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1 Executive Summary

1.1 Abstract

Total returns to USA rivers was 869; this is the sum of documented returns to traps and returns estimated by redd counts. This, year ranks 24 out of 28 years for the 1991-2018 time series. Documented returns to traps totaled 833 and returns estimated by redd counts was 36 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 99.2% of the total returns. Overall, 37.3% of the adult returns to the USA were 1SW salmon, 62.4% were 2SW salmon and 3% were 3SW or repeat spawners. Most (88.1 %) returns were of hatchery smolt origin and the balance (11.9%) originated from either natural reproduction, 0+ fall stocked parr, hatchery fry, or eggs. A total of 5,558,043 juvenile salmon (eggs, fry, parr, and smolt), and 5,715 adults were stocked into US rivers. Of those fish, 246,218 carried a mark and/or tag. Eggs for USA hatchery programs were taken from a total of 1,999 females consisting of 249 sea-run females and 1,750 captive/domestic and domestic females. Total egg take (7,794,619) was similar to the previous three years' average of 7,144,788. 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

Atlantic salmon are not subject to a plan review by the National Marine Fisheries Service because the current fishery management plan prohibits their possession as well as any directed fishery or incidental (bycatch) for Atlantic salmon in federal waters. Similar prohibitions exist in state waters. Atlantic salmon found 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 NEFSC using the Standardized Bycatch Reporting Methodology (e.g., Wigley and Tholke 2017). While bycatch is uncommon, we summarize observed events from 1989 through August 2018 using reports and data queries. Prior to 1993, observers recorded Atlantic salmon as an aggregate weight per haul. Therefore, no individual counts are available for these years, however 8 observed interactions occurred. After 1993, observers recorded Atlantic salmon on an individual basis. Between 1993 and 2018, 7 observed interactions have occurred, with a total count of 7 individuals. Atlantic salmon bycatch has been observed across 7 statistical areas in the Gulf of Maine region, primarily in benthic fisheries. 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 869 (Table 1.3.1), a decrease of 17% from 2017 (Table 1.3.2). Returns are reported for three meta-population areas (Figure 1.3.1): Long Island Sound (LIS, 2 total returns), Central New England (CNE, 5 total returns), and Gulf of Maine (GOM, 862 total returns). Changes from 2017 within areas were: LIS -900%, CNE -160%, and GOM -17%. 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 2016 smolt cohort for the Penobscot River equaled 0.08% (Figure 1.3.3). This was a decrease over the 2015 smolt cohort. This was a slight decrease over the 5-year average (2012 – 2016) of 0.09%. and much below the 10-year average of 0.2%. The 1SW SAR for hatchery smolts in the Penobscot also decreased from 2016 (Figure 1.3.4).

In the US, returns are well below conservation spawner requirements. Returns of 2SW fish from traps, weirs, and estimated returns were only 0.6% of the US CL, with returns to the three areas ranging from 0 to 0.9 % of spawner requirements (Table 1.3.3). Out of select rivers with a long-time series of return data, the Penobscot was the highest at about 6.9% of CL followed by the Narraguagus (4.74%) and the Dennys (3.73%) (Table 1.3.4).

1.4 Stock Enhancement Programs

During 2018, a total of 5,558,043 juvenile salmon were released into USA rivers. Of these, 2,490,011 were fry; 2,016,039 were planted eyed eggs; 391,924 were fall fingerlings; and 660,069 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 (559,130) and the Narraguagus (99,930) River. In addition, 5,715 adult salmon were released into USA rivers (Table 1.4.2). A total of 1,894 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 246,218 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 2020, compared to recent years, given a substantial increase in the number of smolts stocked into marine net pens in 2018.

In 2018, 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.

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 29 May, which continued smolt assessments for a 22nd consecutive year. At total of 173 naturally reared and 6,382 hatchery smolts were captured. The estimate for naturally reared smolts was 604 ± 186. This was a severe departure from previous years and reflects low recruitment due to reduced stocking and spawning in previous years.

MDMR operated three RSTs at one site on the Sheepscot River from 22 April to 30 May, which marked the 17th year of assessment on this river. A total of 228 smolts were captured (121 naturally reared, 107 hatchery reared and 1 unknown origin). The total smolt population estimate was 1,652 ± 357. The estimate was 883 ± 220 for naturally reared smolts, and 587 ± 122 for 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 8 June, which was the 6th consecutive year of trapping on this river. Staff captured 198 smolts of naturally-reared (11) and hatchery (187) origin. The total estimate of smolt migration was 1,049 ± 186. Based on trap catches, we assume that approximately 6% of these were of naturally reared origin.

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	32.7

Table 1.3.1 Estimated Atlantic salmon returns to USA by geographic area, 2018. "Natural" includes fish originating from natural spawning and hatchery fry or eggs. Some numbers are based on redds. Ages and origins are prorated where fish are not available for handling.

Area	1SW		2SW		3SW		Repeat Spawners		TOTAL
	Hatchery	Natural	Hatchery	Natural	Hatchery	Natural	Hatchery	Natural	
LIS	0	0	0	2	0	0	0	0	2
CNE	0	1	0	4	0	0	0	0	5
GOM	300	23	463	73	0	1	1	1	862
Total	300	24	463	79	0	1	1	1	869

Table 1.3.2 Estimated Atlantic salmon returns to the USA, 1967-2018. "Natural" includes fish originating from natural spawning and hatchery fry or eggs. Starting in 2003 estimated returns based on redds are included.

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

2006	442	1,007	2	5	1,456	1,167	289
2007	299	958	3	1	1,261	940	321
2008	812	1,758	12	23	2,605	2,191	414
2009	243	2,065	16	16	2,340	2,017	323
2010	552	1,081	2	16	1,651	1,468	183
2011	1,084	3,053	26	15	4,178	3,560	618
2012	26	879	31	5	941	731	210
2013	78	525	3	5	611	413	198
2014	110	334	3	3	450	304	146
2015	150	761	9	1	921	739	182
2016	232	389	2	3	626	448	178
2017	363	663	13	2	1041	806	235
2018	324	542	2	1	869	764	98

Table 1.3.3 Two sea winter (2SW) returns for 2018 in relation to spawner requirements (i.e. 2SW Conservation Limits) for USA rivers.

Area		Spawner Requirement	2SW returns 2017	Percentage of Requirement
Long Island Sound	LIS	17,785	2	0.0%
Central New England	CNE	5,516	4	0.1%
Gulf of Maine	GOM	61,355	536	0.9%
Total		84,656	542	0.6%

Table 1.3.4. 2018 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	2,599	2	0.08%
CNE	Pawcatuck	-71.133	41.937	358	0	0.00%
GOM	Dennys	-67.228	44.868	161	6	3.73%
GOM	Narraguagus	-67.783	44.654	401	19	4.74%
GOM	Penobscot	-68.82	44.769	6,938	479	6.90%
GOM	Pleasant	-67.5781	44.722	72	0	0.00%
GOM	Union	-68.474	44.643	557	0	0.00%
LIS	Connecticut	-72.374	41.593	17,427	2	0.01%

Table 1.4.1 Number of juvenile Atlantic salmon by lifestage stocked in USA, 2018.

Area	N	Rivers	Eyed Egg	Fry	0 Parr	1 Parr	1 Smolt	2 Smolt	Total
LIS	2	Connecticut, Pawcatuck		394,350	16,984				411,334
CNE	2	Merrimack, Saco	70,300	356,172					426,472
GOM	8	Androscoggin to Dennys	1,945,739	1,739,489	374,288	652	659,060	1,009	4,720,237
OBF	1	Aroostook							0
Total	13		2,016,039	2,490,011	391,272	652	659,060	1,009	5,558,043

Table 1.4.2 Stocking summary for sea-run, captive reared domestic adult Atlantic salmon for the USA in 2018 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	1,894	791			2,685
Gulf of Maine	GOM	Restoration	342	2,251	2	435	3,030
Total for USA			2,236	3,042	2	435	5,715

Table 1.5.1 Summary of tagged and marked Atlantic salmon released in USA, 2018. Includes hatchery and wild origin fish.

Mark Code	**Life Stage**	**CNE**	**GOM**	**LIS**	**Total**
Adipose punch	Adult				0
Passive Integrated Transponder (PIT)	Adult		3,909		3,909
Radio tag	Adult		6		6
Upper caudal punch	Adult				0
Adipose clip	Parr		140,636		140,636
Adipose clip	Smolt		99,930		99,930
Acoustic Tag	Smolt		650		650
Passive Integrated Transponder (PIT)	Smolt		288		288
Radio tag	Smolt		799		799
		0	246,218	0	246,218

Table 1.6.1. State of Maine - USA commercial Atlantic salmon aquaculture production and suspected aquaculture captures to Maine rivers 2000 to 2018. Due to confidentiality statutes in ME marine resources regulations related to single producer, adult production rates are not available 2011 to 2018.

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		67,988	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
2018	2,035,690	45,000	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

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**
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
2018	483	604	725	663	883	1,103

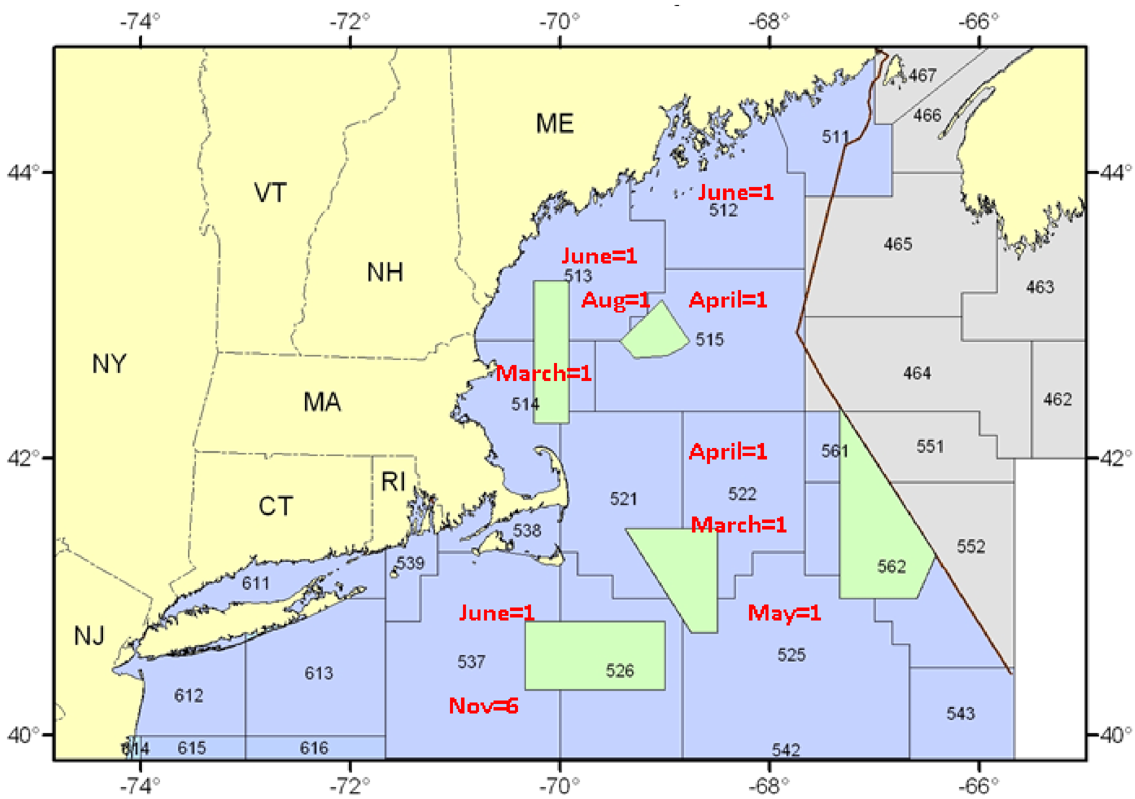

Figure 1.2.1 Map of Gulf of Maine region showing the month and number of Atlantic salmon interactions (e.g., June=1: 1 salmon interaction in the area in June). Location of the label within the statistical grid does not denote more specific locations. Blue polygons are USA statistical areas, grey zones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

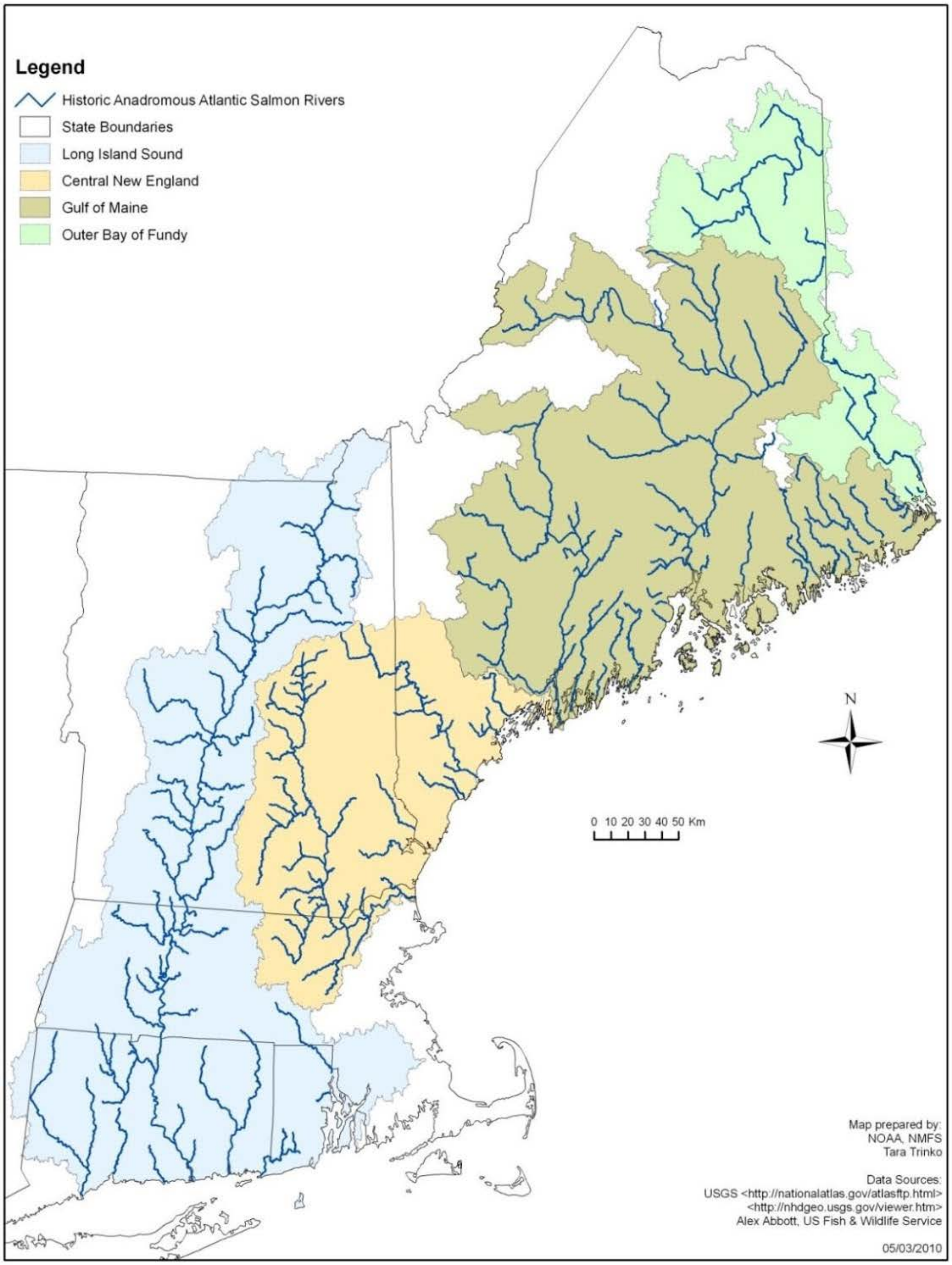

Figure 1.3.1 Map of geographic areas used in summaries of USA data for returns, stocking, and marking in 2018.

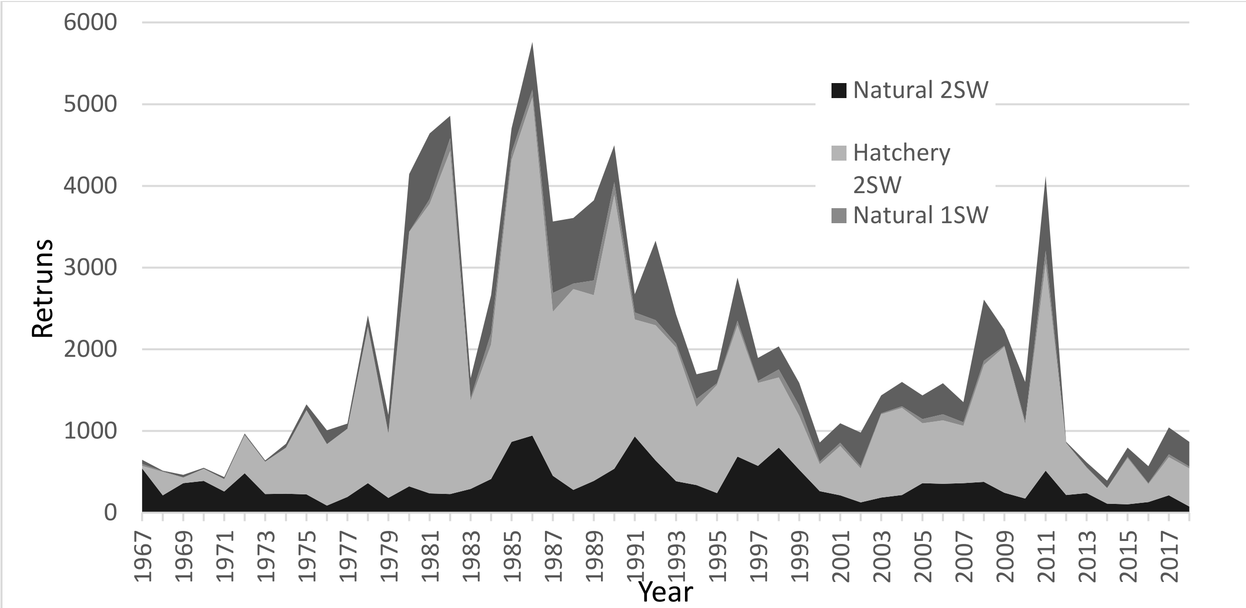

Figure 1.3.2 Origin and sea age of Atlantic salmon returning to USA rivers, 1967 to 2018.

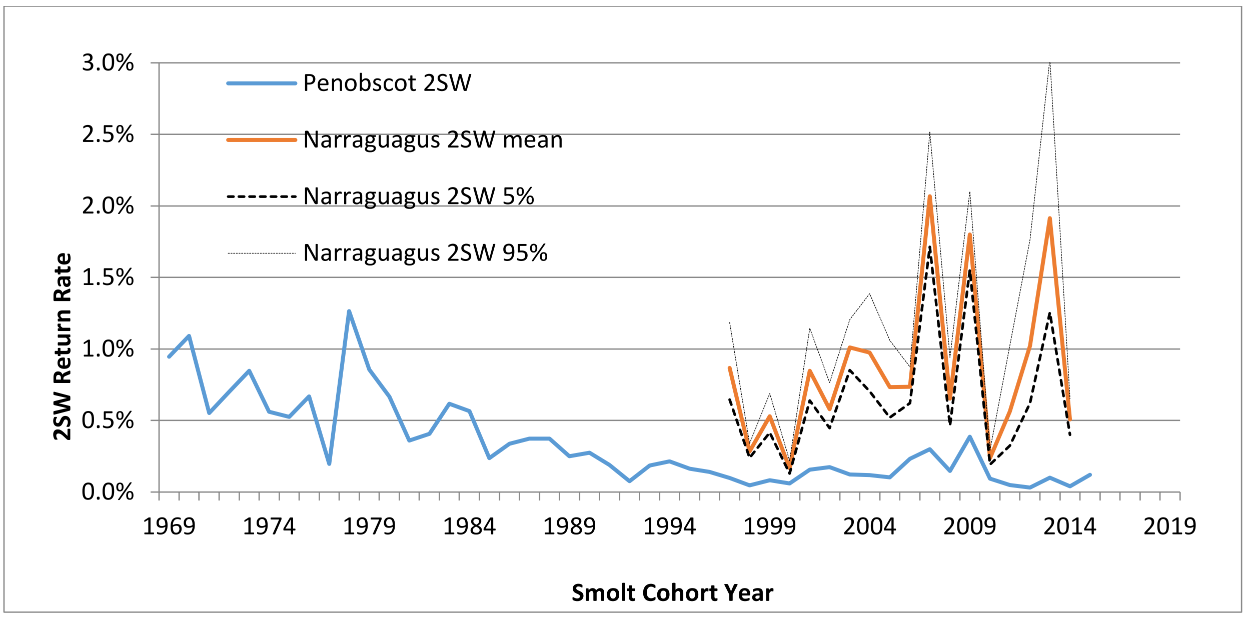

Figure 1.3.3 Return rate of 2SW adults to Gulf of Maine area rivers by smolt cohort year (1969 – 2015) of hatchery-reared Atlantic salmon smolts (Penobscot River solid line) and estimated wild smolt emigration (Narraguagus River dashed line) with 95% CI (gray dotted line) USA.

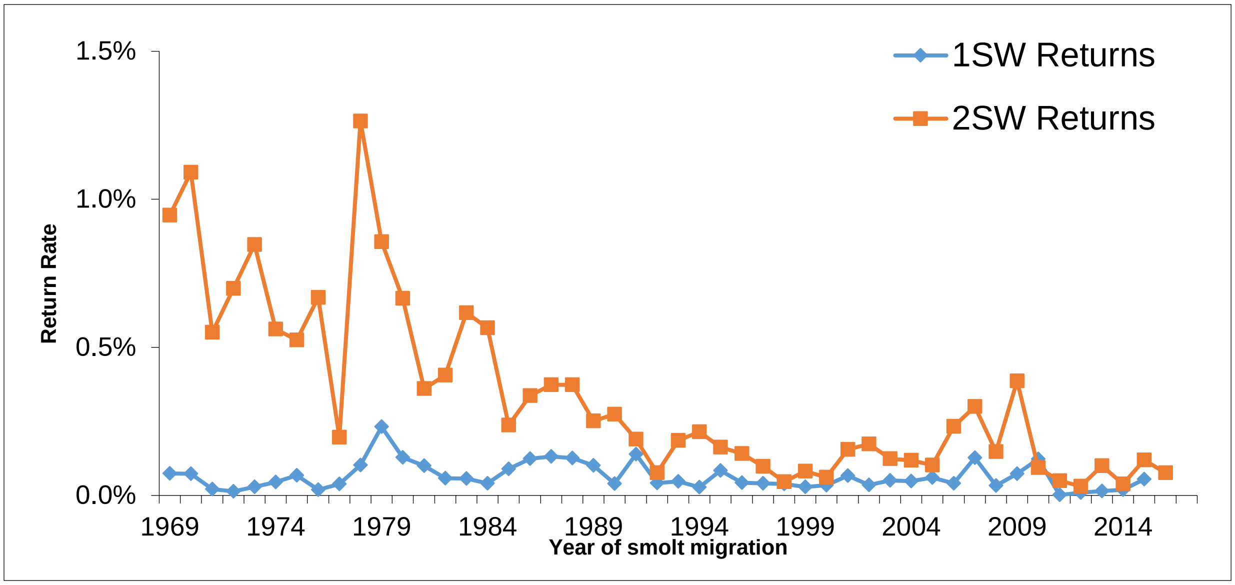

Figure 1.3.4. River return rates (%) of hatchery released smolt from the Penobscot River (Maine, USA) as 1SW and 2SW salmon

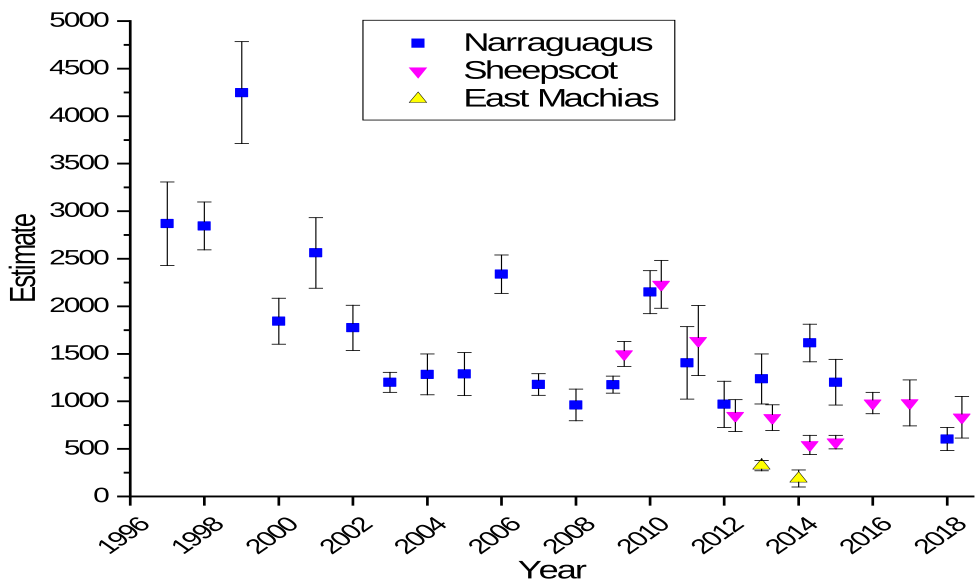

Figure 1.7.1. Population Estimates (± Std. Error) of emigrating naturally-reared smolt in the Narraguagus (no estimate in 2016 and 2017), Sheepscot, Piscataquis (discontinued in 2015), and East Machias (no estimate 2015-2017) rivers, Maine (1997-2018), using DARR 2.0.2.

