults, a more conservative adult CL is calculated using just CH values. The CL for just CH in the Gulf of Maine is 44,555 adults, 16,800 less than the Gulf of Maine total potential. Combining CH for the Gulf of Maine with the values for Central New England and Long Island Sound, the CL for US rivers totals 67,856 2SW adults (Table 1.3.3). This is still an increase from the CL presented by Baum (1995) of 49,474 adults. It should be noted that the Wright et.al. (2008) model only considers Maine drainages and if similar modeling were applied to all of New England, the US CL would undoubtedly increase further. Further discussions are being held to refine these numbers further. Considerations of barriers to upstream movements or determining the likely hood of recolonization of vacant streams may remove or add habitat reaches to the total available. Results of these discussions will be available in the 2019 report.

In the US, using the CL estimate of 67,856 2SW adults, returns are well below conservation spawner requirements. Returns of 2SW fish from traps, weirs, and estimated returns were only 1.0% of the US CL, with returns to the three areas ranging from 0 to 1.4 % of spawner requirements (Table 1.3.3). Out of select rivers with a long-time series of return data, the Dennys was the highest at about 8.33% of CL followed by the Pleasant (4.07%) and the Penobscot (3.11%) (Table 1.3.5).

1.4 Stock Enhancement Programs

During 2017, a total of 4,262,454 juvenile salmon were released into USA rivers. Of these, 1,578,166 were fry, 1,587,166 were planted eyed eggs, 511,362 were fall fingerlings, and 688,892 were smolts (Table 1.4.1). Fry were stocked in the Connecticut, Merrimack, Saco, Penobscot, and five coastal rivers within the GOM DPS. The majority of smolts were stocked in the GOM in the Penobscot (569,662) and the Narraguagus (99,045) River. In addition, 4,849 adult salmon were released into USA rivers (Table 1.4.2). A total of 1,018 of these were pre-spawn, non-sea run adults released into sub-drainages of the Merrimack River to provide a limited recreational opportunity.

1.5 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 265,528 salmon released into USA waters were marked or tagged. Tags and marks for parr, smolts, and adults included: Floy, PIT, radio, acoustic, and fin clips and punches. Nearly all the tagging occurred in the GOM area (Table 1.5.1).

1.6 Farm Production

Reporting an annual estimate of production of farmed Atlantic salmon has been discontinued because of confidentiality statutes in Maine Department of Marine Resources regulations since 2010 (Table 1.6.1). However, it is expected that production of farmed salmon will increase in 2019, compared to recent years, given a substantial increase in the number of smolts stocked into marine net pens in 2017.

In 2017, no aquaculture origin fish were reported captured in Maine rivers. MDMR maintains a protocol; *"Maine Department of Marine Resources Suspected Aquaculture Origin Atlantic Salmon Identification and Notification Protocol" (*MDMR, 2016) that guides procedures and reporting for disposition of captured aquaculture Atlantic salmon. Also, at the 2018 meeting the USASAC compiled a list of aquaculture origin Atlantic salmon captured in Maine rivers either at salmon traps or through other means (trap nets, incidental angling, etc.) (Table 1.6.1).

Atlantic salmon farming operations in the northeastern United States (U.S.) have typically been concentrated in marine net pens among the many islands in large bays characteristic of the Maine coast. There is recent interest in initiating land-based Atlantic salmon aquaculture in Maine. Two proposals are currently being considered State of Maine and municipal One would be to build a land-based aquaculture facility on the Penobscot River and a second for a facility located in Belfast, Maine at a former water works on the Little River.

1.7 Smolt Emigration

NOAA's National Marine Fisheries Service (NOAA) and the Maine Department of Marine Resources (MDMR) have conducted seasonal field activities assessing Atlantic salmon smolt populations using Rotary Screw Traps (RSTs) in selected Maine rivers since 1996 (Figure 1.7.1). Currently three rivers are monitored: the Sheepscot, Narraguagus and East Machias Rivers.

MDMR monitored smolt migration using RSTs at two sites on the Narraguagus River from 18 April to 31 May, which continued smolt assessments for a 21st consecutive year. Trapping operations were suspended over four separate periods due to unsafe river discharge conditions and 12 fishing days were lost. Because of this, MDMR was not able to calculate a population estimate for the Narraguagus River.

MDMR operated three RSTs at one site on the Sheepscot River from 11 April to 30 May, which marked the 16th year of assessment on this river. A total of 334 smolts was captured (156 naturally reared, 177 hatchery reared and 1 unknown origin). The total smolt population estimate was 2,758 ± 609. The estimate was 985±242 for naturally reared smolts, and 1,932 ± 593for hatchery origin smolts stocked as fall parr.

In partnership with the Downeast Salmon Federation (DSF), MDMR operated two RSTs at one site on the East Machias River from 18 April to 9 June, which was the fifth consecutive year of trapping on this river. Staff captured 260 smolts of naturally-reared (33) and hatchery (227) origin. The total estimate of smolt migration was 1,501 ± 253. Due to a very low recapture rate an estimate for naturally reared smolts was not possible. For hatchery origin smolts stocked as fall parr the estimate was 1,323 ± 224.

Table 1.2.1 Overview of Northeast Fisheries Observer Program and At-Sea Monitoring Program documentation of Atlantic salmon bycatch. A minimum of one fish is represented by each interaction count. Total weights for 1990 and 1992 may represent 1 or more fish, whereas post-1992 weights represent individual fish.

Year	Month	Area	Interaction Count	Total Weight (kg)
1990	June	512	1	0.5
1992	June	537	1	1.4
1992	November	537	6	10.4
2004	March	522	1	0.9
2005	April	522	1	1.8
2005	May	525	1	1.3
2009	March	514	1	4.1
2011	June	513	1	5.0
2013	April	515	1	4.1
2013	August	513	1	3.2
Totals			15	32.6

Table 1.3.1 Estimated Atlantic salmon returns to USA by geographic area, 2017. Estimated returns are the sum of documented returns to traps and returns estimated by redd counts. "Natural" includes fish originating from natural spawning, hatchery fry stocking, or hatchery egg planting. 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	0	0	18	0	2	0	0	20
CNE	3	2	3	5	0	0	0	0	13
GOM	325	33	466	171	9	2	0	2	1,008
Total	328	35	469	194	9	4	0	2	1,041

Table 1.3.2 Estimated Atlantic salmon returns to the USA, 1997-2017. "Natural" includes fish originating from natural spawning, hatchery fry stocking, or hatchery egg planting Starting in 2003 estimated returns also include returns estimated adult returns from redd counts.

Year	Sea age					Origin	
	1 SW	2SW	3SW	Repeat	Total	Hatchery	Natural
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
2016	232	389	2	3	626	448	178
2017	363	663	13	2	1041	806	235

Table 1.3.3 Two sea winter (2SW) returns for 2017 in relation to spawner requirements (i.e. 2SW Conservation Limits) for USA rivers. Spawner requirements represent the 2017 updated values as detailed in Section 1.3.

Area		Spawner Requirement	2SW returns 2016	Percentage of Requirement
Long Island Sound	LIS	17,785	18	0.1%
Central New England	CNE	5,516	8	0.1%
Gulf of Maine (CH only)	GOM	44,555	637	1.4%
Total		67,856	663	0.8%

Table 1.3.4 Updated Conservation Limits (CL) of Atlantic salmon in New England USA. Adults calculated on 7,200 egg fecundity and 1:1 M to F ratio. A unit of habitat = 100 m^2

Map Index #	DPS or SHRU	State	River	Habitat Units	Hectares	Eggs at 240 / unit	CL Number of Adults
1	OBoF	**Maine**	Aroostook	60,775	607.8	14,586,000	4,052
7	OBoF	**Maine**	Meduxnekeag	5,000	50.0	1,200,000	333
7	OBoF	**Maine**	Prestile	835	8.4	200,400	56
9	OBoF	**Maine**	St. Croix	29,260	292.6	7,022,400	1,951
11	OBoF	**Maine**	Boyden Stream	85	0.9	20,400	6
12	OBoF	**Maine**	Pennamaquan	85	0.9	20,400	6
13	DEC	**Maine**	Dennys	2,166	21.7	519,943	144
15	DEC	**Maine**	Hobart Stream	412	4.1	98,978	27
16	DEC	**Maine**	East Stream	337	3.4	80,880	22
16	DEC	**Maine**	Orange	321	3.2	77,146	21
17	DEC	**Maine**	East Machias	6,666	66.7	1,599,744	444
18	DEC	**Maine**	Machias	15,668	156.7	3,760,250	1,045
21	DEC	**Maine**	Chandler	1,212	12.1	290,976	81
22	DEC	**Maine**	Indian	445	4.4	106,730	30
23	DEC	**Maine**	Harrington	341	3.4	81,840	23
23	DEC	**Maine**	Pleasant	2,586	25.9	620,633	172
24	DEC	**Maine**	Narraguagus	7,174	71.7	1,721,820	478
26	DEC	**Maine**	Tunk Stream	1,029	10.3	246,919	69
26	DEC	**Maine**	Whitten Parritt	121	1.2	29,155	8
27	DEC	**Maine**	Patten Stream	972	9.7	233,198	65
27	DEC	**Maine**	Union	14,149	141.5	3,395,758	943
29	PEN	**Maine**	Orland River	1,775	17.7	425,885	118
30	PEN	**Maine**	Penobscot (Critical Hab.)	255,266	2,552.7	61,263,862	17,018
30	PEN.	**Maine**	Penobscot (Not Critical Hab)	152,772	1,527.7	36,665,388	10,185
60	PEN	**Maine**	Passagassawakeag	1,041	10.4	249,914	69
62	PEN	**Maine**	Ducktrap	996	10.0	238,949	66
63	MMB	**Maine**	St. George	7,132	71.3	1,711,726	475
64	MMB	**Maine**	Medomak	2,443	24.4	586,210	163
65	MMB	**Maine**	Pemaquid River	525	5.2	125,916	35
66	MMB	**Maine**	Sheepscot River	7,101	71.0	710,100	473
68	MMB	**Maine**	Kennebec (Critical Hab.)	91,240	912.4	21,897,600	6,083
68	MMB	**Maine**	Kennebec (Non-Critical Hab.)	230,454	2,304.5	55,308,905	15,364
78	MMB	**Maine**	Androscoggin (Critical Hab.)	16,757	167.6	4,021,620	1,117
78	MMB.	**Maine**	Androscoggin (Non-Critical Hab.	99,226	992.3	23,814,334	6,615
83	CNE	**Maine**	Royal River	420	4.2	100,800	28
84	CNE	**Maine**	Presumpscot	85	0.9	20,400	6
87	CNE	**Maine**	Saco River	25,080	250.8	6,019,200	1,672
96	CNE	**Maine**	Kennebunk	85	0.9	20,400	6
100	CNE	**New Hampshire**	Merrimack	57,065	570.7	13,695,600	3,804
136	LIS	**Rhode island**	Pawcatuck	5,370	53.7	1,288,800	358
142	LIS	**Connecticut**	Connecticuit	261,400	2,614.0	62,736,000	17,427
			Grand Totals	**1,365,872**	**13,659**	**326,815,178**	**91,058**
			MMB SHRU only include CH	355,651	3,557	84,362,076	23,710
			PEN SHRU only include CH	259,078	2,591	62,178,610	17,272
			DEC SHRU	53,600	536	12,863,971	3,573
			GoM DPS only include CH	**668,328**	**6,683**	**159,404,657**	**44,555**
			Pen. = Not CH	152,772	1,528	36,665,388	10,185
			MMB. = Not CH	99,226	992	23,814,334	6,615
		Maine	**Total includes all Maine rivers**	**1,042,037**	**10,420**	**249,094,778**	**69,469**
			OBoF	96,040	960	23,049,600	6,403
			CNE	82,735	827	19,856,400	5,516
			LIS	266,770	2,668	64,024,800	17,785
			GoM	920,327	9,203	219,884,378	61,355

Table 1.3.5 2017 2SW returns against 2SW Conservation Limits for select US rivers.

Region	Name	Longitude	Latitude	CL	Returns	% of CL Met
CNE	Merrimack	-71.036	42.837	3,804	4	0.11%
CNE	Pawcatuck	-71.133	41.937	358	0	0.00%
GOM	Dennys	-67.228	44.868	144	12	8.33%
GOM	Narraguagus	-67.783	44.654	478	7	1.46%
GOM	Penobscot	-68.82	44.769	17,018	530	3.11%
GOM	Pleasant	-67.5781	44.722	172	7	4.07%
GOM	Union	-68.474	44.643	943	0	0.00%
LIS	Connecticut	-72.374	41.593	17,427	18	0.10%

Table 1.4.1 Number of juvenile Atlantic salmon by lifestage stocked in USA, 2017.

Area	N	Rivers	Eyed Egg	Fry	0 Parr	1 Parr	1 Smolt	2 Smolt	Total
LIS	2	Connecticut, Pawcatuck		375,464					375,464
CNE	2	Merrimack, Saco	53,000	120,364					173,364
GOM	8	Androscoggin to Dennys	1,534,166	999,206	511,362		668,892		3,713,626
OBF	1	Aroostook							0
Total	13		1,587,166	1,495,034	511,362		668,892		4,262,454

Table 1.4.2 Stocking summary for sea-run, captive reared domestic adult Atlantic salmon for the USA in 2016 by purpose and geographic area.

Area		Purpose	Captive Reared Domestic		Sea Run		Total
			Pre-spawn	Post-spawn	Pre-spawn	Post-spawn	
Central New England	CNE	Recreation	1,018				1,018
Gulf of Maine	GOM	Restoration	763	2,553	12	503	3,831
Total for USA			1,781	2,553	12	503	4,849

Table 1.5.1 Summary of tagged and marked Atlantic salmon released in USA, 2017. Includes hatchery and wild origin fish.

Mark Code	Life Stage	CNE	GOM	LIS	Total
Adipose punch	Adult	1	55		56
Floy tag	Adult			11	11
Passive Integrated Transponder (PIT)	Adult		3,977	5	3,982
Radio tag	Adult		20		20
Upper caudal punch	Adult		2		2
Adipose clip	Parr		258,058		258,058
Acoustic Tag	Smolt		772		772
Passive Integrated Transponder (PIT)	Smolt		1,876		1,876
Radio tag	Smolt		751		751
		1	265,511	16	265,528

Table 1.6.1. State of Maine - USA commercial Atlantic salmon aquaculture production and suspected aquaculture captures to Maine rivers 2000 to 2017. Due to confidentiality statutes in ME marine resources regulations related to single producer, adult production rates are not available 2011 to 2017.

Year	Total Salmon Stocked (smolt + fall parr + clips)	RV clipped fish stocked	Harvest total (metric tons)	Suspect aquaculture origin captures (Maine DPS Rivers)
2000	4,511,361		16,461	34
2001	4,205,161		13,202	84
2002	3,952,076		6,7988	15
2003	2,660,620		6,007	4
2004	1,580,725		8,514	0
2005	294,544		5,263	12
2006	3,030,492	252,875	4,674	5
2007	2,172,690	154,850	2,715	0
2008	1,470,690		9,014	0
2009	2,790,428		6,028	0
2010	2,156,381	128,716	11,127	0
2011	1,838,642	45,188	NA	3
2012	1,947,799	137,207	NA	7
2013	1,329,371	170,024	NA	0
2014	2,285,000	0	NA	0
2015	1,983,850	446,129	NA	0
2016	1,892,511	262,410	NA	3
2017	2,224,348	211,043	NA	0

Table 1.7.1 Naturally reared smolt population estimate from rotary screw trap mark-recapture maximum likelihood estimates for the Narraguagus and Sheepscot Rivers, Maine USA.

	Narraguagus River			.	Sheepscot River		
Smolt Year	Lower 95% CL	Pop Estimate	Upper 95% CL	.	Lower 95% CL	Pop Estimate	Upper 95% CL
1997	1,940	2,749	3,558	.	N/A	N/A	N/A
1998	2,353	2,845	3,337	.	N/A	N/A	N/A
1999	3,196	4,247	5,298	.	N/A	N/A	N/A
2000	1,369	1,843	2,317	.	N/A	N/A	N/A
2001	1,835	2,562	3,289	.	N/A	N/A	N/A
2002	1,308	1,774	2,240	.	N/A	N/A	N/A
2003	995	1,201	1,407	.	N/A	N/A	N/A
2004	863	1,284	1,705	.	N/A	N/A	N/A
2005	846	1,287	1,728	.	N/A	N/A	N/A
2006	1,943	2,339	2,735	.	N/A	N/A	N/A
2007	954	1,177	1,400	.	N/A	N/A	N/A
2008	637	962	1,287	.	N/A	N/A	N/A
2009	1,000	1,176	1,352	.	1,243	1,498	1,753
2010	1,704	2,149	2,594	.	1,736	2,231	2,726
2011	657	1,404	2,151	.	916	1,639	2,363
2012	491	969	1,447	.	520	849	1,178
2013	722	1,237	1,752	.	566	829	1,091
2014	1,227	1,615	2,003	.	342	542	742
2015	729	1,201	1,673	.	431	572	713
2016	NA	NA	NA		762	983	1,204
2017	NA	NA	NA		743	985	1,227

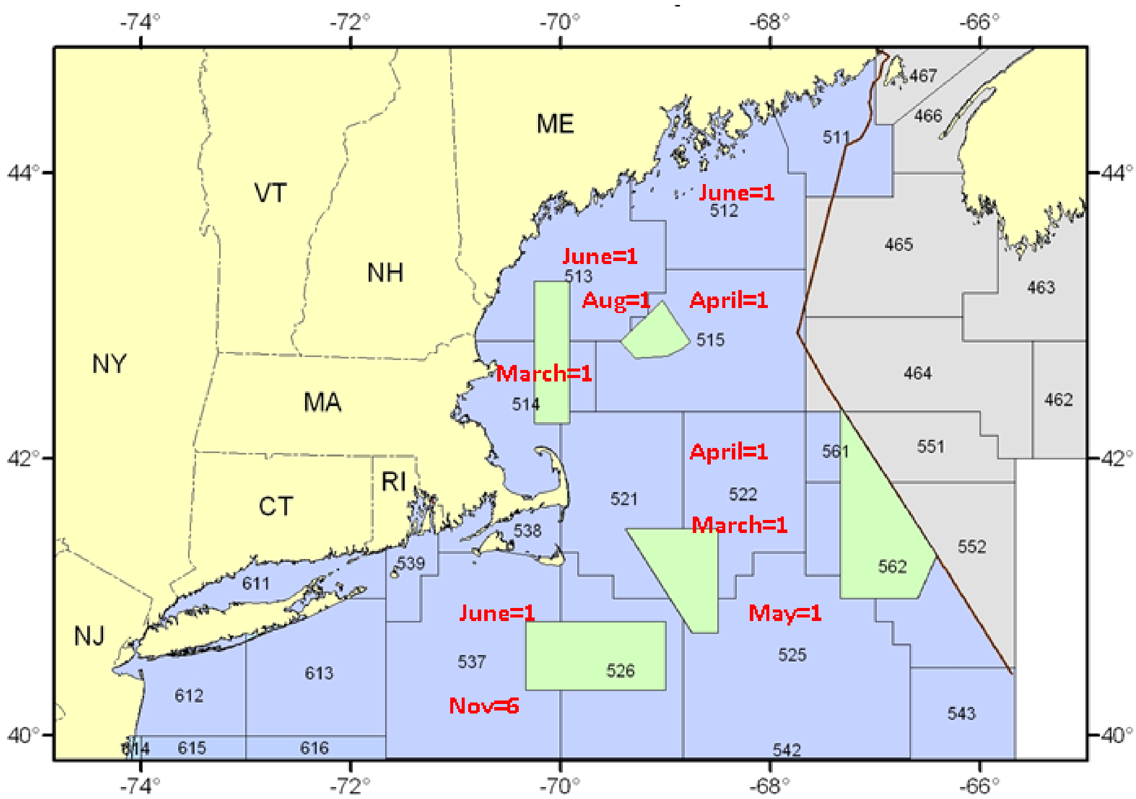

Figure 1.2.1 Map of Gulf of Maine region showing the month and number of Atlantic salmon interactions (e.g., June=1: 1 salmon interaction in the area in June). Location of the label within the statistical grid does not denote more specific locations. Blue polygons are USA statistical areas, grey zones are in Canada and green-shaded polygons represent regulated access areas

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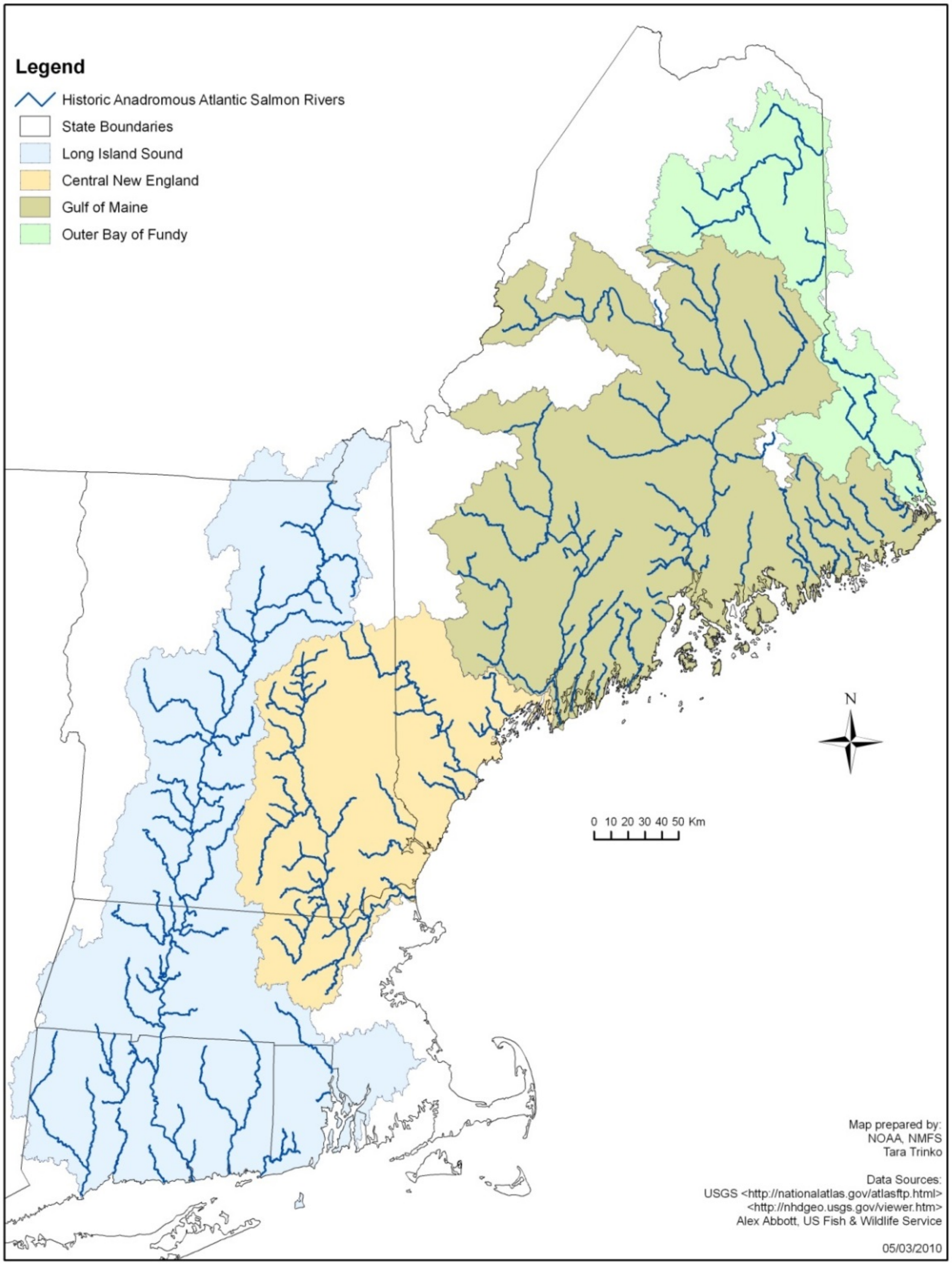

Figure 1.3.1 Map of geographic areas used in summaries of USA data for returns, stocking, and marking in 2017.

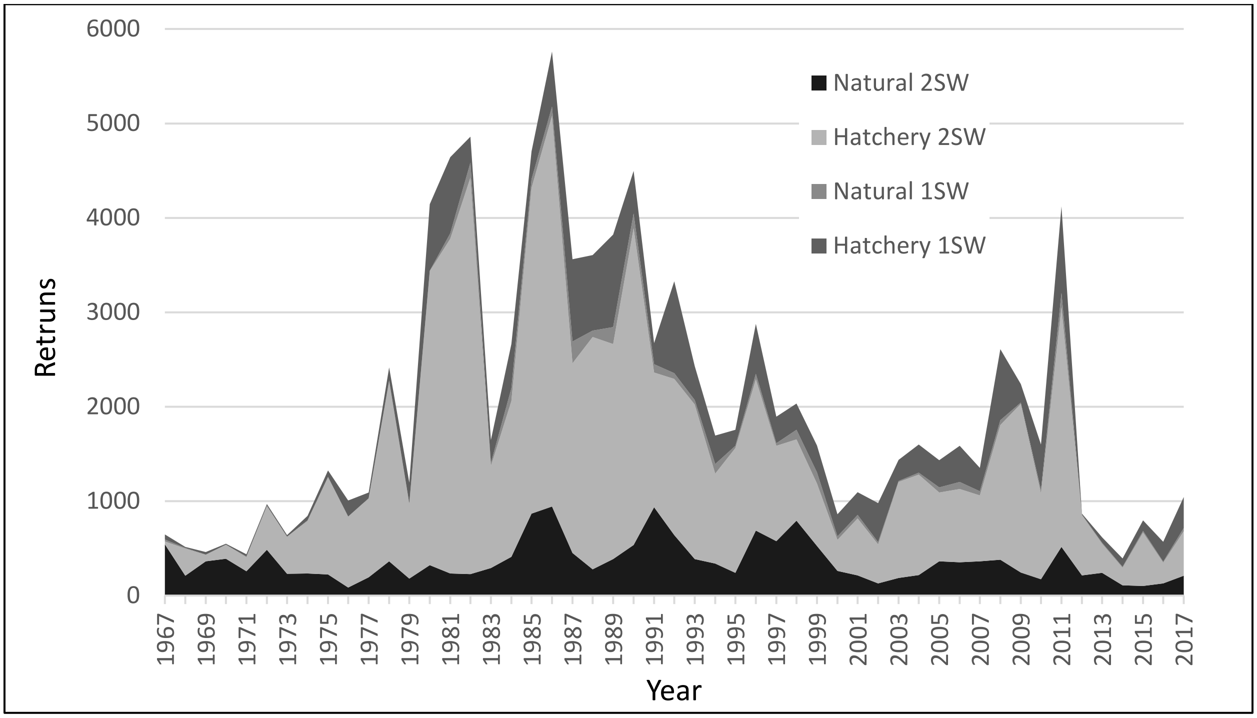

Figure 1.3.2 Origin and sea age of Atlantic salmon returning to USA rivers, 1967 to 2017.

