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U.S. ATLANTIC SALMON ASSESSMENT COMMITTEE

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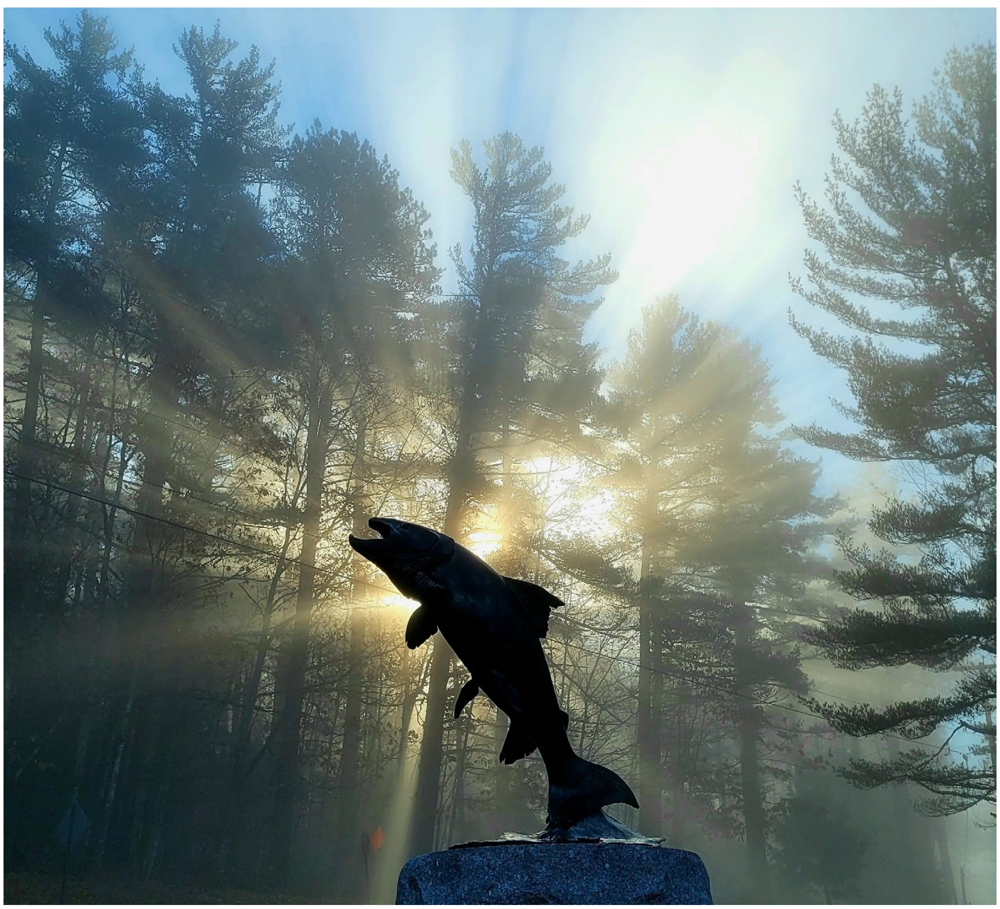

“The Leaper” by sculptor G. Motycka, photo credit by D. Buckley

PREPARED FOR
U.S. SECTION TO NASCO

The United States Atlantic Salmon Program and Assessment Committee suffered significant loss within the past year. We dedicate this report to our colleagues and friends:

Dr. Joan G. Trial of Maine Atlantic salmon program, passed away unexpectedly March 5, after a brief illness. Joan played a big role in fisheries management and research in Maine, ranging from local brook trout management to the international stage of ICES North Atlantic Salmon Working Group. She was a trailblazer for women in fisheries in Maine and an essential part of this committee from 2000 to her retirement in 2013. At the time of her death, she was working with Project SHARE to coordinate assessment work related to Atlantic salmon habitat rehabilitation. She was still mentoring graduate students and overall staying active. The fisheries community lost a remarkable person with a passion for Atlantic salmon and their ecosystems.

Robert A. "Bob" Jones of Connecticut Atlantic salmon program, passed away at age 92 on March 31. Bob served as head of the Connecticut Fisheries Division and later Fish and Wildlife from 1979 until 1992. He was a strong supporter of Atlantic salmon restoration and conservation. He helped launch the Connecticut River program and personally dealt with Maine biologists such as Al Meister to bring eggs to the Connecticut River. He served on the Connecticut River Atlantic Salmon Commission as well as the New England Fisheries Management Council, and Atlantic States Marine Fisheries Commission and led the transformation of his agency into a modern natural resource agency. In retirement he served as president of the Connecticut River Salmon Association and as a non-federal Commissioner to NASCO. Bob was a friend and mentor to a whole generation of biologists and his impact will persist for many years in the Atlantic salmon world and beyond.

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1 Executive Summary

1.1 Abstract

Total returns to USA rivers in 2022 was 1,529 salmon; this is the sum of documented returns to traps and returns estimated by redd counts. Returns to the USA ranks 17th out of the 32-year time series (1991-2022) and 28th out of the full 56-year time series (1967-2022). Most returns (1520; 99.4%) were to the Gulf of Maine Distinct Population Segment (GoM DPS), which includes the Penobscot River, Kennebec River, Sheepscot River and Eastern Maine coastal rivers with only 9 returns documented outside of the GoM DPS. Documented returns to traps totaled 1,447 and returns estimated by redd counts were 73 adult salmon. Overall, 24.5% of the adult returns to the USA were 1SW salmon, 74.6% were 2SW salmon and 0.9% were 3SW or repeat spawners. Most (85.3%) returns were of hatchery smolt origin and the balance (14.7%) originated from either natural reproduction, hatchery fry, or planted eggs. A total of approximately 3,941,537 juvenile salmon (eggs, hatchery fry, parr, and 1 smolt), and 2,832 adults were stocked into U.S. rivers. Atlantic salmon at various origins and life-stages had marks applied during the year, with a total of 130,589 marks administered in 2022. In 2021, eggs for USA hatchery programs were taken from a total of 1,370 females consisting of 77 sea-run females and 1,293 captive/domestic and domestic females. Total egg take (5,266,000). The 2022 estimates are not currently available (late spawn year), but will be reported in 2023.

1.2 Adult Returns to USA Rivers

Total returns to USA rivers was 1,529 (Table 1.2.1), which is a significant increase from 2021 (680, Table 1.2.2). Returns are reported for three distinct population segments (Figure 1.2.1): Long Island Sound (LIS, 4 total returns), Central New England (CNE, 5 total returns), and Gulf of Maine (GOM, 1,520 total returns). The ratio of sea ages for fish sampled at traps and weirs was used to prorate the number of spawners by sea age for the adults estimated via the redd counts conducted in 2022. Overall, the majority of the 1,529 adult returns to USA (documented and pro-rated) were 2SW (1,141 = 74.6%), with 1SW (375 = 24.5%), 3SW (8 = 0.5%) and repeat spawners (5 = 0.3%) making up the remainder of the total (Table 1.2.2). The percentage of 2SW returns in 2022 (74.6%) was similar to the 10-year average of 74.7%. Most (85.3%) returns were hatchery smolt origin, with the remainder (14.7%) natural origin. Age and origin of returns in 2022 were consistent with historical numbers with 2SW salmon making up the largest proportion for both origins (Figure 1.2.2).

In the U.S., returns were well below conservation spawner requirements (i.e. conservation limit; CL). Returns to monitored rivers represented only 5.2% of the USA CL in these 14 populations. In monitored populations, the Kennebec River ranked the highest at 76.1% of CL followed by the Pleasant (23.6%) and Penobscot (14.9%; Table 1.2.3). It should be noted that the U.S. 2SW conservation limits were first reported by Baum (1995) and represents accessible habitat only. For this Kennebec River, only a small amount of habitat was accessible in 1995 and therefore the CL was estimated at 67 2SW spawners. In recent years a significant restoration activities involving trucking pre-spawned adult salmon captured at the lowermost main-stem dam in addition to egg planting activities has resulted in modest number of spawning being located within the Sandy River, a tributary to the Kennebec. The habitat present with the Sandy River is not considered within the estimated CL for the Kennebec, which is why the percent CL achieved is so high for this system. Given situations like this and other evolving management activities and priorities, the U.S. is working to update our CLs based on the best available information and these updated CLs will be used to track attainment of CLs in the future.

Marine return rate estimates are calculated based on known smolt migrants (estimated populations of naturally reared, or hatchery stocked) and corresponding adult returns. The return rate for Penobscot River hatchery origin smolts until 2020 used total smolts stocked and subsequent adult returns by sea age to generate a smolt-to-adult return rate (SAR). Beginning in 2022, the time series was revised by using the method proposed by Stevens et al. (2019) to decouple losses of smolts in the river and the estuary to provide an estimate of postsmolts entering the Gulf of Maine. This method accounted for stocking location and subsequent natural mortality in the riverine and estuarine environments and flow-specific mortality related to dam passage. This postsmolt estimate was then compared to subsequent adult returns to calculate a postsmolt to adult return rate (PSAR). The US Atlantic Salmon Assessment Committee (USASAC) discussed the approach and agreed it would provide a better estimate of marine return rate by eliminating the impact of stocking location, dams and other river/estuary impacts.

Two sea-winter PSAR rates for Penobscot River smolts from the 2020 equaled 0.17% (PSAR) which was an increase from the 2019 estimate (0.06%). SAR estimates are not available if smolt population estimates were not generated one (1SW SAR) or two (2SW SAR) years prior. (Figure 1.2.3 and Table 1.2.4).

1.3 Description of Fisheries and By-catch in USA Waters

Atlantic salmon (*Salmo salar*), are not subject to a fishery management plan review by the National Marine Fisheries Service because the current plan prohibits their possession and any directed fishery or incidental (bycatch) in federal waters. Similar prohibitions exist in state waters. Atlantic salmon found in USA waters of the Northeast Shelf could be from four 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 USA 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 (Wigley and Tholke 2020) and we present a summary of all occurrences from 1990 to the present in Table 1.3.1. Prior to 1993, observers recorded Atlantic salmon as an aggregate weight per haul. Therefore, no individual counts are available for these years, however eight observed interactions occurred. After 1993, observers recorded Atlantic salmon encounters on an individual basis. Between 1993 and 2020, seven observed interactions have occurred, with a total count of seven individuals. In total, Atlantic salmon bycatch has been observed across seven 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 (Figure 1.3.1). Bycatch of Atlantic salmon is a rare event as interactions have been observed in only seven years of a 31-year time series and no Atlantic salmon have been observed since August 2013.

1.4 Stock Enhancement Programs

During 2022, approximately 3,941,537 juvenile salmon were released into USA rivers (Table 1.4.1). Of these, 1,755,565 were hatchery fry; 1,143,150 were planted eyed eggs; 295,009 were parr; and 746,813 were smolts. Most of these restoration stockings were within the GoM DPS with the Connecticut (LIS), Pawcatuck (CNE) and Saco (CNE) rivers receiving limited allocations of fry and eyed eggs, which are to be stocked in the Connecticut River, as well as continue the legacy program including Salmon-in-Schools program (Table 1.4.1).

Besides juveniles, 2,832 adult salmon were released into USA rivers, all of which were stocked into the GoM (Table 1.4.2). Of these adults stocked, 353 were pre-spawn release, with most (345) from the Salmon for Maine's River program, which is aimed at using smolt to adult supplementation to introduce adults into high quality spawning habitat. In May 2021, a cohort of hatchery reared smolts were transferred from Green Lake National Fish Hatchery to the University of Maine Center for Cooperative Aquaculture Research (CCAR), where they are being reared to maturity. Upon transfer to CCAR, the smolts were transitioned to saltwater and vaccinated. In fall of 2022, the salmon were assessed for maturity. Individuals identified as maturing were stocked directly into vacant habitat within the East Branch of the Penobscot River and Old Stream (Tributary of the Machias River) in October 2022, as identified in the stocking plan. Planned assessment and monitoring will include telemetry to assess migration behavior for a subset of the released salmon, redd counts, and juvenile production via electro-fishing.

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 130,589 salmon released into USA waters were marked or tagged. Tags and marks for parr, smolts, and adults included: PIT, radio, clips and punches. All but two marks (CNE) occurred within the GoM (Table 1.5.1).

1.6 Farm Production

Reporting an annual estimate of production of farmed Atlantic salmon has been discontinued due to confidentiality statutes in Maine Department of Marine Resources (MDMR) regulations since 2010 (Table 1.6.1).

In 2022, there were no reported escapes of farmed fish and no aquaculture origin Atlantic salmon captured in Maine Rivers. Production of farmed Atlantic salmon is assumed to be similar to previous years as the number of fish stocked into marine cages in the spring was similar to past years. Salmon smolts were stocked into five locations (Black Island, Black Island South, Calf Island, Sand Cove, and Spectacle Island) in 2022.

Every year critically endangered adult Atlantic salmon returning to the Penobscot River are captured for broodstock and held at the Craig Brook National Fish Hatchery until spawning. During their time in captivity, all of the sea run wild fish are screened for specific pathogens of concern. In 2022, there were no confirmed pathogen detections.

1.7 Smolt Emigration

NOAA's National Marine Fisheries Service (NOAA) and the MDMR have conducted seasonal field activities assessing Atlantic salmon smolt populations using Rotary Screw Traps (RSTs) in selected Maine Rivers since 1996. Monitoring has focused on estimating abundance of migrating populations via stratified mark-recapture methods (Figure 1.7.1, Table 1.7.1), as well as using the RST platform for tagging and sample collection. Currently two rivers are monitored: Narraguagus and Sandy Rivers (tributary of the Kennebec River). Historically, smolt monitoring activities have occurred on several rivers to answer specific questions (i.e. abundance) or provide access to Atlantic salmon smolts (i.e. telemetry). Other recent studies include abundance estimates on the Sheepscot (2001 – 2019) and East Machias Rivers (2013 – 2021; Table 1.7.1).

MDMR monitored smolt migration using RSTs at two sites (river km 11.16 and 47.69) on the Narraguagus River, which continued smolt assessments for a 26th 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 encompasses the majority of the juvenile rearing habitat and is used for the historical time series (Table 1.7.1). A total of 400 smolts were captured at the lower site (373 naturally reared, 27 hatchery origin). The estimate of naturally-reared smolts exiting the system was 1,031 (95% 949 to 1,113).

MDMR scientists operated two RSTs at one site on the Sandy River (river km 27.48) which marked the 2nd year of assessment (Table 1.7.1). A total of 1,682 naturally-reared smolts were captured. The estimate of naturally-reared smolt migration was 9,694 (95% 9,080 to 10,308).

Citations

Baum, E. 1995. Atlantic salmon Spawner Targets for USA Rivers. Working Paper 1995.

Stevens, J.R., J.F. Kocik, and T.F. Sheehan. 2019. Modeling the impacts of dams and stocking practices on an endangered Atlantic salmon (Salmo salar) population in the Penobscot River, Maine, USA. Canadian Journal of Fisheries and Aquatic Sciences 76(10): 1795-1807.

USASAC (U.S. Atlantic Salmon Assessment Committee). 2020. Annual report of the U.S. Atlantic Salmon Assessment Committee 32: 2019 activities. Portland, Maine.

Wigley SE, Tholke C. 2020. 2020 discard estimation, precision, and sample size analyses for 14 federally managed species groups in the waters off the Northeastern United States. NOAA Technical Memorandum NMFS-NE-261; 175 p.

Table 1.2.1 Estimated Atlantic salmon returns to USA by geographic area, 2022. Natural reared (Natural) includes fish originating from natural spawning, stocked and hatchery fry or eggs. Returns are composed of documented returns at traps and returns estimated by redd counts.

Area	1SW Hatchery	1SW Natural	2SW Hatchery	2SW Natural	3SW Hatchery	3SW Natural	Repeat Spawners Hatchery	Repeat Spawners Natural	Total
LIS	0	0	0	4	0	0	0	0	4
CNE	2	0	0	3	0	0	0	0	5
GOM	354	19	937	197	6	2	5	0	1,520
Total	356	19	937	204	6	2	5	0	1,529

Table 1.2.2 Estimated Atlantic salmon returns to the USA, 1967-2022. "Natural" includes fish originating from natural spawning and hatchery fry or eggs. "Hatchery" includes Atlantic salmon that were stocked as parr or smolts. Starting in 2003, returns estimated by redd counts are included.

Year	Sea Age 1SW	Sea Age 2SW	Sea Age 3SW	Repeat Spawners	Total	Hatchery Origin	Natural Origin
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

Year	Sea Age 1SW	Sea Age 2SW	Sea Age 3SW	Repeat Spawners	Total	Hatchery Origin	Natural Origin
1992	1,056	2,255	6	20	3,337	2,678	659
1993	405	1,953	11	37	2,406	1,971	435
1994	342	1,266	2	25	1,635	1,228	407
1995	168	1,582	7	23	1,780	1,484	296
1996	574	2,168	13	43	2,798	2,092	706
1997	278	1,492	8	36	1,814	1,296	518
1998	340	1,477	3	42	1,862	1,146	716
1999	402	1,136	3	26	1,567	959	608
2000	292	535	0	20	847	562	285
2001	269	804	7	4	1,084	833	251
2002	437	505	2	23	967	832	135
2003	233	1,185	3	6	1,427	1,238	189
2004	319	1,266	21	24	1,630	1,395	235
2005	317	945	0	10	1,272	1,019	253
2006	442	1,007	2	5	1,456	1,167	289
2007	299	958	3	1	1,261	940	321
2008	812	1,758	12	23	2,605	2,191	414
2009	243	2,065	16	16	2,340	2,017	323
2010	552	1,081	2	16	1,651	1,468	183
2011	1,084	3,053	26	15	4,178	3,560	618
2012	26	879	31	5	941	731	210
2013	78	525	3	5	611	413	198
2014	110	334	3	3	450	304	146
2015	150	761	9	1	921	739	182
2016	232	389	2	3	626	448	178
2017	363	663	13	2	1,041	806	235
2018	324	542	2	1	869	764	105
2019	398	1,131	3	3	1,535	1,162	373
2020	234	1,452	22	7	1,715	1,324	391
2021	235	434	7	4	680	521	159
2022	375	1,141	8	5	1,529	1,304	225

Table 1.2.3. 2022 Two sea winter (SW) returns against 2SW Conservation Limits (CL) for select US rivers. The adult return numbers include eight multi sea winter returns (MSW) for the Penobscot River. Although the CL is a 2SW, these MSW fish do contribute eggs and are contributing to the total egg deposition in this system. Habitat units and corresponding CL data are taken from Baum et al. 1995, the U.S. is working to update our CLs based on the best available information and these updated CLs will be used to track attainment of CLs in the future.

Region	Name	Habitat (metric units)	CL	Returns	% CL
GOM	Dennys	2,415	161	5	3.1%
GOM	East Machias	2,145	143	14	9.8%
GOM	Machias	6,685	446	8	1.8%
GOM	Pleasant	1,085	72	17	23.6%
GOM	Narraguagus	6,015	401	12	3.0%
GOM	Union	8,360	557	0	0.0%
GOM	Penobscot	102,575	6,838	1,016	14.9%
GOM	Ducktrap	585	39	4	10.3%
GOM	Sheepscot	2,845	190	7	3.7%
GOM	Kennebec	1,005	67	51	76.1%
GOM	Androscoggin	3,175	212	9	4.2%
CNE	Saco	12,540	836	3	0.4%
CNE	Merrimack	38,980	2,599	0	0.0%
LIS	Connecticut	145,900	9,727	4	0.0%
-	Monitored Rivers	334,310	22,288	1,150	5.2%

Table 1.2.4. Time series of 1SW and 2SW smolt to adult return rates (SAR) and postsmolt to adult return rates (PSAR) for monitored USA rivers. Estimated return rates for monitored rivers are identified as being derived from hatchery origin (Hat.) or naturally reared origin (NR). Blank cells indicate that an estimate is not available due to smolt estimates not being calculated one or two years prior. The previous five and ten-year averages are included.

