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1 Executive Summary

1.1 Abstract

Total returns to USA rivers in 2019 was 1,535 salmon; this is the sum of documented returns to traps and returns estimated by redd counts. Returns to the US ranks 15 out of the 1991-2019 time series. Most returns (1,528, 99.5%) were to the Gulf of Maine Distinct Population Segment (GoM DPS), which includes the Penobscot River, Kennebec River and Eastern Maine coastal rivers with only 7 returns documented outside of the GoM DPS. Documented returns to traps totaled 1,263 and returns estimated by redd counts was 265 adult salmon. Overall, 25.9% of the adult returns to the USA were 1SW salmon, 73.7% were 2SW salmon and 0.2% were 3SW or repeat spawners. Most (75.7 %) returns were of hatchery smolt origin and the balance (24.3%) originated from either natural reproduction, 0+ fall stocked parr, hatchery fry, or eggs. A total of 4,775,484 juvenile salmon (eggs, fry, parr, and smolt), and 5,710 adults were stocked into US rivers. Of those fish, 367,088 carried a mark and/or tag. Eggs for USA hatchery programs were taken from a total of 1,324 females consisting of 280 sea-run females and 1,044 captive/domestic and domestic females. Total egg take (5,173,240) was lower than 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 (*Salmo salar*), 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 the Northeast Fisheries Science Center using the Standardized Bycatch Reporting Methodology. While bycatch is uncommon, we summarize observed events from 1989 through September 2019 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 2019, 7 observed interactions have occurred, with a total count of 7 individuals. In total, 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 years of a 30-year time series and no Atlantic salmon have been observed since August 2013.

1.3 Adult Returns to USA Rivers

Total returns to USA rivers was 1,535 (Table 1.3.1), a 1.8 fold increase from 2018 (869, Table 1.3.2). Returns are reported for three meta-population areas (Figure 1.3.1): Long Island Sound (LIS, 3 total returns), Central New England (CNE, 4 total returns), and Gulf of Maine (GOM, 1,528 total returns). 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. The majority of adult returns to USA were 2SW (73.7%) with 25.9% being 1SW and 0.2% being 3SW or repeat spawners (Figure 1.3.2). Most (75.7 %) returns were of hatchery smolt origin and the balance (24.3%) originated from either natural reproduction, 0+ fall stocked parr, hatchery fry, or eggs.

In the US, returns are well below conservation spawner requirements. Returns of 2SW fish were only 5.1% of the US CL, with returns to the three areas ranging from 0 to 5.1% of spawner requirements. Out of select rivers with a long-time series of return data, the Pleasant River was the highest at about 16.1% of CL followed by the Narraguagus River (14.6%) and the Dennys River (11.9%). The Penobscot population was at 7.0% (Table 1.3.3).

Two sea-winter smolt to adult returns (SAR) rates for the 2017 smolt cohort for the Penobscot River equaled 0.130% (Figure 1.3.3). This was an increase over the 2016 smolt cohort (0.076%), an increase over the 5-year average (2013 – 2017) of 0.073% and around the 10-year average of 0.134%. The 1SW SAR for hatchery smolts in the Penobscot increased from the 2018 (0.048%) to 2019 (0.052%) cohorts (Table 1.3.4).

1.4 Stock Enhancement Programs

During 2019, a total of 4,775,484 juvenile salmon were released into USA rivers. Of these, 1,826,951 were fry; 1,952,469 were planted eyed eggs; 345,916 were fall fingerlings; and 650,148 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 (554,652) and the Narraguagus (95,496) River. In addition, 5,710 adult salmon were released into USA rivers (Table 1.4.2).

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 367,088 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. All tagging and marking 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 2019, 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. There were no reported escapes from the commercial salmon farming industry in Maine. However, on August 20,2019 there was an escape of approximately 2,500 roughly 2 Kg size fish reported from a site in New Brunswick, Canada. The cause of the escape was a mechanical failure during treatment.

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 moving forward for building land based Recirculating Aquaculture Systems (RAS) in Maine; one at the former site of the Verso Paper Mill along the shores of the Penobscot River, and the other facility proposed for the Belfast area; to be built at the former Belfast Water Works along the shores of the Little River. Both proposals to date are to build a RAS facility to produce Atlantic salmon for commercial sale. The facilities are planning to use Atlantic salmon that do not originate from North America for production. A potential source of Atlantic salmon eggs for importation annually would be Stofnfiskur; a company based in Iceland and is a well-known for exporting clean disease-free ova supporting salmon aquaculture throughout the world. A thorough review of the information provided along with discussions concerning designs of the facility for wastewater discharge permits are ongoing with the applicants. A quarantine facility will also be required for receiving imported eyed eggs from out of the State of Maine. The facility owned by Whole Oceans in Brewer, Maine was issued a discharge permit by the State of Maine Department Environmental Protection with further federal review of a facility Containment plan prior to building the facility and starting production.

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 which continued smolt assessments for a 23rd consecutive year. These sites were divided between the upper and lower drainages to determine the differential production between regions. Data is presented only for the lower site which is used for the historical time series (Table 1.7.1). A total of 526 smolts were captured (140 naturally reared, 386 hatchery origin). The estimate of naturally-reared smolt migration was 829 (95% 627 to 1,031).

MDMR operated three RSTs at one site on the Sheepscot River which marked the 17th year of assessment on this river (Table 1.7.1). A total of 308 smolts were captured (141 naturally reared, 167 hatchery origin). The estimate of naturally-reared smolt migration was 576 (95% 460 to 692).

1.8 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

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, 2019. "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	3	0	0	0	0	3
CNE	0	1	2	1	0	0	0	0	4
GOM	358	39	798	327	2	1	2	1	1,528
Total	358	40	800	331	2	1	2	1	1,535

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

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
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	105
2019	398	1131	3	3	1535	1162	368

Table 1.3.3. 2019 2SW returns against 2SW Conservation Limits for select US rivers.

Region	Name	CL	Returns	% of CL Met
CNE	Merrimack	2,599	0	0.00%
CNE	Pawcatuck	358	0	0.00%
GOM	Androscoggin	847	1	0.12%
GOM	Dennys	109	13	11.87%
GOM	Ducktrap	50	0	0.00%
GOM	East Machias	337	32	9.50%
GOM	Kennebec	4,628	53	1.15%
GOM	Machias	792	23	2.90%
GOM	Narraguagus	363	53	14.62%
GOM	Penobscot	12,899	899	6.97%
GOM	Pleasant	131	21	16.07%
GOM	Sheepscot River	342	21	6.13%
GOM	Union	715	2	0.28%
LIS	Connecticut	17,427	3	0.02%

Table 1.3.4. Available time series of 1SW and 2SW smolt to adult return rates (SAR) for monitored US rivers. SAR for monitored rivers are identified as being derived from hatchery origin (Hat.) or naturally reared origin (NR) salmon. No smolt estimates were available for smolt years 2016 and 2017 for the Narraguagus River so no corresponding SAR estimates are available.

River	Penobscot		Merrimack		Connecticut		Narraguagus		Sheepscot		East Machias	
Origin	Hat.		Hat.		Hat.		NR		NR		NR	
Smolt year	1SW	2SW	1SW	2SW	1SW	2SW	1SW	2SW	1SW	2SW	1SW	2SW
1969	0.074%	0.947%										
1970	0.074%	1.091%										
1971	0.021%	0.551%										
1972	0.014%	0.699%			0.000%	0.006%						
1973	0.029%	0.848%			0.000%	0.009%						
1974	0.045%	0.562%			0.000%	0.004%						
1975	0.068%	0.525%			0.000%	0.010%						
1976	0.019%	0.668%			0.000%	0.261%						
1977	0.038%	0.197%			0.003%	0.050%						
1978	0.103%	1.265%			0.004%	0.174%						
1979	0.232%	0.857%			0.003%	0.354%						
1980	0.128%	0.665%		0.045%	0.012%	0.110%						
1981	0.101%	0.361%	0.003%	0.054%	0.004%	0.050%						
1982	0.058%	0.406%	0.010%	0.028%	0.000%	0.031%						
1983	0.057%	0.617%	0.058%	0.102%	0.007%	0.299%						
1984	0.041%	0.567%	0.012%	0.048%	0.000%	0.088%						
1985	0.090%	0.238%	0.010%	0.050%	0.000%	0.135%						
1986	0.124%	0.337%	0.008%	0.015%	0.000%	0.032%						
1987	0.131%	0.373%	0.003%	0.017%	0.000%	0.028%						
1988	0.127%	0.374%	0.003%	0.122%	0.000%	0.057%						
1989	0.102%	0.251%	0.005%	0.130%	0.000%	0.077%						
1990	0.040%	0.274%	0.001%	0.056%	0.000%	0.074%						
1991	0.140%	0.190%	0.014%	0.022%	0.001%	0.039%						

Table 1.3.4. Available time series of 1SW and 2SW smolt to adult return rates (SAR) for monitored US rivers. SAR for monitored rivers are identified as being derived from hatchery origin (Hat.) or naturally reared origin (NR) salmon. No smolt estimates were available for smolt years 2016 and 2017 for the Narraguagus River so no corresponding SAR estimates are available.

River	Penobscot		Merrimack		Connecticut		Narraguagus		Sheepscot		East Machias	
Origin	Hat.		Hat.		Hat.		NR		NR		NR	
Smolt year	1SW	2SW	1SW	2SW	1SW	2SW	1SW	2SW	1SW	2SW	1SW	2SW
1992	0.042%	0.076%	0.000%	0.002%	0.000%	0.084%						
1993	0.047%	0.186%	0.000%	0.031%	0.000%	0.041%						
1994	0.028%	0.215%	0.002%	0.052%	0.000%	0.038%						
1995	0.084%	0.163%	0.016%	0.061%								
1996	0.043%	0.141%	0.018%	0.090%								
1997	0.041%	0.098%	0.019%	0.112%			0.113%	0.942%				
1998	0.039%	0.046%	0.089%	0.062%			0.249%	0.284%				
1999	0.029%	0.082%	0.046%	0.129%			0.314%	0.531%				
2000	0.035%	0.061%	0.010%	0.032%	0.002%	0.006%	0.279%	0.167%				
2001	0.067%	0.155%	0.063%	0.261%			0.161%	0.847%				
2002	0.036%	0.174%	0.023%	0.180%			0.000%	0.464%				
2003	0.050%	0.124%	0.034%	0.049%	0.000%	0.004%	0.084%	1.010%				
2004	0.049%	0.118%	0.016%	0.128%	0.000%	0.034%	0.081%	0.975%				
2005	0.061%	0.102%	0.018%	0.104%	0.015%	0.022%	0.244%	0.732%				
2006	0.040%	0.233%	0.016%	0.154%	0.000%	0.019%	0.086%	0.778%				
2007	0.127%	0.301%	0.012%	0.082%	0.007%	0.018%	0.345%	1.722%				
2008	0.033%	0.148%	0.004%	0.045%	0.000%	0.006%	0.435%	0.653%				
2009	0.073%	0.386%	0.032%	0.170%	0.000%	0.035%	0.257%	1.800%	0.279%	0.836%		
2010	0.123%	0.094%	0.176%	0.111%	0.005%	0.002%	0.946%	0.615%	0.103%	0.334%		
2011	0.001%	0.050%	0.000%	0.017%	0.000%	0.011%	0.000%	0.724%	0.098%	0.261%		
2012	0.010%	0.031%	0.000%	0.083%			0.000%	0.680%	0.083%	0.826%		
2013	0.015%	0.100%	0.010%	0.020%			0.000%	2.348%	0.166%	0.332%	0.752%	2.068%
2014	0.020%	0.039%					0.000%	0.570%	0.125%	0.438%	0.315%	1.366%

Table 1.3.4. Available time series of 1SW and 2SW smolt to adult return rates (SAR) for monitored US rivers. SAR for monitored rivers are identified as being derived from hatchery origin (Hat.) or naturally reared origin (NR) salmon. No smolt estimates were available for smolt years 2016 and 2017 for the Narraguagus River so no corresponding SAR estimates are available.

River	Penobscot		Merrimack		Connecticut		Narraguagus		Sheepscot		East Machias	
Origin	Hat.		Hat.		Hat.		NR		NR		NR	
Smolt year	1SW	2SW	1SW	2SW	1SW	2SW	1SW	2SW	1SW	2SW	1SW	2SW
2015	0.055%	0.120%					0.000%	0.621%	0.131%	0.984%	1.212%	2.828%
2016	0.053%	0.076%					na	na	0.138%	0.138%	0.183%	1.100%
2017	0.048%	0.130%					na	na	0.079%	0.830%	0.139%	2.231%
2018	0.052%						1.589%		0.328%		0.803%	
prev 5-year mean	0.034%	0.073%					0.000%	1.055%	0.120%	0.543%		
prev 10-year mean	0.043%	0.134%					0.205%	1.081%				

Table 1.4.1 Number of juvenile Atlantic salmon by lifestage stocked in USA, 2019 by area and drainage. Central New England (CNE); Gulf of Maine (GOM); Long Island Sound (LIS)

Area	Drainage	Year	0 Parr	1 Smolt	2 Smolt	Eyed Egg	Fry	Total
CNE	Saco	2019				84,192	163,566	247,758
GOM	Dennys	2019	10,000				175,000	185,000
GOM	East Machias	2019	226,000				0	226,000
GOM	Kennebec	2019				917,614	0	917,614
GOM	Machias	2019			91	91,000	183,000	274,091
GOM	Narraguagus	2019		95,496	99	66,000	179,000	340,595
GOM	Penobscot	2019	92,916	554,652		490,663	631,000	1,769,231
GOM	Pleasant	2019				88,000	132,000	220,000
GOM	Sheepscot	2019	17,000			215,000	9,000	241,000
GOM	Union	2019					1,757	1,757
LIS	Connecticut	2019					336,278	336,278
LIS	Pawcatuck	2019					16,350	16,350
		Total	345,916	650,148	190	1,952,469	1,826,951	4,775,674

Table 1.4.2 Stocking summary for sea-run, captive reared domestic adult Atlantic salmon for the USA in 2019 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	1,748	1,117	0	0	2,865
Gulf of Maine	GOM	Restoration	0	2,269	97	479	2,845
Total for USA			1,748	3,386	97	479	5,710

Table 1.5.1 Summary of tagged and marked Atlantic salmon released in USA, 2019. Includes hatchery and wild origin fish.

Mark Code	Life Stage	CNE	GOM	LIS	Total
Adipose clip	0 Parr	-	243,347	-	243,347
Adipose clip	Adult	-	34	-	34
Floy tag	Adult	-	17	-	17
Passive Integrated Transponder (PIT)	Adult	-	3,492	-	3,492
Radio tag	Adult	-	85	-	85
Upper caudal punch	Adult	-	2	-	2
Acoustic Tag	Smolt	-	433	-	433
Adipose clip	smolt	-	119,489	-	119,489
Passive Integrated Transponder (PIT)	Smolt	-	114	-	114
Radio tag	Smolt	-	75	-	75
		0	367,088	0	367,088

Table 1.6.1. State of Maine - USA commercial Atlantic salmon aquaculture production and suspected aquaculture captures to Maine rivers 2000 to 2019. Due to confidentiality statutes in ME marine resources regulations related to single producer, adult production rates are not available 2011 to 2019.

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
2019	1,996,662	60,480	NA	0

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

	Narraguagus River			Sheepscot River		
Smolt Year	Lower 95% CL	Pop Estimate	Upper 95% CL	Lower 95% CL	Pop Estimate	Upper 95% CL
1997	1,940	2,749	3,558	N/A	N/A	N/A
1998	2,353	2,845	3,337	N/A	N/A	N/A
1999	3,196	4,247	5,298	N/A	N/A	N/A
2000	1,369	1,843	2,317	N/A	N/A	N/A
2001	1,835	2,562	3,289	N/A	N/A	N/A
2002	1,308	1,774	2,240	N/A	N/A	N/A
2003	995	1,201	1,407	N/A	N/A	N/A
2004	863	1,284	1,705	N/A	N/A	N/A
2005	846	1,287	1,728	N/A	N/A	N/A
2006	1,943	2,339	2,735	N/A	N/A	N/A
2007	954	1,177	1,400	N/A	N/A	N/A
2008	637	962	1,287	N/A	N/A	N/A
2009	1,000	1,176	1,352	1,243	1,498	1,753
2010	1,704	2,149	2,594	1,736	2,231	2,726
2011	657	1,404	2,151	916	1,639	2,363
2012	491	969	1,447	520	849	1,178
2013	722	1,237	1,752	566	829	1,091
2014	1,227	1,615	2,003	342	542	742
2015	729	1,201	1,673	431	572	713
2016	NA	NA	NA	762	983	1,204
2017	NA	NA	NA	743	985	1,227
2018	483	604	725	663	883	1,103
2019	627	829	1,031	460	576	692

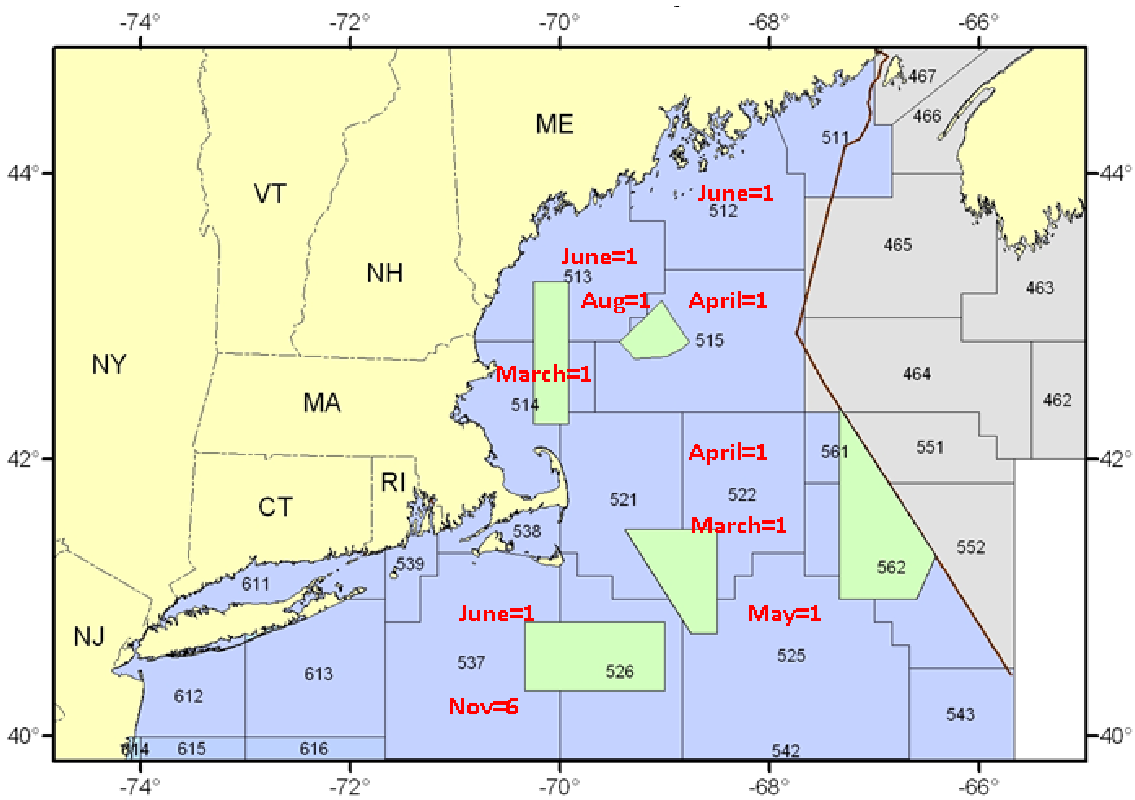

Figure 1.2.1 Map of Gulf of Maine region showing the month and number of Atlantic salmon interactions between 1993 and 2019 (e.g., June=1: 1 salmon interaction in the area in June). Location of the label within the statistical grid does not denote more specific locations. Blue polygons are USA statistical areas, grey zones are in Canada and green-shaded polygons represent regulated access areas.

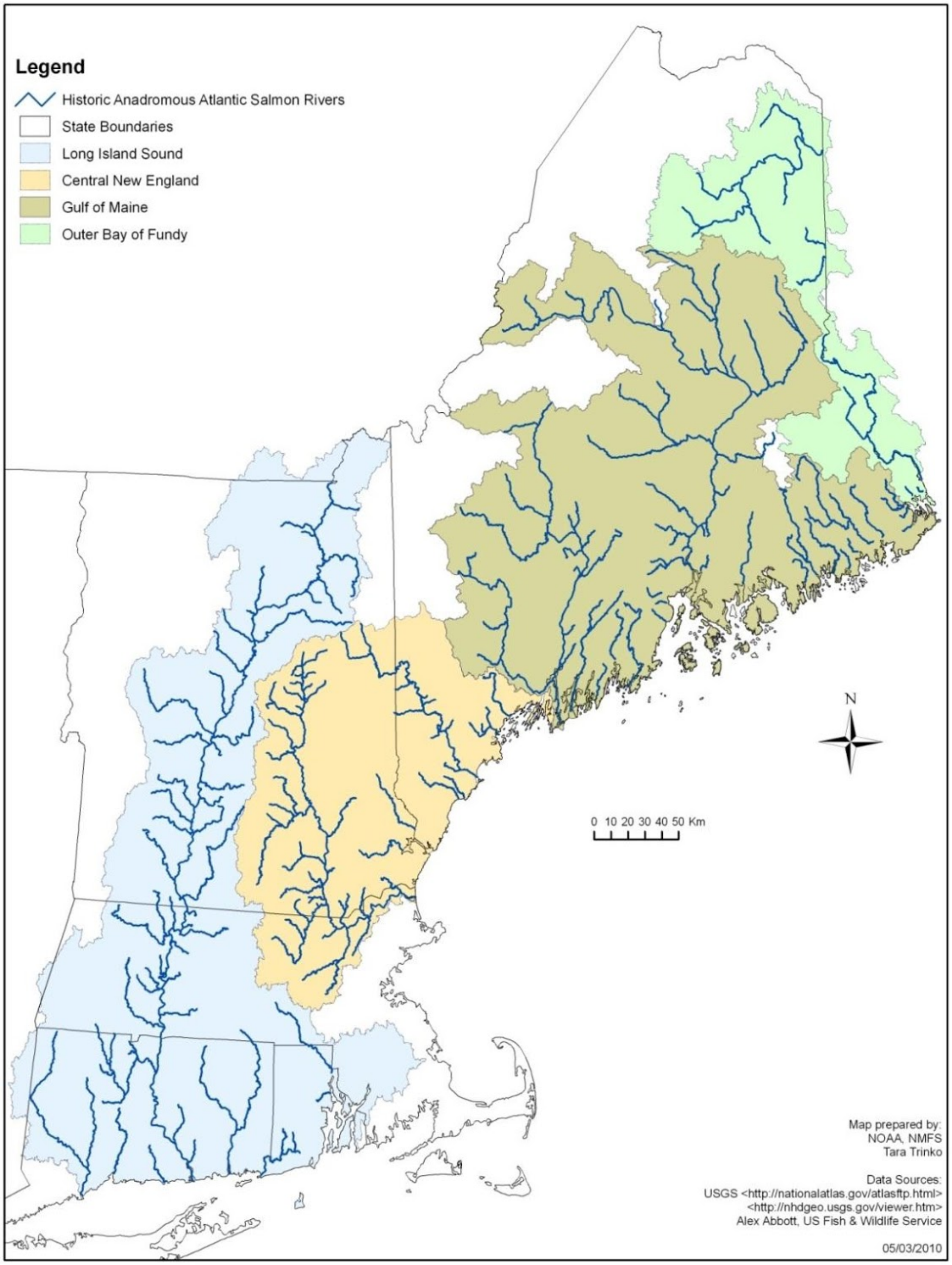

Figure 1.3.1 Map of geographic areas used in summaries of USA data for returns, stocking, and marking in 2019.

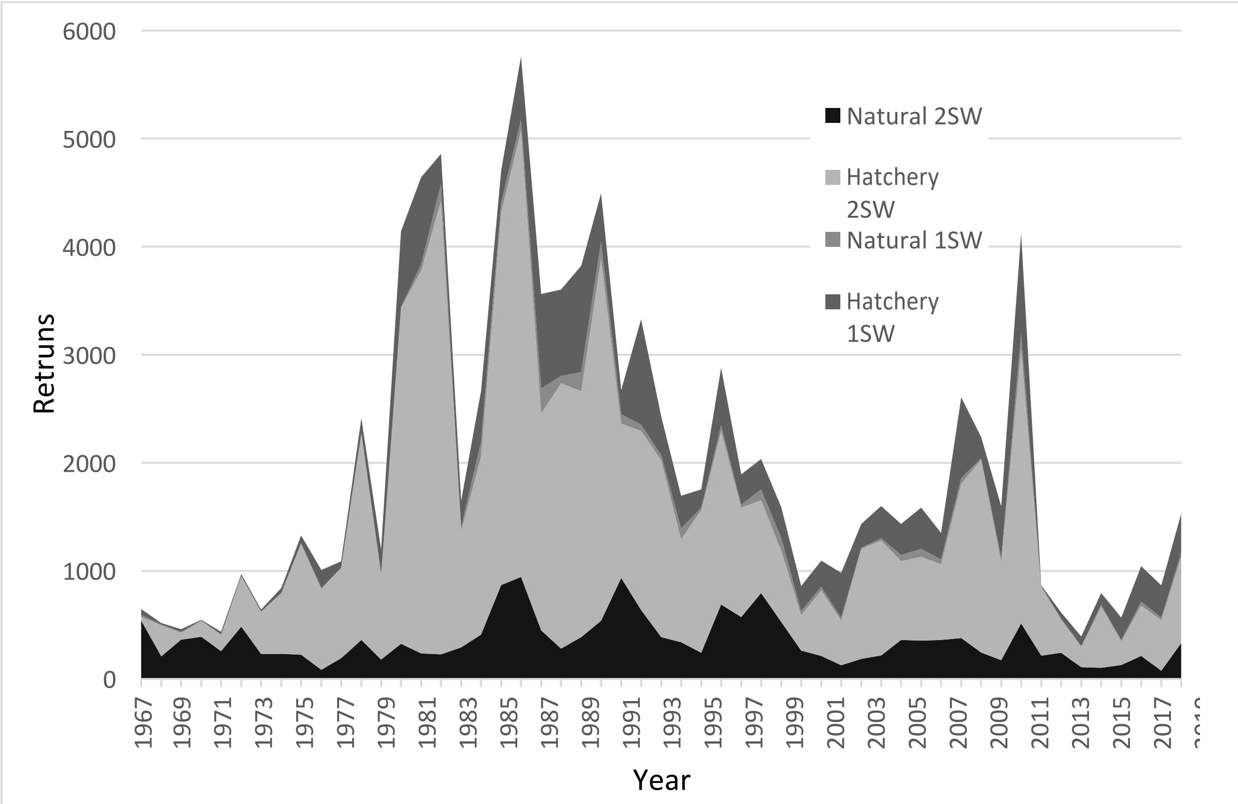

Figure 1.3.2 Origin and sea age of Atlantic salmon returning to USA rivers, 1967 to 2019.