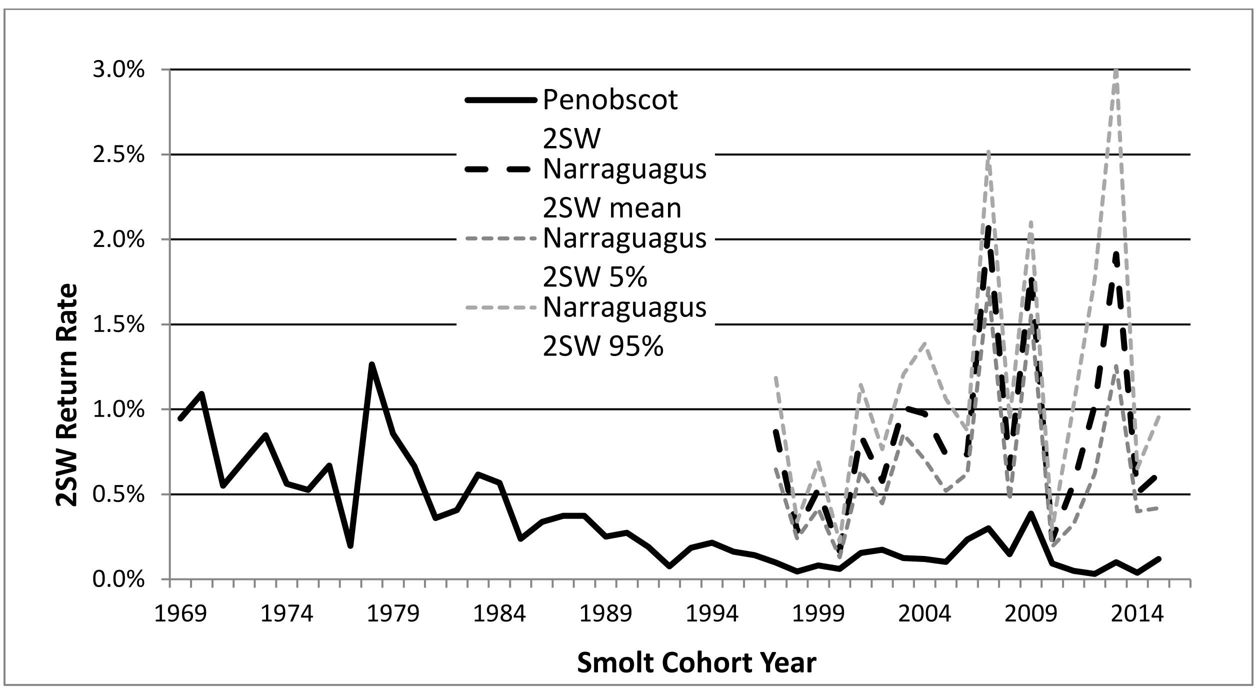

Figure 1.3.3 Return rate of 2SW adults to Gulf of Maine area rivers by smolt cohort year (1969 - 2015) of hatchery-reared Atlantic salmon smolts (Penobscot River solid line) and estimated wild smolt emigration (Narraguagus River dashed line) with 95% CI (gray dotted line) USA.

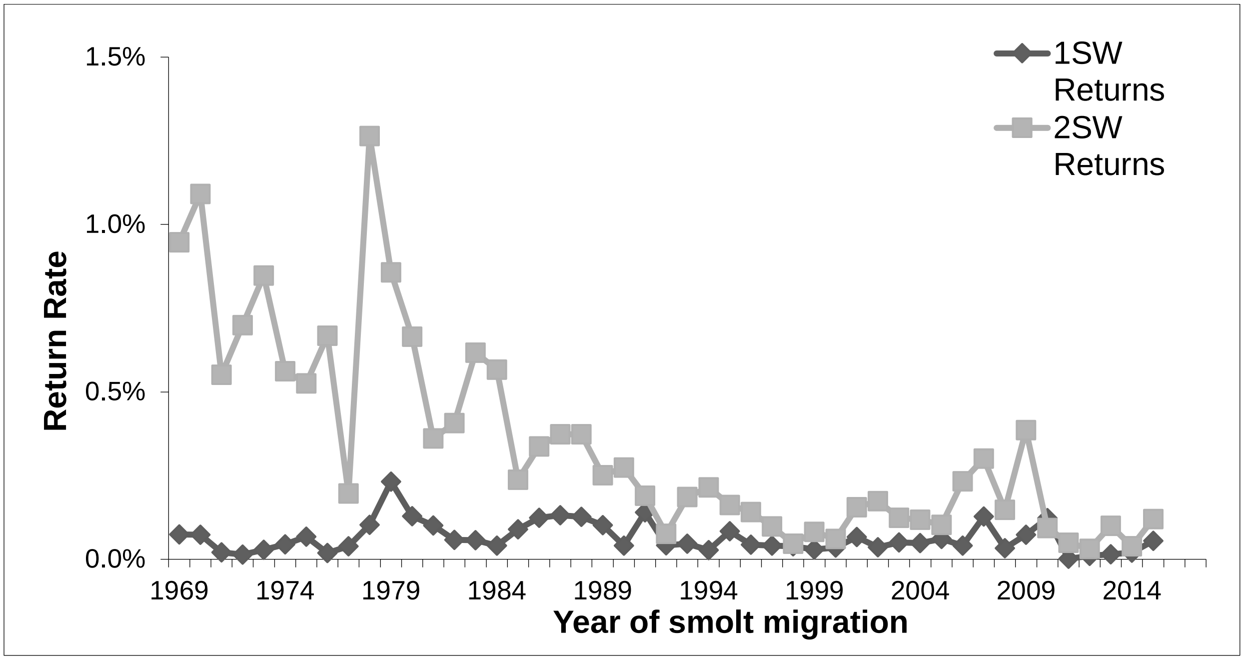

Figure 1.3.4. River return rates (%) of hatchery released smolt from the Penobscot River (Maine, USA) as 1SW and 2SW salmon

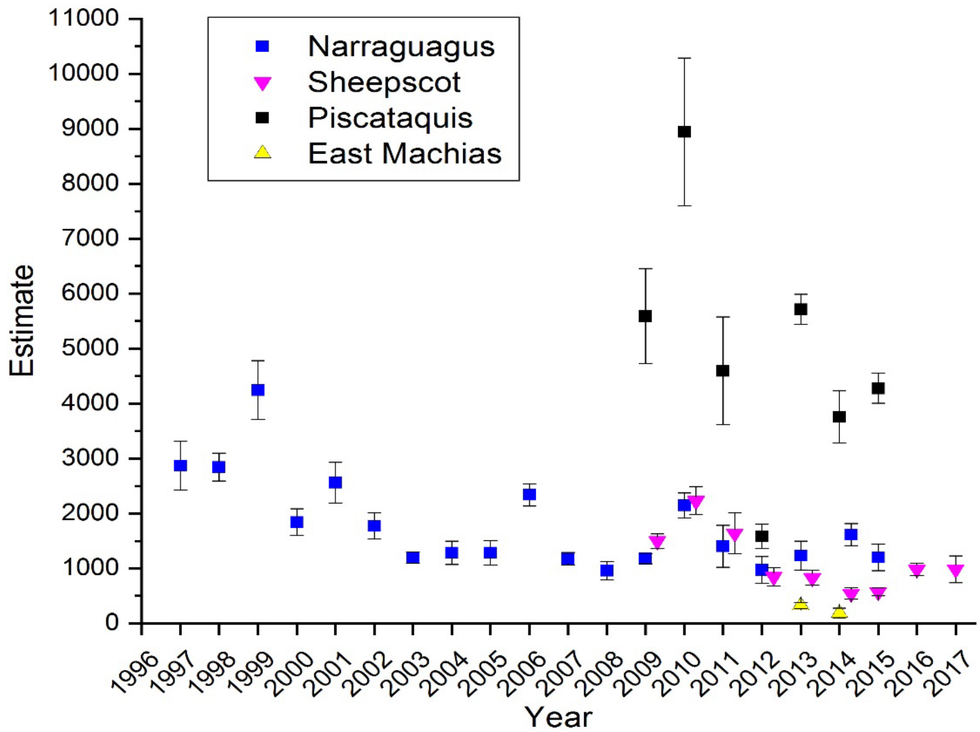

Figure 1.7.1. Population Estimates (± Std. Error) of emigrating naturally-reared smolt in the Narraguagus (no estimate in 2016 and 2017), Sheepscot, Piscataquis (discontinued in 2015), and East Machias (no estimate 2015-2017) rivers, Maine (1997-2017), using DARR 2.0.2.

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Wigley SE, and Tholke, C. 2017. 2017 Discard estimation, precision, and sample size analyses for 14 federally managed species groups in the waters off the northeastern United States. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 17-07; 170 p. Available Online

Wright, J., J. Sweka, A. Abbott, and T. Trinko. 2008. GIS-Based Atlantic salmon habitat model. Appendix C of Critical habitat rule for GOM DPS for Atlantic salmon (74 FR 29300). -link

2 Viablity Assessment - Gulf of Maine Atlantic Salmon

2.1 Overview of DPS and Annual Viability Synthesis

2.1.1 Change in Status Assessment Approach

The US Atlantic Salmon Assessment Committee (USASAC), a team of state and federal biologists is tasked with compiling data on the species throughout New England and reporting population status. Historically, the approach was aligned with NOAA Status of Stocks (SOS) documents and included all US populations including Long Island Sound (LIS) and Central New England (CNE) DPS areas. Metrics in this format (e.g., fishing effort) are no longer essential to assessment efforts. In the past five years, overall US salmon conservation efforts have contracted from two major river restoration programs (Connecticut and Merrimack) and recovery of the GOMDPS to a smaller program that is more focused on endangered GOMDPS populations. There are continuing efforts in the Connecticut Legacy Program and Saco River that have limited monitoring and the status of these two programs are synthesized in LIS and CNE sections. These populations continue to be included in overall US metrics and general trends to address US reporting needs for ICES WGNAS in support of NASCO (e.g. Chapter 1).

Because of US managers' need to monitor GOMDPS overall viability similarly to other endangered salmonids, the focus of this chapter has changed from a SOS approach to a viability assessment. This approach is more supportive of recovery of endangered species. As such, this chapter is transitioning in 2018 to an annual viability assessment of the GOMDPS using a Viable Salmonid Populations (VSP) approach (McElhany et al. 2000). Taking this approach will allow the Maine Stock Assessment Action Team to integrate the GOMDPS assessment within the overall US assessment making more effective use of staff resources. Integrating this annual reporting (required under the GOMDPS Recovery Framework) will also allow additional review of the GOMDPS viability assessment by a wider group of professionals assembled at the USASAC. This section is meant to be a brief annual summary not a benchmark 5-year viability assessment. That benchmark assessment will be produced in a future assessment cycle.

2.1.2 DPS Boundary Delineation

For non-ESA listed LIS and CNE DPS, abundance and management are summarized in other sections of this document and geographic boundaries are listed in Fay et al (2006). For the GOMDPS, this section synthesizes data on the abundance, population growth, spatial distribution, and diversity to better characterize population viability (e.g. McElhany et al. 2000; Williams et al. 2016). There are three Major Population Groupings (MPG) referred to as Salmon Habitat Recovery Units (SHRU) for the GOMDPS (NMFS 2009) based on watershed similarities and remnant populations structure. The three SHRUs are Downeast Coastal (DEC), Penobscot Bay (PNB), and Merrymeeting Bay (MMB). The GOMDPS critical habitat ranges from the Dennys River southward to the Androscoggin River (NMFS 2009).

At the time of listing, nine distinct individual populations (DIPs) were identified. In the DEC SHRU, there were five extant DIPs in the Dennys, East Machias, Machias, Pleasant and Narraguagus Rivers. In the PNB SHRU, there were three - Cove Brook, Ducktrap River, and mainstem Penobscot. In the MMB SHRU there was one DIP in the Sheepscot River. Of these nine populations, seven of them are supported by conservation hatchery programs. Cove Brook and the Ducktrap River DIPs were not supplemented.

Because conservation hatchery activities play a major role in fish distribution and recovery, a brief synopsis is included in the boundary delineation. The core conservation hatchery strategy for six of these is broodstock collected primarily from wild-exposed or truly wild parr collections. These juveniles are then raised to maturity in a freshwater hatchery. All five extant DEC populations (Dennys, East Machias, Machias, Pleasant, and Narraguagus) are supported using this approach as well as the Sheepscot DIP in the MMB SHRU. For the mainstem Penobscot, the primary hatchery strategy is collection of sea-run adult broodstock that are a result of smolt stocking (85% or more of adult collections) or naturally-reared or wild returns. For Cove Brook and Ducktrap River populations, no conservation hatchery activities were implemented. In general, DIPs are stocked in their natal river. However, because there are expansive areas of Critical Habitat that are both vacant and of high production quality, these seven populations (primarily the Penobscot) have served as donor stocks for other systems, especially the Kennebec River in MMB SHRU.

2.1.3 Synthesis of 2017 Viability Assessment

Totaling 1,008 estimated adult returns, the 2017 spawning run was the first to exceed 1,000 fish since 2011. The majority (75%) of returns were of hatchery-stocked smolt origin returning to the Penobscot River. Naturally-reared returns remained low across the GOMDPS (208). About 50% of these naturally-reared returns were documented in the PNB SHRU. Abundance remains critically low relative to interim recovery targets of 500 naturally reared returns per SHRU; the PNB

SHRU was at 21% of this target, doubling returns to the MMB SHRU (10%). The 5 populations in the DEC SHRU numbered only 55 estimated naturally-reared returns (11%).

While naturally-reared growth rates can be quite variable at these low levels of abundance, geometric mean population growth rates have stabilized at average estimates that are generally above 1.0 for all SHRUs since 2012. In 2017, the MMB SHRU had the highest growth rate (1.81; 95% CI: 1.15 – 2.87) and PNB SHRU had the lowest growth rate (0.96; 95% CI: 0.49 – 1.89). The DEC SHRU growth rate was 1.12 (95% CI: 0.6 – 2.07). Because error bounds fall below 1 for PNB and DEC, there is concern about population trajectories.

The spatial structure of populations represents a combination of wild production areas that are very limited and supplemented stream reaches that produce naturally-reared juveniles. For 2017 spawner distributions, 45 redds were documented in the DEC SHRU representing 52% of documented spawning. In MMB, 25 redds (29%) were counted with most (16) in the Sheepscot River. Documented PNB SHRU spawning was found in three tributaries (6 redds) below the Milford Fishway and Broodstock Collection Facility. Another 10 redds were found upstream of that facility. It should be noted that spawning escapement is low in the larger Penobscot and Kennebec Rivers due to low marine survival and removal of fish for broodstock. Additionally, redd survey coverage is limited in the larger systems. Conservation hatchery supplementation of these populations enhanced juvenile production capacity in all SHRUs with the addition of over 3.7 million eggs, fry, and parr across 45 of 286 HUC 12 watersheds listed as critical habitat.

Genetic diversity of the DPS is monitored through assessment of sea-run adults for the Penobscot River and juvenile parr collections for 6 other populations. Allelic diversity has remained relatively constant since the mid-1990's. However, slight decreases have been detected in the East Machias and Dennys populations. Estimates of effective population size have increased for the Penobscot, likely due to increased broodstock targets and equalized broodstock sex ratios, but for the remaining rivers effective population size estimates have either remained constant or slightly decreased. Implementation of pedigree lines have helped to retain diversity following bottleneck (Pleasant) and variable parr broodstock captures (Dennys) by retaining representatives of all hatchery families and supplementing with river-caught parr from fry stocking or natural reproduction.

Another metric used to monitor diversity is the tracking of the recapture of hatchery-produced family groups in broodstock collections. Genetic assignment of parentage allows identification of hatchery origin through assignment to specific spawning pair. Monitoring of the proportion of hatchery families in broodstock collections can help inform managers relative to the diversity being maintained in the hatchery relative to that recaptured through broodstock collection. Recapture of hatchery-produced family groups has been inconsistent between rivers, but proportion recaptured is increasing in Sheepscot, East Machias, Machias, and Narraguagus.

2.2 Population Size

Overall stock health can be measured by comparing monitored abundance to target spawning escapements. Because juvenile rearing habitat has been measured or estimated accurately, 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 all US populations, and CSE targets total 44,555 spawners for the Gulf of Maine DPS (Symons 1979; USASAC 2017). CSE levels are based on spawning escapement needed to fully seed juvenile habitat. In self-sustaining populations, the number of returns can frequently exceed this amount by 50-100%, allowing for sustainable harvests and buffers against losses between return and spawning. When calculating CSE for US populations in the context of international assessments by the ICES WGNAS, only counts of all 2SW adult returns (hatchery and natural-reared) are used. Adult returns used in the estimation of population growth rate (see below) are still the product of natural spawning, egg planting, and fry stocking. If returning adults resulting from stocked fry or eggs are reproducing and contributing to the next generation, then true wild population trends may be masked (McClure et al. 2003), and the true population growth rate may be lower than current estimates. In this case, the minimum population required to have a less than 50 percent chance of falling below 500 spawners under another period of low marine survival is 2,000 spawners per year in each SHRU. Estimates of population growth rate can be corrected for the input of hatchery fish, but this requires differentiating between returns of wild origin and egg/fry-stocked salmon; this in turn requires genetic determination of parentage, but the ability to adequately sample returning adults on all rivers is limited. The estimate of 2,000 spawners thus serves as a starting point for evaluating population status, but this benchmark and the methods by which it is calculated should be re-evaluated in the future as more data and better methods for partitioning returning adults become available. The threshold of 2,000 wild spawners per SHRU, totaling 6,000 annual wild spawners for the GOM DPS is the current recovery target for delisting.

Because the goal of the GOMDPS Recovery Plan is a wild, self-sustaining population, monitoring (counts and growth rates) of wild fish are a desired metric. However, with extensive and essential conservation hatchery activities (planting eggs and stocking fry and fingerlings), it is currently not feasible to enumerate only wild fish. Initially, NMFS (2009) attempted to minimize bias in estimating abundance (and mean population growth rates) by excluding the Penobscot River due to stocking of hatchery fish (smolts and marked parr). In subsequent years, the assessment team has established an intermediate target – 500 naturally-reared adult spawners (i.e., returning adults originating from wild spawning, egg planting, fry stocking, or fall parr stocking). This is a helpful metric in the short-term to monitor recovery progress of wild fish combined with individuals that have had 20 + months of stream rearing before migrating to sea.

However, full recovery will only be achieved with abundance from adult spawners of wild origin. All fish handled at traps are classified as to rearing origin by fin condition and scale analysis. For redd-based estimates, each population is pro-rated on an annual basis using naturally-reared to stocked ratios at smolt emigration or other decision matrices to partition naturally-reared and stocked returns. This method is more rigorous than just excluding the Penobscot population from the analysis as it estimates stocked parr in other systems. The assessment team is actively working on improved methods to parse out wild spawners and spawners produced from stocking hatchery products. Further, naturally-reared adult spawners are likely to be more fit than hatchery-origin adult spawners, as their fitness is less due to hatchery influence and the majority of their lifetime is spent under the influence of natural selection processes in the wild. In addition, carrying capacities in the freshwater environment elicit a density-dependent effect on survivorship above which additional fry stocking would not produce greater numbers of fish at later life stages (McMenemy 1995, Armstrong et al. 2003). Finally, a population reliant upon hatchery fish for sustainability is indicative of a population that continues to be at risk.

Total adult returns to the GOM DPS in 2017 were 1,008 and 761 of these were hatchery origin fish returning to the Penobscot River (Figure 2.2.1 and Table 2.1). Because of this smolt-stocked component, returns to the Penobscot Bay SHRU (86%) dominated total abundance with 866 returns. An additional, 39 hatchery returns were documented in the DEC SHRU (28) and Merrymeeting Bay SHRU (11).

Naturally-reared returns were also highest in Penobscot Bay at 105 (Figure 2.2.2). The DEC SHRU had 55 documented naturally-reared returns across 5 of 6 monitored river systems while the Merrymeeting Bay SHRU had 48 returns to 2 of the 3 monitored rivers.

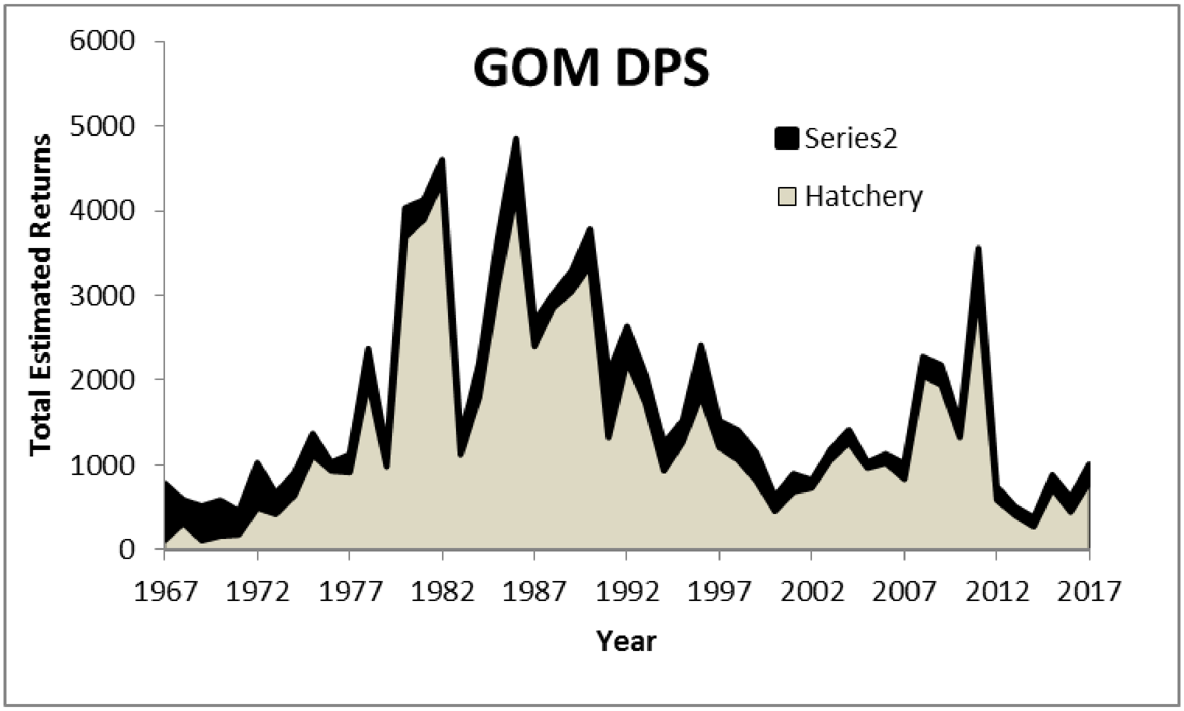

Figure 2.2.1. Time-series of total estimated returns to the GOM DPS of Atlantic salmon illustrating the dominance of hatchery-reared origin Atlantic salmon compared to naturally-reared (wild, egg stocked, fry stocked) origins.

Table 2.2.1. Documented returns from trap and redd-count monitoring for GOM DPS Atlantic salmon by SHRU for return year 2017 and percentage of naturally-reared fish relative to the 500 fish target (% of 500) by SHRU.

SHRU	Hatchery	Natural	Sub Totals	% of 500
Downeast Coastal	28	55	83	11 %
Penobscot Bay	761	105	866	21 %
Merrymeeting Bay	11	48	59	10 %
Gulf of Maine DPS	**800**	**208**	**1,008**	-

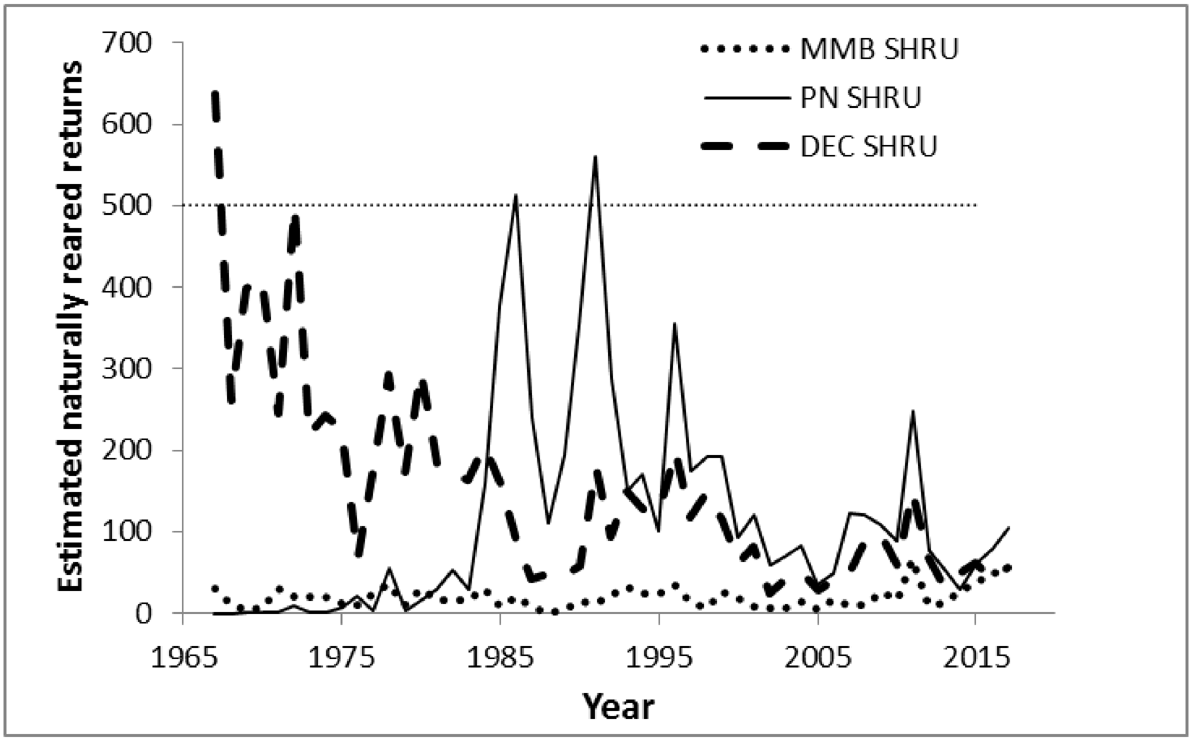

Figure 2.2.2. Time series of naturally-reared adult returns to the Merrymeeting Bay, Penobscot Bay, and Downeast Coastal SHRUs from 1969 to present. Naturally-reared interim target of 500 natural spawners is indicated for reference.

2.3 Population Growth Rate

Another metric, of recovery progress is each SHRU demonstrating a sustained population growth rate indicative of an increasing population. The mean life span of Atlantic salmon is 5 years; therefore, consistent population growth must be observed for at least two generations (10 years) to show sustained improvement. If the geometric mean population growth rate of the most recent 10-year period is greater than 1.0, this provides assurance that recent population increases are not random population fluctuations but more likely are a reflection of true positive population growth. The geometric mean population growth rate is calculated as:

$$GM_{\bar{R}} = \exp(mean[R_t, R_{t-1}, R_{t-2}, \dots, R_{t-9}])$$

where $GM_{\bar{R}}$ is the geometric mean population growth rate of the most recent 10-year period and R_t is the natural log of the 5-year replacement rate in year *t*. The 5-year replacement rate in year t is calculated as:

$$R_t = ln(N_t / N_{t-5})$$

where N_t is the number of adult spawners in year t and N_{t-5} is the number of adult spawners 5 years prior. Naturally-reared adult spawners are counted in the calculation of population growth rate in the current recovery phase (reclassification to threatened) objectives. In the future, only wild adult spawners will be used in assessing progress toward delisting objectives. As described in the 2009 Critical Habitat rule, a recovered GOM DPS must represent the natural population where the adult returns must originate from natural reproduction that has occurred in the wild.

In a future when the GOM DPS is no longer at risk of extinction and eligible for reclassification to threatened status, an updated hatchery management plan will detail how hatchery supplementation should be phased out. This plan would include population benchmarks that trigger decreasing hatchery inputs. The benchmarks should be based upon improved PVA models that incorporate contemporary demographic rates and simulate various stocking scenarios to assess the probability of achieving long-term demographic viability.

The geometric mean population growth rate based on estimates of naturally reared returns fell below 1.0 for all SHRUs during the mid-2000s as a result of declining numbers of returning salmon. In more recent years, the population in each SHRU has stabilized at low numbers and the geometric mean population growth rate increased to approximately 1.0 for all SHRUs by 2012 (Figure 2.3.1). In the most recent year (2017) the Merrymeeting Bay SHRU had the highest growth rate (1.81; 95% CI: 1.15 – 2.87) and the Penobscot SHRU had the lowest growth rate (0.96; 95% CI: 0.49 – 1.89) (Table 2.3.1).