River (Origin/Return Rate Method)	Penobscot (Hat/PSAR)	Penobscot (Hat/PSAR)	Narraguagus (NR/SAR)	Narraguagus (NR/SAR)	Sheepscot (NR/SAR)	Sheepscot (NR/SAR)	East Machias (NR/SAR)	East Machias (NR/SAR)
Smolt Year	1SW	2SW	1SW	2SW	1SW	2SW	1SW	2SW
1970	0.11%	1.56%	-	-	-	-	-	-
1971	0.03%	0.82%	-	-	-	-	-	-
1972	0.02%	1.23%	-	-	-	-	-	-
1973	0.05%	1.58%	-	-	-	-	-	-
1974	0.06%	0.72%	-	-	-	-	-	-
1975	0.11%	0.84%	-	-	-	-	-	-
1976	0.04%	1.30%	-	-	-	-	-	-
1977	0.08%	0.39%	-	-	-	-	-	-
1978	0.19%	2.34%	-	-	-	-	-	-
1979	0.58%	2.13%	-	-	-	-	-	-
1980	0.29%	1.52%	-	-	-	-	-	-

River (Origin/Return Rate Method)	Penobscot (Hat/PSAR)	Penobscot (Hat/PSAR)	Narraguagus (NR/SAR)	Narraguagus (NR/SAR)	Sheepscot (NR/SAR)	Sheepscot (NR/SAR)	East Machias (NR/SAR)	East Machias (NR/SAR)
1981	0.17%	0.60%	-	-	-	-	-	-
1982	0.16%	1.11%	-	-	-	-	-	-
1983	0.12%	1.26%	-	-	-	-	-	-
1984	0.10%	1.34%	-	-	-	-	-	-
1985	0.23%	0.61%	-	-	-	-	-	-
1986	0.32%	0.88%	-	-	-	-	-	-
1987	0.30%	0.85%	-	-	-	-	-	-
1988	0.39%	1.14%	-	-	-	-	-	-
1989	0.21%	0.52%	-	-	-	-	-	-
1990	0.10%	0.69%	-	-	-	-	-	-
1991	0.41%	0.55%	-	-	-	-	-	-
1992	0.16%	0.29%	-	-	-	-	-	-
1993	0.18%	0.70%	-	-	-	-	-	-
1994	0.10%	0.75%	-	-	-	-	-	-
1995	0.11%	0.22%	-	-	-	-	-	-
1996	0.10%	0.33%	-	-	-	-	-	-
1997	0.10%	0.25%	0.11%	0.90%	-	-	-	-
1998	0.12%	0.15%	0.25%	0.28%	-	-	-	-
1999	0.10%	0.29%	0.31%	0.53%	-	-	-	-
2000	0.10%	0.18%	0.28%	0.17%	-	-	-	-
2001	0.23%	0.53%	0.16%	0.85%	-	-	-	-
2002	0.13%	0.61%	0.00%	0.46%	-	-	-	-
2003	0.17%	0.41%	0.08%	1.01%	-	-	-	-
2004	0.17%	0.41%	0.08%	0.98%	-	-	-	-
2005	0.17%	0.28%	0.24%	0.73%	-	-	-	-
2006	0.10%	0.60%	0.09%	0.78%	-	-	-	-
2007	0.30%	0.71%	0.34%	1.72%	-	-	-	-

River (Origin/Return Rate Method)	Penobscot (Hat./PSAR)	Penobscot (Hat./PSAR)	Narraguagus (NR/SAR)	Narraguagus (NR/SAR)	Sheepscot (NR/SAR)	Sheepscot (NR/SAR)	East Machias (NR/SAR)	East Machias (NR/SAR)
Smolt Year	**1SW**	**2SW**	**1SW**	**2SW**	**1SW**	**2SW**	**1SW**	**2SW**
2008	0.08%	0.36%	0.44%	0.65%				
2009	0.17%	0.90%	0.26%	1.80%	0.28%	0.84%	-	-
2010	0.30%	0.23%	0.95%	0.61%	0.10%	0.33%	-	-
2011	0.00%	0.12%	0.00%	0.72%	0.10%	0.26%	-	-
2012	0.03%	0.10%	0.00%	0.68%	0.08%	0.83%	-	-
2013	0.03%	0.20%	0.00%	2.35%	0.17%	0.33%	0.75%	2.07%
2014	0.02%	0.05%	0.00%	0.57%	0.13%	0.44%	0.32%	1.37%
2015	0.07%	0.15%	0.00%	0.62%	0.13%	0.98%	1.21%	2.83%
2016	0.06%	0.09%	-	-	0.14%	0.14%	0.18%	1.10%
2017	0.06%	0.16%	-	-	0.08%	0.83%	0.14%	2.23%

River (Origin/Return Rate Method)	Penobscot (Hat./PSAR)	Penobscot (Hat./PSAR)	Narraguagus (NR/SAR)	Narraguagus (NR/SAR)	Sheepscot (NR/SAR)	Sheepscot (NR/SAR)	East Machias (NR/SAR)	East Machias (NR/SAR)
2018	0.06%	0.22%	1.99%	3.31%	0.33%	0.72%	0.80%	2.01%
2019	0.04%	0.06%	0.27%	0.40%	0.21%	0.64%	0.33%	1.31%
2020	0.04%	0.17%	-	-	-	-	-	-
2021	0.06%	-	0.49%	-	-	-	0.36%	-
Previous 5-Year Mean	0.05%	0.14%	1.13%	1.86%	0.19%	0.58%	0.36%	1.66%
Previous 10-Year Mean	0.04%	0.13%	0.32%	1.24%	0.15%	0.57%	0.53%	1.84%

Table 1.3.1 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 1.4.1. Number of juvenile Atlantic salmon by life-stage stocked in USA, 2022 by area/DPS (Central New England (CNE); Gulf of Maine (GoM); Long Island Sound (LIS)) and drainage. Parr and smolt life stages broken out into age categories.

Area	Drainage	0 Parr	1 Parr	1 Smolt	2 Smolt	Eyed Egg	Fry	Total
LIS	Connecticut	-	-	-	-	-	608,670	608,670
LIS	Pawcatuck	-	-	-	-	-	4,900	4,900
CNE	Saco	-	-	-	-	2,000	2400	4,400
GOM	Androscoggin	-	-	-	-	-	3,700	3,700
GOM	Dennys	-	-	-	-	-	262,195	262,195
GOM	East Machias	164,747	-	-	-	-	19,291	184,038
GOM	Kennebec		-	97,539	-	438,093	3,200	538,832

Area	Drainage	0 Parr	1 Parr	1 Smolt	2 Smolt	Eyed Egg	Fry	Total
GOM	Machias	15,591	-	939	-	-	220,775	237,305
GOM	Narraguagus	89,677	-	-	-	-	71,600	161,277
GOM	Penobscot	11,444	-	648,335	1000	438,093	212,595	1,311,467
GOM	Pleasant	-	-	-	-	-	326,239	326,239
GOM	Sheepscot	-	13,550	-	-	264,964	19,000	297,514
GOM	Union	-	-	-	-	-	1,000	1,000
-	-	281,459	13,550	746,813	1,000	1,143,150	1,755,565	3,941,537

Table 1.4.2 Stocking summary for sea-run, captive reared domestic adult Atlantic salmon for the USA in 2022 by purpose and geographic area. Areas represented include: Long Island Sound (LIS), Central New England (CNE) and Gulf of Maine (GOM).

Area	Purpose	Captive Reared Domestic Pre-spawn	Captive Reared Domestic Post-spawn	Sea Run Pre-spawn	Sea Run Post-spawn	Total
LIS	-	-	-	-	-	0
CNE	-	-	-	-	-	0
GOM	Restoration	345	1,949	8	530	2,832
Total for USA	-	345	1,949	8	530	2,832

Table 1.5.1 Summary of tagged and marked Atlantic salmon released in USA, 2022. Includes hatchery and wild origin fish.

Mark Code	Life Stage	CNE	GOM	LIS	Total
Adipose clip	0 Parr	-	89,677	-	89,677
Adipose punch	Adult	2	325	-	327
Adipose clip	Adult	-	-	-	0
Upper Caudal Punch	Adult	-	13	-	13
Passive Integrated Transponder (PIT)	Adult	-	3,723	-	3,723
Radio tag	Adult	-	-	-	0
Acoustic Tag	Adult	-	126	-	126
Acoustic Tag	Smolt	-	148	-	148
Adipose clip	Smolt	-	36,575	-	36,575
Passive Integrated Transponder (PIT)	Smolt	-	-	-	0
Radio tag	Smolt	-	-	-	0
-	-	2	130,587	0	130,589

Table 1.6.1. State of Maine - USA commercial Atlantic salmon aquaculture production and suspected aquaculture captures to Maine rivers 2000 to 2022. Due to confidentiality statutes in MDMR regulations related to single producer, adult production rates are not available 2011 to 2022 because of confidentiality statutes in Maine Department of Marine Resources regulations, these years are represented by an "NA" designation.

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	0	16,461	34
2001	4,205,161	0	13,202	84
2002	3,952,076	0	67,988	15
2003	2,660,620	0	6,007	4
2004	1,580,725	0	8,514	0
2005	294,544	0	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	0	9,014	0
2009	2,790,428	0	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
2020	2,225,000	40,000	NA	0
2021	2,080,309	31,140	NA	4
2022	1,983,106	54,174	NA	0

Table 1.7.1. Naturally reared smolt population estimate (± Std. Error) from maximum likelihood estimates for the Narraguagus (Narr; Natural spawning, fry stocking and egg planting), Sandy (Sand; Egg planting), Sheepscot (Natural Spawning, fry stocking, egg planting and parr stocking – monitoring discontinued in 2019) and East Machias (E Mac; Parr and fry stocking – monitoring discontinued) Rivers Maine USA. Blank cells indicate that no population estimates were derived during particular year.

Smolt Year	Narr. R SE Low	Narr R. Pop Est.	Narr R. SE Up	Sand R. SE Low	Sand R. Pop Est.	Sand R. SE Up	Sheepscot R. SE Low	Sheepscot R. Pop Est.	Sheepscot R. SE Up	E. Mac R. SE Low	E Mac R. Pop Est.	E Mac R. SE Up
1997	2,429	2,869	3,309	-	-	-	-	-	-	-	-	-
1998	2,594	2,845	3,096	-	-	-	-	-	-	-	-	-
1999	3,711	4,247	4,783	-	-	-	-	-	-	-	-	-
2000	1,601	1,843	2,085	-	-	-	-	-	-	-	-	-
2001	2,191	2,562	2,933	-	-	-	-	-	-	-	-	-
2002	1,536	1,774	2,012	-	-	-	-	-	-	-	-	-
2003	1,096	1,201	1,306	-	-	-	-	-	-	-	-	-
2004	1,069	1,284	1,499	-	-	-	-	-	-	-	-	-
2005	1,062	1,287	1,512	-	-	-	-	-	-	-	-	-
2006	2,137	2,339	2,541	-	-	-	-	-	-	-	-	-
2007	1,063	1,177	1,291	-	-	-	-	-	-	-	-	-
2008	796	962	1,128	-	-	-	-	-	-	-	-	-
2009	1,086	1,176	1,266	-	-	-	1,661	1,813	1,965	-	-	-
2010	1,922	2,149	2,376	-	-	-	3,572	3,944	4,316	-	-	-
2011	1,023	1,404	1,785	-	-	-	2,706	3,176	3,646	-	-	-
2012	725	969	1,213	-	-	-	2,132	2,507	2,882	-	-	-
2013	974	1,237	1,500	-	-	-	2,799	3,036	3,273	147	249	351
2014	1,417	1,615	1,813	-	-	-	1,416	1,650	1,884	614	852	1090
2015	960	1,201	1,442	-	-	-	1,372	1,558	1,744	183	229	275
2016	-	-	-	-	-	-	2,662	2,924	3,186	719	938	1157
2017	-	-	-	-	-	-	2,149	2,758	3,367	1099	1,323	1547
2018	483	604	725	-	-	-	1,295	1,652	2,009	842	1,043	1244
2019	627	829	1,031	-	-	-	1,244	1,442	1,640	915	1,101	1287
2020	-	-	-	-	-	-	-	-	-	-	-	-
2021	1,334	1,426	1,518	11,935	13,229	14,523	-	-	-	636	792	948
2022	949	1,031	1,113	9,080	9,694	10,308	-	-	-	-	-	-

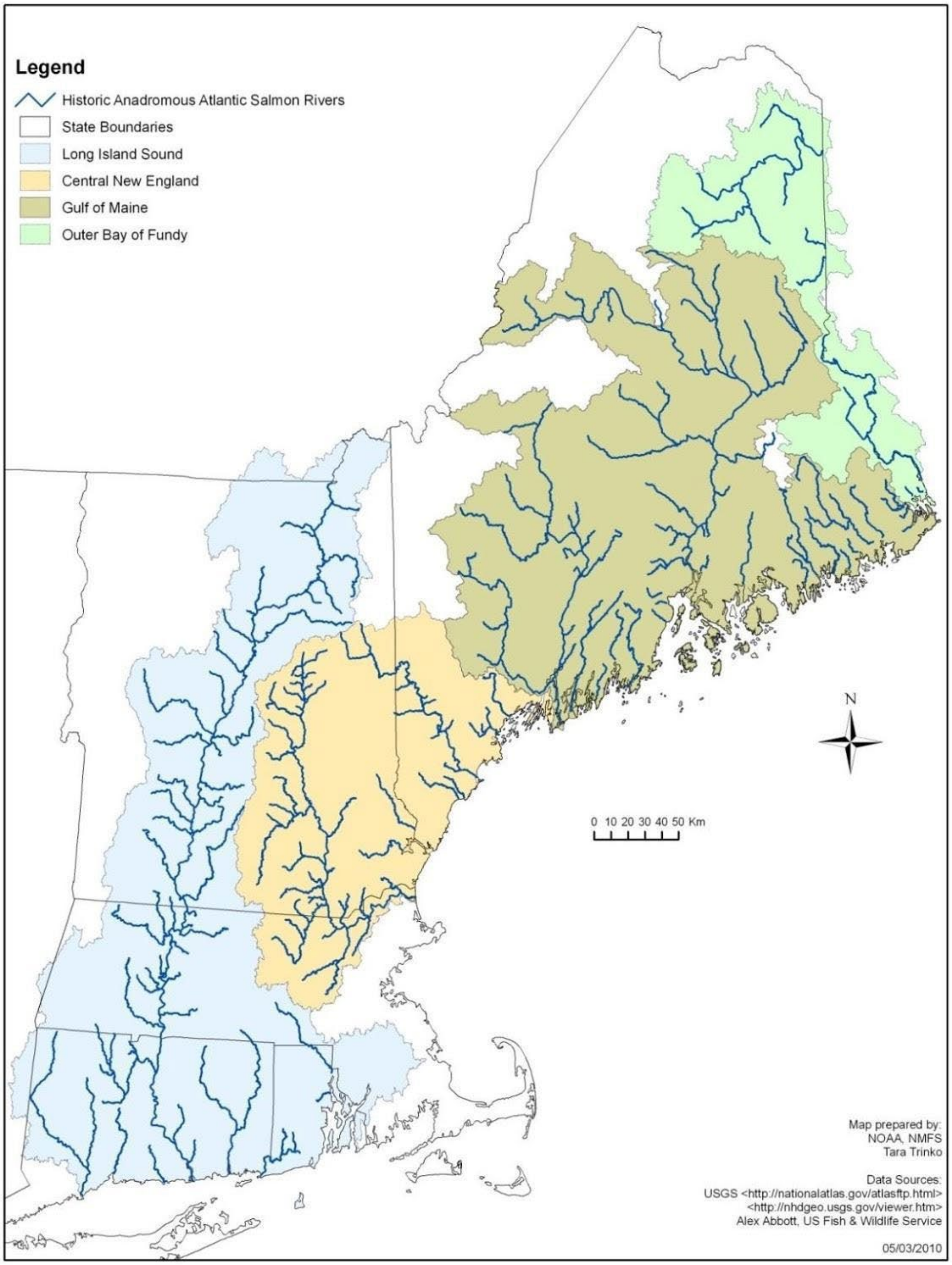

Figure 1.2.1 Map of Distinct Population Segments used in summaries of USA data for returns, stocking, and marking in 2022.

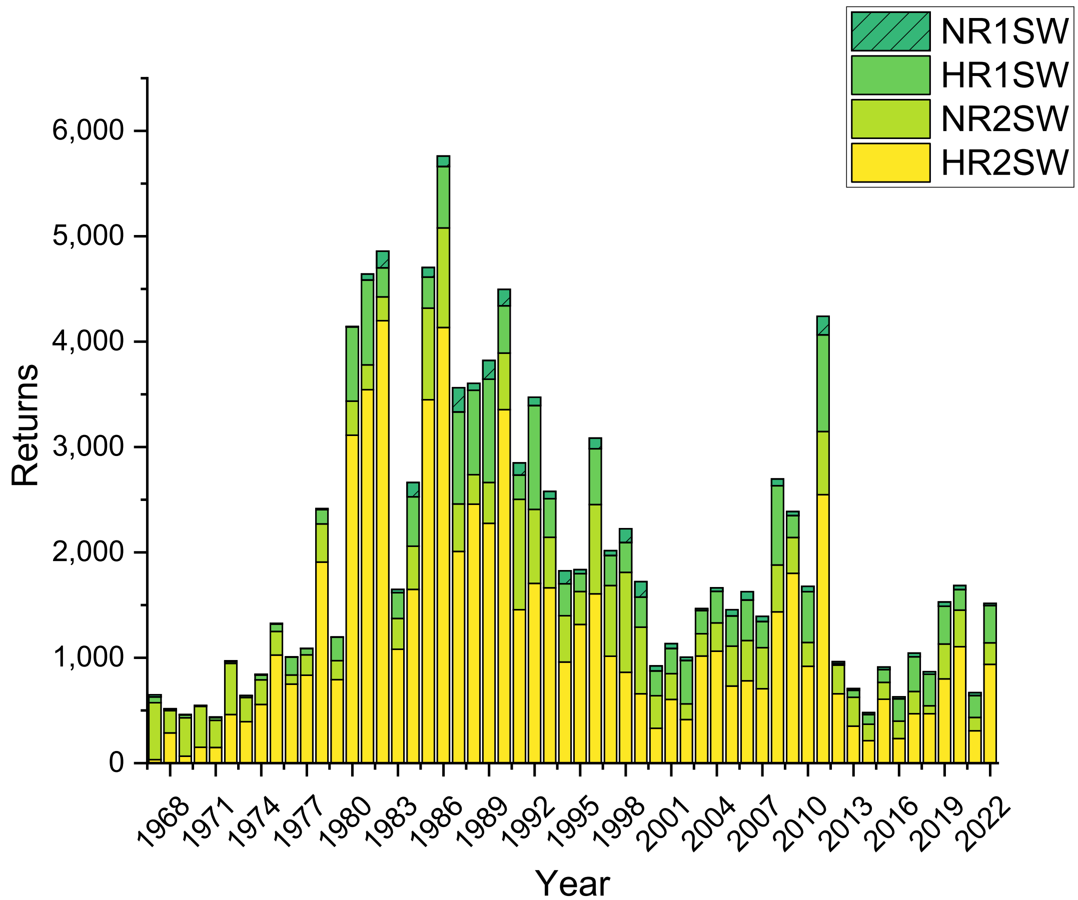

Figure 1.2.2 Origin and sea age (age 1 and 2 only) Atlantic salmon returning to USA rivers, 1967 to 2022 (NR1SW = Naturally Reared One Sea Winter; HR1SW = Hatchery Reared One Sea Winter; NR2SW = Naturally Reared Two Sea Winter; HR2SW = Hatchery Reared Two Sea Winter).

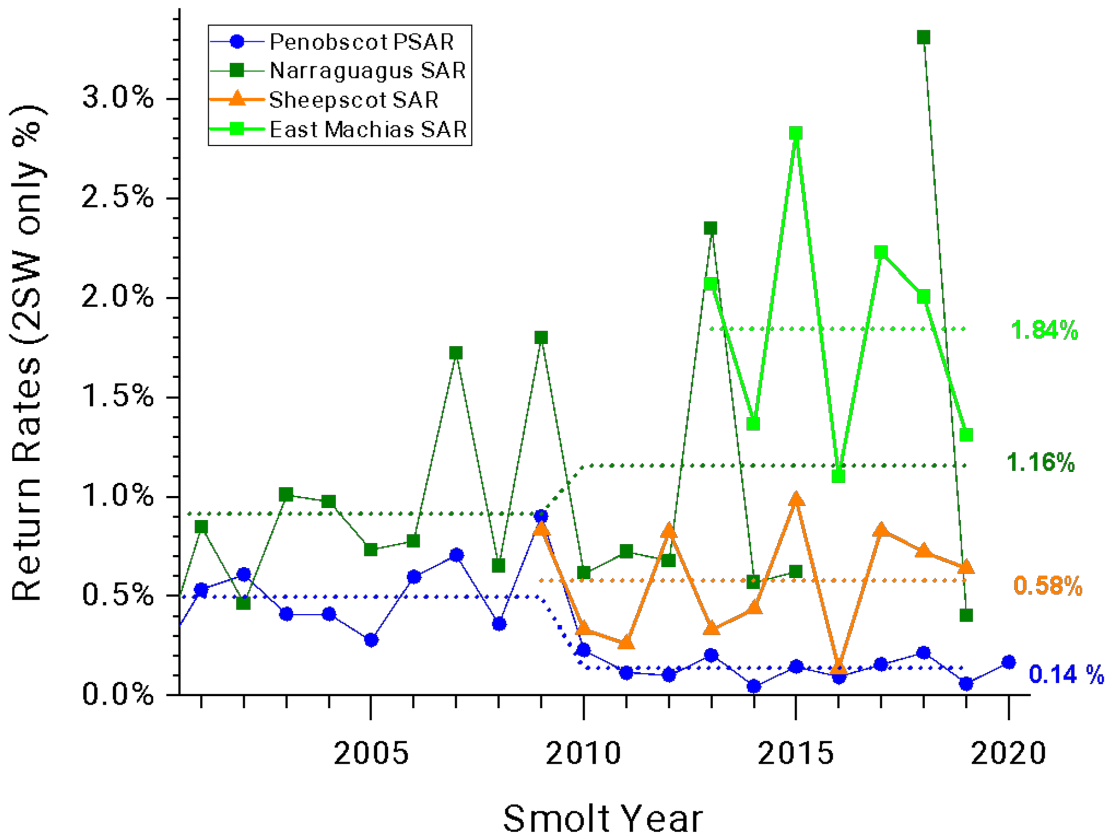

Figure 1.2.3 Smolt to Adult (SAR) and Postsmolt to Adult (PSAR) return rates for 2SW adults for fourMaine Rivers: Narraguagus, Sheepscot, East Machias and the Penobscot for the 2000 to 2020 Atlantic salmon smolt cohorts. Decadal (or time series) averages expressed as line labeled with percent returns.