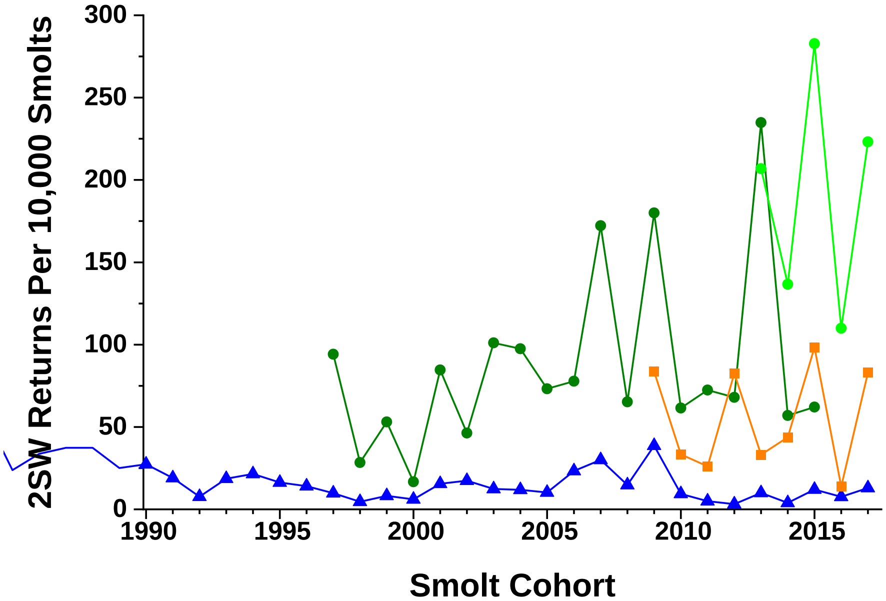

Figure 1.3.3 Return rate of 2SW adults to Gulf of Maine area rivers by smolt cohort year (1990 – 2017) of hatchery-reared Atlantic salmon smolts (Penobscot River blue triangles), estimated naturally-reared smolt emigration (Narraguagus River dark green dots), and fall parr (Sheepscot River orange squares), (East Machias River light green dots) USA.

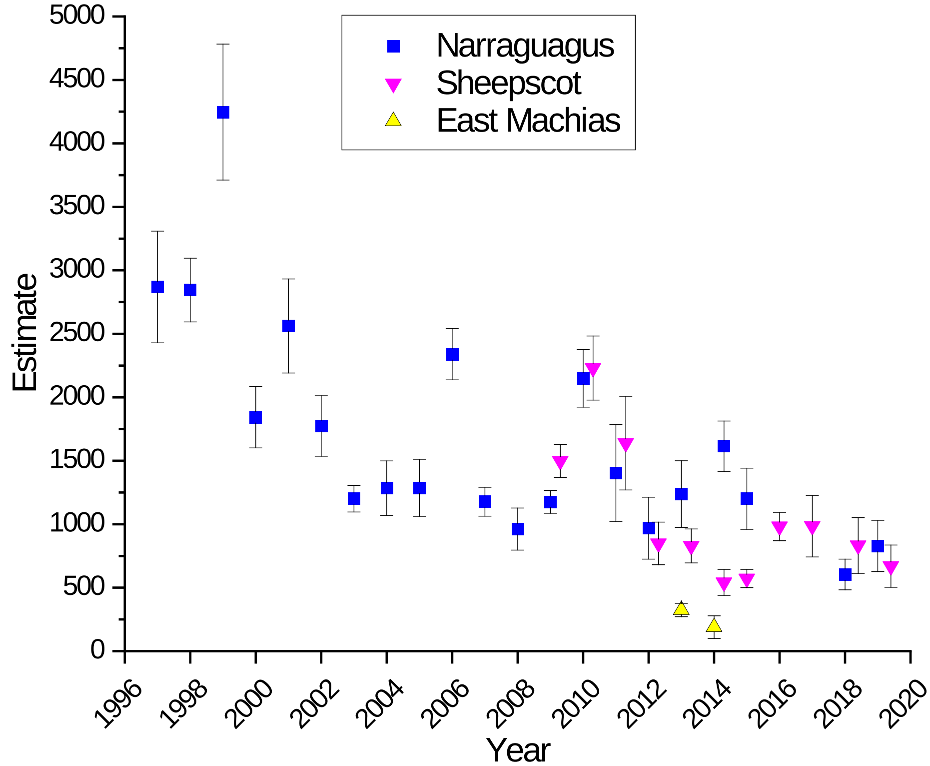

Figure 1.7.1. Population Estimates (± Std. Error) of emigrating naturally-reared smolt in the Narraguagus (no estimate in 2016 and 2017), Sheepscot, and East Machias (no estimate 2015-2017) rivers, Maine (1997-2019), using DARR 2.0.2.

2 Viability Assessment - Gulf of Maine Atlantic Salmon

2.1 Overview of DPS and Annual Viability Synthesis

2.1.1 Change in Status Assessment Approach

While this report summarizes, all US populations related to metrics and general trends to national reporting needs in support of NASCO (e.g. Chapter 1), increasingly these populations are dominated by the endangered GOMDPS in Maine. This section summarizes the more detailed metrics needed to monitor the health of these populations using metrics used for other endangered salmonids in the US. This section of the report represents an annual viability assessment of the GOMDPS using a Viable Salmonid Populations (VSP) approach (McElhany et al. 2000). Taking this approach allows US stock assessment scientists 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. A benchmark assessment will be produced in a future assessment cycle.

2.1.2 DPS Boundary Delineation

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.

2.1.3 Synthesis of 2019 Viability Assessment

Totaling 1,528 estimated adult returns to the GOM DPS, the 2019 spawning run was the 9th highest return since 1991. The majority (76%) of returns were of hatchery-stocked smolt origin. Naturally reared returns remained low across the GOMDPS (368) but were above 100 in PNB and DEC SHRUs. About 48% 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 35% of this target, 2.6-fold higher than returns to the MMB SHRU (14%). The populations in the DEC SHRU were estimated at 122 naturally reared returns (24%). With no documented returns in 2019, the Ducktrap Population is at an elevated risk with returns documented in only 4 of the last 10 years.

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 2019 this was not the case. The MMB SHRU had the highest growth rate (1.84; 95% CI: 1.15 – 2.96) and DEC SHRU had the lowest growth at 0.99 (95% CI: 0.54 – 1.82. The PNB SHRU while above 1 (1.08) had a lower 95%CL of 0.49. Because error bounds fall below 1 for PNB and DEC, there remains concern about population trajectories. Additionally, newly calculated metrics of natural population growth that include genetic elements to better understand wild production have finite growth rates below 1 (declining population) for all 3 SHRU. This new method will be undergoing peer review in the coming year.

The spatial structure of juvenile populations represents a combination of wild production areas that are very limited and supplemented stream reaches that produce naturally reared juveniles. Spawner surveys in 2019 covered 1,422 units (13%) of 10,994 units of mapped spawning habitat representing a 7% increase in effort over 2018. Coverage is limited in MMB and PNB habitat but does focus on priority management areas. In the DEC SHRU, redds were found in 16 of 69 HUC12s (23%). In the MMB SHRU, redds were found in 8 of 71 HUC12s (11%) and in the PNB SHRU, redds were found in 6 of 148 HUC12s (4%). Overall survey coverage was limited so likely underrepresents WPA. Modeling of juvenile production areas from these spawner surveys suggest that of overall juvenile habitat 9.3% of the DEC SHRU will have wild production. In MMB SHRU this occupancy decreases to 2.6% and in PNB SHRU it is 2.2%. These Wild Production Areas will be buffered from stocking in 2020 to minimize competition between wild and hatchery origin juveniles. In addition, in 2022 these areas will be targeted for broodstock electrofishing efforts in efforts to bring components of wild spawning into the captive reared brood program. For the 2019 assessment, we modeled the occupied freshwater production habitat in December and summarized the production area from both natural redds (WPA) and geo-referenced stocking locations. For this analysis, we assume that 3 cohorts of fish comprise the overall freshwater population (2017, 2018, and 2019). The DEC SHRU with 69 HUC-12 areas had cohort occupancy of between 9,800 and 10,300 units in 22 areas (32%) where these 3 cohorts had a proportion occupancy above 0.01. The PNB SHRU with 148 HUC-12 areas had cohort occupancy of between 7,900 and 18,400 units for the 3 cohorts in 23 areas (16%). Finally, the MMB SHRU with 71 HUC-12 areas had cohort occupancy of between 12,000 and 12,700 units in 16 areas (23%) where these 3 cohorts had a proportion occupancy above 0.01. These spatial distribution summaries indicate that juvenile rearing is distributed across all 3 SHRUs and that stocking programs are responsible for expanding the freshwater range substantially. However, the analysis also indicates that at a HUC12 level most habitat is unoccupied and HUC12 areas with production do not have full occupancy. The next steps of spatial stock assessment will work towards integrating density based on historic electrofishing and other sources. Independent efforts to look at climate resilience could then be merged with this spatial assessment to better manage Atlantic salmon habitat, hatchery supplementation, and passage priorities to support salmon conservation now and in the future.

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 Penobscot and Sheepscot populations. All populations are now above 10 of 18 monitored loci but stabilizing diversity is essential and genetic rescue methods could be further investigated. Estimates of effective population size have increased for the Penobscot, 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 through 2016. 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. Populations below 100 LDNe are at elevated risk and the upward trajectory of all these populations between 2016 and 2019 should be maintained.

2.2 Population Size

Overall stock health can be measured by comparing monitored adult abundance to management targets. 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 the Conservation Limit (CL). These values have been calculated for all US populations. The Conservation Limit for the Gulf of Maine DPS is 29,192 adults (Atkinson 2020). 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 the CL for US populations in the context of international assessments by the ICES WGNAS, the metric focuses on only 2SW adult returns (hatchery and natural-reared). The 2SW CL is 22,134. These CL targets represent long-term goals for sustainable population sizes. Adult returns are partitioned into two categories. Hatchery returns are those adult salmon that are a product of an accelerated smolt program or released as fall parr or fall fingerlings. The other category, naturally reared returns are those adult salmon that are a product of natural spawning, egg planting, and fry stocking.

Given the endangered status of GoM ATS, the first management target for downlisting from endangered to threatened is 500 naturally reared returns in each of the 3 SHRUs. For delisting, the next target is 2,000 naturally reared returns. This level of abundance is the minimum population required to have a less than 50 percent chance of falling below 500 spawners under another period of low marine survival. Estimates of both abundance and 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. That metric 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 wild spawners annually 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, managers have 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 (See Sweka et al. Working Paper 2020).

Total adult returns to the GOM DPS in 2019 were 1,528 adults with 1,160 of 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 dominated (78%) total abundance with 1,205 returns. The additional 132 hatchery returns were documented in the DEC SHRU (114) and Merrymeeting Bay SHRU (18).

Naturally reared returns were also highest in Penobscot Bay at 177 (Table 2.2.1 and Figure 2.2.2). However, the Ducktrap River population had 0 documented returns for the second consecutive year. The 10-year average for this system was 3 adults with 0 returns in 6 of these years. The DEC SHRU had 122 documented naturally reared returns across 6 of 6 monitored river systems while the Merrymeeting Bay SHRU had 69 natural returns to 2 of the 3 monitored systems (Androscoggin had 0 natural returns).

Table 2.2.1. Documented returns from trap and redd-count monitoring for GOM DPS Atlantic salmon by SHRU for return year 2019 and percentage of naturally reared fish relative to the interim 500 fish target (% of 500) by SHRU.

SHRU	Hatchery	Natural	Sub Totals	% of 500
Downeast Coastal	114	122	236	24.4%
Penobscot Bay	1,028	177	1,205	35.4%
Merrymeeting Bay	18	69	87	13.8%
Gulf of Maine DPS	**1,160**	**368**	**1,528**	**-**

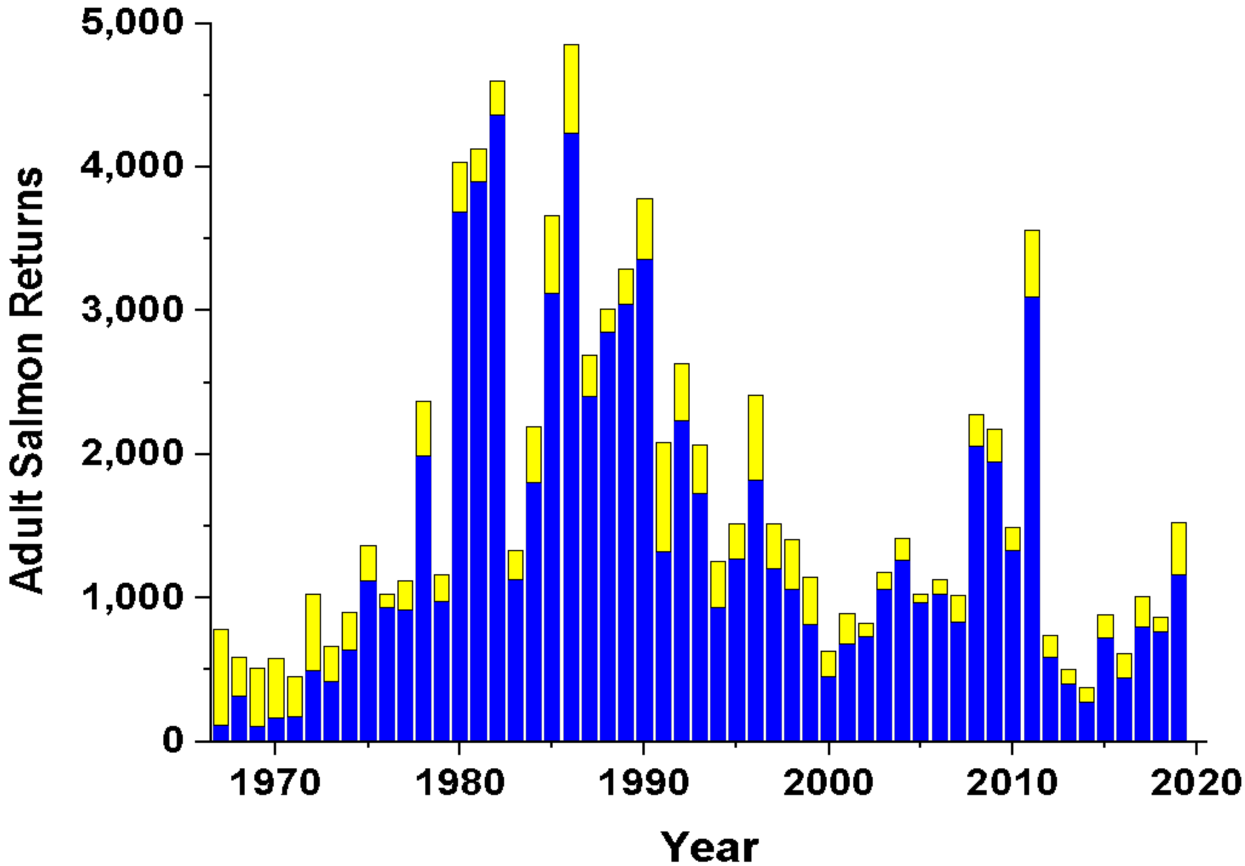

Figure 2.2.1. Time-series of total estimated returns to the GOM DPS of Atlantic salmon illustrating the dominance of hatchery-reared origin (blue) Atlantic salmon compared to naturally reared (wild, egg stocked, fry stocked) origin (yellow).

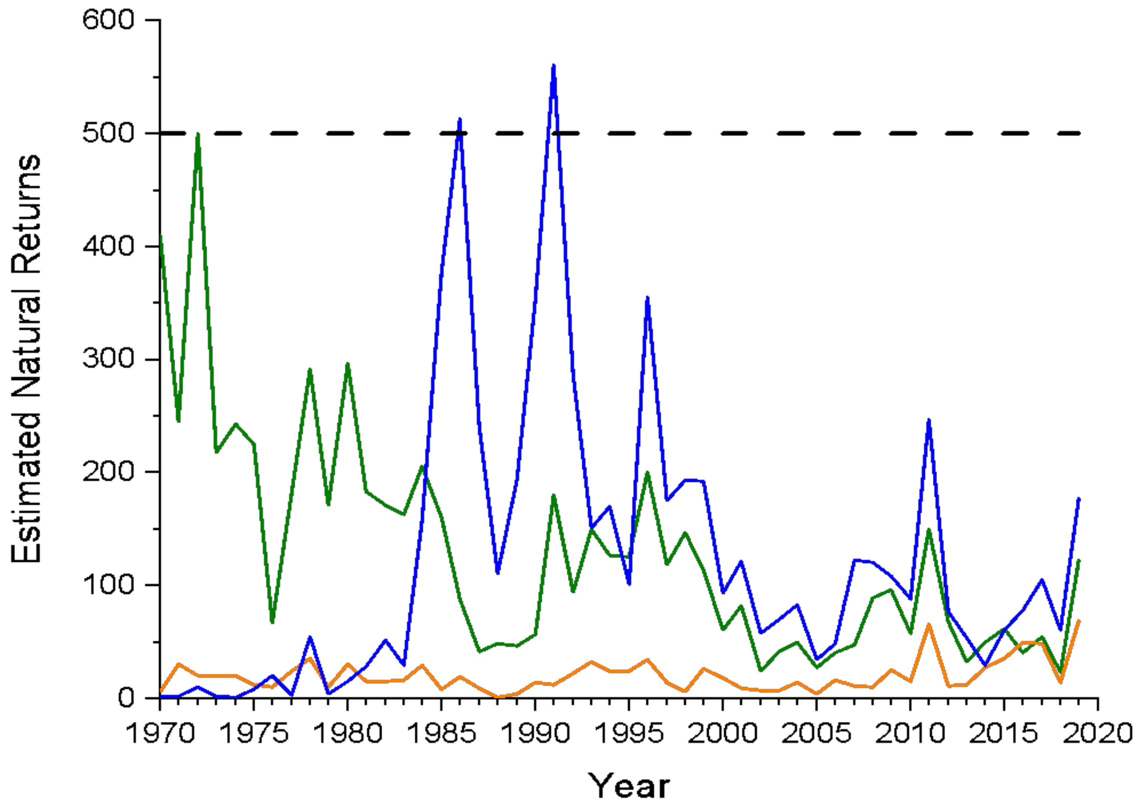

Figure 2.2.2. Time series of naturally reared adult returns to the Merrymeeting Bay (Orange), Penobscot Bay (Blue), and Downeast Coastal (Green) SHRUs from 1970 to present. Naturally reared interim target of 500 natural spawners is indicated for reference.

2.1 Population Growth Rate

Another metric of recovery progress in each SHRU demonstrates 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:

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

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:

$$R_t = ln\left(\frac{N_t}{N_{t-5}}\right)$$

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 (1.84; 95% CI: 1.15 – 2.95) and the Penobscot SHRU had the lowest growth rate (1.08; 95% CI: 0.49 – 2.37) (Table 2.3.1).

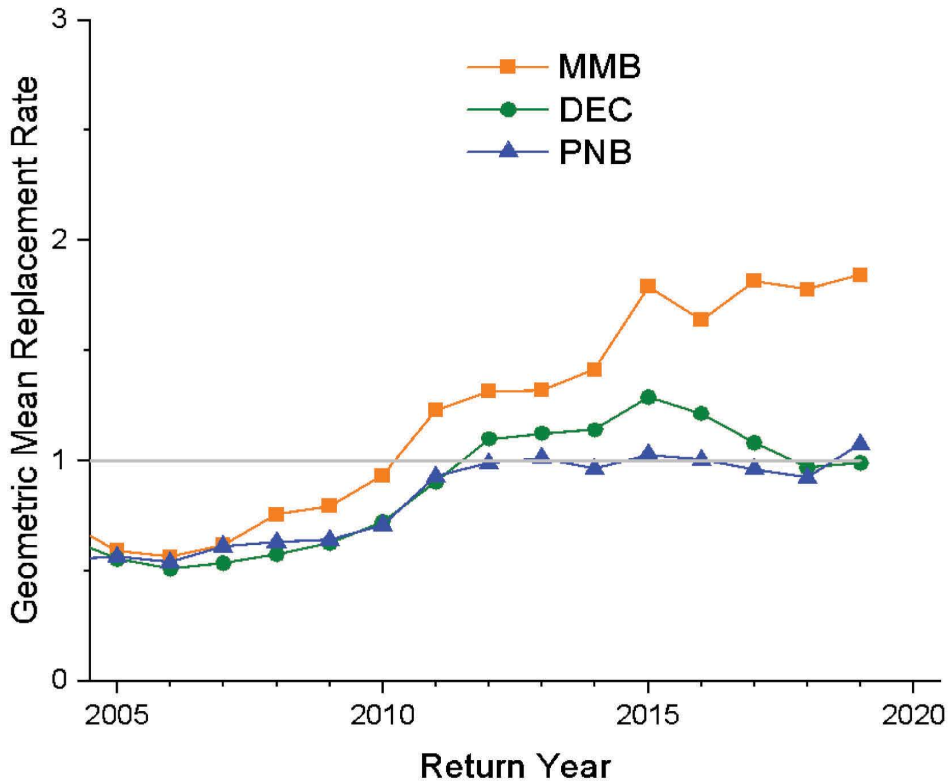

Figure 2.3.1. Ten-year geometric mean replacement rates for the GOM DPS of Atlantic salmon for Merrymeeting Bay (Orange), Penobscot Bay (Blue), and Downeast Coastal (Green) for each SHRU individually from 2005 to present.

Table 2.3.1. Ten-year geometric mean replacement rates (GM_R) for GOM DPS Atlantic salmon as calculated for 2019 return year with 95% confidence limits (CL).

SHRU	**GM_R**	**Lower 95% CL**	**Upper 95% CL**
Downeast Coastal	0.99	0.54	1.82
Penobscot	1.08	0.49	2.37
Merrymeeting Bay	1.84	1.15	2.96
Gulf of Maine DPS	**1.12**	**0.60**	**2.10**

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.

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 $\boldsymbol{N_{t+1}}$ is the number of salmon at time t+1, $\boldsymbol{N_t}$ is the number of salmon at time t, $\boldsymbol{\mu}$ is the instantaneous population growth rate, and $\boldsymbol{\varepsilon}$ 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 ($\boldsymbol{R_t}$) 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:

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

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

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

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

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

where T = an approximate 5 year generation time for Atlantic Salmon and $\widehat{w}_t$= 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 2009 - 2019 which represents the last 10 years of 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

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

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 $(S_{W,t})$ was then

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

and the number of hatchery origin spawners in year t $(S_{H,t})$ 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]).

Results

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	0.0493 (-0.0560, 0.1546)	-0.2291 (-0.3344, -0.1238)	1.0505 (0.9455, 1.1672)	0.7953 (0.7158, 0.8836)
Penobscot	-0.0549 (-0.1268, 0.0169)	-0.6987 (-0.7706, -0.6269)	0.9465 (0.8809, 1.0171)	0.4972 (0.4628, 0.5343)
Merrymeeting Bay	0.0179 (-0.0240, 0.0598)	-0.2848 (-0.3267, -0.2429)	1.0181 (0.9763, 1.0616)	0.7522 (0.7213, 0.7843)
Gulf of Maine	**-0.0443 (-0.1148, 0.0261)**	**-0.6097 (-0.6801, -0.5393)**	**0.9566 (0.8916, 1.0264)**	**0.5435 (0.5066, 0.5832)**

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 2019, none of the three SHRUs approached this level of spawning in the wild. Trap counts provide some insights into the spatial structure of spawners at a watershed level, but the details provided by redd counts during spawner surveys enhance our understanding of escapement and wild production at a finer geographic scale. Spawning was documented in all three SHRUs and monitoring of both spawning activity and conservation hatchery supplementation programs allow an informative evaluation of habitat occupancy and juvenile production potential.

We evaluated the spatial structure of juvenile production by modeling occupancy at a sub drainage level - USGS Hydrologic Unit Codes (HUC)-12 level - to describe recruitment at a spatial scale proposed to better manage critical habitat. This evaluation informs managers relative to the most likely habitats where wild spawning or juvenile stocking has produced freshwater production cohorts. These summaries provide visual products to better evaluate production habitat use at a SHRU level while also providing quantitative estimates of occupancy in Critical Habitat management areas. These evaluations can assist in evaluation of the spatial structure of production and set expectation for natural-reared production based on modelled habitat use.

Our spatial assessment objectives this year were to 1) calculate first-year salmon distribution for wild production of spawners in 2019 and 2) visualize and quantify distribution of the likely juvenile distributions of 3 freshwater production cohorts in 2019. These evaluations provide metrics to measure the relative impact of wild spawning and supplementation in each of the three SHRUs. This is the first year this method has been applied to multiple cohorts and should be considered provisional. This approach is evolving to provide a tool to allow a better understanding of spatial drivers and relative contributions of wild and stocked production on pre-smolt populations. Our goal in this 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 understand production shortfalls (wild and hatchery supplementation) to better optimize natural smolt production across critical habitat at a watershed level.

2.4.1 Wild Production Areas – Redd Distributions and the 2020 Cohort

Spawner surveys in 2019 covered 1,422 units (13%) of 10,994 units of mapped spawning habitat (see Section 5). This coverage represents a 7% increase in effort over 2018 due to a longer redd counting season because of later ice-in. Given the low spawner escapement relative to available habitat, monitoring is limited in MMB and PNB habitat but focused on priority management areas. In the DEC SHRU where redd surveys consistently exceed 80% coverage, estimates of wild production areas more accurately represent overall production. In MMB, redd counts generally capture expected redds related to documented escapement and likely closely represent overall wild production. In PNB, escapement and redd surveys are more variable and spawning areas are expansive and not well described. As such, while provided for context the PNB underrepresented wild production.

The geolocation of redds in 2019 were used to document Wild Production Areas (WPA) of the 2020-yearclass in these river systems. The spatial extent of WPA assumes an upstream distribution of juveniles of 0.5 km upstream and 1 km downstream (including tributary streams). In the DEC SHRU, redds were found in 16 of 69 HUC12s (23%). Within these 16 areas over, 31% of total rearing habitat (5,380 units) was documented as WPA. Within a HUC-12 the proportion occupancy ranged from 0.004 to 0.51 (Figure 2.4.1.1) In the MMB SHRU, redds were found in 8 of 71 HUC12s (11%) and within these areas proportion occupancy ranged from .001 to 0.51. Although overall survey coverage was incomplete, coverage of actively managed areas was high. Within these 8 areas over, 29% of total rearing habitat (3,643 units) was documented as WPA. In the PNB SHRU, redds were found in 6 of 148 HUC12s (4%) and overall survey coverage was limited low so likely underrepresents WPA.

These WPA will be buffered from stocking in 2020 to minimize competition between wild and hatchery origin juveniles. In addition, in 2022 these areas will be targeted for broodstock electrofishing efforts in efforts to bring components of wild spawning into the captive reared brood program.

Table. 2.4.1.1. Estimates of total juvenile nursery habitat units (100 m^2) occupied by wild Atlantic salmon in the 2020 cohort determined from 2019 spawning surveys.