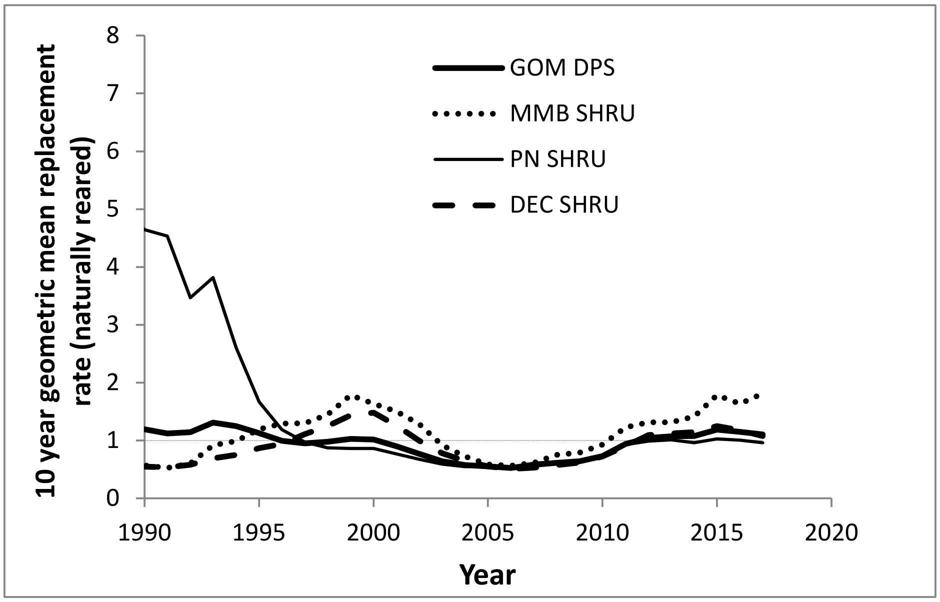

Figure 2.3.1. Ten-year geometric mean replacement rates for the GOM DPS of Atlantic salmon. The figure shows the replacement rate for the GOM DPS as a whole as well as for each SHRU individually.

Table 2.3.1. Ten-year geometric mean replacement rates (GM_R) for GOM DPS Atlantic salmon as calculated for 2017 return year with 95% confidence limits (CL).

SHRU	GM_R	Lower 95% CL	Upper 95% CL
Downeast Coastal	1.12	0.60	2.07
Penobscot	0.95	0.48	1.86
Merrymeeting Bay	1.81	1.15	2.87
Gulf of Maine DPS	**1.11**	**0.62**	**1.98**

Future estimates of population growth rate. -

Although the ten-year geometric mean replacement rate indicates the growth of the naturally reared population of Atlantic salmon, it does not completely reflect the true population growth rate. This is because naturally-reared salmon returns include individuals that are the product of natural reproduction in the wild as well as individuals that are products of our hatchery system (e.g. stocked fry and planted eggs). The inclusion of hatchery products in the ten-year geometric mean replacement rate gives a biased estimate of the true wild population growth rate.

In order to remove this bias and gain an estimate of the true wild population growth rate, we need to be able to discern returns resulting from hatchery inputs from those resulting from natural reproduction in the wild. We can determine if a returning adult salmon was stocked as a parr or smolt through the presence of marks or scale analysis but determining if a returning adult was the result of natural reproduction or stocking at the fry or egg stage is problematic because these life stages are not marked by the time of stocking.

A solution to this problem is to use genetic parentage analysis. All hatchery broodstock are genotyped and matings between individuals in the hatchery are known. By genotyping salmon collected in the wild at later life stages, we can determine if they were the product of a known hatchery mating. If the individual cannot be matched to a known set of parents in the hatchery, it can be assumed that individual is the product of natural spawning. Since we genotype returning adult salmon that are captured in trapping facilities and parr that are collected for future broodstock, we can use parentage analysis of the individuals deemed to be naturally reared to determine the proportion of these individuals that are produced from natural reproduction (truly wild) and the proportion that are the product of fry stocking and/or egg planting. Because US commercial aquaculture broodstock parents are also genetically characterized, monitoring introgression of these fish into populations can also be evaluated in future assessments. Knowing these proportions, we can then partition the total number of returning adult salmon into true wild versus hatchery components of the population. Once we can better partition the number of returning salmon in wild versus hatchery components, we can then use analytical methods described by Holmes and Fagan (2002) and McClure et al. (2003) to gain better estimates of the true wild population growth rates. These methods use a running sum of adult returns to dampen the often-large annual fluctuations in raw return data and use an adjustment for the proportion of the returns that are of hatchery origin.

We plan to implement this approach to estimating the wild population growth rate within the next year.

2.4 Spatial Structure of DPS

For the GOMDPS, a sustained census population of 500 naturally-reared adult spawners (assuming a 1:1 sex ratio) in each SHRU was chosen to represent the effective population size for down listing to threatened. In 2017, none of the three SHRUs approached this level of spawning in the wild. Trap counts provide some insights into the overall spatial structure of spawners, but the details provided by redd counts during spawner surveys enhance our understanding of escapement and finer scale resolution. Spawning was documented in all three SHRUs and monitoring of both spawning activity and conservation hatchery supplementation programs do allow an informative evaluation of habitat occupancy and juvenile production potential. This evaluation will inform managers relative to the spatial components of production across habitats at a river-reach level of resolution. This information will be informative to both assessing the spatial structure of production and informing future conservation efforts. These data can be summarized by USGS Hydrologic Unit codes at various levels, depending on the need for assessment or management.

Our spatial assessment objectives this year were to begin 1) formalizing assumptions of first-year distribution for wild production of spawners in 2017 and 2) visualize and quantify distribution of the 2017 year class related to supplementation and 2016 spawning. In addition, the evaluation provides new metrics to measure the relative impact of wild spawning and supplementation in each of the three SHRUs. This method will be applied to multiple cohorts in the future to allow a better understanding of spatial drivers and relative contributions of wild and stocked production on pre-smolt populations. Our goal in this pilot year was to develop and vet these summary metrics as tools to both investigate both gaps in assessment data and inform hatchery stocking practices to reduce interactions between wild-spawned and hatchery fish. Overall, improved spatial data should help managers to better optimize natural smolt production across the landscape.

2.4.1 Wild Production Units – Redd Counts

Spawner surveys in 2017 covered 1,685 units (18 %) of 9,365 units of surveyed spawning habitat. Because of incomplete coverage, redd counts should be considered a minimal estimate of spawning escapement. With basic assumptions of 2 redds per female and a 1:1 sex ratio of sea run fish, redd counts can also be interpreted as minimal escapement numbers. Survey coverage was highest in the DEC SHRU where 870 (75%) of 1,154 units of mapped spawning habitat was surveyed. Similar spatial coverage was achieved in the Sheepscot River of the Merrymeeting Bay SHRU and the Ducktrap River and Cove Brook in the Penobscot Bay SHRU. Given the low spawner escapement relative to available habitat, coverage was very limited in MMB and PNB habitat in larger rivers such as the Kennebec and Penobscot. Redd counts totaled 80 in the GOMDPS: 45 in DEC, 19 in MMB, and 16 in PNB last autumn. The distribution of survey effort and observed redds were mapped for the entire GOMDPD (Figure

2.4.1). The geolocation of redds in 2017 are used to document Wild Production Areas (WPA) of the 2018-yearclass in these river systems. The spatial extend of WPA assumes and upstream distribution of juveniles of 0.5 km upstream and 1 km downstream (including tributary streams). These WPA will be buffered from stocking in 2018 to minimize competition between wild and hatchery origin juveniles. In addition, in 2020 these areas will be targeted for broodstock electrofishing efforts in efforts to bring components of wild spawning into the captive reared brood program.

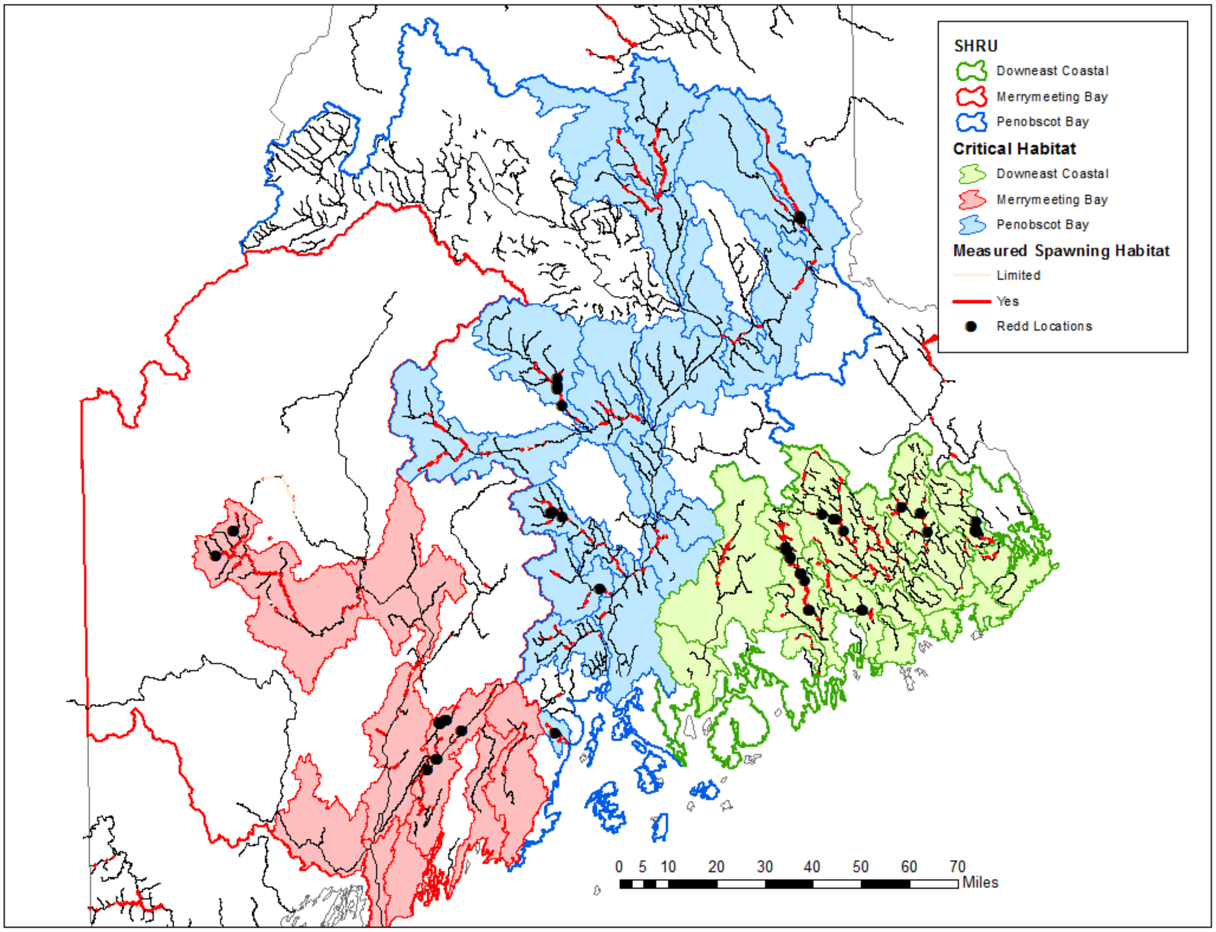

Figure 2.4.1.1 Map highlighting river habitat (thin black lines), surveyed spawning habitat, and general location of redds (black dots) documented in spawning surveys of Atlantic salmon in 2017.

2.4.2 Hatchery Production Units – 2017 Cohort

An important element of GOMDPS Atlantic salmon populations is their dependence on conservation hatcheries (Legault 2005). Since most US salmon are products of stocking, it is important to understand the magnitude, types, and spatial distribution of these inputs to understand salmon spatial structure. US Atlantic salmon hatcheries are operated by the US Fish and Wildlife Service and the Downeast Salmon Federation. All egg takes occur at FWS hatcheries and these hatchery programs are conservation hatcheries that produce fish from remnant local stocks within the GOMDPS and stock them into their natal rivers or in some cases populations are stocked in other rivers with vacant habitat in the GOMDPS range to re-establish production. As noted in section 2.2, smolts (especially Penobscot River smolts) consistently produce over 75% of the adult salmon returns to the US Coast and hatchery capacity issues prevent more extensive use of smolts. From a management perspective, rebuilding Atlantic salmon populations in the US will require increasing natural production of smolts in US river systems that 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, habitat occupancy, and effective population sizes.

Fall parr, (8-9 months old) are stocked in some rivers. Some fall parr are the smaller mode of the hatchery smolt program that are stocked out to manage hatchery densities to produce an age-1 smolt (wild smolts are age 2 or 3). These fall parr are typically larger than stream-reared fish of the same age. Another fall parr rearing practice is to raise the fish under different environmental conditions and more closely mimic wild parr sizes. Most fish are stocked as fry, which is another important conservation tool because it is designed to minimize selection for hatchery traits at the juvenile stage. Analyses show that naturally-reared smolts resulting from fry stocking typically have a higher marine survival rate than hatchery reared smolts. In recent years, egg planting has increased in use given the apparent success in producing more wild-like smolts. Finally, at various points in the program history pre-spawn captive adult broodstock have been released. The numbers of hatchery fish released in the GOMDPS are presented in Chapter 3. The focus of this chapter is the distribution of these fish.

For the 2017 assessment, we are introducing a summary map of occupied habitat that illustrates production by both natural redds and stocking (Figure 2.4.2.1). In this section, we summarize wild production for the 2017 cohort (2016 Spawners). As noted in the previous section, WPA is the result of observed redds and models of year-1 dispersion. In the future, we will assess the relative intensity of WPA in a more quantitative manner by using Critical Habitat as a baseline of juvenile production habitat. This baseline will be used for all hatchery products as well. These hatchery production areas are Egg Planted Production Areas (EPA) that are based on point positions of artificial redds and similar diffusion models as WPA. For Fry or Parr stocked production areas (FPA or PPA), these areas are based on linear distances stocked and a similar diffusion model from both the upstream stocking point and downstream end of the reach. By combining all these production areas, we can estimate the amount of vacant CH (vacant CH = total CH – WPA – EPA- FPA-PPA). It is important to note that this map should be considered minimal occupancy areas because: not all redds are counted, assumptions on dispersion need additional study, and these occupancy areas represent only 1 of 3 to 4 year classes currently rearing in these watersheds. However, by organizing these data spatially, the Stock Assessment Team is providing a resource to further refine occupancy by targeting areas to conduct juvenile assessments and to further refine density and dispersion measures. We will continue work spatial distribution modelling in 2018.

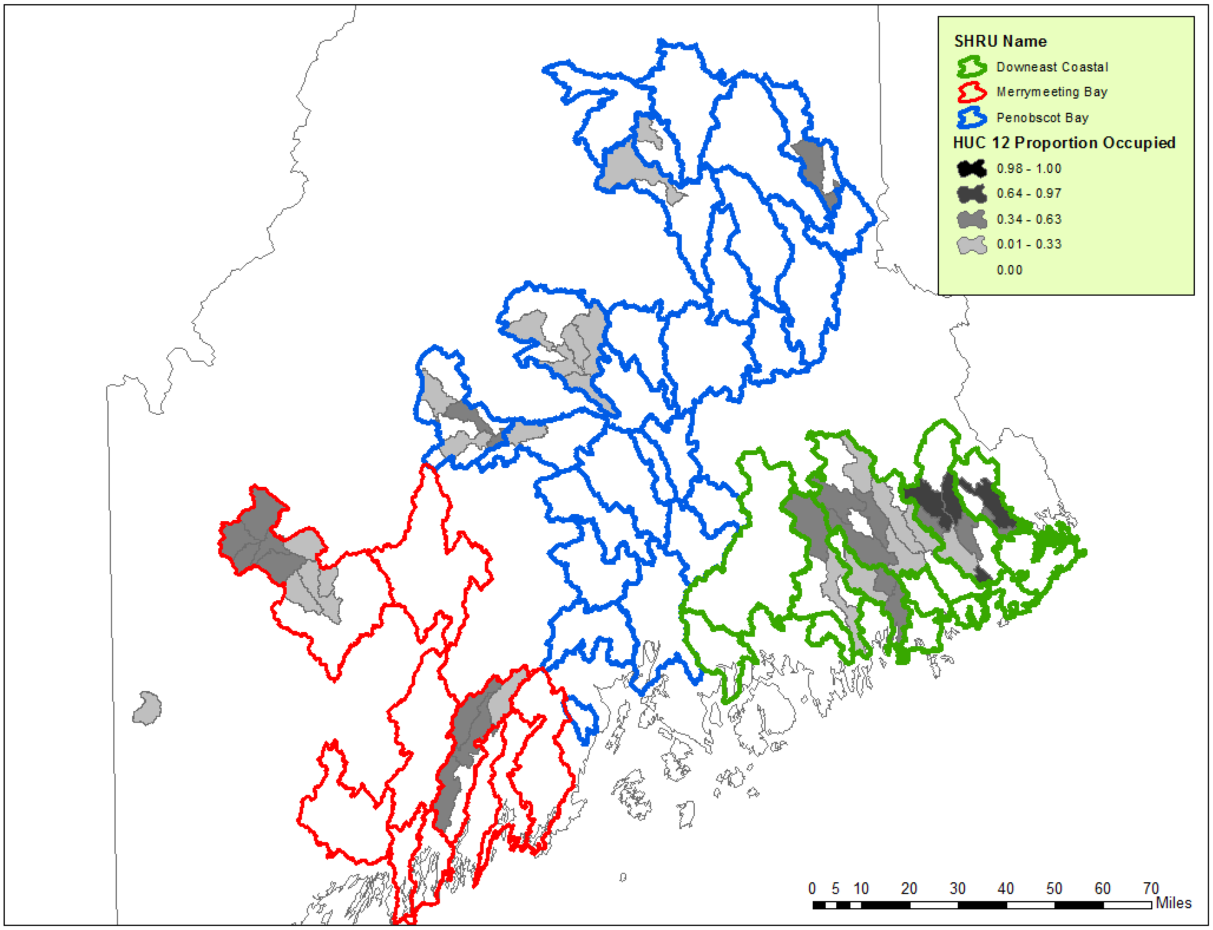

Figure 2.4.2.1. Map highlighting the relative proportion of river habitat occupied (see figure legend) by the 2017 cohort at a HUC-12 watershed summary level. Production is a synthesis of modeled distributions from spawning surveys of Atlantic salmon in 2016, fall 2016 egg planting, and 2017 egg, fry, and parr stocking.

2.5 Genetic Diversity

Effective population size (N_e) is defined as the size of an ideal population (N) that will result in the same amount of genetic drift as the actual population being considered. Many factors can influence Ne, such as sex ratios, generation time (Ryman et al. 1981), overlapping generations (Waples 2002), reproductive variance (Ryman and Laikre 1991), and gene flow (Wainwright and Waples 1998). Applied to conservation planning, the concept of N_e has been used to identify minimal targets necessary to maintain adequate genetic variance for adaptive evolution in quantitative traits (Franklin and Frankham 1980), or as the lower limit for a wildlife population to be genetically viable (Soulé 1987). Estimation of N_e in Atlantic salmon is complicated by a complex life history that includes overlapping generations, precocious male parr, and repeat spawning (Palstra et al. 2009). Effective population size is measured on a per generation basis, so counting the number of adults spawning annually is only a portion of the total N_e for a population. In Atlantic salmon, Palstra et al. (2009) identified a range of N_e to N ratios from 0.03 to 0.71, depending on life history and demographic characteristics of populations. Assuming an N_e to N ratio of 0.2 for recovery planning, the N_e for a GOM DPS of Atlantic salmon population should be approximately equal to the average annual spawner escapement, assuming a generation length of 5 years. Although precocious male parr can reproduce and therefore be included in estimates of the number of adult spawners, Palstra et al. (2009) determined that reproduction by male Atlantic salmon parr makes a limited contribution to the overall N_e for the population.

For the GOMDPS our diversity goals are to 1) monitor genetic diversity of each of broodstock; 2) screen for non-DPS origin fish in the broodstock (including commercial aquaculture escapees) and 3) evaluate diversity to help inform hatchery practices, stocking activities and other recovery activities. Of 8 extant stocks, 7 are in the conservation hatchery program. The Penobscot River is supported by capture of returning sea-run adult broodstock at Milford Dam, which are transported to Craig Brook National Fish Hatchery for spawning. A domestic broodstock, maintained at Green Lake National Fish Hatchery, also supports production in the Penobscot River, and is created annually by offspring from the spawned sea-run adults at Craig Brook National Fish Hatchery. Six other populations have river-specific broodstocks, maintained by parr-based broodstocks, comprising offspring resulting from natural reproduction which may occur, or primarily recapture of stocked fry.

2.5.1 Allelic Diversity

A total of 18 variables, microsatellite loci are used to characterize genetic diversity for all individuals considered for use in broodstocks. Loci analyzed were Ssa197, Ssa171, Ssa202, Ssa85 (O'Reilly et al. 1996), Ssa14, Ssa289 (McConnell et al. 1995), SSOSL25, SSOSL85, SSOSL311, SSOSL438 (Slettan et al. 1995, 1996), and SSLEEN82 (GenBank accession number U86706), SsaA86, SsaD157, SsaD237, SsaD486, (King et al 2005), Sp2201, Sp2216, and SsspG7 (Paterson et al. 2004). Annual characterization allows for comparison of allelic diversity between broodstocks, and over time. A longer time series allows for comparison of allelic diversity from the mid 1990's, but with a subset of 11 of the 18 loci. Based on that smaller subset of 11 loci, allelic diversity has ranged from 5.727 to 11.0 alleles per locus in the Pleasant River since 1995, with an average ranging between 7.412 alleles per locus in the Pleasant River to 9.062 alleles per locus in the Penobscot River. When evaluating allelic diversity based on 18 loci, starting in 2008, the average number of alleles per locus ranged from 10.17 alleles per locus for the Pleasant River to 13.55 alleles per locus for the Penobscot River.

2.5.2 Observed and Expected Heterozygosity

Observed and expected heterozygosity is estimated for each broodstock. Average estimates of expected heterozygosity based on 18 microsatellite loci ranged from 0.669 in the East Machias to 0.688 for the Penobscot. Observed heterozygosity estimates based on 18 loci ranged from 0.685 in the Dennys to 0.705 in the Penobscot.

2.5.3 Effective Population Size

Estimates of effective population size, based on 18 loci, varies both within broodstocks over time, and between broodstocks. Estimates are obtained using the linkage disequilibrium method which incorporates bias correction found in NeEstimator (V2.01, Do et al. 2013). Estimates are based on the minimum allele frequency of 0.010, and confidence intervals are generated by the jackknife option. Parr-based broodstocks, typically incorporate a single year class, thereby not violating assumptions for effective population size estimates of overlapping generations. Within the parr-based broodstocks, the lowest Ne was estimated for the Dennys 2013 collection year (N_e=12.8, 11.7-13.9 95% CI), and the highest was observed in the Narraguagus 2011 collection year (N_e=147.4 (136.7-159.4 95% CI). N_e estimates fluctuate annually, so starting in 2008, average Ne across the parr-based broodstocks ranges from N_e=69.0 in the Dennys to N_e=132.8. Within the Penobscot River, adult broodstocks typically include three to four year classes (including grilse). N_e estimates for the Penobscot since 2008 have ranged from N_e=546.5 (465.8-650.7 95% CI) to N_e=287.6 (265.7-312.0 95% CI), with an average N_e=404.79.

2.5.4 Inbreeding Coefficient

Inbreeding coefficients are an estimate of the fixation index. Estimates ranged from -0.022 in both the Dennys and Machias to -0.03 in both the East Machias and Pleasant.

2.5.5 Summary

Maintenance of genetic diversity within Maine Atlantic salmon populations is an important component of restoration. Past population bottlenecks, the potential for inbreeding, and low effective population sizes that have been sustained for multiple generations contribute to concerns for loss of diversity. Contemporary management of hatchery broodstocks, which consists of most of the Atlantic salmon currently maintained by the population works to monitor estimates of diversity and implement spawning and broodstock collection practices that contributed to maintenance of diversity. Overall, genetic diversity is being maintained since the start of consistent genetic monitoring in the mid 1990's, although there are concerns about slight decreases in allelic diversity in the Dennys and East Machias. Implementation of pedigree lines to retain representatives of all hatchery produced families helped to limit loss of diversity resulting from a genetic bottleneck in the Pleasant River. However, low sustained estimates of effective population size in the six parr-based broodstocks should continue to be monitored, as it indicates that populations are at a risk for loss of genetic diversity.

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3 Long Island Sound

3.1 Long Island Sound: Connecticut River

The Connecticut River Atlantic Salmon Restoration Program 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. The following is a summary of work on Atlantic salmon.

3.1.1. Adult Returns

A total of 20 sea-run Atlantic salmon adults was observed returning to the Connecticut River watershed: 11 on the Connecticut River mainstem, one in the Salmon River, three on the Farmington River, and five in the Westfield River. No sea-run salmon were retained for broodstock at any facility. Five salmon trapped at the Holyoke Fishlift were trucked to the Conte Lab for experimental trials prior to release (see section 3.1.7). One Holyoke salmon died in the lift and was taken to the Conte Lab for examination. Five other salmon captured at Holyoke were handled, Floy tagged, and released into the fishway to continue to migrate upstream. The salmon captured at West Springfield Fishway (Westfield River) were transported by truck to suitable upstream habitat. All salmon trapped at the Leesville and Rainbow fishways were was allowed to continue upstream of the dam. The Leesville salmon was handled and given a Floy tag. The Rainbow salmon were not handled but observed on video and allowed to continue upstream untouched.

None of the adult salmon were of hatchery (smolt-stocked) origin. All were of 'wild' (fry-stocked) origin. Only the fish from the Westfield River and Holyoke were scale-sampled. Of those, 14 were determined to be a W2:2. The other two were W2:3. The Rainbow and Leesville fish were postulated to be W2:2 based upon their size and because all past wild sea returns from the Connecticut River have been greatly dominated by 2:2 fish.

3.1.2 Hatchery Operations

Egg Collection

A total of 589,856 green eggs was produced. Only the Kensington State Fish Hatchery (KSFH) in CT maintained domestic broodstock. Contributing broodstock included 96 females and 96 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 194,082 juvenile Atlantic Salmon was stocked into the Connecticut River watershed, all in Connecticut. Selected stream reaches in the Farmington River received 106,379 fry and selected reaches in the Salmon River received 71,503 fry with the assistance of many volunteers. Totals of 127,267 fed fry and 50,615 unfed fry were stocked into these tributary systems. These numbers were much higher than the approximately 70,000 fry stocked in 2016, which was plagued by extremely poor eye-up rates due to a non-functioning chiller. 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 16,200 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

No smolt migration monitoring was conducted anywhere in the basin. Smolt counts were made at the viewing window at the Rainbow Dam Fishway (Farmington River) but since the number of fish that passed down the fishway is an unknown percentage of the total fish descending the river and passing the dam by other routes, these data have limited value.

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 specific for salmon were not conducted in other states.

3.1.5. Fish Passage

<u>Hydropower Relicensing</u>- The licenses of five large hydropower projects (four main stem dams) will expire in 2018. State and Federal resource agencies have spent considerable time on FERC-related processes for these re-licensings, including requesting numerous fish population, habitat, and fish passage studies. Due to the termination of the salmon restoration program, none of these requested studies involved Atlantic salmon. Many improvements to upstream and downstream fish passage are expected to result from the conditions placed on the new licenses but by the time they are implemented, very few salmon are expected to access that portion of the basin.

<u>Fish Passage Monitoring</u>- 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.

<u>New Fishways</u> - No new fishways were constructed.

<u>Dam Removals</u>- One dam was removed in the watershed: the Springborn Dam in the Scitico section of Enfield, CT. This tributary is reported to have hosted salmon runs

historically but has never been part of the Connecticut River restoration program and is not stocked by the Legacy Program.

Planning continued on the removal of the Blackledge River Dam (Blackledge River/Salmon River watershed), which will benefit salmon as part of the Legacy Program.

Culvert Fish Passage Projects- There were many undertaken in the Basin but none 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.

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 16,200 eggs for 81 tanks in 59 schools in Connecticut. An estimated 4,000 students participated.