References:

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

2 Viability Assessment - Gulf of Maine Atlantic Salmon

2.1 Overview of DPS and Annual Viability Synthesis

Historically, the USASAC stock assessment 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 related to the recovery of a protected salmonid species. In 2013, overall US salmon conservation efforts contracted from two restoration programs (Connecticut and Merrimack) and recovery of the GOMDPS to a targeted program 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. All populations are 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 changed in 2018 to a viability assessment. This assessment represents the annual viability assessment of the GOMDPS using a Viable Salmonid Populations (VSP) approach (McElhany et al. 2000). Taking this approach allows the Maine Stock Assessment Action Team to integrate an annual 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.

2.1.1 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 DIPs 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 DIPs (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) can serve as donor stocks for other systems, especially the Kennebec River in MMB SHRU.

2.1.2 Synthesis of 2018 Viability Assessment

Totaling 862 estimated adult returns, the 2018 spawning run was the 24th lowest return since 1991. The majority (82%) of returns were of hatchery-stocked smolt origin returning to the Penobscot River. Naturally-reared returns remained low across the GOMDPS (98). About 60% 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 12% of this target, 4-fold higher than returns to the MMB SHRU (3%). The 5 populations in the DEC SHRU numbered only 23 estimated naturally-reared returns (<5%). These estimates represent a minimal count of returning fish. Estimates of 5 of these populations rely on redd counts and water conditions resulted in lower spatial coverage than is typical.

While naturally-reared growth rates can be quite variable at these low levels of abundance, geometric mean population growth rates have typically been stabilized at average estimates that are generally above 1.0 for all SHRUs since 2012. However, in 2018 this was not the case. The MMB SHRU had the highest growth rate (1.78; 95% CI: 1.12 – 2.83) and PNB SHRU had the lowest growth rate (0.92; 95% CI: 0.47 – 1.80). The DEC SHRU growth rate was 0.97 (95% CI: 0.53 – 1.76). 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. A total of 48 redds were documented in 2018 surveys that covered 661 units of spawning habitat. This effort represents 6% coverage of a total of 10,944 units of spawning habitat located in critical habitat. For 2018 GOM DPS spawner distributions, 33 redds (69%) were documented in the DEC SHRU survey. In MMB, 15 redds (31%) were counted with only 11in the Sheepscot River. Of these, only 2 were thought to be from searun salmon with 11 from adult broodstock releases by USFWS. No documented PNB SHRU spawning was recorded in 2018 but only 33.6 units of habitat were surveyed. It should be noted that spawning escapement is low in the larger Penobscot and Kennebec Rivers due to removal of fish for broodstock (Penobscot) and low marine survival overall. Additionally, redd survey spatial coverage is very limited (1-3%) in the larger systems relative to available habitat. Conservation hatchery supplementation of all MPGs enhances juvenile production capacity with the addition of eggs, fry, and parr across 55 of 153 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 2018 were 862 and 764 of these were hatchery-origin fish returning to the Penobscot, Narraguagus, and Sheepscot Rivers (Figure 2.2.1 and Table 2.2.1). Because of the abundance of the PNB SHRU smolt-stocked component, returns to that SHRU (90%) dominated total abundance with 772 returns. The additional, 53 hatchery returns were documented in the DEC SHRU (49) and Merrymeeting Bay SHRU (4).

Naturally-reared returns were also highest in Penobscot Bay at 61 (Figure 2.2.2). The DEC SHRU had 23 documented naturally-reared returns across 5 of 6 monitored river systems while the Merrymeeting Bay SHRU had 14 returns to 2 of the 3 monitored rivers.

Table 2.2.1. Documented returns from trap and redd-count monitoring for GOM DPS Atlantic salmon by SHRU for return year 2018 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	49	23	72	4.6 %
Penobscot Bay	711	61	772	12.2 %
Merrymeeting Bay	4	14	18	2.8 %
Gulf of Maine DPS	764	**98**	862	-

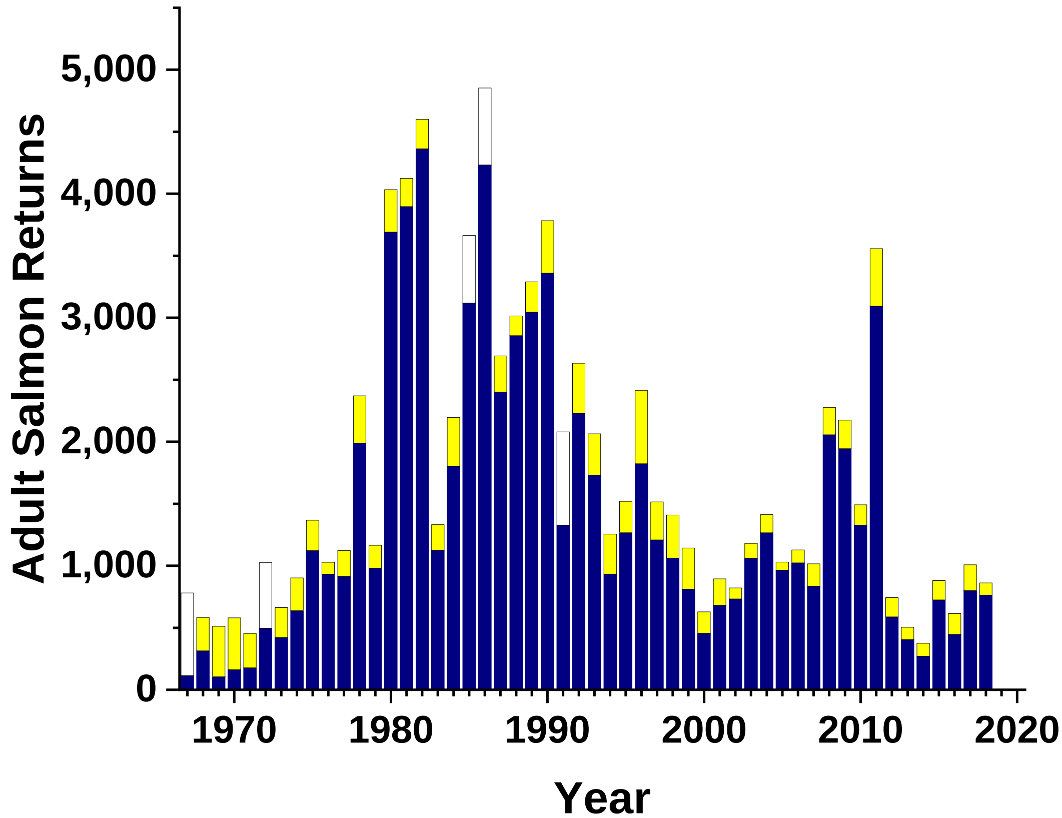

Figure 2.2.1. Time-series of total estimated returns to the GOM DPS of Atlantic salmon illustrating the dominance of hatchery-reared origin (navy) Atlantic salmon compared to naturally-reared (wild, egg stocked, fry stocked) origin (yellow).

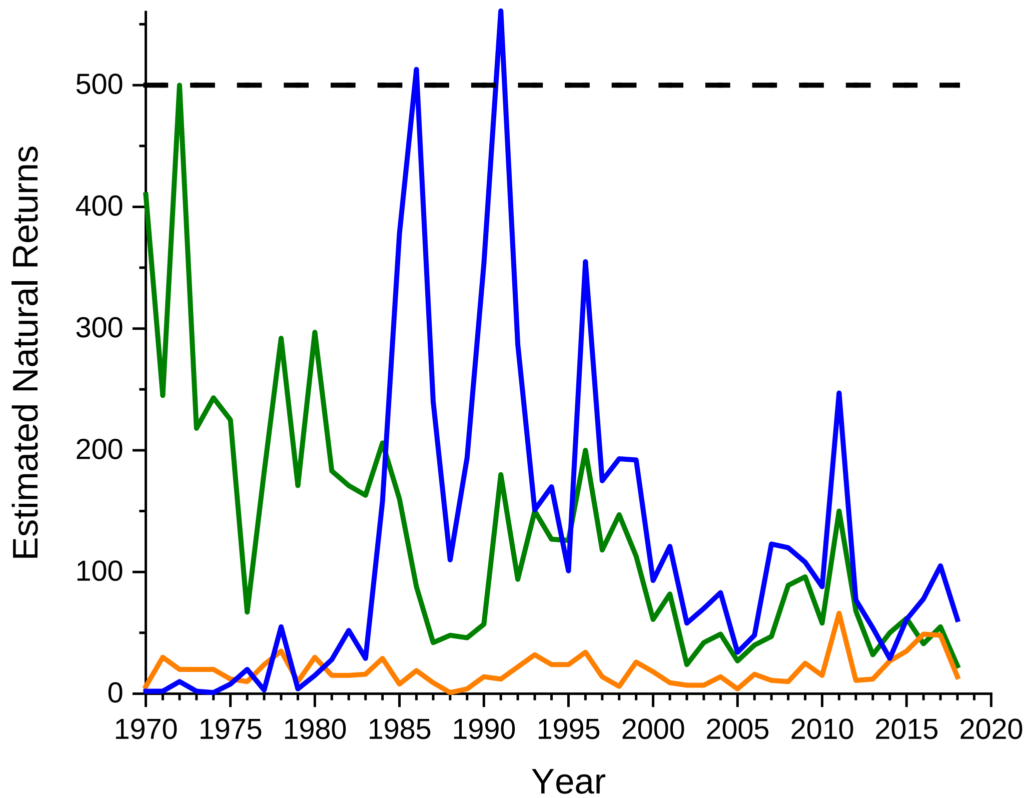

Figure 2.2.2. Time series of naturally-reared adult returns to the Merrymeeting Bay (Orange), Penobscot Bay (Blue), and Downeast Coastal (Green) SHRUs from 1970 to present. Naturally-reared interim target of 500 natural spawners is indicated for reference.

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:

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

where GMR is the geometric mean population growth rate of the most recent 10-year period and Rt 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 Nt is the number of adult spawners in year t and Nt-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 (2018) the Merrymeeting Bay SHRU had the highest growth rate (1.78; 95% CI: 1.12 – 2.83) and the Penobscot SHRU had the lowest growth rate (0.92; 95% CI: 0.47 – 1.79) (Table 2.3.1).

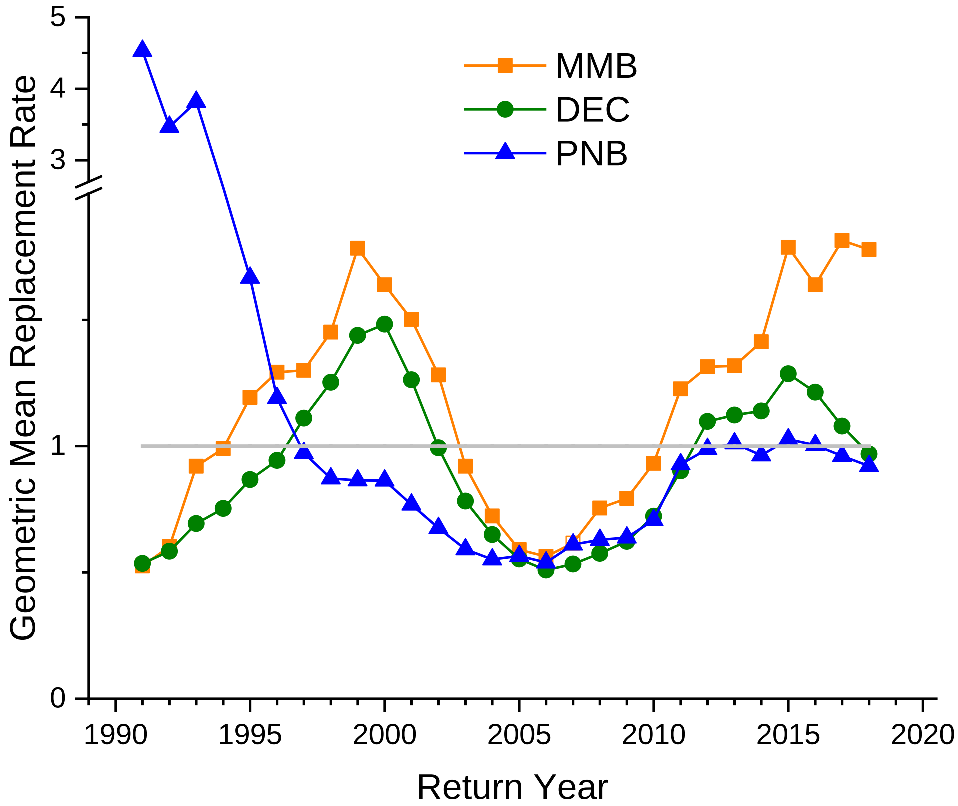

Figure 2.3.1. Ten-year geometric mean replacement rates for the GOM DPS of Atlantic salmon for Merrymeeting Bay (Orange), Penobscot Bay (Blue), and Downeast Coastal (Green) for each SHRU individually.

Table 2.3.1. Ten-year geometric mean replacement rates (GM_R) for GOM DPS Atlantic salmon as calculated for 2018 return year with 95% confidence limits (CL).

SHRU	GM_R	Lower 95% CL	Upper 95% CL
Downeast Coastal	0.97	0.53	1.76
Penobscot	0.92	0.47	1.79
Merrymeeting Bay	1.78	1.12	2.83
Gulf of Maine DPS	**1.04**	**0.59**	**1.83**

The geometric mean population growth rate based on the 5-year replacement rate does not completely reflect the true population growth rate 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 10-year geometric mean replacement rate gives an overestimate 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 a 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. We can then partition the total number of returning adult salmon into true wild versus hatchery components of the population and use analytical methods to gain better estimates of the true wild population growth rates.

Model description

This new method for estimating the wild population growth rate is described by Sweka and Bartron (*manuscript in preparation*) and uses methods described by Holmes (2001) and McClure et al. (2003). Underlying this approach was an exponential decline model (Dennis et al 1991):

$$N_{t+1} = N_t e^{(\mu+\varepsilon)} \qquad [1]$$

where N_{t+1} is the number of salmon at time t+1, N_t is the number of salmon at time t, μ is the instantaneous population growth rate, and ε is normally distributed error with a mean of 0 and variance of σ^2. Total estimated adult returns were used as input data and were the combination of salmon observed in trapping facilities and salmon estimated from redd surveys. The use of raw return data presents problems when estimating μ because spawners only represent a single life stage and the delay between birth and reproduction can lead to large fluctuations in annual spawner numbers (McClure et al. 2003). Therefore, we used a running sum (R_t) of five consecutive years of spawning counts (S_{t+j-1}) as input data to estimate μ as recommended by Holmes (2001) and Holmes and Fagan (2002).

$$R_t = \sum_{j=1}^{5} S_{t+j-1} \qquad [2]$$

Five consecutive counts were summed together because the majority of Atlantic Salmon in the GOM DPS will return to spawn five calendar years after their parents spawned. The population growth rate ($\hat{\mu}$) was estimated as:

$$\hat{\mu} = \text{mean}\left[\ln\left(\frac{R_{t+1}}{R_t}\right)\right] \qquad [3]$$

We used a slope method (Holmes 2001; Holmes and Fagan 2002) to gain an estimate of the variance on the population growth rate ($\hat{\sigma}^2$)

$$\hat{\sigma}^2 = \text{slope of variance of } \left[\ln\left(\frac{R_{t+\tau}}{R_t}\right)\right] \text{ vs. } \tau \qquad [4]$$

for τ = 1,2,3,4, and 5 corresponding to time lags in the life history of Atlantic Salmon from spawning until offspring return to spawn.

The input of hatchery origin fish confounds estimates of the population growth rate (μ). If these hatchery origin fish successfully reproduce and contribute to the next cohort, which is the goal of stocking these hatchery fish, then estimates of μ based on total spawners is overestimated and subsequent extinction risks are underestimated. We estimated μ in two ways: (1) using running sums of total spawners as described in equation [3] (hereafter referred to as $\hat{\mu}_{Total}$) and (2) adjusting for the proportion of hatchery origin fish in the running sums of spawners (McClure et al. 2003; hereafter referred to as $\hat{\mu}_{Wild}$) as

$$\hat{\mu}_{Wild} = \text{mean}\left[\frac{1}{T}\ln(\hat{w}_t) + \ln\left(\frac{R_{t+1}}{R_t}\right)\right] \qquad [5]$$

where T = an approximate 5 year generation time for Atlantic Salmon and $\hat{w}_t$= the proportion of the running sum of adult returns that were born in the wild. The value of $\hat{\mu}_{Wild}$ assumes that hatchery fish that survive to spawn, reproduce at the same rate as wild fish and that wild spawners in the time series could have come from either hatchery or wild parents. We can view the value of $\hat{\mu}_{Total}$ as the population growth rate under stocking levels that produced the observed time series of total spawners and the value of $\hat{\mu}_{Wild}$ as the population growth rate of wild fish only, in the absence of stocking.

Input Data

Time series of adult return data were obtained from the U.S. Atlantic Salmon Assessment Committee database. Although the available data extended back to 1967, we restricted the data used in this analysis to 2004 - 2018 which represents the last 10 years within the running sum of adult returns.

Genetic parentage analysis of broodstock taken to the hatchery was used to differentiate wild and hatchery fish within the naturally reared component of returning salmon. Penobscot River broodstock were obtained by trapping adults and transporting them to Craig Brook National Fish Hatchery. Other rivers used a captive broodstock program whereby fish were captured as age 1+ parr in the rivers, and transported to Craig Brook National Fish Hatchery for culture until they matured and could be spawned in the hatchery. We make the assumption that the broodstock collected and subsequently analyzed for parentage are representative of all salmon in the natural environment.

Growth rates were estimated for each SHRU and for the GOM DPS as a whole. Therefore, adult returns and the proportion of naturally reared returns that were wild origin were combined among rivers within a SHRU and among all rivers for the entire GOM DPS. Information from parentage analysis to determine the proportion of naturally reared returns that were wild origin was available for spawning runs from 2003 – 2018. In the Penobscot SHRU, the year of broodstock collection and parentage analysis corresponded to the year the adults returned. However, in other SHRUs the year of broodstock collection and parentage analysis did not correspond to the year these fish would have returned as adults because they were collected as parr (mostly age 1). Therefore, we made the assumption that the proportion of naturally reared fish that were wild origin found in the parr collected for broodstock would be the same for fish from these cohorts that remained in the river and would return as sea run adults three years later. [The majority of naturally reared returns in the GOM DPS become smolts at age 2 and return after two winters at sea.] Within this assumption, we assumed that any differential survival between hatchery and wild origin fish took place over the first year of life when the fish were at the fry and age 0 parr stages.

Within a year, the proportion of returns that were wild ($\widehat{w}_t'$) was estimated as

$$\widehat{w}_t' = \rho_t S_{NR,t}/S_{T,t} \qquad [8]$$

where ρ_t = the proportion of naturally reared returns that were of wild origin as estimated through parentage analysis at time t, $S_{NR,t}$ = the number of naturally reared spawners, and $S_{T,t}$ = the total number of spawners. The number of wild origin returns in year t $\left(S_{W,t}\right)$ was then

$$S_{W,t} = \widehat{w}_t' S_{T,t} \qquad [9]$$

and the number of hatchery origin spawners in year t $\left(S_{H,t}\right)$ was

$$S_{H,t} = S_{T,t} - S_{W,t} \qquad [10]$$

Bootstrap simulations

Bootstrap simulations were conducted program R (version 3.5.1) to estimate the wild population growth rate ($\hat{\mu}_{Wild}$). Bootstrap simulations were necessary because we did not have estimates of ρ_t for all years in all SHRUs. For years where estimates of ρ_t were available, these estimates were used, but in years where estimates ρ_t were not available, values of ρ_t were randomly chosen from the available values in other years. Bootstrap simulations were not needed to estimate the total population growth rate (hatchery and wild fish combined; $\hat{\mu}_{Total}$) because this value was simply based on the total number of adult returns (equation [3]).

<u>Results</u>

Instantaneous population growth rates were near 0 and 95% confidence limits overlapped 0 for all SHRUs and the Gulf of Maine as a whole when we include all returning Atlantic salmon regardless of origin. These results indicate neither increasing nor decreasing populations. However, when we account for the proportion of adult returns that were of hatchery origin, all SHRUs had wild population growth rates that were less than 0 with the Penobscot SHRU being the most negative. The reason why the Penobscot SHRU has the lowest population growth rate is because the vast majority of adult returns to this SHRU are of hatchery origin. The negative growth rates for the wild component of these populations indicates that if stocking hatchery origin fish were to cease, these populations would show abrupt declines.

Table 2.3.1. Population growth rates of Atlantic Salmon in the GOM DPS estimated by the running sum method for both the total population and the wild component. Growth rates are presented as both instantaneous (μ) and finite (λ) rates. Numbers in parentheses represent 95% confidence limits.

SHRU	μ_{total}	μ_{wild}	λ_{total}	λ_{wild}
Downeast Coastal	0.0174 (-0.1248, 0.1597)	-0.2254 (-0.3676, -0.0831)	1.0176 (0.8826, 1.1731)	0.7982 (0.6924, 0.9203)
Penobscot	-0.0252 (-0.1689, 0.1185)	-0.6593 (-0.803, -0.5156)	0.9751 (0.8446, 1.1258)	0.5172 (0.448, 0.5971)
Merrymeeting Bay	0.0744 (-0.0705, 0.2192)	-0.2386 (-0.3834, -0.0937)	1.0772 (0.932, 1.2451)	0.7877 (0.6815, 0.9105)
Gulf of Maine	**-0.0186** **(-0.1578,0.1206)**	**-0.5795** **(-0.7187,-0.4403)**	**0.9816** **(0.854,1.1282)**	**0.5602** **(0.4874,0.6439)**

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 2018 covered 661 units (6%) of 10,994 units of mapped 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 lower than typical this year due to high flows and poor visibility canceling many planned surveys. In the DEC SHRU where 390 (28.9%) of

1,348 units of mapped spawning habitat was surveyed. Because of their smaller size, better spatial coverage was achieved in the Sheepscot River (173 of 315 units – 55%) of the Merrymeeting Bay SHRU and the Ducktrap River and Cove Brook in the Penobscot Bay SHRU (33 of 51 units 65%). Given the low spawner escapement relative to available habitat, monitoring is very limited in MMB and PNB habitat in larger rivers such as the Kennebec and Penobscot. Redd counts totaled 48 in the GOMDPS: 33 in DEC, 15 in MMB, and 0 in PNB last autumn. The distribution of survey effort and observed redds were mapped for the entire GOMDPD (Figure 2.4.1.1). The geolocation of redds in 2018 are used to document Wild Production Areas (WPA) of the 2019-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 2019 to minimize competition between wild and hatchery origin juveniles. In addition, in 2021 these areas will be targeted for broodstock electrofishing efforts in efforts to bring components of wild spawning into the captive reared brood program.