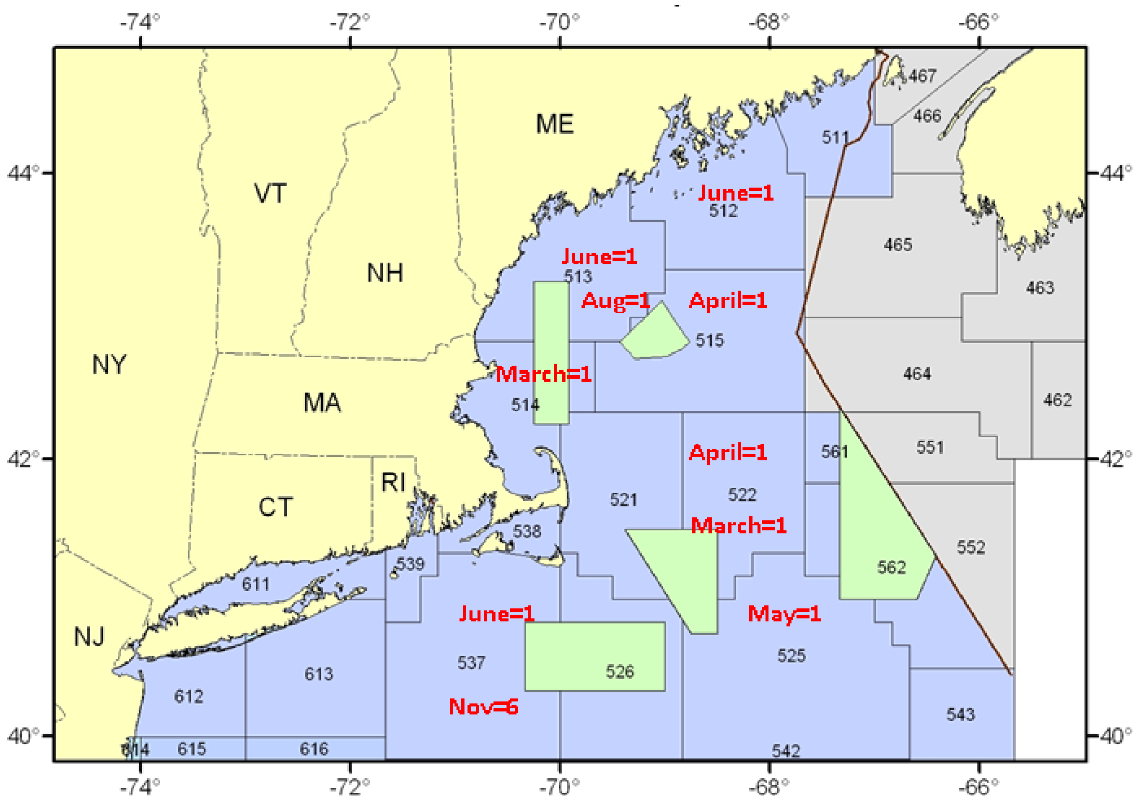

Figure 1.3.1 Map of Gulf of Maine region showing the month and number of Atlantic salmon interactions between 1993 and 202. Blue polygons are USA statistical areas, grey zones are in Canada and green-shaded polygons represent regulated access areas. Red text highlights the month and number of individuals for each documented interaction within each statistical area. Location of the label within the statistical grid does not denote more specific locations.

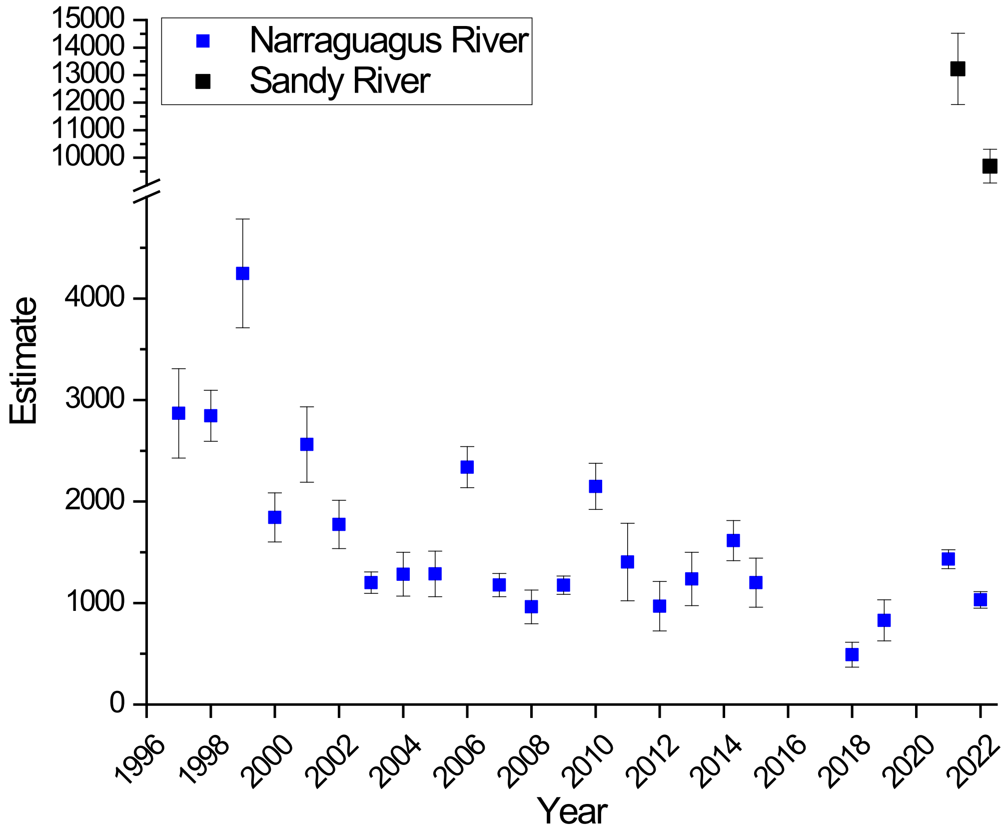

Figure 1.7.1. Population Estimates (± Std. Error) of emigrating naturally-reared smolts of naturally reared smolts on the Narraguagus (natural spawning, egg planting and fry stocking) and Sandy (egg planting), in Maine U.S.

2 Viability Assessment - Gulf of Maine Atlantic Salmon

2.1 Executive Summary of DPS and Annual Viability Synthesis 2022

The adult Atlantic salmon **abundance** of the 2022 GOM DPS spawning run (1,520 estimated adult returns) was ranked 10th out of 32 cohorts since 1991. Hatchery-origin adults (N=1,302) represented 86% of the returns. Naturally-reared returns remained low across the GOM DPS (218) totaling 117 in PNB, 56 in DEC and 45 in MMB SHRUs. Over 54% of naturally-reared returns were documented in the PNB SHRU. However, abundance remains critically low relative to interim recovery targets of 500 naturally-reared returns per SHRU. The PNB SHRU was at 23.4% of this target, 2.6-fold higher than returns to the MMB SHRU (5%). Returns to the DEC SHRU were estimated at 56 only 11.2% of recovery targets. In 2022, the Ducktrap DIP in the PNB SHRU remains at an elevated extirpation risk with five documented returns and a revised estimate for 2021 of two. In the past decade, only 25 returns were documented and in five of the last 10 years, there were no documented returns in the Ducktrap.

Population **growth** is monitored by 10-year geometric mean population growth rates of naturally-reared adults (USFWS & NMFS 2018). The GOM DPS rate for 2022 returns was 0.97 (95% CL 0.58-1.64). Error bounds around this rate overlap 1.0, so this indicates relative stability. This rate does not reflect the true wild population growth rates because naturally-reared salmon returns include not only individuals that are the product of wild reproduction but also products of the U.S. hatchery system (e.g., stocked fry and planted eggs).Therefore, the inclusion of hatchery products in the 10-year geometric mean replacement rate overestimates wild population growth rate. New methods to evaluate the wild-reared component were developed, described, and reported (USASAC Report 34 and see Section 2.4.1). These metrics suggest that wild population components have growth rates below 1 (declining population) for all three SHRUs. Note that these new methods were based on McClure et al. (2003) and will undergo peer review in the future. The methods are described in this report for the purposes of information and soliciting feedback.

The **spatial structure** of juvenile populations represents a combination of wild production areas that are monitored for spawning activity and stream reaches that are stocked and produce naturally-reared juveniles. We summarized occupancy for the 2022 cohort production from four sources - wild, egg planted, fry stocked, or parr stocked fish for core managed and surveyed HUC-12 units. In aggregate, 45 HUC-12 units had documented wild and/or hatchery occupancy. Twenty-six HUC-12 units had one source of production. HUC-12s with more than one source numbered 14 with two sources, four with three sources, and one HUC-12 with all four sources. As such, considering there are 300 HUC-12 units in CH, most freshwater rearing habitats were not occupied by the 2022 cohort. Occupancy was proportionally greatest in DEC SHRU and lowest in PNB SHRU. Furthermore, occupancy in individual HUC-12 units rarely exceeded 75% further underscoring limited spatial production capacity, with analysis showing 7 of 155 (4.5%) HUC 12 in PNB SHRU were surveyed for natural reproduction. Of those areas surveyed, 86% (6/7) % had redds and are considered occupied. Overall, this analysis shows that most juvenile rearing habitat is vacant and much of the occupied habitat is underutilized. With such low freshwater abundance, expectations for reaching adult recovery targets should be tempered.

Genetic **diversity** of the GOM DPS was monitored through assessment of sea-run adults for the Penobscot River and juvenile parr collections for six other populations. Allelic diversity has remained relatively constant since the mid-1990s. All populations now possess more than 10 of 18 monitored loci. Estimates of the effective population size had increased to above 500 for the Penobscot River population in 2017 but have since fallen below 500. For the other rivers, effective population size estimates have remained either constant or slightly decreased but are often below 100. Past guidance was based on the ‘50-500 rule’ for small populations. More recently, Frankham et al. (2014) suggested that minimum populations should be greater than 100 to reduce the risk of inbreeding over the short term and greater than 1,000 to maintain evolutionary potential. The GOM DPS Recovery Plan has far exceeded the definition of “short term” (five fish generations) for the Penobscot population and has just reached this point for the coastal river populations. Therefore, there is urgency to revisiting broodstock collection, hatchery operations, and their impacts on conservation genetics. There is a need to evaluate genetic rescue approaches that have been used elsewhere for listed salmonids.

2.2 Status Assessment Approach

This report summarizes all US populations related to metrics and general trends to national reporting needs in support of NASCO (e.g., Chapter 1). These populations are now dominated by the endangered GOM DPS in Maine. Sections 2.2 -2.5 summarizes the more detailed metrics needed to monitor the health of these populations using standard metrics for endangered salmonids in the U.S. This section of the report represents an annual viability assessment of the GOM DPS using a Viable Salmonid Populations (VSP) approach (McElhany et al. 2000). Taking this approach allows U.S. stock assessment scientists to integrate the annual GOM DPS assessment within the overall U.S. assessment structure. This minimizes redundancies and leverages similar needs to optimize staff time. Four parameters form the key to evaluating population viability status: abundance, population growth rate, population spatial structure, and diversity. Integrating this annual VSP reporting (requested by the GOM DPS Collaborative Management Strategy) will also allow additional review of the GOM DPS 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 five-year viability assessment. Benchmark assessments will be produced and published separately.

2.2.1 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). These characterizations also represent metrics used to monitor progress for the Recovery Plan. There are three Major Population Groupings (MPG) referred to as Salmon Habitat Recovery Units (SHRU) for the GOM DPS (NMFS 2009) based on watershed similarities and remnant population 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 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. These hatchery programs propagate wild-exposed parr or returning adults to supplement spawning populations. The Ducktrap River DIP is not supplemented and Cove Brook native populations were extirpated in 2009.

Because conservation hatchery activities play a major role in fish distribution and recovery, a brief synopsis is included in the boundary delineation. The conservation hatchery strategy for six of these DIPs is to collect broodstock 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 the Ducktrap River population, no conservation hatchery activities were implemented. In general, fish from DIPs are stocked into their natal rivers. 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 rivers reaches, especially the Kennebec River in MMB SHRU and Cove Brook within the PNB SHRU.

2.3 Population Targets and Annual Abundance

Comparing monitored adult abundance to management targets is an instructive metric of overall stock health. The number of returning Atlantic salmon needed to utilize fully all juvenile rearing habitats is termed the Conservation Limit (CL). The CL for the GOM DPS is 29,192 adults (Atkinson 2020). When calculating the CL for U.S. populations in the context of international assessments by the ICES WGNAS, the metric focuses on only 2SW adult returns (hatchery and natural-reared) in critical habitat and is 22,134. These CL targets represent long-term goals for sustainable population sizes. Given the endangered status of the GOM DPS, the current management target for down listing from endangered to threatened is **500 naturally-reared returns** in each of the three SHRUs. 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 from endangered species listing. As such, adult returns are partitioned into hatchery returns (adult salmon that are a product of an accelerated smolt program or released as fall parr or fall fingerlings) or naturally-reared returns (products of natural spawning, egg planting, and fry stocking).

The goal of the GOM DPS Recovery Plan is a wild, self-sustaining population and therefore counts of wild fish are important to monitor progress toward the goal. However, with extensive and essential conservation hatchery activities (planting eggs and stocking fry and fingerlings), it is currently not feasible to distinguish all hatchery products from wild fish for such counts. All fish handled at traps are classified as to rearing origin by fin condition and scale analysis. To partition naturally-reared and stocked returns for redd-based estimates, each population is pro-rated on an annual basis using the ratio of naturally-reared to stocked at the time of smolt emigration or other decision matrices (USASAC 2020).

2.3.1 Total Adult Returns

Total adult returns to the GOM DPS in 2022 were 1,520 adults with 1,302 hatchery-origin fish returning to the East Machias, Narraguagus, Penobscot, Sheepscot, Kennebec, and Androscoggin rivers (Figure 2.2.1 and Table 2.2.1). Because of the abundance of the PNB SHRU smolt-stocked returns (1,217), this SHRU dominated (83%) total abundance with 1,334 returns. An additional 85 hatchery returns were documented from the DEC (17) and MMB SHRU (68).

Naturally-reared returns were also highest in PNB at 117 (Table 2.2.1 and Figure 2.2.2). Of these, five adults returned to the Ducktrap River. Additionally, after naturally-reared fry were observed here in 2022, protocols updated 2021 returns to two. For the last decade, this population only had returns in five of 10 years. Extirpation risk is high. Elsewhere the DEC SHRU had 56 documented naturally-reared returns across all six of monitored river systems while the Merrymeeting Bay SHRU had 45 natural returns to all three of monitored systems.

Table 2.3.1. Documented returns from trap and redd-count monitoring for GOM DPS Atlantic salmon by SHRU for return year 2022 and percentage of naturally-reared (NR) fish relative to the interim 500 fish target (% of 500) by SHRU.

SHRU	Hatchery	Natural	Sub Totals	% NR of 500
Downeast Coastal	17	56	73	11.2%
Penobscot Bay	1,217	117	1,334	23.4%
Merrymeeting Bay	68	45	113	9.0%
Gulf of Maine DPS	**1,302**	**218**	**1,520**	**-**

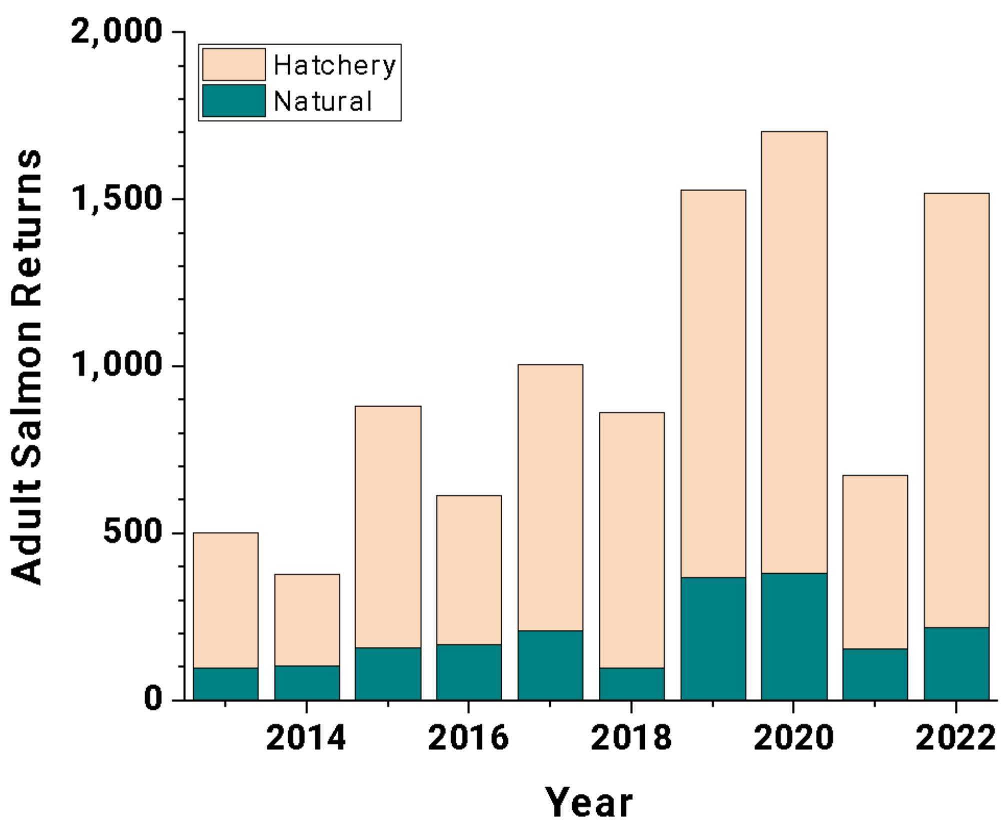

Figure 2.3.1. Time-series of total estimated returns to the GOM DPS of Atlantic salmon for the last decade illustrating the dominance of hatchery-reared origin (parr or smolt stocked; tan bars) Atlantic salmon compared to naturally-reared (wild, egg stocked, fry stocked; teal bars) origin.

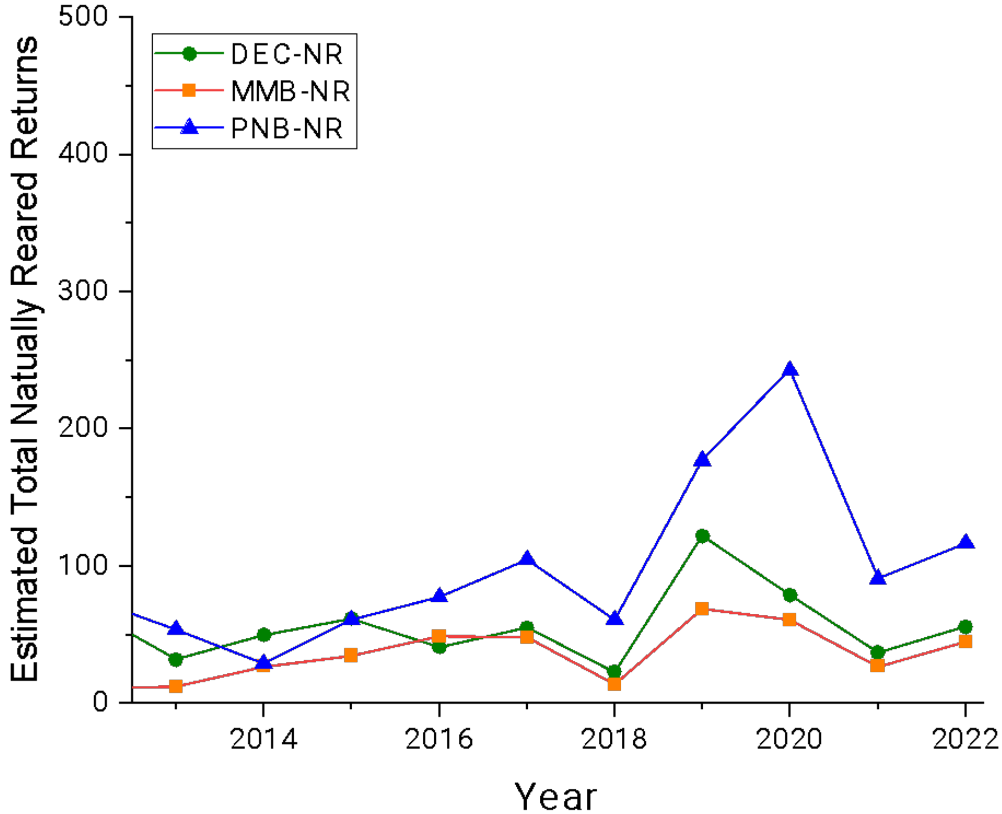

Figure 2.3.2. Time series of last decade of naturally-reared adult returns to the Merrymeeting Bay (Orange), Penobscot Bay (Blue), and Downeast Coastal (Green) SHRUs. Note: Naturally-reared interim target of 500 natural spawners is maximum axis value.

2.3.2 Adult Return Rates

The USASAC updated adult return rate metrics for Penobscot River hatchery-origin smolts based on 2022 returns. For naturally-reared smolts produced in the Narraguagus, Sheepscot, and East Machias rivers, no 2SW returns were updated because no smolt estimates were conducted in 2020 due to the pandemic. Typically, for these three populations, smolt emigration estimates and subsequent adult returns by sea age are used to generate a smolt-to-adult return rate (SAR). For the Penobscot River, we used 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 both stocking location and flow-specific mortality to generate a postsmolt survival estimate that was then applied to subsequent adult returns to calculate a postsmolt to adult survival rate (PSAR) for the Penobscot.

Naturally-reared smolt abundance was the result of wild spawning, egg planting, fry stocking and stocking of fall parr (ambient-temperature reared parr). The longest time series is for naturally-reared populations is the Narraguagus River starting with the 1997 smolt cohort. Most of the adult return data for this population comes from trap counts of adults at the Cherryfield Dam. In years of high flow (more fish bypass the trap), redd counts are used as they more accurately reflect total returns. All these age-based adult estimates are in USASAC databases. Sheepscot River smolts were monitored from 2009 to 2019. This effort was switched to the Sandy River in 2021 post pandemic. East Machias smolt monitoring was conducted from 2013-2019 and 2021. Due to capacity constraints, monitoring ended in 2021. When adult returns are estimated from redd counts, ages are pro-rated by standard methods used by USASAC.