Dr. Ted Castro-Santos (USGS) performed tests as part of the third year of a study on the sprinting performance and kinematics of adult Atlantic salmon at the Silvio Conte Anadromous Fish Research Center in Turners Falls, MA. Five 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.

3.1.8. Migratory Fish Habitat Enhancement and Conservation

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

3.2 Long Island Sound: Pawcatuck River

The U.S. Fish and Wildlife Service (USFWS) no longer formally supports the effort to restore Atlantic Salmon to the Pawcatuck River watershed. Although a small portion of the watershed lies in Connecticut, all activities involving Atlantic Salmon have been conducted solely by Rhode Island Department of Environmental Management (RIDEM) within the state of Rhode Island. RIDEM still continues minimal efforts with salmon, mostly for public outreach purposes. The following is a summary of available information.

3.2.1 Adult Returns

No adult salmon were known to have returned to the river.

3.2.2 Hatchery Operations

RIDEM received 80,000 eggs from USFWS Nashua NFH, and 20,000 from USFWS North Attleboro NFH from excess stock. Most of those eggs were committed to a smolt and future broodstock program and 10,000 went to the Salmon in the Classroom Program, the survivors of which and were stocked as fry (estimates at 3,900 fry stocked). Rhode Island DEM is currently raising smolts to release this year, and planning on future broodstock production.

Juvenile Atlantic salmon Releases

No Atlantic salmon smolts were stocked into the watershed. A total of 3,900 fry was stocked into the watershed.

3.2.2.1 Juvenile Population Status

Minimal electrofishing surveying of Atlantic salmon was done. Young of year were sampled in Beaver River and Meadow Brook.

3.2.2.2 Fish Passage

Bradford Dam and fishway (second on the Pawcatuck River) were removed. Even though the dam had a fishway, this removal will improve the passage of Atlantic Salmon into upstream habitat.

3.2.2.3 Genetics

No information is available.

3.2.2.4 General Program Information

3.2.2.5 Migratory Fish Habitat Enhancement and Conservation

Studies are being conducted to assess connectivity and temperature fluctuations in several systems that have suitable habitat for Atlantic salmon.

4 Central New England

4.1 Merrimack River

4.1.1 Adult Returns

Five (5) 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. 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 2017, 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 in 2017 provided an estimated 945,898 green eggs.

Sea-Run Broodstock

No sea-run fish were retained for broodstock.

Domestic Broodstock

A total of 307 females (F1 from sea-runs) broodstock spawned at Nashua NFH. Of the 307 females, 13 were two years old, 273 were three years old and 21 were four years old. The captive broodstock spawning season began on November 14, 2017 and ended 20, 2017, and include 7 spawning events to reach target eggs production.

Juvenile stocking is limited to educational salmon in schools program in 2017 at about 1,850 eggs provided to schools to rear and release in the Merrimack River watershed. We report those eggs are stocked at fry with zero loss. In 2017 a surplus of Merrimack Broodstock eggs of 99,211 was provided to The State of Rhode Island for restoration efforts and outreach opportunities.

4.1.3 Juvenile population Status

Yearling Fry / Parr Assessment

In 2017, 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.

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 directed stocking of Adult Atlantic salmon for their broodstock fishery in the spring of 2014. Additional adult fish were stocked in April, 2017; NHFG released 164 3+ and 853 4+ fish into the Merrimack.

Adopt-A-Salmon Family

The 2017 school year marked the twenty-fifth year of the Adopt-A-Salmon Family Program in central New England. In January and February, an estimated 1,850 salmon eggs were distributed from the NNFH to about 6 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.

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 Saco River

4.2.1 Adult Returns

Brookfield Renewable Energy Partners 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 1 May to 31 October, 2017. Nine 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 17 May to 31 October, 2017. A total of nine Atlantic salmon returned to the Saco River for the 2017 trapping season. However, the count could exceed two due to the possibility of adults ascending Cataract without passing through one of the counting facilities.

4.2.2 Hatchery Operations

Egg Collection

In 2017, 529,522 eyed eggs from Merrimack River origin broodstock were transferred from the Nashua National Fish Hatchery to the Saco Salmon Restoration Alliance. A portion of these were distributed to school programs (Fish Friends) and the remaining reared at the hatchery for release as fry.

4.2.3 Stocking

Juvenile Atlantic salmon Releases

Approximately 127,000 fry, reared at the Saco Salmon Restoration Alliance, were released into one mainstem reach and 31 tributaries of the Saco River. In 2017 the Saco Salmon Restoration Alliance planted 53,000 eyed-eggs in two tributaries to the Saco River.

Adult Salmon Releases

No adult Atlantic salmon were stocked into the Saco River.

4.2.4 Juvenile Population Status

Index Station Electrofishing Surveys

ME-DMR conducted six electrofishing surveys in the Saco River watershed in 2017. All five sites were directed at assessing juvenile Atlantic salmon production from the egg planting efforts conducted in the Saco River.

Smolt Monitoring

There was no smolt monitoring in 2017

Tagging

No salmon outplanted into the Saco were tagged or marked in 2017.

4.2.5 Fish Passage

Blank placeholder

4.2.6 Genetics

No genetic samples were collected in 2017.

4.2.7 General Program Information

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

4.2.7 Migratory Fish Habitat Enhancement and Conservation

No habitat enhancement or conservation projects directed solely towards Atlantic salmon were conducted in the watershed during 2017.

5 Gulf of Maine

Summary

Documented adult Atlantic salmon returns to rivers in the geographic area of the Gulf of Maine DPS (73 FR 51415-51436) in 2017 were 1,008. Returns are the sum of counts at fishways and weirs (925) and estimates from redd surveys (83). 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. Once again, conditions were marginal for adult dispersal throughout the rivers due to below normal discharge throughout much of Maine from July to September, Conditions improved slightly in the fall so redd surveys covered more area than reported in 2016.

Escapement to these same rivers in 2017 was 482 (Table 5.1). Escapement to the GOM DPS area equals releases at traps and free swimming individuals (estimated from redd counts) plus released pre-spawn captive broodstock (adults used as hatchery broodstock are not included) and recaptured downstream telemetry fish.

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). 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. 5.2).

Table 5.1 Table of returns versus escapement.

Source	Returns	Brood Stock	Loss to telemetry	DOA	Escapement
Penobscot	849	520	0	2	327
Kennebec	40	0	4	0	36
Narraguagus	36	0	0	0	36
Redds Estimate	83	N/A	N/A	N/A	83
	1,008	520	4	2	482

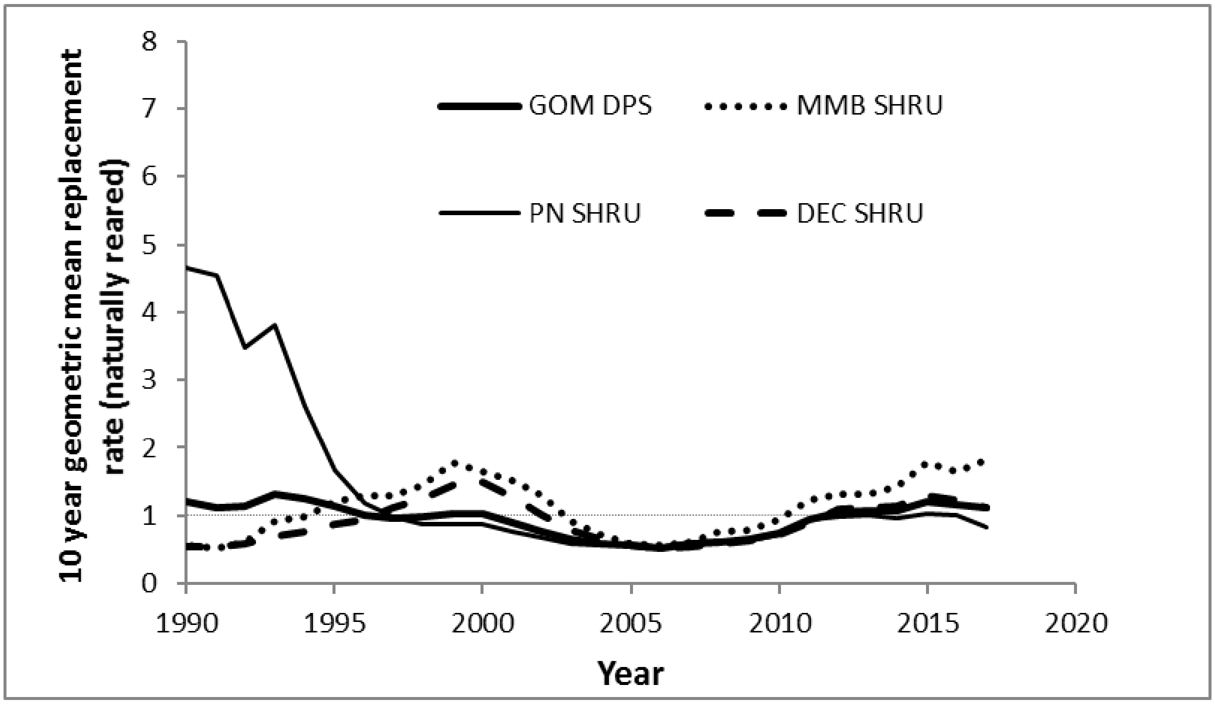

Figure 5.1. Ten-year geometric mean of replacement rate for returning naturally reared Atlantic salmon in the GOM DPS and the three Salmon Habitat Recovery Units (SHRU).

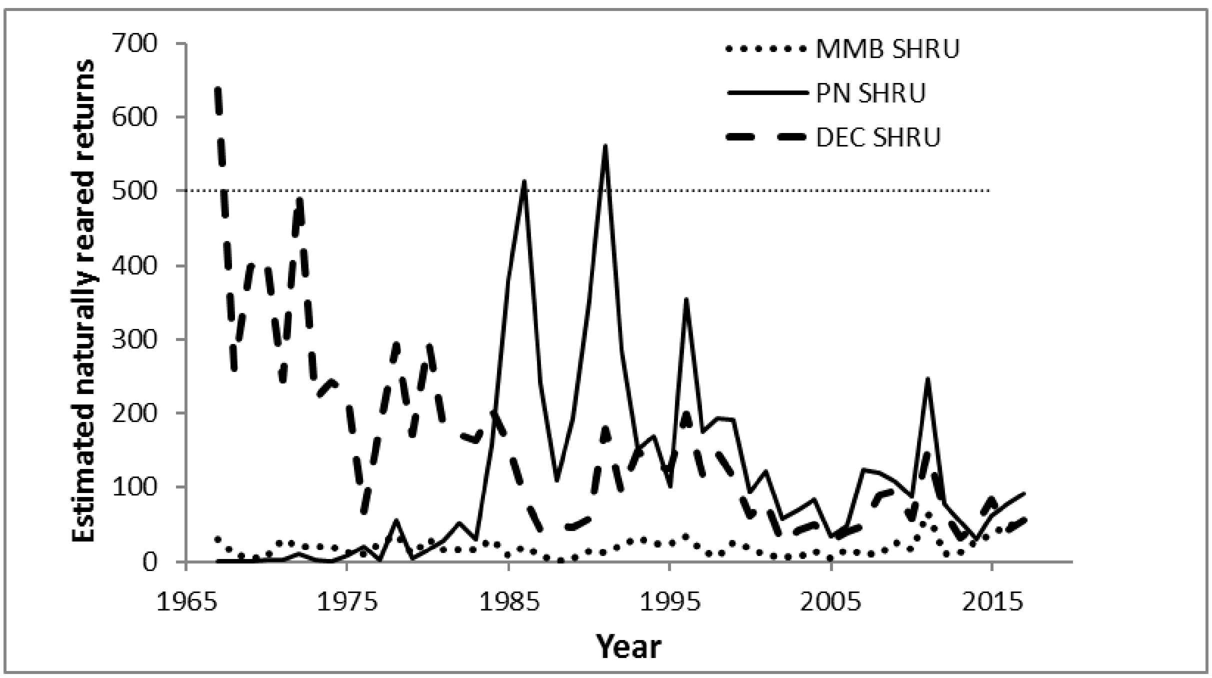

Figure 5.2 Estimated Naturally Reared Returns to the GOM 1965 to 2017

5.1 Adult returns and escapement

5.1.1 Merrymeeting Bay

Androscoggin River

The Brunswick fishway trap was operated from 26 April to 30 October (Table 5.1.1) by a combination of MDMR and Brookfield Renewable Energy Group (BREG) staff. No adult Atlantic salmon were captured at the Brunswick fishway trap.

Occasionally an adult Atlantic salmon will pass undetected through the fishway at Brunswick during maintenance/cleaning, so a minimal redd count effort was conducted. Two small sections of the Little River where redds have been documented in past years were surveyed for redd presence, totaling 0.12 river kilometers covered. No redds or test pits were found in these sections of river.

Kennebec River

The Lockwood Dam fish lift was operated by BREG staff from 6 May to 31 October (Table 5.1.1). Forty adult Atlantic salmon were captured. Biological data were collected from all returning Atlantic salmon in accordance with MDMR protocols, and the presence of marks and tags were recorded. Of the 40 returning Atlantic salmon, 35 (87.5%) were 2SW, 3 (7.5%) were grilse (1SW) and 2 (5%) were 3SW. All salmon were naturally reared in origin. Of these, 20 were transported to the Sandy River and released and 20 were radio tagged and released below the Lockwood Dam for telemetry studies. Of these, 16 were recaptured at the fish lift and transported to the Sandy River.

All stocking and translocation of salmon in the Kennebec River drainage occur in the Sandy River. The 40 adults trapped at Lockwood fish lift are likely from the Sandy River because scale analysis revealed that all were naturally reared. Redd surveys were conducted in 14% of known spawning habitat and three redds were observed. Preliminary spot checks occurred intermittently between 5 October and 28 November; unfortunately, extreme high flow events most likely coincided with spawning.

Sebasticook River at Benton Falls fish lift facility was operated by MDMR staff from 01 May to 01 August, 2017. No Atlantic salmon were captured (Table 5.1.1).

Sheepscot River

There were 16 redds observed in the Sheepscot River; eight were observed in the mainstem and eight were observed in the West Branch. A total of 80% (32.7km) of known spawning habitat was surveyed in the Sheepscot River drainage; 85% (22.1km) of mainstem habitat and 71% (10.6km) of West Branch habitat was covered. Based on the Returns to Redds Model, 19 salmon returns were projected.

5.1.2 Penobscot Bay

Penobscot River

The fish lift at the Milford Hydro-Project, owned by BREG, was operated daily by MDMR staff from 24 April through 15 November. The fish lift was also used to collect adult sea-run Atlantic salmon broodstock for the U.S. Fish and Wildlife Service (USFWS). In addition to the Milford fish lift, BREG operated a fish lift daily at the Orono Hydro project. The counts of salmon collected at that facility are included in the Penobscot River totals.

A total of 849 sea-run Atlantic salmon returned to the Penobscot River (Table 5.1.1). Scale samples were collected from 688 salmon captured in the Penobscot River and analyzed to characterize the age and origin structure of the run. The origins of the remaining Atlantic salmon not scale sampled were prorated based on the observed proportions, considering the presence of tags or marks observed and dorsal fin deformity. Of returning salmon, 530 were age 2SW (62%), 310 were age 1SW (37%), and nine were age 3SW (1%). Approximately 90% (761) of the salmon that returned were of hatchery origin and the remaining 10% (88) were of wild or naturally reared origin. No aquaculture suspect salmon were captured.

DMR staff conducted redd surveys in three watersheds and seven tributaries within the Penobscot River drainage. The tributaries located below the Milford and Orono fish lifts were surveyed to evaluate spawning escapement. Redd surveys in North Branch Marsh Stream and Great Works Stream found no evidence of spawning activity. Redd counts in Kenduskeag Stream (11% surveyed) and its tributary French Stream (62% surveyed) as well as Souadabscook Stream (31% surveyed) were conducted several times early in the season anticipating spawning due to the increased adult returns at the Milford fish lift. During these initial surveys, one redd and two test pits were observed in the Kenduskeag River. Final surveys were completed in December after the spawning season. Four redds and four test pits were observed in the Kenduskeag (including French Stream), and one test pit in the

Souadabscook. The redds found in the Kenduskeag may be a result of fry (25k) that were stocked in 2013. Based on the Returns to Redds Model, nine salmon returns were projected for the Kenduskeag Drainage and four were projected for the Souadabscook River (Table 5.1.2).

Redd surveys above the Milford and Orono fish lifts were conducted in late November in the Mattawamkeag and Piscataquis drainages, including Pollard Stream. Three redds were found on a reach within the East Branch Mattawamkeag; surveys covered 10% (7.2km) of known spawning habitat. Due to elevated spawning activity observed in 2016, a more intensive survey was conducted on the Pleasant River (a tributary to Piscataquis River), including the East and West Branches, and a portion of the Middle Branch. Surveys were conducted on over 75% (38km) of the spawning habitat within these reaches. The surveys in the Pleasant River, which receives low levels of stocking, were conducted once late in the season after rains increased flows to allow the use of canoes. Six redds and sixteen test pits were documented during the survey. However, it should be noted that it's possible that a portion of the test pits observed may have been redds that had been partially covered by shifting gravel during the high-water events prior to the survey. The Piscataquis River including the lower reach of the West Branch was surveyed late in the season and one redd and two test pits were found. The West Branch had 36.4% (1.1km) of the spawning habitat surveyed and 9% of the upper mainstem Piscataquis. For 2017, 30% of the known spawning habitat was surveyed (2016= 16 %) (Table 5.1.2).

Ducktrap River

The Ducktrap River has long standing redd survey trend data (1984 to present). In this time series, we observed redds every five years. Redds were expected in 2016 but none were observed. However, young-of-the year (YOY) were found during juvenile electrofishing surveys in 2017. Therefore, spawning occurred but was not observed in 2016. Surveys conducted in 2017, covering 54.2% of the drainage (5.5km) detected one redd and one test pit. Although the YOY found in 2017 will not be genetically characterized, parr scales from previous years are currently being analyzed to determine whether these fish are Ducktrap or Penobscot origin through genetic analysis. Based on the Returns to Redds Model, four salmon returns were projected (Table 5.1.3).

Cove Brook

Zero redds were observed in Cove Brook. Surveys covered 71% (5.2km) of spawning habitat.

5.1.3 Downeast Coastal

Dennys River

There were 11 redds surveyed in the Dennys River in 2017. Surveys covered 79% of the habitat and 35.24 km of stream. Based on the Returns to Redds Model, 15 salmon returns were projected.

East Machias River

Four redds were counted during the 2017 redd surveys covering approximately 98% (25.5km) of known spawning habitat. This was the second cohort of adults to return from fall parr outplanted as part of the project by the Downeast Salmon Federation (DSF) to raise and release fall parr. There were 77,568 fall parr associated with the adult cohort. Based on the Returns to Redds Model, nine salmon returns were projected.

Machias River

A total of nine redds was counted. Surveys covered 66% of the habitat and 66 km of stream. Based on the Returns to Redds Model, 14 salmon returns were projected.

Pleasant River

Four redds were observed. Surveys covered 85% of the habitat and 22 km of stream. Based on the Returns to Redds Model, nine salmon returns were projected.

Narraguagus River

Returns to the fishway trap (36) were much higher than 2016 (3). This was the first year of 1 SW salmon returns from hatchery smolt released in 2016. Hatchery origin grilse (20) represented 55% of the total returns to the Narraguagus. Naturally reared returns were up from 2016 with both grilse and 2SW returns. Additionally, there were two repeat spawner captured at the trap. Redd surveys accounted for 17 redds with surveys covering 89% (50.27km) of known spawning habitat. Based on the Returns to Redds Model, 19 salmon returns were projected, but this estimate is superseded by the trap count return.

Union River

The fish trap at Ellsworth Dam on the Union River is operated by the dam owners, BREG, under protocols established by the DMR. The trap was operated from 1 May to 31 October 2017. No Atlantic salmon were captured during this period.

Table 5.1.1 Age and origin of sea run Atlantic salmon returns to Maine by river, 2017.

River	Total Sea-run Returns	Hatchery					Wild					
		1SW	2SW	3SW	RPT	Total	1SW	2SW	3SW	MSW	RPT	Total
Downeast Coastal SHRU												
Narraguagus River	36	20	0	0	0	20	7	7	0	0	2	16
Union River	0	0	0	0	0	0	0	0	0	0	0	0
Penobscot Bay SHRU												
Penobscot River	849	301	451	9	0	761	9	79	0	0	0	88
Merrymeeting Bay SHRU												
Lower Kennebec River	40	0	0	0	0	0	3	35	2	0	0	40
Lower Androscoggin R.	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
Total	925	321	451	9	0	781	19	121	2	0	2	144

Table 5.1.2 Results of redd surveys by drainage and stream for 2017. Effort is shown by both total kilometers and the proportion of spawning habitat surveyed.

SHRU	Drainage	Drainage Total	% Drainage Spawn Habitat Surveyed	Total Drainage KM Surveyed	Stream Name	Redds	Total Stream KM Surveyed
Downeast Coastal	Dennys	11	78.94	35.24	Cathance Stream	0	15.14
					Dennys River	11	20.1
	East Machias	4	98.15	25.51	Barrows Stream	0	0.42
					Beaverdam Stream	0	3.39
					Chase Mill Stream	0	2.13
					East Machias River	1	8.11
					Northern Stream	3	10.08
					Seavey Stream	0	1.38
	Machias	9	58.99	66.02	Crooked River	0	2.57
					Machias River	1	23.34
					Mopang Stream	0	9.83
					New Stream	0	1.1
					Old Stream	0	18.39
					West Branch Machias River	8	10.79
	Narraguagus	17	89.69	50.27	Baker Brook	0	0.25
					Bog Brook	0	0.13
					Narraguagus River	17	49.89
	Pleasant	4	84.65	22.07	Eastern Little River	0	3.36
					Pleasant River	4	18.71
Merrymeeting Bay	Lower Andro.	0		0.12	Little River	0	0.12
	Sandy River	3	2.53	23.54	Avon Valley Brook	0	0.07
					Bond Brook	0	3.39
					Mt Blue Stream	0	0.05
					Orbeton Stream	2	9.39
					Perham Stream	0	0.84
					Saddleback Stream	0	0.18
					Sandy River	1	4.9
					South Branch Sandy River	0	0.8
					Temple Stream	0	0.36
					Togus Stream	0	3.56
	Sheepscot	16	75.54	32.66	Sheepscot River	8	22.06
					West Branch Sheepscot River	8	10.6
Penobscot	Ducktrap	1	54.22	5.48	Ducktrap River	1	5.48
	Mattawamkeag	3	9.79	7.23	East Branch Mattawamkeag River	3	7.23
	Penobscot	5	5.85	19.27	Cove Brook	0	5.21
					French Stream	3	1.76
					Great Works Stream	0	1.28
					Kenduskeag Stream	1	6.21
					North Branch Marsh Stream	0	0.71
					Pollard Brook	0	0.71
					Souadabscook Stream	1	3.39
	Piscataquis	7	29.76	45.49	East Branch Pleasant River	3	5.96
					Middle Branch Pleasant River	0	0.99
					Piscataquis River	1	6.81
					Pleasant River	3	21.76
					West Branch Piscataquis River	0	1.08
					West Branch Pleasant River	0	8.89
	Total Redds	80	Total River KM	332.9			

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, Dennys and Pleasant rivers (USASAC 2010). Total estimated return based on redd counts for the small coastal rivers was 89 (95% CI = 63 - 120) (Table 5.1.3). Estimates include returns to the Union River.

Survival Estimates

Atlantic salmon survival rates were calculated for hatchery stocks and naturally reared stocks for the Narraguagus and Penobscot Rivers (Table 5.1.4). Calculations were based on known numbers of stocked salmon, smolt estimates, and adult returns. Origins of returning adults are determined by marks or scale analysis. Smolt-to-adult (SAR) survival rates varied by origin; naturally reared smolt on the Narraguagus River had the highest average SAR survival (0.915%). Penobscot average SAR rates of hatchery smolt are significantly lower, (0.153%) ($p < 0.05$). However, the 2015 Penobscot cohort returned at a higher rate than previous years 2011 to 2014.

Table 5.1.3 Regression estimates and confidence intervals (90% CI) of adult Atlantic salmon in the five Downeast Coastal rivers from 1991 to 2017.

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
2016	26	62	156
2017	63	89	120

Table 5.1.4. Summary table of 2SW Atlantic salmon survival rates from the Penobscot and Narraguagus rivers. All rates for stocked origin stocks were based on marked groups or scale analysis.

Cohort Year	Origin of Smolt Number	Number of Smolt	Number of Survivors	% Survival
Narraguagus River Naturally Reared SAR				
2008	Estimate	962	8	0.654%
2009	Estimate	1,176	25	1.801%
2010	Estimate	2,149	25	0.237%
2011	Estimate	1,404	14	0.563%
2012	Estimate	969	6	1.023%
2013	Estimate	1,237	22	1.914%
2014	Estimate	1,615	8	0.507%
2015	Estimate	1,201	7	0.621%
			Mean	**0.915%**
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	283	0.051%
2012	Stocked	555,200	237	0.043%
2013	Stocked	553,000	631	0.114%
2014	Stocked	557,700	218	0.039%
2015	Stocked	375,600	451	0.120%
			Mean	**0.153%**

5.2 Juvenile Population Status

Juvenile abundance estimate

Juvenile population assessments were performed using 248 sampling locations to evaluate annual population variation or specific studies of interest, e.g. egg planting. Of these 248 sites, 135 were selected using the Generalized Random Tessellated Stratified (GRTS) design. GRTS sites were selected for the Narraguagus, East Machias, Sandy River, Sheepscot, Mattawamkeag, Cove Brook and Piscataquis). The remaining sites were focused on specific project questions like egg planting follow up or follow up on natural spawning (Table 5.2.1 and Figure 5.2.1). As in 2016, two sites were surveyed in the Dennys River for the purpose of collecting tissues from YOY. MDMR staff collected 50 samples of YOY suspected of being from Aquaculture Suspect (AQS) origin. These samples were forwarded to the USFWS Lamar Lab for genetic analysis

Trends from GRTS surveys across the DPS for relative parr abundance from 2011 to 2017 appear to track each other in variation but generally remain flat over the six-year period (Figures 5.2.2 – 5.2.4). Of note is abundance of large parr in the East Machias River. With continued use of fall parr planted in late October the increased abundances reflect the input of greater numbers of a larger lifestage. This strategy also has improved smolt out-migrations (See smolt trapping summary below and Working Paper WP18-02-Smolt Update). Notable high values for YOY in the Pleasant River show a response to the use of eyed eggs planted in January versus the status quo of stocking fry (Table 5.2.1)

An example of a specific project was the Sandy River egg to parr assessment. In this study, a series of sites in the Sandy River was sampled to generate a survival estimate of 0+parr from eyed egg planting. The sampling plan for 0+parr focused on a single planting site in Mt. Blue Stream, a tributary to the Sandy River. This planting location was chosen due its isolation from both wild spawning and other planting sites, as well as its continuous reaches of juvenile rearing habitat. The sampling sites were randomly chosen and intended to be evenly distributed in juvenile habitat around the planting sites. Each site was sampled using CPUE methodology (300 second single pass, open site). Sampling continued upstream and downstream, moving away from the planting site until less than one 0+parr was captured. All fish captured were counted, measured and weighed. No scales were taken; therefore, length was used to determine age class.

To estimate survival, a density (fish per 100 meters2) was calculated from each CPUE by using watershed specific catchability (0.64 n=58). A regression was then generated from the site population estimates and distance from the planting site. The slope of the regressions, along with estimated densities, was used to produce a reach estimate around the planting site (Sweka 2006). The estimate in 2017 was part of a multi-year assessment of egg planting density and resulting survival. The resulting reach population estimate for 2017 indicated a survival of 24% from eyed egg to 0+parr that compares favorably to previous years (Table 5.2.2).

Table 5.2.1 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, 2017. Drainages are grouped by Salmon Habitat Recovery Unit (line).