SHRU	Total Habitat Units (# HUC12s)	Total Habitat Units In WPA with redds (# HUC12s)	WPA 2020 Cohort	% Occupied WPS in HUC12 with Redds	% Occupied WPA o All HUC12s
DEC	57,563 (69)	17,495 (16)	9,029	0.31	0.093
MMB	137,258 (71)	12,470 (8)	11,255	0.29	0.026
PNB	240,274 (148)	9,558 (6)	19,611	0.22	0.009
Total	435,095 (227)	39,524 (30)	39,895		

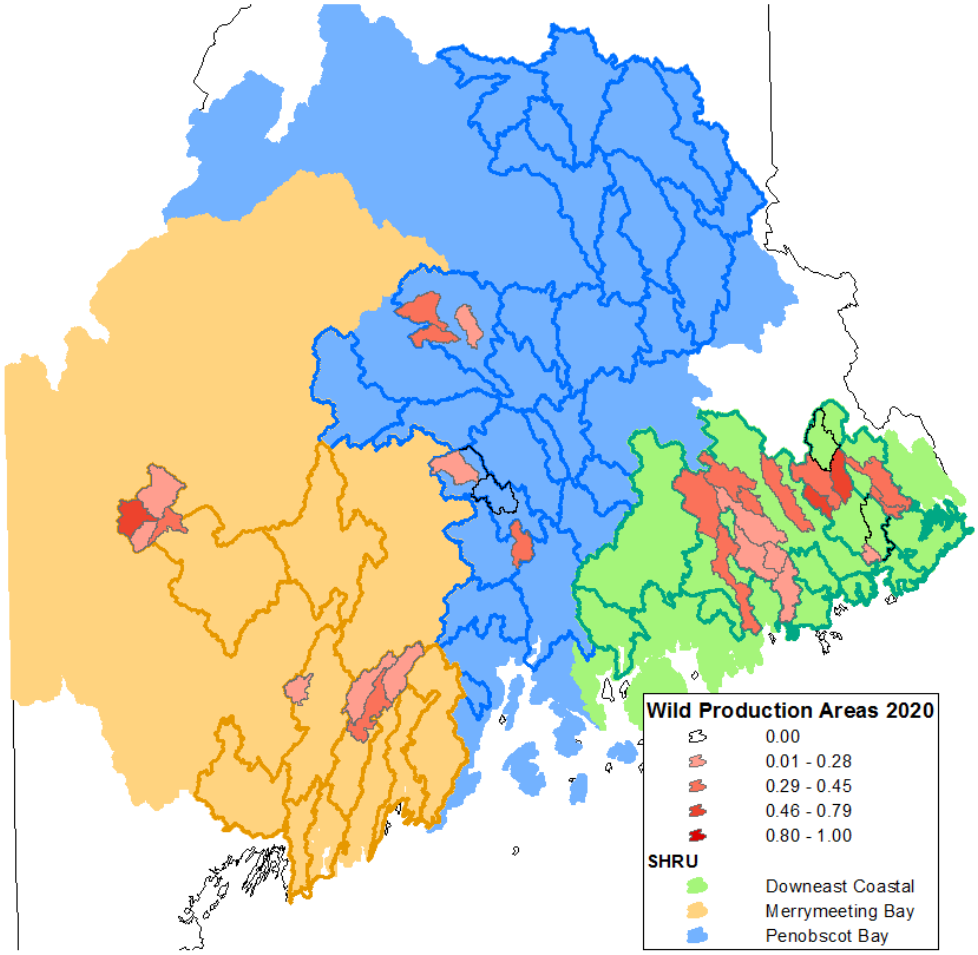

Figure 2.4.1.1 Map highlighting wild production in individual HUC 12 areas where redds were documented and redd dispersion was modeled to indicate occupancy (fish present or absent). For example, for 100 units of habitat, if the distribution model predicted fish in 15 units – proportion occupancy would be 0.15.

2.4.2 2019 Freshwater Cohorts and Hatchery Production Units

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 juvenile spatial structure throughout Critical Habitat. Atlantic salmon hatcheries are operated by the FWS and the Downeast Salmon Federation (DSF). All egg takes occur at FWS facilities operating as conservation hatcheries that collect fish from remnant local stocks within the GOMDPS and produce products to stock back into their natal rivers. In some cases, donor populations are used to stock vacant critical habitat in the GOMDPS range to re-establish production. For example, the Sandy River in the MMB SHRU has received donor stocking from the Penobscot and Dennys Rivers populations. From a management perspective, rebuilding Atlantic salmon populations will require increasing natural production of smolts in all available Critical Habitat (Recovery Plan). This management is focused on best use of hatchery production to optimally maintain population diversity, habitat occupancy, and effective population sizes. Examining the spatial contributions of multiple cohorts provides insights into likely gaps in freshwater production and where they occur on the landscape. This will provide an information base to further examine fish dispersal, optimal production areas, and site-specific stocking targets. Ultimately, these data should inform targeted management at a more refined spatial scale than an entire watershed and facilitate subdrainage (HUC12) management.

The goal of this spatial analysis is to visualize and assess freshwater production at a HUC-12 level. This composite of freshwater production comes from a GIS Analysis of wild production from redds combined with naturally reared production resulting from spatially explicit stocking data for egg-planted, fry stocked, or parr stocked juveniles. This freshwater production yields both wild and naturally reared smolts that are an important conservation tool because these supplementation methods are designed to minimize selection for hatchery traits at the juvenile stage. Analyses show that these wild and naturally reared smolts typically have a higher (4-7 times) marine survival rate than hatchery reared smolts. The numbers of hatchery fish released, and eggs planted in the GOMDPS are presented in Section 3. The focus here is on the distribution of these fish throughout critical habitat and providing insights on densities relative to optimizing habitat use.

For the 2019 assessment, we modeled the occupied freshwater production habitat in December. This summary was based on production from both natural redds (WPA) and geo-referenced stocking locations. For this analysis, we assume that 3 cohorts of fish comprise the overall freshwater population. Numerically most juveniles would be age-0 (2019 cohort). By biomass, age-1 (2018 cohort) fish would dominate as they comprise most of the pre-smolt population and would be the second most abundant age class. Finally, a smaller number of age-2 (2017 cohort) fish would make up the balance of the river population. Occupancy was estimated by geospatial documentation of both WPA and egg planting and juvenile stocking for each cohort through November 2019. All input data were georeferenced and the Atkinson-Kocik occupancy model was used to document dispersal rates (Working Paper in Progress). We are continuing to develop these methods and metrics. As noted above, the spatial extent of WPA assumed an upstream distribution of juveniles of 0.5 km upstream and 1 km downstream (including tributary streams). Similar dispersions were calculated 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 while well supported in literature and locally need additional study, and weighting of redd survey areas needs further refinement.

Using this method, we estimated December 2019 mean proportion occupancy for each of the 3 SHRUs at a HUC-12 resolution (Figure 2.4.1.2). While the 3 SHRU vary in size and number of HUC-12 units, the amount of occupied juvenile rearing area is typically around 10,000 to 12,000 units of habitat in each SHRU. The DEC SHRU with 69 HUC-12 areas had cohort occupancy of between 9,800 and 10,300 units in 22 areas (32%) where these 3 cohorts had a proportion occupancy above 0.01 (Figure2.4.1.2). While still at only modest occupancy, the DEC SHRU has a generally broad distribution of juveniles in the Dennys, East Machias, Macias, Narraguagus, and Pleasant Rivers. The PNB SHRU with 148 HUC-12 areas had cohort occupancy of between 7,900 and 18,400 units for the 3 cohorts in 23 areas (16%) where these 3 cohorts had a proportion occupancy above 0.01 (Figure2.4.1.2). Dispersal was relatively broad but mean proportion occupancy was lower (Table 2.4.1.2). In addition, changing management focus is notable with 14 HUC12 areas being occupied for all 3 cohorts and 8 being occupied in only 1 of the 3 years. Finally, the MMB SHRU with 71 HUC-12 areas had cohort occupancy of between 12,000 and 12,700 units in 16 areas (23%) where these 3 cohorts had a proportion occupancy above 0.01 (Figure2.4.1.2). The consistent focus on the Sheepscot and Sandy River has led to 12 HUC12 areas being occupied by all 3 cohorts and moderately high proportional occupancy in the core areas.

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. Until there is significantly more wild production and/or greatly increased hatchery that would allow complete use of all HUC12 units in critical habitat, it is important to look at juvenile production spatially to examine effort and approaches to supplementation to maximize smolt production. This can be accomplished by considering production density at a HUC12 level and projecting climate impacts on habitats and distinct individual populations. The next steps of spatial stock assessment will work towards integrating density based on historic electrofishing and other sources. Independent efforts to look at climate resilience could then be merged with this spatial assessment to better manage Atlantic salmon habitat, hatchery supplementation, and passage priorities to support salmon conservation now and in the future.

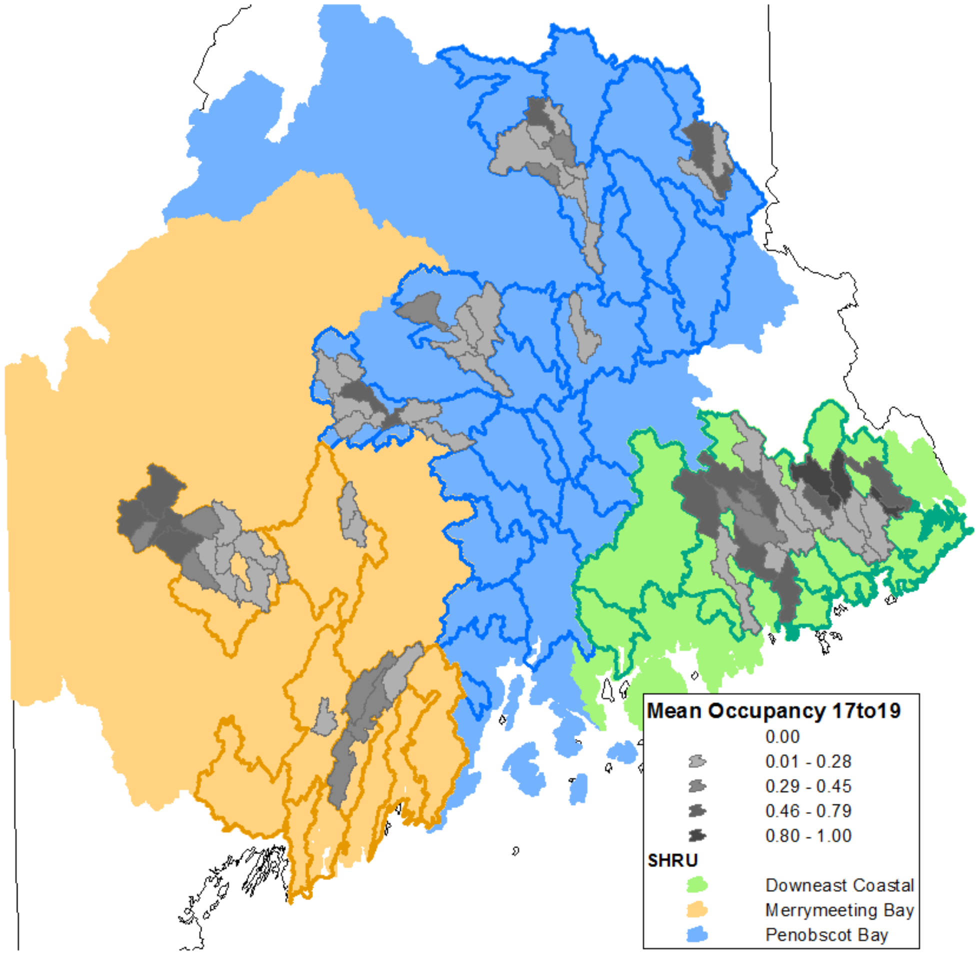

Figure 2.4.1.2 Map highlighting the relative proportion of river habitat occupied (see figure legend) by the 2017, 2018, and 2019 cohorts at a HUC-12 watershed summary level. Production is a synthesis of modeled distributions from spawning surveys of Atlantic salmon in the autumn proceeding the cohort year, cohort year egg planting, and fry and parr stocking.

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.

2.1.1 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). Individuals characterized represent either parr collected for broodstock purposes (Dennys, East Machias, Machias, Narraguagus, Pleasant, and Sheepscot rivers), or adults returning to the Penobscot River and collected for broodstock at Craig Brook NFH. Individuals represent those to be used for broodstock purposes following screening of any individuals to be removed based on screening to remove potential aquaculture origin individuals, or landlocked Atlantic salmon. 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. For this report, evaluating allelic diversity based on 18 loci, between 2008 and 2017 collection years (or 2019 if considering the Penobscot), the average number of alleles per locus ranged from 10.68 alleles per locus for the Pleasant River to 13.52 alleles per locus for the Penobscot River.

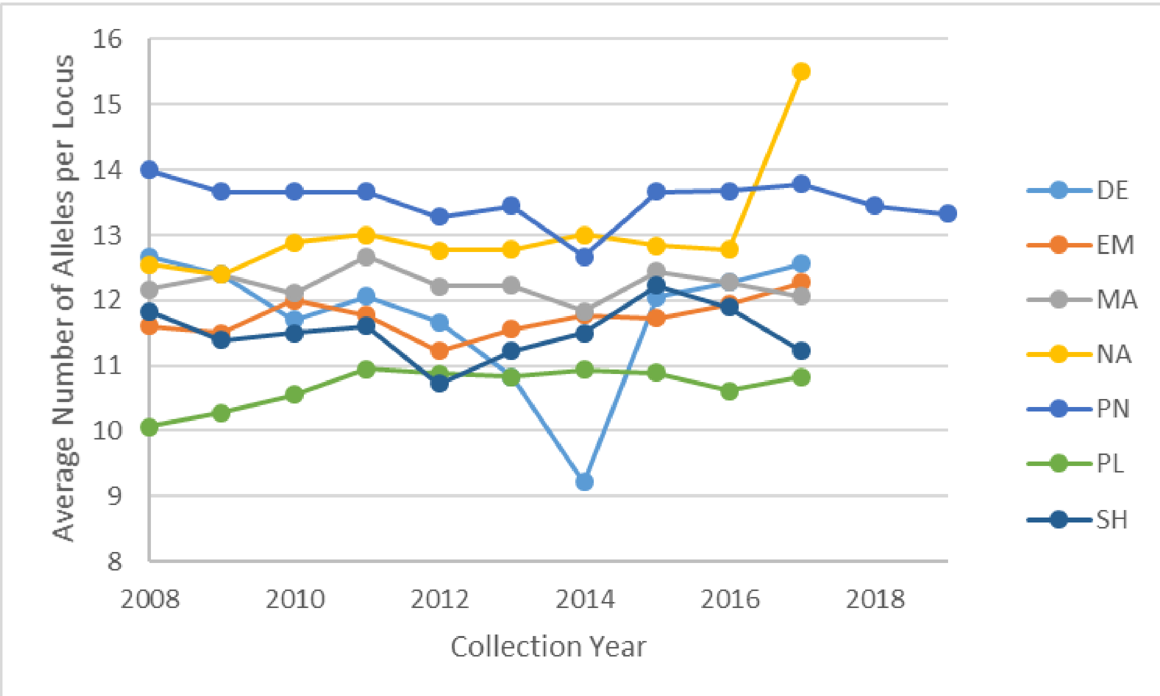

Figure 2.5.1.1. Allelic diversity time series for GOMDPS salmon populations, measured from 18 microsatellite loci. purposes (DE- Dennys, EM-East Machias, MA- Machias, NA-Narraguagus, PN-Penobscot, PL-Pleasant, SH-Sheepscot populations).

2.1.2 Observed and Expected Heterozygosity

Observed and expected heterozygosity is estimated for each broodstock. For the 2017 collection year parr broodstock and 2019 collection year Penobscot adult returns, average estimates starting in 2008 of expected heterozygosity based on 18 microsatellite loci ranged from 0.67 in the East Machias to 0.687 for the Penobscot. Observed heterozygosity estimates based on 18 loci ranged from 0.673 in the Machias to 0.707 in the Penobscot broodstock.

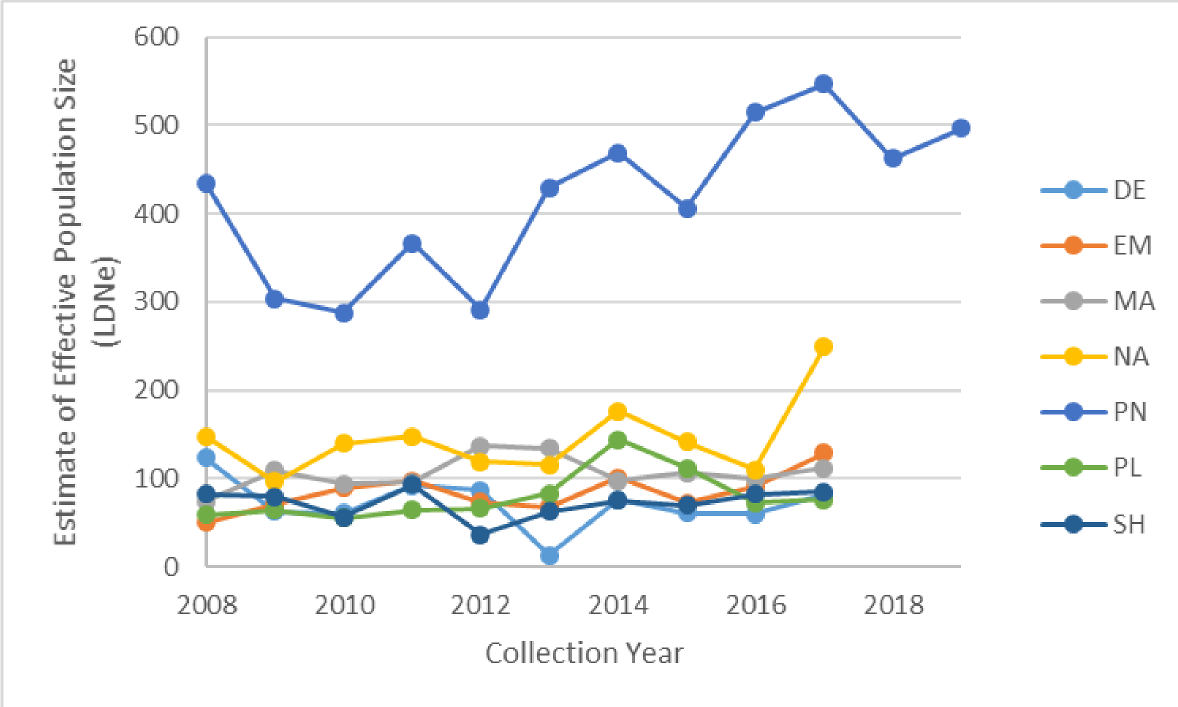

Figure 2.5.1.2. Time series of effective population size for 7 GOMDPS distinct individual populations. Estimates for the parr-based broodstock populations approximate the number of breeders, since estimates are obtained from primarily a single cohort, and are sampled as juveniles (parr), from each river. 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 (DE- Dennys, EM-East Machias, MA- Machias, NA-Narraguagus, PN-Penobscot, PL-Pleasant, SH-Sheepscot populations).

2.1.3 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 N_e from the 2017 collection year was estimated for the Pleasant broodstock (N_e =75.6, 69.9-81.8 95% CI), and the highest was observed in the Narraguagus broodstock (N_e =249.1 (223.5-279.9 95% CI). Ne estimates fluctuated annually, so beginning with 2008, average Ne across the parr-based broodstocks ranges from N_e=71.6 in the Dennys to N_e =144.2 in the Narraguagus. Within the Penobscot River, adult broodstocks typically include three to four year classes (including grilse). N_e estimates for the Penobscot since 2008 have ranged from N_e =546.5 (465.8-650.7 95% CI) in 2017 to N_e =287.6 in 2009 (265.7-312.0 95% CI), with an average N_e =417.2, and in the 2019 return the broodstock N_e = 496.6 (438

2-568.7 95% CI).

2.1.4 Inbreeding Coefficient

Inbreeding coefficients are an estimate of the fixation index. Estimates in the 2017 parr collection year ranged from -0.028 in the Machias River to -0.062 in the Sheepscot River. The 2019 collection year for the Penobscot had an estimated inbreeding coefficient of -0.041.

2.1.5 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 has been 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 Sheepscot 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, along with 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

Three 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. The latter explanation is becoming increasingly likely. None of the salmon were 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 718,740 green eggs was produced. Only the Kensington State Fish Hatchery (KSFH) in CT maintained domestic broodstock. Contributing broodstock included 128 females and 106 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 336,278 juvenile Atlantic Salmon was stocked into the Connecticut River watershed, all in Connecticut. Selected stream reaches in the Farmington River received 206,175 fed fry and selected reaches in the Salmon River received 130,103 unfed fry with the assistance of many volunteers. These numbers were higher than the number of fry stocked in 2018 due to unexpectedly high eye-up rates. 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 10,000 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

The only smolt migration monitoring occurred with videography at the viewing window at the Rainbow Dam Fishway (Farmington River. A total of 17 smolts were observed (2018= 0) but the majority of smolts were assumed to have passed the dam using the downstream bypass, which was not monitored.

3.1.4.2 Index Station Electrofishing Surveys

The only electrofishing surveys of juvenile salmon populations were conducted on Dickinson Creek (Salmon River) to assess the survival of fry from the Tripp Streamside Incubation Facility. Survival of 1+ parr was comparable to the long-term average of 8%. Survival of 0+ parr was much lower than the long-term average with only 12% of juveniles surviving to the end of the first growing season, compared to a long-term average rate of 25%.

3.1.5 Fish Passage

3.1.5.1 Hydropower Relicensing-

State and Federal resource agencies continue to spend considerable time on FERC-related processes for the re-licensings of four mainstem dams and one pumped storage facility. This includes requesting and reviewing the results of numerous studies of fish population, habitat, and fish passage and discussions of a possible Settlement Agreement. 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 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. No salmon were observed using videography.

3.1.5.3 New Fishways-

Three new fishways were constructed on tributaries to the Connecticut River. The Kensington Pond Dam Fishway on the Mattabesset River and the Dolan Pond and Millpond dam fishways on the Falls River. All three of these fishways target river herring and have no direct benefit to Atlantic Salmon but the increase of forage in the estuaries could indirectly benefit salmon.

3.1.5.4 Dam Removals-

Several dams in the basin were removed:

- Lyman Mill Dam, Manhan River, MA
- Thompsonburg Dam, Thompsonburg Brook, VT
- East Putney Brook Dam, East Putney Brook, VT
- Unnamed dam, South Branch Saxton River, VT
- Clark Brook Dam, Clark Brook, NH

These projects are not likely to directly benefit Atlantic Salmon but will benefit diadromous species and resident species and improve the quality of water and habitat in the basin.

3.1.5.4 Culvert Fish Passage Projects-
No information is available for 2019.

3.1.6 Genetics
The genetics program previously developed for the Connecticut River program has been terminated. A 1:1 spawning ratio was attempted for domestic broodstock spawned at the KSFH but in 2019 there was a shortage of males.

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 14,000 eggs for 70 tanks in 52 schools in 38 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 several 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
Although a small portion of the watershed lies in Connecticut, all activities involving Atlantic Salmon have been conducted solely by the 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 200,000 eggs from USFWS Nashua NFH. Of those eggs, 137,000 died due to a variety of causes. A total of 5000 eggs were produced by 300 salmon broodstock held in RIDEM hatchery (2017 Nashua NFH origin). All of the eggs died prior to distribution. An additional 40,000 eggs of Sebago stock (2017 VT origin) were taken and 30,000 survived. A total of 54,000 salmon survived in the hatchery by the end of 2019 and some will be retained for broodstock and some will be released in 2021 for the landlocked salmon program.

3.2.3 Stocking
A total of 7,400 feeding fry were stocked into the watershed. An additional 8,950 feeding fry were stocked by schools in the Salmon in the Classroom program.

3.2.4 Juvenile Population Status

Electrofishing surveying was conducted in areas stocked by the classroom program. Four individual parr were captured and sampled from three streams.

3.2.5 Fish Passage

No additional work in 2019.

3.2.6 Genetics

No genetics program relative to the broodstock program was reported.

3.2.7 General Program Information

The Salmon in the Classroom program continues to grow with 25 schools participating in the 2018-19 season and ten more added for the 2019-20 season.

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 conducted a tagging study (American Shad and Alewife) 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

No sea-run Atlantic salmon were counted in the Merrimack River at the Essex Dam, Lawrence, MA and no salmon were transported to the Nashua National Fish Hatchery (NNFH), NH. Instead all fish were allowed to run the river. A total of 14 fish were counted at the viewing window, but these fish were all believed to be released hatchery broodstock that dropped back below the dam.

4.1.2 Hatchery Operations

Atlantic salmon were not spawned at NNFH in 2019. The final year of spawning Merrimack strain salmon at NNFH occurred in the fall of 2018. Two-hundred broodstock were subsequently transferred to the Saco Salmon Restoration Alliance (SSRA) hatchery to be used for broodstock in 2019 for the Saco River. The remainder of broodstock were stocked in the Merrimack River.

4.1.3 Juvenile population status

Yearling Fry / Parr Assessment

In 2019, 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 were stocked in the Merrimack.

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 2019 (total of 1,748) into the Merrimack and spent broodstock were stocked out in December of 2019 (total of 1,117). These fish have been classified as recreational/restoration, as there is some potential that they could produce some restoration benefit.

Adopt-A-Salmon Family

The last transfer of eggs from NNFH to the RI salmon in schools program occurred in February 2019.

Central New England - Integrated ME/NH Hatchery Production

The FWS Eastern New England Fishery Resources Complex had 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 provided that NNFH and/or NANFH produced juvenile Atlantic salmon for continued Saco Salmon Restoration Alliance (SSRA) “grow-out” or release to the Saco River. The agreement has now ended.

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, 2019. Only visual observations are recorded at Cataract, as the fish are never handled. Four Atlantic salmon were captured, at a third passage facility upriver at Skelton Dam, which operated from 1 May to 31 October, 2019. A total of four Atlantic salmon returned to the Saco River for the 2019 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

The Saco Salmon Restoration Alliance & Hatchery (SSRA) has ceased receiving eggs from Nashua National Fish Hatchery and has begun spawning in their own hatchery. In the fall of 2019, the SSRA spawned 21 salmon that were transferred from the Merrimack River Program at Nashua National Fish Hatchery. The SSRA took approximately 55,500 eggs from the adults. The progeny of the adults will be used to supplement the Saco River as well as support the Salmon in Schools Program.

Broodstock Collections.

In the fall of 2019 the Saco Salmon Restoration Alliance & Hatchery began a captive parr broodstock program. In October, 119 naturally reared and wild parr were taken from both Swan Pond Stream and Cooks Brooks, tributaries to the Saco River.

4.2.3 Stocking

Juvenile Atlantic salmon Releases

Estimated 163,566 fry reared at the Saco Salmon Restoration Alliance, were released into one mainstem reach and 34 tributaries of the Saco River. In 2019 the Saco Salmon Restoration Alliance planted 84,192 eyed-eggs in five tributaries to the Saco River.

Adult Salmon Releases

No adult Atlantic salmon were stocked into the Saco River in 2019.

4.2.4 Juvenile Population Status

Index Station Electrofishing Surveys

ME-DMR did not conduct any electrofishing surveys in the Saco River watershed in 2019.

Smolt Monitoring

There was no smolt monitoring in 2019.

Tagging

No salmon outplanted into the Saco were tagged or marked in 2019.

4.2.5 Fish Passage

The hydro owners on the lower Saco River, in an effort to improve American shad passage is in the process of replacing the fishway in one of the two dams that cross the Saco River just above the Cataract Hydro Project. The lock used for passage is being replaced with a nature like fishway. In 2019 it became operational.

4.2.6 Genetics

All adult returns captured at Skelton Dam are tissue sampled. Samples are persevered and kept at MDMR in Augusta. Currently no plans have been made to characterize them genetically.

4.2.7 General Program Information

In 2019 the Saco Salmon Restoration Alliance & Hatchery (SSRA) began a partnership with the University of New England (UNE). The partnership relies on the UNE to rear future broodstock and assist the SSRAH with spawning. As part of this change in the program, the remaining Merrimack River broodstock held at Nashua National Fish Hatchery were transferred to the SSRAH and spawned. In addition, to maintain a source of broodstock the SSRA will collect parr. The parr will be taken annually from the Saco River drainage and be reared until spring in the SSRA hatchery and then transferred to the UNE.

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 2019.

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 2019 were 1,528. Returns are the sum of counts at fishways and weirs (1,382) and estimates from redd surveys (146). 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 2019 was 1,022 (Table 5.1). Escapement to the GOM DPS area equals releases at traps and free swimming individuals (estimated from redd counts) plus released pre-spawn captive broodstock (adults used as hatchery broodstock are not included) and recaptured downstream telemetry fish.