The 1 SW PSAR for the Penobscot 2022 returns was 0.06% and the SAR for the Narraguagus was 0.49%. Trends in the last decade (smolt cohorts 2011-2020) indicate Penobscot hatchery-reared 1SW population PSAR averaged 0.05%. The Narraguagus River had higher SAR decadal average of 0.39%, despite several years without estimates. For the entire 11-year time series for the Sheepscot River, the average SAR was 0.16% and for the East Machias the seven-year average was 0.51%. Grilse in Maine are typically a smaller component of returns and most commonly males.

Salmon predominantly return at 2SW, therefore return rates are higher for these fish. In 2022, the 2020 smolt cohort PSAR for the Penobscot was 0.17%, more than 2.5 times 2021 2SW return rates (Figure 2.3.2.1). These rates are similar to those of 2SW salmon in the last decade when the Penobscot PSAR averaged 0.13% (Figure 2.2.1.1). This PSAR is substantially lower than the decadal average SAR for 2SW returns to the Narraguagus (1.16%) and Sheepscot rivers (0.55%) or the East Machias (1.84%). While the interannual variability is large in these smaller populations, these data suggest better marine performance for naturally-reared smolts. Despite the higher rates for the Narraguagus, Sheepscot, and East Machias, overall low smolt freshwater production results in lower number of adult returns in these three populations.

Marine survival remains a primary threat to the recovery of all GOM DPS stocks. Reviews of marine survival indicate the best management strategy to address current ocean conditions is to maximize the production of wild or naturally-reared smolts. Given the amount of vacant habitat across the DPS (Section 2.5), there is significant unused habitat capacity. Additional hatchery capacity would be expected to boost returns by utilizing more habitat to produce fish. As would prioritizing use of higher quality habitat and further evaluating habitat quality. For hatchery smolts, research and adaptive management changes could help close the marine performance gap and yield more spawners. Ongoing efforts to ensure safe downstream passage for both naturally-reared and hatchery smolts remains essential.

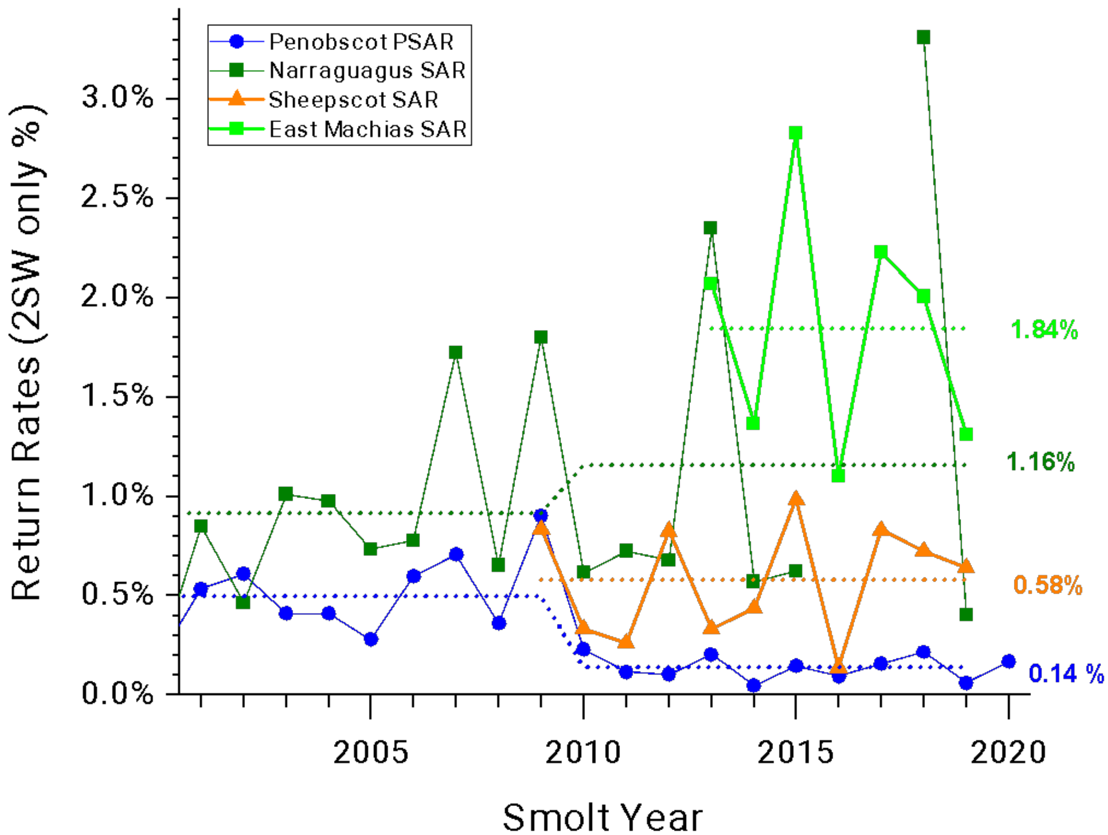

Figure 2.3.2.1. Time series of post-smolt to 2SW adult return rates for the Penobscot hatchery smolts (blue) and naturally-reared smolt to adult return rates for the Sheepscot (orange), Narraguagus (olive), and East Machias (green) for the 2001-2020 smolt cohorts. Dashed lines are decadal averages of the populations and percentages listed are for that average.

2.4 Population Growth Rate

Another metric of recovery progress in each SHRU is a sustained population growth rate indicative of an increasing population. The mean life span of Atlantic salmon is five 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 five-year replacement rate in year t. The five-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 five years prior. Naturally-reared adult spawners are counted in the calculation of population growth rate in the objectives of the current recovery phase (reclassification to threatened). 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 due to 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 2022, the MMB SHRU had the highest growth rate (1.39; 95% CI: 0.89 – 2.17) and the DEC SHRU had the lowest growth rate (0.79; 95% CI: 0.50 – 1.24). The PNB SHRU had an intermediate growth rate of 1.03 (95% CI: 0.50-2.12) (Table 2.4.1).

Table 2.4.1. Ten-year geometric mean replacement rates (GM_R) for GOM DPS Atlantic Salmon as calculated for 2022 return year with 95% confidence limits (CL).

SHRU	**GM_R**	**Lower 95% CL**	**Upper 95% CL**
Downeast Coastal	0.79	0.5	1.24
Penobscot Bay	1.03	0.5	2.12
Merrymeeting Bay	1.39	0.89	2.17
Gulf of Maine DPS	**0.98**	**0.58**	**1.64**

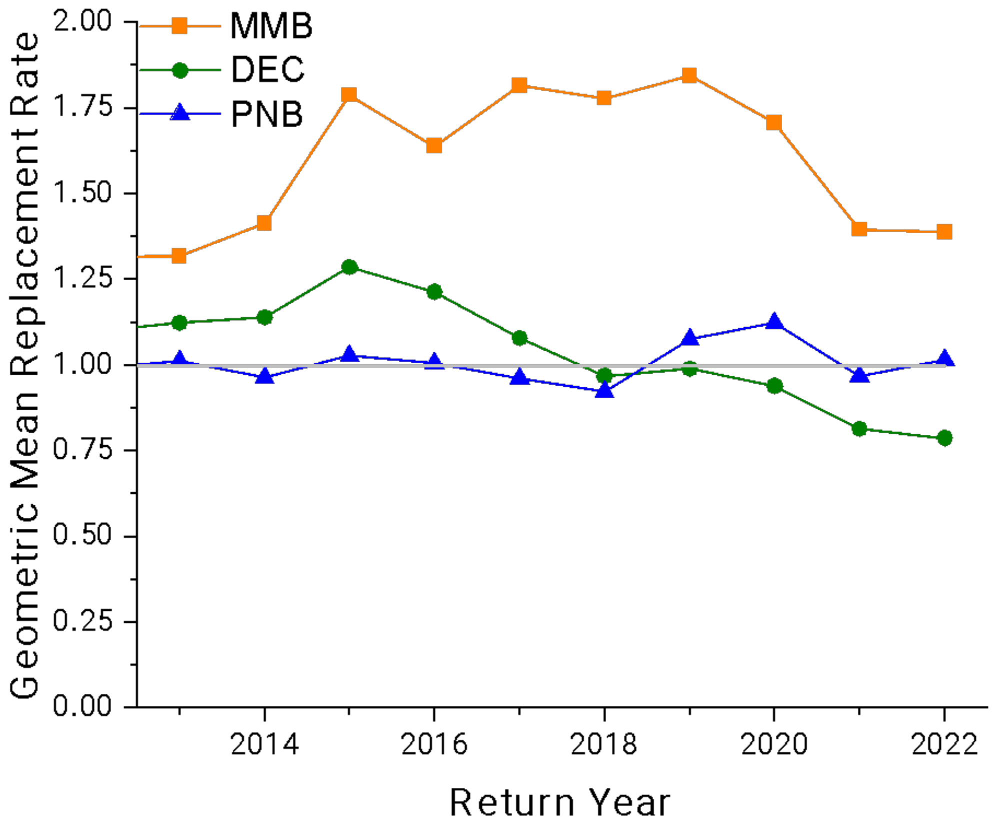

Figure 2.4.1. Annually calculated ten-year geometric mean replacement rates for the GOM DPS of

Atlantic salmon for Merrymeeting Bay (orange), Penobscot Bay (blue), and Downeast Coastal (green) for each SHRU individually for the last decade.

The geometric mean population growth rate based on the five-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 the 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.

2.4.1 Genetic Parentage Analysis

To remove this bias of including hatchery products in the evaluation and gain an estimate of the true wild population growth rate, we developed a method to discern returns resulting from hatchery inputs from those resulting from natural reproduction in the wild. We have been able to 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. Because 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.

<u>Model description</u>

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

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

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

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

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

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

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

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

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

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

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

where T = an approximate five-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 USASAC database. Although the available data extended back to 1967, we restricted the data used in this analysis to 2011 - 2021 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 CBNFH. Other rivers used a captive broodstock program whereby fish were captured as age 1+ parr in the rivers and transported to CBNFH for culture until they matured and could be spawned in the hatchery. We made 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 PNB 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 $\left(S_{W,t}\right)$ was then

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

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

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

Results

Data were not available at press time to update analyses so these results represent spawning populations for 2021 (Table 2.4.1.1). Instantaneous population growth rates (µ) were near 0 and 95% confidence limits overlapped 0 for all SHRUs and the GOM DPS as a whole when we include all returning Atlantic salmon regardless of origin (Table 2.4.1.1). 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 (µ) that were less than 0 with the PNB SHRU being the lowest. The reason why the PNB 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 2.4.1.1. Instantaneous population growth rates (µ) and finite rate of increase of the population (λ- 0-<1) population decreases, 1 population stable, and > 1 population increases) by SHRU calculated using Sweka and Bartron method.

SHRU	**μ_{total}**	**μ_{wild}**	**λ_{total}**	**λ_{wild}**
Downeast Coastal	0.0380 (-0.0381, 0.1140)	-0.2851 (-0.3612, -0.2091)	1.0387 (0.9626, 1.1208)	0.7519 (0.6969, 0.8113)
Penobscot Bay	-0.0386 (-0.2133, 0.1360)	-0.6871 (-0.8617, -0.5124)	0.9621 (0.8079, 1.1457)	0.5030 (0.4224, 0.5990)
Merrymeeting Bay	0.0119 (-0.0556, 0.0794)	-0.3198 (-0.3872, -0.2523)	1.0120 (0.9460, 1.0826)	0.7263 (0.7770, 0.01114)
Gulf of Maine	**-0.0305 (-0.1914, 0.1304)**	**-0.6112 (-0.7720, -0.4503)**	**0.9699 (0.8258, 1.1392)**	**0.5427 (0.4621, 0.6374)**

2.5 Spatial Structure of DPS

We evaluated the spatial structure of juvenile production at the USGS Hydrologic Unit Codes (HUC)-12 level to document the contributions of both wild spawners and stock enhancement efforts. The HUC-12 level provides a useful scale for determining the most likely habitats where wild spawning or egg planting and juvenile stocking contribute to Atlantic salmon occupancy. For Age-0 salmon, occupancy begins with alevins still in the gravel on 1 January that were a product of redds documented the previous November. Managers supplement occupancy by: 1) planting eggs directly in the gravel in January and February, 2) stocking fry in May, and 3) stocking parr in October. These four sources contribute to a single naturally-reared cohort of the GOM DPS. To summarize these contributions, we use georeferenced redd and stocking data to produce a series of maps that show the percent of habitat where juvenile salmon are likely rearing in river nursey areas (termed "occupancy") at the HUC-12 level within each SHRU. These maps illustrate not only occupancy but also areas where habitat is underutilized, vacant, or status is uncertain. Combined, these georeferenced data: 1) prevent redd superimposition with egg planting, 2) reduce interaction of stocked fish with wild fish by buffering wild production reaches, and 3) allow spatial planning of stocking to optimize stocking locations. Additionally, these occupancy maps provides a tool for managers to evaluate likely salmon presence and compare to critical habitat maps or the atlas of juvenile rearing habitat for 2-3 cohorts. All input data were georeferenced and an occupancy model was developed using standard dispersal distances.

An important characteristic of GOM DPS Atlantic salmon populations is their dependence on conservation hatcheries (Legault 2005). Because most US salmon are products of stocking, it is important to understand the magnitude, types, and distribution of stocking inputs to understand juvenile spatial structure throughout Critical Habitat. Atlantic salmon hatcheries are operated by USFWS and the Downeast Salmon Federation (DSF). All egg takes occur at USFWS facilities operating as conservation hatcheries. Fish are collected from remnant local stocks within the GOM DPS, grown to maturity at the hatchery, and produce eggs or juveniles to stock back into their natal rivers. In some cases, donor populations are used to stock vacant Critical Habitat in the GOM DPS range to re-establish populations. For example, the Sandy River in the MMB SHRU has received donor stocking from the Penobscot and Dennys rivers. From a management perspective, rebuilding Atlantic salmon populations will require increasing natural production of smolts throughout all Critical Habitat. Examining the spatial contributions of multiple recruitment sources provides insights into 1) both spatial density of freshwater production and 2) occupied/unoccupied areas of the watershed. This approach also provides an information base to examine fish dispersal, optimal production areas, and site-specific stocking targets. Ultimately, these data should help facilitate management at a more refined spatial scale than an entire watershed and facilitate management actions at a sub-drainage (HUC12 or finer) level.

To document Wild Production Areas (WPAs), the geolocation of redds was used to delineate distributions. For this metric, the occupancy model assumes an upstream distribution of juveniles of 0.5 km upstream and 1 km downstream from each redd or cluster of redds - including adjacent tributary streams (Beall et al. 1994; Eisenhauer et al. 2021). Mapped WPAs are excluded from egg planting and stocking in the following year to minimize competition between wild and hatchery-origin juveniles. Additionally, in two years, these areas will be targeted for broodstock collection during electrofishing efforts to bring components of wild spawning into the captive reared brood program.

To document Hatchery Production Areas (HPAs), distributions were calculated for all hatchery products using the occupancy model assumption of juvenile dispersal of 0.5 km upstream and 1 km downstream from each egg planting location or stocking start/end locations. Egg-Planted Production Areas (EPA) are based on point positions of artificial redds and the standard diffusion model as used for WPA. Fry and parr stocked production areas (FPA or PPA) were based on linear distances stocked and dispersion from both the upstream and downstream apex of a stocking effort. By combining the four production types, we can estimate occupancy and percent of rearing habitat in a SHRU that is occupied. Additionally, the amount of vacant CH can be calculated (vacant CH = total CH – WPA – EPA- FPA-PPA). These values should be considered minimal occupancy areas because: 1) not all redds are counted; 2) assumptions on dispersion (although well supported in literature and with local data) need additional study; and 3) additional redd survey coverage is needed in larger watersheds. However, given the relatively high proportion of spawning habitat surveyed in active management areas and numeric and spatial demographic scope of hatchery products, these production areas are informative and meaningful metrics at the HUC-12 scale for managed areas.

2.5.1 Wild Production Areas – Redd Distributions of the 2022 Cohort

Redd survey coverage included 26 HUC-12s in autumn 2021 (Figure 2.5.1.1). This coverage was similar to previous years and surveys were focused on actively managed HUCs. Redds were found in 25 HUC-12s with the most in the DEC SHRU, where occupancy in 11 HUC-12s totaled 4,136 units. Seven HUC-12s had redds in both MMB SHRU (seeding 2,375 units) and PNB SHRU (seeding 2,459 units). Within these SHRU, occupancy was highest in DEC averaging 25% of rearing habitat per HUC-12 followed by MMB with an average of 16% (Figure 2.5.1.1). In PNB, occupancy averaged only 10% but redd surveys were focused only on the Piscataquis River (Figure 2.5.1.1). In DEC SHRU, where redd surveys consistently exceed 80% spatial coverage annually, estimates of wild production areas most accurately represent overall production. In MMB, coverage is similar as actively managed areas - the Sheepscot and Sandy Rivers (Figure 2.5.1.1). In PNB SHRU, escapement is more variable spatially due to a broad distribution of egg planting and fry stocking and difficulties monitoring natural production across four large sub-basins. As such, while provided for context, the PNB occupancy may underrepresent wild production and more work is needed to understand better potential wild contributions.

2.5.2 Freshwater Cohorts and Hatchery Production Units in 2022

Egg planting occurred in 10 HUC-12s in 2022, all of which were in MMB. Seven HUC-12s were in the Sandy River and three in the Sheepscot River (Figure 2.5.2.1; Table 2.5.1). The occupancy in the Sheepscot averaged 29% across the three areas planted (977 units) and the Sandy averaged 28% (4,386 units). Fry stocking occurred in all three SHRUs (Figure 2.5.2.2) across 25 HUC-12s (Table 2.5.1). In the DEC area, 16 HUC-12s were stocked (7,349 units) with an average occupancy of 42% (Figure 2.5.2.2). In PNB, six HUC-12s were fry stocked (1,348 units) with an occupancy averaging 10%. The PNB stocking focused mostly in the Piscataquis or lower Penobscot sub-drainages (Figure 2.5.2.2). In MMB, all fry stocking was in the Sheepscot River across three HUC-12s (229 units) with an average density of 7%. Autumn parr stocking occurred primarily in the DEC SHRU with eight HUC-12s receiving parr (4,231 units) and an average occupancy of 40% (Figure 2.5.2.3). Additionally, about 13,500 parr were stocked in the Sheepscot River across two HUC-12s, supplementing 412 units at average occupancy of 14%.

In aggregate, 45 HUC-12 units had documented wild production or hatchery supplementation. Twenty-six HUC-12 units had only one source of production (sources are wild, egg planted, fry stocked or parr stocked). HUC-12s with more than one source numbered 14 with two, four with three, and only on HUC-12 (Clary Lake-Sheepscot River) had all four strategies used. These stocking efforts are designed to have minimal spatial overlap with each other and wild production. For example, in the Sheepscot River parr stocking is spatially distant from other reaches within a HUC-12. Similarly, in the Narraguagus River, fall parr are stocked in wider mainstem habitat while fry stocking is focused in tributary streams.

By organizing these data spatially, the USASAC is providing a resource to refine occupancy assessments to targeting areas to conduct juvenile assessments to increase efficiency and lead to a better understanding of dispersion metrics. The next steps of spatial stock assessment would work towards integrating density based on redd densities, stocking rates, juvenile abundance, and other sources. Independent efforts to look at climate resilience could then be merged with a spatial assessment to manage Atlantic salmon habitat, hatchery supplementation, and passage priorities to support salmon conservation now and in the future.

2.5.3 Wild Production Areas in 2022: 2023 Wild Cohort

Redd survey coverage included 29 HUC-12s in 2022 (Figure 2.5.3.1; Section 3). This coverage was similar to previous years and surveys are focused on actively managed HUCs. Redds were found in all but one HUC-12 surveyed. Dispersion from these redds and WPA for 2023 cohort will be presented in next year's annual report. These data will be used to inform all stocking activities in 2023.