	Parr				YOY			
Drainage	**n**	**Min**	**Median**	**Max**	**n**	**Min**	**Median**	**Max**
Dennys	2	2.18	2.9	3.63	2	0.99	1.45	1.91
East Machias	24	0.2	2.6	6.3	24	0	0	6
Machias	4	2.38	2.78	6.18	4	0.6	2.29	4.74
Narraguagus	12	0.19	2.17	660	12	0	1.68	660
Pleasant	4	0	0.78	1.2	4	5.2	8.41	9.14
Lower Kennebec	75	0	0.6	3.38	75	0	0.2	6.95
Sheepscot	32	0	0.49	4.58	32	0	0.54	5.35
Ducktrap	6	0	1.4	2.25	6	0	0	0
Mattawamkeag	7	0	0.64	2.26	7	0	0	3.65
Penobscot	24	0	2.61	6.32	24	0	0	0.38
Piscataquis	30	0	0.49	3.23	30	0	0.87	7.44
Little River (Penobscot)	2	0	0.1	0.2	2	0.2	0.7	1.19

Table 5.2.2 Survival estimates of eyed egg to late summer 0+parr in Mt. Blue Stream.

Site	Year	Eggs Planted	Estimate 0+parr	Low	High	Survival
Mt Blue S.	2010	51,457	13,858	4,255	23,461	0.27
Mt Blue S.	2012	28,770	4,697	3,183	8,849	0.16
Mt Blue S.	2017	4,968	1,178	504	1,401	0.24

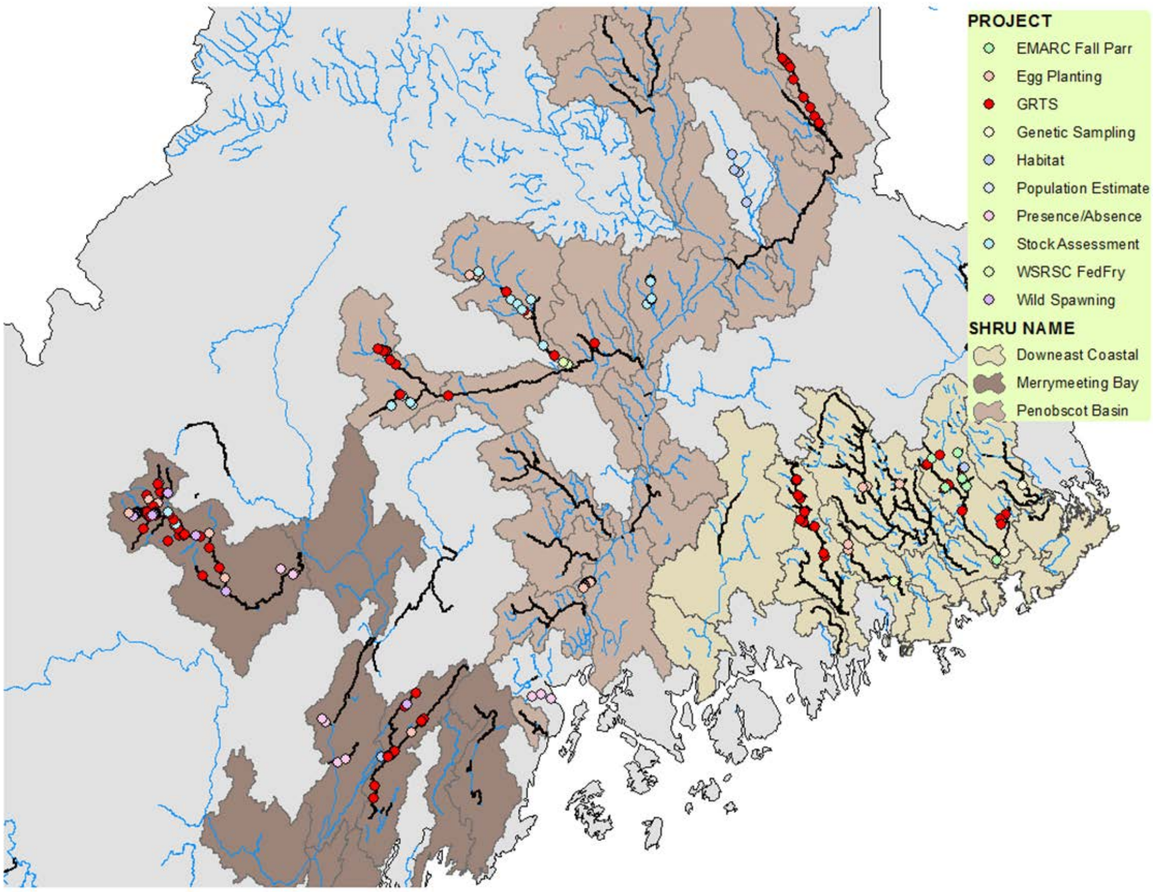

Figure 5.2.1. Distribution of electrofishing survey sites throughout the GOM DPS in 2017. Most of sampling effort was for the GRTS survey (red circles). Other survey objectives are noted by project color.

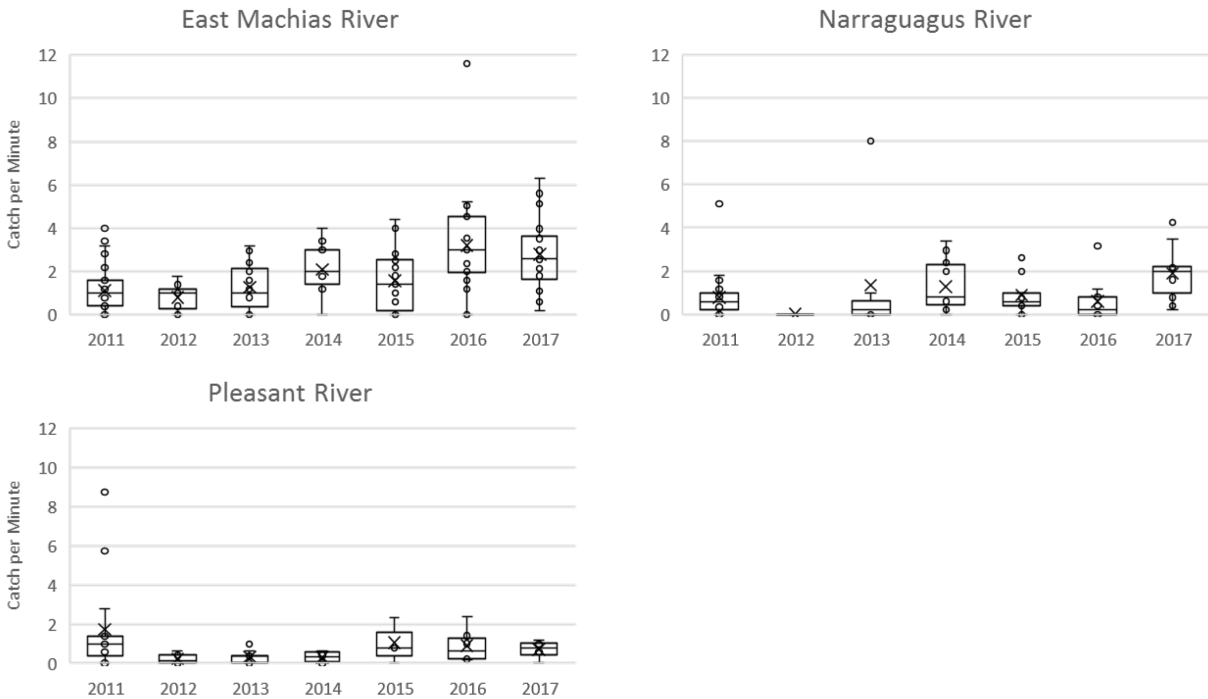

Figure 5.2.2. Mean Catch per minute for Atlantic salmon parr 2011 to 2017 for selected drainages in the Downeast SHRU.

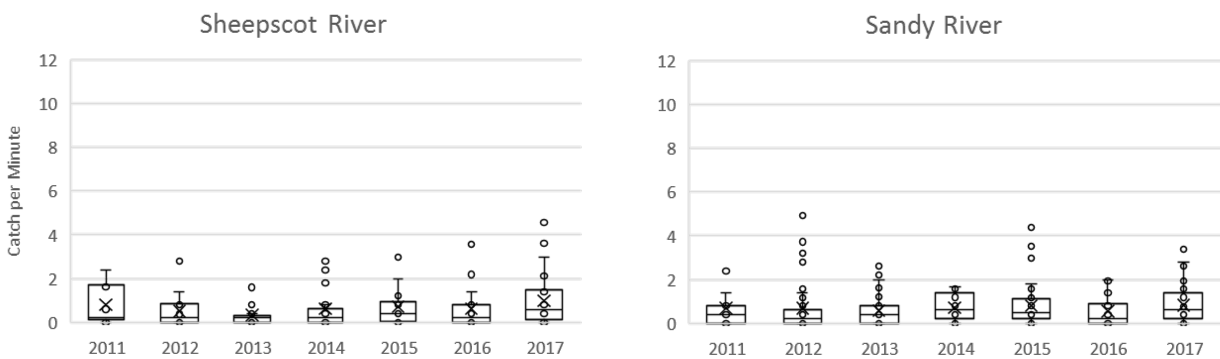

Figure 5.2.3. Mean Catch per minute for Atlantic salmon parr 2011 to 2017 for selected drainages in the Merrymeeting Bay SHRU.

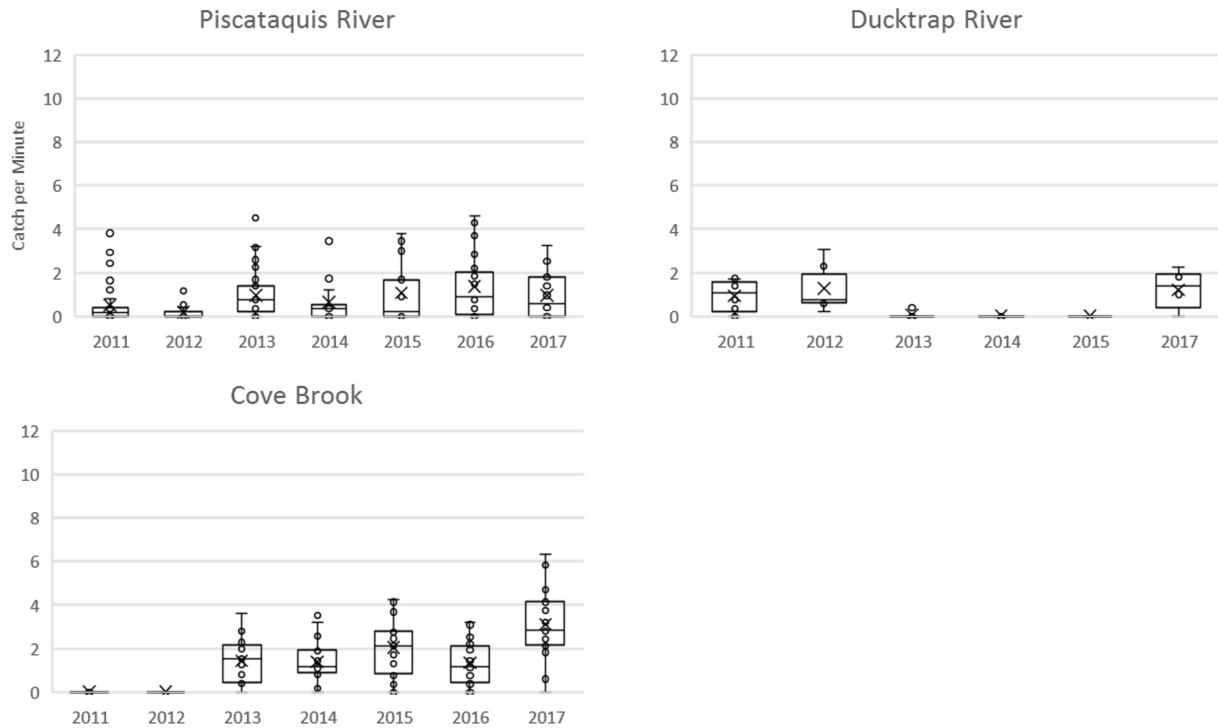

Figure 5.2.4. Mean Catch per minute for Atlantic salmon parr 2011 to 2017 for selected drainages in the Penobscot SHRU.

Smolt Abundance

The following is a summary of activities intended to obtain smolt population estimates based on mark-recapture techniques at several sites within the GOM. A more detailed report on smolt population dynamics is included in Working Paper WP18-02-Smolt Update.

MDMR enumerated smolt populations using Rotary Screw Traps (RSTs) in several of Maine's coastal rivers. These include the East Machias (in partnership with DSF), Narraguagus, and Sheepscot rivers. A total of 797 smolts was trapped at all sites between 11 April and 9 June (Table 5.2.3).

MDMR 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 (Figures 5.2.5 and 5.2.6; Table 5.2.4). The East Machias 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 1,501 ± 253. The hatchery population estimate was estimated to be 1,323 ± 224. Insufficient recaptures prohibited calculation of the wild origin population estimate. The total population estimate for all smolts exiting the Sheepscot River (hatchery 0+ parr origin and naturally reared origin) was 2,758 ± 609. The hatchery population estimate was calculated to be 1,932 ± 593. The naturally reared population estimate was calculated to be 985 ± 242. A two-site mark-recapture design was used on the Narraguagus River, which continued smolt assessments for the 21st consecutive year on this river. Non-fishing days (11) due to unsafe river conditions occurred frequently during the peak of the run, prohibiting calculation of a population estimate for the Narraguagus River. Further details on age, origin, and other data are presented in *Working Paper WP18-02-Smolt Update*.

Table 5.2.3 Atlantic salmon smolt trap deployments, total captures, and capture timing by origin in Maine rivers, 2017.

River	Date Deployed		Origin	Total Captures	First Capture	Median Capture Date	Last Capture
East Machias	18-Apr	9-Jun	H	227	19-Apr	13-May	3-Jun
			W	33	29-Apr	9-May	27-May
Narraguagus	18-Apr	31-May	H	87	23-Apr	2-May	14-May
			W	116	22-Apr	13-May	30-May
Sheepscot	11-Apr	30-May	H	177	30-Apr	11-May	23-May
			W	156	29-Apr	10-May	21-May
			Unk	1	18-May	18-May	18-May
Total				797			

Table 5.2.4. Maximum likelihood mark-recapture population estimates for naturally reared and hatchery origin Atlantic salmon smolts emigrating from Maine rivers, 2017.

River	Estimate Type	Origin	Population Estimate
East Machias	One site	Hatchery	1,323 ± 224
		Naturally reared	n/a
		Both	1,501 ± 253
Narraguagus	Two site	Hatchery	n/a
		Naturally reared	n/a
Sheepscot	One site	Hatchery	1,932 ± 593
		Naturally reared	985 ± 242
		Both	2,758 ± 609

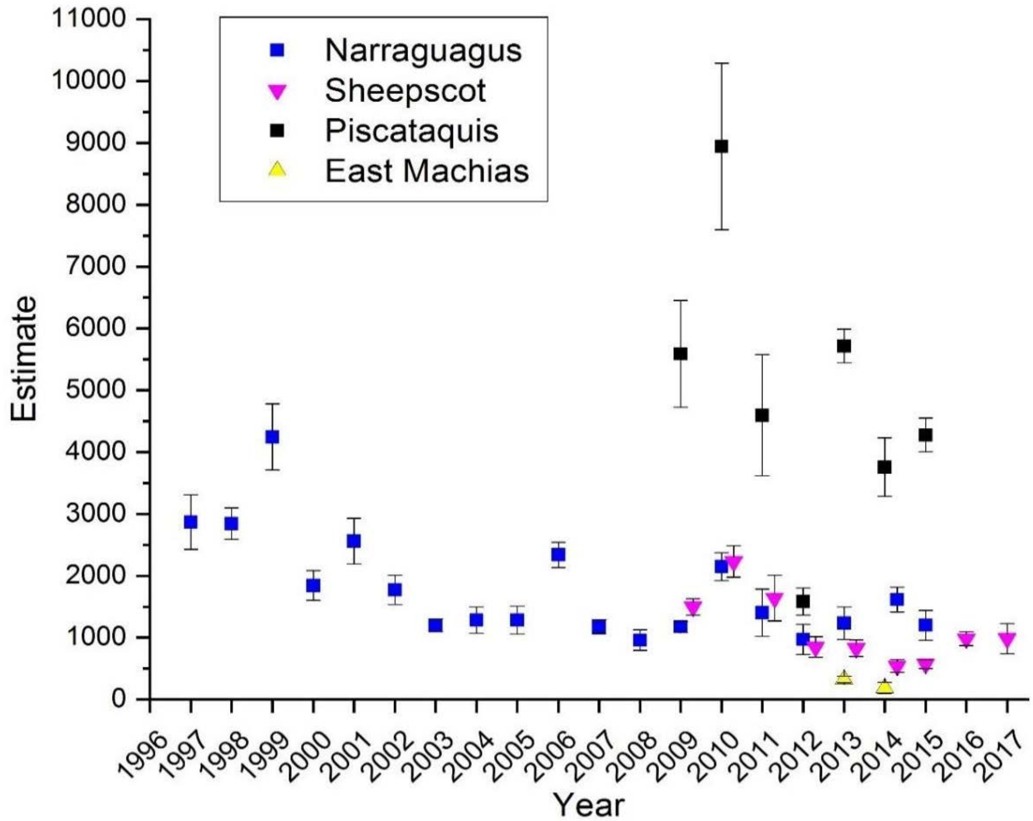

Figure 5.2.5. Population Estimates (± Std. Error) of emigrating naturally-reared smolts in the Narraguagus (no estimate in 2016 and 2017), Sheepscot, Piscataquis (discontinued in 2015), and East Machias (no estimate 2015-2017) rivers, Maine, using DARR 2.0.2.

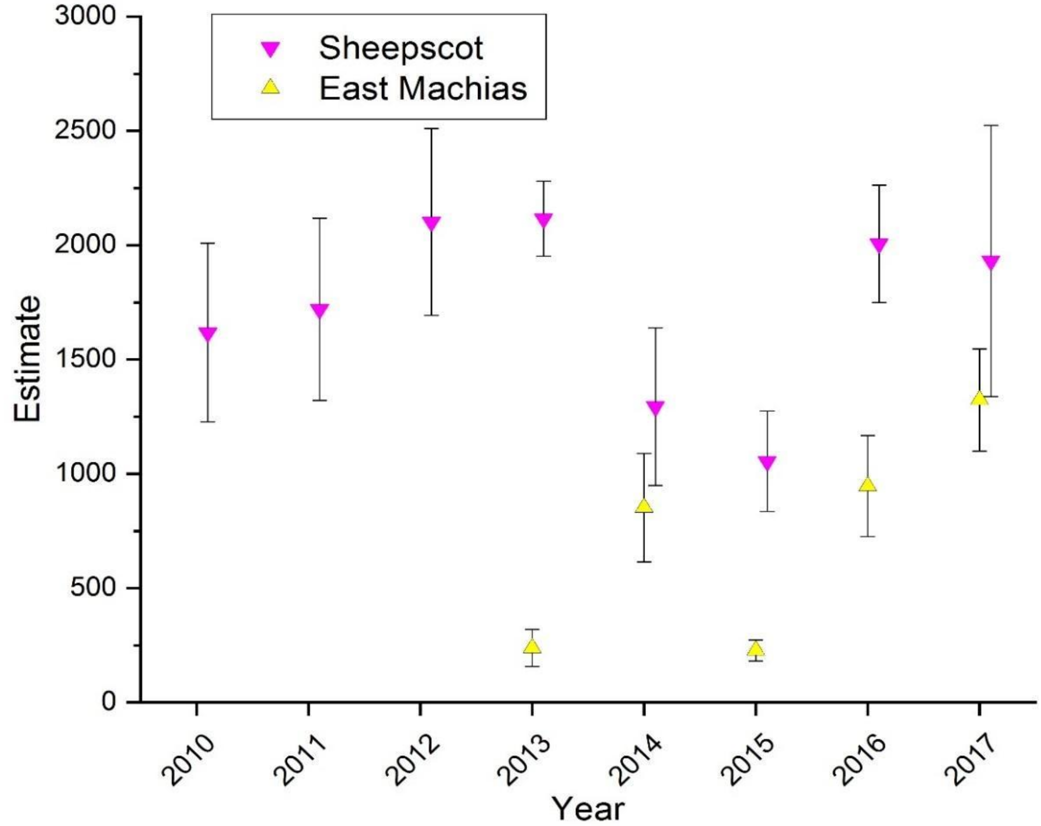

Figure 5.2.6. Population Estimates (± Std. Error) of emigrating hatchery-origin smolts stocked as fall parr in the Sheepscot and East Machias rivers, Maine, 2010-2017, using DARR 2.0.2.

5.3 Fish Passage and Migratory Fish Habitat Enhancement and Conservation

Fish Passage Studies

MDMR, Brookfield White Pine Hydro, and NOAA Fisheries collaborated to study upstream passage on the Kennebec River. As was outlined in the Interim Species Protection Plan for the Lockwood Hydro Project, the project owner committed to assessing upstream passage for adult Atlantic salmon to document passage effectiveness of existing project conditions. In summer 2017, Brookfield crews captured and radio tagged 20 naturally-reared adult Atlantic salmon with Lotek MCFT2-3EM transmitter (12 mm x 53mm) tags at the Lockwood Project. After tagging, adults were allowed to recover and were released approximately 1.15 miles below the project.

To determine behavior in the project area, stationary receivers were deployed above and below the release site. Data from this study are still being analyzed but indicate 70% of the salmon found the passage facility after considerable time searching. Notably, two tagged salmon were detected above the Lockwood Dam and later captured at the newly operational fish lift at the Hydro Kennebec Project. This verifies long standing anecdotal reports that salmon were able to move above the Lockwood Project. Overall, most of the adults were recaptured and moved upstream into nursery habitat.

Habitat Assessment

MDMR staff conducted habitat surveys in two streams within the Sandy River sub-drainage located in the Merrymeeting Bay SHRU. Staff surveyed Avon Valley and Mt. Blue Streams and recorded 9.16 and 9.67 units of habitat ($100m^2$) and 2.4 and 1.0 units of spawning habitat respectively. This totaled 1,538 units of rearing habitat and 3.4 units of spawning habitat. Data are currently being geo-referenced and will be appended to the current habitat geo-database. An updated GIS dataset will be issued in March 2018. Survey data will be utilized to establish broodstock requirements and direct habitat and/or connectivity improvements.

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 that block the movement of diadromous fish, other aquatic and terrestrial species, sediment, nutrients and woody debris exist in Maine streams. 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, costlier 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. 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 since 2006. Partners leading this effort in recent years include The Nature Conservancy, Maine Forest Service (MFS), Maine Audubon, USDA Natural Resources Conservation Service (NRCS), and the U.S. Fish and Wildlife Service (USFWS).

After 11 years of fieldwork, well over three quarters of the state's perennial and high-value intermittent stream crossings have been assessed (Figure 3.3.11). About 14,000 stream crossings have been assessed within the Gulf of Maine DPS. A wide variety of private owners, municipalities, and agencies is using survey information to prioritize 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.

About 2,000 stream barrier surveys will be completed in the Kennebec, Androscoggin and St. John watersheds in 2018. The survey team is still seeking permission from one of Maine's largest landowners to access other crossings.

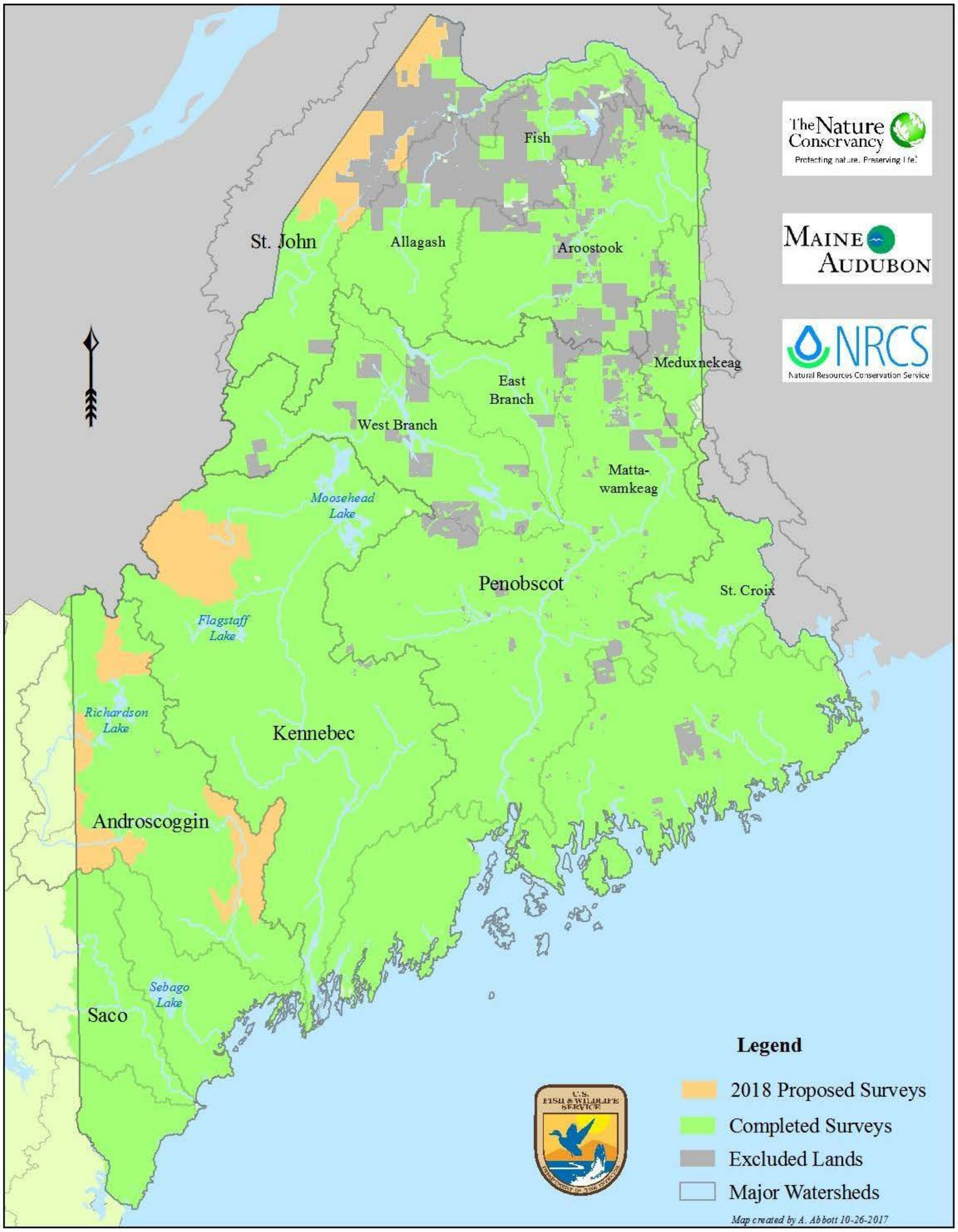

Figure 5.3.1 Maine barrier survey status map. (credit Alex Abbott USFWS GOMCP).

Highlighted Connectivity Projects: In 2017, 21 additional aquatic connectivity projects were completed across the Gulf of Maine DPS (Table 5.3.1) with the primary goal of restoring aquatic organism connectivity and ecological stream processes by allowing the natural flow of materials (water, wood, sediment). Over 50 km of stream were made accessible as a result of these projects. These efforts were made possible due to strong partnerships between NRCS, Penobscot Indian Nation, Project SHARE, Maine Dept. of Inland Fisheries and Wildlife, MDMR, Maine Dept. of Conservation, MFS, NOAA Fisheries, ASF, USFWS, The Nature Conservancy, Downeast Lakes Land Trust, municipalities, lake associations, towns, and numerous private landowners.

Table 5.3.1. Projects restoring stream connectivity in GOM DPS Atlantic salmon watersheds, indicating project type, lead partner, watershed, stream name, and miles of stream habitat access above the barrier that was restored.