Estimated replacement (adult to adult) of naturally reared returns to the DPS has varied since 1990 although the rate has been somewhat consistent since 1997 at or below 1 (Figure 5.1). Most of these were 2SW salmon that emigrated as 2-year-old smolt, thus, cohort replacement rates were calculated assuming a five-year lag. These were used to calculate the geometric mean replacement rate for the previous ten years (e.g. for 2000: 1991 to 2000) for the naturally reared component of the DPS overall and in each of three Salmon Habitat Recovery Units (SHRU). Despite an apparent increase in replacement rate since 2008, naturally reared returns are still well below 500 (Fig. 5.2).

Table 5.1 Table of Sea-run returns versus escapement.

Drainage	Returns	Brood Stock	DOA	Escapement
Androscoggin	1	0	0	1
Cove Brook*	0	0	0	0
Dennys*	16	0	0	16
Ducktrap*	0	0	0	0
East Machias*	40	0	0	40
Kenduskeag*	6	0	0	6
Kennebec	60	0	0	60
Machias*	29	0	0	29
Narraguagus	123	0	3	120
Penobscot	1,196	502	1	693
Pleasant*	26	0	0	26
Sheepscot*	26	0	0	26
Souadabscook*	3	0	0	3
Union	2	0	0	2
	1,528	502	4	1,022

* Indicates Redd based estimate

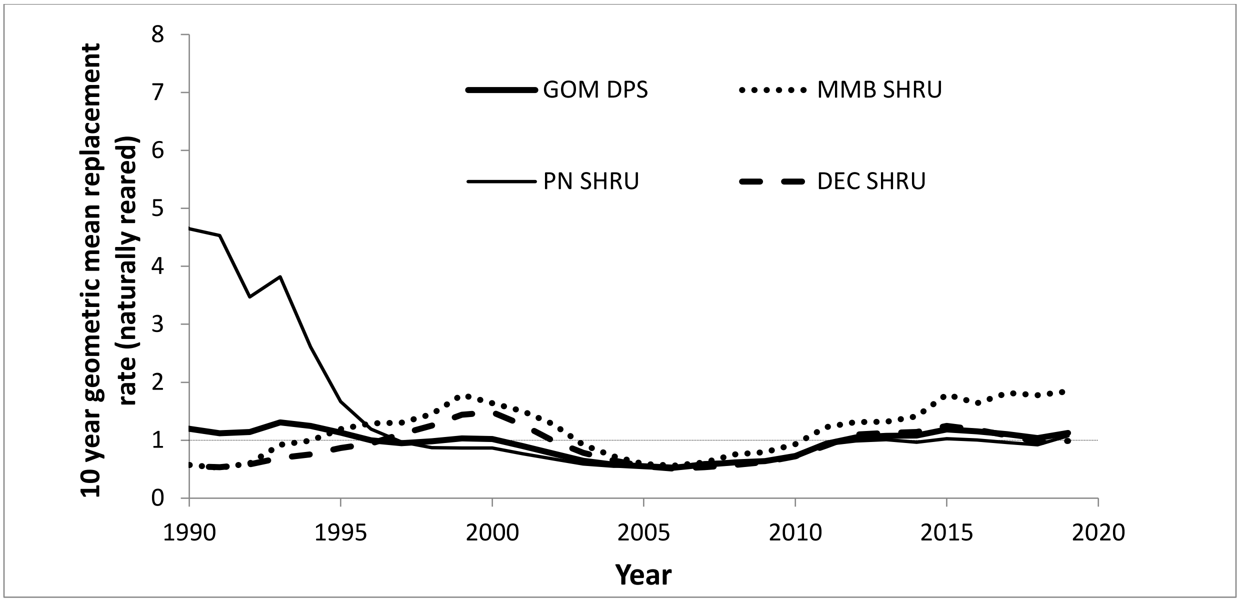

Figure 5.1. Ten-year geometric mean of replacement rate for returning naturally reared Atlantic salmon in the GOM DPS and the three Salmon Habitat Recovery Units (SHRU).

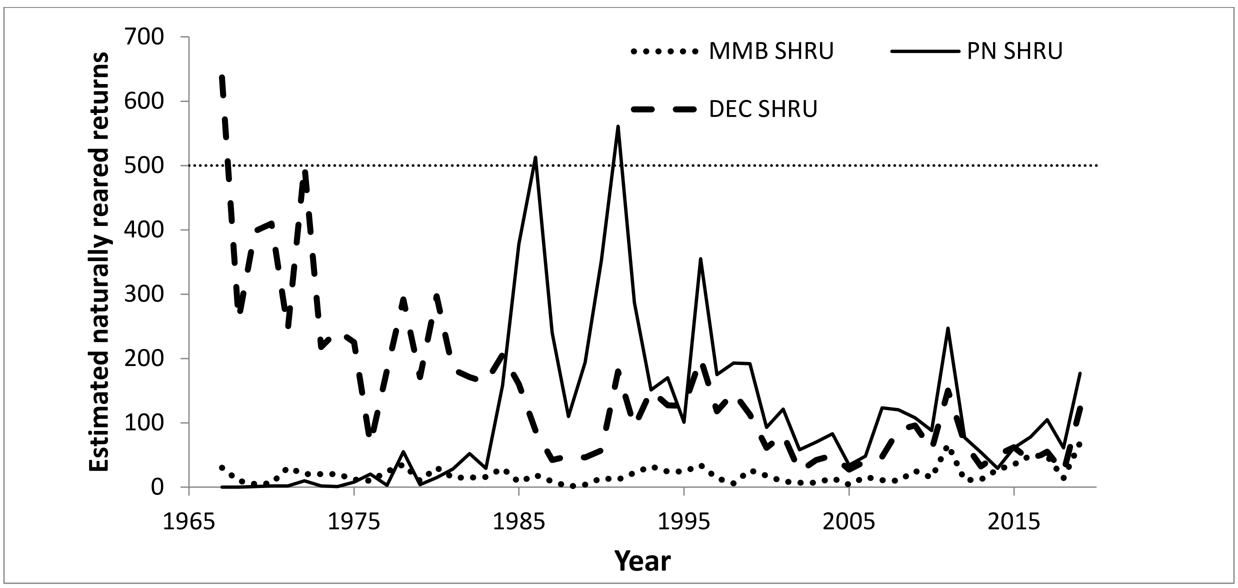

Figure 5.2 Estimated Naturally Reared Returns to the GOM 1965 to 2019

5.1 Adult returns and escapement

5.1.1 Merrymeeting Bay

Androscoggin River

The Brunswick fishway trap was operated from 07 May to 31 October 2019 (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 0.04 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 7 May to 31 October, 2019 (Table 5.1.1). A total of 60 adults returned to the Kennebec in 2019. Fifty-six adult Atlantic salmon were captured at the lift. In addition, due to the dam configuration adults are occasionally rescued from a set of ledges in the bypass canal. Thus, in July, four additional salmon were captured returning to the Kennebec River bringing the total captures at Lockwood Dam to sixty. 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 60 returning Atlantic salmon, 55 (91.7%) were 2SW, 6 (10.0%) were grilse (1SW) and 1 (1.7%) long absence repeat spawner. Two salmon were of hatchery origin and 58 were naturally reared in origin. Thirty-nine of the returning salmon were transported to the Sandy River Drainage a large tributary to the Kennebec River and released. The remaining 21 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 USGS and MDMR. Of these 21 salmon, 9 were recaptured transported and released to the Sandy River. The 57 adults trapped at Lockwood fish lift and ledges are likely from the Sandy River because scale analysis revealed that all were naturally reared and given this is the only sub drainage in the Kennebec River currently under active supplementation. One adult captured at the Lockwood fish lift was an adipose clipped fish indicating it likely came from another program. Redd surveys were conducted in 18.73% of known spawning habitat primarily within the Sandy sub-drainage. Twenty-one redds were observed in the Sandy River and one in Bond Brook for a total of 22 redds in the Kennebec Drainage.

Sebasticook River at Benton Falls fish lift facility was operated by MDMR staff from 01 May to 04 November, 2019. No Atlantic salmon were captured (Table 5.1.1).

Sheepscot River

There were 30 redds observed in the Sheepscot River; twenty-seven were observed in the mainstem and one was observed in the West Branch. The 28 redds were likely from sea-run adults. A total of 88.82% (34.55km) of known spawning habitat was surveyed in the Sheepscot River drainage; Based on the Returns to Redds Model, between 10 and 69 with a mean of 26 salmon returns were estimated.

5.1.2 Penobscot Bay

Penobscot River

The fish lift at the Milford Hydro-Project, owned by BRP, was operated daily by MDMR staff from 3 May through 13 November, 2019. 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 1,196 sea-run Atlantic salmon returned to the Penobscot River (Table 5.1.1). Scale samples were collected from 1,014 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, 899 were age 2SW (75%), 295 were age 1SW (25%). Approximately 86% (1028) of the salmon that returned were of hatchery origin and the remaining 14% (168) were of wild or naturally reared origin. No aquaculture suspect salmon were captured.

Redd surveys in the Penobscot Drainage are divided across the Penobscot SHRU including small tributaries to the mainstem. Total observed redds were 3 (Table 5.1.2).

Cove Brook

Zero redds were observed in Cove Brook. Surveys covered 62.04% (1.96 km) of spawning habitat.

Souadabscook Stream

There was one redd observed in the Souadabscook Stream survey which covered 0.2 km of known spawning habitat.

French Stream

There was one redd observed in French Stream. Coverage was 1.75 km and 62.21% of the spawning habitat.

Kenduskeag Stream

Two redds were observed in Kenduskeag Stream. Coverage was 6.17 km and 10.81% of the spawning habitat.

Ducktrap River

In the Ducktrap River spawner surveys covered 71.1% (1.45 km) of the available spawning habitat. Zero redds were observed (Table 5.1.2).

5.1.3 Downeast Coastal

Dennys River

There were 13 redds surveyed in the Dennys River in 2019. Surveys covered only 85.2% of the habitat and 18.38 km of stream. Based on the Returns to Redds Model, estimated escapement was between 6 and 42 with a mean of 16 salmon.

East Machias River

Escapement to the East Machias was at a ten-year high. Sixty redds were counted during 2019 redd surveys covering approximately 76% (51.24 km) of known spawning habitat. This was the fourth 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 192,000 fall parr associated with this adult cohort. Based on the Returns to Redds Model, estimated escapement was between 15 and 106 with a mean of 40 salmon.

Machias River

A total of 35 redds were counted. Surveys covered 60.47% of the habitat and 73.12 km of stream. Based on the Returns to Redds Model, estimated escapement was between 11 and 76 with a mean of 29 salmon.

Pleasant River

The pleasant also saw a large increase in adult returns. 30 redds were observed mostly adjacent to areas the planted eyed ova are used to populate habitat. Surveys covered 84.65% of the habitat and 26.07 km of stream.

Narraguagus River

Returns to the fishway trap (81) were higher than 2018 (42). This was the second cohort of 2SW salmon returns from hatchery smolt released starting in 2016. Hatchery origin grilse (58) represented 78% of the total returns to the Narraguagus. Naturally reared returns were down from 2018 with both grilse and 2SW returns. Redd surveys accounted for 148 redds with surveys covering 90% 115.44 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 1 May to 31 October 2019. Two Atlantic salmon were captured during this period.

Table 5.1.1 Counts of sea-run, Atlantic salmon returns to Maine rivers in 2019 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	01 May	29 Jun	23 Oct	58	6	1	2	0	5	0	0	0	0	72	0	9
Union River	01 May	-	31 Oct	0	0	0	0	0	2	0	0	0	0	2	0	0
Penobscot Bay SHRU																
Penobscot River	19 Apr	02 Jul	15 Nov	295	397	1	0	0	502	1	0	0	0	1,196	0	0
Merrymeeting Bay SHRU																
Lower Kennebec River	09 May	05 Jun	31 Oct	6	32	0	1	0	21	0	0	0	0	60	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	--	--	--	359	435	2	3	0	531	1	0	0	0	1331	0	9

Table 5.1.2. Results of redd surveys by SHRU, Drainage and Stream for 2019. Effort is shown by both total kilometers surveyed and the proportion of the spawning habitat surveyed for Drainage and individual stream.

SHRU	Drainage Surveyed	Drainage Total	% Drainage Spawn Habitat Surveyed	Total Drainage KM surveyed	Stream Name	Redds	% Stream Spawn Habitat Surveyed	Total Stream km
Downeast Coastal	Dennys	13	85.2	18.38	Dennys River	13	85.27	18.38
					Cathance Stream	0	0	0
	East Machias	54	76.07	51.24	Barrows Stream	0	0	4.36
					Beaverdam Stream	0	100	12.76
					Chase Mill Stream	10	100	2.63
					Creamer Brook	1	40	0.37
					East Machias River	27	58.07	12.17
					Harmon Stream	0	0	2.57
					Long Lake Stream	0	0	0.81
					Northern Stream	13	100	10.24
					Richardson Brook	0	0	1.37
					Seavey Stream	3	100	3.96
	Machias	35	60.47	73.12	Crooked River	8	59.87	5.14
					Machias River	0	52.98	15.89
					Mopang Stream	3	53.65	9.93
					Old Stream	14	79.95	31.16
					West Branch Machias River	10	93.29	11
	Narraguagus	146	89.97	115.44	Baker Brook	1	8.46	0.25
					Bog Brook	0	0	0.11
					Narraguagus River	143	97.36	111.18
					West Branch Brook	2	100	3.9
	Pleasant	30	84.65	26.07	Eastern Little River	0	80	3.99
					Pleasant River	30	84.68	22.08
Merrymeeting Bay	Lower Androscoggin	0	0	0.04	Little River	0	0	0.04
	Lower Kennebec	22	4.6	56.9	Avon Valley Brook	0	0	0.7
					Barker Brook	0	0	0.22
					Bond Brook	1	100	3.99
					Cottle Brook	0	0	0.91
					Messalonskee Stream	0	44.4	0.15
					Mt Blue Stream	0	0	1.79
					Orbeton Stream	4	98.02	17.78
					Perham Stream	0	84.13	6.06
					Saddleback Stream	1	0	0.16
					Sandy River	15	8.3	17.33

				South Branch Sandy River	1	100	3.89
				Temple Stream	0	0	0.33
				Togus Stream	0	100	3.55
				Valley Brook	0	0	0.04
	Sheepscot	30	81.46	39.08	Ben Brook	0	100	0.52
					Sheepscot River	27	84.35	23.68
					Trout Brook	0	11.72	0.28
					West Branch Sheepscot River	3	81.37	14.6
	Ducktrap	0	69.64	1.45	Ducktrap River	0	71.1	1.45
	Mattawamkeag	0	10.79	0.53	Mattawamkeag River	0	18.09	0.53
Penobscot	Penobscot	3	3.56	11.08	Cove Brook	0	62.04	1.96
					French Stream	1	62.21	1.75
					Kenduskeag Stream	2	10.81	6.17
					Pollard Brook	0	0	1.18
					Souadabscook Stream	1	0	0.02
	Piscataquis	0	0.48	9.12	Houston Brook	0	0	1.13
					Middle Branch Pleasant River	0	0	1.6
					Pleasant River	0	2.25	0.62
					Schoodic Stream	0	0	0.13
					West Branch Pleasant River	0	0	5.64

Redd Based Returns to Small Coastal Rivers

Scientists historically estimated 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 were 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). Since it has been over ten years since the model had been updated and since the trapping facilities used for calculation of the model are no longer in service, a new method to estimate abundance needed to be created. Scientists reviewed several methods to estimate abundance and have selected a new model that uses log normal redd counts and log normal adult returns (Equation 5.1). The process used to develop this model is described in Working Paper WP20-10 (Sweka et.al. 2020). Using the new estimator, the total estimated returns for the small coastal rivers was between 81 and 575 adults with a total estimate of 216 (Table 5.1.3, Figure 5.1.1).

Equation 1. New regression estimator to calculate adult abundance based on observed redds.

$$\ln Adults = 1.1986 + 0.6098(\ln Redds)$$

Table 5.1.3. Redds based regression estimates and confidence intervals of total Atlantic salmon escapement to Cove Brook, Dennys, Ducktrap, East Machias, Kenduskeag, Machias, Pleasant, Sheepscot and Soudabscook Rivers for 2019.

Drainage	Total Spawn Habitat	Surveyed Habitat	Surveyed Redds	Predicted Returns	L95	U95
Cove Brook	7.3	4.5	0	0	0	0
Dennys	238.51	203.22	13	16	6	42
Ducktrap	43.77	30.5	0	0	0	0
East Machias	58.92	44.82	60	40	15	106
Kenduskeag	7.14	7.14	2	5	2	14
Machias	449.77	271.96	35	29	11	76
Narraguagus	265.82	239.16	148	70	26	189
Pleasant	141.41	119.7	30	26	10	69
Sheepscot	325.36	265.05	30	26	10	69
Souadabscook	15.88	15.88	1	3	1	9
Grand Total	1553.88	1201.93	319	216	81	575

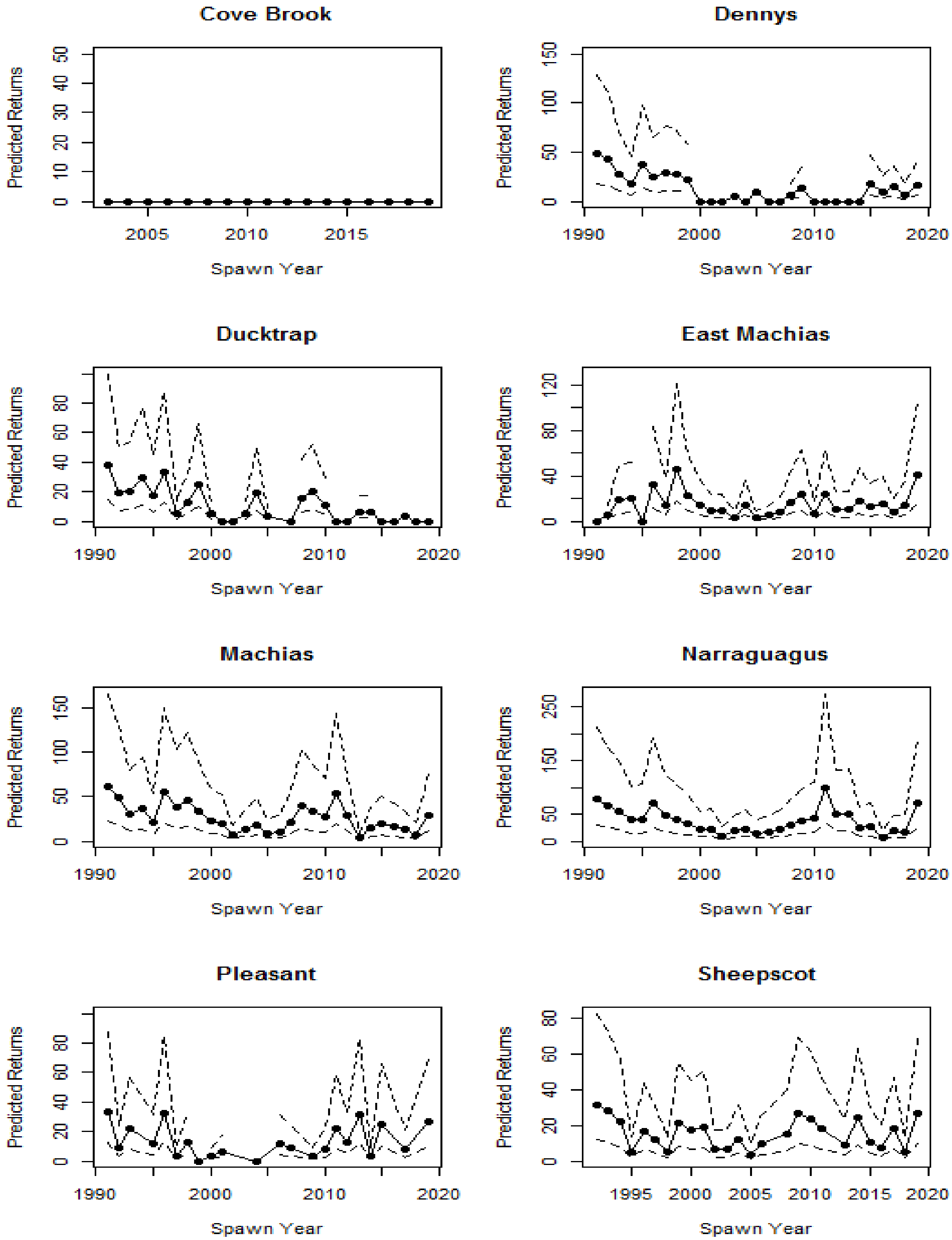

Figure 5.1.1. Annual Redds Based estimate of 2019 adult returns to managed drainages in the Gulf of Maine DPS.

5.2 Juvenile Population Status

Juvenile abundance estimate

A total of 328 sites (Figure 5.2.1) were surveyed in 2019 using a combination of single pass and multi-pass removal techniques. Of these, 104 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 continues 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 2019.

SHRU	Drainage	EMARC 0+ Parr Study	Brood-stock	Dispersal Study	EXTRA	GRTS	Head to Head	PALS	Presence / Absence	UPPER NG INDEX	Wild Spawning	Totals
Downeast Coastal	Dennys		7								3	10
Downeast Coastal	East Machias	10	10									20
Downeast Coastal	Machias		2	24	2							28
Downeast Coastal	Narraguagus		5	23		11				10		49
Downeast Coastal	Pleasant			15								15
Merrymeeting Bay	Lower Kennebec					31	47		8		4	90
Merrymeeting Bay	Sheepscot	3	12			12		4				31
N/A	Saco		2									2
Penobscot	Ducktrap				2	6			1			9
Penobscot	East Branch Penobscot								12			12
Penobscot	Mattawamkeag				1	7						8
Penobscot	Penobscot					6						6
Penobscot	Piscataquis			4	11	31						46
Penobscot	Little River								2			2
	Totals	13	38	66	16	104	47	4	23	10	7	328

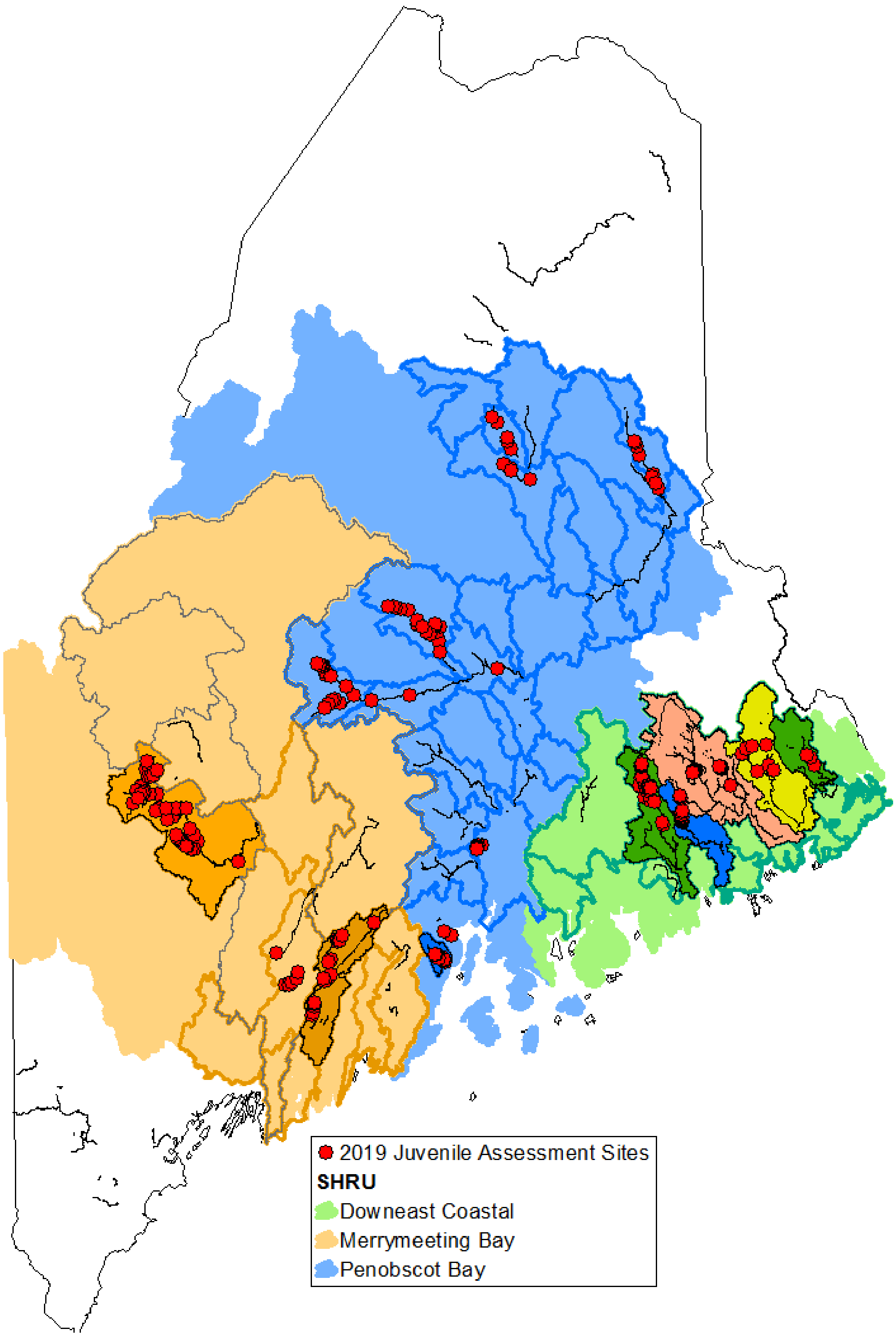

Figure 5.2.1. Location of sites surveyed in 2019 selected using the GRTS method.

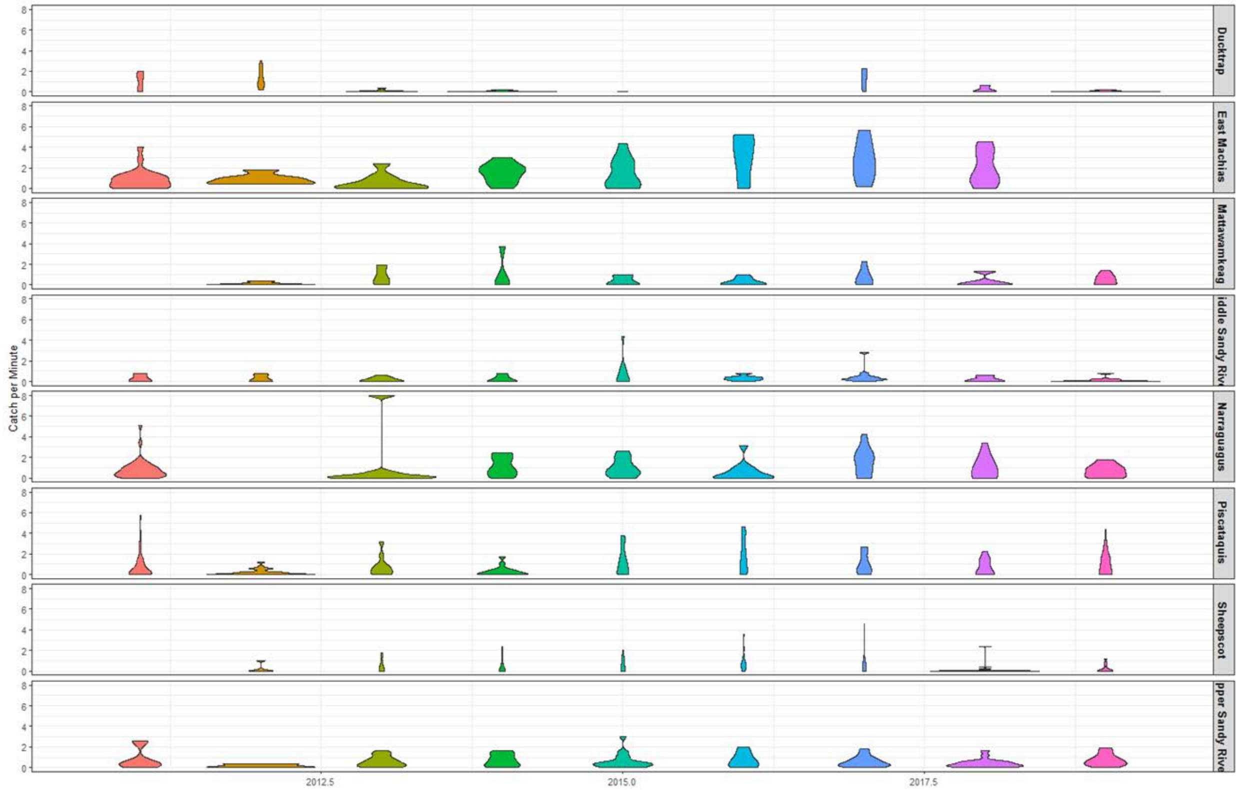

Figure 5.2.2. Catch per minute of large parr across Gulf of Maine DPS rivers 2011 to 2019 in drainages where GRTS sampling occurred. The East Machias was not surveyed under the GRTS selection in 2019.