Table 2.5.1. Summary of number of HUC-12 units in 2022 where occupancy was documented for Wild Production Areas (WPA) and hatchery production areas for each hatchery product that results in natural production in a river. Note: because sources overlap in some HUC-12 units, the total below (70) exceeds the aggregate total (45) described above. Abbreviations: EPA = Egg-Planted Production Area, FPA = Fry Stocked Production Area and PPA = Parr Stocked Production Area,

SHRU	**WPA**	**EPA**	**FPA**	**PPA**
Downeast Coastal	11	0	16	8
Penobscot Bay	7	0	6	0
Merrymeeting Bay	7	10	3	2
Gulf of Maine DPS	**25**	**10**	**25**	10

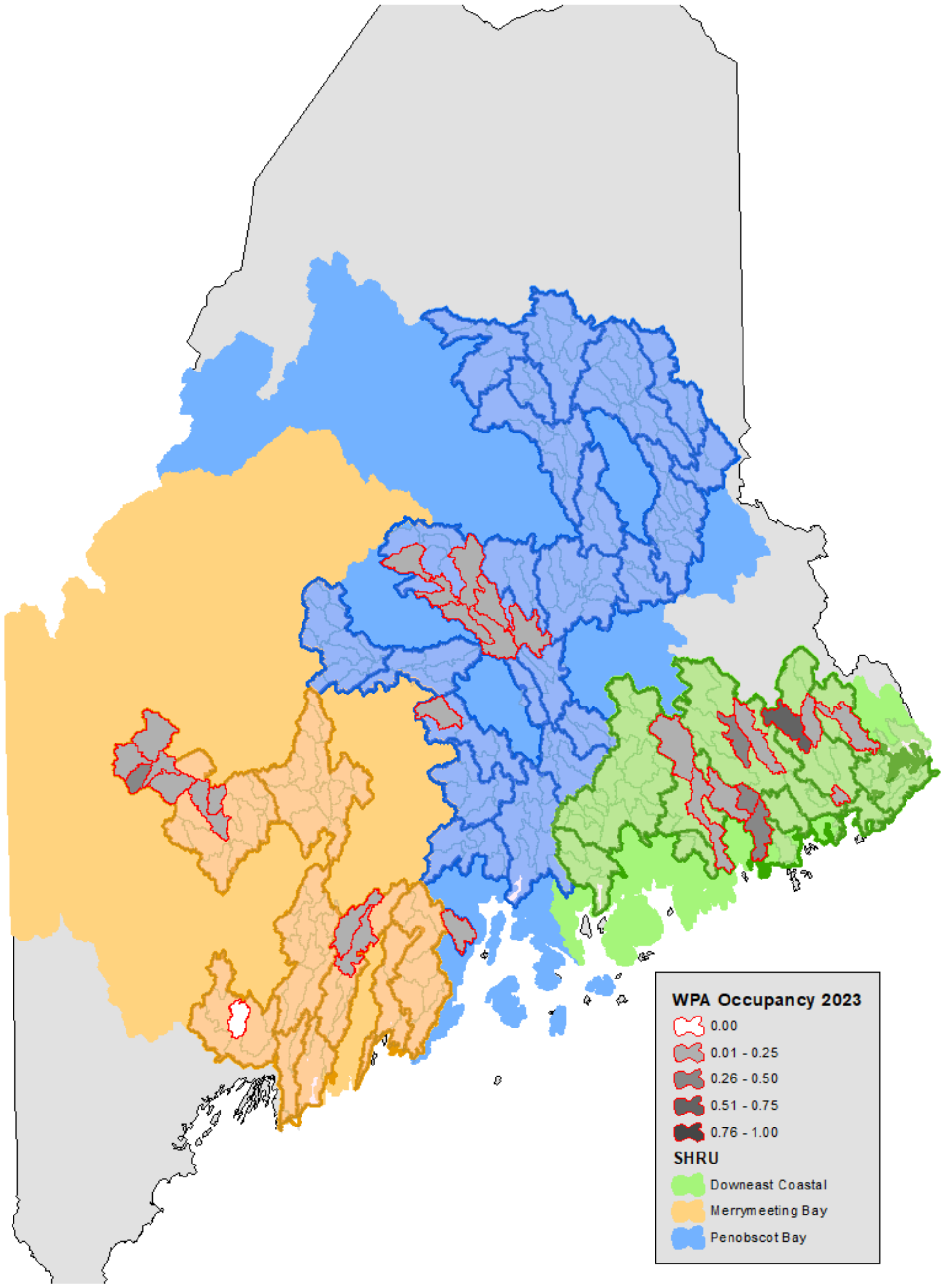

Figure 2.5.1.1.Wild Production Areas 2023. Map highlighting known spawning activity in 2022 at a HUC-12 watershed summary level that visualizes occupancy in HUC-12 units where redd surveys were conducted (red outline of HUC denotes redd surveys conducted.

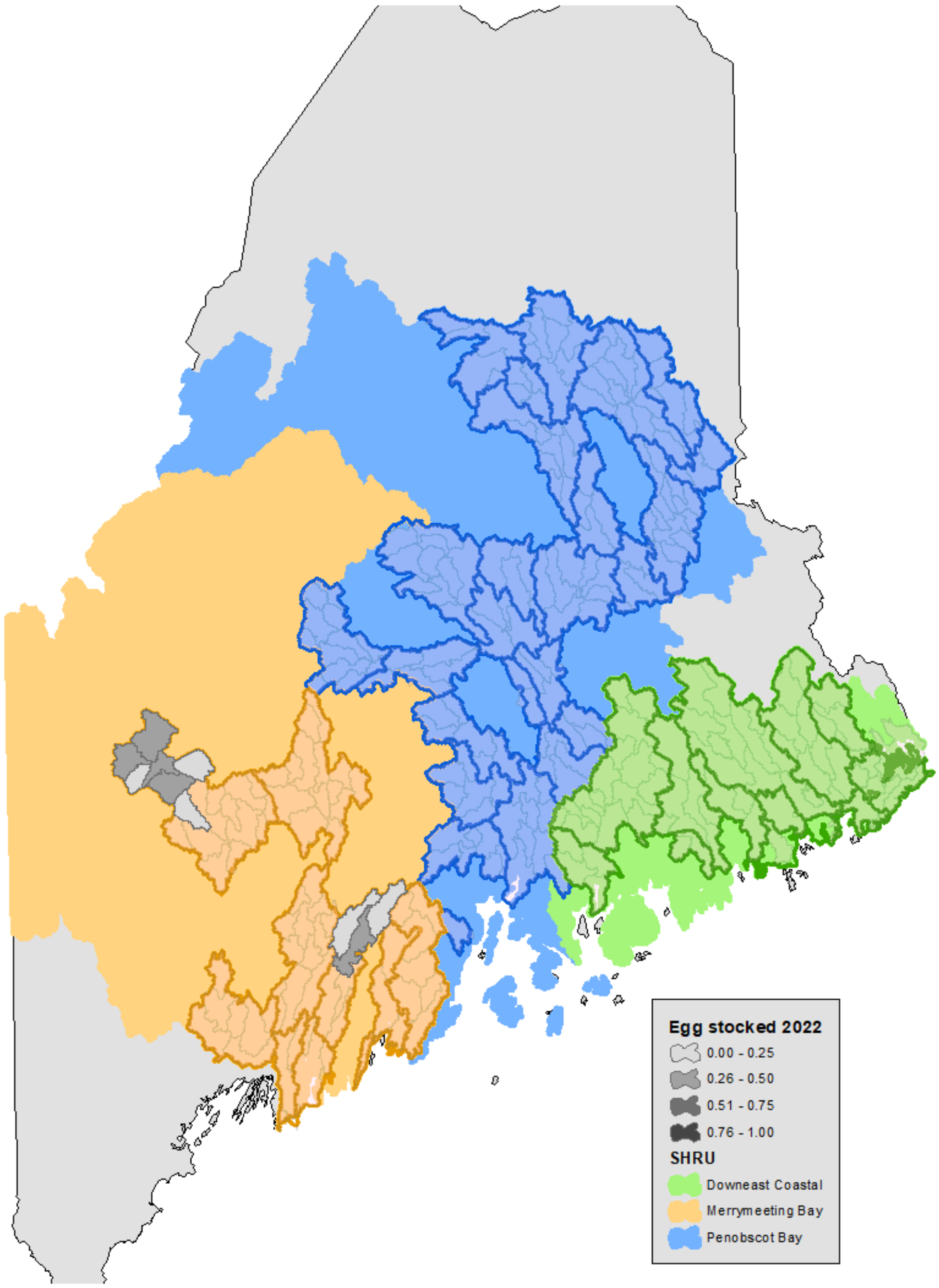

Figure 2.5.2.1 Egg Production Areas. Map highlighting HUC-12 watershed to visualize where egg planting was used and occupancy within each HUC-12 of this life stage in the 2022 year class

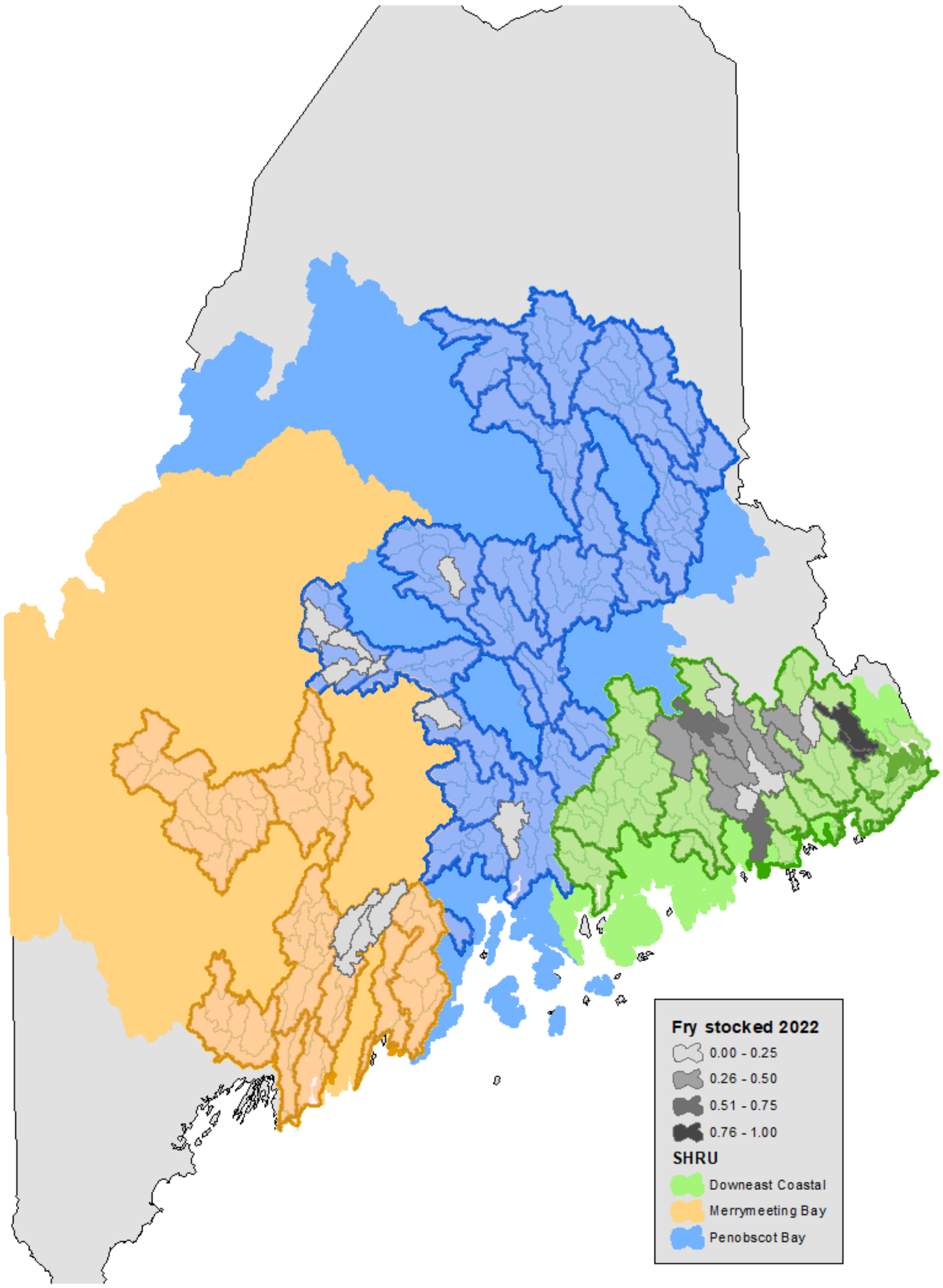

Figure 2.5.2.2 Fry Production Areas. Map highlighting HUC-12 watershed to visualize where fry stocking was used and occupancy within each HUC-12 of this life stage in the 2022 year class (see Table 2.5.1).

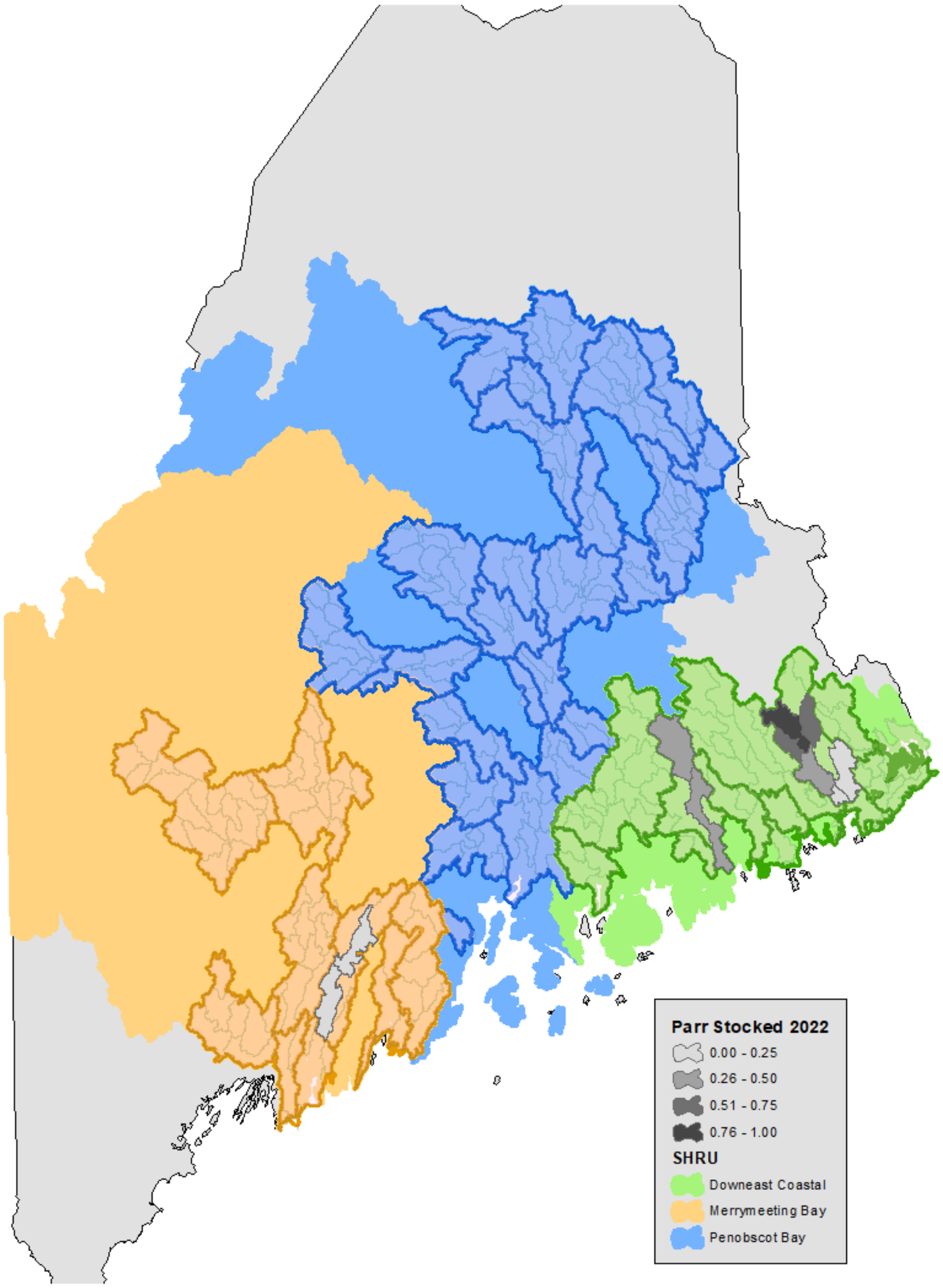

Figure 2.5.2.3 Parr Production Areas. Map highlighting HUC-12 watershed to visualize where fry stocking was used and occupancy within each HUC-12 of this life stage in the 2022 year class (see Table 2.5.1).

2.6 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 N_e has been used to identify minimal targets necessary to maintain adequate genetic variance for adaptive evolution in quantitative traits (Franklin and Frankham 1980), or as the lower limit for a wildlife population to be genetically viable (Soulé 1987). Estimation of N_e in Atlantic salmon is complicated by a complex life history that includes overlapping generations, precocious male parr, and repeat spawning (Palstra et al. 2009). Effective population size is measured on a per generation basis, so counting the number of adults spawning annually is only a portion of the total N_e for a population. In Atlantic salmon, Palstra et al. (2009) identified a range of N_e to *N* ratios from 0.03 to 0.71, depending on life history and demographic characteristics of populations. Assuming 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 five years. Although precocious male parr can reproduce and be included in estimates of the number of adult spawners, Palstra et al. (2009) determined that reproduction by male Atlantic salmon parr makes a limited contribution to the overall N_e for the population.

For the GOM DPS 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 eight extant stocks, seven are in the conservation hatchery program. The Penobscot River is supported by capture at Milford Dam of returning sea-run adult broodstock (1 – 2 years at sea), which are transported to CBNFH for spawning. Domestic broodstock maintained at GLNFH also supports enhancement efforts in the Penobscot and Kennebec rivers. This product is created annually by offspring from the spawned sea-run adults from CBNFH. Six other populations also have river-specific broodstocks but these collected as parr after 18+ months of river exposure. These parr resulted from limited natural reproduction or stocked fry/eggs. Most fish are released in river of broodstock collection but the Penobscot broodstock typically serves as a sole donor stock for the Sandy/Kennebec River.

2.6.1 Allelic Diversity

Allelic diversity of a population is obtained by computing the mean number of unique alleles per locus. We monitor 18 variable microsatellite loci to characterize genetic diversity for all individuals considered for use in broodstocks (Figure 2.6.1.1). 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 CBNFH. Annual characterization allows for comparison of allelic diversity among broodstocks and years. This year's characterization added in parr broodstock collected 2020 and sea-run broodstock collected in 2022. Based on 18 loci, the average number of alleles per locus ranged from 10.69 alleles per locus for the Pleasant River to 13.34 alleles per locus for the Penobscot River (Figure 2.6.1.1). This characterization also enables screening for individuals that originated from the aquaculture industry or landlocked salmon populations and avoid their use as broodstock.

2.6.2 Observed and Expected Heterozygosity

Observed heterozygosity is "the number of heterozygotes as a proportion of the total individuals typed", whereas expected heterozygosity is "the proportion of heterozygotes expected from the allele frequencies under random mating, based on Hardy-Weinberg equilibrium" (Frankham et al. 2017). Both metrics are estimated for each broodstock for 2020 collection year parr and 2022 collection year Penobscot adult returns. Average estimates of expected heterozygosity based on 18 microsatellite loci (starting in 2008) ranged from 0.670 in the East Machias to 0.687 for the Penobscot broodstock. Observed heterozygosity estimates of broodstocks based on 18 loci ranged from 0.681 in the Machias to 0.708 in the Penobscot.

2.6.3 Effective Population Size

Estimates of effective population size, based on 18 loci, vary both within broodstocks over time, and between broodstocks. Estimates are obtained using the linkage disequilibrium method that incorporates bias correction found in Ne Estimator (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 2018 collection year was estimated for the Dennys broodstock (N_e =72.2, 59.5-88.4 95% CI), and the highest was observed in the East Machias broodstock (N_e =117.5 (94.3-149.8 95% CI). N_e estimates fluctuate annually (Figure 2.6.3.1). So, beginning with 2008, average N_e across the parr-based broodstocks ranges from N_e=70.3 in the Dennys to N_e =137.0 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 maximum N_e =546.5 (465.8-650.7 95% CI) in 2017 to the low N_e =287.6 in 2009 (265.7-312.0 95% CI), with an average N_e =408.7. The N_e estimate for the 2022 return the broodstock falls below the average, N_e = 346.7 (295.7-412.0 95% CI).

2.6.4 Inbreeding Coefficient

The inbreeding coefficient (F) is used to measure the degree of inbreeding and represents the probability that two alleles at a given locus within an individual come from a common ancestor. Inbreeding coefficients are an estimate of the fixation index. An individual that is not inbred will have F = 0, and an inbred individual will have F = 1 (Kalinowski et al. 2012; Frankham et al. 2017). Estimates in the 2020 parr collection year ranged from -0.025 in the Narraguagus River to -0.051 in the Dennys River. The 2022 collection year for the Penobscot had an estimated inbreeding coefficient of -0.042.

2.6.5 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. There are concerns about slightly lower estimates of allelic diversity in the Dennys, Sheepscot, and Pleasant relative to the other broodstocks and observed declines in the Machias broodstock. 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 and declining estimates of effective population size in the Penobscot River should continue to be monitored, as they indicate that populations are at a risk for loss of genetic diversity.

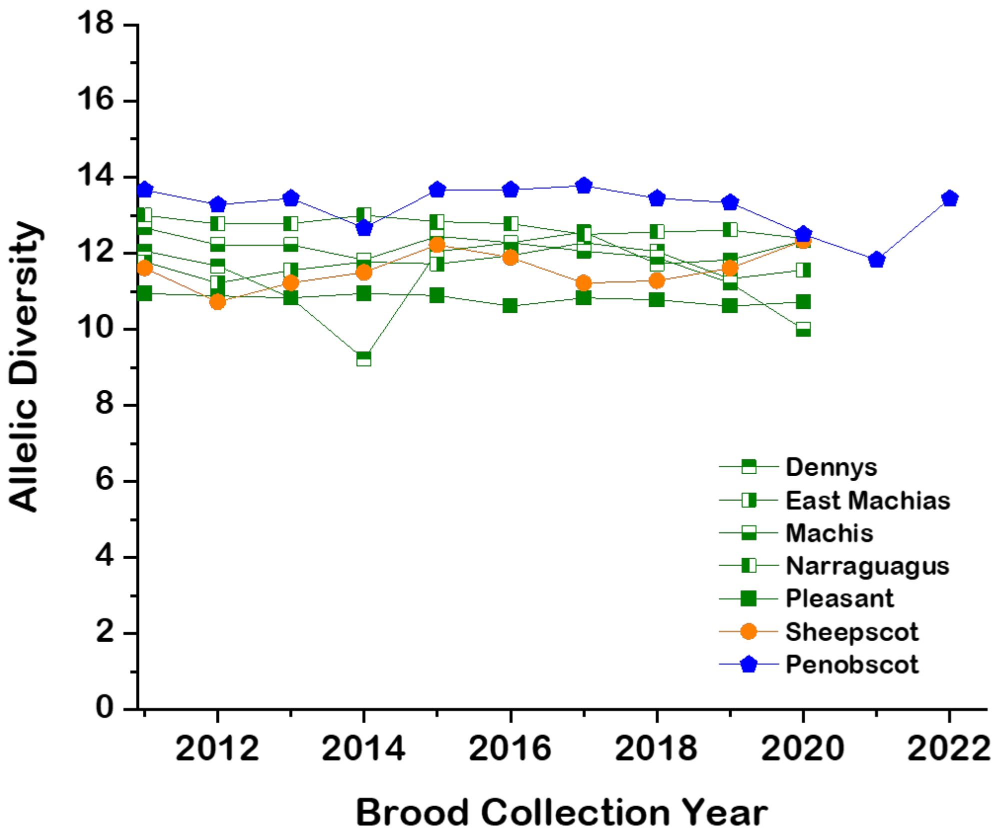

Figure 2.6.1.1. Allelic diversity time series for GOM DPS salmon populations, measured from 18 microsatellite loci (DE- Dennys, EM-East Machias, MA- Machias, NA-Narraguagus, PN-Penobscot, PL-Pleasant, SH-Sheepscot populations).