Project Type	Lead Partner	Watershed	Stream	Stream miles	Kilometers
Block Bridge	NRCS	Kennebec	Jackin Brook	1.70	2.74
Block Bridge	NRCS	Kennebec	Tributary to Jackin Brook	0.10	0.16
Block Bridge	NRCS	Sheepscot	Carton Brook	0.60	0.97
Block Bridge	NRCS	Piscataquis	Ladd Brook	2.40	3.86
Block Bridge	NRCS	West Branch Pleasant	Unnamed Tributary	1.62	2.61
Block Bridge	NRCS	West Branch Pleasant	Unnamed Tributary	0.30	0.48
Block Bridge	NRCS	Little Androscoggin	Indian Stream	0.44	0.71
Block Bridge	NRCS	Little Androscoggin	Unnamed Tributary	0.20	0.32
Block Bridge	NRCS	Pushaw	Dead Stream	4.60	7.40
Block Bridge	NRCS	Pushaw	Tributary to Dead Stream	1.00	1.61

Block Bridge	NRCS	Pushaw	Unnamed Tributary	0.30	0.48
Block Bridge	NRCS	Pushaw	Unnamed Tributary	0.10	0.16
Block Bridge	NRCS	Pushaw	Unnamed Tributary	0.10	0.16
Block Bridge	NRCS	Pushaw	Unnamed Tributary	0.10	0.16
Multiple Box Culverts	Private Road Association	Union	Great Brook	13.60	21.89
Box Culvert	Hancock County SWD	Union River Bay	Patten Stream	0.30	0.48
Box Bridge	Town of Surry	Union River Bay	Winkumpaugh Brook	1.70	2.74
Arch Culvert	Project SHARE	Narraguagus	Tributary to Gould Brook	0.90	1.45
Arch Culvert	Project SHARE	Narraguagus	Tributary to Gould Brook	0.30	0.48
Arch Culvert	Project SHARE	Narraguagus	Tributary to Gould Brook	0.10	0.16
Decommission	Project SHARE	Narraguagus	Tributary to Gould Brook	0.40	0.64
Arch Culvert	Project SHARE	Narraguagus	Tributary to Narraguagus River	0.90	1.45
Arch Culvert	Project SHARE	Narraguagus	Tributary to Narraguagus River	0.40	0.64
			TOTAL	**32.16**	**51.76**

Figure 5.3.2 Stream Simulation Design culvert replacement (Ladd Brook Block Bridge) in Piscataquis River watershed (credit Ben Naumann USDA-NRCS).

Habitat Complexity

Narraguagus Focus Area Restoration:

Project SHARE has identified the Upper Narraguagus Watershed as a high priority focus area for salmonid habitat restoration. 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.

In collaboration with state and federal agencies, landowners, and nonprofit organizations, Project SHARE 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 cold water 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 cold-water 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 (0.83˚ C) since 1970, with winter temperatures rising most rapidly, 4˚ F (2.2˚ C) 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 cold water 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.

Project SHARE is collaborating on 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 NMFS, USFWS, the University of Maine, MDMR, 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 enroute to the ocean.

Project SHARE investigated high density large woody debris (HD LWD) treatment using the Post-assisted Log Structure (PALS) method (Camp 2015). MDMR scientists recommended treatment of a mainstem habitat reach from the outlet of 28 Pond to the confluence of Rocky Brook (river km 55.82 – 54.54). The reach has an 18-year time-series of juvenile population estimates as well as a multi-decadal substrate embeddedness sampling dataset to compare pre and post-treatment fish and geomorphic response to wood treatment. Project SHARE staff, with assistance from MDMR and USFWS scientists and numerous volunteers constructed 29 PALS structures below the outlet of 28 Pond (Figures 5.3.3 and 5.3.4). MDMR scientists conducted initial electrofishing sampling approximately one month post-treatment in September. Results indicated post-treatment large parr density (11.4 parr/100m^2) was nearly four times greater than the time-series average (3.1 parr/100m^2) (Figure 5.3.5). MDMR scientists will continue to provide juvenile population monitoring in treatment reaches annually.

West Branch Sheepscot River PALS Project:

Project SHARE and MDMR scientists treated a 50-meter section of the West Branch Sheepscot River with PALS at river km 26.2. Prior to treatment, a detailed habitat survey was completed in the site, along with a 50-meter stretch above and below the site. This section was deemed parr habitat; however, it was over-widened, shallow and lacked complexity. An electrofishing CPUE survey was also performed prior to treatment within the site, along with 50 meters above and below. Survey results indicated parr resided at low densities just above and below the section, but none within. After pretreatment surveys were completed, the section was treated with 6 log structures with intentions to create a thalweg within the channel and habitat complexity (Figure 5.3.6). This section will be re-surveyed next year using the same methods as used prior to treatment to document any changes to habitat or parr recruitment.

Figure 5.3.3. Post-assisted log structures in late fall, Outlet 28 Pond, Narraguagus River, Maine, 2017. (credit Christopher Federico, Project SHARE)

Figure 5.3.4. Aerial drone photo of post-assisted log structures, Outlet 28 Pond, Narraguagus River, Maine, 2017. (credit Carter Stone, University of Maine, Barbara Wheatland Geospatial and Remote Sensing Program)

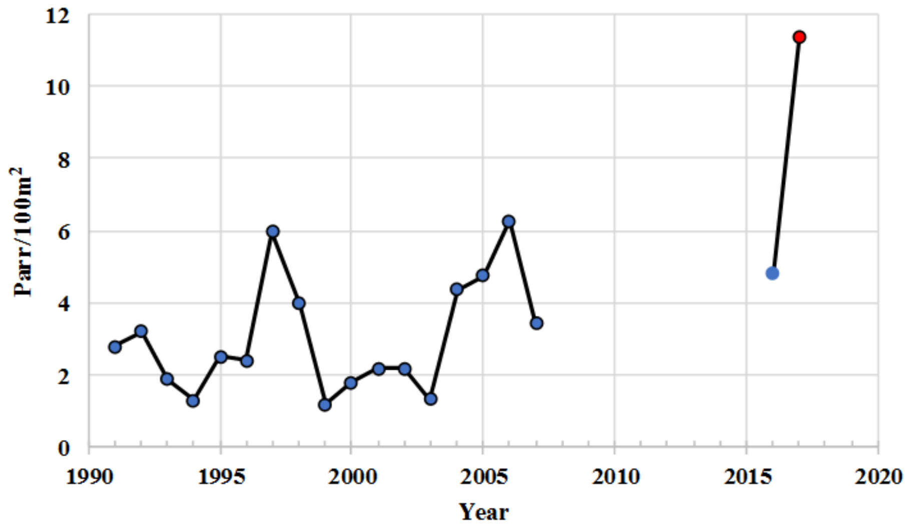

Figure 5.3.5. Atlantic salmon large parr density (parr/100m^2), Outlet 28 Pond, Narraguagus River, Maine, 1991-2017. (credit Maine DMR)

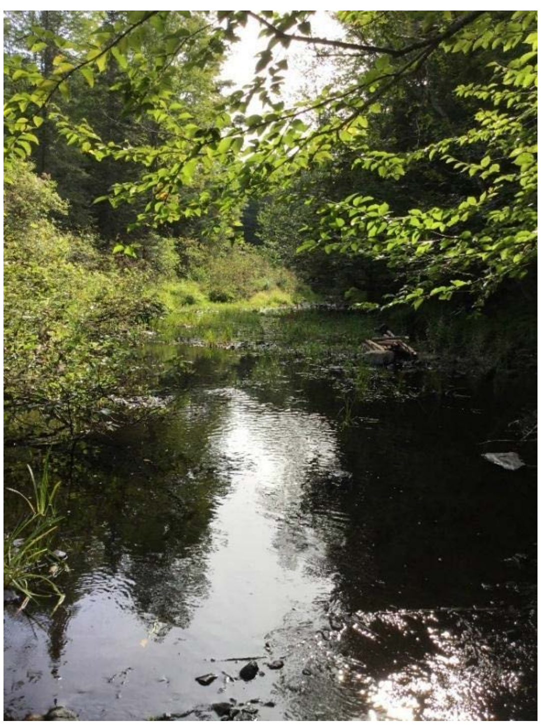

Figure 5.3.6. Post-assisted log structures pre- (left) and post- (right) treatment, Bed Frame reach, West Branch Sheepscot River, Maine, 2017. (credit Jen Noll, Maine DMR)

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5.4 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 6,677,895 eggs for the Maine program: 2,288,571 eggs from Penobscot sea-run broodstock; 2,152,012 eggs from domestic broodstock; 2,237,312 eggs from captive and pedigreed 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 2017, both facilities used year-class crosses as well as spawning optimization software to avoid spawning closely related individuals within captive and domestic broodstock populations.

A total of 310 Penobscot sea-run origin females and 668 captive/domestic females was spawned at CBNFH between November 6th and November 30th. Eggs produced at CBNFH were used for egg planting, fry stocking, age 0+ parr stocking and educational programs. Additionally, Penobscot sea-run eggs and Narraguagus captive eggs produced at CBNFH were transferred to GLNFH for parr and smolt production.

CBNFH relies solely on ambient water sources and therefore, eggs taken in October may be exposed to water temperatures above optimal levels for spawning and egg incubation. Above-optimal water temperatures during early egg development may affect egg survival, embryonic deformities and fry survival. CBNFH uses a photoperiod treatment to modify the biological clock of the Penobscot sea-run broodstock, delaying the onset of spawning into early November, using artificial light. Filtered ambient light is still available; extra light is administered via overhead lighting using a predetermined schedule and time clocks. The treatment extends the light available during the summer solstice (June 21) for approximately ten days which delays spawning, allowing eggs to be collected in more favorable water temperatures.

At GLNFH, 581 Penobscot-origin domestic females were spawned to provide eggs for egg planting, smolt production, domestic broodstock and educational programs.

Egg Transfers

CBNFH and GLNFH transferred 2,046,000 eyed eggs from six strains to various partners (Table 5.4.1). MDMR received 80,000 eyed eggs from the DSF Wild Salmon Resource Center (WSRC) for egg planting in the Pleasant River.

Table 5.4.1. Eyed egg transfers from Craig Brook National Fish Hatchery (CBNFH) and Green Lake National Fish Hatchery (GLNFH) in 2017. *Egg numbers rounded to the nearest 1,000.

Facility	Strain	Rearing History	Receiving Entity	Purpose	Number*
CBNFH	East Machias	Captive/domestic	Downeast Salmon Federation	Private rearing	378,000
CBNFH	Machias	Captive/domestic	Department of Marine Resources	Egg planting	61,000
CBNFH	Narraguagus	Captive/domestic	Green Lake National Fish Hatchery	Smolt production	151,000
CBNFH	Penobscot	Sea-run	Green Lake National Fish Hatchery	Smolt production	393,000
CBNFH	Penobscot	Sea-run	Fish Friends / Salmon-in-Schools	Education	5,000
CBNFH	Pleasant	Captive/domestic	Downeast Salmon Federation	Private rearing	147,000
CBNFH	Sheepscot	Captive/domestic	Department of Marine Resources	Egg planting	305,000
CBNFH	Sheepscot	Captive/domestic	Fish Friends / Salmon-in-Schools	Education	1,000
GLNFH	Penobscot	Captive/domestic	Department of Marine Resources	Egg Planting	597,000
GLNFH	Penobscot	Captive/domestic	Fish Friends / Salmon-in-Schools	Education	8,000
					2,046,000

Wild Broodstock Collection

A total of 532 adult sea-run Atlantic salmon captured at the Milford Dam, on the Penobscot River, was transported to CBNFH for use as broodstock. Broodstock were transported beginning on May 17th. A total of 63 trips was made until July 17th. The Penobscot broodstock target is 650 sea run adults.

Original parr broodstock collection targets were established in the 2006 Captive Broodstock Management Plan (Bartron, et. al. 2006). After assessing family recapture and other diversity metrics some of these targets have been raised. Pleasant River parr targets increased to 200 in 2008. Increased parr collection targets for the Dennys, East Machias, Machias, Narraguagus, and Sheepscot captive broodstock populations were established in 2013 (Table 5.4.2). In addition to efforts to increase parr collections for each population, greater attention was given to ensuring parr were collected in a manner that equalized the distribution of hatchery-origin products and those of wild reproduction. All collection targets were exceeded.

Table 5.4.2. Parr collection targets and totals for the GOM DPS for 2017.

Drainage	Target	Total Parr Collected
Dennys	200	257
East Machias	200	253
Machias	300	328
Narraguagus	300	310
Pleasant	200	210
Sheepscot	200	219
		1,577

Pedigree and Domestic Broodstock Production

Pedigree Broodstock

Current broodstock management for the Maine Atlantic salmon program focuses on the release of hatchery products (as eggs, fry, or age 0+ parr) and the recapture of those products as age 1+ parr along with the incorporation of naturally-spawned age 1+ parr. When recovery of hatchery-origin individuals is low or unevenly distributed, the potential for reducing genetic diversity within the broodstock and the potential of inbreeding is increased. One method to minimize with these risks is to implement a "pedigree broodstock".

Pedigree broodstocks are comprised of two components originating from the same egg cohort. The domestic component, comprised of an equal number of offspring per 1:1 mating (typically 4-12 eyed eggs per mating), is raised entirely in at the hatchery. The captive component is released into its natal river system, recaptured at age 1+ and then reared to sexual maturity at the hatchery.

Recaptured hatchery products exposed to some natural selection in the wild (captive component) are used preferentially for spawning. The domestic component provides a genetic resource from which representatives can be drawn to supplement the captives. Parentage analysis for each component ensures retention of representatives from the entire cohort.

In addition to domestic and captive parr, the progeny of naturally spawning adults may be identified during genetic analysis. These parr are also incorporated in the spawning population.

The guidelines for implementation of pedigree broodstock at CBNFH are when:

- The number of new captive broodstock for a population is low.
- There is a threat of either few or no hatchery-origin or naturally-spawned parr being recaptured.
- If loss of family variation in the near future through general parr collection practices is projected to cause appreciable losses in local population diversity.

Domestic Broodstock

GLNFH retained approximately 1,200 fish from the 2016 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. Samples of reproductive fluids are collected from each female and male spawned at CBNFH. Additionally, ovarian fluid is collected from 150 females at GLNFH. 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 2017. Incoming adults were isolated in the screening facility to undergo sampling procedures and await the results of PCR testing. Two suspects were identified in 2017 and were returned to the river.

No sea-run adults were specifically sacrificed for health screening purposes. Testing requirements were met through incidental mortalities and subsequent routine necropsies as well as sampling of ovarian fluid and milt during spawning.

GLNFH encountered an outbreak of enteric redmouth disease (ERM) in six pools during 2017. Fish samples were collected from the six pools that had experienced a low but persistent level of mortality and sent to LFHU. The fish health screening detected *Yersinia ruckeri*, the causal bacteria for ERM. Following the ERM diagnosis, additional samples from the asymptomatic pools that had previously tested positive for *Y. ruckeri* were retested and the results were negative. Fish in the six ERM-positive pools were treated with medicated feed. There have been no further clinical signs of disease.

Stocking

Stocking activities within the GOM DPS resulted in the release of 3,713,626 Atlantic salmon. These releases included Atlantic salmon from all life stages and were initiated by federal and state agencies, NGOs, researchers and educational programs.

Juvenile Stocking

Two federal hatcheries, two private hatcheries and two educational programs released 3,713,626 juveniles (eyed eggs, fry, parr, and smolts) throughout the GOM DPS (Table 5.4.3).

Table 5.4.3. Stocking activities in the Gulf of Maine Distinct Population Segment for 2017. Values are rounded to the nearest 1,000.

Drainage	Parr	Smolt	Egg Eyed	Fry	Total
Dennys				125,515	125,515
East Machias	211,559			10,087	221,646
Kennebec			447,106		447,106
Machias			60,800	187,310	248,110
Narraguagus	31,053	99,045		169,706	299,804
Penobscot	253,304	569,662	574,821	409,130	1,806,917
Pleasant			80,010	54,532	134,542
Sheepscot	15,446		371,429	18,133	405,008
Union		185		24,793	24,978
Totals	511,362	668,892	1,534,166	999,206	3,713,626

Adult Stocking

A total of 3,831 adults were stocked into GOM drainages (Table 5.4.4). Of these, twelve gravid Penobscot sea-run broodstock were returned to the river by CBNFH; two salmon were returned to the river after testing positive for ISA, and ten were early-season grilse exchanged for later season catches. All 12 pre-spawn fish were released above the Milford Dam. CBNFH released 503 Penobscot post-spawn sea-run broodstock back into the Penobscot River. CBNFH released surplus domestic sub-adults from the Dennys and Narraguagus strains into their respective rivers in both May and November 2017. These individuals represented duplicate siblings within the domestic portions of three pedigreed brood lines. Additionally, a small number of barren age five brood were released with the sub-adults prior to spawning. The size of these fish ranged from 1.80 to 2.74 fish/kg (0.07 - 0.11 kg/ea) and 19.8 – 22.6 cm fork length. Based on experience with raising domestics at CBNFH we estimate that less than 2% would actually have been mature in 2017.

Table 5.4.4. Adult and sub-adult broodstock released pre- and post-spawn from Craig Brook and Green Lake National Fish Hatcheries in 2017.

Drainage	Stock Origin	Pre/Post Spawn	Lot	Number Stocked
Dennys	DE	Post-Spawn	Captive/Domestic	233
Dennys	DE	Pre-Spawn	Captive/Domestic	297
East Machias	EM	Post-Spawn	Captive/Domestic	142
Machias	MC	Post-Spawn	Captive/Domestic	368
Narraguagus	NG	Post-Spawn	Captive/Domestic	299
Narraguagus	NG	Pre-Spawn	Captive/Domestic	466
Penobscot	PN	Post-Spawn	Captive/Domestic	1,105
Penobscot	PN	Post-Spawn	Sea Run	503
Penobscot	PN	Pre-Spawn	Sea Run	12
Pleasant	PL	Post-Spawn	Captive/Domestic	222
Sheepscot	SHP	Post-Spawn	Captive/Domestic	184
			Total	3,831

U. S. Fish & Wildlife Service Schools Programs

2017 marked the twenty-third year of USFWS' outreach and education program, Salmon-in-Schools. This program is closely aligned with the Fish Friends Program organized by the Atlantic Salmon Federation. Both programs focus on endangered Atlantic salmon populations and habitats in Maine rivers. Participants are provided the opportunity to raise river-specific Atlantic salmon eggs and fry in classrooms and release the fry into their natal rivers. 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, a local business is annually invited to participate in the program to broaden exposure to the general public. The two programs, working in partnership, reach over 3,600 people each school year.

5.6 General Program Information

GOM DPS Recovery Plan

A draft of the Recovery Plan for the Gulf of Maine Distinct Population Segment of Atlantic Salmon has been completed by the USFWS and NOAA in close collaboration with MDMR and the Penobscot Indian Nation. The draft was sent out for public comment in the spring of 2016 and sent out for expert peer review in the summer of 2017. The final plan has not yet been published.

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 30 June to November 9th, 2017. Three Atlantic salmon were captured and released upstream in 2017. All three salmon (2 1SW grilse and 1 2SW female) were reported as wild origin.

6.2 Hatchery Operations

Stocking

No juvenile lifestages were stocked in 2017.

Adult Salmon Releases

No adults were stocked in 2017.

6.3 Juvenile Population Status

Electrofishing Surveys

There were no population assessments in the Aroostook River watershed in 2017.

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 Emerging Issues in New England Salmon and Terms of Reference

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 refining database methods to enable better automated queries from Maine Department of Marine Resources, US Fish and Wildlife master databases and more formalized cross-agency and partner physical queries (e.g. tagging and marking databases). This information is highlighted in the following four sections: 7.1) Updating Age-Specific Partitioning of Redds-Based Estimates of Returns in Maine; 7.2) Scale Archiving and Inventory Update; 7.3) Review of Databases and Source Information to Document Escapement; 7.4) Transition from Status of Stock Format to Viable Salmonid Population Assessment for Gulf of Maine Populations. Finally, based on actions and discussions at the meeting draft terms of reference for next year's meeting were developed (7.5).

7.1 Redds-Based Estimates of Returns in Maine: Updates and Documenting Origin and Age Proration Methods

Upon completion of annual stream surveys by MDMR, redd counts and areas surveyed are entered into the MDMR redds database in Access. These data are then used with the redds-returns regression model within an Excel spreadsheet model that uses the add-in program @Risk. The output of this model is a return estimate and 95% upper and lower bounds. For annual reporting purposes the mean return estimate is used as a minimal estimate of returns in these rivers without counting facilities (see section 2.2

for details). Returns to the DEC SHRU and the Sheepscot River are primarily monitored using this method. In addition, lower Penobscot tributaries (below the Milford counting facility) are also monitored by stream surveys. The Ducktrap River and Cove Brook have longer time series of monitoring and recently efforts have been more consistent in Kenduskeag River, Marsh Stream, and Souadabscook Stream. Despite monitoring, few redds have been observed in these systems in the last decade. However, in 2017 redds were found in the Ducktrap River, Kenduskeag River, and Souadabscook Stream. These returns account for an estimated 17 (16%) of 105 naturally-reared fish documented in the PNB SHRU. Given past distribution of greater than 95% of naturally-reared fish at main stem counting facilities, this shift warrants further monitoring and evaluation. With the increasing utility and cost-effectiveness of spawner survey data, a new benchmark model should be developed. In the 2018 assessment, redds-return model calculations will be moved to an R-based model tool and a full audit and evaluation of the redd count database monitoring effort (spatial and temporal efforts) will conducted. This review will be presented next year to determine if there is a need to pro-rate based on survey coverage variation.

Another element of data pro-ration was addressed at the 2018 USASAC meeting. ICES assessments are based on 2SW (large salmon) returns for US stocks. For past redds-based returns, these numbers required a pro-ration by origin (hatchery or naturally-reared) and age. Origin and age-based numbers were estimated on an annual basis and reported to ICES in US reports. However, these pro-rations were not carried forward in USASAC databases and methods used each year were not documented outside working papers or reports. Because methods change relative to data availability each year, understanding and documenting methods would be useful to future users of these data. These time series of data are available in other databases but the proration method was not readily available. Since 2014, pro-ration methods were discussed at the USASAC meeting and methods and rationale for assumptions were made by consensus and documented. Methods for these 2014-2017 returns were documented in a supporting spreadsheet and origin and age details added to USASAC databases at this year's meeting. Reconstruction and documentation of past prorate methods will be conducted in 2018 for the entire 1991-2013 time series. The goal is to update the USASAC database return table and also add a supporting metadata table that provides a narrative on methods at the 2019 meeting.

7.2 Scale Archiving and Inventory Update

During 2017, inventories were conducted by New England fishery agencies participating in USASAC. Much information is currently contained in databases such as the Maine program's Adult Trap Database or Bioscale. However, storage and condition of fish scales has not been adequately summarized. At the 2018 USASAC meeting, we discussed several options to both inventory and archive the scales. Since both actions would require extra time to complete, we discussed several funding opportunities available that could be used to underwrite a position to accomplish this task. The other important piece is where to store the scales once inventoried? We discussed looking into what archival resources were available in either Maine State Government or at the NMFS at Woods Hole, MA. As a result of these discussions, we formed an ad-hoc committee to work towards drafting a proposal to submit for anticipated RFP's and investigate long-term storage options for scale samples.

7.3 Review of Databases and Source Information Needed to Document Adult Atlantic Salmon Spawning Escapement

Based on a request for the USASAC to provide estimated Atlantic salmon spawner escapement data on both an annual basis and time-series level of resolution for the Penobscot River, the USASAC worked in advance and at the meeting to assess available datasets, methodology and data gaps. This request led to a pre-meeting data audit to compare legacy databases residing in excel files (e.g. Smolt Adult Returns (SAR) workbook) and other multi-sourced flat files to the two more modern Access relational databases (MDMR Adult Trap & USASAC Master Databases) with a single data steward and more frequent and formal quality control and assurance. This audit identified some issues in the SAR workbook that were tracked to changes in the source database following scale audits or other error traps in MDMR Adult Trap databases. All issues were corrected in the SAR workbook and the USASAC database that had similar errors. As a result of this audit, there is congruity across all 3 data sets from 1978 to

2017. This type of audit should occur every 5 years to ensure any changes to the source MDMR databases are updated in the USASAC database.

Another important reminder that arose during this audit is that return data in the USASAC relational database (that matches the SAR worksheet) is the authoritative source for Maine Atlantic Salmon Adult Returns from 1967 to 1977. These data are not in any relational databases currently maintained by the MDMR. Physical datasheets and scale samples may be available but at present there is no relational database archive file other than the USASAC.

Once the data above were reviewed and findings verified by the group, the USASAC discussed available datasets, methodology and data gaps. We determined that while many of the components to report escapement are available in USASAC databases, a better roadmap to these data and their interpretation was needed. The USASAC also identified some gaps in databases that need to be addressed to better automate the process and provide full quality control and assessment of datasets. We had a discussion of the source databases that feed into USASAC and the definitions of and components to escapement. Most adult data from the USASAC are reported as returns. Returns are defined as the total number of documented fish returning from the ocean to a river. Escapement is one component of returns and is defined as the total number of fish that are counted and thought to be able to freely access natal spawning sites. The other components of returns are broodstock collections (mature adults transported to a hatchery) and documented in-river losses or other observations. Historically, in-river losses were quite high and were primarily due to angling and are documented in the MDMR Rod Catch database. Current observations of documented river losses are in the MDMR Adult Trap database if death was associated with fish passage or handling. Our discussions revealed that other observed mortalities, fish kills, or poaching, do not have a standardized database for reporting. This was identified as an action item for USASC and MDMR as data from fish that were poached or observed dead need to be tracked in a more formal manner. We propose creation of an incidental observation table within the USASC database. USASAC members agreed that past reporting in USASAC documents often includes these fish in summary tables with associated footnotes or narratives but there is no mechanism to recover and understand these incidental observations. It is important to note that these incidental observations can influence both returns and escapement accuracy. Likewise, it is important to note that these observations are relatively rare events (estimated to be < 5 fish per 10 years).

The USASAC discussion specifically related to escapement focused on the component parts of escapement and the databases that would support accurate calculation. The Adult Trap Database (MDMR) enumerates all fish released directly at traps or weirs or trucked to an upstream release site. The location data for these releases is also included. Typically, these data represent the bulk of escapement in larger rivers like the Penobscot and Kennebec Rivers. The second major component of escapement comes from the Hatchery Stocking Database (FWS) that enumerates all fish released to the river by location for both pre-spawn releases and post-spawn releases. Typically, fish that are known to be mature and released pre-spawning should be included in escapement. These fish can come from two sources: sea run broodstock (returned to rivers due to genetic management, fish health mitigation, or designed studies) or captive-reared or F2 broodstock released for similar reasons as sea-run fish. For many assessment needs, it will be important to track the origin and age of these fish. This may require more complicated queries that track individual fish age and origin in the Adult Trap Database through PIT tags to those fish stocked-out pre-spawn by the hatchery. So datastreams can be more easily repeated in the future, the USASAC recommends that all database queries be included within the databases themselves, query libraries, or as appendices or notes to non-Access data products.

Finally, another source of escapement data particularly for populations without traps or weirs to monitor returns is redd counts. Redd count data can be used directly as an index of escapement under the assumption of 2 redd per female and a 1:1 sex ratio. It is important to recognize that redds-based return estimates are designed to estimate total returns not escapement. Given complexities of tracking these different databases and queries and auditing results for accuracy, the USASAC determined this should be a 2019 Term of Reference but that the task could likely be completed before next assessment meeting but should be reviewed at the meeting by the full team.

7.4 Transition from Status of Stock Format to Viable Salmonid Population Assessment for Gulf of Maine Populations.

The format of Chapter 2 was formerly aligned with NOAA Status of Stocks (SOS) documents and included all US populations including Long Island Sound and Central New England DPS areas. In the past 5 years, overall US salmon conservation efforts have contracted substantially. With efforts now focused primarily on the recovery of the GOM DPS, the USASAC decided to transition the SOS section to an annual viability assessment synopsis of the GOM DPS using a Viable Salmonid Populations (VSP) approach (McElhany et al. 2000). Integrating this annual reporting (required under the GOM DPS Recovery Framework) will facilitate additional review of the contents of the viability assessment. This section will be a brief annual summary not a benchmark 5-year viability assessment.