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 WP19-02-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 (in partnership with Project SHARE), and Sheepscot rivers. A total of 1,169 smolts were unique captures at all sites between 26 April and 17 June 2019 (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). Population estimates for each river/site were 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 naturally reared origin) was 1,289 ± SE 233. The hatchery population estimate was calculated 1,101 ±SE 186. The naturally reared origin population estimate was not calculated due to low captures and low recapture rate. The total population estimate for all smolts exiting the Sheepscot River (hatchery 0+ parr origin and naturally reared origin) was 1,442 ±SE 198. The hatchery population estimate was calculated 1,065 ±SE 233. The naturally reared population estimate was 576 ±SE 116. Two sites were operated on the Narraguagus River in 2019. Long-term monitoring continued at the lower river site at Little Falls. The total population estimate for all smolts exiting the Narraguagus River (hatchery 0+ parr origin and naturally reared origin) was 2,555 ±SE 264. The hatchery population estimate was calculated 1,783 ±SE

203. The naturally reared smolt population estimate was 829 ±SE 202. Additionally, production was evaluated in the upper Narraguagus River at Route 9. The naturally reared smolt population emigrating from the upper watershed was estimated 306 ±SE 38. Further details on age, origin, and other data are presented in *Working Paper WP19-07-Smolt Update*.

Table 5.2.3 Atlantic salmon smolt trap deployments, total captures, and capture timing by origin in Maine rivers, 2019.

River	Dates Deployed		Origin	Total Captures	First Capture	Median Capture Date	Last Capture
East Machias	22-Apr	20-Jun	H	202	30-Apr	19-May	17-Jun
			W	18	26-Apr	18-May	7-Jun
Narraguagus (Route 9)	23-Apr	4-Jun	W	115	7-May	16-May	31-May
Narraguagus (Little Falls)	4-May	4-Jun	H	386	5-May	12-May	31-May
			W	140	8-May	21-May	3-Jun
Sheepscot	25-Apr	11-Jun	H	167	1-May	26-May	8-Jun
			W	141	30-Apr	16-May	4-Jun
Total				1,169			

Table 5.2.4. Maximum likelihood mark-recapture population estimates ±SE for naturally reared and hatchery origin Atlantic salmon smolts emigrating from Maine rivers, 2019.

River	Origin	Population Estimate
East Machias	Hatchery	1,101 ± 186
	Naturally Reared	n/a
	Both	1,289 ± 233
Narraguagus (Route 9)	Naturally Reared	306 ± 38
Narraguagus (Little Falls)	Hatchery	1,783 ± 203
	Naturally Reared	829 ± 202
	Both	2,555 ± 264
Sheepscot	Hatchery	1,065 ± 233
	Naturally Reared	576 ± 116
	Both	1,442 ± 198

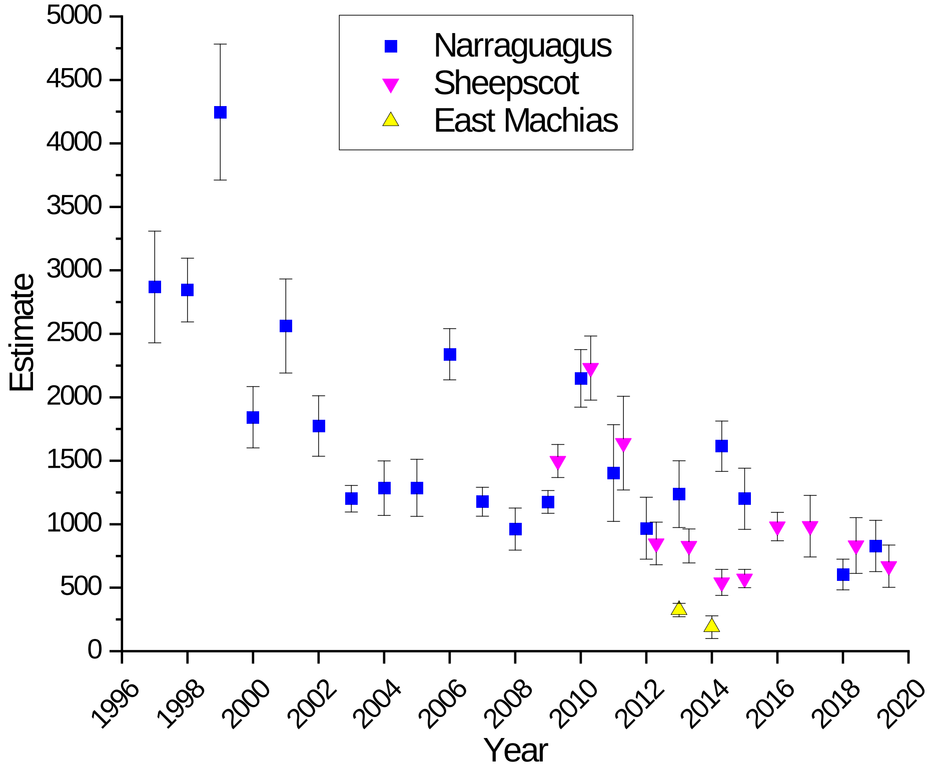

Figure 5.2.3. Population Estimates (± Std. Error) of emigrating naturally-reared smolts in the Narraguagus (no estimate in 2016 and 2017), Sheepscot, and East Machias (no estimate 2015-2019) rivers, Maine, using DARR 2.0.2.

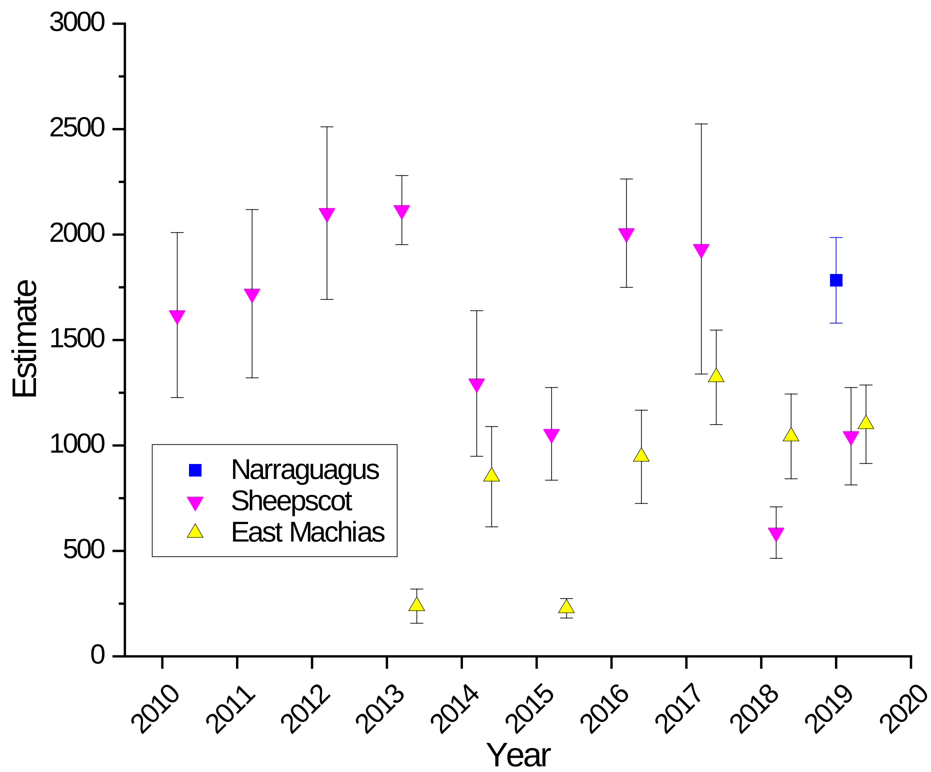

Figure 5.2.4. Population Estimates (± Std. Error) of emigrating hatchery-origin smolts stocked as fall parr in the Sheepscot and East Machias rivers, Maine, 2010-2019, using DARR 2.0.2.

5.3 Fish Passage and Migratory Fish Habitat Enhancement and Conservation

Salmon Energetics Study

During the 2019 field season, the USGS Cooperative Fisheries and Wildlife Unit with support from DMR, tagged and released 20 multi sea-winter adult salmon at Milford Dam on the Penobscot River to contribute to a salmon energetics study. Each adult Atlantic Salmon were equipped with Lotek MCFT2-3L radio tags that were implanted gastrically, measured with a Distell Fish Fatmeter (model FFM-692), and PIT-tagged by DMR staff. Tagged salmon were transported approximately 18.5 km downstream to the Brewer Boat Launch and released to assess upstream migration timing. Movements of the tagged fish back upstream to Milford were tracked with both stationary radio telemetry receivers and mobile radio tracking units. By the end of the field season, 18 of the 20 tagged salmon in the Penobscot River were recaptured re-ascending Milford Dam fish lift, and of the remaining two, one was eventually tracked moving back to sea after spending the summer below the dam, and the last was detected on the PIT tag reader moving upstream, but was not recaptured. Recaptured salmon were measured a second time with the Fatmeter and sent to Craig Brook National Fish Hatchery as broodstock.

Migration Timing of Adult Atlantic Salmon

In the Spring of 2019, 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 DMR at the Milford Dam Fish Lift Sorting Facility. Thirty Atlantic salmon were tagged between 7 June and 9 June. Each adult Atlantic Salmon were equipped with Lotek MCFT2-3L radio tags that were implanted gastrically and were 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, bi-weekly mobile tracking, and PIT arrays located at the entrances and exits of fishways on dams in the mainstem Penobscot, Piscataquis, and Passadumkeag rivers.

Twenty-eight of the radio-tagged fish re-ascended Milford and were then released upstream. Twenty of these fish were detected near the downstream end of the Howland dam bypass, and sixteen were confirmed to have passed successfully. Three radio-tagged salmon approached Browns Mill Dam, but only one initiated passage and was successful. Three other non-radio salmon also attempted passage at Browns Mill but were unsuccessful, for a total passage rate of 25%.

Eight radio-tagged salmon approached the fishway at West Enfield dam. Three of these were detected within the fishway, along with thirty-one salmon carrying only PIT tags. Further upstream at Weldon Dam, nine non-radio fish were detected in the fishway. We can confirm that at least two radio-tagged fish passed Weldon Dam, as they were later detected in the East Branch. Only one non-radio salmon was detected at Pumpkin Hill Dam. This fish initiated passage but appears to have been unsuccessful.

Data from the past two field seasons (2018-2019) suggests that movement rates for salmon are on average 25 times faster in free-flowing versus impounded reaches of the river during their upstream migration.

Habitat Assessment

MDMR staff conducted habitat surveys in one stream within the Merrymeeting Bay SHRU in 2019. The survey quantified physical spawning and rearing habitat in the newly restored section of river following the removal of Cooper's Mill Dam. Staff surveyed 0.93 kilometers upstream of the restoration site between Long Pond and the removal site. Approximately 104 units of rearing habitat were documented. Additionally, staff documented 25 units of spawning habitat. Data are currently being entered in the DMR Habitat database for use in GIS. The new dataset will be appended to the current habitat database and a new GIS dataset will be issued in March 2020.

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.

Barrier Surveys: A coordinated effort was undertaken in Maine to identify aquatic connectivity issues across the state from 2006 through 2019. State and federal agencies and non-governmental organizations worked together to inventory and assess fish passage barriers in Maine and to develop barrier removal priorities. Partners include U.S. Fish and Wildlife Service (USFWS), Maine Forest Service (MFS), The Nature Conservancy, Maine Audubon, USDA Natural Resources Conservation Service (NRCS), the Maine Department of Inland Fisheries and Wildlife (MDIFW), Maine Department of Marine Resources (MDMR), Maine Department of Transportation (MDOT), Maine Natural Areas Program (MNAP), Maine Coastal Program, Trout Unlimited, Atlantic Salmon Federation, Maine Rivers, National Oceanic and Atmospheric Agency (NOAA), and the Androscoggin Valley and Oxford County Soil and Water Conservation Districts.

After 13 years of fieldwork, approximately 90% of the state's perennial stream crossings have been assessed (Figure 5.3.1). About 12,650 stream crossings have been assessed within the Gulf of Maine DPS. A wide variety of private owners, municipalities, and agencies are using survey information to prioritize road-stream crossing improvement projects. Many local, state, and private road managers have requested data showing where problems are so they can include them in long-term budget and repair schedules. A large portion of the crossing data, along with dams and natural barriers assessed are available through the Maine Stream Habitat Viewer (https://webapps2.cgis-solutions.com/MaineStreamViewer/), a website currently hosted by MDMR (See below; Online data viewer), which allows users to view and query barrier data, and to view a wide array of aquatic habitat datasets.

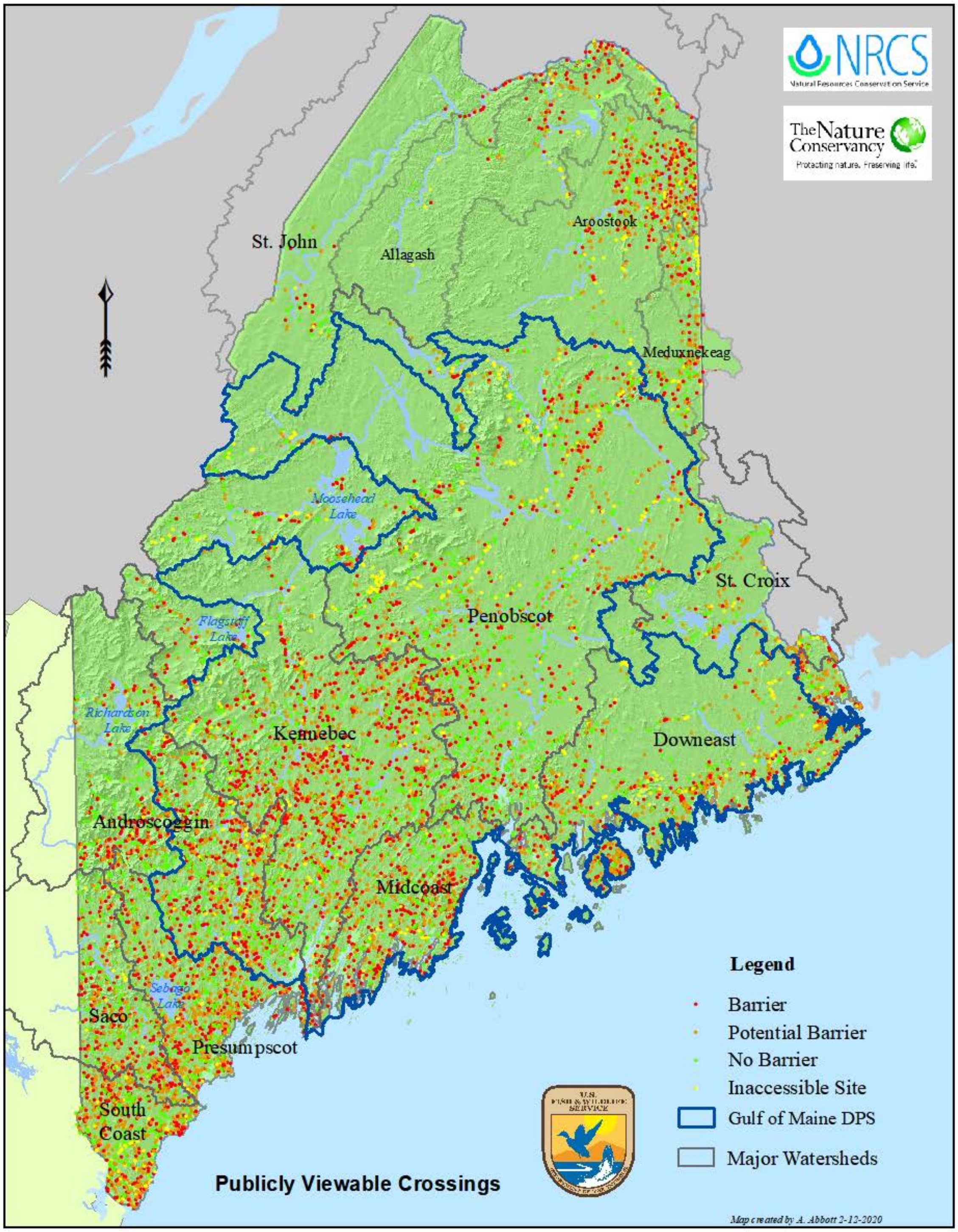

Figure 5.3.1 Maine barrier survey status map. (credit: Alex Abbott, USFWS GOMCP).

Highlighted Connectivity Projects: In 2019, 24 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 USDA NRCS, The Nature Conservancy, Maine Dept. of Marine Resources, Maine Dept. of Transportation, U.S. Fish and Wildlife Service, Broad Reach Fund of the Maine Community Foundation, China Region Lakes Alliance, China Lake Association, Community Building Grant Program of the Maine Community Foundation, Maine Rivers, Narragansett Number One Foundation, National Fish and Wildlife Foundation, Sebasticook Regional Land Trust, Hancock County Soil and Water Conservation District, Project SHARE, Androscoggin River Watershed Council, Atlantic Salmon Federation, Downeast Salmon Federation, municipalities, lake associations, anonymous foundations, contributing individuals, and numerous private landowners.

Table 5.3.1. Projects restoring stream connectivity in GOM DPS Atlantic salmon watersheds (2019), 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
AOP Crossing	NRCS/TPL	Androscoggin	Unnamed Trib to Mainstem Andro	2.30	3.73
AOP Crossing	NRCS/TPL	Androscoggin	Unnamed Trib to Mainstem Andro	1.20	1.94
AOP Crossing	NRCS/TPL	Androscoggin	Unnamed Trib to Mainstem Andro	0.10	0.16
AOP Crossing	NRCS/TPL	Androscoggin	Unnamed Trib to Mainstem Andro	0.60	0.97
AOP Crossing	NRCS/TPL	Androscoggin	Unnamed Trib to Mainstem Andro	0.60	0.97
AOP Crossing	Maine DOT	Penobscot	Unnamed Trib to Blackmon Stream	1.44	2.32
AOP Crossing	NRCS	East Branch Penobscot	Unnamed trib to Matagamon Lake	0.35	0.57
AOP Crossing	NRCS	East Branch Penobscot	Unnamed trib to Matagamon Lake	1.25	2.03
AOP Crossing	Maine DOT	East Machias	Rocky Brook	5.50	8.85
AOP Crossing	Maine DOT	Machias	Bog Stream	2.00	3.22
Arch Culvert	ARWC	Lower Androscoggin	Darnit Brook	7.90	12.70
AOP Crossing	NRCS/TNC	Lower Androscoggin	Trib to Tucker Valley Brook	2.25	3.65
AOP Crossing	NRCS/TNC	Lower Kennebec	Unnamed trib to Mitchell Brook	0.60	0.97
AOP Crossing	NRCS/TNC	Lower Kennebec	Unnamed Trib to Middle Carry Pond	0.60	0.97
AOP Crossing	NRCS/TNC	Lower Kennebec	Outlet Stream	1.40	2.27
AOP Crossing	NRCS/TNC	Lower Kennebec	Unnamed stream	0.25	0.41
Fishway*	Maine Rivers	Lower Kennebec	Outlet Stream (Ladd Dam)	1.50	2.43
Fishway	Maine DMR	Lower Kennebec	Togus Stream (Togus Pond Dam)	41.00	66.00
Arch Culvert	Project SHARE	Narraguagus	Baker Brook	2.50	4.00
Arch Culvert	Project SHARE	Narraguagus	Sinclair Brook	2.40	3.90
Bridge	HCSWCD	Penobscot Bay	Hurd Brook	3.90	6.30
AOP Crossing	NRCS/TNC	Lower Penobscot	Boyd Stream	0.75	1.22
AOP Crossing	NRCS/TNC	Lower Penobscot	Trib to Hoyt Brook	0.51	0.83
Decommission	NRCS/TNC	Lower Penobscot	Unnamed trib to Dead Stream	0.26	0.42

AOP Crossing	NRCS/TNC	Piscataquis	Cook Brook	0.56	0.91
AOP Crossing	Maine DOT	Piscataquis	Fox Brook	3.00	4.83
AOP Crossing	Maine DOT	Sandy	Gray Farm Brook	4.00	6.44
Dam Breach	ASF	Sheepscot	Sheepscot River (Head Tide Dam)	70.00	112.70
Dam Removal	DSF	Union	Branch Lake Stream (Dam)	5.60	9.00
			TOTAL	**164.20**	**264.71**

**Restored access to 43-acre alewife pond*

Stream Smart training: In 2019, Maine Audubon continued to lead a statewide partnership to educate professionals responsible for road-stream crossings on how to improve stream habitat by creating better crossings. The partnership hosted 4 workshops around the state (in southern, central, and northern Maine) with 75 attendees. Since 2012, over 1,000 people representing 125 towns have attended Stream Smart workshops. Workshops inform public and private road owners about opportunities to replace aging and undersized culverts with designs that last longer, improve stream habitat, save money on maintenance, and can reduce flooding. Participants in the workshops included town road commissioners, public works directors, contractors, forest landowners, foresters, loggers, engineers, conservation commissions, watershed groups and land trusts. Additional project partners include the Maine Coastal Program, Maine Department of Environmental Protection, Maine Department of Transportation, Maine Department of Inland Fisheries & Wildlife, NOAA, US Fish & Wildlife Service, USDA NRCS, Maine Forest Service, Maine Rivers, Casco Bay Estuary Partnership, Project SHARE, Sustainable Forestry Initiative, the Nature Conservancy, and US Army Corps.

Figure 5.3.2. Stream Smart training workshops provide natural resource professionals instruction on culvert assessment and design methodologies.

Two of the workshops were Stream Assessment Field trainings meant to introduce stream survey techniques and approaches for developing initial recommendations for road-stream crossings. The trainings provided information to allow participants to:

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

New in 2019, the Maine Department of Environmental Protection began hosting workshops for municipalities in preparation for the 2019 Municipal Infrastructure Stream Crossing Upgrade Grants RFP. Five workshops were held across the state to provide information to prospective applicants on the value of Stream Smart crossings, basic Stream Smart design, natural resources being targeted for habitat improvement under the grant program, regulatory oversight of stream crossing projects, and tools available for gathering information on specific crossings to create preliminary Stream Smart designs and for completing the grant applications. Applications received for the grant program after workshops were conducted were significantly better than those received before the outreach, with better projects being brought into the application process.

Online data viewer – The Maine Stream Habitat Viewer provides easy access to habitat and barrier datasets (https://webapps2.cgis-solutions.com/MaineStreamViewer/). The viewer has been hosted for three years by MDMR, and is scheduled to be moved over to be hosted by MDIFW in 2020. The Viewer contains Atlantic salmon spawning and rearing habitat, and modeled rearing datasets along with dams, natural barriers and publicly available data on road-stream crossings. The Viewer was created to enhance statewide stream restoration and conservation efforts, and provides a starting point for towns, private landowners, and others to learn more about stream habitats across the state. The Viewer allows you to:

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

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 continues to investigate high density large woody debris ($_{HD}$LWD) treatments, using the Post-assisted Log Structure (PALS) method (Camp 2015). MDMR scientists recommended treatment of a mainstem habitat reach from the Just above the confluence of Humpback Brook to a canoe landing at the end of the 30-35-0 Rd (River Km 52.01 – 51.1). Project SHARE staff, with assistance from MDMR, NOAA, and USFWS scientists and numerous volunteers constructed 39 PALS structures during the 2019 field season (Figure 5.3.3 – Figure 5.3.5).

In Township 39, another treatment of self-placing wood was added to the mainstem of the Narraguagus River. This treatment involved using a truck-mounted grapple claw to place 12 commercially harvested red pine trees into the river at the 31-00-0 road bridge (a commercial logging road crossing at River Km 62.49). The intent is for the trees to wash downstream during the fall and spring floods before hanging up and becoming key logs (i.e. self-placing). Two other self-placing wood additions also occurred in the upper Narraguagus; one in West Branch Brook and one above the 2019 PALS treatment area at River Km 52.17. These treatments will continue over the next 3-5 years with the hypothesis that multiple naturally-formed log jams will develop.

Twenty-eight trees were also added throughout the watershed using a Griphoist. In Baker Brook, 8 trees were added downstream of the new arch culvert installed on the 45-00-0 Rd in Devereaux Township (River Km 3.24). Also, in Devereaux Township, 13 trees were added to Sinclair Brook below the new arch culvert on the 45-00-0 Rd. Within the Narraguagus PALS treatment reach, 7 trees were added to the river. These differed from the other Griphoist additions in that they were felled into the riparian area and then pulled root ball first into the river.

Table 5.3.2. Large wood additions implemented in 2019 by Project SHARE in support of the Upper Narraguagus Watershed Restoration Project.

Tributary	**Addition Type**	**Large Wood Pieces Added**	**Habitat Units Treated**
Narraguagus Mainstem	Post-Assisted Log Structures	154	119.3
Narraguagus Mainstem	Self-placing Wood	60	78.7
Narraguagus Mainstem	Griphoist Trees	7	10.05
West Branch Brook	Self-placing Wood	13	12.98
Sinclair Brook	Griphoist Trees	13	7.65
Baker Brook	Griphoist Trees	8	0.74

Figure 5.3.3. Project SHARE seasonal crew and NOAA interns posing on a large red pine tree that was just pulled into the Narraguagus River manually, using a Griphoist. (photo credit: Chris Federico, Project SHARE)

Figure 5.3.4. Driving posts on a PALS, Narraguagus River, Maine, 2019. (photo credit: Chris Federico, Project SHARE)

Figure 5.3.5. Aerial photo showing PALS being constructed near the confluence of Sinclair Brook and the Narraguagus River, Maine, 2019. (photo credit: Chris Federico, Project SHARE)

<u>West Branch Sheepscot River Focus Area Restoration</u>

As a collaborative effort, MDMR and Project SHARE treated 3 sections of the West Branch Sheepscot River with PALS (post-assisted log structures) between river kilometer 26.24 and 24.29 (Figure 5.3.6). Cumulatively, approximately 500m were treated with 40 structures. Due to substrate size beneath gravel, 5 structures were unable to be anchored by posts. Highly detailed habitat surveys have been completed in each treated section of river, along with an untreated control section of river as pre-monitoring efforts. Electrofishing surveys have been completed in each treated section of river, along with a control section prior to installation as a pre-monitoring measures to determine parr usage as habitat. The section of river located at river kilometer 26.2 was treated in 2017; however, ice movement and spring freshets removed most of the 6 structures installed. Precautionary steps were taken to prevent this from occurring again, including tying front and rear posts together for added structure stability, building structures that constricted the width of the stream less, and constructing the structures at less of an angle relative to the stream bank to allow movement of ice and high water to flow past the structures.