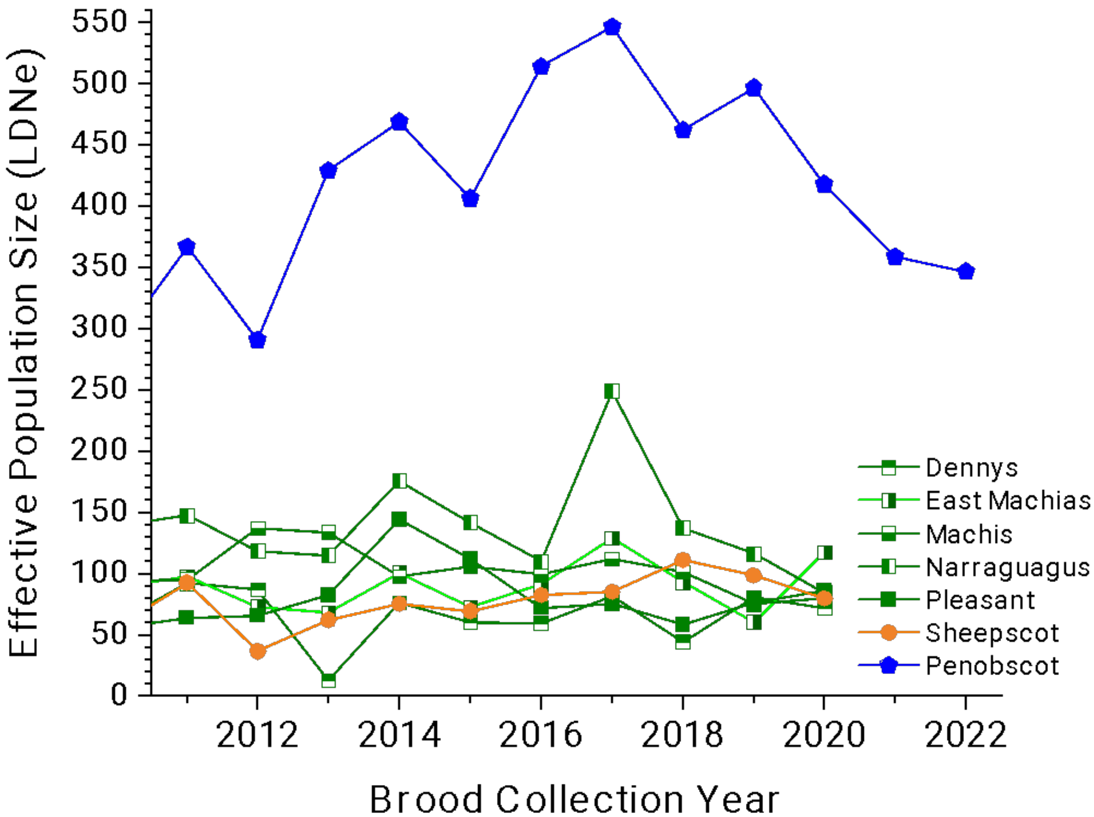

Figure 2.6.3.1 Time series of effective population size for seven GOM DPS distinct individual populations. Estimates for the parr-based broodstock populations approximate the number of breeders, since estimates are obtained from primarily a single cohort, and are sampled as juveniles (parr), from each 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).

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3 Gulf of Maine

Summary

Documented adult Atlantic salmon returns to rivers in the geographic area of the Gulf of Maine (GOM) Distinct Population Segment (DPS; collectively known as the GOM DPS; 73 FR 51415-51436) (NMFS 2009) in 2022 was 1,520 salmon (Table 3.1.). Returns are the sum of counts at fishways and weirs (1,447) and estimates from redd surveys (73). 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.

Escapement to these same rivers in 2022 was 1,313 salmon (Table 3.2). 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 and released as kelts are not included), stocked pre-spawn adults, and recaptured downstream telemetry fish.

Naturally reared population growth rates to the DPS have varied since 1990 although the rate has been somewhat consistent since 1997 with a mean growth rate of 0.90, (Figure 3.1). Most of these were two Sea-Winter (2SW – two years at Sea) salmon that emigrated as 2-year-old smolts, thus, cohort replacement rates are calculated assuming a five-year lifespan. To show sustained improvement, population growth is observed for at least two generations (10 years). The 10-year geometric mean naturally reared growth rate for the period 2013 to 2022 is 0.98 (0.58 – 1.64) for the DPS. Dividing this further by Salmon Habitat Recovery Unit (SHRU), Merrymeeting Bay at 1.39 (0.89 – 2.17) saw the largest growth rate, Penobscot Bay was 1.03 (0.50 -2.12) and Downeast Coastal was 0.79 (0.50 – 1.24). This indicates that the DPS has been hovering right around replacement. It is likely that consistent annual stocking rates have helped maintain the replacement rate and variations are due to marine survival. Naturally reared returns are still well below 500 (Figure 3.2). For more detail on population growth rates, see Section 2.3 above.

Table 3.0.1. Returns to the Gulf of Maine in 2022 for each of the Salmon Habitat Recovery Units (SHRUs). Counts are from fishway traps at dams or redds based estimates from spawner surveys. Age and origins are prorated based on observed catches at traps, cohort specific catches at smolt traps or historical age ratios. Abbreviations: SHRUs - Downeast Coastal (DEC); Penobscot Bay (PNB) and Merrymeeting Bay (MMB); Sea-Winter Abbreviations (how many winters at sea fish spent): 1SW = One Sea-Winter, or Grilse, 2SW = two Sea-Winter, 3SW = Three Sea-Winter).

SHRU	Drainage	Method	1SW - Hatchery	2SW - Hatchery	3SW - Hatchery	Repeat Spawner - Hatchery	1SW - Naturally Reared	2SW - Naturally Reared	3SW - Naturally Reared	Repeat Spawner - Naturally Reared	Total Hatchery	Total Naturally Reared	Grand Total
DEC	Dennys	Redd	0	0	0	0	1	5	0	0	0	6	6
DEC	East Machias	Redd	3	13	0	0	0	1	0	0	16	1	17
DEC	Machias	Redd	0	0	0	0	2	8	0	0	0	10	10
DEC	Pleasant	Redd	0	0	0	0	4	17	0	0	0	21	21
DEC	Narraguagus	Redd	0	1	0	0	7	11	0	0	1	18	19
DEC	Union	Trap	0	0	0	0	0	0	0	0	0	0	0
PNB	Penobscot	Trap	308	909	6	5	0	94	2	0	1,228	96	1,324
PNB	Kenduskeag	Redd	0	0	0	0	1	4	0	0	0	5	5
PNB	Souadabscook	No Survey	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
PNB	Cove Brook	Redd	0	0	0	0	0	0	0	0	0	0	0
PNB	Duck Trap	Redd	0	0	0	0	1	4	0	0	0	5	5
MMB	Sheepscot	Redd	1	4	0	0	1	3	0	0	5	4	9
MMB	Kennebec	Trap	34	12	0	0	2	39	0	0	46	41	87
MMB	Androscoggin	Trap	8	9	0	0	0	0	0	0	17	0	17
		Totals	354	948	6	5	19	186	2	0	1,313	202	1,520

Table 3.0.2. Sea-run returns versus escapement in 2022 by Salmon Habitat Recovery Units (SHRUs) and drainages. Salmon are counted either at trapping facilities or using a redds based estimate. Escapement is the total returns and pre-spawn adults into a drainage, minus broodstock and dead on arrival salmon. SHRU abbreviations: DEC = Downeast Coastal; PNB = Penobscot Bay and MMB = Merrymeeting Bay.

Method	SHRU	Drainage	Returns	Brood Stock	DOA	Escapement	Captive Pre-Spawn	Sea-run Pre-Spawn	Total Escapement
Estimate	DEC	Dennys	6	0	0	6	0	0	6
Estimate	DEC	East Machias	17	0	0	17	0	0	17
Estimate	DEC	Machias	10	0	0	10	40	0	50
Trap	DEC	Narraguagus	19	0	0	19	0	0	19
Estimate	DEC	Pleasant	21	0	0	21	0	0	21
Trap	DEC	Union	0	0	0	0	0	0	0
Trap	MMB	Androscoggin	17	0	0	17	0	0	17
Trap	MMB	Kennebec	87	0	0	87	0	0	87
Estimate	MMB	Sheepscot	9	0	0	9	0	0	9
Estimate	PNB	Cove Brook	0	0	0	0	0	0	0
Estimate	PNB	Ducktrap River	5	0	0	5	0	0	5
Trap	PNB	Penobscot	1,324	557	3	764	305	8	1,077
Estimate	PNB	Kenduskeag	5	0	0	5	0	0	5
-	-	-	1,520	557	3	960	345	8	1,313

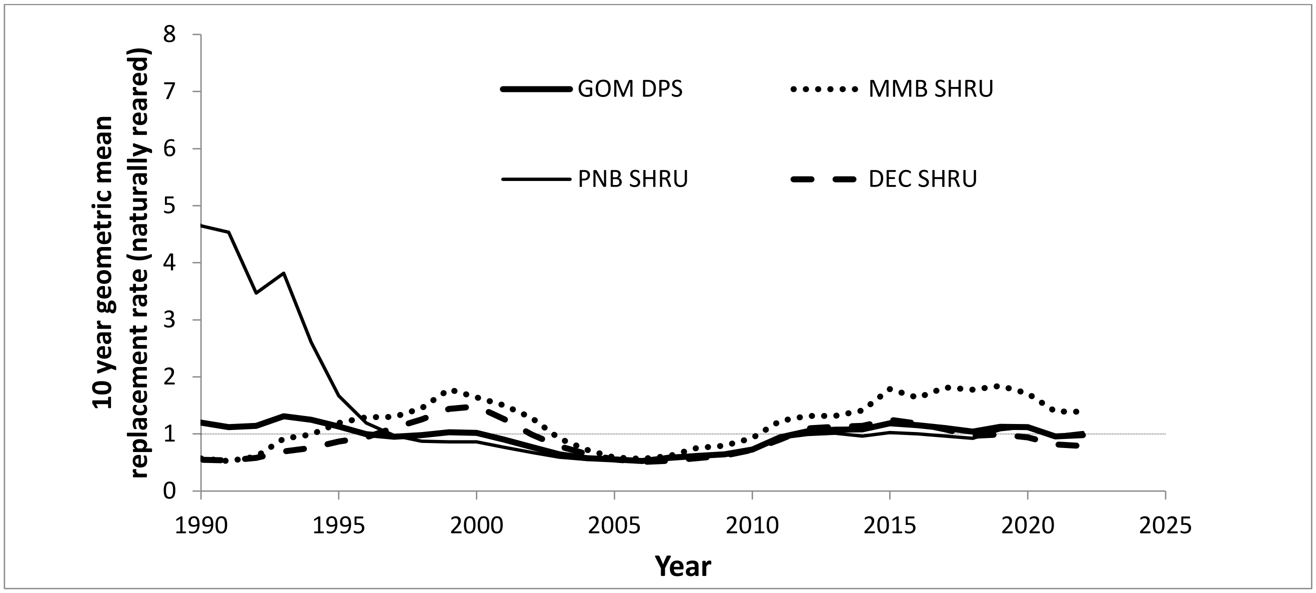

Figure 3.0.1. Ten-year geometric mean of replacement rate for returning naturally reared Atlantic salmon in the Gulf of Maine (GOM) Distinct Population Segment (DPS) and the three Salmon Habitat Recovery Unit (SHRU) 1990 to 2022. SHRU abbreviations: PNB = Penobscot Bay, MMB = Merrymeeting Bay and DEC = Downeast Coastal

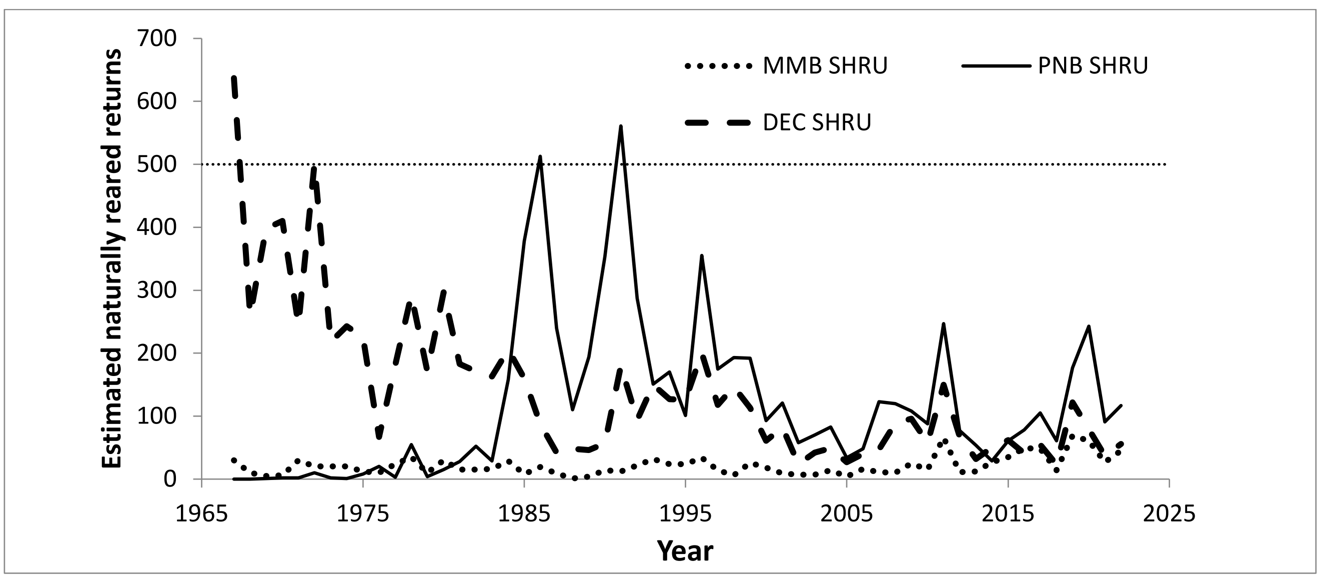

Figure 3.0.2. Estimated Naturally Reared Returns to the Gulf of Maine 1965 to 2022. Naturally reared refers to the egg, fry, and 0+ parr lifestages. Salmon Habitat Recovery Unit (SHRU) abbreviations: PNB = Penobscot Bay, MMB = Merrymeeting Bay and DEC = Downeast Coastal.

3.1 Adult returns and escapement

3.1.1. Merrymeeting Bay

Androscoggin River

The Brunswick fishway trap was operated from 29 April to 15 November 2022 (Table 3.1.1.1.) by a combination of Maine Department of Marine Resources (MDMR) and Brookfield Renewable Partners (BRP) staff. Seventeen adult Atlantic salmon were passed at the Brunswick fishway trap. These consisted of eight (47.0%) hatchery reared grilse and nine (53.0%) hatchery reared 2SW adults (Table 3.0.1.). One hatchery grilse was recaptured. Due to the proximity of the Androscoggin River to several other trapped rivers, adults that are handled at this facility are marked differently from other rivers with an upper caudal punch in order to identify strays from recaptured salmon. Biological data were collected from 13 trap-captured returning Atlantic salmon in accordance with MDMR protocols, and the presence of marks and tags were recorded.

Pro-ration of data for Androscoggin returns to Brunswick Fishway

On the mainstem Androscoggin River, adult Atlantic salmon are sampled and biological data collected from each fish prior to passing into the head pond. Typically, when sampling fish, eight-to-10 scales are taken as part of the standard biological sampling. However, sometimes these scales are partially or completely unreadable due to regeneration. Other common reasons for not handling Atlantic salmon at Brunswick include sampling protocols temperature cut-offs preventing biologists from collecting scale samples over 23°C and Atlantic salmon are documented passing upstream during cleaning and maintenance procedures. In 2022, scale samples from two Atlantic salmon were regenerated and unreadable in the freshwater portion of the scales, all sea ages were readable (Table 3.1.1.2.). Three Atlantic salmon were not sampled due to passing during cleaning/maintenance and temperature cut-offs (Table 3.1.1.3.). Of the two that were sampled but had regenerated scale samples, the sea ages were readable: one was a one Sea-Winter (1SW or grilse – spending one year at sea) and the other a 2SW. Of the three salmon that were not sampled all were recorded via video. The fork length of one was estimated as shorter than 63cm (prorated as 1SW) and the other two were estimated as longer than 63cm (prorated as 2SW). Of the eleven 1SW and 2SW salmon that were aged, 100% were of hatchery (smolt stocked) origin. Therefore, all five were determined to be of hatchery origin.

Table 3.1.1.1. Corresponding date, sex (M = Male, F = Female and G = Grilse or 1SW salmon), fork length, dorsal score, sea-winter age data for adult salmon with unknown age/origin captured or viewed at Brunswick Fishway on the mainstem Androscoggin River. Final prorated sea-winter age/freshwater age/origin assignments are listed. Abbreviations: Sex (M = Male, F = Female and G = Grilse or 1 Sea-Winter salmon) and Origin (H = Hatchery, W = Wild).

Date Captured	Sex	Fork Length (cm)	Dorsal Score	FW age	SW age	Prorated Origin	Prorated FW age
31-May	M	74	2	-	2	H	H
14-Jun	G	53.8	3	-	1	H	H
21-Jun	G	53.3	3	-	Prorated – 1	H	H
8-Jul	F	79	1	-	Prorated – 2	H	H
12-Jul	F	76.2	1	-	Prorated - 2	H	H

Because salmon can go undetected through the fishway at Brunswick during maintenance/cleaning, a minimal redd count effort was conducted. One small section of the Little River where redds have been documented in past years were surveyed for redd presence, totaling 0.23 river kilometers covered, but zero redds were observed in 2022 (Table 3.1.3.1.).

Kennebec River

The Lockwood Dam fish lift was operated by BRP staff from 1 May to 31 October 2022. Eighty-seven adult Atlantic salmon were captured at the lift (Table 3.0.1.). Of these salmon captured, 2SW salmon accounted for 59% of the returns and 1SW salmon the remaining 41%. For 2SW returns, 39 were naturally reared and 12 were hatchery origin. For 1SW returns, two were naturally reared origin and 34 were hatchery reared origin. The hatchery reared origin returns were likely from stocked smolts raised at the Nashua National Fish Hatchery in New Hampshire. Hatchery origin salmon made up 53% of returns to the Kennebec with naturally reared salmon making up the remaining 47%.

Pro-ration of data for Kennebec returns to Lockwood Fishlift

Biological data and samples are typically collected from each salmon prior to transporting the fish to the Sandy River. When sampling fish, eight-to-10 scales are taken as part of the standard biological sampling, however sometimes these scales are partially or completely unreadable due to regeneration. In 2022, scale samples from seven Atlantic salmon were regenerated and unreadable in the freshwater portion of the scales, all sea ages were readable. Ages for the salmon scales read were the following: two salmon were 2SW and five were 1SW (Table 3.1.1.3.). Of the 2SW salmon that were aged, 86.36% were determined to be of wild or naturally reared origin and 13.64% were of hatchery (smolt stocked) origin (Table 3.1.1.3.). Since there was such a small number of 2SW fish that needed to be pro-rated, dorsal scores were taken into consideration. Dorsal erosion is a common indicator of hatchery rearing due to fin wear in hatchery pools. Dorsal scores were as follows: 0 (pristine fin with no erosion) and 3 (fin with considerable erosion, to the point of fin missing). Therefore, the 2SW fish with a dorsal score of 0 was deemed wild, and the other with a dorsal score of 3 was deemed of hatchery origin (Table 3.1.1.3.). The prorated wild fish was given a freshwater age of 2 because 71% of the aged wild fish had a freshwater age of 2. Of the 1SW salmon that were aged, 6.45% were determined to be of wild or naturally reared origin and 93.55% were of hatchery (smolt stocked) origin (Table 3.1.1.3.). Of the five 1SW, 4.68 (rounded to five) of them were assigned as hatchery origin. Dorsal scores could have been considered in this determination since one had a dorsal score of 0, one of 1, one of 2 and 2 of three, but about 10% of the grilse with known ages had a dorsal score of 0, so it was not a good indicator for this group (Table 3.1.1.3.).

Table 3.1.1.2. Returning adult salmon to Lockwood Fish lift and corresponding date, sex, fork length, dorsal score, sea-winter age data. Final pro-rated freshwater age/origin is provided. If origin is Hatchery then the freshwater age will be noted as H. Abbreviations: Sex (M = Male, F = Female and G = Grilse or 1 Sea-Winter salmon) and Origin (H = Hatchery, W = Wild).