7.5 USASAC Draft Terms of Reference for 2019 Meeting

The purpose of this section is to outline terms of reference identified at the USASAC annual meeting in March 2018 and to start an outline for refinement at our summer 2018 teleconference and intersessional work prior to final TOR that will be produced after the ICES WGNAS and NASCO Meetings (July 2018).

1. In **support of North American Commission to NASCO**, we anticipate reporting on the following with respect to Atlantic salmon in the United States
    a. Describe the key events of the 2018 fisheries bycatch (targeted fisheries are closed) and aquaculture production
    b. Update age-specific stock conservation limits based on new information as available including updating the time-series of the number of river stocks with established CL's by jurisdiction.
    c. Describe the status of the stocks including updating the time-series of trends in the number of river stocks meeting CL's by jurisdiction.

2. **Scale Archiving** - Continue efforts to foster retention of all US Atlantic salmon scales, tissue, and associated databases for future analysis by seeking funding and capacity to both complete the task and secure long-term storage

3. **Escapement Summary Table-** Develop databases, connections, and query methods in USASAC databases to populate both a time series and an annual table of escapement describing total number of adults that are available (sea-run, captive releases, etc.) for spawning escapement by drainage.
4. **Conservation Limits** Continue refinement of Conservation Limits especially within the Gulf of Maine DPS. Review and update the number of rivers with conservation limits and the monitored time series.
5. **Update Redd Based Return Estimate Benchmark.** Transition model calculations from a @Risk-based system to a more universally accessible R-based model. The benchmark should revisit the regression model relative to 1) reporting of error bounds; 2) clarifying advice relative to the description of the median estimate metric as a minimal estimate; 3) an analysis of survey effort spatial and temporal variability and evaluation of scaling up to 100% of habitat; and 4) developing a method of proration for origin and age guiding principles and reporting/review.
6. **Juvenile Assessment Update.** Develop a synthesis document that describes both the long-term index sites through 2012 and new Generalized Random - Tessellation Stratified (GRTS; Stevens and Olsen 2004) design (2013-2017) for Maine. From this foundation, document lessons learned and best path forward for monitoring juvenile production status and trends in one index river system in each SHRU. From this foundational work, develop a list of research needs for historic data related to time-series and climate, approaches for index rivers, and complementary efforts that address specific restoration questions (e.g. dispersion from artificial redds, fry vs. parr etc.).

8 List of Attendees, Working Papers, and Glossaries

Table 8.1. List of Attendees

First Name	Last Name	Primary Email	Agency	Location
Ernie	Atkinson	Ernie.Atkinson@maine.gov	MEDMR	Jonesboro, ME
Michael	Bailey	michael_bailey@fws.gov	USFWS	Nashua, NH
Denise	Buckley	denise_buckley@fws.gov	USFWS	East Orland, ME
Kelly	Chadbourne	kelly_chadbourne@fws.gov	USFWS	Falmouth, ME
Steve	Gephard	Steve.Gephard@po.state.ct.us	CT-DEEP	Old Lyme, CT
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
Mitch	Simpson	Mitch.Simpson@maine.gov	MEDMR	Bangor, ME
John	Sweka	John_Sweka@fws.gov	USFWS	Lamar, PA

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

Number	Authors	Title
WP18-01	John F. Kocik, Christopher Tholke, and Timothy Sheehan	Annual Bycatch Update Atlantic Salmon 1989 through September 2017
WP18-02	Colby Bruchs, Ernie Atkinson, James Hawkes, Christine Lipsky, Ruth Hass-Castro, Paul Christman, Jennifer Noll, Zach Sheller, Rachel Gorich, Justin Stevens, Groham Goullete	Update on Maine River Atlantic Salmon Smolt Studies: 2017
WP18-03	David Bean, Marcy Nelson, and Ernie Atkinson	Maine and Neighboring Canadian Commercial Aquaculutre Activities and Production
WP18-04	James Hawkes, Graham Goulette, and Alejandro Moctezuma	Update on coastal Maine Atlantic salmon smolt telemetry studies: 2017
WP18-05	Ruth Haas-Castro, Graham Goullette, James Hawkes, Christine Lipsky, Tim Sheehan, Brandon Ellingson, Ernie Atkinson, Colby Bruchs, Paul Christman, and Jason Overlock	Review of Image Analysis:20167 (Part 1) and Work Plan for 2018 (Part 2)
WP18-06	R. Goreham and H. Almeda	2017 Milltown Fishway research trap report
WP18-07	Rory Saunders	Report of the Working Group on North Atlantic Salmon (WGNAS) (PPT)
WP18-08	Steve Gephard	Connecticuit and Pawcatuck Rivers Update (PPT)
WP18-09	Ernie Atkinson	Saco, GOM, OBF Updates (PPT)
WP18-10	Rory Saunders	NASCO Overview (PPT)
WP18-11	Michael Bailey	Merrimack River Update (Oral)
WP18-12	Kelly Chadbourne and Denise Buckley	The Maine stocking database, development and overview (PPT)

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
Downeast Salmon Federation	DSF
Downeast Salmon Federation Wild Salmon Resource Center	DSFWSRC
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
Infectious Salmon Anemia Virus	ISAV
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
Maine Inland Fish and Wildlife	MIFW
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
The Nature Conservancy	TNC
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

Glossary of Definitions

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.

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.

Appendix 7. Juvenile Atlantic salmon stocking summary for New England in 2017.

United States

No. of fish stocked by lifestage

River	Egg	Fry	0 Parr	1 Parr	2 Parr	1 Smolt	2 Smolt	Total
Connecticut	0	193,000	0	0	0	0	0	193,000
Total for Connecticut Program								**193,000**
Dennys	0	126,000	0	0	0	0	0	126,000
East Machias	0	10,000	211,600	0	0	0	0	221,600
Kennebec	447,000	0	0	0	0	0	0	447,000
Machias	61,000	187,000	0	0	0	0	0	248,000
Narraguagus	0	170,000	31,100	0	0	99,000	0	300,100
Penobscot	575,000	409,000	253,300	0	0	569,700	0	1,807,000
Pleasant	80,000	55,000	0	0	0	0	0	135,000
Saco	53,000	119,000	0	0	0	0	0	172,000
Sheepscot	371,000	18,000	15,400	0	0	0	0	404,400
Union	0	25,000	0	0	0	200	0	25,200
Total for Maine Program								**3,886,300**
Merrimack	0	2,000	0	0	0	0	0	2,000
Total for Merrimack Program								**2,000**
Pawcatuck	0	4,000	0	0	0	0	0	4,000
Total for Pawcatuck Program								**4,000**
Total for United States								**4,085,300**
Grand Total								**4,085,300**

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 2017.

Drainage	Purpose	Captive/Domestic Pre-Spawn	Captive/Domestic Post-Spawn	Sea Run Pre-Spawn	Sea Run Post-Spawn	Total
Dennys	Rest	297	233	0	0	530
East Machias	Rest	0	142	0	0	142
Machias	Rest	0	368	0	0	368
Merrimack	Restoration/Recreation	1,018	0	0	0	1,018
Narraguagus	Rest	466	299	0	0	765
Penobscot	Restoration	0	1,105	12	503	1,620
Pleasant	Rest	0	222	0	0	222
Sheepscot	Rest	0	184	0	0	184
Total		1,781	2,553	12	503	4,849

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 **2017** .*

Marking Agency	Age	Life Stage	H/W	Stock Origin	Primary Mark or Tag	Number Marked	Secondary Mark or Tag	Release Date	Release Location
Conte		Adult	W	Connecticut	PIT	2		Jun	Connecticut
Conte		Adult	W	Connecticut	PIT	3		May	Connecticut
CTDEEP		Adult	W	Connecticut	FLOY	1		Jun	Connecticut
Holyoke Gas&E		Adult	W	Connecticut	FLOY	3		May	Connecticut
Holyoke Gas&E		Adult	W	Connecticut	FLOY	1		Aug	Connecticut
Holyoke Gas&E		Adult	W	Connecticut	FLOY	1		Jun	Connecticut
MADFW		Adult	W	Connecticut	FLOY	1		May	Connecticut
MADFW		Adult	W	Connecticut	FLOY	4		Jun	Connecticut
USFWS	5	Adult	H	Dennys	PIT	5	PUNCH	Nov	Dennys
USFWS	2	Adult	H	Dennys	PIT	111	PUNCH	May	Dennys
USFWS	3	Adult	H	Dennys	PIT	84	PUNCH	Nov	Dennys
USFWS	2	Adult	H	Dennys	PIT	97	PUNCH	Nov	Dennys
USFWS	4	Adult	H	Dennys	PIT	8	PUNCH	Dec	Dennys
USFWS	3	Adult	H	Dennys	PIT	169	PUNCH	Dec	Dennys
USFWS	5	Adult	H	Dennys	PIT	56	PUNCH	Dec	Dennys
USFWS	5	Adult	H	East Machias	PIT	74	PUNCH	Dec	East Machias
USFWS	3	Adult	H	East Machias	PIT	35	PUNCH	Dec	East Machias
USFWS	4	Adult	H	East Machias	PIT	33	PUNCH	Dec	East Machias
MEDMR		Adult	W	Kennebec	AP	6		Jul	Kennebec
MEDMR		Adult	W	Kennebec	AP	9		Jun	Kennebec
MEDMR		Adult	W	Kennebec	AP	3		Sep	Kennebec
MEDMR		Adult	W	Kennebec	RAD	16	AP, PIT	Jun	Kennebec
MEDMR		Adult	W	Kennebec	RAD	2	AP, PIT	May	Kennebec
MEDMR		Adult	W	Kennebec	RAD	2	PIT	May	Kennebec
MEDMR		Adult	W	Kennebec	AP	2		Oct	Kennebec

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	Machias	PIT	121	PUNCH	Dec	Machias
USFWS	3	Adult	H	Machias	PIT	75	PUNCH	Dec	Machias
USFWS	4	Adult	H	Machias	PIT	72	PUNCH	Dec	Machias
MEDMR		Adult	W	Narraguagus	UCP	1		Jun	Narraguagus
MEDMR		Adult	W	Narraguagus	UCP	1		Jul	Narraguagus
MEDMR		Adult	W	Narraguagus	AP	1		Oct	Narraguagus
MEDMR		Adult	W	Narraguagus	AP	17		Jun	Narraguagus
MEDMR		Adult	W	Narraguagus	AP	17		Jul	Narraguagus
USFWS	3	Adult	H	Narraguagus	PIT	132	PUNCH	Dec	Narraguagus
USFWS	5	Adult	H	Narraguagus	PIT	99	PUNCH	Dec	Narraguagus
USFWS	2	Adult	H	Narraguagus	PIT	351	PUNCH	May	Narraguagus
USFWS	4	Adult	H	Narraguagus	PIT	68	PUNCH	Dec	Narraguagus
USFWS	2	Adult	H	Narraguagus	PIT	98	PUNCH	Nov	Narraguagus
USFWS	5	Adult	H	Narraguagus	PIT	17	PUNCH	Nov	Narraguagus
MEDMR		Adult	W	Penobscot	PIT	2	UCP	Sep	Penobscot
MEDMR		Adult	W	Penobscot	PIT	75	AP	Jul	Penobscot
MEDMR		Adult	W	Penobscot	PIT	1	AP	May	Penobscot
MEDMR		Adult	W	Penobscot	PIT	1	AP	Oct	Penobscot
MEDMR		Adult	W	Penobscot	PIT	13	AP	Sep	Penobscot
MEDMR		Adult	W	Penobscot	PIT	503	PUNCH	Dec	Penobscot
MEDMR		Adult	W	Penobscot	PIT	17	UCP	Jul	Penobscot
MEDMR		Adult	W	Penobscot	PIT	19	UCP	Jun	Penobscot
MEDMR		Adult	W	Penobscot	PIT	118	AP	Jun	Penobscot
USFWS		Adult	W	Penobscot	PIT	12	PUNCH	Jul	Penobscot
USFWS	4	Adult	H	Penobscot	PIT	685	PUNCH	Dec	Penobscot
USFWS	3	Adult	H	Penobscot	PIT	420	PUNCH	Dec	Penobscot
USFWS	4	Adult	H	Pleasant	PIT	48	PUNCH	Dec	Pleasant

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	Pleasant	PIT	121	PUNCH	Dec	Pleasant
USFWS	3	Adult	H	Pleasant	PIT	53	PUNCH	Dec	Pleasant
Brookfield		Adult	W	Saco	AP	1		Jun	Saco
USFWS	3	Adult	H	Sheepscot	PIT	17	PUNCH	Dec	Sheepscot
USFWS	4	Adult	H	Sheepscot	PIT	40	PUNCH	Dec	Sheepscot
USFWS	5	Adult	H	Sheepscot	PIT	127	PUNCH	Dec	Sheepscot
EMARC	0	Parr	H	East Machias	AD	211,559		Oct	East Machias
MEDMR	0	Parr	H	Narraguagus	AD	31,053		Oct	Narraguagus
USFWS	0	Parr	H	Sheepscot	AD	15,446		Sep	Sheepscot
MEDMR	2 / 3	Smolt	W	Narraguagus	PIT	76		May	Narraguagus
NOAA	1	Smolt	H	Narraguagus	PING	202	PIT	May	Narraguagus
NOAA/USGS	1	Smolt	H	Narraguagus	PIT	1,800	AD	May	Narraguagus
Brookfield	1	Smolt	H	Penobscot	RAD	573		May	Penobscot
USGS	1	Smolt	H	Penobscot	PING	450		Apr	Penobscot
Brookfield	1	Smolt	H	Union	RAD	178		May	Union
Brookfield	1	Smolt	H	Union	PING	120		May	Union

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 ***2017****.*

Origin	Total External Marks	Total Adipose Clips	Total Marked
Hatchery Adult	3,216	0	3,216
Hatchery Juvenile	259,858	259,858	261,381
Wild Adult	848	0	855
Wild Juvenile	0	0	76
Total			**265,528**

Appendix 10. Estimates of Atlantic salmon returns to New England in 2017 from trap counts and redd surveys.

	Assessment Method	1SW		2SW		3SW		Repeat			2013-2017
		Hatchery	Wild	Hatchery	Wild	Hatchery	Wild	Hatchery	Wild	Total	Average
Connecticut	Trap	0	0	0	18	0	2	0	0	**20**	34
Dennys	Redd Est	0	3	0	12	0	0	0	0	**15**	15
Ducktrap	Redd Est	0	1	0	3	0	0	0	0	**4**	4
East Machias	Redd Est	2	0	6	1	0	0	0	0	**9**	9
Kenduskeag Stream	Redd Est	0	2	0	7	0	0	0	0	**9**	9
Kennebec	Trap	0	3	0	35	0	2	0	0	**40**	27
Machias	Redd Est	0	3	0	11	0	0	0	0	**14**	14
Merrimack	Trap	0	1	0	4	0	0	0	0	**5**	17
Narraguagus	Trap	20	7	0	7	0	0	0	2	**36**	13
Penobscot	Trap	301	9	451	79	9	0	0	0	**849**	546
Pleasant	Redd Est	0	2	0	7	0	0	0	0	**9**	4
Saco	Trap	3	1	3	1	0	0	0	0	**8**	4

	Assessment Method	1SW Hatchery	1SW Wild	2SW Hatchery	2SW Wild	3SW Hatchery	3SW Wild	Repeat Hatchery	Repeat Wild	Total	2013-2017 Average
Sheepscot	Redd Est	2	2	9	6	0	0	0	0	**19**	19
Souadabscook Stream	Redd Est	0	1	0	3	0	0	0	0	**4**	4
Total		**328**	**35**	**469**	**194**	**9**	**4**	**0**	**2**	**1,041**	**719**

Note: The origin/age distribution for returns to the Merrimack River after 2013 were based on observed distributions over the previous 10 years because fish were not handled.

Appendix 11. Summary of Atlantic salmon green egg production in Hatcheries for New England rivers in 2017.

Source River	Origin	Females Spawned	Total Egg Production
Connecticut	Domestic	96	590,000
Dennys	Domestic	87	392,000
Merrimack	Domestic	307	946,000
Penobscot	Domestic	581	1,760,000
Dennys	Captive	95	328,000
East Machias	Captive	92	383,000
Machias	Captive	122	525,000
Narraguagus	Captive	134	322,000
Pleasant	Captive	83	346,000
Sheepscot	Captive	81	334,000
Total	**Captive/Domestic**	**1,678**	**5,926,000**
Penobscot	Sea Run	310	2,289,000
Total	**Sea Run**	**310**	**2,289,000**
Grand Total for Year	**2017**	**1,988**	**8,215,000**

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															
1993-2007	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															
1977-2007	1,788	19,231,000	7,800	26,511	169,106,000	5,900	0	0		2,147	26,296,000	10,100	30,446	214,632,000	6,400
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
2016	0	0		70	535,000	7,600	0	0		0	0		70	535,000	7,600
2017	0	0		96	590,000	6,100	0	0		0	0		96	590,000	6,100
Total Connecticut	2,071	21,265,000	7,300	33,888	210,011,000	6,500	0	0		2,395	28,934,000	9,400	38,354	260,209,000	6,700
Dennys															
1939-2007	26	214,000	7,600	0	0		1,133	4,763,000	4,200	40	330,000	7,700	1,199	5,307,000	5,000
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
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	

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
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
2016	0	0		0	0		27	155,000	5,700	0	0		27	155,000	5,700
2017	0	0		87	392,000	4,500	95	328,000	3,500	0	0		182	721,000	4,000
Total Dennys	26	214,000	7,600	212	1,079,000	4,600	1,610	6,867,000	4,400	40	330,000	7,700	1,888	8,491,000	4,600
East Machias															
1995-2007	0	0		0	0		1,065	4,450,000	4,300	0	0		1,065	4,450,000	4,300
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
2016	0	0		0	0		113	473,000	4,200	0	0		113	473,000	4,200
2017	0	0		0	0		92	383,000	4,200	0	0		92	383,000	4,200
Total East Machias	0	0		0	0	0	1,880	7,737,000	4,036	0	0		1,880	7,737,000	4,000
Kennebec															
1979-2007	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.

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
1992-2007	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															
1941-2007	456	3,263,000	7,300	0	0		1,903	8,001,000	4,300	8	52,000	6,400	2,367	11,316,000	6,000
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
2016	0	0		0	0		114	165,000	1,400	0	0		114	165,000	1,400
2017	0	0		0	0		122	525,000	4,300	0	0		122	525,000	4,300
Total Machias	456	3,263,000	7,300	0	0	0	3,108	12,363,000	3,618	8	52,000	6,400	3,572	15,678,000	3,800
Merrimack															
1983-2007	1,256	9,722,000	8,000	10,132	51,736,000	4,800	0	0		381	3,952,000	10,700	11,769	65,410,000	6,100
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
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

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
2015	0	0		234	761,000	3,300	0	0		0	0		234	761,000	3,300
2016	0	0		363	946,000	2,600	0	0		0	0		363	946,000	2,600
2017	0	0		307	946,000	3,100	0	0		0	0		307	946,000	3,100
Total Merrimack	1,582	12,306,000	7,700	12,884	61,759,000	3,800	0	0		540	5,709,000	11,000	15,006	79,773,000	4,600
Narraguagus															
1962-2007	0	1,303,000		0	0		1,908	7,145,000	3,700	0	0		1,908	8,448,000	3,700
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
2016	0	0		0	0		112	393,000	3,500	0	0		112	393,000	3,500
2017	0	0		0	0		134	322,000	2,400	0	0		134	322,000	2,400
Total Narraguagus	0	1,303,000		0	0	0	3,221	12,221,000	3,873	0	0		3,221	13,524,000	3,900
Orland															
1967-2007	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															
1992-2007	18	152,000	8,300	6	6,000	1,100	0	0		9	61,000	6,600	33	219,000	6,900
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

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
2012	2	5,000	2,500	550	2,000	0	0	0		0	0		552	7,000	0
Total Pawcatuck	20	157,000	5,400	556	8,000	600	0	0		13	76,000	4,700	589	241,000	3,600
Penobscot															
1871-2007	19,218	165,074,000	7,900	6,965	18,878,000	2,800	329	1,400,000	4,300	0	0		26,512	185,353,000	7,400
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	2,640,000	7,600	381	780,000	2,000	0	0		0	0		729	3,420,000	4,700
2016	134	885,000	6,600	635	1,530,000	2,400	0	0		0	0		769	2,415,000	3,100
2017	310	2,289,000	7,400	581	1,760,000	3,000	0	0		0	0		891	4,048,000	4,500
Total Penobscot	21,727	184,521,000	7,700	11,338	32,360,000	3,100	329	1,400,000	4,300	0	0		33,394	218,281,000	5,100
Pleasant															
2001-2007	0	0		0	0		296	1,220,000	5,000	0	0		296	1,220,000	5,000
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
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

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
2015	0	0		0	0		63	214,000	3,400	0	0		63	214,000	3,400
2016	0	0		0	0		53	235,000	4,400	0	0		53	235,000	4,400
2017	0	0		0	0		83	346,000	4,200	0	0		83	346,000	4,200
Total Pleasant	0	0		123	469,000	5,900	841	3,216,000	3,818	0	0		964	3,684,000	4,100
Sheepscot															
1995-2007	18	125,000	6,900	0	0		900	3,598,000	3,800	45	438,000	9,900	963	4,162,000	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
2016	0	0		0	0		133	109,000	800	0	0		133	109,000	800
2017	0	0		0	0		81	334,000	4,100	0	0		81	334,000	4,100
Total Sheepscot	18	125,000	6,900	0	0	0	1,726	6,169,000	3,309	45	438,000	9,900	1,789	6,733,000	3,400
St Croix															
1993-2007	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															
1974-2007	600	4,611,000	7,900	0	0		0	0		0	0		600	4,611,000	7,900
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	7,300	33,888	210,010,000	6,600	0	0		2,395	28,935,000	9,400	38,354	260,209,000	6,700
Dennys	26	214,000	7,600	212	1,080,000	4,600	1,610	6,868,000	4,400	40	330,000	7,700	1,888	8,491,000	4,600
East Machias	0	0		0	0		1,880	7,737,000	4,000	0	0		1,880	7,737,000	4,000
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		3,108	12,363,000	3,600	8	52,000	6,400	3,572	15,678,000	3,800
Merrimack	1,582	12,306,000	7,700	12,884	61,758,000	3,800	0	0		540	5,709,000	11,000	15,006	79,773,000	4,600
Narraguagus	0	1,303,000		0	0		3,221	12,221,000	3,900	0	0		3,221	13,524,000	3,900
Orland	39	270,000	7,300	0	0		0	0		0	0		39	270,000	7,300
Pawcatuck	20	157,000	5,400	556	8,000	500	0	0		13	76,000	4,700	589	241,000	3,600
Penobscot	21,727	184,521,000	7,700	11,338	32,359,000	3,100	329	1,400,000	4,300	0	0		33,394	218,280,000	5,100
Pleasant	0	0		123	468,000	5,900	841	3,215,000	3,800	0	0		964	3,683,000	4,100
Sheepscot	18	125,000	6,900	0	0		1,726	6,169,000	3,300	45	438,000	9,900	1,789	6,733,000	3,400
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	**26,592**	**228,428,000**	**8,600**	**59,001**	**305,683,000**	**5,200**	**12,715**	**49,973,000**	**3,900**	**3,041**	**35,540,000**	**11,700**	**101,349**	**619,624,000**	**6,100**

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								
2001-2007	0	8,000	0	0	0	0	0	8,000
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
2016	0	2,000	0	0	0	0	0	2,000
Totals:Androscoggin	**0**	**20,000**	**0**	**0**	**0**	**500**	**0**	**20,500**
Aroostook								
1978-2007	0	3,433,000	317,400	38,600	0	32,600	29,800	3,851,400
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								
1988-2007	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								
1967-2007	0	120,400,000	2,834,300	1,813,400	14,900	3,771,300	1,434,100	130,268,000
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
2016	0	64,000	0	0	0	0	0	64,000
2017	0	194,000	0	0	0	0	0	194,000
Totals:Connecticut	**0**	**149,374,000**	**2,849,700**	**1,836,700**	**64,700**	**3,771,900**	**1,828,100**	**159,725,100**
Dennys								
1975-2007	0	2,386,000	225,400	7,300	0	532,700	29,200	3,180,600

	Egg	Fry	0 Parr	1 Parr	2 Parr	1 Smolt	2 Smolt	Total
	Number of fish stocked by life stage							
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
2016	0	343,000	0	0	0	0	0	343,000
2017	0	126,000	0	0	0	0	0	126,000
Totals:Dennys	**0**	**4,627,000**	**225,400**	**7,300**	**0**	**532,700**	**30,000**	**5,422,400**
Ducktrap								
1986-2007	0	68,000	0	0	0	0	0	68,000
Totals:Ducktrap	**0**	**68,000**	**0**	**0**	**0**	**0**	**0**	**68,000**
East Machias								
1973-2007	0	2,736,000	7,500	42,600	0	108,400	30,400	2,924,900
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
2016	0	12,000	199,700	0	0	0	0	211,700
2017	0	10,000	211,600	0	0	0	0	221,600
Totals:East Machias	**0**	**3,786,000**	**891,400**	**42,600**	**0**	**108,400**	**30,400**	**4,858,800**
Kennebec								
2001-2007	74000	166,000	0	0	0	0	0	239,476
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
2016	619000	3,000	0	0	0	0	0	622,364
2017	447000	0	0	0	0	0	0	447,106
Totals:Kennebec	**5,956,000**	**331,000**	**0**	**0**	**0**	**800**	**0**	**6,287,722**
Lamprey								
1978-2007	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**
Machias								
1970-2007	0	4,434,000	98,900	122,000	0	191,300	44,100	4,890,300

	Number of fish stocked by life stage							
	Egg	**Fry**	**0 Parr**	**1 Parr**	**2 Parr**	**1 Smolt**	**2 Smolt**	**Total**
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
2016	40000	186,000	0	0	0	0	0	226,348
2017	61000	187,000	0	0	0	0	0	247,800
Totals:Machias	**177,000**	**7,656,000**	**101,000**	**125,700**	**0**	**250,400**	**44,100**	**8,354,567**
Merrimack								
1975-2007	0	35,458,000	232,600	598,100	0	1,619,000	638,100	38,545,800
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
2015	0	4,000	0	0	0	0	0	4,000
2016	0	4,000	0	0	0	0	100	4,100
2017	0	2,000	0	0	0	0	0	2,000
Totals:Merrimack	**0**	**41,797,000**	**431,800**	**658,200**	**0**	**1,981,500**	**638,200**	**45,506,700**
Narraguagus								
1970-2007	0	4,146,000	96,100	14,600	0	107,800	84,000	4,448,500
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
2016	0	219,000	0	0	0	97,100	0	316,100
2017	0	170,000	31,100	0	0	99,000	0	300,100
Totals:Narraguagus	**79,000**	**7,737,000**	**148,200**	**14,600**	**0**	**596,300**	**84,000**	**8,659,245**
Pawcatuck								
1979-2007	0	5,587,000	1,209,200	268,100	0	112,200	500	7,177,000
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
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