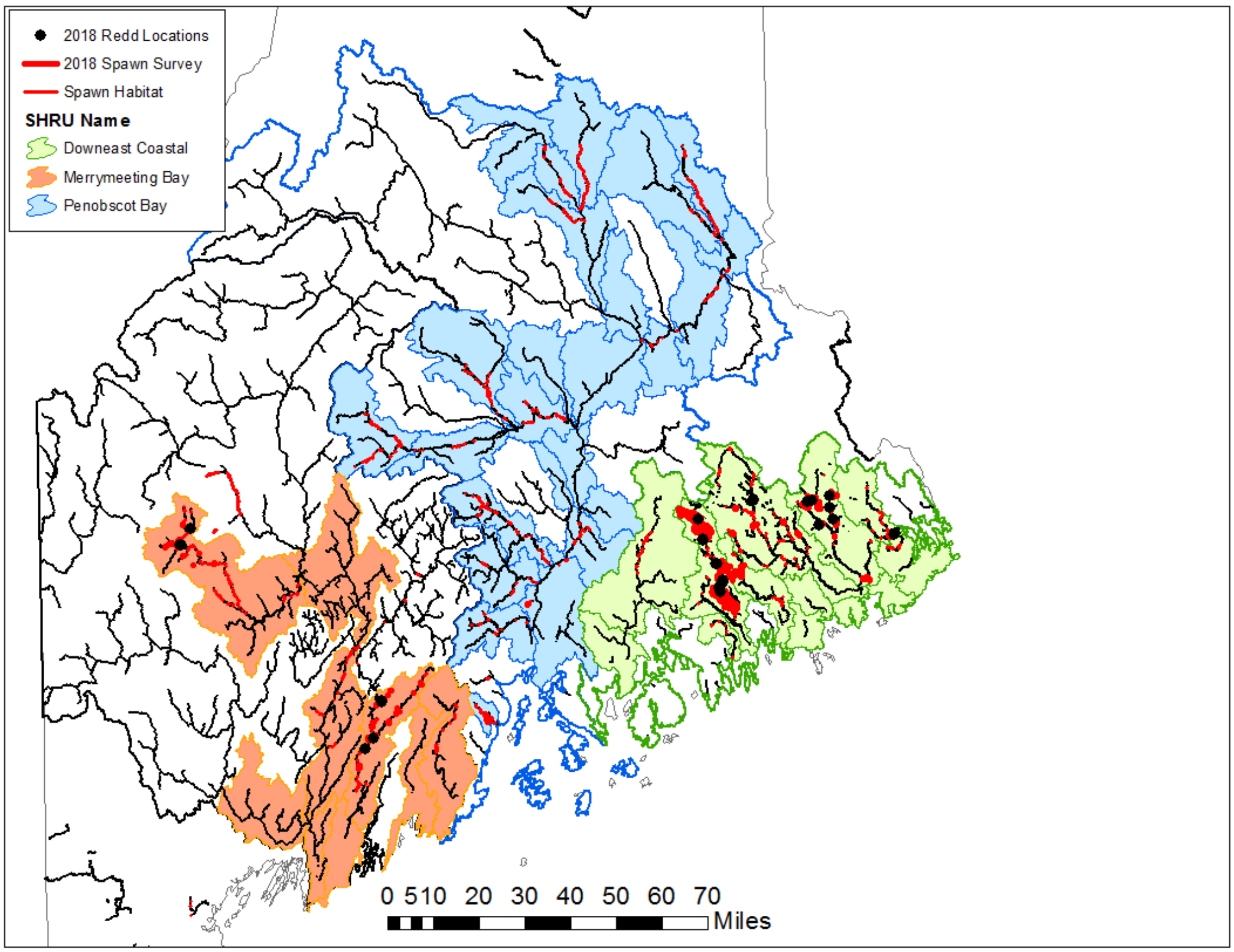

Figure 2.4.1.1 Map highlighting river habitat (thin black lines), mapped spawning habitat (thin red lines), and location of Atlantic salmon redds (black dots) documented in spawning habitat surveyed in 2018 (thick red lines).

2.4.2 Hatchery Production Units – 2018 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 2018 assessment, we summarized occupied habitat in a composite map that illustrates production by both natural redds and stocking (Figure 2.4.2.1). This was first presented in the 2017 assessment as a pilot analysis. Using this method, we estimate that the 2018 cohort occupied a total of 19% of available juvenile production areas in critical habitat (Table 2.4.1.1). This is an increase of 5% over 2017 cohort estimates. Occupancy is estimated by geospatial documentation of both wild production for the 2018 cohort (2017 Spawners) and stocking and documented dispersal rate. We will continue developing these metrics in the future. Steps will include assessing the relative intensity of WPA in a more quantitative manner by refining dispersal models. Similar baselines will be refined 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 both occupancy and the amount of vacant CH (vacant CH = total CH – WPA – EPA- FPA-PPA). These values 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.

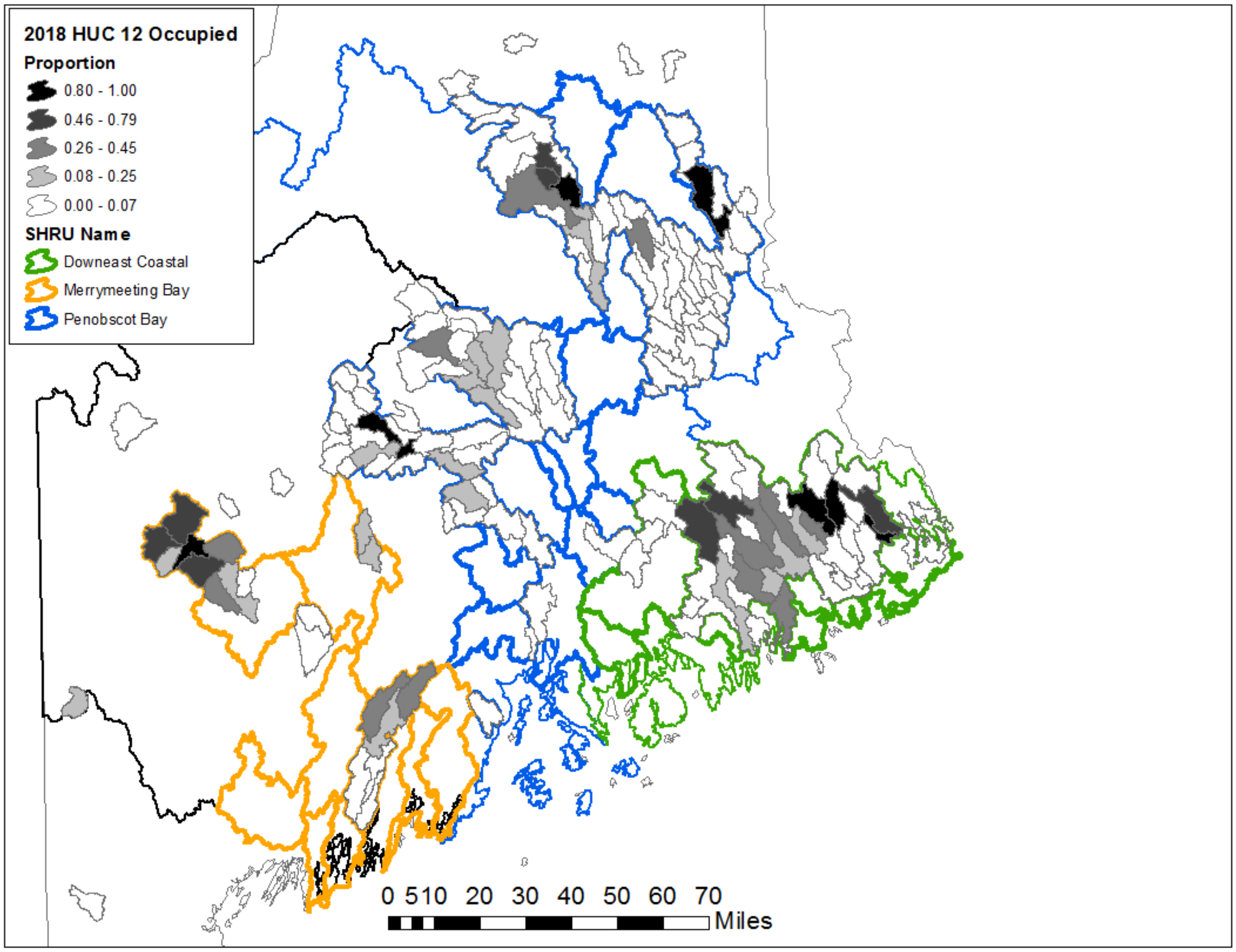

Figure 2.4.2.1. Map highlighting the relative proportion of river habitat occupied (see figure legend) by the 2018 cohort at a HUC-12 watershed summary level. Production is a synthesis of modeled distributions from spawning surveys of Atlantic salmon in 2017, fall 2017 egg planting, and 2018 fry and parr stocking.

Table. 2.4.1.1. Estimate of total habitat units (100 m^2) occupied by wild and stocked Atlantic salmon in the 2018 cohort.

SHRU	Total Habitat (# HUC 12 Units)	Habitat Occupied by 2018 Cohort	Percent of Total Habitat
DEC	41,738 (40)	9,029	0.22
MMB	32,618 (23)	11,255	0.35
PNB	132,983 (90)	19,611	0.15
Total	207,339 (153)	39,895	0.19

2.5 Genetic Diversity

As part of the Atlantic salmon recovery program, maintenance of genetic diversity is a critical component of the process. Genetic diversity for the Atlantic salmon program is monitored through assessment of collected broodstock from the wild, which represent both individuals from natural reproduction and stocked individuals from the hatchery. Identification of origin (hatchery or wild) is determined through genetic parentage analysis. Therefore, estimates of these two groups combined represent the total genetic diversity present in the various populations monitored.

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 N_e, 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 Ne 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 a 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 Ne 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 (Figure 2.5.1). 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. Evaluating allelic diversity based on 18 loci, between 2008 and 2016 collection years (or 2018 if considering the Penobscot), the average number of alleles per locus ranged from 10.67 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. For the 2016 collection year parr broodstock and 2018 collection year Penobscot adult returns, average estimates starting in 2008 of expected heterozygosity based on 18 microsatellite loci ranged from 0.672 in the Dennys to 0.688 for the Penobscot. Observed heterozygosity estimates based on 18 loci ranged from 0.687 in the Dennys to 0.703 in the both the Penobscot and Sheepscot broodstocks.

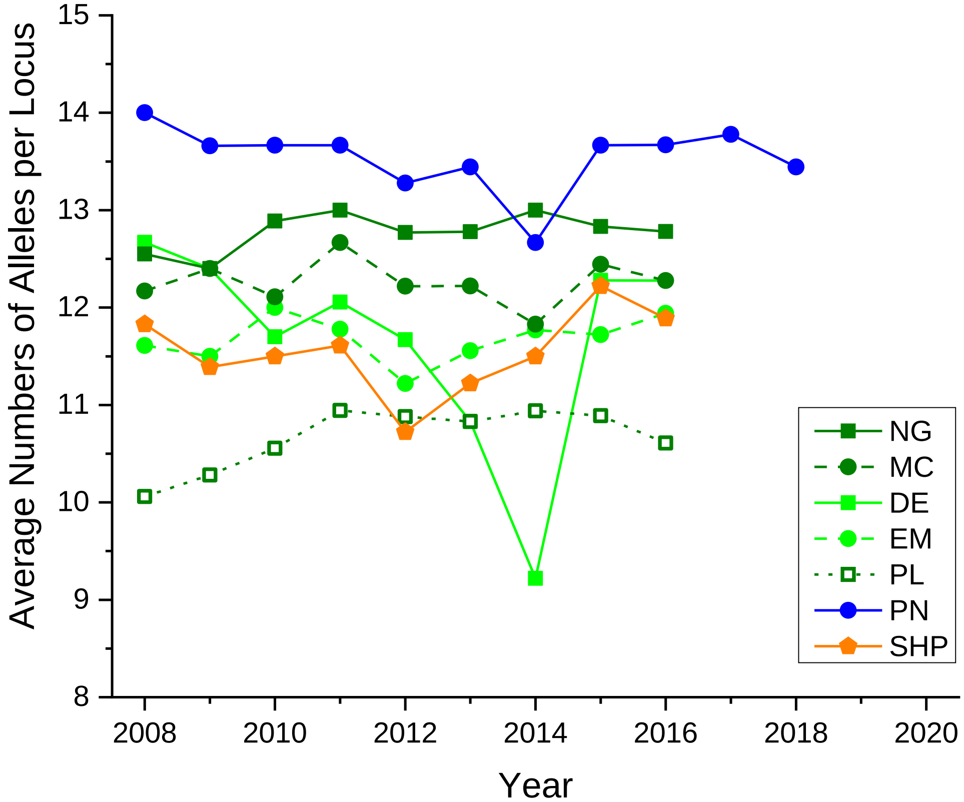

Figure 2.5.1.1. Allelic diversity time series for GOMDPS salmon populations, measured from 18 microsatellite loci.

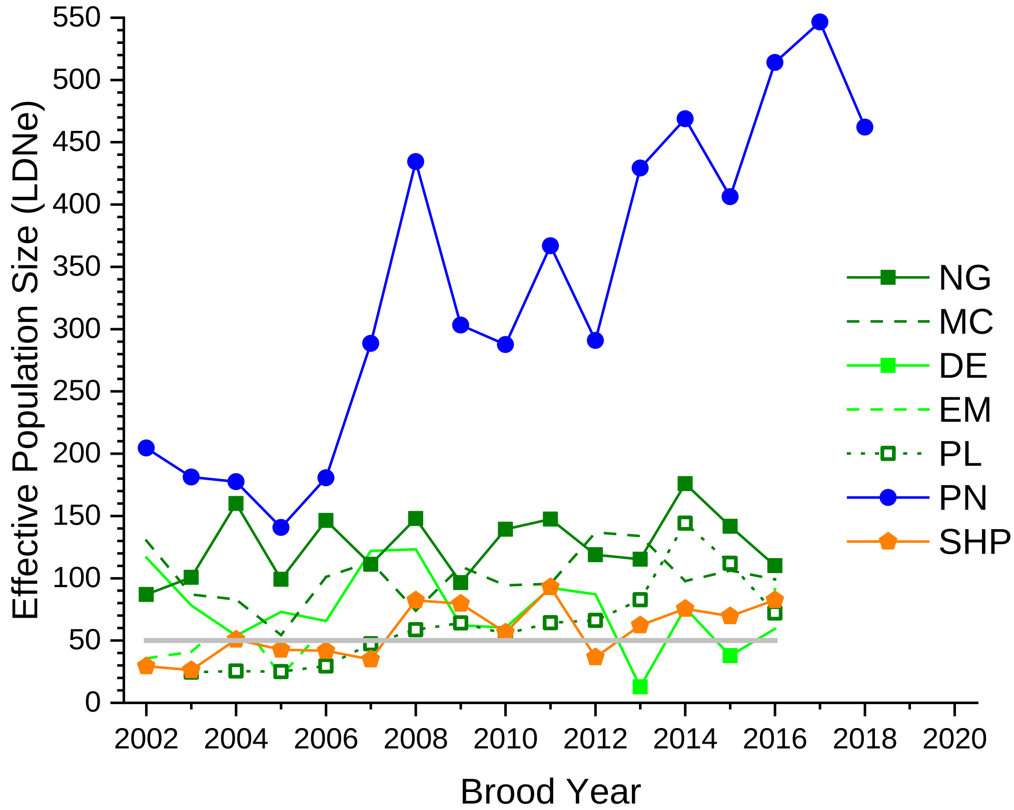

Figure 2.5.1.2. Time series of effective population size for 7 GOMDPS distinct individual populations. Estimates for the parr-based broodstock populations approximate the number of breeders, since estimates are obtained from primarily a single cohort, and are sampled as juveniles (parr), from each river. Estimates of effective population size for the Penobscot broodstock are obtained from returning adults in a given year to the Penobscot River, and represent multiple cohorts.

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 from the 2016 collection year was estimated for the Dennys broodstock (Ne=59.5, 57.2-61.8 95% CI), and the highest was observed in the Narraguagus broodstock (Ne=110.1 (103.6-117.2 95% CI). Ne estimates fluctuated annually, so beginning with 2008, average Ne across the parr-based broodstocks ranges from Ne=69.0 in the Dennys to Ne=132.8 in the Narraguagus. Within the Penobscot River, adult broodstocks typically include three to four year classes (including grilse). Ne estimates for the Penobscot since 2008 have ranged from Ne=546.5 (465.8-650.7 95% CI) in 2017 to Ne=287.6 in 2009 (265.7-312.0 95% CI), with an average Ne=410.00.

2.5.4 Inbreeding Coefficient

Inbreeding coefficients are an estimate of the fixation index. Estimates in the 2016 parr collection year ranged from -0.025 in the Sheepscot River to -0.054 in the East Machias. The 2018 collection year for the Penobscot had an estimated inbreeding coefficient of -0.037.

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 as measured by allelic variability is being maintained since the start of consistent genetic monitoring in the mid 1990's, although there are concerns about slightly lower estimates of allelic diversity in the East Machias and Pleasant relative to the other broodstocks. Implementation of pedigree lines in the past to retain representatives of all hatchery produced families helped to limit loss of diversity resulting from a genetic bottleneck in the Pleasant River, as well as active management to limit loss of diversity through stocking and broodstock collection practices. 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

Two sea-run Atlantic salmon adults were observed returning to the Connecticut River watershed, both at the Holyoke Dam Fishlift on the Connecticut River mainstem. No fry were stocked upstream of Holyoke after 2013 so either these fish went out as smolts older than two years or these fish originate in Connecticut streams and strayed to the mainstem. Neither salmon was retained for broodstock at any facility but were allowed to proceed upstream. They were not seen at the next upstream fishway nor anywhere else.

Due to the fact that neither salmon were handled and scale-sampled, it is not possible to determine their ages. Both were of multi-year salmon size and based on runs of past years, these fish were considered to be WX:2 fish.

3.1.2 Hatchery Operations

A total of 738,071 green eggs was produced. Only the Kensington State Fish Hatchery (KSFH) in CT maintained domestic broodstock. Contributing broodstock included 128 females and 126 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

3.1.3.1 Juvenile Atlantic Salmon Releases

A total of 197,175 juvenile Atlantic Salmon was stocked into the Connecticut River watershed, all in Connecticut. Selected stream reaches in the Farmington River received 110,134 fed fry and selected reaches in the Salmon River received 87,041 unfed fry with the assistance of many volunteers. These numbers were similar the fry stocked in 2017. 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 11,200 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.

3.1.3.2 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

3.1.4.1 Smolt Monitoring

No smolt migration monitoring was conducted anywhere in the basin. Smolt counts were attempted at the viewing window at the Rainbow Dam Fishway (Farmington River) but no smolts were observed.

3.1.4.2 Index Station Electrofishing Surveys

Due to high stream flows and staff limitations, no electrofishing surveys of juvenile salmon populations were conducted in 2018.

3.1.5 Fish Passage

3.1.5.1 Hydropower Relicensing-

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.

3.1.5.2 Fish Passage Monitoring-

Salmonsoft® computer software was again used with lighting and video cameras to monitor passage at Turners Falls, Vernon, Bellows Falls, Wilder, Rainbow and Moulson Pond fishways. The software captures and stores video frames only when there is movement in the observation window, which greatly decreases review time while allowing 24h/d passage and monitoring.
New Fishways – No new fishways were constructed.

3.1.5.3 Dam Removals-

One dam was removed in the watershed: the Blackledge River Dam in Glastonbury, CT. This was the last major dam in the Salmon River drainage. The Blackledge River continues to be stocked with salmon fry as part of the Legacy Program.

3.1.5.4 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 11,200 eggs for 81 tanks in 62 schools in 40 towns in Connecticut. An estimated 4,000 students participated.

A total of 1,000 0+ parr from KSFH were provided to Dr. Steve McCormick of the Silvio Conte Anadromous Research Center in Turners Falls, MA to support Atlantic Salmon research.

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. 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 142,000 eggs from USFWS Nashua NFH. Of those eggs, 6,000 went to the Salmon in the Classroom Program, the survivors of which and were stocked as fry. The balance of the eggs were retained in a hatchery by the Rhode Island DEM and were intended for the production of smolts. However, a power failure in August resulted in a loss of most of the fry in the hatch house. Less than 1,000 remain for rearing as future broodstock.

3.2.3 Stocking

A total of 10,000 smolts were stocked into the watershed. A total of 5,100 fry was stocked into the Wood-Pawcatuck drainage.

3.2.4 Juvenile Population Status

No electrofishing surveying of Atlantic salmon was reported.

3.2.5 Fish Passage

No additional work in 2018.

3.2.6 Genetics

There is no broodstock program and no genetics work has been conducted.

3.2.7 General Program Information

No information to add.

3.2.8 Migratory Fish Habitat Enhancement and Conservation

There have been many fish passage projects conducted on this river in recent years, including the removal of two dams and the construction or improvement of three fishways. The Conte Anadromous Fish Research Center and other partners are tagging American Shad to study the effectiveness of fish passage at existing and former dam sites and the results will be relevant to the movement of Atlantic Salmon.

4 Central New England

4.1 Merrimack River

4.1.1 Adult Returns

Two (2) suspected sea-run 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. A total of seven (7) fish were counted at the viewing window, two had observed adipose clips (suspected sea returns stocks out as parr or smolts), three had adipose fins, and two were not recorded. The fish with adipose fins could have been domestics stocked in the river or may have been sea-run wild fish. With limited morphometric data, origin was not known, 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 focused the primary effort of Nashua National Fish Hatchery to the Saco River program. In 2018, 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 2018 provided an estimated 1,023,397 green eggs.

Sea-Run Broodstock

No sea-run fish were retained for broodstock.

Domestic Broodstock

A total of 264 three years old females (F2 from sea-runs) broodstock were spawned at Nashua NFH. The captive broodstock spawning season began on October 31, 2018 and ended November 14, 2018, and include 3 spawning events to reach target eggs production.

Due to the U.S. Federal government shutdown there was no participation in Adopt-A-Salmon Family Program for 2018-2019. Juvenile stocking is typically limited to educational "salmon in schools" programs. In 2018 a surplus of Merrimack Broodstock eggs of 142,350 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 2018, 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 substantially increase. 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. Gravid broodstock (in excess of the need under the Saco River agreement) and small amounts of fry used in the "salmon in schools" program are still stocked in the Merrimack. Some natural reproduction is likely occurring where fish can access suitable spawning habitat.

Atlantic salmon Broodstock Sport Fishery

NHFG had their last licensed recreational fishery for adult Atlantic salmon in the spring of 2014. Adult fish were stocked in April of 2018 (1,220 2+, 658 3+ and 16 4+ fish) into the Merrimack and spent broodstock were stocked out in December of 2018 (total of 791 3+). These fish have been classified as recreational/restoration, as there is some potential that they could produce some restoration benefit.

Adopt-A-Salmon Family

Due to the US Federal government shutdown there was no participation in Adopt-A-Salmon Family Program for 2018-2019. Typically, schools incubated eggs in the classroom and released fry into tributaries in late spring and early summer. The program is typically conducted by a core group of dedicated volunteers with assistance from USFWS staff.

Central New England - Integrated ME/NH Hatchery Production

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

4.2 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, 2018. 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, 2018. A total of three Atlantic salmon returned to the Saco River for the 2018 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 2018, 591,013 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 356,172 fry reared at the Saco Salmon Restoration Alliance, were released into one mainstem reach and 37 tributaries of the Saco River. In 2018 the Saco Salmon Restoration Alliance planted 70,300 eyed-eggs in five 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 four electrofishing surveys in the Saco River watershed in 2018. These surveys were conducted to follow up on egg planting activities conducted over the past several years.

Smolt Monitoring

There was no smolt monitoring in 2018.

Tagging

No salmon outplanted into the Saco were tagged or marked in 2018.

4.2.5 Fish Passage

No reported changes in fish passage.

4.2.6 Genetics

No genetic samples were collected in 2018.

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.

4.2.8 Migratory Fish Habitat Enhancement and Conservation

No habitat enhancement or conservation projects directed solely towards Atlantic salmon were conducted in the watershed during 2018.

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 2018 were 862. Returns are the sum of counts at fishways and weirs (826) and estimates from redd surveys (36). 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. Conditions improved for adult dispersal through drainages but fall spawner surveys were hampered by first high discharge and then unseasonably cold temperature that resulted in ice conditions. These factors severely reduced the coverage of all spawner surveys.

Escapement to these same rivers in 2018 was 406 (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). High water conditions and early ice-in impaired spawner surveys by reducing visibility and reducing overall coverage.

Table 5.1 Table of Sea-run returns versus escapement.