Figure 5.3.6. PALS project treatment site, pre- (left) and post- (right), West Branch Sheepscot River, Maine, 2019. (photo credit: Jennifer Noll, Maine DMR)

Water Quality Improvements

Despite restored access, Atlantic salmon (*Salmo salar*) populations in eastern Maine remain low. Loss of fish populations due to acidification in the North Atlantic region has been well documented. Most waters in eastern Maine periodically experience acidic conditions (pH <6.5), resulting in detrimental impacts to salmon, especially during snow melt and spring/fall runoff. Liming acidic waters (using agricultural lime) has increased salmon abundance in Scandinavia and Nova Scotia, and has been recommended as a restoration action for Maine. A 2009 Project SHARE pilot study investigating the efficacy of using clam shells to lime streams suggested a positive trend. The Downeast Salmon Federation, in collaboration with the Maine Department of Environmental Protection, has begun a multi-year effort in the East Machias River watershed to further investigate the efficacy of this mitigation method. Project goals include increasing macroinvertebrate abundance and diversity and increasing juvenile salmon abundance.

The first two years of the project characterized baseline conditions by monitoring water quality May-November. Shells were added to the treatment stream July through October 2019 (Figure 5.3.7). There were no significant changes in water quality parameters following the first shell application. Periodic stressful conditions are still occurring as observed during baseline monitoring, including low pH (minimum of 4.19), high temperature (maximum of 27.7 °C), low calcium (minimum of 0.70 mg/L), and high exchangeable aluminum (maximum of 53 ug/L). The lack of change may be due to frequent rain events diluting any buffering capacity of the shells, or because shells were spread incrementally over more than two months, or because of seasonal limitations that prevented much data collection after the full dose was applied. Shells were spread mostly in the shallow stream edges and on the banks, so would only be in contact with the stream during higher flows, such as occurred after monitoring equipment was retrieved for the winter. Additional shell treatments are planned for 2020, and monitoring will continue for at least five years from the first shell placement to determine the efficacy of using clam shells to mitigate acidity.

Figure 5.3.7. Clam shell treatment site, Richardson Brook, Maine, 2019. (photo credit: Emily Zimmerman, Maine DEP)

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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 5,553,000 eggs for the Maine program: 1,960,000 eggs from Penobscot sea-run broodstock; 1,600,000 eggs from domestic broodstock; 1,993,000 eggs from captive broodstock populations. Eggs produced at CBNFH and GLNFH are used for egg planting, fry stocking, age 0+ parr stocking and educational programs. In addition, an aliquot of each family group of Penobscot sea-run eggs produced at CBNFH are transferred to GLNFH for parr and smolt production.

Spawning protocols for Atlantic salmon broodstock at CBNFH and GLNFH prioritize first time spawners and utilize 1:1 paired matings. In 2019, both facilities used year-class crosses as well as spawning optimization software to avoid spawning closely related individuals. A total of 280 Penobscot sea-run origin females and 592 captive females were spawned at CBNFH between November 4th and December 2nd and 647 Penobscot-origin domestic females were spawned at GLNFH between November 19th and December 3rd.

CBNFH relies on two ambient water sources, Craig Pond and Alamoosook Lake. Eggs taken early in the spawning season may be exposed to water temperatures at or above-optimal levels for egg development which may affect egg survival, embryonic deformities and fry survival. CBNFH used a photoperiod treatment to modify spawn timing of Penobscot sea-run broodstock as well as Machias and Narraguagus captive broodstocks. The treatment delayed spawning and allowed eggs to be collected in more favorable water temperatures. Hatchery water sources were mixed to ensure eggs were collected at water temperatures above 5°C. The collection of eggs was delayed for one week for untreated populations as temperatures in late October were not favorable.

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 2019. *Egg numbers rounded to the nearest 1,000.

Facility	Strain	Rearing History	Receiving Entity	Purpose	Number*
CBNFH	East Machias	Captive/domestic	Downeast Salmon Federation	Private rearing	370,000
CBNFH	Machias	Captive/domestic	Department of Marine Resources	River-of-origin egg planting	91,000
CBNFH	Narraguagus	Captive/domestic	Department of Marine Resources	River-of-origin egg planting	66,000
CBNFH	Penobscot	Sea-run	Green Lake National Fish Hatchery	Smolt production	952,000

CBNFH	Penobscot	Sea-run	Fish Friends / Salmon-in-Schools	Education	4,000
CBNFH	Pleasant	Captive/domestic	Downeast Salmon Federation	Private rearing	142,000
CBNFH	Pleasant	Captive/domestic	Department of Marine Resources	River-of-origin egg planting	88,000
CBNFH	Sheepscot	Captive/domestic	Department of Marine Resources	River-of-origin egg planting	215,000
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	1,412,000
GLNFH	Penobscot	Captive/domestic	Fish Friends / Salmon-in-Schools	Education	9,800

Wild Broodstock Collection

A total of 596 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 15th. A total of 58 trips were made until August 29th.

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 (100 m^2). In 2018 the FWS decided to both equalize parr broodstock collection targets across populations and focus on maintaining a minimum effective population size of 50. In 2019 collections totaled 1,283 (Dennys, 214; East Machias, 214; Machias, 215; Narraguagus, 215; Pleasant, 208; Sheepscot, 217).

Domestic Broodstock Production

GLNFH retained approximately 900 fish from the 2018-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) were allowed to join the general hatchery population. In 2019 17 HPR0 positive adults were released to the Penobscot River, a marked increase from prior years.

In cases where a positive result detects a pathogenic strain of ISA, the affected individual is euthanized. The affected individual's cohort is isolated for an additional 28 days and resampled. In 2019 a single individual was identified by LFHU as being positive for an unknown strain of ISA. LFHU collaborated with Kennebec Biosciences to confirm their findings. 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 individual was euthanized. No clinical signs of ISA were observed prior to euthanasia. The cohort of the affected individual was quarantined for 28 days and resampled. No additional positive results were found and the fish were allowed to join the general population.

Juvenile Stocking

Stocking activities within the GOM DPS that involved two federal hatcheries and two private hatcheries released 4,188,000 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 2019.

Drainage	Parr	Smolt	Egg Eyed	Fry	Total
Dennys	10,000			175,000	185,000
East Machias	226,000			10,000	236,000
Kennebec			918,000		918,000
Machias			91,000	183,000	274,000
Narraguagus		95,000	66,000	179,000	340,000
Penobscot	93,000	555,000	495,000	631,000	1,774,000
Pleasant			88,000	132,000	220,000
Sheepscot	17,000		215,000	9,000	241,000
Totals	346,000	650,000	1,873,000	1,319,000	4,188,000

Adult Stocking

A total of 2,986 adults were stocked into GOM drainages (Table 5.4.3). Eighty Penobscot sea-run adults were released in the East Branch Penobscot in July, ten with radio tags, to track movements of spawners in the area ahead of a proposed net-pen reared adult project.

Table 5.4.3. Adult broodstock released pre- and post-spawn from Craig Brook and Green Lake National Fish Hatcheries in 2019.

Drainage	Stock Origin	Pre/Post Spawn	Lot	Number Stocked
Dennys	DE	Post-Spawn	Captive/Domestic	264
Dennys	DE	Pre-Spawn	Captive/Domestic	0
East Machias	EM	Post-Spawn	Captive/Domestic	194
East Machias	EM	Pre-Spawn	Captive/Domestic	0
Machias	MC	Post-Spawn	Captive/Domestic	251
Machias	MC	Pre-Spawn	Captive/Domestic	0
Narraguagus	NG	Post-Spawn	Captive/Domestic	253
Narraguagus	NG	Pre-Spawn	Captive/Domestic	0
Penobscot	PN	Post-Spawn	Captive/Domestic	958
Penobscot	PN	Post-Spawn	Sea Run	479
Penobscot	PN	Pre-Spawn	Sea Run	97
Pleasant	PL	Post-Spawn	Captive/Domestic	171
Pleasant	PL	Pre-Spawn	Captive/Domestic	0
Sheepscot	SHP	Post-Spawn	Captive/Domestic	129
Sheepscot	SHP	Pre-Spawn	Captive/Domestic	0
			Total	2,986

Outreach Programs

In 2018, the Fish Friends Program organized by the Atlantic Salmon Federation took over coordination of the USFWS' Salmon-in-Schools program effectively creating a single program. This year marked the twenty-fifth year of the fry outreach and education program. Classroom curriculum involves the life cycle of Atlantic salmon and other diadromous fish, habitat requirements and human impacts which can affect their survival. The 2019 program involved 86 different schools, 4 different organizations, and 10 watersheds to reach over 6,465 students and stock 14,351 fry of which 12,920 where in the GOM DPS. In addition, eight 0+ parr were on display in the Bangor's Municipal Wastewater Treatment Facility. The programs contributed to many rivers within the GOM DPS (Table 5.4.4).

Table 5.4.4. Outreach stocking activities in the Gulf of Maine Distinct Population Segment for 2019.

Drainage	Fry	Smolt	Total
Androscoggin	1,724		1,724
East Machias	488		488
Kennebec	2,667		2,667
Passagassawakeag	1,651		1,651
Penobscot	3,464	8	3,472

Pleasant	190		190
Sheepscot	992		992
Union	1,736		1,736
Totals	12,912	8	12,920

Research

In 2019, Green Lake NFH provided 750 smolts to researchers for various studies. Smolts were used for a downstream migration studies in the Penobscot Drainage to evaluate movement, delay, and survival (n = 508). The researchers used the hatchery facilities to mark, tag, and hold telemetry study fish prior to release. Smolts were also used in a saltwater challenge study to evaluate fed and fasted hatchery smolts as they are transitioned to saltwater at three different time periods (n = 242). The researchers used the hatchery facility to conduct the saltwater challenge study.

5.6 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 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 02 July to 01 November 2019. Nine Atlantic salmon were captured and released upstream in 2019. The salmon captured consisted of 6 2SW females, and 3 2SW males. Of these fish 5 were hatchery origin and 4 were naturally reared.

6.2 Hatchery Operations

Stocking

No juvenile lifestages were stocked in 2019.

Adult Salmon Releases

No adults were stocked in 2019.

6.3 Juvenile Population Status

Electrofishing Surveys

There were no population assessments in the Aroostook River watershed in 2019.

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 US Salmon and Terms of Reference

7.1 Summary

The purpose of this section is to provide an 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. 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 other sections. This section reviews select working papers, ensuing discussions, and ad hoc topics to both synthesize information in working papers and provide information on discussions and decisions made by the working group.

Work at the 2020 meeting focused on both improving stock assessment of Atlantic salmon in the US and better monitoring of the effectiveness of recovery actions. Work sessions were prefaced by discussions focused on current research or changes in assessment methods. Of note was the completion of work to update tools (R model) and improve the estimate of spawner escapement through a redds-based estimate (RBE- see below in Section 7.2). This work started in 2019 and was completed at this meeting. 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. The introduction of genetic-based methods into population growth parameters was updated again this year providing a new metric for managers. The USASAC will continue to work with Pacific salmonid scientists to both improve and standardize methods as appropriate. Summaries of primary discussions are listed below under several theme sessions. Additionally, the USASAC developed a new draft Terms of Reference for the 2020 meeting.

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

For monitored 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. Substantial progress was made on an updated RBE model, prior to and at the working group meeting. We finalized a working paper that represents the 2020 benchmark assessment. This paper synthesized data through 2019 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 on the new R-based model and specific details are documented in this working paper. This model also incorporated an additional 8 years of available training data in the model. Additionally, this paper has more detailed descriptions of the methods used to pro-rate basin-wide adult salmon returns by both origin and sea age. These pro-rations have been documented in the past only in spreadsheets that are difficult to access. Adding the proration methods to a working paper better documents the methods and can provide a reference for the USASAC Database tables that contain output data.

7.3 Scale Archiving and Inventory Update

The USASAC noted that the lack of dedicated resources and capacity has delayed an expansive effort to better archive and inventory historic scale samples throughout New England. In 2017, a general inventory was conducted by New England fishery agencies participating in USASAC. We found that 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 last

3 meetings, we discussed several options to develop a comprehensive inventory of available US scales and to pursue proper archiving and storage of said scales. We discussed funding options to support this work but no successful grants were found in 2019. Possible sources might be NOAA Preserve America Initiative but this has limited funding and other historical archiving resources need to be identified The USASAC supports continued efforts of an ad-hoc committee to work towards identifying funding sources and drafting a proposal to add capacity for a New England wide effort.

The USASAC was made aware of a recent ICES workshop entitled ICES Workshop on Biochronology Archives (WKBioArc) which was held in Galway Ireland March 2020. The objectives of the meeting were to: a) Review and report on issues and solutions for establishing, maintaining and managing biochronology archives of biomineral samples (scales, otoliths and other bones, etc.) to ensure protection and access of these valuable archives for future scientific use; b) Establish common database designs that facilitate the sharing of the archives across national boundaries; and c) Promote and report on international collaboration opportunities and potential new projects using archive material and data in order to address regional scale questions and to develop new scientific understanding and quality advice. The report from this workshop is set to be delivered April 2020 and the USASAC will use that report 2021 to assess next steps towards scale archiving and inventory updating at their 2021meeting.

In the short term, the USASAC agreed that a more modest pilot project could be investigated prior to 2021 to both inventory and store a smaller sub-group of scales according to the guidelines identified by WKBioArc. The pilot project should focus on the Maine smolt scale collection. NOAA and DMR will work collaboratively to both integrate the existing Maine Databases, identify storage needs and location documentation, etc.

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 databases in 2019, the committee deemed that more accurate 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.

Estimates using these methods were first reported in 2019 for the 2018 year of adult returns. However, following discussion by committee members, a full time series of escapement was not put forth at the 2019 meeting. With intersessional work and efforts at the 2020 meeting, the USASAC team was able to populate the full time series of escapement (1970-2019) and add this information to the USASAC database in 2020.

7.5 Recovery Metrics, Definitions of Naturally-Reared Fish, and Calculation of Replacement Rates

Working with managers on the Cooperative Management Strategies reports for the 3 salmon habitat recovery units (SHRUs), an issue was raised relative to the definition of naturally-reared returns. With the release of the new recovery plan in late 2018, the evaluation criteria for naturally-reared fish was changed from the former production classes of wild production, egg planting, and fry stocking to include fall stocking (parr). Upon looking at current data summaries and metrics, this change will impact two parameters that we report annually – adult returns (partitioned by natural reared and hatchery origin) and natural population growth rates. We also reviewed our current list of terms in our glossary and determined that we need to update our definitions of population origin because currently the report glossary definition of wild is not consistent with the document that uses naturally reared. With the advent of management level egg planting an update is needed. Additionally, our review of current database structure, query designs, and associated workloads, the USASAC determined that making these adjustments will take additional time and resources to accurately capture the time series of data for adult returns. Adult return data for each river will need to be partitioned into wild, naturally reared, and hatchery origin, and re-entered for the entire time series in order to calculate a naturally reared population growth rate according to the new definition of naturally reared (wild production + egg planting + fry stocked + fall parr stocked). In the coming year, the USASAC will work with managers to examine the utility of historic time series compared to new metrics for 2020 and beyond.

7.6 Smolt and Fall Parr Working Paper Discussion

Smolt assessment discussion centered around the low estimates on two of the three rivers studied in 2019. The Narraguagus naturally-reared population estimate was the second lowest observed in the 23-year time-series. The drivers are two-fold: Narraguagus strain hatchery egg production has declined to pre-listing levels resulting in a reduction in unfed fry inputs and the allocation of eggs towards a second period of age-1 smolt stocking (2016-2019). With limited natural spawning, the 2019 and 2020 naturally-reared smolt cohorts will represent two of the lowest fry inputs in the timeseries.

The Sheepscot River naturally-reared population declined by 35% from the previous year; the third lowest in the time-series. Average naturally-reared smolt production was greater during the period of unfed fry stocking (2009 –2014; mean 1,365) than the recent period of eyed egg planting (2015 – 2019; mean 800). The Sheepscot River smolt population produced by age-0 parr stocking increased 55% compared to 2018 yet remained below the 5-year average. This result is likely due to a 15% decrease in the number of fall parr stocked from 2016 to 2018. Further, the USFWS will no longer provide fall parr from CBNFH and parr will no longer be stocked in the Sheepscot River.

The fall parr smolt production working paper led to a detailed discussion regarding age-0 parr produced and stocked from the Peter Gray Hatchery on the East Machias River. This streamside effort has shown some promising results over the past several years with continued success in 2019. Populations between 2018 and 2019 increased by 5% and remain above the 5-year average. Results indicated age-0 parr reared at the Peter Gray Hatchery represent an age distribution similar to wild and fry stocked smolts with similar ratios of age-2/age-3 smolts (p20/p32 origins) as in the Narraguagus River. This is different from the Sheepscot Rivers where USFWS-reared parr are younger Age-1 smolts (P-8). Much of the discussion focused on numbers of parr dedicated to this project with suggestions that there may be over saturation of habitat and fewer fish could get the same result. With addition of other populations, this excess production could be used in other river systems. Plots of production per habitat unit and the smolt recruitment curve support this suggestion and adaptive management can be used to better understand optimal stocking levels of this product. The USASAC encourages continued dialogue and analysis to answer these management questions.

Lastly, we discussed the image analysis working paper. Smolts sampled during the field season were summarized and were consistent with previous data for each of the study rivers. Proportions of age-2 smolts made up the majority (>75%) for both the Sheepscot and Narraguagus Rivers. Meanwhile, the East Machias was represented by a greater proportion of age-3 fish (56%), although the low sample size is always a consideration. In long-standing comparison of age-2 naturally reared smolts on the Narraguagus and Sheepscot Rivers, it was noted that the age-2 smolts are smaller at age in the modern time-series than they were in the past. It is unclear what is driving this result (environment, densities, etc.), but further investigation should be considered.

7.7 An Update on determination of Conservation Limits

In 2017, the US Atlantic salmon assessment committee (USASAC) discussed an update of conservation limits (CL) for the United States (Section 7.3 USASAC Annual Report 2017/29, TOR 3.2.2). This was summarized in a working paper (Atkinson and Kocik, 2017) that described changes to the CL based on updated available habitat estimates as described by (Wright et.al. 2008). The previous CL for the USA was 29,189 2- Sea winter (2SW) salmon (Baum, 1995). The 2017 Cl increased to 85,560 adults. This increase was questioned since it was such a dramatic change and was not aligned with recovery goals outlined in the Atlantic salmon Recovery Plan (U.S. Fish and Wildlife Service and NMFS, 2018). The number of adults presented in the 2017 working paper was calculated based on estimated habitat for New England Atlantic salmon Rivers and the increase was driven by an increase in the estimate of available habitat described by Wright et al. (2008). In 2019, the WGNAS formally requested a review of the U.S. Cl (NAC (13)4 WGNAS, 2019).

The following methods were applied to determine the US Conservation limits for 2020.

- Only use drainages that are currently contained within the Gulf of Maine DPS and designated as Critical Habitat. This is because these drainages have the backing of the US Endangered Species Act (ESA) and are currently undergoing stock enhancement and restoration activities at a scale much greater than other New England rivers.

- Exclude non-critical habitat in the Gulf of Maine. Since these habitat reaches are not currently managed due to migration barriers or other reasons.

- The total amount of critical habitat was applied to the following equation to calculate total escapement targets for the US: Number of adults = (amount of rearing habitat (m^2) *2.4 eggs/7,200 Eggs fecundity) *2. To determine the 2SW target escapement, the proportion of 2SW to 1SW (0.785) was applied to the total escapement.

After presenting the revised numbers and discussion during the March 2020 USASAC meeting, the following are set for US salmon: a management objective as described by WGNAS (NAC (13)4 WGNAS, 2019) of 4,549 2SW salmon. This is based on recovery criteria established for the Gulf of Maine under the ESA. The updated 2SW conservation limit is 22,134.

7.8 Updating Marine Survival Rates to Remove In-River Mortality

The USASAC discussed updating the US marine survival metrics report annually for Penobscot River hatchery origin smolts. Currently, this estimate uses total smolts stocked and subsequent adult returns by sea age to generate a smolt-to-adult return rate (SAR). The revised estimates would use the methods of Stevens et al. (2019) to decouple losses of smolts in-river and in the estuary to provide an estimate of postsmolts entering the Gulf of Maine. This method accounts for stocking location and flow-specific mortality. This postsmolt estimate could then be applied to subsequent adult returns to calculate a postsmolt to adult survival rate (PSAR). The USASC discussed the concept and agreed it would provide a better estimate of marine survival. While deriving new estimates at the meeting, analysts noted that there were some inconsistencies in stocking locations and total number between two databases. While the intent is to develop a revised estimate of Penobscot hatchery origin smolt marine survival, the group decided to delay implementation of the change for another year to allow more time for data audits. A working paper is in development that will include data tables that incorporate smolts stocked, postsmolts estimated and marine survival from 1970 to 2020 adult returns.

7.9 USASAC Draft Terms of Reference for 2021 Meeting

The purpose of this section is to outline terms of reference identified at the USASAC annual meeting in March 2020. These draft Terms of Reference are meant to be revisited during our summer 2020 teleconference and intersessional work. These draft TOR will be integrated with requests and needs that emerge from the ICES WGNAS (March 2020); NASCO Meetings (June 2020), and the Maine Collaborative Management Strategy Annual Report (April 2020) to develop Final 2021 TOR and an agenda for the 2021 USASAC Meeting.

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 2020 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.*
>
> *Update framework of indicators – what it is, how it works, what the US has contributed in the past*

In **support of Maine Cooperative Management Strategy Implementation Team**, we anticipate reporting on the following with respect to Atlantic salmon in the Gulf of Maine DPS.

Status of US Populations for the Gulf of Maine DPS including:
- *Adult Returns Estimate (Hatchery and Naturally Reared)*
- *Freshwater Production Summaries – Smolts and pre-smolt production CPUE*
- *Marine Survival – hatchery index Penobscot and naturally-reared Narraguagus*
- *Compilation of Tag releases*
- *Hatchery production*

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. Initiate a pilot project with a subset of scales in 2020.

Marine Survival Updates - Upon completion of smolt stocking data audit. Develop a final working paper and data tables that incorporate methods of Stevens et al. (2019) to decouple losses of smolts in-river and in the estuary, to develop a revised estimate of marine survival from 1970 to 2020.

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.

Naturally-Returned Fish and Definitions - The USASAC will work to update database queries to output. Need to revisit glossary and update fish origins consistent with NASCO and ESA (see Section 7.5)

Smolt age distribution - To better inform international stock assessment activities, there is opportunity to provide more detailed population dynamics information for US populations within ICES WGNAS assessment models. Detailed information on age-specific adult abundance, estimates of annual escapement, estimates of annual smolts ages, etc. would be welcomed by the ICES WGNAS. To support this effort, estimates of US annual smolt age distributions will be developed, reviewed and provided to ICES WGNAS as appropriate.

Hatchery product comparisons - Sheepscot River. The effectiveness and productivity of different rearing techniques can be compared and contrasted by standardizing the number of stocked individuals to a 'common currency' (e.g. number of eggs). Once standardized, different productivity metrics (e.g. juvenile density, biomass, and contributions to emigrating smolts, etc.) can be more appropriately be compared across rearing techniques. These comparisons will allow for the development of optimization curves of egg resources. This approach will be undertaken for the Sheepscot River as a case study to develop the techniques and approaches.

8 List of Attendees, Working Papers, and Glossaries

8.1 List of Attendees

First Name	Last Name	Primary Email	Agency	Location
Ernie	Atkinson	Ernie.Atkinson@maine.gov	MDMR	Jonesboro, ME
Dan	Kircheis	Dan.Kircheis@noaa.gov	NOAA	Orono, ME
Oliver	Cox	Oliver_Cox@fws.gov	USFWS	Ellsworth, 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
Colby	Bruchs	Colby.W.B.Bruchs@maine.gov	MDMR	Jonesboro, 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
Rory	Saunders	Rory.Saunders@noaa.gov	NOAA	Orono, ME
Paul	Christman	Paul.Christman@maine.gov	MDMR	Hallowell, ME
Meredith	Bartron	Meredith_Bartron@fws.gov	USFWS	Lamar, PA
Sheehan	Tim	Tim.Sheehan@noaa.gov	NOAA	Woods Hole, MA

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

Number	Authors	Title
WP20-01	John Kocik, Christopher Tholke and Timothy Sheehan	Annual Bycatach for Atlantic Salmon, 1989 through September 2019 (WP)
WP20-02	David Bean	Maine and Neighboring Canadian Commercial Aquaculture Activities and Production (WP)
WP20-03	John Sweka, Ernie Atkinson and John Kocik	Benchmark Redd-Based Estimates (RBE) of Adult Returns to the Gulf of Maine Distinct Population Segment and Proration of Origin and Sea Age (WP)
WP20-04	Colby Bruchs, James Hawkes, Ernie Atkinson, Ruth Haas-Castro, Paul Christman, Jennifer Noll, Zach Sheller, Rachel Pineo, Chris Federico and Graham Goulette	Update on Maine River Atlantic Salmon Smolt Studies: 2019 (WP)
WP20-05	Ruth Haas-Castro, Brandon Ellingson, Graham Goulette, James Hawkes, Timothy Sheehan, Justin Stevens, Ernie Atkinson, Colby Bruchs, Paul Christman and Jennifer Noll	Review of Atlantic Salmon Age & Image Analysis Studies: 2019 (WP)
WP20-06	Ernie Atkinson	Maine Atlantic Salmon - Summary of 2019 Activities (PPT)
WP20-07	Ernie Atkinson	Proposed sampling plan for Estimates of abundance of juvenile life stage in Gulf of Maine DPS (PPT)
WP20-08	Colby Bruchs	Maine Hatchery 0+ Parr Origin Smolt Populations Data Summary (PPT)
WP20-09	Timothy Sheehan	Report of the working group on North Atlantic Salmon (WGNAS; WP)
WP20-10	Ernie Atkinson	Determination of Conservation Limits for New England Atlantic salmon Rivers, USA (WP)

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 – 8, 2019	Ernie Atkinson	MDMR
Portland, ME	March 2 – 6, 2020	Ernie Atkinson	MDMR

8.4 Glossary of Abbreviations

AASF - Adopt-A-Salmon Family
ARH - Arcadia Research Hatchery
BRP - Brookfield Renewable Partners
CNEFRO - Central New England Fisheries Resource Office
CRASA - Connecticut River Atlantic Salmon Association
CTDEP - Connecticut Department of Environmental Protection
CTDEEP - Connecticut Department of Energy and Environmental Protection
CRASC - Connecticut River Atlantic Salmon Commission
CBNFH - Craig Brook National Fish Hatchery
DSI - Decorative Specialties International
DI - Developmental Index
DDENFH - Dwight D. Eisenhower National Fish Hatchery
DPS - Distinct Population Segment
DSRFH - Division of Sea Run Fisheries and Habitat
DSF - Downeast Salmon Federation
DSFWSRC - Downeast Salmon Federation Wild Salmon Resource Center
FERC - Federal Energy Regulatory Commission
GIS - Geographic Information System
GCC - Greenfield Community College
GLNFH - Green Lake National Fish Hatchery
ICES - International Council for the Exploration of the Sea
ISAV - Infectious Salmon Anemia Virus
KSSH - Kensington State Salmon Hatchery
MAA - Maine Aquaculture Association
MASC - Maine Atlantic Salmon Commission
MDMR - Maine Department of Marine Resources
MDOT - Maine Department of Transportation
MIFW - Maine Inland Fish and Wildlife
MAFW - Massachusetts Division of Fisheries and Wildlife
MAMF - Massachusetts Division of Marine Fisheries
NNFH - Nashua National Fish Hatchery
NAS - National Academy of Sciences
NHD - National Hydrologic Dataset
NOAA - National Oceanic and Atmospheric Administration
NMFS - National Marine Fisheries Service
NEASC - New England Atlantic Salmon Committee
NHFG - New Hampshire Fish and Game Department
NHRRTF - New Hampshire River Restoration Task Force
NASCO - North Atlantic Salmon Conservation Organization
NANFH - North Attleboro National Fish Hatchery
NEFSC - Northeast Fisheries Science Center
NUSCO - Northeast Utilities Service Company
PIT - Passive Integrated Transponder
PGE - PG&E National Energy Group
PNFH - Pittsford National Fish Hatchery
PPT - Power Point, Microsoft
PSNH - Public Service of New Hampshire

RIFW - Rhode Island Division of Fish and Wildlife
RCNSS - Richard Cronin National Salmon Station
RRSFH - Roger Reed State Fish Hatchery
RFCS - Roxbury Fish Culture Station
SSSV - Salmon Swimbladder Sarcoma Virus
SOCNFW - Silvio O. Conte National Fish and Wildlife Refuge
SNHHDC - Southern New Hampshire Hydroelectric Development Corp
SOFA - Sunderland Office of Fishery Assistance
TNC - The Nature Conservancy
UMASS - University of Massachusetts / Amherst
USACOE - U.S. Army Corps of Engineers
USASAC - U.S. Atlantic Salmon Assessment Committee
USGen - U.S. Generating Company
USGS - U.S. Geological Survey
USFWS - U.S. Fish and Wildlife Service
USFS - U.S. Forest Service
VTFW - Vermont Fish and Wildlife
WSFH - Warren State Fishery Hatchery
WRNFH - White River National Fish Hatchery
WSS - Whittemore Salmon Station

8.5 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 that have been 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.