Date Captured	Sex	Fork Length (cm)	Dorsal Score	FW age	SW age	Prorated Origin	Prorated FW age
2-Jun	M	73	3	-	2	H	H
3-Jun	M	73	1	-	2	W	2
18-Jun	G	50	1	-	1	H	H
20-Jun	G	54	3	-	1	H	H
22-Jun	G	57	0	-	1	H	H
8-Jul	G	55	3	-	1	H	H
8-Jul	G	54	2	-	1	H	H

Table 3.1.1.3. Ratios used to determine origin of each age class of Sea-Winter (SW) returns of Atlantic salmon of unknown origin/ freshwater age on the mainstem Kennebec River at Lockwood Fishlift. Five 1SW and two 2SW Atlantic salmon were prorated using these ratios. 1SW ratios are based on 31 in season captures of known age/origin. 2SW ratios are based on 44 in season captures on known age/origin.

Sea age	Count	Hatchery	Wild
1SW - Known %	31	93.55%	6.45%
1SW - Pro-rated proportion	**5**	**4.68**	**0.32**
2SW – Known %	44	13.64%	86.36%
2SW - Pro-rated proportion	**2**	**0.27**	**1.73**

Spawning surveys were limited to the Sandy River, Togus Stream and Bond Brook. Forty redds were observed in the Sandy River and none in Bond Brook or Togus Stream. A total of 87.35 river kilometers were surveyed which covered 23.74% of the surveyed spawning habitat in the Kennebec River drainage. Sandy River surveys covered 59.51 river kilometers and 64.92 of the spawning habitat. Togus Stream surveys covered 10.49% of the spawning habitat and the Bond Brook surveyed covered 86.26% of the spawning habitat (Table 3.1.3.1).

Sebasticook River at Benton Falls fish lift facility was operated by MDMR staff from 01 May to 01 November 2022. Five Atlantic salmon were captured; all were pro-rated as hatchery reared 2SW as they are not handled at this facility. (Table 3.1.1.4).

Pro-ration of data for Sebasticook returns to Benton Falls Fishway

On the Sebasticook River, five adult Atlantic salmon were viewed at the Benton Falls fishway (Table 3.1.1.4.). None of the salmon were handled, but data is taken visually through a viewing window. Given that the hatchery smolts are stocked right at the confluence of the Sebasticook and Kennebec Rivers and there is no Atlantic Salmon supplementation program for the Sebasticook River, and no salmon have been viewed at this fishway for years, but multiple salmon are showing up on the first year of smolt stocking returns; these fish are likely returns from the Kennebec smolt stocking program. As further evidence, the average dorsal score of all five adults was 1.6 which is higher than the average 2SW hatchery score at Lockwood fish lift. All salmon passed were estimated to be larger than 63cm, therefore prorated as 2SW.

Table 3.1.1.4. Corresponding date, sex, estimated fork length, and dorsal score for adult salmon with unknown age/origin at Benton Falls fishway on the Sebasticook River. Final prorated ages/origins are listed.

Date Captured	Sex	Fork Length (cm)	Dorsal Score	FW age	Prorated SW age	Prorated Origin	Prorated FW age
5-May	F	69	1	-	2	H	H
23-May	F	72	2	-	2	H	H
31-May	M	69	1	-	2	H	H
8-June	M	67	2	-	2	H	H
29-June	M	74	2	-	2	H	H

Sheepscot River

There were five redds observed in the Sheepscot River; four were observed in the mainstem and one was observed in the West Branch. A total of 59.71 river kilometers were surveyed which contained 79.61% of the spawning habitat in the drainage (Table 3.1.3.1.). The Redds Based Returns model estimate was nine (3 – 24; Table 3.1.3.2.).

3.1.2 Penobscot Bay

Penobscot River

The fish lift at the Milford Hydro-Project, owned by BRP, was operated daily by MDMR staff from 15 April through 15 November. Biological data including length, sex, scales, genetics, and injury assessment were collected on all fish handled and released. Fish were only handled five days a week (Monday through Friday) due to available staffing and only handled under 23°C per MDMR handling protocols for fish safety. The fish lift was also used to collect adult sea-run Atlantic salmon broodstock for the U.S. Fish and Wildlife Service (USFWS). Biological data was collected by USFWS staff on all broodstock and provided to MDMR. This allows for broodstock collection at temperatures exceeding 23°C, as fish are not worked up until they are tempered below safe handling temperatures reducing stress on fish and redundant efforts between agencies. Fish were worked up on the day of capture when possible. In cases where workup was delayed (typically 1-2 days) multi – sea winter (MSW) vs Grilse size counts were maintained in daily catch data and were backfilled with data when workup was completed based on size and numbers. In addition to the Milford fish lift, BRP operated a fish lift daily at the Orono Hydro project. BRP staff identify MSW or Grilse by size and identify male or female if obvious, check for adipose clips (or punches), and scan for passive integrated transponder (PIT) tags. Fish captured at the Orono facility are trucked to the boat launch located in the Milford head pond just upstream of the Milford dam on the western shore. The counts of salmon collected at that facility are included in the Penobscot River totals.

A total of 1,324 sea-run Atlantic salmon returned to the Penobscot River (Table 3.0.1.). Scale samples were collected from 787 salmon captured in the Penobscot River and analyzed to characterize the age and origin structure of the run. In addition, video monitoring is conducted at the Milford Dam to aid in counts when environmental conditions warrant reduced handling, i.e., warm water temperatures. The origin, sex, and age of both 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, eight were 3SW (1%), 1,003 were age 2SW (76%), 308 were age 1SW (23%), and five were repeat spawners (<1%). Hatchery origin returns were 92% (1,217) of the returning salmon and the remaining 8% (107) were naturally reared origin (Table 3.0.1). No aquaculture suspect salmon were captured.

Spawner surveys in the Penobscot drainage were limited to the Piscataquis River, Cove Brook, Kenduskeag Stream and the Ducktrap River. In the Ducktrap 32.67% of spawning habitat and 1.99 of river km were surveyed (Table 3.1.3.1.). Two redds were observed. Additionally, during fall juvenile assessment work, Young-Of-the-Year (YOY) were found indicating there were returns to the Ducktrap in 2021. Subsequent search found the remnant of a redd co-located with these YOY. This redd was added to the redds database assigned to the 2021 redd year, as well as the addition of two adults, which were estimated as a result of this redds discovery, therefore, returns for the Ducktrap in 2021 (formerly 0). In Cove Brook, 46.22% of spawning habitat and 1.04 river km was surveyed. There were no redds observed in Cove Brook. In the Piscataquis Drainage a total 18.36 river km and 18.36% of the spawning habitat were surveyed. 64 redds were observed in Schoodic Brook a tributary to the Piscataquis River (Table 3.1.3.1.).

Proration of data for Penobscot origin adult Atlantic salmon.

Data and sample collection provide critical information for demographics of returning adults during a given year, but can be challenging and often left incomplete. Sample collection can be impacted in a variety of ways, including loss or damage (i.e., regenerated scales), or not collected due to environmental challenges (i.e., high temperatures) or lack of staffing. As a result, proration is done using existing data or sample collection to fill gaps of unknown variables. Many of the Atlantic salmon that are given a proration are not handled, which makes this task more difficult. Data sources such as video monitoring, observational data, etc. each come in different quality or conditions which can add an additional layer to assigning prorated data. The most common proration actions include assignments to the following variables: “Sex”, “Origin”, “Freshwater Age”, “Sea Age”, and “in-season recaptures”.

Sex proration

Proration of “Sex” occurs at the end of the season by analyzing observed data of fish handled at trapping facilities upon initial capture, as well as incorporating data obtained at the hatchery during spawning. These ratios are used to assign the remaining proportion of unknown/unhandled fish during the season. Known sex data on spawned broodstock is not exclusively used to generate the ratio since there are many reasons why a fish may be sent to the hatchery beyond broodstock sex ratio targets.

Origin proration

Proration of “Origin” occurs at the end of the season by analyzing scale samples, incorporating observed marks and/or tags, and fin condition data.

Freshwater Age proration

Salmon not assigned as hatchery fish “H” are given an assigned “Freshwater Age”. Proration of this field occurs at the end of the season by analyzing the scale data on fish handled and applying that ratio to unknown fish. Freshwater age proration occurs after origin has been prorated to naturally reared “W”. The freshwater age structure of all observed “W” fish is applied to the prorated “W” individuals in equal proportions.

Sea Age proration

Proration of "Sea Age" for returning adult Atlantic salmon is generally assigned by observed size with salmon < 63 cm assigned as 1SW and salmon > 63 cm assigned as 2SW or greater. These fish are observed via video or other means without handling the fish. Sea age for multi sea winter fish is based on previous scales collected and read to determine ratios and applied to unknown Sea Age fish. Fish that are noted as being potential three Sea-Winter (3SW) fish are assigned first and the remaining MSW subset is prorated as described.

<u>Recapture proration</u>

Because a proportion of returning salmon to the Penobscot are not handled but instead are counted using video and therefore not marked, it's important to estimate "video" recaptures to so as not to inflate estimates of returns to the Penobscot. However, obtaining a direct count of "recaptures" is more complicated without empirical data to make decisions. The method of enumeration, capture events, mortalities, broodstock, known marked fish, known unmarked fish, and known recapture events are recorded daily. The proportion of marked and unmarked fish that are captured and are observed via telemetry, PIT tag antennae, external tags, or visually observed are assumed to represent the overall catch on any given day and are used to inform on the capture events for fish of unknown status and prorate for recapture events. Only fish in the river are used to prorate counts, known removals (mortality, broodstock, etc.) are excluded from the population at large. Atlantic salmon reintroduced to the river (failure to pass disease screening, etc.) are once again considered in the population at large and included within the proration. Proration for in season recaps occurs by calculating a proration percentage based on a daily running total, using Microsoft Excel's integer function to calculate whole fish, excluding fractions of fish because sample rounding is biased low by rounding down, underestimating the total catch for the day.

There are four primary datapoints used in recapture calculations: total capture events, as well as number of: in season recaptures, known marked fish in the river and known unmarked fish in the river. Capture events are calculated by adding all the individual events in which fish were encountered minus any known mortalities which are no longer in the population at large. Recapture events were calculated by adding all the events in which it was clear that a fish had been previously handled. This includes visual observation of marks (adipose clip/punch), injuries observed, or documentation via Radio or PIT tag detection, or Floy tag observation.

Unmarked in river fish were calculated daily by subtracting fish that were marked on a day from the total number of fish observations on a given day as well as removing any recaptured fish captured that day from overall capture events.

New fish were calculated daily with the ratio of known marked fish and unmarked fish informing proration of unknown individuals. The beginning of the season is heavily represented because of favorable temperatures, with regular handling of fish and marks applied. Later in the season, with higher temperatures and reduced staffing,, prorated marks were included as part of the running total to inform estimated recapture events. At the end of each day, an estimated total of new fish versus recaptured individuals were used to calculate a running total by day feeding back into the calculation such that marked ratio of fish included prorated marks as the probability of incidence of recapture increases as the number of marked individuals at large in the population increases, or the recapture rate would have been underestimated.

3.1.3 Downeast Coastal

Dennys River

Three redds were observed in the Dennys River in 2022. Surveys covered 85.2% of the habitat and 37.83 km of stream (Table 3.1.3.1.). Surveys were not conducted in Cathance Stream due to flood conditions affecting visibility. Based on the Redds Based Returns model, estimated escapement was six (2 -18) (Table 3.1.3.2.).

East Machias River

Fourteen redds were counted during the 2022 redd surveys covering 78.81% (50.36 km) of known spawning habitat (Table 3.1.3.1.). This was the sixth 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 119,465 fall parr (2018) associated with the 2SW adult cohort. Based on the Redds Based Returns model, estimated escapement was 17 (6 - 43) (Table 3.1.3.2.).

Machias River

A total of six redds were counted in 2022. Surveys covered 59.26% of the habitat and 56.61 km of stream (Table 3.1.3.1.). Based on the Redds Based Returns model estimated escapement was 10 (4 – 26) (Table 3.1.3.2.).

Pleasant River

There were 21 redds recorded in 2022. This was large increase from previous years. Surveys covered 84.65% of the habitat and 22.70 km of stream (Table 3.1.3.1.). Based on the Redds Based Returns model estimated escapement was 21 (8 – 56) (Table 3.1.3.2.).

Narraguagus River

The Narraguagus Trap located at the Cherryfield ice control dam was operated from 26 April to 26 October 2022. Returns to the fishway trap (19) were like 2021 (21) indicating a return to base line production from only fry stocking as an enhancement tool. Redd surveys accounted for 18 redds with surveys covering 93.61% and 113.68 km of known spawning habitat (Table 3.1.3.1.). The trap count was used to document returns the Narraguagus because it was the same as the Redds based estimate and breakdown of age and origins are based on data collected at the trap. The Redds Based Returns model the estimated return was 19 (7 – 51) (Table 3.1.3.2.). Breakdown of returns are as follows: one 2SW Hatchery origin salmon representing 5% of the returns. There were seven 1SW (37%) and 11 naturally reared 2SW salmon (Table 3.0.1.).

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 2022. No salmon were captured in 2022. (Table 3.0.1.)

Table 3.1.3.1. Results of redd surveys by Salmon Habitat Recovery Unit (SHRU), Drainage and Stream for 2021. Effort is shown by both total kilometers surveyed and the proportion of the spawning habitat surveyed for

Drainage and individual stream. There is no habitat survey for the Androscoggin so no estimate of surveyed spawning habitat. Abbreviations for SHRUs: DEC = Downeast Coastal, MMB = Merrymeeting Bay and PNB = Penobscot Bay.

SHRU/Drainage	Stream Name	Redds	% Stream Spawn Habitat Surveyed	Stream Total KM surveyed
DEC/Dennys River	Dennys River	3	85.27	37.83
Dennys River Drainage Total	**All Surveyed**	**3**	**85.27**	**37.83**
DEC/East Machias River	Barrows Stream	5	100	2.18
DEC/East Machias River	Beaverdam Stream	0	100	6.38
DEC/East Machias River	Chase Mill Stream	0	100	1.89
DEC/East Machias River	Creamer Brook	0	40	0.37
DEC/East Machias River	East Machias River	4	63.12	12.25
DEC/East Machias River	Northern Stream	5	100	19.37
DEC/East Machias River	Seavey Stream	0	100	7.92
East Machias River Drainage Total	**All Surveyed**	**14**	**78.81**	**50.36**
DEC/Machias River	Crooked River	0	59.87	5.14
DEC/Machias River	Machias River	0	51.57	8.72
DEC/Machias River	Mopang Stream	0	47.84	11.32
DEC/Machias River	Old Stream	6	79.95	20.43
DEC/Machias River	West Branch Machias River	0	93.29	11
Machias River Drainage Total	**All Surveyed**	**6**	**59.26**	**56.61**
DEC/Narraguagus River	Baker Brook	0	8.46	0.25
DEC/Narraguagus River	Narraguagus River	13	97.36	107.6
DEC/Narraguagus River	Pork Brook	0	100	1.06
DEC/Narraguagus River	Spring River	0	100	0.87
DEC/Narraguagus River	West Branch Brook	5	100	3.9
Narraguagus River Drainage Total	**All Surveyed**	**18**	**93.61**	**113.68**
DEC/Pleasant River	Eastern Little River	0	80	3.99
DEC/Pleasant River	Pleasant River	21	84.68	18.71
Pleasant River Drainage Total	**All Surveyed**	**21**	**84.65**	**22.70**
MMB/Androscoggin River	Little River	0	N/A	0.23
Androscoggin River Drainage Total	**All Surveyed**	**0**	**N/A**	**0.23**
MMB/Kennebec River	Avon Valley Brook	5	N/A	6.52
MMB/Kennebec River	Barker Brook	1	N/A	0.74
MMB/Kennebec River	Bond Brook	0	86.26	3.42
MMB/Kennebec River	Cottle Brook	0	N/A	5.27
MMB/Kennebec River	Mt. Blue Stream	2	N/A	6.47
MMB/Kennebec River	Orbeton Stream	10	98.02	16.77
MMB/Kennebec River	Perham Stream	0	84.13	2.48
MMB/Kennebec River	Sandy River	18	64.92	59.51

SHRU/Drainage	Stream Name	Redds	% Stream Spawn Habitat Surveyed	Stream Total KM surveyed
MMB/Kennebec River	South Branch Sandy River	4	100	4.81
MMB/Kennebec River	Togus Stream	0	10.49	0.36
Kennebec River Drainage Total	**All Surveyed**	**40**	**23.74**	**106.35**
MMB/Sheepscot River	Sheepscot River	4	83.08	33.78
MMB/Sheepscot River	West Branch Sheepscot River	1	93.04	25.93
Sheepscot River Drainage Total	**All Surveyed**	**5**	**79.61**	**59.71**
PNB/Ducktrap River	Ducktrap River	1	33.31	1.79
PNB/Ducktrap River	Kendall Brook	1	18.18	0.2
Ducktrap River Drainage Total	**All Surveyed**	**2**	**32.67**	**1.99**
PNB/Penobscot River	Cove Brook	0	46.22	1.8
PNB/Penobscot River	French Stream	2	62.21	1.75
PNB/Penobscot River	Kenduskeag Stream	0	21	7.37
Penobscot River Drainage Total	**All Surveyed**	**2**	**4.33**	**10.92**
PNB/Piscataquis River	East Branch Pleasant River	0	15.37	1.04
PNB/Piscataquis River	Piscataquis River	0	8.99	6.81
PNB/Piscataquis River	Pleasant River	0	54.42	2.25
PNB/Piscataquis River	Schoodic Stream	64	N/A	0.86
PNB/Piscataquis River	West Branch Piscataquis River	0	27.27	0.65
Piscataquis River Drainage Total	**All Surveyed**	**64**	**18.36**	**11.61**

Redd Based Returns to Small Coastal Rivers

Estimated returns to Maine are based on the total number of adult Atlantic salmon returning to traps (Androscoggin, Kennebec, Penobscot, Union and Narraguagus Rivers, as well as spawner surveys. For small coastal rivers without traps, capture data from the Pleasant, Narraguagus and Union River traps are used to predict returns in the Cove Brook, Dennys River, Ducktrap River, East Machias, Kenduskeag Stream, Machias River, Pleasant River, and the Sheepscot River based on observed redd counts. Estimated returns based on redd counts are computed using the equation: lnAdults = 1.1986 +0.6098(lnRedds).

A total of 71 redds were surveyed across all SHRUs. The predicted redds based estimate of returns for 2022 is 92 adults (95% CI 35 to 245; Table 3.1.3.2.). Total Redd numbers across the GOM DPS were similar to 2021 and the trend remains flat at around 70 to 90 estimated returns to un-trapped drainages (Figure 3.1.3.1.). This was reflected across surveyed drainages with slightly fewer returns apart from the Pleasant and Dennys River which saw increases from 2021(Figure 3.1.3.2). Redds were observed in the Ducktrap (2) River and French Stream (2) a tributary to the Kenduskeag Stream.

Table 3.1.3.2. Redds based regression estimates and 95% confidence intervals of total Atlantic salmon escapement to several of Maine's Rivers for 2022.

SHRU	Drainage	Total Spawn Habitat	Surveyed Habitat	Surveyed Redds	Predicted Returns	L95	U95
DEC	Dennys	238.5	203.2	3	6	2	18
DEC	East Machias	58.9	46.4	14	17	6	43
DEC	Machias	449.8	266.6	6	10	4	26
DEC	Narraguagus	265.8	248.8	18	19	7	51
DEC	Pleasant	141.4	119.7	21	21	8	56
MMB	Sheepscot	325.4	259	5	9	3	24
PNB	Cove Brook	7.3	3.4	0	0	NA	NA
PNB	Ducktrap River	42.9	14.3	2	5	2	14
PNB	Kenduskeag	66	13.9	2	5	2	14
	Grand Total	1,596.00	1,175.30	71	92	35	245

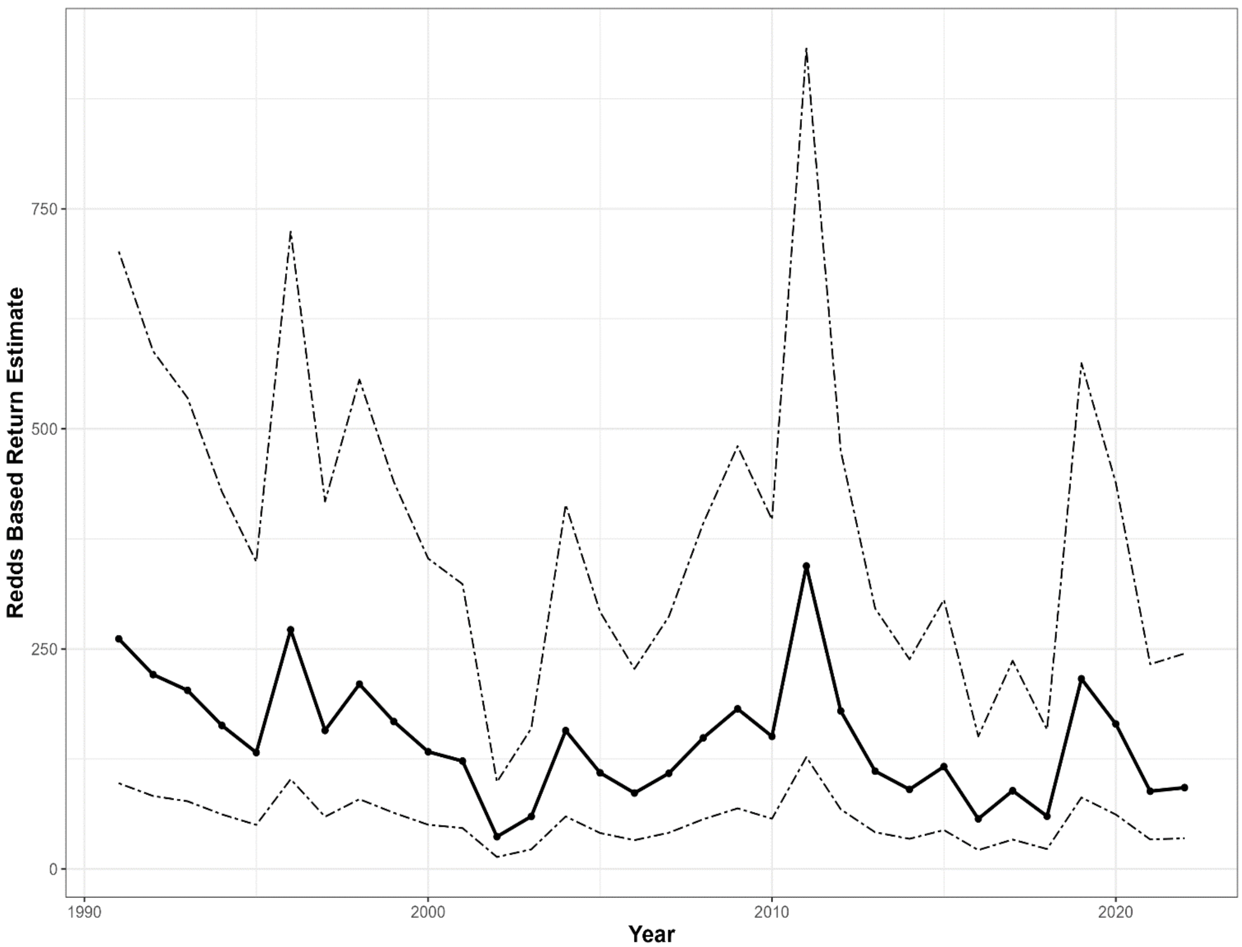

Figure 3.1.3.1. Annual total redds based returns estimate for Cove Brook, Dennys, Ducktrap, East Machias, Kenduskeag, Machias, Narraguagus, Pleasant, Sheepscot and Soudabscook Rivers through 1991 – 2022.