Drainage	Returns	Brood Stock	DOA	Escapement
Androscoggin	1	0	0	1
Kennebec	11	0	0	11
Narraguagus	42	0	0	42
Penobscot	772	455	1	316
Union	0	0	0	0
Redds Estimate	36	N/A	N/A	36
	862	455	1	406

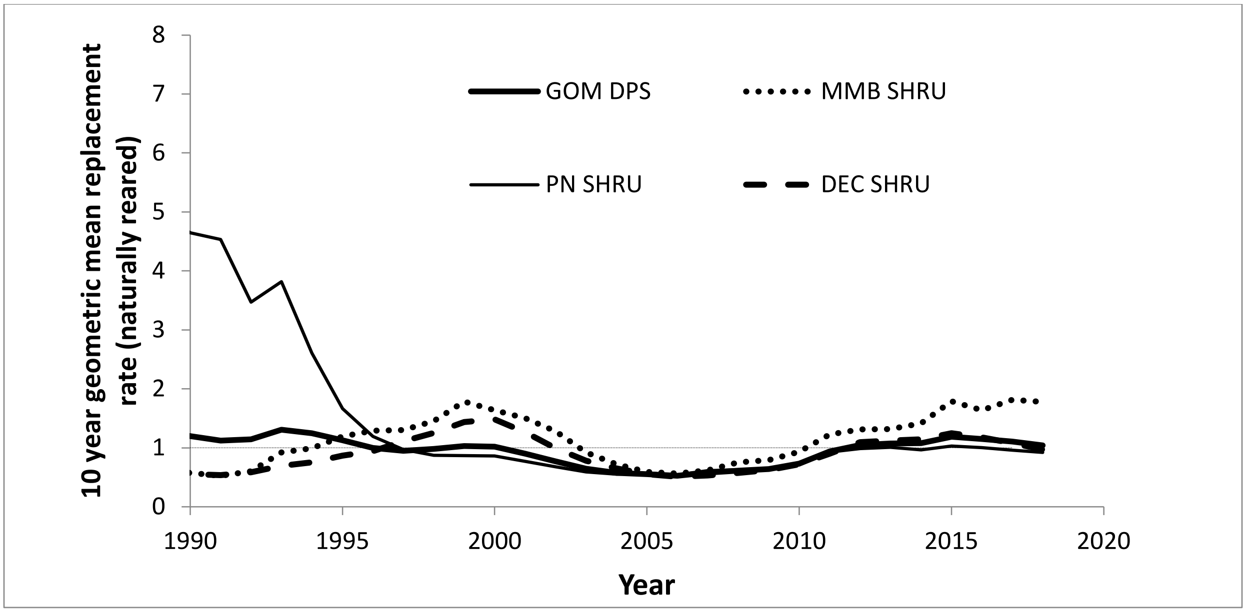

Figure 5.1. Ten-year geometric mean of replacement rate for returning naturally reared Atlantic salmon in the GOM DPS and the three Salmon Habitat Recovery Units (SHRU).

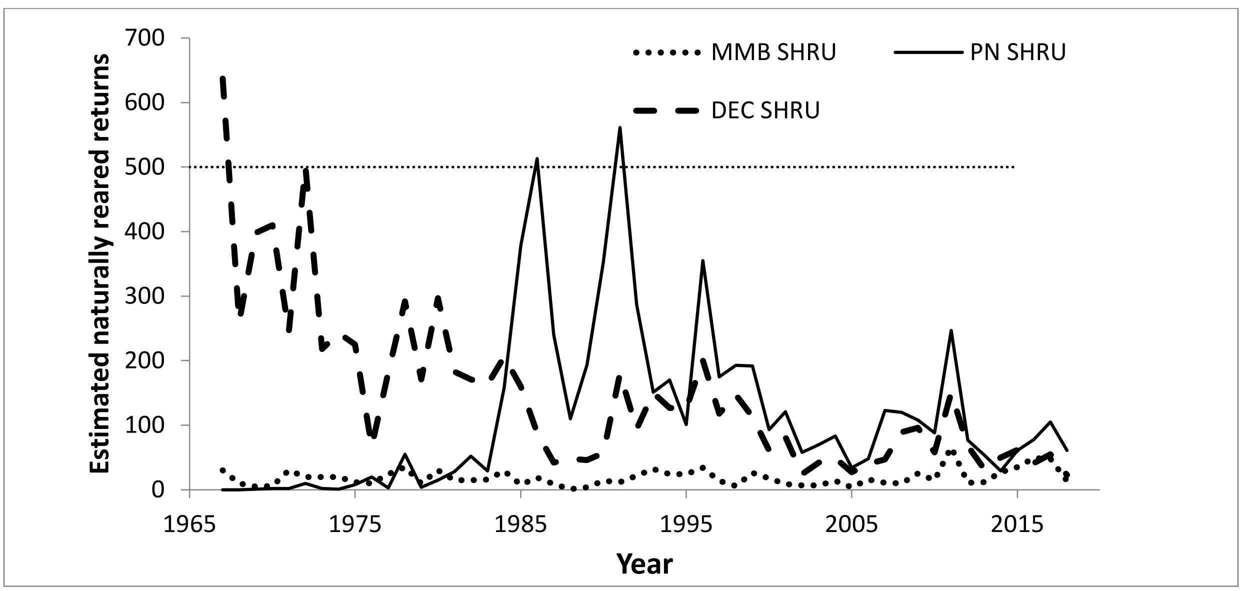

Figure 5.2 Estimated Naturally Reared Returns to the GOM 1965 to 2018

5.1 Adult returns and escapement

5.1.1 Merrymeeting Bay

Androscoggin River

The Brunswick fishway trap was operated from 23 April to 1 November (Table 5.1.1) by a combination of MDMR and Brookfield Renewable Partners (BRP) staff. one adult Atlantic salmon was 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 BRP staff from 9 May to 31 October (Table 5.1.1). Eleven 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 11 returning Atlantic salmon, 8 (72.7%) were 2SW and 3 (27.3%) were grilse (1SW). one salmon was of hatchery origin and 10 were naturally reared in origin. Five of the returning salmon were transported to the Sandy River Drainage and released. The remaining 6 were radio tagged and released below the Lockwood Dam for research related to an assessment of energetic impacts resulting from passage delays conducted by the University of Maine. Of these six salmon, 4 were recaptured and also released into the Sandy River sub-drainage. All stocking and translocation of salmon in the Kennebec River drainage occur in the Sandy River. The 11 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 1.2% of known spawning habitat primarily within the Sandy sub-drainage. Three redds were observed in the Sandy River and 1 in Togus Stream for a total of 4 redds in the Kennebec Drainage.

Sebasticook River at Benton Falls fish lift facility was operated by MDMR staff from 01 May to 12 November, 2018. No Atlantic salmon were captured (Table 5.1.1).

Sheepscot River

There were 11 redds observed in the Sheepscot River; nine were observed in the mainstem and two were observed in the West Branch. The nine redds in the mainstem likely were made by captive reared gravid adults released in October. A total of 53% (13.93km) of known spawning habitat was surveyed in the Sheepscot River drainage; Based on the Returns to Redds Model, between 2 and 11 with a mean of 6 salmon returns were estimated.

5.1.2 Penobscot Bay

Penobscot River

Penobscot River

The fish lift at the Milford Hydro-Project, owned by BRP, was operated daily by MDMR staff from 19 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, BRP 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 772 sea-run Atlantic salmon returned to the Penobscot River (Table 5.1.1). Scale samples were collected from 580 salmon captured in the Penobscot River and analyzed to characterize the age and origin structure of the run. In addition, video monitoring in conducted at the Milford Dam to aide in counts when environmental conditions warrant reduced handling, i.e. warm water temperatures. The origins of the video counted and trapped Atlantic salmon that were not scale sampled were prorated based on the observed proportions, considering the size, presence of tags or marks observed and dorsal fin deformity. Of returning salmon, 479 were age 2SW (62%), 291 were age 1SW (37%), and one was a repeat spawner (<1%). Approximately 92% (711) of the salmon that returned were of hatchery origin and the remaining 8% (61) were of wild or naturally reared origin. No aquaculture suspect salmon were captured.

Redd surveys in the Penobscot Drainage were limited to the Piscataquis sub-drainage. In the Piscataquis, less than 1% (0.37km) of the spawning habitat in the Pleasant River was surveyed and zero redds were observed (Table 5.1.2).

Ducktrap River

In the Ducktrap River spawner surveys covered 71% (2.73km) of the available spawning habitat. Zero redds were observed (Table 5.1.2).

Cove Brook

Zero redds were observed in Cove Brook. Surveys covered 28% (0.74km) of spawning habitat.

Souadabscook Stream

Zero redds were observed in the Souadabscook Stream survey which covered 0.2 km of known spawning habitat.

5.1.3 Downeast Coastal

Dennys River

There were 3 redds surveyed in the Dennys River in 2018. Surveys covered only 26% of the habitat and 16.7 km of stream. Based on the Returns to Redds Model, estimated escapement was between 3 and 14 with a mean of 7 salmon.

East Machias River

Ten redds were counted during the 2018 redd surveys covering approximately 96% (17.96km) of known spawning habitat. This was the third 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, estimated escapement was between 6 and 28 with a mean of 14 salmon.

Machias River

A total of four redds were counted. Surveys covered 8.4% of the habitat and 6.77 km of stream. Based on the Returns to Redds Model estimated escapement was between 4 and 17 with a mean of 9 salmon.

Pleasant River

Zero redds were observed. Surveys covered 35% of the habitat and 5 km of stream.

Narraguagus River

Returns to the fishway trap (42) were higher than 2017 (36). This was the first year of 2SW salmon returns from hatchery smolt released in 2016. Hatchery origin grilse (20) represented 48% of the total returns to the Narraguagus. Naturally reared returns were down from 2017 with both grilse and 2SW returns. Redd surveys accounted for 16 redds with surveys covering 69% 42.06 km) of known spawning habitat.

Union River

The fish trap at Ellsworth Dam on the Union River is operated by the dam owners, BRP, under protocols established by the DMR. The trap was operated from 3 May to 31 October 2018. No Atlantic salmon were captured during this period.

Table 5.1.1 Counts of sea-run, Atlantic salmon returns to Maine rivers in 2018 by gender and sea-age (One sea-winter, 1SW; two sea-winter, 2SW; three sea-winter, 3SW; multi sea-winter, MSW; and repeat spawner, RPT). Also included are counts of aquaculture (AQS) and captive reared freshwater (CRF) adults captures. Drainages are grouped by Salmon Habitat Recovery Unit (SHRU).

				Male				Female				Unknown		Adult Counts		
River	Open Date	Median Catch Date	Close Date	1SW	2SW	3SW	RPT	1SW	2SW	3SW	RPT	1SW	MSW	Sea-run	AQS	CRF
Downeast Coastal SHRU																
Narraguagus River	30 Apr	24 Jun	26 Oct	20	14	0	0	0	6	1	0	1	0	42	0	43
Union River	03 May	-	31 Oct	0	0	0	0	0	0	0	0	0	0	0	0	0
Penobscot Bay SHRU																
Penobscot River	19 Apr	02 Jul	15 Nov	291	175	0	0	0	285	0	2	0	19	772	0	0
Merrymeeting Bay SHRU																
Lower Kennebec River	09 May	05 Jun	31 Oct	3	3	0	0	0	5	0	0	0	0	11	0	0
Lower Androscoggin R.	23 Apr	03 Jun	01 Nov	0	0	0	0	0	1	0	0	0	0	1	0	0
Sebasticook River	01 May	N/A	12 Nov	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	--	--	--	314	192	0	0	0	297	1	2	1	19	826	0	43

Table 5.1.2 Results of redd surveys by drainage and stream for 2018. Effort is shown by both total kilometers and the proportion of drainage 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	3	26.1	16.7	Cathance Stream	3	15.14
					Dennys River	0	1.56
	East Machias	10	96.18	17.96	Barrows Stream	1	2.16
					Beaverdam Stream	0	2.68
					Chase Mill Stream	0	2.13
					East Machias River	4	6.35
					Northern Stream	4	3.89
					Seavey Stream	1	0.75
	Machias	4	8.39	6.77	Crooked River	0	2.57
					Machias River	4	0.3
					Mopang Stream	0	0.78
					New Stream	0	1.1
					Old Stream	0	1.02
					West Branch Machias River	0	1
	Narraguagus	16	69.4	42.06	Baker Brook	0	0
					Bog Brook	0	0
					Narraguagus River	16	42.06
	Pleasant	0	34.71	4.95	Eastern Little River	0	0
					Pleasant River	0	4.95
Merrymeeting Bay	Lower Andro.	0	0	0.07	Little River	0	0.07
	Lower Kennebec	4	2.53	12.1	Avon Valley Brook	0	0.04
					Barker Brook	0	0.14
					Bond Brook	0	3.69
					Cottle Brook	0	0.07
					Mt Blue Stream	0	0.18
					Orbeton Stream	0	1.09
					Perham Stream	1	0.48
					Saddleback Stream	0	0.31
					Sandy River	2	2.23
					South Branch Sandy River	0	0.36
					Togus Stream	1	3.51
	Sheepscot	11	53.29	13.93	Sheepscot River (captive origin)	9	8.03
					West Branch Sheepscot River	2	5.9

	Ducktrap	0	71.03	2.73	Ducktrap River	0	2.73
	Mattawamkeag	0	0	0	East Branch Mattawamkeag River	0	0
Penobscot	Penobscot	0	0.28	0.94	Cove Brook	0	0.74
					French Stream	0	0
					Great Works Stream	0	0
					Kenduskeag Stream	0	0
					North Branch Marsh Stream	0	0
					Pollard Brook	0	0
					Souadabscook Stream	0	0.2
	Piscataquis	0	0.05	0.37	East Branch Pleasant River	0	0
					Middle Branch Pleasant River	0	0
					Piscataquis River	0	0.37
					Pleasant River	0	0
					West Branch Piscataquis River	0	0
					West Branch Pleasant River	0	0
	Total Redds	48	Total River KM	118.58			

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 returns based on redd counts for the small coastal rivers was between 19 and 90 adults with a total estimate of 36 (Table 5.1.3).

Table 5.1.3. Redds based regression estimates and confidence intervals of total Atlantic salmon escapement to the Dennys, East Machias, Machias, Pleasant, Ducktrap and Sheepscot Rivers for 2018 based on 1,000 iterations of the model. The table includes the pro-rated break out of age and origins. Proration based on adult and smolt counts at traps in drainage or in neighboring drainages.

Year	Drainage	Mean	sdev	Lowq5%	Upperq95%	W1SW	W2SW	H1SW	H2SW
2018	Cove Brook	0	0	0	0	0	0	0	0
2018	Dennys	7	4	3	14	1	6	0	0
2018	Ducktrap	0	0	0	1	0	0	0	0
2018	East Machias	14	7	6	27	0	2	2	10
2018	Machias	9	5	4	18	2	7	0	0
2018	Pleasant	0	0	0	1	0	0	0	0
2018	Sheepscot	15	7	6	29	1	2	1	2

5.2 Juvenile Population Status

Juvenile abundance estimate

A total of 235 sites (Figure 5.2.1) were surveyed in 2018 using a combination of single pass and multi-pass removal techniques. Of these, 123 sites were used to track status and trends. They were selected using the Geographic Randomized Tessellation Stratification (GRTS) technique (Stevens & Olsen, 2004). Additional electrofishing efforts were used to evaluate hatchery products, habitat improvements and parr brood stock collections. A list of survey types for each drainage is presented in Table 5.2.1.

For this report an annual weighted estimate of abundance was calculated for the Narraguagus, East Machias, Sheepscot, Sandy, Piscataquis, Mattawamkeag, and Ducktrap Rivers based on sites selected using the GRTS process. Using the habitat model developed by (Wright, Sweka, Abbott, & Trinko, 2008) as a sampling frame, each habitat segment in a drainage is broken into four stream width categories to be used as strata for the weighting process. The width categories are “A” 0-6 m, “B” 6-12 m, “C” 12-18 m, and “D” >18 m. Weighting is based on the total potential sites by width class in a drainage divided by the number of sites sampled. This ratio is used to weight CPUE within width classes to estimate abundance for the entire drainage. In Figure 5.2.2, a summary of weighted CPUE is presented across the eight years the GRTS process has been used. Fig 5.2.2 illustrates trends across drainages. This estimate will continue to be refined and may be utilized to connect to previous trend analyses to continue the record of historical abundances. Next steps include refining the survey selection and examining the effect stocking rates have on subsequent abundance.

Table 5.2.1. Summary of electrofishing effort within the Gulf of Maine DPS in 2018. Four sites were surveyed outside the DPS in the Saco Drainage in support of egg planting activities.

SHRU	Drainage	Brood stock	Culvert	Egg Planting	EMARC Fall Parr	Genetics	GRTS	LW / PALS	Population Estimate	Presence / Absence	Totals
Downeast Coastal	Dennys	1									1
	East Machias	2			12		11			4	29
	Machias	3		3							6
	Narraguagus						12	4			16
	Pleasant	2									2
Merrymeeting Bay	Lower Kennebec						34		23	4	61
	Sheepscot	11					12			1	24
Penobscot	Ducktrap					1	7			2	10
	Mattawamkeag						8			3	11
	Penobscot			23			4				27
	Piscataquis	2	1	2			29			12	46
	Western Penobscot Bay Coastal									2	2
	Totals	21	1	32	12	1	117	4	23	28	**235**

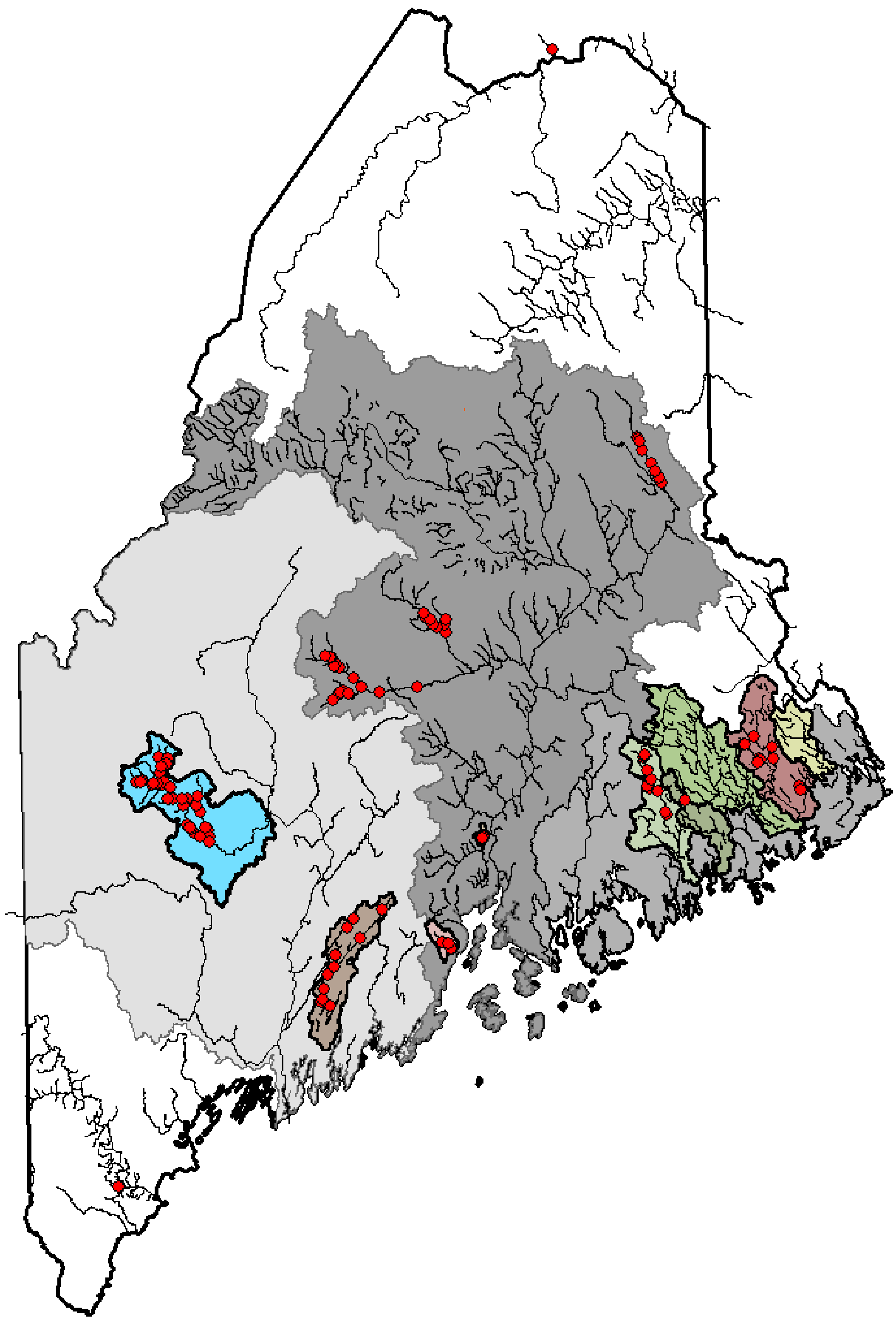

Figure 5.2.1. Location of sites surveyed in 2018 selected using the GRTS method.

Figure 5.2.2. Annual Weighted estimates of abundance across drainages for sites selected using the GRTS methods.

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 6,982 smolts were unique captures at all sites between 21 April and 3 June 2018 (Table 5.2.3).

MDMR scientists calculated population estimates using Darroch Analysis with Rank Reduction (DARR) 2.0.2 for program R (Bjorkstedt, 2005, 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 1,049 ± 186. The hatchery population estimate was estimated to be 1,043 ± 201. 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 1,652 ± 357. The hatchery population estimate was calculated to be 587 ± 122. The naturally reared population estimate was calculated to be 883 ± 220. A two-site mark-recapture design was used on the Narraguagus River, which continued smolt assessments for the 22nd consecutive year on this river. The naturally reared population estimate was 604 ± 121. Estimation of the hatchery origin age 1 smolt component of the population was not attempted in 2018. 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, 2018.

River	Dates Deployed		Origin	Total Captures	First Capture	Median Capture Date	Last Capture
East Machias	18-Apr	*8-Jun*	H	187	21-Apr	10-May	3-Jun
			W	11	3-May	11-May	3-Jun
Narraguagus	23-Apr	29-May	H	6,382	25-Apr	11-May	26-May
			W	173	2-May	8-May	24-May
Sheepscot	22-Apr	30-May	H	107	1-May	15-May	26-May
			W	121	1-May	9-May	22-May
Total				6,981			

Table 5.2.4. Maximum likelihood mark-recapture population estimates for naturally reared and hatchery origin Atlantic salmon smolts emigrating from Maine rivers, 2018.

River	Estimate Type	Origin	Population Estimate
East Machias	One site	Hatchery	1,043 ± 201
		Naturally reared	n/a
		Both	1,049 ± 186
Narraguagus	Two site	Hatchery	n/a
		Naturally reared	604 ± 121
Sheepscot	One site	Hatchery	587 ± 122
		Naturally reared	883 ± 220
		Both	1,652 ± 357

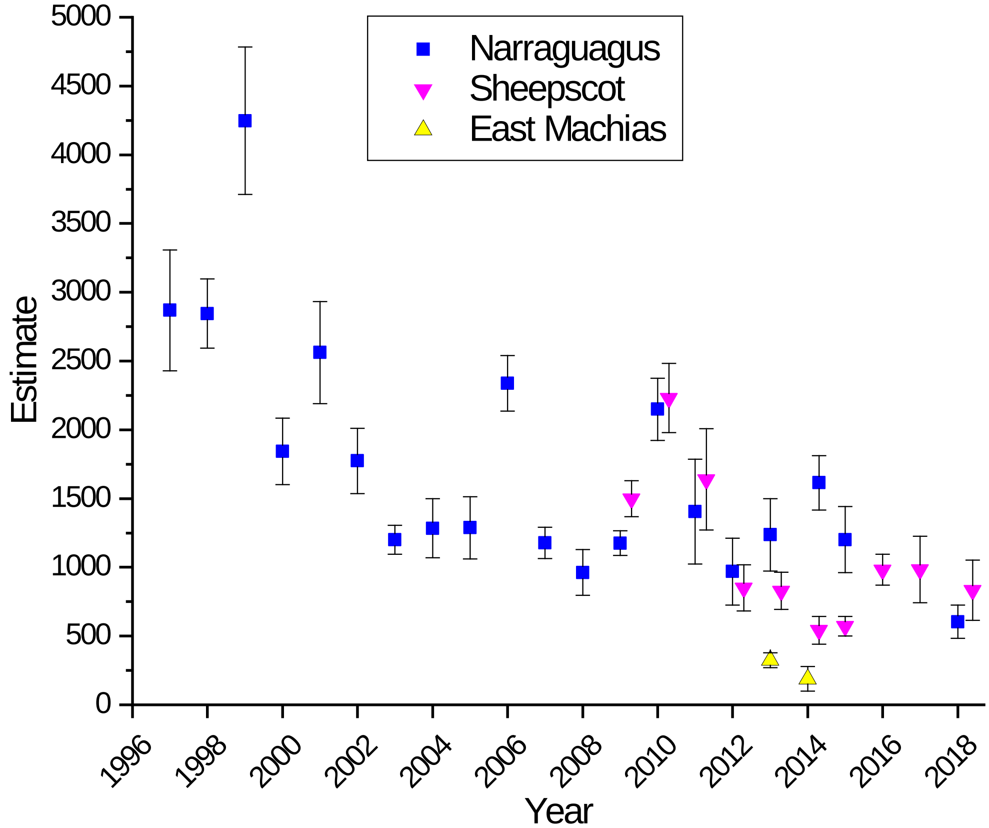

Figure 5.2.3. Population Estimates (± Std. Error) of emigrating naturally-reared smolts in the Narraguagus (no estimate in 2016 and 2017), Sheepscot, and East Machias (no estimate 2015-2018) rivers, Maine, using DARR 2.0.2.