	Number of fish stocked by life stage							
	Egg	**Fry**	**0 Parr**	**1 Parr**	**2 Parr**	**1 Smolt**	**2 Smolt**	**Total**
2015	0	7,000	0	0	0	0	0	7,000
2016	0	7,000	0	0	0	1,200	0	8,200
2017	0	4,000	0	0	0	0	0	4,000
Totals:Pawcatuck	**0**	**6,319,000**	**1,209,200**	**268,100**	**0**	**128,700**	**500**	**7,925,500**
Penobscot								
1970-2007	0	20,761,000	5,199,500	1,394,400	0	14,380,800	2,508,200	44,243,900
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
2016	473000	1,025,000	263,200	0	0	569,300	0	2,330,673
2017	575000	409,000	253,300	0	0	569,700	0	1,806,821
Totals:Penobscot	**1,812,000**	**29,545,000**	**7,459,100**	**1,394,400**	**0**	**19,798,100**	**2,508,200**	**62,516,606**
Pleasant								
1975-2007	0	824,000	16,000	1,800	0	63,400	42,100	947,300
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
2016	63000	53,000	0	0	0	0	0	115,700
2017	80000	55,000	0	0	0	0	0	135,010
Totals:Pleasant	**189,000**	**1,983,000**	**16,000**	**1,800**	**0**	**246,900**	**42,400**	**2,478,310**
Saco								
1975-2007	0	5,832,000	438,700	219,200	0	345,800	9,500	6,845,200
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
2016	35000	371,000	4,000	0	0	12,000	0	421,818
2017	53000	119,000	0	0	0	0	0	172,000
Totals:Saco	**88,000**	**9,004,000**	**518,900**	**232,000**	**0**	**444,100**	**9,500**	**10,296,318**
Sheepscot								

	Number of fish stocked by life stage							
	Egg	**Fry**	**0 Parr**	**1 Parr**	**2 Parr**	**1 Smolt**	**2 Smolt**	**Total**
1971-2007	18000	2,608,000	132,900	20,600	0	92,200	7,100	2,878,600
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
2016	209000	20,000	15,400	0	0	0	0	244,170
2017	371000	18,000	15,400	0	0	0	0	404,829
Totals:Sheepscot	**1,035,000**	**3,402,000**	**283,000**	**20,600**	**0**	**92,200**	**7,100**	**4,840,080**
St Croix								
1981-2007	0	1,268,000	498,000	158,300	0	808,000	20,100	2,752,400
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								
1971-2007	0	462,000	371,400	0	0	379,700	251,000	1,464,100
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
2016	0	26,000	0	0	0	0	0	26,000
2017	0	25,000	0	0	0	200	0	25,200
Totals:Union	**0**	**654,000**	**371,400**	**0**	**0**	**379,900**	**251,000**	**1,656,300**
Upper StJohn								
1979-2007	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	19,000	0	0	0	500	0	**19,900**
Aroostook	0	6,901,000	317,400	38,600	0	32,600	29,800	**7,319,700**
Cocheco	0	1,958,000	50,000	10,500	0	5,300	0	**2,024,200**
Connecticut	0	149,372,000	2,849,700	1,836,700	64,800	3,771,900	1,828,200	**159,658,800**
Dennys	0	4,627,000	225,400	7,300	0	532,800	30,000	**5,422,300**
Ducktrap	0	68,000	0	0	0	0	0	**68,000**
East Machias	0	3,784,000	891,400	42,600	0	108,400	30,400	**4,857,200**
Kennebec	5,956,000	331,000	0	0	0	900	0	**6,288,000**
Lamprey	0	1,593,000	427,700	58,800	0	201,400	32,800	**2,313,700**
Machias	177,000	7,657,000	100,900	125,600	0	250,400	44,100	**8,355,400**
Merrimack	0	41,797,000	431,700	658,100	0	1,981,400	638,300	**45,506,500**
Narraguagus	79,000	7,738,000	148,100	14,600	0	596,500	84,000	**8,660,000**
Pawcatuck	0	6,318,000	1,209,200	268,100	0	128,700	500	**7,924,600**
Penobscot	1,812,000	29,544,000	7,459,100	1,394,400	0	19,798,000	2,508,200	**62,515,600**
Pleasant	188,000	1,983,000	16,000	1,800	0	247,000	42,400	**2,478,700**
Saco	88,000	9,004,000	518,800	232,000	0	444,000	9,500	**10,295,800**
Sheepscot	1,035,000	3,403,000	283,000	20,600	0	92,200	7,100	**4,840,800**
St Croix	0	1,270,000	498,000	158,300	0	808,000	20,100	**2,754,200**
Union	0	653,000	371,400	0	0	379,900	251,000	**1,655,400**
Upper StJohn	0	2,165,000	1,456,700	14,700	0	5,100	27,700	**3,669,200**
TOTALS	**280,186,000**	**17,254,600**	**4,882,800**	**64,800**	**29,385,000**	**5,584,000**		**346,628,100**

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									
1983-2007	43	543	6	2	7	86	0	1	**688**
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**
2012	0	0	0	0	0	0	0	0	**0**
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**
2016	0	0	0	0	0	6	0	0	**6**
2017	0	0	0	0	0	0	0	0	**0**
Total for Androscoggin	57	602	6	2	10	115	0	1	**793**
Cocheco									
1992-2007	0	0	1	1	6	10	0	0	**18**
Total for Cocheco	0	0	1	1	6	10	0	0	**18**
Connecticut									
1974-2007	49	3,559	28	2	96	1,897	13	1	**5,645**
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**
2016	0	0	0	0	0	5	0	0	**5**
2017	0	0	0	0	0	18	2	0	**20**
Total for Connecticut	58	3,612	28	2	140	2389	16	3	**6,248**
Cove Brook									
2017	0	0	0	0	0	0	0	0	**0**
Total for Cove Brook	0	0	0	0	0	0	0	0	**0**
Dennys									
1967-2007	38	317	0	1	32	746	3	31	**1,168**

	HATCHERY ORIGIN				WILD ORIGIN				
	1SW	2SW	3SW	Repeat	1SW	2SW	3SW	Repeat	**Total**
2008	0	1	0	0	1	3	0	3	**8**
2009	0	0	0	0	0	6	1	1	**8**
2010	1	1	0	0	0	4	0	0	**6**
2011	0	1	0	0	2	5	1	0	**9**
2017	0	0	0	0	3	12	0	0	**15**
Total for Dennys	39	320	0	1	38	776	5	35	**1,214**
Ducktrap									
1985-2007	0	0	0	0	3	30	0	0	**33**
2017	0	0	0	0	1	3	0	0	**4**
Total for Ducktrap	0	0	0	0	4	33	0	0	**37**
East Machias									
1967-2007	21	250	1	2	12	329	1	10	**626**
2017	2	6	0	0	0	1	0	0	**9**
Total for East Machias	23	256	1	2	12	330	1	10	**635**
Kenduskeag Stream									
2017	0	0	0	0	2	7	0	0	**9**
Total for Kenduskeag Stream	0	0	0	0	2	7	0	0	**9**
Kennebec									
1975-2007	18	200	6	1	5	17	0	0	**247**
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**
2016	0	0	0	0	1	38	0	0	**39**
2017	0	0	0	0	3	35	2	0	**40**
Total for Kennebec	24	260	6	7	19	193	2	0	**511**
Lamprey									
1979-2007	10	17	1	0	13	16	0	0	**57**
Total for Lamprey	10	17	1	0	13	16	0	0	**57**
Machias									
1967-2007	32	329	9	2	33	1,592	41	131	**2,169**
2017	0	0	0	0	3	11	0	0	**14**
Total for Machias	32	329	9	2	36	1603	41	131	**2,183**
Merrimack									

	HATCHERY ORIGIN				WILD ORIGIN				
	1SW	2SW	3SW	Repeat	1SW	2SW	3SW	Repeat	Total
1982-2007	332	1,352	22	8	128	1,011	27	0	**2,880**
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**
2013	0	6	0	3	0	12	0	0	**21**
2014	4	25	1	0	0	10	0	0	**40**
2015	0	8	1	0	0	3	1	0	**13**
2016	1	1	0	0	0	3	0	0	**5**
2017	0	0	0	0	1	4	0	0	**5**
Total for Merrimack	504	1,786	53	12	154	1224	40	0	**3,773**
Narraguagus									
1967-2007	92	650	19	54	95	2,429	71	155	**3,565**
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**
2016	0	0	0	0	0	3	0	0	**3**
2017	20	0	0	0	7	7	0	2	**36**
Total for Narraguagus	205	804	23	56	130	2502	72	162	**3,954**
Pawcatuck									
1982-2007	2	150	1	0	1	17	1	0	**172**
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**
2015	0	0	0	0	0	0	0	0	**0**
2016	0	0	0	0	0	0	0	0	**0**
Total for Pawcatuck	2	151	1	0	1	25	1	0	**181**
Penobscot									
1968-2007	11,296	44,415	288	709	726	3,842	35	99	**61,410**

	HATCHERY ORIGIN				WILD ORIGIN				
	1SW	2SW	3SW	Repeat	1SW	2SW	3SW	Repeat	Total
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	409	819	0	11	23	53	0	0	**1,315**
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**
2014	82	153	2	2	1	21	0	0	**261**
2015	110	552	7	1	9	52	0	0	**731**
2016	208	218	2	1	10	68	0	0	**507**
2017	301	451	9	0	9	79	0	0	**849**
Total for Penobscot	14,062	52,559	322	745	866	4583	37	102	**73,276**
Pleasant									
1967-2007	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**
2017	0	0	0	0	2	7	0	0	**9**
Total for Pleasant	7	13	0	0	16	238	3	2	**279**
Saco									
1985-2007	129	614	3	7	28	81	3	0	**865**
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**
2016	0	0	0	0	0	2	0	0	**2**
2017	3	3	0	0	1	1	0	0	**8**
Total for Saco	183	714	5	7	51	122	6	0	**1,088**
Sheepscot									
1967-2007	6	42	0	0	30	345	10	0	**433**
2017	2	9	0	0	2	6	0	0	**19**
Total for Sheepscot	8	51	0	0	32	351	10	0	**452**
Souadabscook Stream									
2017	0	0	0	0	1	3	0	0	**4**
Total for Souadabscook Stream	0	0	0	0	1	3	0	0	**4**

	HATCHERY ORIGIN				WILD ORIGIN				
	1SW	2SW	3SW	Repeat	1SW	2SW	3SW	Repeat	Total
St Croix									
1981-2007	720	1,124	38	12	880	1,340	78	34	**4,226**
2008	0	0	1	0	0	0	0	0	**1**
Total for St Croix	720	1,124	39	12	880	1340	78	34	**4,227**
Union									
1973-2007	274	1,841	9	28	1	16	0	0	**2,169**
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**
2017	0	0	0	0	0	0	0	0	**0**
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	115	0	1	**793**
Cocheco	0	0	1	1	6	10	0	0	**18**
Connecticut	58	3,612	28	2	140	2,389	16	3	**6,248**
Cove Brook	0	0	0	0	0	0	0	0	**0**
Dennys	39	320	0	1	38	776	5	35	**1,214**
Ducktrap	0	0	0	0	4	33	0	0	**37**
East Machias	23	256	1	2	12	330	1	10	**635**
Kenduskeag Stream	0	0	0	0	2	7	0	0	**9**
Kennebec	24	260	6	7	19	193	2	0	**511**
Lamprey	10	17	1	0	13	16	0	0	**57**
Machias	32	329	9	2	36	1,603	41	131	**2,183**
Merrimack	504	1,786	53	12	154	1,224	40	0	**3,773**
Narraguagus	205	804	23	56	130	2,502	72	162	**3,954**
Pawcatuck	2	151	1	0	1	25	1	0	**181**
Penobscot	14,062	52,559	322	745	866	4,583	37	102	**73,276**
Pleasant	7	13	0	0	16	238	3	2	**279**
Saco	183	714	5	7	51	122	6	0	**1,088**
Sheepscot	8	51	0	0	32	351	10	0	**452**
Souadabscook Stream	0	0	0	0	1	3	0	0	**4**
St Croix	720	1,124	39	12	880	1,340	78	34	**4,227**
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 2012 and earlier).

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	0	0	30	70	0	0
2011	438	12	0.027	0	83	0	17	0	0	0	0	0	0	0	100	0	0	0
2012	85	3	0.035	0	0	0	0	100	0	0	0			0	0	100	0	
2013	62	11	0.176	0	0	0	0	100		0				0	0	100		
Total	**10,161**	**1,704**																
Mean			**0.471**	**0**	**8**	**0**	**4**	**68**	**3**	**0**	**3**	**0**	**0**	**0**	**12**	**68**	**7**	**0**

Means includes year classes with complete return data (year classes of 2012 and earlier).

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 (%)										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	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 2012 and earlier).

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	0	0	35	66	0	0
2011	601	29	0.048	3	34	0	7	55	0	0	0	0	0	3	41	55	0	0
2012	173	12	0.069	0	17	0	25	42	17	0	0			0	42	42	17	
2013	186	19	0.102	5	0	0	0	95		0				5	0	95		
2014	20	0	0.000	0	0		0							0	0			
2015	39	0	0.000	0										0				
Total	**14,899**	**2,545**																
Mean			**0.371**	**0**	**12**	**0**	**4**	**68**	**1**	**0**	**4**	**0**	**0**	**0**	**16**	**68**	**6**	**0**

Means includes year classes with complete return data (year classes of 2012 and earlier).

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 2012 and earlier).

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	0	0	25	75	0	0
2011	76	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2012	35	0	0.000	0	0	0	0	0	0	0	0			0	0	0	0	
2013	56	3	0.054	0	0	0	0	100		0				0	0	100		
2014	12	0	0.000	0	0		0							0	0			
2015	27	0	0.000	0										0				
Total	**2,400**	**376**																
Mean			**0.255**	**0**	**22**	**0**	**4**	**57**	**0**	**0**	**7**	**0**	**0**	**0**	**27**	**57**	**7**	**0**

Means includes year classes with complete return data (year classes of 2012 and earlier).

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 (%) 1.1	1.2	1.3	2.1	2.2	2.3	3.1	3.2	3.3	4.2	Age (years) dist'n (%) 2	3	4	5	6
1975	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 2012 and earlier).

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	0	0	88	12	0
2011	89	6	0.067	0	50	0	0	50	0	0	0	0	0	0	50	50	0	0
2012	102	3	0.030	0	0	0	0	100	0	0	0			0	0	100	0	
2013	11	4	0.360	0	0	0	0	100		0				0	0	100		
2014	1	1	0.800	0	0		100							0	100			
2015	0	0	0.000	0										0				
Total	**4,183**	**1,418**																
Mean			**2.038**	**0**	**3**	**0**	**10**	**64**	**4**	**2**	**8**	**0**	**0**	**0**	**12**	**66**	**12**	**1**

Means includes year classes with complete return data (year classes of 2012 and earlier).

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 2012 and earlier).

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	0	0	0
2011	1	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2012	1	0	0.000	0	0	0	0	0	0	0	0			0	0	0	0	
2013	1	0	0.000	0	0	0	0	0		0				0	0	0		
2014	0	0	0.000	0	0		0							0	0			
2015	1	0	0.000	0										0				
Total	**632**	**27**																
Mean			**0.125**	**0**	**4**	**1**	**1**	**34**	**0**	**0**	**4**	**0**	**0**	**0**	**4**	**35**	**4**	**0**

Means includes year classes with complete return data (year classes of 2012 and earlier).

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 (%)										Age (years) dist'n (%)				
				1.1	1.2	1.3	2.1	2.2	2.3	3.1	3.2	3.3	4.2	2	3	4	5	6
1987	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 2012 and earlier).

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	0	0	75	25	0	0
2011	24	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2012	15	1	0.069	0	0	0	0	100	0	0	0			0	0	100	0	
2013	21	1	0.048	0	0	0	0	100		0				0	0	100		
2014	8	0	0.000	0	0		0							0	0			
2015	12	0	0.000	0										0				
Total	**563**	**122**																
Mean			**0.233**	**0**	**18**	**0**	**5**	**56**	**0**	**0**	**0**	**0**	**0**	**0**	**23**	**56**	**0**	**0**

Means includes year classes with complete return data (year classes of 2012 and earlier).

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 (%) 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
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 2012 and earlier).

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	0	0	100	0	0
2011	59	1	0.017	100	0	0	0	0	0	0	0	0	0	100	0	0	0	0
2012	39	3	0.078	0	0	0	0	33	67	0	0			0	0	33	67	
2013	47	3	0.064	0	0	0	0	100		0				0	0	100		
Total	**1,717**	**320**																
Mean			**0.183**	**4**	**4**	**0**	**9**	**72**	**0**	**0**	**7**	**0**	**0**	**4**	**13**	**72**	**7**	**0**

Means includes year classes with complete return data (year classes of 2012 and earlier).

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 2012 and earlier).

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	0	0	11	78	11	0
2011	95	56	0.588	0	0	0	0	88	0	4	9	0	0	0	0	92	9	0
2012	107	92	0.858	0	0	0	8	67	0	2	23			0	8	69	23	
2013	72	66	0.914	0	0	0	12	88		0				0	12	88		
2014	82	9	0.110	0	0		100							0	100			
2015	52	0	0.000	0										0				
Total	**2,799**	**5,009**																
Mean			**4.810**	**0**	**0**	**0**	**16**	**73**	**1**	**3**	**7**	**0**	**0**	**0**	**16**	**76**	**8**	**0**

Means includes year classes with complete return data (year classes of 2012 and earlier).

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	0.067	0.000	0.048	0.027	0.000	0.000	0.017	0.588
2012	0.030	0.000	0.069	0.035	0.069	0.000	0.078	0.858
2013	0.360	0.000	0.102	0.176	0.048	0.054	0.064	0.914
2014	0.800	0.000	0.000		0.000	0.000		0.110
2015	0.000	0.000	0.000		0.000	0.000		0.000
Mean	**2.093**	**0.130**	**0.380**	**0.483**	**0.243**	**0.263**	**0.190**	**4.951**
StDev	**5.212**	**0.406**	**0.452**	**0.703**	**0.261**	**0.302**	**0.173**	**6.408**

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 (2012 and earlier).

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

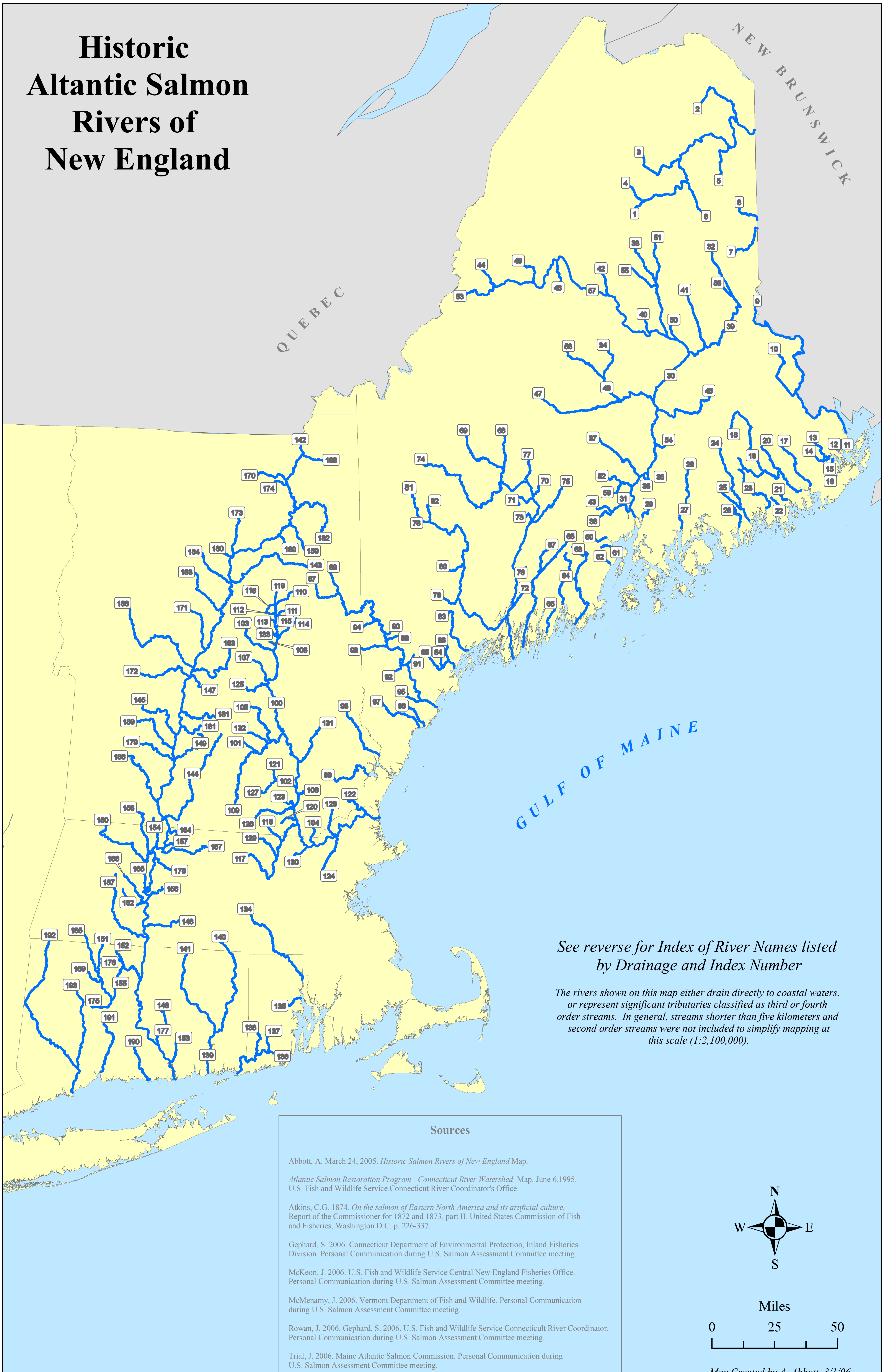
	Mean age class (smolt age. sea age) distribution (%)										**Mean age (years) (%)**				
	1.1	**1.2**	**1.3**	**2.1**	**2.2**	**2.3**	**3.1**	**3.2**	**3.3**	**4.2**	**2**	**3**	**4**	**5**	**6**
Connecticut (above Holyoke)	0	9	0	4	80	4	0	4	0	0	0	13	80	7	0
Connecticut (basin)	0	13	0	5	75	2	0	4	0	0	0	18	75	7	0
Farmington	0	24	0	4	64	0	0	7	0	0	0	28	64	8	0
Merrimack	0	3	0	12	72	4	2	9	0	0	0	15	74	13	1
Pawcatuck	0	8	2	2	78	0	0	10	0	0	0	10	80	10	0
Penobscot	0	0	0	18	73	1	3	8	0	0	0	18	76	9	0
Salmon	0	21	0	6	73	0	0	0	0	0	0	27	73	0	0
Westfield	4	4	0	9	74	3	0	7	0	0	4	12	74	10	0
Overall Mean:	**1**	**10**	**0**	**8**	**74**	**2**	**1**	**6**	**0**	**0**	**1**	**18**	**74**	**8**	**0**

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

Historic Atlantic Salmon Rivers of New England – Index

Drainage	River Name	Index
Aroostook	Aroostook River	1
	Little Madawaska River	2
	Big Machias River	3
	Mooseleuk Stream	4
	Presque Isle Stream	5
	Saint Croix Stream	6
St. John	Meduxnekeag River	7
	North Branch Meduxnekeag River	8
St. Croix	Saint Croix River	9
	Tomah Stream	10
Boyden	Boyden Stream	11
Pennamaquan	Pennamaquan River	12
Dennys	Dennys River	13
	Cathance Stream	14
Hobart	Hobart Stream	15
Orange	Orange River	16
East Machias	East Machias River	17
Machias	Machias River	18
	Mopang Stream	19
	Old Stream	20
Chandler	Chandler River	21
Indian	Indian River	22
Pleasant	Pleasant River	23
Narraguagus	Narraguagus River	24
	West Branch Narraguagus River	25
Tunk	Tunk Stream	26
Union	Union River	27
	West Branch Union River	28
Penobscot	Orland River	29
	Penobscot River	30
	Cove Brook	31
	East Branch Mattawamkeag River	32
	East Branch Penobscot River	33
	East Branch Pleasant River	34
	Eaton Brook	35
	Felts Brook	36
	Kenduskeag Stream	37
	Marsh Stream	38
	Mattawamkeag River	39
	Millinocket Stream	40
	Molunkus Stream	41
	Nesowadnehunk Stream	42
	North Branch Marsh Stream	43
	North Branch Penobscot River	44
	Passadumkeag River	45
	Pine Stream	46
	Piscataquis River	47
	Pleasant River (Penobscot)	48
	Russell Stream	49
	Salmon Stream	50
	Seboeis River	51
	Souadabscook Stream	52
	South Branch Penobscot River	53
	Sunkhaze Stream	54
	Wassataquoik Stream	55
	West Branch Mattawamkeag River	56
	West Branch Penobscot River	57
	West Branch Pleasant River	58
	West Branch Souadabscook Stream	59
Passagassawakeag	Passagassawakeag River	60
Little	Little River	61
Ducktrap	Ducktrap River	62
Saint George	Saint George River	63
Medomak	Medomak River	64
	Pemaquid River	65
Sheepscot	Sheepscot River	66
	West Branch Sheepscot River	67
Kennebec	Kennebec River	68
	Carrabassett River	69
	Carrabassett Stream	70
	Craigin Brook	71
	Eastern River	72
	Messalonskee Stream	73
	Sandy River	74
	Sebasticook River	75
	Togus Stream	76
	Wesserunsett Stream	77
Androscoggin	Androscoggin River	78
	Little Androscoggin River	79
	Nezinscot River	80
	Swift River	81
	Webb River	82
Royal	Royal River	83
Presumpscot	Presumpscot River	84
	Mill Brook (Presumpscot)	85
	Piscataqua River (Presumpscot)	86
Saco	Saco River	87
	Breakneck Brook	88
	Ellis River	89
	Hancock Brook	90
	Josies Brook	91
	Little Ossipee River	92
	Ossipee River	93
	Shepards River	94
	Swan Pond Brook	95
Kennebunk	Kennebunk River	96
Mousam	Mousam River	97
Cocheco	Cocheco River	98
Lamprey	Lamprey River	99
Merrimack	Merrimack River	100
	Amey Brook	101
	Baboosic Brook	102
	Baker River	103
	Beaver Brook	104
	Blackwater River	105
	Bog Brook	106
	Cockermouth River	107
	Cohas Brook	108
	Contoocook River	109
	East Branch Pemigewasset River	110
	Eastman Brook	111
	Glover Brook	112
	Hubbard Brook	113
	Mad River	114
	Mill Brook (Merrimack)	115
	Moosilauke Brook	116
	Nashua River	117
	Nissitissit River	118
	Pemigewasset River	119
	Pennichuck Brook	120
	Piscataquog River	121
	Powwow River	122
	Pulpit Brook	123
	Shawsheen River	124
	Smith River	125
	Souhegan River	126
	South Branch Piscataquog River	127
	Spicket River	128
	Squannacook River	129
	Stony Brook	130
Merrimack	Suncook River	131
	Warner River	132
	West Branch Brook	133
Blackstone	Blackstone River	134
Pawtuxet	Pawtuxet River	135
Pawcatuck	Pawcatuck River	136
	Beaver River	137
	Wood River	138
Thames	Thames River	139
	Quinebaug River	140
	Shetucket River	141
Connecticut	Connecticut River	142
	Ammonoosuc River	143
	Ashuelot River	144
	Black River	145
	Blackledge River	146
	Bloods Brook	147
	Chicopee River	148
	Cold River	149
	Deerfield River	150
	East Branch Farmington River	151
	East Branch Salmon Brook	152
	Eightmile River	153
	Fall River	154
	Farmington River	155
	Fort River	156
	Fourmile Brook	157
	Green River	158
	Israel River	159
	Johns River	160
	Little Sugar River	161
	Manhan River	162
	Mascoma River	163
	Mill Brook (Connecticut)	164
	Mill River (Hatfield)	165
	Mill River (Northhampton)	166
	Millers River	167
	Mohawk River	168
	Nepaug River	169
	Nulhegan River	170
	Ompompanoosuc River	171
	Ottauquechee River	172
	Passumpsic River	173
	Paul Stream	174
	Pequabuck River	175
	Salmon Brook	176
	Salmon River	177
	Sawmill River	178
	Saxtons River	179
	Stevens River	180
	Sugar River	181
	Upper Ammonoosuc River	182
	Waits River	183
	Wells River	184
	West Branch Farmington River	185
	West River	186
	Westfield River	187
	White River	188
	Williams River	189
Hammonasset	Hammonasset River	190
Quinnipiac	Quinnipiac River	191
Housatonic	Housatonic River	192
	Naugatuck River	193

Historic Altantic Salmon Rivers of New England



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

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

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