Wild Smolt	A wild smolt is an Atlantic salmon which is the product of natural spawning, emerged from a redd and was reared in the river prior to emigrating to the ocean.
Hatchery Smolt	A hatchery smolt is a product of hatchery spawning which has spent nine months (or more) of its life within a hatchery prior to stocking. These include fall parr origin (i.e. fingerlings, parr 8, parr 20, or parr 32), Age 1 and Age 2 smolts. This definition was modified by the 2019 Status Review. See Naturally Reared Smolt below.***
Naturally Reared Smolt	A naturally reared smolt is the product of wild spawning, egg planting, or fry stocking. Currently (March 2020), it is not reasonable to differentiate between wild smolt and a smolt the product of egg planting or fry stocking. Databases prior to 2021 will include fall fingerling or parr stocked fish as naturally-reared.***
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	Hatchery fish released in the period from two years after hatch. Prior to 2000, this stage was a common hatchery product of between 15 and 25 cm and intended to be a functional migratory smolt. Starting in 2009, this age category represents a larger life stage (30 - 50 cm) released for hatchery operational purposes, not as a targeted tool to create searun returns.
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.

****** NOTE: These revised definitions are provisional and may be modified upon review by USASAC and partners at the 2021 meeting.***

Appendix 1. Juvenile Atlantic salmon stocking summary for New England in 2019.

United States

Number of fish stocked by lifestage

River	Egg	Fry	0 Parr	1 Parr	2 Parr	1 Smolt	2 Smolt	Total
Connecticut	0	336,000	0	0	0	0	0	336,000
Total for Connecticut Program								**336,000**
Dennys	0	175,000	10,000	0	0	0	0	185,000
East Machias	0	0	226,000	0	0	0	0	226,000
Kennebec	918,000	0	0	0	0	0	0	918,000
Machias	91,000	183,000	0	0	0	0	100	274,100
Narraguagus	66,000	179,000	0	0	0	95,500	100	340,600
Penobscot	491,000	631,000	92,900	0	0	554,700	0	1,769,600
Pleasant	88,000	132,000	0	0	0	0	0	220,000
Saco	84,000	164,000	0	0	0	0	0	248,000
Sheepscot	215,000	9,000	17,000	0	0	0	0	241,000
Union	0	2,000	0	0	0	0	0	2,000
Total for Maine Program								**4,424,300**
Pawcatuck	0	16,000	0	0	0	0	0	16,000
Total for Pawcatuck Program								**16,000**
Total for United States								**4,776,300**
Grand Total								**4,776,300**

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

*2 Smolt: Hatchery fish released in the period from two years after hatch. Prior to 2000, this stage was a common hatchery product of between 15 and 25 cm and intended to be a functional migratory smolt. Starting in 2009, this age category represents a larger life stage (30 - 50 cm) released for hatchery operational purposes, not as a targeted tool to create searun returns.

Appendix 2. Number of adult Atlantic salmon stocked in New England rivers in2019 .

Drainage	Purpose	Captive/Domestic Pre-Spawn	Captive/Domestic Post-Spawn	Sea Run Pre-Spawn	Sea Run Post-Spawn	Total
Dennys	Restoration	0	264	0	0	264
East Machias	Restoration	0	194	0	0	194
Machias	Restoration	0	251	0	0	251
Merrimack	Restoration/Recreation	1,748	1,117	0	0	2,865
Narraguagus	Restoration	0	253	0	0	253
Penobscot	Restoration	0	958	97	479	1,534
Pleasant	Restoration	0	171	0	0	171
Saco	Restoration	0	49	0	0	49
Sheepscot	Restoration	0	129	0	0	129
Total		1,748	3,386	97	479	5,710

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 2019 .

Marking Agency	Age	Life Stage	H/W	Stock Origin	Primary Mark or Tag	Number Marked	Secondary Mark or Tag	Release Date	Release Location
EMARC	0	0_Parr	H	East Machias	AD	226,347		Oct	East Machias
USFWS	0	0_Parr	H	Sheepscot	AD	17,000		Sep	Sheepscot
USFWS	6	Adult	H	Dennys	PIT	7	DUCP	Nov	Dennys
USFWS	3	Adult	H	Dennys	PIT	65	DUCP	Nov	Dennys
USFWS	5	Adult	H	Dennys	PIT	125	DUCP	Nov	Dennys
USFWS	4	Adult	H	Dennys	PIT	67	DUCP	Nov	Dennys
USFWS	5	Adult	H	East Machias	PIT	93	DUCP	Nov	East Machias
USFWS	3	Adult	H	East Machias	PIT	63	DUCP	Nov	East Machias
USFWS	4	Adult	H	East Machias	PIT	38	DUCP	Nov	East Machias
MEDMR		Adult	W	Kennebec	AD	33		Jun	Kennebec
MEDMR		Adult	W	Kennebec	RAD	25	AP	Jun	Kennebec
MEDMR		Adult	W	Kennebec	UCP	2		Jun	Kennebec
USFWS	3	Adult	H	Machias	PIT	60	DUCP	Dec	Machias
USFWS	3	Adult	H	Machias	PIT	91	DAP	Jun	Machias
USFWS	5	Adult	H	Machias	PIT	108	DUCP	Dec	Machias
USFWS	4	Adult	H	Machias	PIT	83	DUCP	Dec	Machias
USFWS	5	Adult	H	Narraguagus	PIT	84	DUCP	Dec	Narraguagus
USFWS	4	Adult	H	Narraguagus	PIT	47	DUCP	Dec	Narraguagus
USFWS	3	Adult	H	Narraguagus	PIT	122	DUCP	Dec	Narraguagus
USFWS	3	Adult	H	Narraguagus	PIT	99	DAP	Jun	Narraguagus
MEDMR		Adult	W	Penobscot	AD	1		Jun	Penobscot
MEDMR		Adult	W	Penobscot	PIT	576	AP	Dec	Penobscot
MEDMR		Adult	W	Penobscot	PIT	70	AP	Jul	Penobscot
MEDMR		Adult	W	Penobscot	PIT	434	AP	Jun	Penobscot
MEDMR		Adult	W	Penobscot	PIT	1	AP,UCP	Jun	Penobscot

Marking Agency	Age	Life Stage	H/W	Stock Origin	Primary Mark or Tag	Number Marked	Secondary Mark or Tag	Release Date	Release Location
MEDMR		Adult	W	Penobscot	PIT	1	DAP	Jun	Penobscot
MEDMR		Adult	W	Penobscot	RAD	10	AP, PIT	Jul	Penobscot
MEDMR		Adult	W	Penobscot	RAD	50	AP, PIT	Jun	Penobscot
USFWS		Adult	W	Penobscot	FLOY	17	AP, PIT	Aug	Penobscot
USFWS	4	Adult	H	Penobscot	PIT	426	DAP	Dec	Penobscot
USFWS	3	Adult	H	Penobscot	PIT	532	DAP	Dec	Penobscot
USFWS	4	Adult	H	Pleasant	PIT	50	DUCP	Dec	Pleasant
USFWS	3	Adult	H	Pleasant	PIT	48	DUCP	Dec	Pleasant
USFWS	5	Adult	H	Pleasant	PIT	73	DUCP	Dec	Pleasant
USFWS	4	Adult	H	Sheepscot	PIT	41	DUCP	Nov	Sheepscot
USFWS	3	Adult	H	Sheepscot	PIT	27	DUCP	Nov	Sheepscot
USFWS	5	Adult	H	Sheepscot	PIT	61	DUCP	Nov	Sheepscot
MEDMR		Smolt	W	Narraguagus	PIT	114	UC	May	Narraguagus
USFWS	1	smolt	H	Narraguagus	AD	95,496		May	Narraguagus
USFWS	1	smolt	H	Penobscot	AD	23,993		Apr	Penobscot
USGS		Smolt	H	Penobscot	RAD	75		May	Penobscot
USGS		Smolt	H	Penobscot	PING	433		May	Penobscot

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; DAP = Double adipose 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 2019.

Origin	Total External Marks	Total Adipose Clips	Total Marked
Hatchery Adult	2,410	0	2,410
Hatchery Juvenile	362,836	362,836	363,344
Wild Adult	1,159	34	1,220
Wild Juvenile	0	0	114
Total			**367,088**

Appendix 4. Estimates of Atlantic salmon returns to New England in 2019 from trap counts and redd surveys. (N.R. represents naturally reared origin.)

	Assessment Method	1SW Hatchery	1SW N.R.	2SW Hatchery	2SW N.R.	3SW Hatchery	3SW N.R.	Repeat Hatchery	Repeat N.R.	Total	2015-2019 Average
Androscoggin	Trap	0	0	1	0	0	0	0	0	**1**	2
Connecticut	Trap	0	0	0	3	0	0	0	0	**3**	10
Cove Brook	Redd Est	0	0	0	0	0	0	0	0	**0**	0
Dennys	Redd Est	0	3	0	13	0	0	0	0	**16**	14
Ducktrap	Redd Est	0	0	0	0	0	0	0	0	**0**	1
East Machias	Redd Est	7	1	29	3	0	0	0	0	**40**	19
Kenduskeag Stream	Redd Est	0	1	0	5	0	0	0	0	**6**	8
Kennebec	Trap	2	4	1	52	0	0	0	1	**60**	36
Machias	Redd Est	0	6	0	23	0	0	0	0	**29**	18
Merrimack	Trap	0	0	0	0	0	0	0	0	**0**	5
Narraguagus	Redd Est	58	9	18	35	0	1	2	0	**123**	47
Penobscot	Trap	288	7	738	161	2	0	0	0	**1196**	811

	Assessment Method	1SW Hatchery	1SW N.R.	2SW Hatchery	2SW N.R.	3SW Hatchery	3SW N.R.	Repeat Hatchery	Repeat N.R.	Total	2015-2019 Average
Pleasant	Redd Est	0	5	0	21	0	0	0	0	**26**	15
Saco	Trap	0	1	2	1	0	0	0	0	**4**	4
Sheepscot	Redd Est	3	2	11	10	0	0	0	0	**26**	14
Souadabscook Stream	Redd Est	0	1	0	2	0	0	0	0	**3**	4
Union	Trap	0	0	0	2	0	0	0	0	**2**	1
Total		**358**	**40**	**800**	**331**	**2**	**1**	**2**	**1**	**1,535**	**1,009**

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 2019 .

Source River	Origin	Females Spawned	Total Egg Production
Connecticut	Domestic	128	719,000
Merrimack	Domestic	21	56,000
Penobscot	Domestic	647	1,600,000
Narraguagus	Captive	81	312,000
Pleasant	Captive	87	310,000
Sheepscot	Captive	80	217,000
Total Captive/Domestic		**1,044**	**3,214,000**
Penobscot	Sea Run	280	1,960,000
Total Sea Run		**280**	**1,960,000**
Grand Total for Year 2019		**1,324**	**5,174,000**

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															
1993-2009	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															
1977-2009	1,919	20,150,000	7,700	30,119	187,992,000	5,900	0	0		2,310	28,128,000	10,200	34,348	236,269,000	6,300
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
2019	0	0		128	719,000	5,600	0	0		0	0		128	719,000	5,600
Total Connecticut	2,071	21,265,000	7,400	34,144	211,468,000	6,600	0	0		2,395	28,934,000	8,600	38,610	261,666,000	6,700
Dennys															
1939-2009	26	214,000	7,600	38	91,000	2,400	1,299	5,573,000	4,300	40	330,000	7,700	1,403	6,208,000	4,900
2010	0	0		87	596,000	6,900	25	105,000	4,200	0	0		112	701,000	6,300
2011	0	0		0	0		0	0		0	0		0	0	
2012	0	0		0	0		0	0		0	0		0	0	
2013	0	0		0	0		46	111,000	2,400	0	0		46	111,000	2,400

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

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

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

Note: Connecticut data are preliminary prior to 1990.

Year	Sea-Run			Domestic			Captive			Kelt			TOTAL		
	No. females	Egg production	Eggs/ female	No. females	Egg production	Eggs/ female	No. females	Egg production	Eggs/ female	No. females	Egg production	Eggs/ female	No. females	Egg production	Eggs/ female
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	4,063	40	330,000	7,700	1,983	8,776,000	4,500
East Machias															
1995-2009	0	0		0	0		1,231	5,111,000	4,200	0	0		1,231	5,111,000	4,200
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	3,960	0	0		2,012	8,158,000	4,000
Kennebec															
1979-2009	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															
1992-2009	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

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
Machias															
1941-2009	456	3,263,000	7,300	0	0		2,188	9,208,000	4,300	8	52,000	6,400	2,652	12,523,000	5,900
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	3,560	8	52,000	6,400	3,664	16,072,000	3,700
Merrimack															
1983-2009	1,370	10,624,000	8,000	10,923	55,134,000	4,700	0	0		483	5,040,000	10,700	12,776	70,799,000	6,000
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
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
2019	0	0		21	56,000	2,600	0	0		0	0		21	56,000	2,600

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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			Domestic			Captive			Kelt			TOTAL		
	No. females	Egg production	Eggs/ female	No. females	Egg production	Eggs/ female	No. females	Egg production	Eggs/ female	No. females	Egg production	Eggs/ female	No. females	Egg production	Eggs/ female
Total Merrimack	1,582	12,306,000	7,600	13,169	62,838,000	3,600	0	0		540	5,709,000	11,200	15,291	80,853,000	4,200
Narraguagus															
1962-2009	0	1,303,000		0	0		2,255	8,813,000	3,900	0	0		2,255	10,116,000	3,900
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
2019	0	0		0	0		81	312,000	3,900	0	0		81	312,000	3,900
Total Narraguagus	0	1,303,000		0	0	0	3,404	12,908,000	3,700	0	0		3,404	14,211,000	3,700
Orland															
1967-2009	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															
1992-2009	18	152,000	8,300	6	6,000	1,100	0	0		13	76,000	5,400	37	234,000	6,500
2012	2	5,000	2,500	550	2,000	0	0	0		0	0		552	7,000	0
Total Pawcatuck	20	157,000	5,400	556	8,000	600	0	0		13	76,000	5,400	589	241,000	3,200
Penobscot															
1871-2009	19,798	170,007,000	7,900	7,629	21,338,000	2,900	329	1,400,000	4,300	0	0		27,756	192,746,000	7,300
2010	289	2,091,000	7,200	314	1,269,000	4,000	0	0		0	0		603	3,360,000	5,600

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

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

Note: Connecticut data are preliminary prior to 1990.

Year	Sea-Run No. females	Sea-Run Egg production	Sea-Run Eggs/ female	Domestic No. females	Domestic Egg production	Domestic Eggs/ female	Captive No. females	Captive Egg production	Captive Eggs/ female	Kelt No. females	Kelt Egg production	Kelt Eggs/ female	TOTAL No. females	TOTAL Egg production	TOTAL Eggs/ female
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
2019	280	1,960,000	7,000	647	1,600,000	2,500	0	0		0	0		927	3,560,000	3,800
Total Penobscot	22,256	188,363,000	7,500	12,747	36,089,000	2,900	329	1,400,000	4,300	0	0		35,332	225,852,000	4,700
Pleasant															
2001-2009	0	0		17	85,000	5,600	397	1,588,000	4,700	0	0		414	1,674,000	4,800
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
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
2019	0	0		0	0		87	310,000	3,600	0	0		87	310,000	3,600
Total Pleasant	0	0		123	468,000	6,000	1,019	3,802,000	3,736	0	0		1,142	4,271,000	3,900
Sheepscot															

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

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

Note: Connecticut data are preliminary prior to 1990.

Year	Sea-Run			Domestic			Captive			Kelt			TOTAL		
	No. females	Egg production	Eggs/ female	No. females	Egg production	Eggs/ female	No. females	Egg production	Eggs/ female	No. females	Egg production	Eggs/ female	No. females	Egg production	Eggs/ female
1995-2009	18	125,000	6,900	0	0		1,061	4,267,000	3,900	45	438,000	9,900	1,124	4,831,000	4,300
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
2019	0	0		0	0		80	217,000	2,700	0	0		80	217,000	2,700
Total Sheepscot	18	125,000	6,900	0	0	0	1,890	6,657,000	3,100	45	438,000	9,900	1,953	7,221,000	3,100
St Croix															
1993-2009	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															
1974-2009	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	7,400	34,144	211,467,000	6,600	0	0		2,395	28,935,000	8,600	38,610	261,666,000	6,700
Dennys	26	214,000	7,600	212	1,080,000	4,600	1,705	7,152,000	4,100	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	3,700
Merrimack	1,582	12,306,000	7,600	13,169	62,837,000	3,600	0	0		540	5,709,000	11,200	15,291	80,852,000	4,200
Narraguagus	0	1,303,000		0	0		3,404	12,908,000	3,700	0	0		3,404	14,211,000	3,700
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	5,400	589	241,000	3,200
Penobscot	22,256	188,363,000	7,500	12,747	36,088,000	2,900	329	1,400,000	4,300	0	0		35,332	225,851,000	4,700
Pleasant	0	0		123	468,000	6,000	1,019	3,802,000	3,700	0	0		1,142	4,270,000	3,900
Sheepscot	18	125,000	6,900	0	0		1,890	6,657,000	3,100	45	438,000	9,900	1,953	7,221,000	3,200
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	**27,121**	**232,270,000**	**8,600**	**60,951**	**311,948,000**	**5,100**	**13,559**	**52,833,000**	**3,900**	**3,041**	**35,540,000**	**11,700**	**104,672**	**632,593,000**	**6,000**

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								
2001-2009	0	11,000	0	0	0	0	0	11,000
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								
1978-2009	0	4,256,000	317,400	38,600	0	32,600	29,800	4,674,400
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								
1988-2009	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								
1967-2009	0	132,917,000	2,838,200	1,813,400	31,700	3,771,300	1,533,200	142,904,800
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
2019	0	336,000	0	0	0	0	0	336,000
Totals:Connecticut	**0**	**149,907,000**	**2,858,200**	**1,836,700**	**64,700**	**3,771,900**	**1,828,100**	**160,266,600**
Dennys								
1975-2009	0	2,995,000	225,400	7,300	0	532,700	30,000	3,790,400
2010	0	430,000	0	0	0	0	0	430,000
2011	0	539,000	0	0	0	0	0	539,000
2014	0	84,000	0	0	0	0	0	84,000
2015	0	110,000	0	0	0	0	0	110,000

	Number of fish stocked by life stage							
	Egg	**Fry**	**0 Parr**	**1 Parr**	**2 Parr**	**1 Smolt**	**2 Smolt**	**Total**
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
2019	0	175,000	10,000	0	0	0	0	185,000
Totals:Dennys	**0**	**5,036,000**	**235,400**	**7,600**	**0**	**532,700**	**30,400**	**5,842,100**
Ducktrap								
1986-2009	0	68,000	0	0	0	0	0	68,000
Totals:Ducktrap	**0**	**68,000**	**0**	**0**	**0**	**0**	**0**	**68,000**
East Machias								
1973-2009	0	3,183,000	7,500	42,600	0	108,400	30,400	3,371,900
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
2019	0	0	226,000	0	0	0	0	226,000
Totals:East Machias	**0**	**3,796,000**	**1,236,900**	**42,600**	**0**	**108,400**	**30,400**	**5,214,300**
Kennebec								
2001-2009	479000	171,000	0	0	0	200	0	650,416
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
2019	918000	0	0	0	0	0	0	917,614
Totals:Kennebec	**8,102,000**	**331,000**	**0**	**0**	**0**	**800**	**0**	**8,433,009**
Lamprey								
1978-2009	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								
1970-2009	0	5,310,000	99,300	122,400	0	191,300	44,100	5,767,100
2010	0	510,000	0	0	0	0	0	510,000
2011	0	347,000	0	500	0	0	0	347,500
2012	0	231,000	0	1,400	0	0	0	232,400
2013	0	172,000	800	1,400	0	59,100	0	233,300

	Number of fish stocked by life stage							
	Egg	**Fry**	**0 Parr**	**1 Parr**	**2 Parr**	**1 Smolt**	**2 Smolt**	**Total**
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
2019	91000	183,000	0	0	0	0	100	274,100
Totals:Machias	**352,000**	**7,984,000**	**101,000**	**125,700**	**0**	**250,400**	**44,200**	**8,858,167**
Merrimack								
1975-2009	0	38,275,000	236,000	607,700	0	1,799,000	638,100	41,555,800
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								
1970-2009	0	5,080,000	117,100	14,600	0	214,700	84,000	5,510,400
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
2019	66000	179,000	0	0	0	95,500	100	340,600
Totals:Narraguagus	**145,000**	**8,016,000**	**169,900**	**15,000**	**0**	**791,700**	**84,700**	**9,222,445**
Pawcatuck								
1979-2009	0	5,986,000	1,209,200	268,100	0	123,600	500	7,587,400
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
2019	0	16,000	0	0	0	0	0	16,000
Totals:Pawcatuck	**0**	**6,335,000**	**1,209,200**	**268,100**	**0**	**128,700**	**500**	**7,941,500**
Penobscot								

	Number of fish stocked by life stage							
	Egg	**Fry**	**0 Parr**	**1 Parr**	**2 Parr**	**1 Smolt**	**2 Smolt**	**Total**
1970-2009	0	23,032,000	5,588,300	1,394,400	0	15,496,500	2,508,200	48,019,400
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
2019	491000	631,000	92,900	0	0	554,700	0	1,769,263
Totals:Penobscot	**2,700,000**	**31,319,000**	**7,771,900**	**1,394,400**	**0**	**20,911,900**	**2,508,200**	**66,604,902**

Pleasant

1975-2009	0	1,092,000	16,000	1,800	0	63,400	42,400	1,215,600
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
2019	88000	132,000	0	0	0	0	0	220,000
Totals:Pleasant	**383,000**	**2,199,000**	**16,000**	**1,800**	**0**	**246,900**	**42,400**	**2,887,813**

Saco

1975-2009	0	6,191,000	447,800	219,200	0	345,800	9,500	7,213,300
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	356,000	0	0	0	0	0	426,300
2019	84000	164,000	0	0	0	0	0	248,192
Totals:Saco	**242,000**	**9,524,000**	**518,900**	**232,000**	**0**	**444,100**	**9,500**	**10,970,810**

Sheepscot

1971-2009	18000	3,011,000	163,800	20,600	0	92,200	7,100	3,312,500
2010	9000	114,000	14,500	0	0	0	0	137,500
2011	0	129,000	15,000	0	0	0	0	144,000
2012	70000	50,000	15,700	0	0	0	0	136,069
2013	122000	18,000	14,000	0	0	0	0	154,476
2014	118000	23,000	15,000	0	0	0	0	155,668
2015	118000	19,000	14,200	0	0	0	0	150,868

	Number of fish stocked by life stage							
	Egg	Fry	0 Parr	1 Parr	2 Parr	1 Smolt	2 Smolt	Total
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
2019	215000	9,000	17,000	0	0	0	0	241,000
Totals:Sheepscot	**1,381,000**	**3,434,000**	**313,100**	**20,600**	**0**	**92,200**	**7,100**	**5,248,210**
St Croix								
1981-2009	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								
1971-2009	0	513,000	371,400	0	0	379,700	251,000	1,515,100
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
2019	0	2,000	0	0	0	0	0	2,000
Totals:Union	**0**	**656,000**	**371,400**	**0**	**0**	**379,900**	**251,000**	**1,658,300**
Upper StJohn								
1979-2009	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	149,906,000	2,858,200	1,836,700	64,800	3,771,900	1,828,200	**160,200,700**
Dennys	0	5,036,000	235,400	7,600	0	532,800	30,400	**5,842,400**
Ducktrap	0	68,000	0	0	0	0	0	**68,000**
East Machias	0	3,795,000	1,236,800	42,600	0	108,400	30,400	**5,213,000**
Kennebec	8,101,000	331,000	0	0	0	900	0	**8,433,300**
Lamprey	0	1,593,000	427,700	58,800	0	201,400	32,800	**2,313,700**
Machias	353,000	7,985,000	100,900	125,600	0	250,400	44,200	**8,858,800**
Merrimack	0	41,797,000	431,700	658,100	0	1,981,400	638,300	**45,506,500**
Narraguagus	145,000	8,017,000	169,900	15,000	0	791,900	84,700	**9,223,400**
Pawcatuck	0	6,334,000	1,209,200	268,100	0	128,700	500	**7,941,000**
Penobscot	2,700,000	31,318,000	7,772,000	1,394,400	0	20,911,800	2,508,200	**66,603,700**
Pleasant	382,000	2,199,000	16,000	1,800	0	247,000	42,400	**2,888,300**
Saco	242,000	9,523,000	518,800	232,000	0	444,000	9,500	**10,970,000**
Sheepscot	1,381,000	3,435,000	313,100	20,600	0	92,200	7,100	**5,248,800**
St Croix	0	1,270,000	498,000	158,300	0	808,000	20,100	**2,754,200**
Union	0	655,000	371,400	0	0	379,900	251,000	**1,657,200**
Upper StJohn	0	2,165,000	1,456,700	14,700	0	5,100	27,700	**3,669,200**
TOTALS	**284,306,000**	**17,983,300**	**4,883,400**	**64,800**	**30,694,200**	**5,585,200**		**356,756,100**

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 naturally reared origin include adults produced from natural reproduction, egg planting, and fry releases.