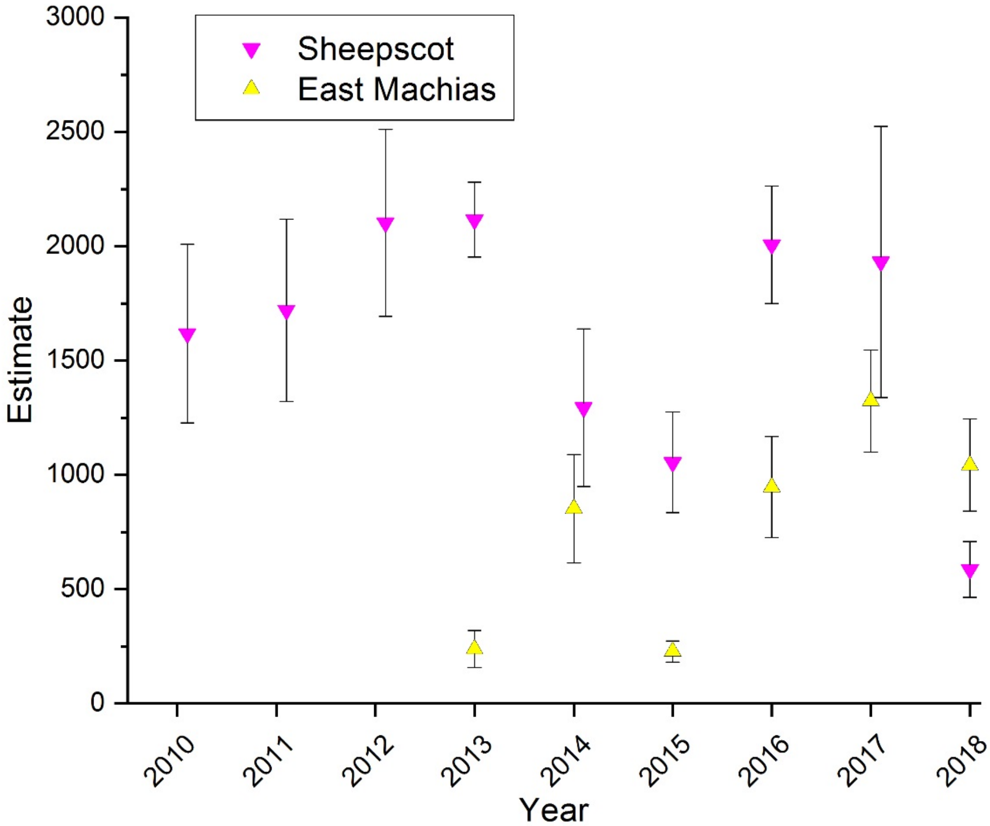

Figure 5.2.4. Population Estimates (± Std. Error) of emigrating hatchery-origin smolts stocked as fall parr in the Sheepscot and East Machias rivers, Maine, 2010-2018, using DARR 2.0.2.

References:

Bjorkstedt, E. P. (2005). NOAA Technical Memorandum NMFS JANUARY 2005 DARR 2 . 0 : UPDATED SOFTWARE FOR ESTIMATING ABUNDANCE FROM STRATIFIED MARK-RECAPTURE DATA. *Administrator*, (January).

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5.3 Fish Passage and Migratory Fish Habitat Enhancement and Conservation

In the Spring of 2018, MDMR staff assisted the USGS Cooperative Fisheries and Wildlife Unit in radio-tagging adult Atlantic salmon to assess upstream migration timing of adult Atlantic salmon in the Penobscot River. Adult Atlantic salmon were collected by MDMR at the Milford Dam Fish Lift Sorting Facility. Twenty-Nine Atlantic salmon were tagged between 21 May and 1 June. Each adult Atlantic Salmon was equipped with Lotek MCFT2-3L radio tags that were implanted gastrically, and was also PIT-tagged by MDMR staff. Tagged salmon were transported approximately 18.5 Km downstream to the Brewer Boat Launch and released to assess upstream migration timing. After release, the tagged salmon were tracked using stationary radio receivers, biweekly mobile tracking, and PIT arrays located at the entrances and exits of fishways on dams in the mainstem Penobscot, Piscataquis, and Passadumkeag rivers. Preliminary data show that twenty-seven of these fish re-ascended Milford and were then released upstream. Eighteen of these fish ascended the Howland bypass, and two were detected below Weldon Dam, though they did not appear to pass. In addition to the USGS study fish, MDMR staff PIT tagged 564 salmon throughout the trapping season during daily tending at the Milford Dam Sorting Facility. Of these, some contributed to upstream passage studies. Data from these fish will also be incorporated into information on the numbers of salmon using various reaches in the Penobscot drainage and the assessment of fish passage effectiveness. USGS is currently in the process of analyzing data, and should soon know how many salmon were detected on the PIT arrays. USGS will calculate movement rates for each Atlantic salmon between dams.

In addition to the above-mentioned migration timing study, a complementary group of salmon were tagged to attempt to characterize specific energetic costs of delays to upstream migrating adult salmon using bioenergetics modeling. Upstream migrating adult Atlantic salmon are often delayed for weeks at a time below dams and there currently exists no clear quantification of risk associated with delay. MDMR supported USGS during the Spring of 2018, in the tagging and release of multi sea-winter adult Atlantic salmon at Milford Dam on the Penobscot River and at Lockwood Dam on the Kennebec River. Salmon tagging occurred between mid-May and early June at both the Milford and Lockwood Dams. Twenty Atlantic salmon were tagged at the Milford Dam Fish Lift and Sorting Facility and six at the Lockwood Dam Fish Lift Trap. Each fish was measured according to MDMR standards, then gastrically tagged with Lotek temperature logging radio tags, and measured with a Distell Fat Meter (model FFM-692). In addition, the salmon were PIT-tagged by MDMR staff. After tagging, fish were transported downstream and released back to their river of origin. Movements of the tagged fish were tracked with both stationary radio telemetry receivers and mobile radio tracking units. Of the 20 radio tagged fish released in the Penobscot River, 14 were recaptured at Milford Fish Lift and Sorting Facility and were measured a second time with the Distell Fat Meter. All 14-recaptured salmon were transported to Craig Brook National Fish Hatchery (CBNFH) for use in as broodstock. On the Kennebec River, 4 of 6 tagged fish were recaptured at the Lockwood Fish Lift Trap.

After data analysis, radio telemetry data will identify the locations and durations of salmon holding below dams. In addition, the two fat meter measurements will give us an idea of energy loss correlated with the time spent below the dams. Because delays below dams expose salmon to warmer river temperatures for extended periods of time, and temperature directly affects metabolic processes, we will use temperatures collected from the radio tags and several loggers placed throughout the watersheds to inform our final bioenergetic model.

Habitat Assessment
MDMR staff conducted habitat surveys in one stream within the Sandy River sub-drainage located in the Merrymeeting Bay SHRU. Staff surveyed Lemon Stream and recorded 1,022.7 units of rearing habitat ($100m^2$) and 209.9 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 2019. 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 installed before disaster.

<u>Barrier Surveys</u>: A coordinated effort is underway in Maine to identify aquatic connectivity issues across the state. Since 2006, state and federal agencies and non-governmental organizations have been working together to inventory and assess fish passage barriers in Maine and to develop barrier removal priorities. Partners leading this effort in recent years include The Nature Conservancy, Maine Forest Service (MFS), USDA Natural Resources Conservation Service (NRCS), and the U.S. Fish and Wildlife Service (USFWS) Gulf of Maine Coastal Program.

After 12 years of fieldwork, well over three quarters of the state's perennial and high value intermittent stream crossings have been assessed (Figure 5.3.1). 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.

In 2019, stream barrier surveys will be completed primarily in the Androscoggin and St. John watersheds, but crews will also be working hard to reach sites requiring extra effort to gain access which were missed in past surveys.

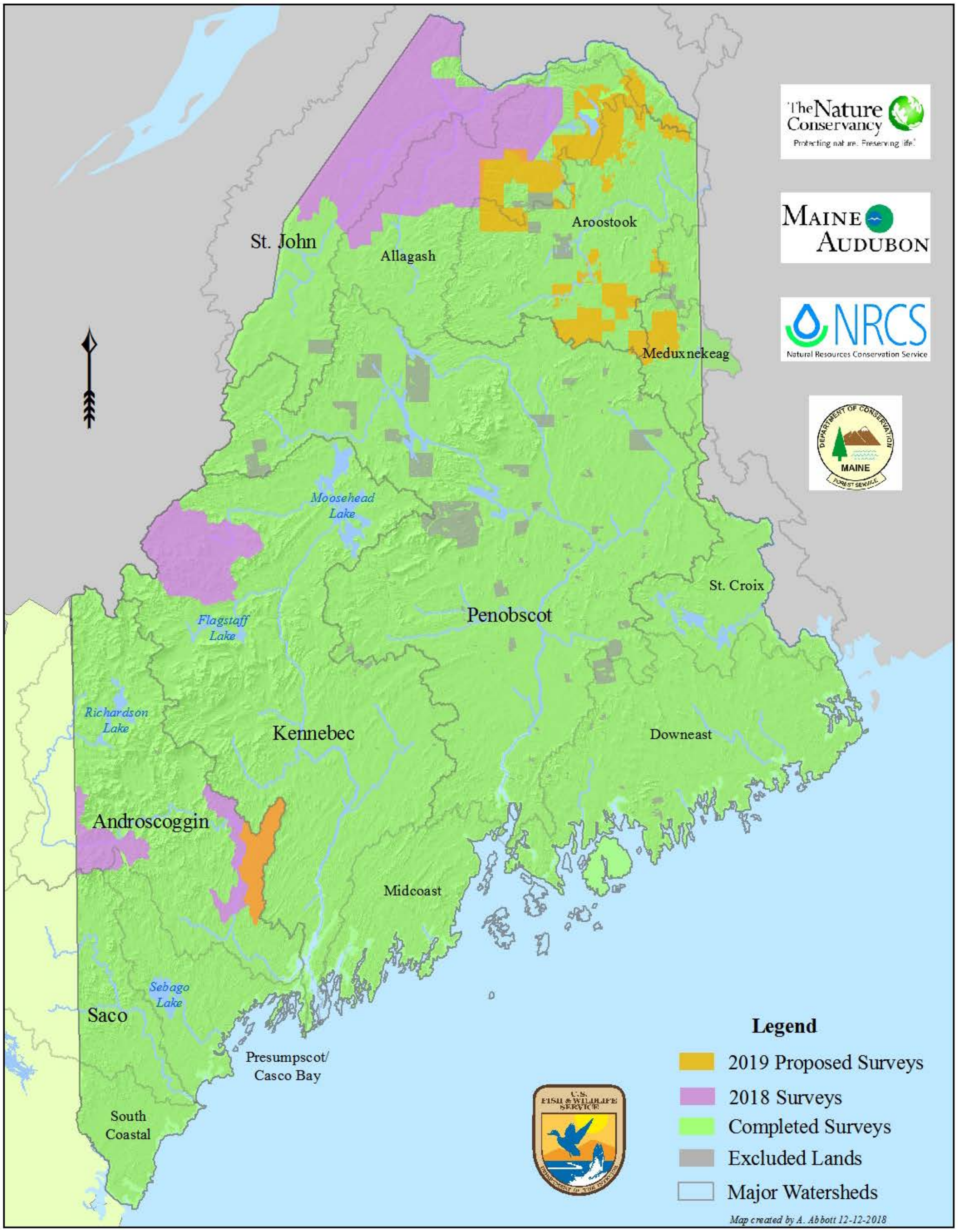

Figure 5.3.1 Maine barrier survey status map. (credit: Alex Abbott, USFWS GOMCP).

Highlighted Connectivity Projects: In 2018, 18 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 174km 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
Bridge	Project SHARE	East Machias	Allen Brook	5.5	8.85
Decommission	DSF	East Machias	Beaverdam Stream	6.8	10.88
Bridge	Project SHARE	East Machias	Lewys Brook	8.1	13.04
ATV Bridge	Project SHARE	East Machias	Unnamed Tributary to Barrows Stream	1.1	1.77
ATV Bridge	Project SHARE	East Machias	Unnamed Tributary to Dead Brook	0.7	1.13
Dam Removal	DSF	Frenchman Bay	Smelt Brook	1.4	2.24
Box Bridge	MDOT	Kennebec	Fields Brook	7.1	11.36
Box Bridge	MDOT	Kennebec	Unnamed Tributary to Three-mile Pond	3.2	5.12
ATV Bridge	Project SHARE	Machias	Unnamed Tributary at Carrick Pitch	0.3	0.48
Bridge	MDOT	Machias	Pembroke Stream	3.34	5.37
Arch Culvert	Project SHARE	Narraguagus	Sinclair Brook	0.3	0.48
Bridge	Project SHARE	Narraguagus	West Branch Brook	10.9	17.54
Arch Culvert	Project SHARE	Narraguagus	Burnham Brook	1.1	1.77
Arch Culvert	Project SHARE	Narraguagus	Rocky Brook	0.2	0.32
Arch Culvert	Project SHARE	Narraguagus	Thirty-Five Brook	1	1.61
Box Bridge	Town of Dedham	Penobscot	Moulton Pond Outlet Stream	0.8	1.28
Box Bridge	MDOT	Penobscot	Unnamed Tributary to Holbrook Pond	1.2	1.92
Dam Removal	ASF	Sheepscot	Sheepscot River	59.0	94.4
			TOTAL	**112.04**	**174.19**

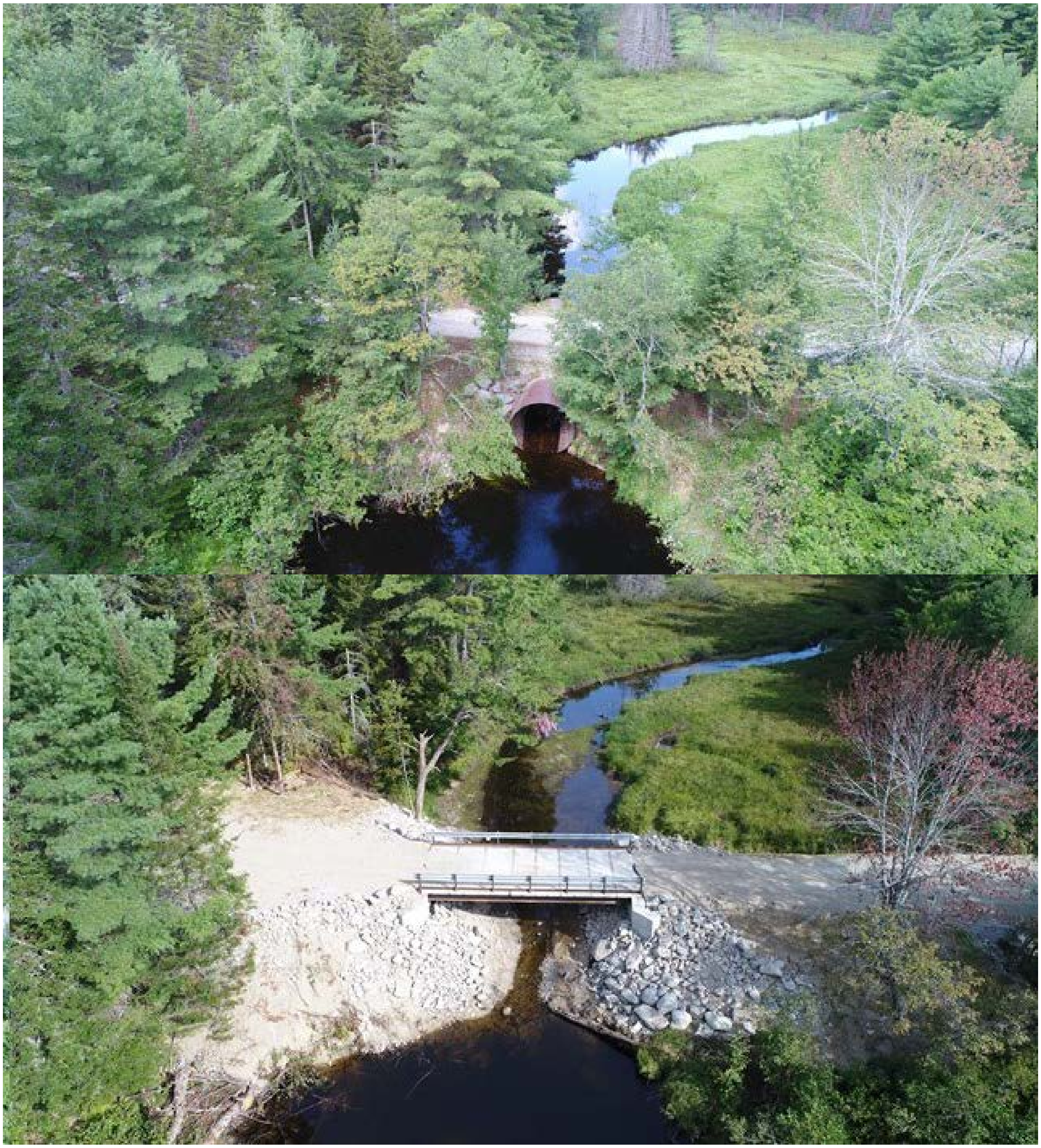

Figure 5.3.2 West Branch Brook culvert replacement, before (top) and after (bottom), Narraguagus River, Maine, 2018. (photo credit: Chris Federico, Project SHARE)

Figure 5.3.3 Coopers Mills Dam removal, before (top) and after (bottom), Sheepscot River, Maine, 2018. (photo credit: Scott Craig, USFWS – MeFWCO)

Habitat Complexity

Narraguagus Focus Area Restoration

Project SHARE has identified the Upper Narraguagus sub-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 will also be positively affected.

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 along with opportunities to restore cold-water refugia and rearing habitat. Cooperatively projects have been done to mitigate those threats and/or restored connectivity and natural stream function. Watershed-scale threat assessments of the Narraguagus River have documented summer water temperatures in mainstem river reaches above sub-lethal stress levels, approaching acute lethal levels. Remnant dams and the associated legacy reservoirs are identified as 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 processes and dynamics rather than restore them. By contrast, efforts to reestablish system processes 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 is 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, 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 in-route 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 ATV bridge at the Ford to the confluence of Humpback Brook (river km 53.07 – 51.81). The reach has a 36-year time-series of spawner (redd) surveys, 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, NOAA, and USFWS scientists and numerous volunteers constructed 55 PALS structures downstream of the ATV bridge (Figures 5.3.4, 5.3.5, and 5.3.6). MDMR scientists conducted spawner surveys in PALS reaches in late November 2018. Redds (4) observed were constructed very near and oriented with PALS (Figures 5.3.7 and 5.3.8). Redds associated with PALS accounted for 80% of spawning locations in the Upper Narraguagus River in 2018. MDMR will conduct juvenile population assessments to document young-of-year (YOY) and large parr production from this spawning event in 2019/2020.

In Township 39, an initial treatment of self-placing wood was added to the mainstem of the Narraguagus River (Figure 5.3.9). This treatment involved using a truck-mounted grapple claw to place 11 commercially harvested red pine trees into the river at the 31-00-0 road bridge (a commercial logging road crossing). The intent is for the trees to wash downstream during the fall and spring freshets before hanging up and becoming key logs (i.e. self-placing). This treatment will continue over the next 3-5 years with the hypothesis that multiple naturally-formed log jams will develop.

Figure 5.3.4 PALS additions before (top; 2016) and after (bottom; 2018) at the Ford Site, Narraguagus River, Maine. (photo credit: left – Doug Thompson, Connecticut College; right – Chris Federico, Project SHARE)

Figure 5.3.5 Driving a post into a PALS at the Ford Site, Narraguagus River, Maine, 2018. (photo credit: Chris Federico, Project SHARE)

Figure 5.3.6 Aerial photo showing all 12 PALS constructed at the Ford Site, Narraguagus River, Maine, 2018. (photo credit: Chris Federico, Project SHARE)

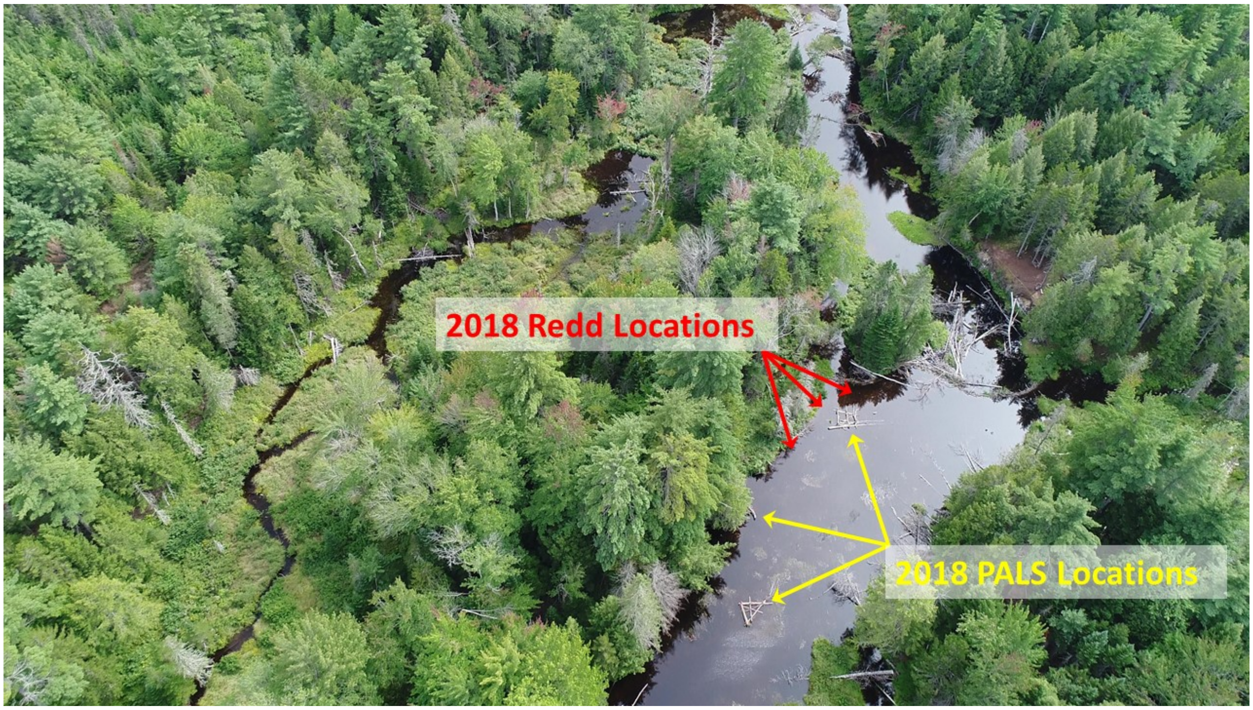

Figure 5.3.7 Redds associated with PALS at the Camp Site, Narraguagus River, Maine, 2018. (photo credit: Chris Federico, Project SHARE)

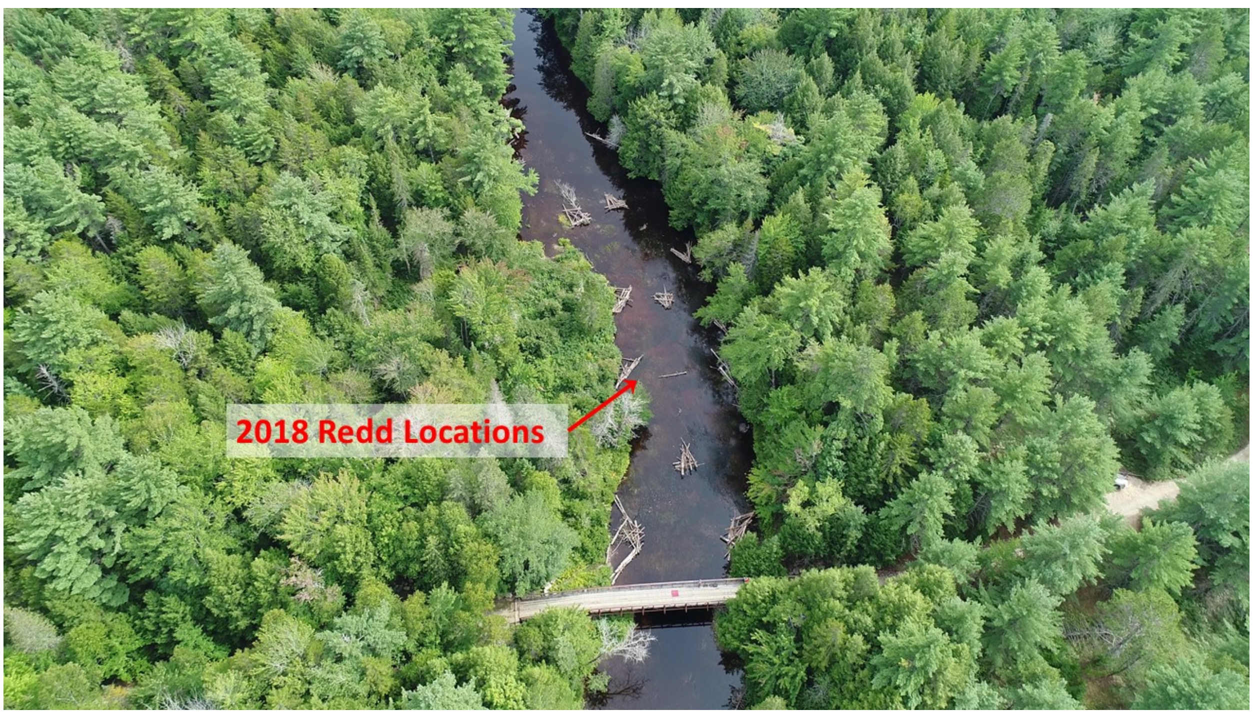

Figure 5.3.8 Redd associated with PALS at the Ford Site, Narraguagus River, Maine, 2018. (photo credit: Chris Federico, Project SHARE)

Figure 5.3.9 Commercially harvested red pine tree addition as self-placing wood, 31-00-0 Rd bridge, Narraguagus River, Maine, 2018. (photo credit: Chris Federico, Project SHARE)

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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 6,033,151 eggs for the Maine program: 1,882,007 eggs from Penobscot sea-run broodstock; 2,128,573 eggs from domestic broodstock; 2,022,571 eggs from captive broodstock populations.

Spawning protocols for Atlantic salmon broodstock at CBNFH and GLNFH prioritize first time spawners and utilize 1:1 paired matings. In 2018, both facilities used year-class crosses as well as spawning optimization software to avoid spawning closely related individuals.

A total of 249 Penobscot sea-run origin females and 596 captive females were spawned at CBNFH between October 29th and December 10th. Eggs produced at CBNFH are used for egg planting, fry stocking, age 0+ parr stocking and educational programs. An aliquot of each family group of Penobscot sea-run eggs produced at CBNFH are transferred to GLNFH for parr and smolt production.

CBNFH relies solely on ambient water sources. Eggs taken early in the spawning season may be exposed to water temperatures at above-optimal levels for egg development which may affect egg survival, embryonic deformities and fry survival. CBNFH has successfully used a photoperiod treatment to modify spawn timing of Penobscot sea-run broodstock since 2010.

In 2018 the same photoperiod treatment was administered to the Narraguagus and Machias captive broodstock. LED bulbs designed to simulate noon-day sun at northern latitudes were installed in existing light fixtures; filtered ambient light was available through skylights. The treatment was administered using a predetermined schedule and time clocks to extend the light available during the summer solstice (June 21) for approximately ten days. The treatment delays spawning and allows eggs to be collected in more favorable water temperatures. Due to the intensity of the LED lights, as compared with the conventional fluorescent lights used for the Penobscot broodstock, spawning was delayed until the end of November into early December for the Machias and Narraguagus. CBNFH plans to continue to use photoperiod manipulation in the future.

At GLNFH, 762 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 3,272,000 eyed eggs from seven strains to various partners (Table 5.4.1).

Table 5.4.1. Eyed egg transfers from Craig Brook National Fish Hatchery (CBNFH) and Green Lake National Fish Hatchery (GLNFH) in 2018. *Egg numbers rounded to the nearest 1,000.

Facility	Strain	Rearing History	Receiving Entity	Purpose	Number*
CBNFH	Dennys	Captive/domestic	Department of Marine Resources	Out-of-basin egg planting	287,000
CBNFH	East Machias	Captive/domestic	Downeast Salmon Federation	Private rearing	187,000
CBNFH	Machias	Captive/domestic	Department of Marine Resources	River-of-origin egg planting	85,000
CBNFH	Narraguagus	Captive/domestic	Green Lake National Fish Hatchery	Smolt production	151,000
CBNFH	Penobscot	Sea-run	Green Lake National Fish Hatchery	Smolt production	863,000
CBNFH	Penobscot	Sea-run	Fish Friends / Salmon-in-Schools	Education	5,000
CBNFH	Pleasant	Captive/domestic	Downeast Salmon Federation	Private rearing	108,000
CBNFH	Pleasant	Captive/domestic	Department of Marine Resources	River-of-origin egg planting	106,000
CBNFH	Sheepscot	Captive/domestic	Department of Marine Resources	River-of-origin egg planting	131,000
CBNFH	Sheepscot	Captive/domestic	Fish Friends / Salmon-in-Schools	Education	2,000
GLNFH	Penobscot	Captive/domestic	Department of Marine Resources	Out-of-basin egg planting / River-of-origin egg planting	1,338,000
GLNFH	Penobscot	Captive/domestic	Fish Friends / Salmon-in-Schools	Education	9,000
					3,272,000

Wild Broodstock Collection

A total of 455 adult sea-run Atlantic salmon captured at the Milford Dam, on the Penobscot River, were transported to CBNFH for use as broodstock. Broodstock were transported beginning on May 10th. A total of 58 trips were made until July 20th.

The State of Maine, NOAA Fisheries, and FWS initially established river-specific broodstock collection targets of parr through the Maine Technical Advisory Committee (Bartron, et. al. 2006). The targets were set at a number of broodstock required to seed available fry habitat with the equal of 240 eggs per habitat unit; targets were 250 parr each for the Machias and Narraguagus; 150 parr each for the Dennys, East Machias, and Sheepscot; 100 parr for the Pleasant.

Ongoing assessment of family recapture rates and other diversity metrics led to an increase to parr collections between 2008 and 2013. Targets for the Machias and Narraguagus were increased to 300 parr each. Targets for all the remaining rivers increased to 200 each. 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.

From 2013 through 2017 all parr collection targets were generally met or exceeded with the exception of the Dennys in 2014 and 2015. In 2018 the FWS decided to both reduce the targets on the Machias and Narraguagus, bringing them in line with the other populations, and limit the amount of parr over the established target that could be collected. The current goal is to focus on maintaining a minimum effective population size of 50. In 2018 collections totaled 1290 (Dennys, 213; East Machias, 214; Machias, 220; Narraguagus, 215; Pleasant, 215; Sheepscot, 213).

Domestic Broodstock Production

GLNFH retained approximately 1,000 fish from the 2017-spawn year 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.

Infectious Salmonid Anemia

Infectious Salmonid Anemia (ISA) is an orthomyxovirus first reported among Norwegian salmon farms. ISA is extremely infectious and may result in high mortalities in aquaculture settings. Due to the proximity of aquaculture installations to Maine rivers sea-run adults returning to the Penobscot River are monitored for the disease.

Sea-run adults are isolated in a screening facility to undergo sampling procedures and await the results of PCR testing. Blood samples are analyzed by the LFHU using Polymerase Chain Reaction (PCR) testing. Adult passing the PCR test are transferred into the main sea-run brood area for future spawning.

In the event of a positive ISA result additional tests are conducted on the affected individual. Should the individual be affected by the non-pathogenic strain of ISA (HPR0) that individual is released into the Penobscot at an upriver location above the Milford dam. The adults initially isolated with the HPR0 individual (cohort) are allowed to join the general hatchery population. In 2018 two HPR0 positive adults were released to the Penobscot River.

In the event a positive result for a pathogenic strain of ISA is detected the affected individual is euthanized. The affected individual's cohort is isolated for an additional 28 days and resampled. In 2018 two individuals were identified by LFHU as being positive for an unknown strain of ISA. LFHU collaborated with Kennebec Biosciences to confirm their findings; Kennebec Biosciences identified the strain as HPR14, a European strain and one not previously found in the Penobscot. The Animal and Plant Health Inspection Service (APHIS) was engaged to provide further analysis. Additional samples of blood and tissues were collected and sent to both LFHU and APHIS; the individuals were euthanized. APHIS confirmed the presence of HPR14 in whole blood samples but not tissues (kidney, liver, spleen and gills). Neither of the affected individuals showed any clinical signs of ISA prior to being euthanized. The cohorts of both individuals were quarantined for 28 days and resampled. No additional positive results were found and the fish were allowed to join the general population.

Enteric Redmouth

In 2018 two Penobscot sea-run adults tested positive for enteric redmouth disease (*Yersina ruckeri*) during analysis of samples collected from mortalities following spawning.

Green Lake NFH encountered an outbreak of enteric redmouth disease (ERM). This represent the second year in a row that ERM was detected at the hatchery. Fish samples were collected from the eight pools that had experienced a low but persistent level of mortality and sent to the U.S. Fish and Wildlife Lamar Fish Health Center. The fish health screening detected *Yersinia ruckeri*, the causal bacteria for ERM. The ERM positive pools were treated with medicated feed. The treated pools responded well to the treatment there have been no clinical signs of disease since.

Stocking

Stocking activities within the GOM DPS resulted in the release of 4,722,877 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 4,719,847 juveniles (eyed eggs, fry, parr, and smolts) throughout the GOM DPS (Table 5.4.2).

Table 5.4.2. Stocking activities in the Gulf of Maine Distinct Population Segment for 2018.

Drainage	Parr	Smolt	Egg Eyed	Fry	Total
Dennys	262	405		234,432	235,099
East Machias	119,465			10,315	129,780
Kennebec			1,227,673		1,227,673
Machias			84,500	144,841	229,341
Narraguagus	21,746	100,534		100,170	222,450
Penobscot	219,942	559,130	397,033	1,142,844	2,318,949
Pleasant			105,503	84,108	189,611

Sheepscot	13,135			131,030	22,779	166,944
Union						0
Totals	374,550	660,069		1,945,739	1,739,489	4,719,847

Adult Stocking

A total of 3,030 adults were stocked into GOM drainages (Table 5.4.3). Pre-spawn releases occurred in seven GOM drainages. Pre-spawn releases were comprised of pedigreed broodstock for the Dennys and Narraguagus rivers, two non-pathogenic ISA positive Penobscot adults, and gravid adults for the Dennys, East Machias, Machias, Pleasant and Sheepscot rivers.

Table 5.4.3. Adult and sub-adult broodstock released pre- and post-spawn from Craig Brook and Green Lake National Fish Hatcheries in 2018.

Drainage	Stock Origin	Pre/Post Spawn	Lot	Number Stocked
Dennys	DE	Post-Spawn	Captive/Domestic	126
Dennys	DE	Pre-Spawn	Captive/Domestic	39
East Machias	EM	Post-Spawn	Captive/Domestic	233
East Machias	EM	Pre-Spawn	Captive/Domestic	64
Machias	MC	Post-Spawn	Captive/Domestic	194
Machias	MC	Pre-Spawn	Captive/Domestic	136
Narraguagus	NG	Post-Spawn	Captive/Domestic	240
Narraguagus	NG	Pre-Spawn	Captive/Domestic	40
Penobscot	PN	Post-Spawn	Captive/Domestic	1,105
Penobscot	PN	Post-Spawn	Sea Run	435
Penobscot	PN	Pre-Spawn	Sea Run	2
Pleasant	PL	Post-Spawn	Captive/Domestic	192
Pleasant	PL	Pre-Spawn	Captive/Domestic	0
Sheepscot	SHP	Post-Spawn	Captive/Domestic	161
Sheepscot	SHP	Pre-Spawn	Captive/Domestic	63
			Total	3,030

U. S. Fish & Wildlife Service Schools Programs

2018 marked the twenty-fourth 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.

In 2018, Green Lake NFH provided 50 parr and 1,575 smolts to researchers for various studies. In some cases, the smolts were transferred directly to the researchers and in other cases the researchers used the hatchery facilities to mark, tag, and hold study fish prior to release. The smolts were used for migration and fish downstream fish passage studies and the parr were used for a smallmouth bass interaction study.

CB - Emma Taccardi – PN sea-lice

CB - Sarah Rubenstein – energy (fat) to reproductive quality

CB - Nishad Jayasundara – egg respiration

5.5 General Program Information

GOM DPS Recovery Plan

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 and was released on February 12th, 2019. This document is available at: https://www.fisheries.noaa.gov/action/final-atlantic-salmon-recovery-plan?utm_medium=email&utm_source=govdelivery

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 03 July to 09 November 2018. Thirty-Nine Atlantic salmon were captured and released upstream in 2018. The salmon captured consisted of 6 1SW female grilse, 25 2SW females, and 8 2SW males. Only one of the 6 grilse captured was of hatchery origin while 6 of the 2SW fish were of hatchery origin with the remaining 27 reported as wild origin.

6.2 Hatchery Operations

Stocking

No juvenile lifestages were stocked in 2018.

Adult Salmon Releases

No adults were stocked in 2018.

6.3 Juvenile Population Status

Electrofishing Surveys

There were no population assessments in the Aroostook River watershed in 2018.

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

7.1 Summary

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 the 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.

Work at the 2019 meeting continued to focus on improving stock assessment of Atlantic salmon in the US. Work sessions were prefaced by discussions focused on current research or changes in assessment methods. Of note is the progress made on improving the estimate of spawner escapement through a redds based estimate (see below in Section 7.1). This change will provide a clearer picture on what is contributing to wild returns. There were continued discussions on data management and biological archiving of fish scales. The Viable Salmonid Population Assessment (VSP) for the Gulf of Maine continues to be developed and the group contributed to further development. Summaries of these discussions are listed below in sections: 7.1 Redds-Based Estimates of Returns in Maine; 7.2 Scale Archiving and Inventory Update; 7.3 Review of Databases and Source Information Needed to Document Adult Atlantic Salmon Spawning Escapement; and 7.4 Transition from Status of Stock Format to Viable Salmonid Population Assessment for Gulf of Maine Populations. Additionally, the USASAC developed a new draft Terms of Reference for the 2020 meeting. These are listed in Section 7.5..

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

For 8 rivers without traps, a redd-based estimate (RBE) is used to estimate returns from surveys of redds. The RBE is a regression model of census salmon data (y) to a predictor variable of redd counts (x). The RBE time series of estimates starts in 1991 and the last benchmark assessment was 2011. That benchmark will be used for the 2018 assessment. Substantial progress was made on a RBE model, prior to and at the working group meeting. We identified a candidate model for use starting in the 2019 salmon year following an additional attempt to bring sex-ratios into the model.

A working paper synthesized data through 2018 and examined the effects of survey effort (spatial and temporal variability), pro-rating by areas, and partitioning out grilse. The working group discussed these results and evaluated both input data and model structure. A consensus was reached for a new candidate model but the group felt that the data needed an additional audit and that it was worth evaluating a MSW female census data approach before finalizing a new benchmark. The USASAC should have a new model developed in 2019 that will incorporate an additional 8 years of data in the model..

7.3 Scale Archiving and Inventory Update

During 2017, inventories were conducted byNew 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. No funding was secured for this effort in 2018 and the ad-hoc group will remain in place with the same goals.

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

Following a review of current data maintained within the USASAC database, the committee deemed that automated reporting of annual estimates of spawner escapement could be done. The USASAC database historically contained "documented" adult return data which represented adult returns that were observed at trapping facilities. Estimates of returns in rivers without trapping that are derived from a statistical model relating the number of redds to returns were not contained within the USASAC database. Changes to the database structure following the 2018 meeting now allow both types of return data to be contained within the database. Additional changes to the USASAC database included the addition of documented in-river mortalities of salmon and the number of sea run returns that are removed from the rivers for hatchery broodstock. These modifications and additions provide the components necessary to estimate annual escapement within the database.

Two types of escapement are now estimated by the USASAC database: 1) natural escapement, and 2) total escapement. Natural escapement represents the number of salmon that are allowed to freely swim a river. The calculation of natural escapement is equal to the number of total sea run returns minus the number of sea run returns removed for broodstock minus the number of documented in-river mortalities. Total escapement is natural escapement with the addition of mature salmon from hatcheries that are stocked prior to spawning and could contribute to the number of salmon spawning in the wild. These stocked adults can be a combination of captive/domestic fish and sea run fish that were removed with the intent of using them as hatchery broodstock, but were ultimately not used due to a number of possible reasons and were placed back into the river prior to spawning.

Natural and total escapement are reported for 2018. However, following discussion by committee members, a full time series of escapement was not put forth at this time. We realized some data management methods by ME DMR and CBNFH could result in double counting of some fish resulting in biased estimates of escapement. Data management methods were proposed by the committee to avoid this double counting in the future and an audit of the number of salmon loaded into trucks destined for the hatchery will be performed over the next year to ensure data accuracy. A full time series of escapement should be possible after the next annual meeting in 2020.

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

This is the second year of reporting where Chapter 2 is focused exclusively on an annual viability assessment synopsis of the GOM DPS using a Viable Salmonid Populations (VSP) approach (McElhany et al. 2000). Integrating this into annual reporting (required under the GOM DPS Recovery Framework) has facilitated additional review and visibility of the contents of the VSP assessment. This section is a brief annual summary not a benchmark 5-year viability assessment. In 2020, the assessment team will work with Pacific salmon biologists with the goal of a 2020 benchmark VSP assessment that is aligned with emerging methods at a national scale and similar time frames.

7.6 USASAC Draft Terms of Reference for 2020 Meeting

The purpose of this section is to outline terms of reference identified at the USASAC annual meeting in March 2019 and to start an outline for refinement at our summer 2019 teleconference and intersessional work prior to final TOR that will be produced after the ICES WGNAS and NASCO Meetings (July 2019).

In **support of North American Commission to NASCO**, we anticipate reporting on the following with respect to Atlantic salmon in the United States

> *Describe the key events of the 2019 fisheries bycatch (targeted fisheries are closed) and aquaculture production*
>
> *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.*
>
> *Describe the status of the stocks including updating the time-series of trends in the number of river stocks meeting CL's by jurisdiction;*

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

Escapement Summary Table- Continue to 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 and a time series of fish that were transferred to CBNFH from the Penobscot

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.

Update Redd Based Return Estimate Benchmark. Transition model calculations from an @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) developing a method of proration for origin and age guiding principles and reporting/review.

Juvenile Assessment Update. Develop a synthesis document that describes both the long-term index sites through 2012 (Sweka) and new Generalized Random - Tessellation Stratified (GRTS; Stevens and Olsen 2004) design (2013-2017) (Atkinson) 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 (for Furey), approaches for index rivers, and complementary efforts that address specific restoration questions (e.g. dispersion from artificial redds, fry vs. parr etc.).

Fall Fingerling Evaluation - Cross Drainages in Maine. The effectiveness of novel rearing techniques to raise fall fingerlings under more natural conditions can be contrasted with similar aged releases from Federal Hatcheries and fry stocking. Metrics to be compared are juvenile density, condition, biomass, and contributions to emigrating smolts. Finally, comparisons of juvenile or smolt per egg take should be examined to develop optimization curves.

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	MDMR	Jonesboro, ME
Casey	Clark	Casey.Clark@maine.gov	MDMR	Augusta, ME
Oliver	Cox	Oliver_Cox@fws.gov	USFWS	Ellsworth, ME
Danielle	Frechette	Danielle.Frechette@gmail.com	Integrated Statistics	Damariscotta, ME
Steve	Gephard	Steve.Gephard@ct.gov	CTDEEP	Old Lyme, CT
James	Hawkes	James.Hawkes@noaa.gov	NOAA	Orono, ME
John	Kocik	John.Kocik@noaa.gov	NOAA	Orono, ME
Christine	Lipsky	Christine.Lipsky@noaa.gov	NOAA	Orono, ME
Rory	Saunders	Rory.Saunders@noaa.gov	NOAA	Orono, ME
Mitch	Simpson	Mitch.Simpson@maine.gov	MDMR	Bangor, ME
John	Sweka	John_Sweka@fws.gov	USFWS	Lamar, PA
Dan	Tierney	Dan.Tierney@noaa.gov	NOAA	Orono, ME
Jason	Valliere	Jason.Valliere@maine.gov	MDMR	Bangor, ME

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

Number	Authors	Title
WP19-01	John F. Kocik, Christopher Tholke, and Timothy Sheehan	Annual Bycatch Update for Atlantic Salmon, 1989 through August 2018
WP19-02	Colby Bruchs, Ernie Atkinson, James Hawkes, Christine Lipsky, Ruth Hass-Castro, Paul Christman, Jennifer Noll, Zach Sheller, Rachel Gorich, and Graham Goulette	Update on Maine River Atlantic Salmon Smolt Studies: 2018
WP19-03	David Bean	Maine and Neighboring Canadian Commercial Aquaculture Activities and Production
WP19-04	Ruth Haas-Castro, Graham Goulette, James Hawkes, Christine Lipsky, Tim Sheehan, Brandon Ellingson, Auden Lacorazza, Ernie Atkinson, Colby Bruchs, Paul Christman, Jennifer Noll, and Jessica Strzempko	Review of Image Analysis Studies: 2018 (Part 1) and Work Plan for 2019 (Part 2)
WP19-05	Tim Sheehan	Report of the Working Group on North Atlantic Salmon (WGNAS)(PPT)
WP19-06	Rory Saunders	NASCO Overview (PPT)
WP19-07	Ernie Atkinson	Saco, GOM, OBF Updates (PPT)
WP19-08	Danielle Frechette	Update on Broodstock Management Plan (PPT)
WP19-09	Justin Stevens, John Kocik, and Tim Sheehan	Modeling the impacts of dams and stocking practices on hatchery contributions to recovery of an endangered Atlantic salmon population in the Penobscot River, Maine, USA

WP19-10	John Kocik	Atlantic salmon Redds-Based Estimate (RBE) Benchmark 2019

Table 8.3 Past meeting locations, dates and USASAC Chair

Location	Meeting Date	Committee Chair	Affiliation
Woods Hole, MA	December 12-16, 1988	Larry Stolte	USFWS
Woods Hole, MA	January 29-February 2, 1990	Jerry Marancik	USFWS
Turners Falls, MA	January 28-February 1, 1991	Jerry Marancik	USFWS
Turners Falls, MA	January 27-31, 1992	Larry Stolte	USFWS
Turners Falls, MA	January 25-29, 1993	Larry Stolte	USFWS
Turners Falls, MA	January 24-28, 1994	Larry Stolte	USFWS
Turners Falls, MA	February 6-9, 1995	Larry Stolte	USFWS
Nashua, NH	March 19, 1996	Larry Stolte	USFWS
Hadley, MA	March 3-5, 1997	Larry Stolte	USFWS
Hadley, MA	March 2-4, 1998	Larry Stolte	USFWS
Gloucester, MA	March 1-4, 1999	Larry Stolte	USFWS
Gloucester, MA	March 6-9, 2000	Jan Rowan	USFWS
Nashua, NH	March 26, 2001	Joseph McKeon	USFWS
Concord, NH	March 5-9, 2002	Joseph McKeon	USFWS
East Orland, ME	February 25-27, 2003	Joseph McKeon	USFWS
Woods Hole, MA	February 23-26, 2004	Joseph McKeon	USFWS
Woods Hole, MA	February 28-March 3, 2005	Joan Trial	MDMR
Gloucester, MA	February 27 - March 2, 2006	Joan Trial	MDMR
Gloucester, MA	March 5-8, 2007	Joan Trial	MDMR
Portland, ME	March 11-13, 2008	John Kocik	NOAA
Portland, ME	March 2-5, 2009	John Kocik	NOAA

Portland, ME	March 1-4, 2010	John Kocik	NOAA
Portland, ME	March 8-10, 2011	John Kocik	NOAA
Turners Falls, MA	March 5-8, 2012	John Kocik	NOAA
Old Lyme, CT	February 25-28, 2013	John Kocik	NOAA
Old Lyme, CT	February 24-27, 2014	Mike Bailey	USFWS
Kittery, ME	February 9-12, 2015	Mike Bailey	USFWS
Yarmouth, ME	February 29-March 3, 2016	Mike Bailey	USFWS
Portland, ME	February 13-16, 2017	Ernie Atkinson	MDMR
Portland, ME	February 26-March 2, 2018	Ernie Atkinson	MDMR
Portland, ME	March 4-March 8, 2019	Ernie Atkinson	MDMR

9 Glossary of Abbreviations

Adopt-A-Salmon Family	AASF
Arcadia Research Hatchery	ARH
Brookfield Renewable Partners	BRP
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 Specialties International	DSI
Developmental Index	DI
Dwight D. Eisenhower National Fish Hatchery	DDENFH
Distinct Population Segment	DPS
Division of Sea Run Fisheries and Habitat	DSRFH
Downeast Salmon Federation	DSF
Downeast Salmon Federation Wild Salmon Resource Center	
	DSFWSR
C 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	SOCNFW
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 1. Juvenile Atlantic salmon stocking summary for New England in 2018.