	HATCHERY ORIGIN				NATURALLY REARED ORIGIN				
	1SW	2SW	3SW	Repeat	1SW	2SW	3SW	Repeat	Total
Androscoggin									
1983-2009	53	567	6	2	9	90	0	1	**728**
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**
2019	0	1	0	0	0	0	0	0	**1**
Total for Androscoggin	57	603	0	2	10	116	0	0	**795**
Cocheco									
1992-2009	0	0	1	1	6	10	0	0	**18**
Total for Cocheco	0	0	0	1	6	10	0	0	**18**
Connecticut									
1974-2009	56	3,587	28	2	99	2,072	14	3	**5,861**
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**
2019	0	0	0	0	0	3	0	0	**3**
Total for Connecticut	58	3,612	16	2	140	2394	16	16	**6,253**
Cove Brook									
2018	0	0	0	0	0	0	0	0	**0**

	HATCHERY ORIGIN				NATURALLY REARED ORIGIN				
	1SW	2SW	3SW	Repeat	1SW	2SW	3SW	Repeat	Total
2019	0	0	0	0	0	0	0	0	**0**
Total for Cove Brook	0	0	0	0	0	0	0	0	**0**
Dennys									
1967-2009	41	348	0	1	75	901	5	35	**1,406**
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**
2019	0	0	0	0	3	13	0	0	**16**
Total for Dennys	42	350	6	1	90	965	6	6	**1,489**
Ducktrap									
1985-2009	0	0	0	0	57	249	0	0	**306**
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**
2019	0	0	0	0	0	0	0	0	**0**
Total for Ducktrap	0	0	0	0	62	274	0	0	**336**
East Machias									
1967-2009	22	254	1	2	65	539	1	10	**894**
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**
2019	7	29	0	0	1	3	0	0	**40**
Total for East Machias	36	314	1	2	83	613	1	1	**1,060**
Kenduskeag Stream									

	HATCHERY ORIGIN				NATURALLY REARED ORIGIN				
	1SW	2SW	3SW	Repeat	1SW	2SW	3SW	Repeat	Total
2017	0	0	0	0	2	7	0	0	**9**
2019	0	0	0	0	1	5	0	0	**6**
Total for Kenduskeag Stream	0	0	0	0	3	12	0	0	**15**
Kennebec									
1975-2009	24	231	6	7	6	27	0	0	**301**
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**
2019	2	1	0	0	4	52	0	1	**60**
Total for Kennebec	26	262	2	7	26	252	2	2	**582**
Lamprey									
1979-2009	10	17	1	0	13	16	0	0	**57**
Total for Lamprey	10	17	0	0	13	16	0	0	**57**
Machias									
1967-2009	40	363	9	2	133	1,995	41	131	**2,714**
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**
2019	0	0	0	0	6	23	0	0	**29**
Total for Machias	43	374	41	2	173	2157	41	41	**2,930**
Merrimack									
1982-2009	342	1,470	24	8	134	1,068	30	0	**3,076**
2010	29	40	0	0	7	7	1	0	**84**

	HATCHERY ORIGIN				NATURALLY REARED ORIGIN				
	1SW	**2SW**	**3SW**	**Repeat**	**1SW**	**2SW**	**3SW**	**Repeat**	**Total**
2011	128	155	12	1	11	90	5	0	**402**
2012	0	81	15	0	1	27	3	0	**127**
2013	0	6	0	3	0	12	0	0	**21**
2014	4	25	1	0	0	10	0	0	**40**
2015	0	8	1	0	0	3	1	0	**13**
2016	1	1	0	0	0	3	0	0	**5**
2017	0	0	0	0	1	4	0	0	**5**
2018	0	2	0	0	0	0	0	0	**2**
2019	0	0	0	0	0	0	0	0	**0**
Total for Merrimack	504	1,788	40	12	154	1224	40	40	**3,775**
Narraguagus									
1967-2009	105	654	19	56	111	2,543	72	165	**3,725**
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**
2019	58	18	0	2	9	35	1	0	**123**
Total for Narraguagus	300	888	74	60	151	2679	74	74	**4,353**
Pawcatuck									
1982-2009	2	150	1	0	1	17	1	0	**172**
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									
1968-2009	12,194	47,393	290	714	761	3,996	36	99	**65,483**
2010	409	819	0	11	23	53	0	0	**1,315**

	HATCHERY ORIGIN				NATURALLY REARED 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**
2019	288	738	2	0	7	161	0	0	**1,196**
Total for Penobscot	14,626	53,731	37	746	888	4789	37	37	**75,244**
Pleasant									
1967-2009	11	33	0	0	41	329	3	2	**419**
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**
2019	0	0	0	0	5	21	0	0	**26**
Total for Pleasant	21	76	3	0	59	400	3	3	**561**
Saco									
1985-2009	141	649	5	7	36	97	6	0	**941**
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**
2019	0	2	0	0	1	1	0	0	**4**
Total for Saco	183	716	6	7	53	125	6	6	**1,095**
Sheepscot									

	HATCHERY ORIGIN				NATURALLY REARED ORIGIN				
	1SW	2SW	3SW	Repeat	1SW	2SW	3SW	Repeat	Total
1967-2009	15	60	0	0	66	472	13	0	**626**
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**
2019	3	11	0	0	2	10	0	0	**26**
Total for Sheepscot	34	136	13	0	81	528	13	13	**792**
Souadabscook Stream									
2017	0	0	0	0	1	3	0	0	**4**
2019	0	0	0	0	1	2	0	0	**3**
Total for Souadabscook Stream	0	0	0	0	2	5	0	0	**7**
St Croix									
1981-2009	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									
1973-2009	274	1,841	9	28	1	16	0	0	**2,169**
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**
2019	0	0	0	0	0	2	0	0	**2**
Total for Union	274	1,842	0	28	1	20	0	0	**2,174**

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				NATURALLY REARED ORIGIN				
	1SW	**2SW**	**3SW**	**Repeat**	**1SW**	**2SW**	**3SW**	**Repeat**	**Total**
Androscoggin	57	603	6	2	10	116	0	1	**795**
Cocheco	0	0	1	1	6	10	0	0	**18**
Connecticut	58	3,612	28	2	140	2,394	16	3	**6,253**
Cove Brook	0	0	0	0	0	0	0	0	**0**
Dennys	42	350	0	1	90	965	6	35	**1,489**
Ducktrap	0	0	0	0	62	274	0	0	**336**
East Machias	36	314	1	2	83	613	1	10	**1,060**
Kenduskeag Stream	0	0	0	0	3	12	0	0	**15**
Kennebec	26	262	6	7	26	252	2	1	**582**
Lamprey	10	17	1	0	13	16	0	0	**57**
Machias	43	374	9	2	173	2,157	41	131	**2,930**
Merrimack	504	1,788	53	12	154	1,224	40	0	**3,775**
Narraguagus	300	888	25	60	151	2,679	74	176	**4,353**
Pawcatuck	2	151	1	0	1	25	1	0	**181**
Penobscot	14,626	53,731	324	746	888	4,789	37	103	**75,244**
Pleasant	21	76	0	0	59	400	3	2	**561**
Saco	183	716	5	7	53	125	6	0	**1,095**
Sheepscot	34	136	0	0	81	528	13	0	**792**
Souadabscook Stream	0	0	0	0	2	5	0	0	**7**
St Croix	720	1,124	39	12	880	1,340	78	34	**4,227**
Union	274	1,842	9	28	1	20	0	0	**2,174**

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 (%)										Age (years) dist'n (%)				
				1.1	1.2	1.3	2.1	2.2	2.3	3.1	3.2	3.3	4.2	2	3	4	5	6
1974	2	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1975	3	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1976	3	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	5	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	5	7	1.400	0	0	0	0	100	0	0	0	0	0	0	0	100	0	0
1979	2	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1980	9	18	2.022	0	0	0	0	100	0	0	0	0	0	0	0	100	0	0
1981	15	19	1.261	0	0	0	11	89	0	0	0	0	0	0	11	89	0	0
1982	13	31	2.429	0	0	0	0	90	10	0	0	0	0	0	0	90	10	0
1983	7	1	0.143	0	100	0	0	0	0	0	0	0	0	0	100	0	0	0
1984	46	1	0.022	0	0	0	0	0	100	0	0	0	0	0	0	0	100	0
1985	29	35	1.224	0	0	0	0	100	0	0	0	0	0	0	0	100	0	0
1986	10	27	2.791	0	0	0	4	96	0	0	0	0	0	0	4	96	0	0
1987	98	44	0.449	0	16	0	0	68	2	0	14	0	0	0	16	68	16	0
1988	93	92	0.992	0	0	0	0	97	1	0	2	0	0	0	0	97	3	0
1989	75	47	0.629	0	6	0	6	85	0	0	2	0	0	0	12	85	2	0
1990	76	53	0.693	0	13	0	0	87	0	0	0	0	0	0	13	87	0	0
1991	98	25	0.255	0	20	0	0	64	0	0	16	0	0	0	20	64	16	0
1992	93	84	0.904	0	1	0	0	85	1	0	13	0	0	0	1	85	14	0
1993	261	94	0.361	0	0	0	2	87	0	0	11	0	0	0	2	87	11	0
1994	393	197	0.502	0	0	0	1	93	0	0	6	0	0	0	1	93	6	0

Means includes year classes with complete return data (year classes of 2014 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	0	0	100	0	0
Total	**10,161**	**1,704**																
Mean			**0.452**	**0**	**8**	**0**	**3**	**70**	**3**	**0**	**3**	**0**	**0**	**0**	**11**	**70**	**6**	**0**

Means includes year classes with complete return data (year classes of 2014 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 (%) 1.1	1.2	1.3	2.1	2.2	2.3	3.1	3.2	3.3	4.2	Age (years) dist'n (%) 2	3	4	5	6
1974	2	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1975	3	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1976	3	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	5	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	5	7	1.400	0	0	0	0	100	0	0	0	0	0	0	0	100	0	0
1979	5	3	0.561	0	100	0	0	0	0	0	0	0	0	0	100	0	0	0
1980	29	18	0.630	0	0	0	0	100	0	0	0	0	0	0	0	100	0	0
1981	17	19	1.129	0	0	0	11	89	0	0	0	0	0	0	11	89	0	0
1982	29	46	1.565	0	0	0	0	89	11	0	0	0	0	0	0	89	11	0
1983	19	2	0.108	0	100	0	0	0	0	0	0	0	0	0	100	0	0	0
1984	58	3	0.051	0	0	0	0	33	33	0	33	0	0	0	0	33	66	0
1985	42	47	1.113	0	0	0	0	100	0	0	0	0	0	0	0	100	0	0
1986	18	28	1.592	0	0	0	4	96	0	0	0	0	0	0	4	96	0	0
1987	117	51	0.436	0	18	0	0	67	2	0	14	0	0	0	18	67	16	0
1988	131	108	0.825	0	0	0	0	97	1	0	2	0	0	0	0	97	3	0
1989	124	67	0.539	0	22	0	7	69	0	0	1	0	0	0	29	69	1	0
1990	135	68	0.505	0	19	0	0	79	0	0	1	0	0	0	19	79	1	0
1991	221	35	0.159	0	17	0	0	63	0	0	20	0	0	0	17	63	20	0
1992	201	118	0.587	0	5	0	0	82	1	0	12	0	0	0	5	82	13	0
1993	415	185	0.446	0	4	0	3	87	0	0	6	0	0	0	7	87	6	0
1994	598	294	0.492	0	5	0	2	88	0	0	5	0	0	0	7	88	5	0

Means includes year classes with complete return data (year classes of 2014 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	0	0	5	0	95	0	0
2014	20	2	0.101	0	0	0	0	100	0	0	0			0	0	100	0	
2015	39	3	0.077	0	0	0	0	100		0				0	0	100		
2016	6	0	0.000	0	0		0							0	0			
2017	19	0	0.000	0										0				
Total	**14,924**	**2,550**																
Mean			**0.357**	**0**	**12**	**0**	**4**	**68**	**2**	**0**	**4**	**0**	**0**	**0**	**16**	**68**	**6**	**0**

Means includes year classes with complete return data (year classes of 2014 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 2014 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	0	0	100	0	0
2014	12	0	0.000	0	0	0	0	0	0	0	0			0	0	0	0	
2015	27	0	0.000	0	0	0	0	0		0				0	0	0		
2016	4	0	0.000	0	0		0							0	0			
2017	11	0	0.000	0										0				
Total	**2,415**	**376**																
Mean			**0.242**	**0**	**21**	**0**	**4**	**56**	**0**	**0**	**6**	**0**	**0**	**0**	**25**	**57**	**7**	**0**

Means includes year classes with complete return data (year classes of 2014 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 2014 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	0	0	100	0	0
2014	1	1	0.800	0	0	0	100	0	0	0	0			0	100	0	0	
2015	0	0	0.000	0	0	0	0	0		0				0	0	0		
2016	0	0	0.000	0	0		0							0	0			
2017	0	0	0.000	0										0				
Total	**4,183**	**1,418**																
Mean			**1.944**	**0**	**3**	**0**	**9**	**66**	**4**	**2**	**8**	**0**	**0**	**0**	**12**	**68**	**12**	**1**

Means includes year classes with complete return data (year classes of 2014 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 .

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 2014 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	0	0	0
2014	0	0	0.000	0	0	0	0	0	0	0	0			0	0	0	0	
2015	1	0	0.000	0	0	0	0	0		0				0	0	0		
2016	1	0	0.000	0	0		0							0	0			
2017	0	0	0.000	0										0				
Total	**633**	**27**																
Mean			**0.115**	**0**	**3**	**1**	**1**	**31**	**0**	**0**	**4**	**0**	**0**	**0**	**4**	**32**	**4**	**0**

Means includes year classes with complete return data (year classes of 2014 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 2014 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	0	0	100	0	0
2014	8	0	0.000	0	0	0	0	0	0	0	0			0	0	0	0	
2015	12	0	0.000	0	0	0	0	0		0				0	0	0		
2016	2	0	0.000	0	0		0							0	0			
2017	7	0	0.000	0										0				
Total	**572**	**122**																
Mean			**0.220**	**0**	**17**	**0**	**5**	**60**	**0**	**0**	**0**	**0**	**0**	**0**	**22**	**60**	**0**	**0**

Means includes year classes with complete return data (year classes of 2014 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 2014 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	0	0	100	0	0
Total	**1,717**	**320**																
Mean			**0.174**	**4**	**4**	**0**	**8**	**72**	**3**	**0**	**6**	**0**	**0**	**4**	**12**	**72**	**9**	**0**

Means includes year classes with complete return data (year classes of 2014 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 2014 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	0	0	11	83	6	0
2014	82	61	0.748	0	0	0	15	66	0	8	11			0	15	74	11	
2015	52	169	3.265	0	1	0	6	91		2				0	7	93		
2016	102	3	0.029	0	0		100							0	100			
2017	41	0	0.000	0										0				
Total	**2,942**	**5,237**																
Mean			**4.574**	**0**	**0**	**0**	**16**	**73**	**1**	**3**	**8**	**0**	**0**	**0**	**16**	**76**	**9**	**0**

Means includes year classes with complete return data (year classes of 2014 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		0.748
2015	0.000	0.000	0.077		0.000	0.000		3.265
2016	0.000	0.000	0.000		0.000	0.000		0.029
2017	0.000	0.000	0.000		0.000	0.000		0.000
Mean	**1.986**	**0.120**	**0.363**	**0.459**	**0.227**	**0.248**	**0.179**	**4.686**
StDev	**5.091**	**0.389**	**0.446**	**0.692**	**0.256**	**0.299**	**0.170**	**6.285**

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	4	76	2	0	4	0	0	0	17	77	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	12	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**	**74**	**2**	**1**	**6**	**0**	**0**	**1**	**18**	**74**	**8**	**0**

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

Appendix 15: Estimates of Atlantic salmon escapement to Maine rivers in 2019.

Natural escapement represents the salmon left to freely swim in a river and is equal to the estimated returns, minus those taken for hatchery 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	16	0	0	16	0	0	16
Ducktrap	0	0	0	0	0	0	0
East Machias	40	0	0	40	0	0	40
Kenduskeag St	6	0	0	6	0	0	6
Kennebec	60	0	0	60	0	0	60
Machias	29	0	0	29	0	0	29
Narraguagus	123	0	3	120	0	0	120
Penobscot	1,196	599	1	596	0	97	693
Pleasant	26	0	0	26	0	0	26
Saco	4	0	0	4	0	0	4
Sheepscot	26	0	0	26	0	0	26
Souadabscook	3	0	0	3	0	0	3
Union	2	0	0	2	0	0	2
Totals	**1532**	**599**	**4**	**929**	**0**	**97**	**1026**

Appendix 16: Estimates of Atlantic salmon escapment to Maine rivers.

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	**Year**	**Estimated Returns**	**Broodstock Take**	**Observed Mortalities**	**Natural Escapement**	**Captive/ Domestic**	**Sea Run**	**Total Escapement**
Androscoggin	**1983 - 2009**	**728**	**0**	**0**	**728**	**0**	**0**	**728**
	2010	**9**	**0**	**0**	**9**	**0**	**0**	**9**
	2011	**44**	**0**	**0**	**44**	**0**	**0**	**44**
	2012	**0**	**0**	**0**	**0**	**0**	**0**	**0**
	2013	**2**	**0**	**0**	**2**	**0**	**0**	**2**
	2014	**3**	**0**	**0**	**3**	**0**	**0**	**3**
	2015	**1**	**0**	**0**	**1**	**0**	**0**	**1**
	2016	**6**	**0**	**0**	**6**	**0**	**0**	**6**
	2017	**0**	**0**	**0**	**0**	**0**	**0**	**0**
	2018	**1**	**0**	**0**	**1**	**0**	**0**	**1**
	2019	**1**	**0**	**0**	**1**	**0**	**0**	**1**
Cove Brook	**2018**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
	2019	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Dennys	**1967 - 2009**	**1406**	**0**	**5**	**1401**	**0**	**0**	**1401**
	2010	**6**	**0**	**0**	**6**	**0**	**0**	**6**
	2011	**9**	**0**	**0**	**9**	**299**	**0**	**308**
	2015	**19**	**0**	**0**	**19**	**0**	**0**	**19**
	2016	**11**	**0**	**0**	**11**	**0**	**0**	**11**
	2017	**15**	**0**	**0**	**15**	**297**	**0**	**312**
	2018	**7**	**0**	**0**	**7**	**39**	**0**	**46**
	2019	**16**	**0**	**0**	**16**	**0**	**0**	**16**
Ducktrap	**1985 - 2009**	**306**	**0**	**0**	**306**	**0**	**0**	**306**
	2010	**12**	**0**	**0**	**12**	**0**	**0**	**12**
	2013	**7**	**0**	**0**	**7**	**0**	**0**	**7**
	2014	**7**	**0**	**0**	**7**	**0**	**0**	**7**
	2017	**4**	**0**	**0**	**4**	**0**	**0**	**4**

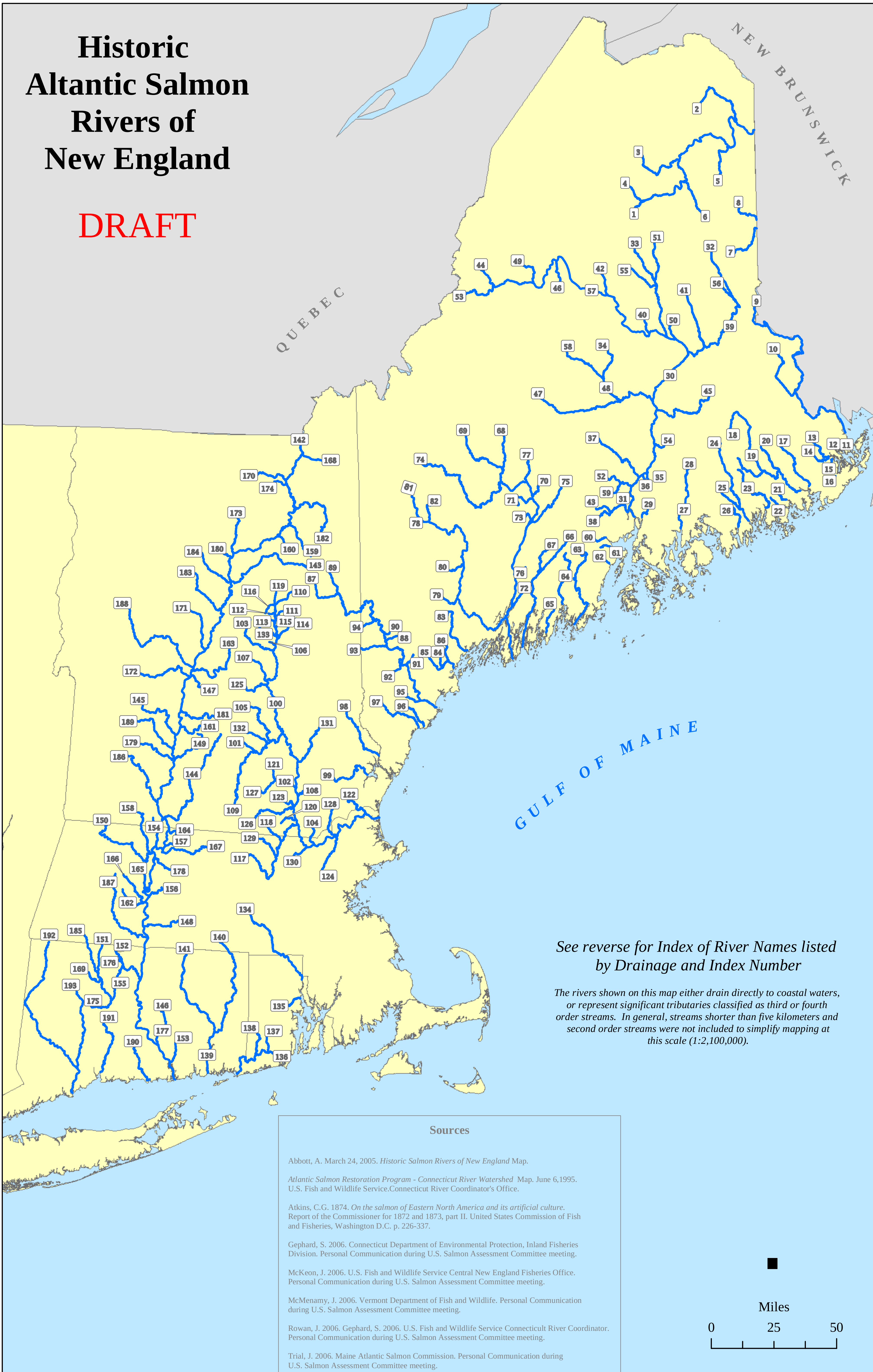
Drainage	Year	Estimated Returns	Broodstock Take	Observed Mortalities	Natural Escapement	Pre-Spawn Stocking Captive/ Domestic	Pre-Spawn Stocking Sea Run	Total Escapement
Ducktrap	2018	0	0	0	0	0	0	0
	2019	0	0	0	0	0	0	0
East Machias	1967 - 2009	894	0	0	894	241	0	1135
	2010	7	0	0	7	40	0	47
	2011	25	0	0	25	41	0	66
	2012	11	0	0	11	52	0	63
	2013	11	0	0	11	0	0	11
	2014	19	0	0	19	0	0	19
	2015	14	0	0	14	0	0	14
	2016	16	0	0	16	0	0	16
	2017	9	0	0	9	0	0	9
	2018	14	0	0	14	64	0	78
	2019	40	0	0	40	0	0	40
Kenduskeag Stream	2017	9	0	0	9	0	0	9
	2019	6	0	0	6	0	0	6
Kennebec	1975 - 2009	301	0	7	294	106	0	400
	2010	5	0	0	5	0	0	5
	2011	64	0	0	64	90	0	154
	2012	5	0	0	5	0	0	5
	2013	8	0	0	8	0	0	8
	2014	18	0	0	18	0	0	18
	2015	31	0	0	31	0	0	31
	2016	39	0	0	39	0	0	39
	2017	40	0	0	40	0	0	40
	2018	11	0	0	11	0	0	11
	2019	60	0	0	60	0	0	60
Machias	1967 - 2009	2714	0	0	2714	261	0	2975
	2010	27	0	0	27	0	0	27
	2011	52	0	0	52	109	0	161
	2012	29	0	0	29	81	0	110
	2013	4	0	0	4	0	0	4
	2014	15	0	0	15	0	0	15
	2015	20	0	0	20	0	0	20
	2016	17	0	0	17	0	0	17

Drainage	Year	Estimated Returns	Broodstock Take	Observed Mortalities	Natural Escapement	Pre-Spawn Stocking Captive/ Domestic	Pre-Spawn Stocking Sea Run	Total Escapement
Machias	2017	14	0	0	14	0	0	14
	2018	9	0	0	9	136	0	145
	2019	29	0	0	29	0	0	29
Narraguagus	1967 - 2009	3725	0	1	3724	0	0	3724
	2010	76	0	0	76	0	0	76
	2011	196	0	0	196	0	0	196
	2012	45	0	0	45	0	0	45
	2013	49	0	0	49	0	0	49
	2014	25	0	0	25	0	0	25
	2015	27	0	0	27	0	0	27
	2016	9	0	0	9	0	0	9
	2017	36	0	0	36	466	0	502
	2018	42	0	0	42	40	0	82
	2019	123	0	3	120	0	0	120
Penobscot	1968 - 2009	65483	16305	209	48969	0	104	49073
	2010	1315	700	1	614	0	129	743
	2011	3125	737	7	2381	0	177	2558
	2012	624	481	0	143	0	7	150
	2013	381	372	0	9	0	0	9
	2014	261	214	2	45	0	0	45
	2015	731	660	5	66	741	7	814
	2016	507	293	4	210	489	0	699
	2017	849	532	3	314	0	12	326
	2018	772	457	2	313	0	2	315
	2019	1196	599	1	596	0	97	693
Pleasant	1967 - 2009	419	0	0	419	0	0	419
	2010	9	0	0	9	0	0	9
	2011	23	0	0	23	0	0	23
	2012	14	0	0	14	56	0	70
	2013	31	0	0	31	0	0	31
	2014	4	0	0	4	0	0	4
	2015	26	0	0	26	0	0	26
	2017	9	0	0	9	0	0	9
	2018	0	0	0	0	0	0	0

Drainage	Year	Estimated Returns	Broodstock Take	Observed Mortalities	Natural Escapement	Pre-Spawn Stocking Captive/ Domestic	Pre-Spawn Stocking Sea Run	Total Escapement
Pleasant	2019	26	0	0	26	0	0	26
Saco	1985 - 2009	941	0	5	936	0	0	936
	2010	20	0	0	20	0	0	20
	2011	94	0	0	94	0	0	94
	2012	12	0	0	12	0	0	12
	2013	3	0	0	3	0	0	3
	2014	3	0	0	3	0	0	3
	2015	5	0	0	5	0	0	5
	2016	2	0	0	2	0	0	2
	2017	8	0	0	8	0	0	8
	2018	3	0	0	3	0	0	3
	2019	4	0	0	4	0	0	4
Sheepscot	1967 - 2009	626	0	0	626	216	0	842
	2010	24	0	0	24	86	0	110
	2011	19	0	0	19	0	0	19
	2012	16	0	0	16	35	0	51
	2013	10	0	0	10	0	0	10
	2014	25	0	0	25	0	0	25
	2015	12	0	0	12	0	0	12
	2016	9	0	0	9	0	0	9
	2017	19	0	0	19	0	0	19
	2018	6	0	0	6	63	0	69
	2019	26	0	0	26	0	0	26
Souadabscook Stream	2017	4	0	0	4	0	0	4
	2019	3	0	0	3	0	0	3
St Croix	1981 - 2009	4227	0	0	4227	0	0	4227
Union	1973 - 2009	2169	0	32	2137	0	0	2137
	2010	0	0	0	0	0	0	0
	2013	1	0	0	1	0	0	1
	2014	2	0	0	2	0	0	2
	2017	0	0	0	0	0	0	0
	2018	0	0	0	0	0	0	0
	2019	2	0	0	2	0	0	2

Historic Altantic Salmon Rivers of New England

DRAFT



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

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

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