United States

No. of fish stocked by lifestage

River	Egg	Fry	0 Parr	1 Parr	2 Parr	1 Smolt	2 Smolt	Total
Connecticut	0	197,000	8,500	0	0	0	0	205,500
Total for Connecticut Program								**205,500**
Dennys	0	234,000	0	300	0	0	400	234,700
East Machias	0	10,000	119,500	0	0	0	0	129,500
Kennebec	1,228,000	0	0	0	0	0	0	1,228,000
Machias	84,000	145,000	0	0	0	0	0	229,000
Narraguagus	0	100,000	21,700	400	0	99,900	600	222,600
Penobscot	397,000	1,143,000	219,900	0	0	559,100	0	2,319,000
Pleasant	106,000	84,000	0	0	0	0	0	190,000
Saco	70,000	557,000	0	0	0	0	0	627,000
Sheepscot	131,000	23,000	13,100	0	0	0	0	167,100
Total for Maine Program								**5,346,900**
Total for United States								**5,552,400**
Grand Total								**5,552,400**

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

Appendix 2. Number of adult Atlantic salmon stocked in New England rivers in 2018.

		Captive/Domestic		Sea Run		
Drainage	**Purpose**	**Pre-Spawn**	**Post-Spawn**	**Pre-Spawn**	**Post-Spawn**	**Total**
Dennys	Restoration	39	126	0	0	165
East Machias	Restoration	64	233	0	0	297
Machias	Restoration	136	194	0	0	330
Merrimack	Restoration/Recreation	1,894	791	0	0	2,685
Narraguagus	Restoration	40	240	0	0	280
Penobscot	Restoration	0	1,105	2	435	1,542
Pleasant	Restoration	0	192	0	0	192
Sheepscot	Restoration	63	161	0	0	224
Total		2,236	3,042	2	435	5,715

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 3.1. Atlantic salmon marking database for New England; marked fish released in 2018.

Marking Agency	Age	Life Stage	H/W	Stock Origin	Primary Mark or Tag	Number Marked	Secondary Mark or Tag	Release Date	Release Location
USFWS	3	Adult	W	Dennys	PIT	117	PUNCH	May	Dennys
USFWS	5	Adult	H	Dennys	PIT	15	PUNCH	Dec	Dennys
USFWS	5	Adult	H	Dennys	PIT	1	PUNCH	Oct	Dennys
USFWS	4	Adult	H	Dennys	PIT	14	PUNCH	Oct	Dennys
USFWS	4	Adult	H	Dennys	PIT	23	PUNCH	Dec	Dennys
USFWS	3	Adult	H	Dennys	PIT	88	PUNCH	Dec	Dennys
USFWS	3	Adult	H	Dennys	PIT	24	PUNCH	Oct	Dennys
USFWS	3	Adult	H	East Machias	PIT	85	PUNCH	Nov	East Machias
USFWS	4	Adult	H	East Machias	PIT	24	PUNCH	Oct	East Machias
USFWS	5	Adult	H	East Machias	PIT	93	PUNCH	Nov	East Machias
USFWS	5	Adult	H	East Machias	PIT	20	PUNCH	Oct	East Machias
USFWS	6	Adult	H	East Machias	PIT	1	PUNCH	Nov	East Machias
USFWS	4	Adult	H	East Machias	PIT	54	PUNCH	Nov	East Machias
USFWS	3	Adult	H	East Machias	PIT	20	PUNCH	Oct	East Machias
USGS		Adult	W	Lower Kennebec	RAD	4	AP	Jun	Lower Kenneb
USGS		Adult	W	Lower Kennebec	RAD	2	AP	May	Lower Kenneb
USFWS	4	Adult	H	Machias	PIT	18	PUNCH	Oct	Machias
USFWS	3	Adult	H	Machias	PIT	65	PUNCH	Dec	Machias
USFWS	5	Adult	H	Machias	PIT	46	PUNCH	Dec	Machias
USFWS	3	Adult	H	Machias	PIT	39	PUNCH	Oct	Machias
USFWS	4	Adult	H	Machias	PIT	83	PUNCH	Dec	Machias
USFWS	5	Adult	H	Machias	PIT	79	PUNCH	Oct	Machias
USFWS	2	Adult	W	Narraguagus	PIT	402	PUNCH	May	Narraguagus
USFWS	3	Adult	H	Narraguagus	PIT	40	PUNCH	Oct	Narraguagus
USFWS	3	Adult	H	Narraguagus	PIT	40	PUNCH	Dec	Narraguagus

Marking Agency	Age	Life Stage	H/W	Stock Origin	Primary Mark or Tag	Number Marked	Secondary Mark or Tag	Release Date	Release Location
USFWS	6	Adult	H	Narraguagus	PIT	7	PUNCH	Dec	Narraguagus
USFWS	4	Adult	H	Narraguagus	PIT	63	PUNCH	Dec	Narraguagus
USFWS	5	Adult	H	Narraguagus	PIT	130	PUNCH	Dec	Narraguagus
USFWS	3	Adult	W	Narraguagus	PIT	202	PUNCH	May	Narraguagus
MEDMR		Adult	W	Penobscot	PIT	1	AD, VIE	Jul	Penobscot
MEDMR		Adult	W	Penobscot	PIT	1	AD, VIE	Jun	Penobscot
MEDMR		Adult	W	Penobscot	PIT	1	AP	Aug	Penobscot
MEDMR		Adult	W	Penobscot	PIT	31	AP	Jul	Penobscot
MEDMR		Adult	W	Penobscot	PIT	69	AP	Jun	Penobscot
MEDMR		Adult	W	Penobscot	PIT	10	AP	Oct	Penobscot
MEDMR		Adult	W	Penobscot	PIT	8	AP	Sep	Penobscot
USFWS	2	Adult	W	Penobscot	PIT	435		Dec	Penobscot
USFWS	4	Adult	W	Penobscot	PIT	359	PUNCH	Dec	Penobscot
USFWS	4	Adult	W	Penobscot	PIT	306	PUNCH	Nov	Penobscot
USFWS	3	Adult	W	Penobscot	PIT	205	PUNCH	Nov	Penobscot
USFWS	3	Adult	W	Penobscot	PIT	235	PUNCH	Dec	Penobscot
USFWS	2	Adult	W	Penobscot	PIT	2	FLOY	Jun	Penobscot
USGS		Adult	W	Penobscot	PIT	2	AP	May	Penobscot
USGS		Adult	W	Penobscot	PIT	7	RAD	Jun	Penobscot
USGS		Adult	W	Penobscot	PIT	28	RAD	May	Penobscot
USFWS	4	Adult	H	Pleasant	PIT	55	PUNCH	Nov	Pleasant
USFWS	5	Adult	H	Pleasant	PIT	41	PUNCH	Nov	Pleasant
USFWS	3	Adult	H	Pleasant	PIT	96	PUNCH	Nov	Pleasant
USFWS	4	Adult	H	Sheepscot	PIT	20	PUNCH	Oct	Sheepscot
USFWS	3	Adult	H	Sheepscot	PIT	10	PUNCH	Oct	Sheepscot
USFWS	6	Adult	H	Sheepscot	PIT	12	PUNCH	Nov	Sheepscot
USFWS	4	Adult	H	Sheepscot	PIT	37	PUNCH	Nov	Sheepscot

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	Sheepscot	PIT	33	PUNCH	Oct	Sheepscot
USFWS	5	Adult	H	Sheepscot	PIT	55	PUNCH	Nov	Sheepscot
USFWS	3	Adult	H	Sheepscot	PIT	57	PUNCH	Nov	Sheepscot
USFWS	1	Parr	W	Dennys	AD	262		May	Dennys
EMARC	0	Parr	H	East Machias	AD	105,503		Oct	East Machias
MEDMR	1	Parr	H	Narraguagus	AD	21,746		Oct	Narraguagus
USFWS	0	Parr	H	Sheepscot	AD	13,125		Sep	Sheepscot
Brookfield	1	Smolt	H	Androscoggin	RAD	250		May	Androscoggin
USFWS	2	Smolt	W	Dennys	PIT	288	PUNCH	May	Dennys
MEDMR	1	Smolt	H	Narraguagus	AD	66,749		May	Narraguagus
MEDMR	1	Smolt	H	Narraguagus	AD	33,181		Apr	Narraguagus
NOAA	1	Smolt	H	Narraguagus	PING	50		Apr	Narraguagus
NOAA	1	Smolt	H	Narraguagus	PING	100		May	Narraguagus
Brookfield	1	Smolt	H	Penobscot	RAD	549		May	Penobscot
USGS	1	Smolt	H	Penobscot	PING	170		Apr	Penobscot
USGS	1	Smolt	H	Penobscot	PING	170		May	Penobscot
USGS	1	Smolt	H	Piscataquis	PING	80		May	Piscataquis
USGS	1	Smolt	H	Piscataquis	PING	80		Apr	Piscataquis

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 3.2. Grand Summary of Atlantic Salmon marking data for New England; marked fish released in 2018.

Origin	Total External Marks	Total Adipose Clips	Total Marked
Hatchery Adult	1,488	0	1,488
Hatchery Juvenile	240,304	240,304	241,753
Wild Adult	1,957	2	2,427
Wild Juvenile	550	262	550
Total			**246,218**

Appendix 4. Estimates of Atlantic salmon returns to New England in 2018 from trap counts and redd surveys.

	Assessment Method	1SW Hatchery	1SW Wild	2SW Hatchery	2SW Wild	3SW Hatchery	3SW Wild	Repeat Hatchery	Repeat Wild	Total	2014-2018 Average
Androscoggin	Trap	0	0	0	1	0	0	0	0	**1**	2
Connecticut	Trap	0	0	0	2	0	0	0	0	**2**	16
Cove Brook	Redd	0	0	0	0	0	0	0	0	**0**	0
Dennys	Redd	0	1	0	6	0	0	0	0	**7**	13
Ducktrap	Redd	0	0	0	0	0	0	0	0	**0**	4
East Machias	Redd	2	0	12	0	0	0	0	0	**14**	14
Kennebec	Trap	0	3	1	7	0	0	0	0	**11**	28
Machias	Redd	0	2	0	7	0	0	0	0	**9**	15
Merrimack	Trap	0	0	2	0	0	0	0	0	**2**	13
Narraguagus	Trap	20	1	17	3	0	1	0	0	**42**	28
Penobscot	Trap	276	15	434	45	0	0	1	1	**772**	624
Pleasant	Redd	0	0	0	0	0	0	0	0	**0**	10

	Assessment Method	1SW Hatchery	1SW Wild	2SW Hatchery	2SW Wild	3SW Hatchery	3SW Wild	Repeat Hatchery	Repeat Wild	Total	2014-2018 Average
Saco	Trap	0	1	0	2	0	0	0	0	**3**	4
Sheepscot	Redd	1	1	2	2	0	0	0	0	**6**	14
Union	Trap	0	0	0	0	0	0	0	0	**0**	1
Total		**299**	**24**	**468**	**75**	**0**	**1**	**1**	**1**	**869**	**786**

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 5. Summary of Atlantic salmon green egg production in Hatcheries for New England rivers in 2018.

Source River	Origin	Females Spawned	Total Egg Production
Connecticut	Domestic	128	738,000
Merrimack	Domestic	264	1,023,000
Penobscot	Domestic	762	2,129,000
Dennys	Captive	95	285,000
East Machias	Captive	132	421,000
Machias	Captive	92	394,000
Narraguagus	Captive	102	375,000
Pleasant	Captive	91	277,000
Sheepscot	Captive	84	271,000
Total	**Captive/Domestic**	**1,750**	**5,913,000**
Penobscot	Sea Run	249	1,882,000
Total	**Sea Run**	**249**	**1,882,000**
Grand Total for Year	**2018**	**1,999**	**7,795,000**

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

Appendix 6. Summary of Atlantic salmon egg production in New England facilities.

	Sea-Run			Domestic			Captive			Kelt			TOTAL		
Year	No. females	Egg production	Eggs/ female	No. females	Egg production	Eggs/ female	No. females	Egg production	Eggs/ female	No. females	Egg production	Eggs/ female	No. females	Egg production	Eggs/ female
Cocheco															
1993-2008	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															
1977-2008	1,873	19,833,000	7,800	28,144	178,086,000	5,900	0	0		2,248	27,486,000	10,200	32,265	225,404,000	6,400
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
2018	0	0		128	738,000	5,800	0	0		0	0		128	738,000	5,800
Total Connecticut	2,071	21,265,000	7,300	34,016	210,749,000	6,600	0	0		2,395	28,934,000	9,000	38,482	260,947,000	6,700
Dennys															
1939-2008	26	214,000	7,600	0	0		1,238	5,213,000	4,200	40	330,000	7,700	1,304	5,757,000	4,900
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	
2012	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.

Year	Sea-Run No. females	Sea-Run Egg production	Sea-Run Eggs/ female	Domestic No. females	Domestic Egg production	Domestic Eggs/ female	Captive No. females	Captive Egg production	Captive Eggs/ female	Kelt No. females	Kelt Egg production	Kelt Eggs/ female	TOTAL No. females	TOTAL Egg production	TOTAL Eggs/ female
2013	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
2018	0	0		0	0		95	285,000	3,000	0	0		95	285,000	3,000
Total Dennys	26	214,000	7,600	212	1,079,000	4,600	1,705	7,152,000	4,256	40	330,000	7,700	1,983	8,776,000	4,500
East Machias															
1995-2008	0	0		0	0		1,150	4,800,000	4,300	0	0		1,150	4,800,000	4,300
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
2018	0	0		0	0		132	421,000	3,200	0	0		132	421,000	3,200
Total East Machias	0	0		0	0	0	2,012	8,158,000	3,955	0	0		2,012	8,158,000	4,000
Kennebec															
1979-2008	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															

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

Note: Connecticut data are preliminary prior to 1990.

Year	Sea-Run No. females	Sea-Run Egg production	Sea-Run Eggs/ female	Domestic No. females	Domestic Egg production	Domestic Eggs/ female	Captive No. females	Captive Egg production	Captive Eggs/ female	Kelt No. females	Kelt Egg production	Kelt Eggs/ female	TOTAL No. females	TOTAL Egg production	TOTAL Eggs/ female
1992-2008	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															
1941-2008	456	3,263,000	7,300	0	0		2,044	8,651,000	4,300	8	52,000	6,400	2,508	11,966,000	6,000
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
2018	0	0		0	0		92	394,000	4,300	0	0		92	394,000	4,300
Total Machias	456	3,263,000	7,300	0	0	0	3,200	12,757,000	3,591	8	52,000	6,400	3,664	16,072,000	3,700
Merrimack															
1983-2008	1,322	10,255,000	8,000	10,407	52,754,000	4,700	0	0		428	4,463,000	10,700	12,157	67,472,000	6,000
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
2015	0	0		234	761,000	3,300	0	0		0	0		234	761,000	3,300

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

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

Note: Connecticut data are preliminary prior to 1990.

Year	Sea-Run No. females	Sea-Run Egg production	Sea-Run Eggs/ female	Domestic No. females	Domestic Egg production	Domestic Eggs/ female	Captive No. females	Captive Egg production	Captive Eggs/ female	Kelt No. females	Kelt Egg production	Kelt Eggs/ female	TOTAL No. females	TOTAL Egg production	TOTAL Eggs/ female
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
2018	0	0		264	1,023,000	3,900	0	0		0	0		264	1,023,000	3,900
Total Merrimack	1,582	12,306,000	7,600	13,148	62,782,000	3,800	0	0		540	5,709,000	11,000	15,270	80,796,000	4,500
Narraguagus															
1962-2008	0	1,303,000		0	0		2,077	7,965,000	3,800	0	0		2,077	9,268,000	3,800
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
2018	0	0		0	0		102	375,000	3,700	0	0		102	375,000	3,700
Total Narraguagus	0	1,303,000		0	0	0	3,323	12,596,000	3,773	0	0		3,323	13,899,000	3,800
Orland															
1967-2008	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															
1992-2008	18	152,000	8,300	6	6,000	1,100	0	0		11	71,000	6,200	35	229,000	6,800
2009	0	0		0	0		0	0		2	5,000	2,500	2	5,000	2,500
2012	2	5,000	2,500	550	2,000	0	0	0		0	0		552	7,000	0

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
Total Pawcatuck	20	157,000	5,400	556	8,000	600	0	0		13	76,000	4,400	589	241,000	3,100
Penobscot															
1871-2008	19,515	167,574,000	7,900	7,317	20,298,000	2,900	329	1,400,000	4,300	0	0		27,161	189,273,000	7,400
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
2018	249	1,882,000	7,600	762	2,129,000	2,800	0	0		0	0		1,011	4,011,000	4,000
Total Penobscot	21,976	186,403,000	7,600	12,100	34,489,000	3,000	329	1,400,000	4,300	0	0		34,405	222,292,000	4,900
Pleasant															
2001-2008	0	0		14	66,000	4,700	343	1,359,000	4,800	0	0		357	1,425,000	4,800
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
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

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
2017	0	0		0	0		83	346,000	4,200	0	0		83	346,000	4,200
2018	0	0		0	0		91	277,000	3,000	0	0		91	277,000	3,000
Total Pleasant	0	0		123	469,000	5,900	932	3,493,000	3,800	0	0		1,055	3,961,000	4,000
Sheepscot															
1995-2008	18	125,000	6,900	0	0		975	3,938,000	3,900	45	438,000	9,900	1,038	4,502,000	4,300
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
2018	0	0		0	0		84	271,000	3,200	0	0		84	271,000	3,200
Total Sheepscot	18	125,000	6,900	0	0	0	1,810	6,440,000	3,200	45	438,000	9,900	1,873	7,004,000	3,200
St Croix															
1993-2008	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															
1974-2008	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 7. 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	34,016	210,749,000	6,600	0	0		2,395	28,935,000	9,000	38,482	260,947,000	6,700
Dennys	26	214,000	7,600	212	1,080,000	4,600	1,705	7,152,000	4,300	40	330,000	7,700	1,983	8,776,000	4,500
East Machias	0	0		0	0		2,012	8,158,000	3,900	0	0		2,012	8,158,000	3,900
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		3,200	12,756,000	3,600	8	52,000	6,400	3,664	16,072,000	3,800
Merrimack	1,582	12,306,000	7,700	13,148	62,781,000	3,800	0	0		540	5,709,000	11,000	15,270	80,797,000	4,500
Narraguagus	0	1,303,000		0	0		3,323	12,596,000	3,800	0	0		3,323	13,899,000	3,800
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	4,300	589	241,000	3,100
Penobscot	21,976	186,403,000	7,600	12,100	34,488,000	3,000	329	1,400,000	4,300	0	0		34,405	222,291,000	4,900
Pleasant	0	0		123	468,000	5,900	932	3,492,000	3,800	0	0		1,055	3,960,000	4,000
Sheepscot	18	125,000	6,900	0	0		1,810	6,440,000	3,200	45	438,000	9,900	1,873	7,004,000	3,300
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	**26,841**	**230,310,000**	**8,600**	**60,155**	**309,574,000**	**5,100**	**13,311**	**51,994,000**	**3,900**	**3,041**	**35,540,000**	**11,700**	**103,348**	**627,420,000**	**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 8. 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								
2001-2008	0	9,000	0	0	0	0	0	9,000
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								
1978-2008	0	3,798,000	317,400	38,600	0	32,600	29,800	4,216,400
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								
1988-2008	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								
1967-2008	0	126,441,000	2,834,300	1,813,400	17,300	3,771,300	1,484,100	136,361,400
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
2018	0	197,000	8,500	0	0	0	0	205,500
Totals:Connecticut	**0**	**149,571,000**	**2,858,200**	**1,836,700**	**64,700**	**3,771,900**	**1,828,100**	**159,930,600**
Dennys								
1975-2008	0	2,678,000	225,400	7,300	0	532,700	29,400	3,472,800
2009	0	317,000	0	0	0	0	600	317,600
2010	0	430,000	0	0	0	0	0	430,000

	Number of fish stocked by life stage							
	Egg	**Fry**	**0 Parr**	**1 Parr**	**2 Parr**	**1 Smolt**	**2 Smolt**	**Total**
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
2018	0	234,000	0	300	0	0	400	234,700
Totals:Dennys	**0**	**4,861,000**	**225,400**	**7,600**	**0**	**532,700**	**30,400**	**5,657,100**
Ducktrap								
1986-2008	0	68,000	0	0	0	0	0	68,000
Totals:Ducktrap	**0**	**68,000**	**0**	**0**	**0**	**0**	**0**	**68,000**
East Machias								
1973-2008	0	2,997,000	7,500	42,600	0	108,400	30,400	3,185,900
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
2018	0	10,000	119,500	0	0	0	0	129,500
Totals:East Machias	**0**	**3,796,000**	**1,010,900**	**42,600**	**0**	**108,400**	**30,400**	**4,988,300**
Kennebec								
2001-2008	320000	169,000	0	0	0	0	0	488,807
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
2018	1228000	0	0	0	0	0	0	1,227,673
Totals:Kennebec	**7,184,000**	**331,000**	**0**	**0**	**0**	**800**	**0**	**7,515,395**
Lamprey								
1978-2008	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								
1970-2008	0	5,019,000	99,000	122,400	0	191,300	44,100	5,475,800
2009	0	291,000	300	0	0	0	0	291,300
2010	0	510,000	0	0	0	0	0	510,000

	Number of fish stocked by life stage							
	Egg	**Fry**	**0 Parr**	**1 Parr**	**2 Parr**	**1 Smolt**	**2 Smolt**	**Total**
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
2018	84000	145,000	0	0	0	0	0	229,500
Totals:Machias	**261,000**	**7,801,000**	**101,000**	**125,700**	**0**	**250,400**	**44,100**	**8,584,067**

Merrimack

1975-2008	0	37,224,000	236,000	607,700	0	1,707,900	638,100	40,413,700
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

1970-2008	0	4,631,000	117,100	14,600	0	161,900	84,000	5,008,600
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
2018	0	100,000	21,700	400	0	99,900	600	222,600
Totals:Narraguagus	**79,000**	**7,837,000**	**169,900**	**15,000**	**0**	**696,200**	**84,600**	**8,881,845**

Pawcatuck

1979-2008	0	5,900,000	1,209,200	268,100	0	118,200	500	7,496,000
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
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

	Number of fish stocked by life stage							
	Egg	**Fry**	**0 Parr**	**1 Parr**	**2 Parr**	**1 Smolt**	**2 Smolt**	**Total**
Totals:Pawcatuck	**0**	**6,319,000**	**1,209,200**	**268,100**	**0**	**128,700**	**500**	**7,925,500**
Penobscot								
1970-2008	0	22,009,000	5,416,100	1,394,400	0	14,935,400	2,508,200	46,263,100
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
2018	397000	1,143,000	219,900	0	0	559,100	0	2,319,033
Totals:Penobscot	**2,209,000**	**30,688,000**	**7,679,000**	**1,394,400**	**0**	**20,357,200**	**2,508,200**	**64,835,639**
Pleasant								
1975-2008	0	995,000	16,000	1,800	0	63,400	42,100	1,118,300
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
2018	106000	84,000	0	0	0	0	0	189,503
Totals:Pleasant	**295,000**	**2,067,000**	**16,000**	**1,800**	**0**	**246,900**	**42,400**	**2,667,813**
Saco								
1975-2008	0	6,190,000	447,800	219,200	0	345,800	9,500	7,212,300
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
2018	70000	557,000	0	0	0	0	0	627,300
Totals:Saco	**158,000**	**9,561,000**	**518,900**	**232,000**	**0**	**444,100**	**9,500**	**10,923,618**
Sheepscot								
1971-2008	18000	2,826,000	145,900	20,600	0	92,200	7,100	3,109,600
2009	0	185,000	17,900	0	0	0	0	202,900
2010	9000	114,000	14,500	0	0	0	0	137,500

	Number of fish stocked by life stage							
	Egg	**Fry**	**0 Parr**	**1 Parr**	**2 Parr**	**1 Smolt**	**2 Smolt**	**Total**
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
2018	131000	23,000	13,100	0	0	0	0	167,130
Totals:Sheepscot	**1,166,000**	**3,425,000**	**296,100**	**20,600**	**0**	**92,200**	**7,100**	**5,007,210**

St Croix

1981-2008	0	1,268,000	498,000	158,300	0	808,000	20,100	2,752,400
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

1971-2008	0	485,000	371,400	0	0	379,700	251,000	1,487,100
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

1979-2008	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 9. 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	149,569,000	2,858,200	1,836,700	64,800	3,771,900	1,828,200	**159,864,500**
Dennys	0	4,861,000	225,400	7,600	0	532,800	30,400	**5,657,400**
Ducktrap	0	68,000	0	0	0	0	0	**68,000**
East Machias	0	3,795,000	1,010,800	42,600	0	108,400	30,400	**4,987,000**
Kennebec	7,184,000	331,000	0	0	0	900	0	**7,515,700**
Lamprey	0	1,593,000	427,700	58,800	0	201,400	32,800	**2,313,700**
Machias	262,000	7,802,000	100,900	125,600	0	250,400	44,100	**8,584,700**
Merrimack	0	41,797,000	431,700	658,100	0	1,981,400	638,300	**45,506,500**
Narraguagus	79,000	7,838,000	169,900	15,000	0	696,400	84,600	**8,882,800**
Pawcatuck	0	6,318,000	1,209,200	268,100	0	128,700	500	**7,924,600**
Penobscot	2,209,000	30,687,000	7,679,100	1,394,400	0	20,357,200	2,508,200	**64,834,500**
Pleasant	294,000	2,067,000	16,000	1,800	0	247,000	42,400	**2,668,300**
Saco	158,000	9,561,000	518,800	232,000	0	444,000	9,500	**10,923,500**
Sheepscot	1,166,000	3,426,000	296,100	20,600	0	92,200	7,100	**5,007,800**
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	**282,680,000**	**17,637,400**	**4,883,400**	**64,800**	**30,044,100**	**5,585,000**		**352,181,600**

Summaries for each river vary by length of time series.

Appendix 10. Estimatated Atlantic salmon returns to New England rivers.

Estimated returns include rod and trap caught fish as well as returns estimated from redd counts. 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									
1983-2008	51	548	6	2	9	87	0	1	**704**
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**
2018	0	0	0	0	0	1	0	0	**1**
Total for Androscoggin	57	602	0	2	10	116	0	0	**794**
Cocheco									
1992-2008	0	0	1	1	6	10	0	0	**18**
Total for Cocheco	0	0	0	1	6	10	0	0	**18**
Connecticut									
1974-2008	56	3,569	28	2	99	2,015	14	3	**5,786**
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**
2018	0	0	0	0	0	2	0	0	**2**
Total for Connecticut	58	3,612	16	2	140	2391	16	16	**6,250**
Cove Brook									
2018	0	0	0	0	0	0	0	0	**0**

	HATCHERY ORIGIN				WILD ORIGIN				
	1SW	2SW	3SW	Repeat	1SW	2SW	3SW	Repeat	Total
Total for Cove Brook	0	0	0	0	0	0	0	0	**0**
Dennys									
1967-2008	41	346	0	1	73	894	3	34	**1,392**
2009	0	2	0	0	2	7	2	1	**14**
2010	1	1	0	0	0	4	0	0	**6**
2011	0	1	0	0	2	5	1	0	**9**
2015	0	0	0	0	4	15	0	0	**19**
2016	0	0	0	0	2	9	0	0	**11**
2017	0	0	0	0	3	12	0	0	**15**
2018	0	0	0	0	1	6	0	0	**7**
Total for Dennys	42	350	6	1	87	952	6	6	**1,473**
Ducktrap									
1985-2008	0	0	0	0	53	232	0	0	**285**
2009	0	0	0	0	4	17	0	0	**21**
2010	0	0	0	0	2	10	0	0	**12**
2013	0	0	0	0	1	6	0	0	**7**
2014	0	0	0	0	1	6	0	0	**7**
2017	0	0	0	0	1	3	0	0	**4**
2018	0	0	0	0	0	0	0	0	**0**
Total for Ducktrap	0	0	0	0	62	274	0	0	**336**
East Machias									
1967-2008	22	254	1	2	60	519	1	10	**869**
2009	0	0	0	0	5	20	0	0	**25**
2010	0	0	0	0	1	6	0	0	**7**
2011	0	0	0	0	5	20	0	0	**25**
2012	0	0	0	0	2	9	0	0	**11**
2013	0	0	0	0	2	9	0	0	**11**
2014	0	0	0	0	4	15	0	0	**19**
2015	1	3	0	0	2	8	0	0	**14**
2016	2	10	0	0	1	3	0	0	**16**
2017	2	6	0	0	0	1	0	0	**9**
2018	2	12	0	0	0	0	0	0	**14**
Total for East Machias	29	285	1	2	82	610	1	1	**1,020**
Kenduskeag Stream									
2017	0	0	0	0	2	7	0	0	**9**

	HATCHERY ORIGIN				WILD ORIGIN				
	1SW	2SW	3SW	Repeat	1SW	2SW	3SW	Repeat	Total
Total for Kenduskeag Stream	0	0	0	0	2	7	0	0	**9**
Kennebec									
1975-2008	24	215	6	1	5	17	0	0	**268**
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**
2018	0	1	0	0	3	7	0	0	**11**
Total for Kennebec	24	261	2	7	22	200	2	2	**522**
Lamprey									
1979-2008	10	17	1	0	13	16	0	0	**57**
Total for Lamprey	10	17	0	0	13	16	0	0	**57**
Machias									
1967-2008	40	363	9	2	126	1,969	41	131	**2,681**
2009	0	0	0	0	7	26	0	0	**33**
2010	0	0	0	0	5	22	0	0	**27**
2011	0	0	0	0	10	42	0	0	**52**
2012	0	0	0	0	6	23	0	0	**29**
2013	0	0	0	0	1	3	0	0	**4**
2014	0	0	0	0	3	12	0	0	**15**
2015	3	11	0	0	1	5	0	0	**20**
2016	0	0	0	0	3	14	0	0	**17**
2017	0	0	0	0	3	11	0	0	**14**
2018	0	0	0	0	2	7	0	0	**9**
Total for Machias	43	374	41	2	167	2134	41	41	**2,901**
Merrimack									
1982-2008	338	1,429	22	8	133	1,040	28	0	**2,998**
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**

	HATCHERY ORIGIN				WILD ORIGIN				
	1SW	2SW	3SW	Repeat	1SW	2SW	3SW	Repeat	Total
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**
2018	0	2	0	0	0	0	0	0	**2**
Total for Merrimack	504	1,788	40	12	154	1224	40	40	**3,775**
Narraguagus									
1967-2008	93	654	19	56	107	2,523	72	165	**3,689**
2009	12	0	0	0	4	20	0	0	**36**
2010	30	33	1	1	3	6	0	2	**76**
2011	55	96	2	1	20	21	0	1	**196**
2012	5	24	3	0	0	13	0	0	**45**
2013	7	33	0	0	0	9	0	0	**49**
2014	0	13	0	0	0	6	0	6	**25**
2015	0	0	0	0	0	27	0	0	**27**
2016	0	0	0	0	0	9	0	0	**9**
2017	20	0	0	0	7	7	0	2	**36**
2018	20	17	0	0	1	3	1	0	**42**
Total for Narraguagus	242	870	73	58	142	2644	73	73	**4,230**
Pawcatuck									
1982-2008	2	150	1	0	1	17	1	0	**172**
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	1	**181**
Penobscot									
1968-2008	12,009	45,710	288	713	749	3,922	35	99	**63,525**
2009	185	1,683	2	1	12	74	1	0	**1,958**
2010	409	819	0	11	23	53	0	0	**1,315**

	HATCHERY ORIGIN				WILD ORIGIN				
	1SW	2SW	3SW	Repeat	1SW	2SW	3SW	Repeat	Total
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**
2018	276	434	0	1	15	45	0	1	**772**
Total for Penobscot	14,338	52,993	37	746	881	4628	37	37	**74,048**
Pleasant									
1967-2008	11	33	0	0	40	326	3	2	**415**
2009	0	0	0	0	1	3	0	0	**4**
2010	0	0	0	0	2	7	0	0	**9**
2011	0	0	0	0	5	18	0	0	**23**
2012	0	0	0	0	3	11	0	0	**14**
2013	5	20	0	0	1	5	0	0	**31**
2014	0	2	0	0	0	2	0	0	**4**
2015	5	21	0	0	0	0	0	0	**26**
2017	0	0	0	0	2	7	0	0	**9**
2018	0	0	0	0	0	0	0	0	**0**
Total for Pleasant	21	76	3	0	54	379	3	3	**535**
Saco									
1985-2008	140	640	5	7	36	93	6	0	**927**
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**
2018	0	0	0	0	1	2	0	0	**3**
Total for Saco	183	714	6	7	52	124	6	6	**1,091**
Sheepscot									
1967-2008	12	47	0	0	64	463	13	0	**599**

	HATCHERY ORIGIN				WILD ORIGIN				
	1SW	2SW	3SW	Repeat	1SW	2SW	3SW	Repeat	Total
2009	3	13	0	0	2	9	0	0	**27**
2010	3	11	0	0	2	8	0	0	**24**
2011	2	9	0	0	2	6	0	0	**19**
2012	2	7	0	0	1	6	0	0	**16**
2013	1	5	0	0	1	3	0	0	**10**
2014	3	12	0	0	2	8	0	0	**25**
2015	1	6	0	0	1	4	0	0	**12**
2016	1	4	0	0	1	3	0	0	**9**
2017	2	9	0	0	2	6	0	0	**19**
2018	1	2	0	0	1	2	0	0	**6**
Total for Sheepscot	31	125	13	0	79	518	13	13	**766**
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**
St Croix									
1981-2008	720	1,124	39	12	880	1,340	78	34	**4,227**
Total for St Croix	720	1,124	78	12	880	1340	78	78	**4,227**
Union									
1973-2008	274	1,841	9	28	1	16	0	0	**2,169**
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**
2018	0	0	0	0	0	0	0	0	**0**
Total for Union	274	1,842	0	28	1	18	0	0	**2,172**

Appendix 11. 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	116	0	1	**794**
Cocheco	0	0	1	1	6	10	0	0	**18**
Connecticut	58	3,612	28	2	140	2,391	16	3	**6,250**
Cove Brook	0	0	0	0	0	0	0	0	**0**
Dennys	42	350	0	1	87	952	6	35	**1,473**
Ducktrap	0	0	0	0	62	274	0	0	**336**
East Machias	29	285	1	2	82	610	1	10	**1,020**
Kenduskeag Stream	0	0	0	0	2	7	0	0	**9**
Kennebec	24	261	6	7	22	200	2	0	**522**
Lamprey	10	17	1	0	13	16	0	0	**57**
Machias	43	374	9	2	167	2,134	41	131	**2,901**
Merrimack	504	1,788	53	12	154	1,224	40	0	**3,775**
Narraguagus	242	870	25	58	142	2,644	73	176	**4,230**
Pawcatuck	2	151	1	0	1	25	1	0	**181**
Penobscot	14,338	52,993	322	746	881	4,628	37	103	**74,048**
Pleasant	21	76	0	0	54	379	3	2	**535**
Saco	183	714	5	7	52	124	6	0	**1,091**
Sheepscot	31	125	0	0	79	518	13	0	**766**
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 12.1: 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 (%) 1.1	1.2	1.3	2.1	2.2	2.3	3.1	3.2	3.3	4.2	Age (years) dist'n (%) 2	3	4	5	6
1974	2	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1975	3	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1976	3	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	5	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	5	7	1.400	0	0	0	0	100	0	0	0	0	0	0	0	100	0	0
1979	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 2013 and earlier).

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

Appendix 12.1: 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	0	0	100	0	0
2013	62	11	0.176	0	0	0	0	100	0	0	0			0	0	100	0	
Total	**10,161**	**1,704**																
Mean			**0.459**	**0**	**8**	**0**	**3**	**69**	**3**	**0**	**3**	**0**	**0**	**0**	**11**	**69**	**6**	**0**

Means includes year classes with complete return data (year classes of 2013 and earlier).

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

Appendix 12.2: 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 2013 and earlier).

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

Appendix 12.2: 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	0	0	42	42	17	0
2013	186	19	0.102	5	0	0	0	95	0	0	0			5	0	95	0	
2014	20	2	0.101	0	0	0	0	100		0				0	0	100		
2015	39	0	0.000	0	0		0							0	0			
2016	6	0	0.000	0										0				
Total	**14,905**	**2,547**																
Mean			**0.363**	**0**	**12**	**0**	**4**	**67**	**2**	**0**	**4**	**0**	**0**	**0**	**17**	**67**	**6**	**0**

Means includes year classes with complete return data (year classes of 2013 and earlier).

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

Appendix 12.3: 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 2013 and earlier).

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

Appendix 12.3: 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	0	0	0
2013	56	3	0.054	0	0	0	0	100	0	0	0			0	0	100	0	
2014	12	0	0.000	0	0	0	0	0		0				0	0	0		
2015	27	0	0.000	0	0		0							0	0			
2016	4	0	0.000	0										0				
Total	**2,404**	**376**																
Mean			**0.248**	**0**	**22**	**0**	**4**	**55**	**0**	**0**	**6**	**0**	**0**	**0**	**26**	**55**	**7**	**0**

Means includes year classes with complete return data (year classes of 2013 and earlier).

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

Appendix 12.4: Return rates for Atlantic salmon that were stocked as fry in the Merrimack River .

Year	Total Fry (10,000s)	Total Returns	Returns (per 10,000)	Age class (smolt age.sea age) distribution (%)										Age (years) dist'n (%)				
				1.1	1.2	1.3	2.1	2.2	2.3	3.1	3.2	3.3	4.2	2	3	4	5	6
1975	4	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1976	6	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	7	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	11	18	1.698	0	0	0	0	11	33	22	28	6	0	0	0	33	61	6
1979	8	43	5.584	0	0	0	0	84	5	2	9	0	0	0	0	86	14	0
1980	13	42	3.333	0	0	0	0	19	5	19	52	5	0	0	0	38	57	5
1981	6	78	13.684	0	0	0	6	81	0	5	8	0	0	0	6	86	8	0
1982	5	48	9.600	0	0	2	2	77	8	0	10	0	0	0	2	79	18	0
1983	1	23	27.479	0	4	4	17	65	4	0	4	0	0	0	21	69	8	0
1984	53	47	0.894	0	13	0	4	77	2	0	4	0	0	0	17	77	6	0
1985	15	59	3.986	0	2	0	7	69	2	0	20	0	0	0	9	69	22	0
1986	52	111	2.114	0	11	0	0	77	1	0	9	0	2	0	11	77	10	2
1987	108	264	2.449	0	2	0	9	85	0	0	4	0	0	0	11	85	4	0
1988	172	93	0.541	1	5	0	0	90	0	0	3	0	0	1	5	90	3	0
1989	103	45	0.435	2	7	0	31	60	0	0	0	0	0	2	38	60	0	0
1990	98	21	0.215	5	0	0	10	81	0	0	5	0	0	5	10	81	5	0
1991	146	17	0.117	0	6	0	6	76	12	0	0	0	0	0	12	76	12	0
1992	112	15	0.134	0	0	0	0	93	7	0	0	0	0	0	0	93	7	0
1993	116	11	0.095	0	0	0	27	45	0	9	18	0	0	0	27	54	18	0
1994	282	53	0.188	0	0	0	13	85	0	0	2	0	0	0	13	85	2	0
1995	283	87	0.308	0	0	0	22	72	0	6	0	0	0	0	22	78	0	0

Means includes year classes with complete return data (year classes of 2013 and earlier).

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

Appendix 12.4: 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	0	0	100	0	0
2013	11	4	0.360	0	0	0	0	100	0	0	0			0	0	100	0	
2014	1	1	0.800	0	0	0	100	0		0				0	100	0		
2015	0	0	0.000	0	0		0							0	0			
2016	0	0	0.000	0										0				
Total	**4,183**	**1,418**																
Mean			**1.986**	**0**	**3**	**0**	**9**	**65**	**4**	**2**	**8**	**0**	**0**	**0**	**12**	**67**	**12**	**1**

Appendix 12.5: 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 2013 and earlier).

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

Appendix 12.5: 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	0	0	0
2013	1	0	0.000	0	0	0	0	0	0	0	0			0	0	0	0	
2014	0	0	0.000	0	0	0	0	0		0				0	0	0		
2015	1	0	0.000	0	0		0							0	0			
2016	1	0	0.000	0										0				
Total	**633**	**27**																
Mean			**0.120**	**0**	**3**	**1**	**1**	**32**	**0**	**0**	**4**	**0**	**0**	**0**	**4**	**33**	**4**	**0**

Means includes year classes with complete return data (year classes of 2013 and earlier).

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

Appendix 12.6: 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 2013 and earlier).

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

Appendix 12.6: 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	0	0	100	0	0
2013	21	1	0.048	0	0	0	0	100	0	0	0			0	0	100	0	
2014	8	0	0.000	0	0	0	0	0		0				0	0	0		
2015	12	0	0.000	0	0		0							0	0			
2016	2	0	0.000	0										0				
Total	**565**	**122**																
Mean			**0.227**	**0**	**18**	**0**	**5**	**58**	**0**	**0**	**0**	**0**	**0**	**0**	**23**	**58**	**0**	**0**

Means includes year classes with complete return data (year classes of 2013 and earlier).

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

Appendix 12.7: Return rates for Atlantic salmon that were stocked as fry in the Westfield River .

Year	Total Fry (10,000s)	Total Returns	Returns (per 10,000)	Age class (smolt age.sea age) distribution (%)										Age (years) dist'n (%)				
				1.1	1.2	1.3	2.1	2.2	2.3	3.1	3.2	3.3	4.2	2	3	4	5	6
1988	1	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	11	1	0.095	0	0	0	0	100	0	0	0	0	0	0	0	100	0	0
1990	27	4	0.146	0	25	0	0	75	0	0	0	0	0	0	25	75	0	0
1991	81	8	0.099	0	0	0	0	75	0	0	25	0	0	0	0	75	25	0
1992	40	15	0.373	0	0	0	0	93	0	0	7	0	0	0	0	93	7	0
1993	66	37	0.559	0	0	0	0	100	0	0	0	0	0	0	0	100	0	0
1994	67	44	0.652	0	0	0	2	91	0	0	7	0	0	0	2	91	7	0
1995	88	17	0.192	0	0	0	18	82	0	0	0	0	0	0	18	82	0	0
1996	71	12	0.170	0	0	0	8	92	0	0	0	0	0	0	8	92	0	0
1997	91	6	0.066	0	0	0	0	100	0	0	0	0	0	0	0	100	0	0
1998	102	8	0.078	0	0	0	25	62	0	0	12	0	0	0	25	62	12	0
1999	71	4	0.056	0	0	0	0	75	0	0	25	0	0	0	0	75	25	0
2000	84	11	0.131	0	9	0	0	73	0	0	18	0	0	0	9	73	18	0
2001	107	20	0.188	0	5	0	5	90	0	0	0	0	0	0	10	90	0	0
2002	89	34	0.381	0	15	0	6	79	0	0	0	0	0	0	21	79	0	0
2003	81	23	0.284	0	17	0	9	70	0	0	4	0	0	0	26	70	4	0
2004	93	36	0.389	0	11	0	0	86	0	0	3	0	0	0	11	86	3	0
2005	84	1	0.012	0	0	0	100	0	0	0	0	0	0	0	100	0	0	0
2006	73	5	0.069	0	0	0	0	80	0	0	20	0	0	0	0	80	20	0
2007	57	5	0.088	0	0	0	0	80	0	0	20	0	0	0	0	80	20	0
2008	63	9	0.143	0	0	0	44	44	0	0	11	0	0	0	44	44	11	0

Means includes year classes with complete return data (year classes of 2013 and earlier).

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

Appendix 12.7: 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	0	0	33	67	0
2013	47	3	0.064	0	0	0	0	100	0	0	0			0	0	100	0	
Total	**1,717**	**320**																
Mean			**0.179**	**4**	**4**	**0**	**9**	**70**	**3**	**0**	**6**	**0**	**0**	**4**	**12**	**70**	**9**	**0**

Means includes year classes with complete return data (year classes of 2013 and earlier).

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

Appendix 12.8: 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 2013 and earlier).

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

Appendix 12.8: 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	0	0	8	69	23	0
2013	72	70	0.969	0	0	0	11	83	0	0	6			0	11	83	6	
2014	82	54	0.662	0	0	0	17	74		9				0	17	83		
2015	52	11	0.212	0	9		91							0	100			
2016	102	0	0.000	0										0				
Total	**2,901**	**5,069**																
Mean			**4.686**	**0**	**0**	**0**	**16**	**73**	**1**	**3**	**8**	**0**	**0**	**0**	**16**	**75**	**9**	**0**

Means includes year classes with complete return data (year classes of 2013 and earlier).

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

Appendix 13. 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	0.969
2014	0.800	0.000	0.101		0.000	0.000		0.662
2015	0.000	0.000	0.000		0.000	0.000		0.212
2016	0.000	0.000	0.000		0.000	0.000		0.000
Mean	**2.038**	**0.125**	**0.371**	**0.471**	**0.233**	**0.255**	**0.183**	**4.810**
StDev	**5.150**	**0.397**	**0.449**	**0.697**	**0.260**	**0.300**	**0.173**	**6.349**

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 14. 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	3	0	4	0	0	0	13	80	7	0
Connecticut (basin)	0	13	0	5	76	2	0	4	0	0	0	17	76	6	0
Farmington	0	24	0	4	64	0	0	7	0	0	0	28	64	7	0
Merrimack	0	3	0	12	70	4	2	8	0	0	0	15	72	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	6	0	0	4	12	74	9	0
Overall Mean:	**1**	**10**	**0**	**7**	**73**	**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.

Appendix 15: Estimates of Atlantic salmon escapement to Maine rivers in 2018.

Natural escapement represents the salmon left to freely swim in a river and is equal to the estimated returns, minus those taken for hatcery broodstock, minus observed in-river mortalities. Total escapement equals the natural escapement plus adult salmon that are stocked prior to spawning.

					Pre-Spawn Stocking		
Drainage	**Estimated Returns**	**Broodstock Take**	**Observed Mortalities**	**Natural Escapement**	**Captive/ Domestics**	**Sea Run**	**Total Escapement**
Androscoggin	1	0	0	1	0	0	1
Cove Brook	0	0	0	0	0	0	0
Dennys	7	0	0	7	39	0	46
Ducktrap	0	0	0	0	0	0	0
East Machias	14	0	0	14	64	0	78
Kennebec	11	0	0	11	0	0	11
Machias	9	0	0	9	136	0	145
Narraguagus	42	0	0	42	40	0	82
Penobscot	772	457	1	314	0	2	316
Pleasant	0	0	0	0	0	0	0
Saco	3	0	0	3	0	0	3
Sheepscot	6	0	0	6	63	0	69
Union	0	0	0	0	0	0	0
Totals	**865**	**457**	**1**	**407**	**342**	**2**	**751**