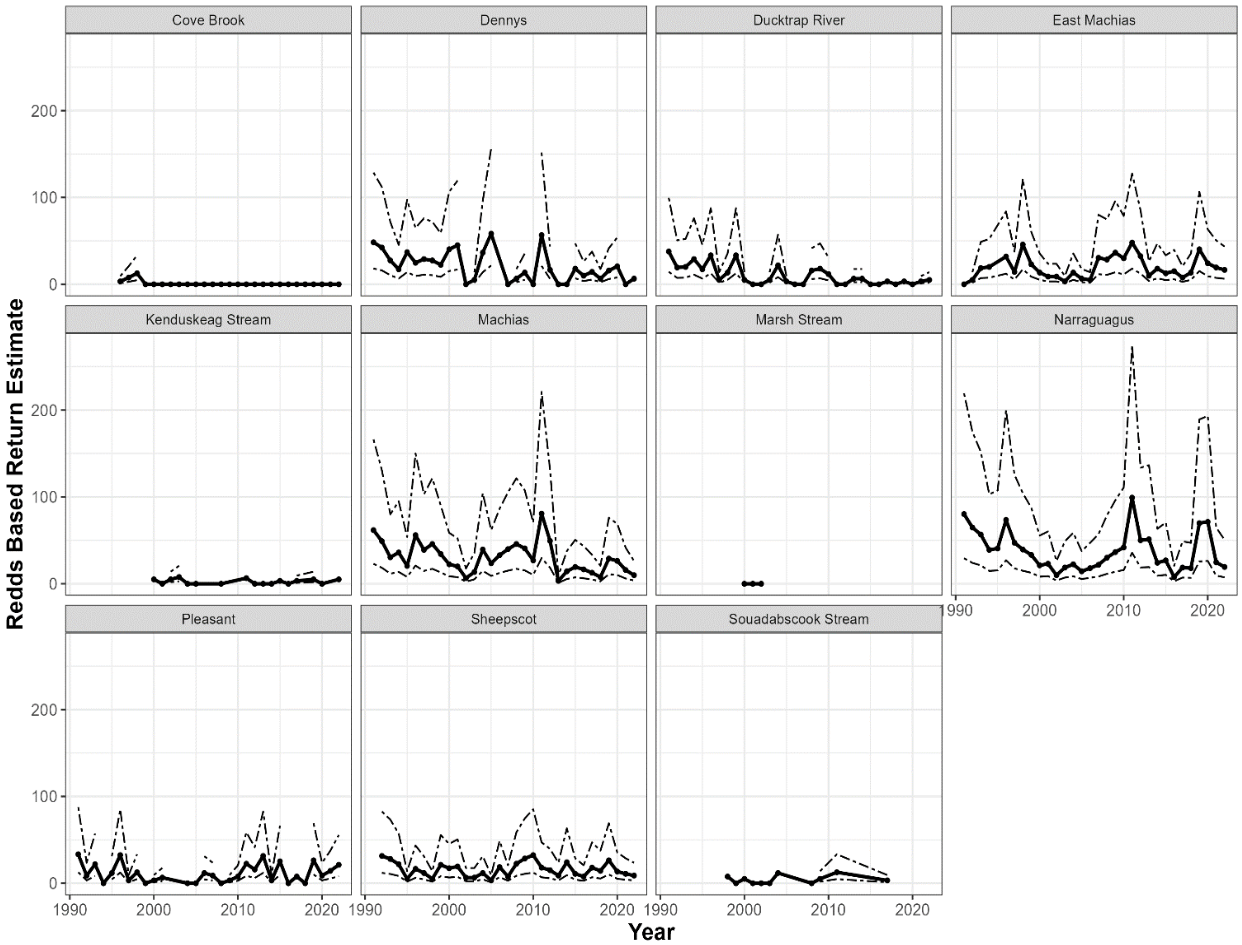

Figure 3.1.3.2. Individual annual redds based estimate of adult returns to managed drainages in the Gulf of Maine Distinct Population Segment, 1991 - 2022.

3.2 Juvenile Population Status -

Understanding the spatial variability of juvenile Atlantic salmon provides information on habitat quality and habitat productivity that is a crucial step towards the recovery of Atlantic salmon. This factor was recognized in the listing of Atlantic Salmon (74 FR 29345; June 19, 2009) and in the designation of Critical Habitat (74 FR 29300; June 19, 2009), when the number of habitat units in each SHRU was prorated, based on a habitat quality score and expressed in terms of functional units. One of the best resources that we use to evaluate habitat quality is to measure juvenile abundance, spatial distribution, and smolt production.

Juvenile abundance estimates

Introduction

MDMR conducts single pass Catch per unit (1 unit = $100m^2$) electrofishing surveys (Bateman et al. 2005; Stevens et al. 2010) at sites that are divided into three groups, those selected using the Generalized Randomized Tessellated Stratification tool (GRTS), Wild Production Areas (WPAs) and Project sites. GRTS sites are sites derived using the Geographic Randomized Tessellation Stratification (GRTS) technique (Stevens and Olsen 2004). WPAs are sites based on locations of redds in years that coincide with the current year's cohort for 0+ parr and are used to evaluate spawning success. Project sites are selected to answer specific questions of juvenile salmon response to stock enhancement changes, habitat alterations or other questions. GRTS sites are sampled annually, WPAs and Project sites change from year to year as defined by redd distribution or research needs.

Sampling locations are divided among the three SHRUs within the GOM. Streams that are included in the sampling design, referred to as management drainages, are streams that are currently managed for Atlantic salmon. This means that there is active restoration work that involves at minimum stock enhancement work or monitoring i.e., spawner surveys (Table 3.2.1). Additionally, the Sandy River and the Narraguagus River have been identified as Life Cycle Management Stations (LCMS) and these drainages receive the greatest focus for GRTS sites.

Table 3.2.1. Currently Managed Streams. Rearing habitat from the Wright et al. 2008 Species Distribution and Habitat Model.

SHRU	Name	Drainage Area (hectares)	Rearing Habitat ($100\ m^2$)	Drainage length (km)
DEC	Dennys	33,836.20	2,098.00	121.33
DEC	East Machias	80,797.25	6,951.00	238.03
DEC	Machias	129,072.74	19,602.00	537.91
DEC	Narraguagus	63,496.33	7,180.00	203.01
DEC	Pleasant	32,845.72	2,580.00	90.89
MMB	Sandy River	153,567.46	36,790.78	1,567.79
MMB	Sheepscot River	64,980.85	6,751.00	163.66
PNB	Cove Brook	14,147.18	218	8.05
PNB	East Branch Penobscot	289,561.27	35,246.00	448.63

Results

A total of 179 sites were surveyed between July 29th and September 30th, 2022, using single pass electrofishing survey techniques across all three SHRU's. Of these, 138 sites were either GRTS selected sites or index sites used to track status and trends. Additional electrofishing efforts were used to evaluate spawner success for hatchery products (WPA), habitat improvements and parr brood stock collections (Projects). A list of survey types for each drainage is presented in Table 3.2.2.

Table 3.2.2. Summary of electrofishing efforts within the Gulf of Maine DPS in 2022 by project Type. Abbreviations for Salmon Habitat Recovery Units (SHRUs): DEC = Downeast Coastal, MMB = Merrymeeting Bay and PNB = Penobscot Bay.

SHRU	Drainage	0+ Parr	Brood-stock	Fish Exclusion	GRTS	Index	Upper NG index	WPA	Totals
DEC	Dennys	0	2	0	0	0	0	0	2
DEC	East Machias	2	3	0	0	0	0	0	5
DEC	Machias	0	5	0	0	1	0	0	6
DEC	Narraguagus	0	2	5	12	0	13	0	32
DEC	Pleasant	0	4	0	0	0	0	0	4
MMB	Lower Androscoggin	0	0	1	0	2	0	0	3
MMB	Lower Kennebec	0	0	3	57	4	0	2	66
MMB	Sheepscot	0	10	0	0	12	0	2	24
PNB	Ducktrap	0	0	0	3	0	0	0	3
PNB	Penobscot	0	0	0	3	0	0	0	3
PNB	Piscataquis	0	0	0	31	0	0	0	31
-	Totals	2	26	9	106	19	13	4	179

Mean parr densities for GRTS and Index sites are shown in Table 3.2.3. Comparison of catch-per-unit (CPU; where a unit equals $100m^2$ of habitat) parr abundance across management reaches indicate that the Piscataquis River had higher abundances than the Middle Sandy, Upper Sandy, and Sheepscot River (ANOVA, $F_{(6, 90)} = 5.942$, $p < 0.001$) all other drainages had similar abundances.

Table 3.2.3. Summary of Single pass catch-per-unit (100m^2) results for Index and Generalized Randomized Tessellated Stratification selected sites across sampled drainages for 2022. Abbreviations for Salmon Habitat Recovery Units (SHRUs): DEC = Downeast Coastal, MMB = Merrymeeting Bay and PNB = Penobscot Bay.

SHRU	Management Reach or Drainage	n	Mean	SD	Low 95	Up 95
DEC	East Machias	2	5	6	0	13.5
DEC	Narraguagus	21	3.9	4	2	5.7
MMB	Middle Sandy River	11	0	0	0	0
MMB	Sheepscot	14	0.2	1	0	0.5
MMB	Upper Sandy River	18	0	0	0	0
PNB	Ducktrap	3	0.2	0	0	0.6
PNB	Piscataquis	28	6.8	8	3.9	9.8

Across both GRTS and Index sites, electrofishing survey sites are stratified into stream width classes. There are four: A = 0 to 6 meters, B = 6 to 12 m, C = 12 to 18 m and D = > 18 m. Catch-per-unit (CPU) across width classes indicate that differences exist between groups (ANOVA, $F_{(3, 661)} = 22.6$, $p < 0.001$). A class stream reaches had significantly greater abundance than the other width classes (p = < 0.05), additionally, differences were found between B and D width classes (p = 0.001), with no differences observed between other width classes (p > 0.05). Comparison of fork lengths (mm) across width classes indicates differences (ANOVA, $F_{(3, 2051)} = 61.76$, $p \leq 0.001$; Figure 3.2.5). Parr from A class sites were smaller ($p \leq 0.001$) than those from all other width class reaches (Table 3.2.5).

This has implications on stock enhancement decisions when considering how and where to use limited resources of available fish. Larger parr should have higher overwinter survival (Close and Anderson 1992) so balancing higher abundance with better growth needs to be prioritized. It is unknown how habitat characteristics contribute to this observation, but it can be guessed that water temperature (Elliot and Elliot 2010) and habitat complexity play a role (Johnston et al. 2004; Finstad et al. 2007). Use of the GRTS methods has helped to identify some of these relationships. Ongoing habitat rehabilitation projects as described below help with increasing complexity and access to thermal refuges. Tying these findings related to juvenile abundance surveys to habitat data to develop tools to identify optimal scenarios for stocking or habitat protections is currently being pursued by the Maine Atlantic Salmon combined group; National Oceanic and Atmospheric Administration (NOAA), USFWS, MDMR, Penobscot Indian Nation, and Non - Government Organizations NGOs.

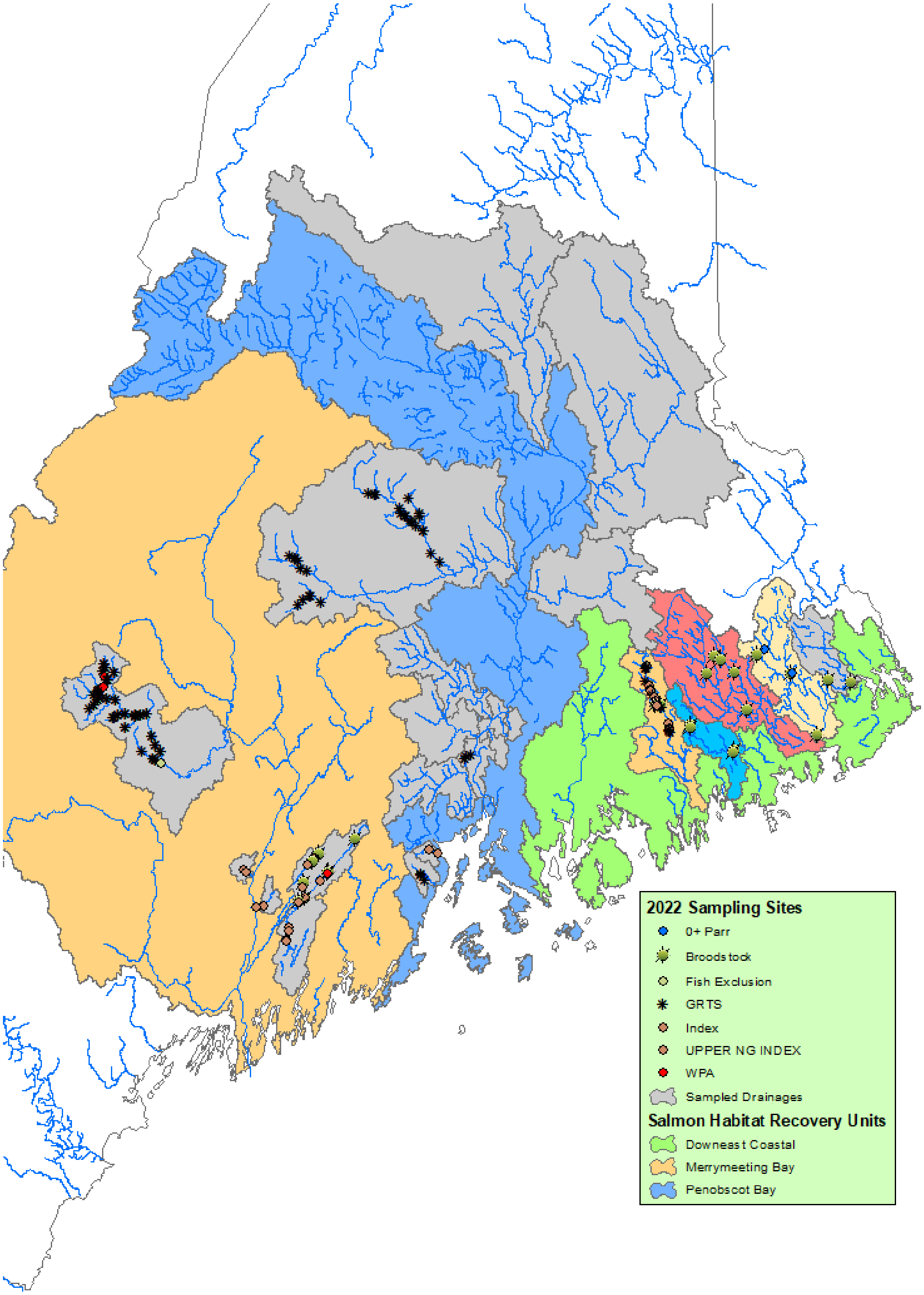

Figure 3.2.1. Location of sites (172) surveyed in 2022 for juvenile abundance and distribution estimates within the Gulf of Maine Distinct Population Segment of Atlantic Salmon.

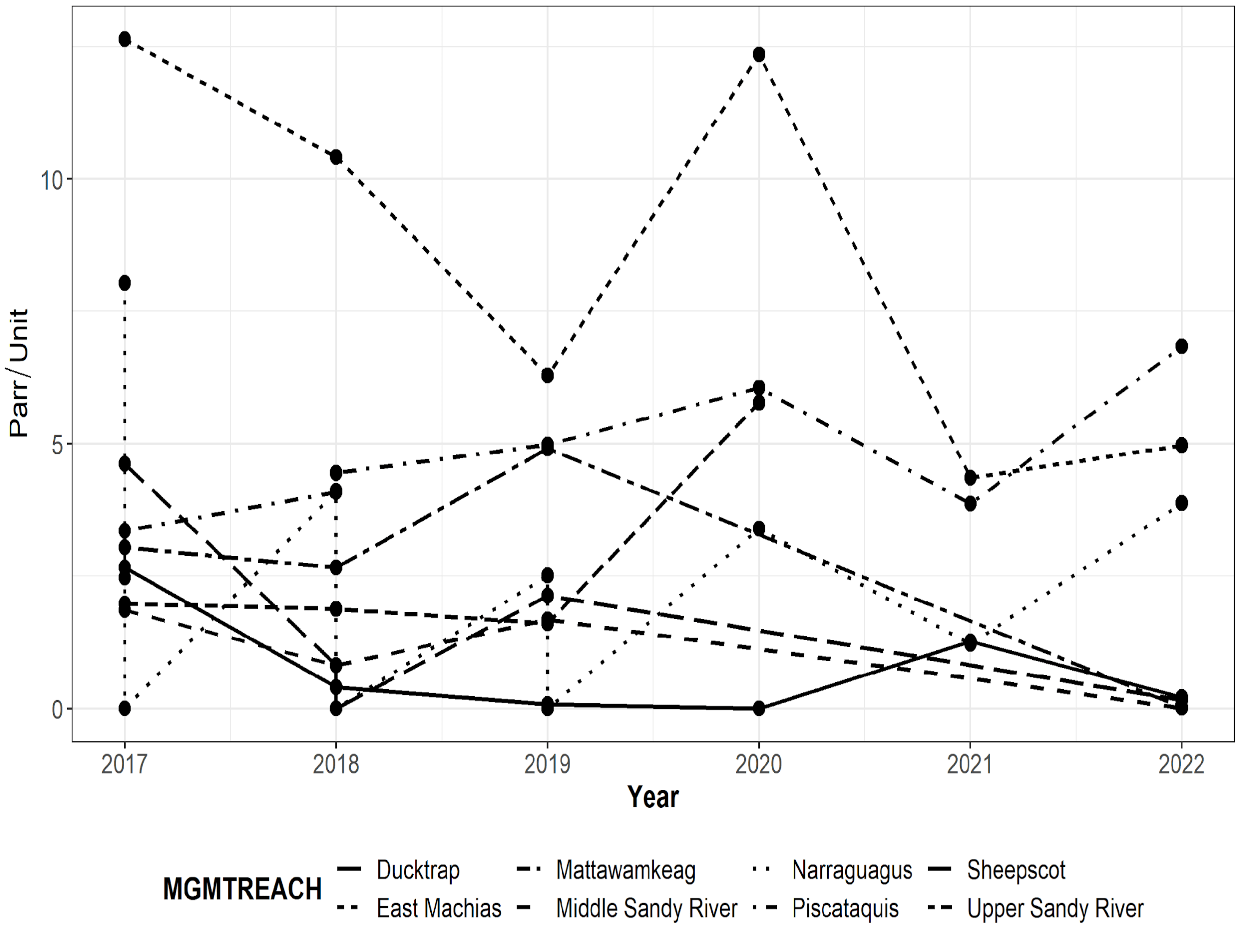

Figure 3.2.2. Trends of mean catch per unit (100m^2) by drainage 2017 to 2022 for index sites across managed drainages within the Gulf of Maine Distinct Population Segment.

Table 3.2.4. Mean parr per unit (100m^2) for large parr across width classes during the years of 2017 to 2022. Width classes include: A = 1 to 6 meters, B = 6 to 12 meters, C = 12 to 18 meters, C = greater than 18 meter stream width.

Width Class	n	Mean	Standard Deviation
A	140	6.8	7.6
B	335	3.8	4.8
C	111	2.8	4.4
D	79	1.3	1.8

Table 3.2.5. Mean fork length (mm) for large parr across width classes during the years of 2017 to 2022. Width classes include: A = 1 to 6 meters, B = 6 to 12 meters, C = 12 to 18 meters, C = greater than 18 meter stream width.

Width Class	n	Mean	Standard Deviation
A	832	108	17.4
B	820	118.8	19.2
C	242	121.8	20.2
D	161	113.9	17.3

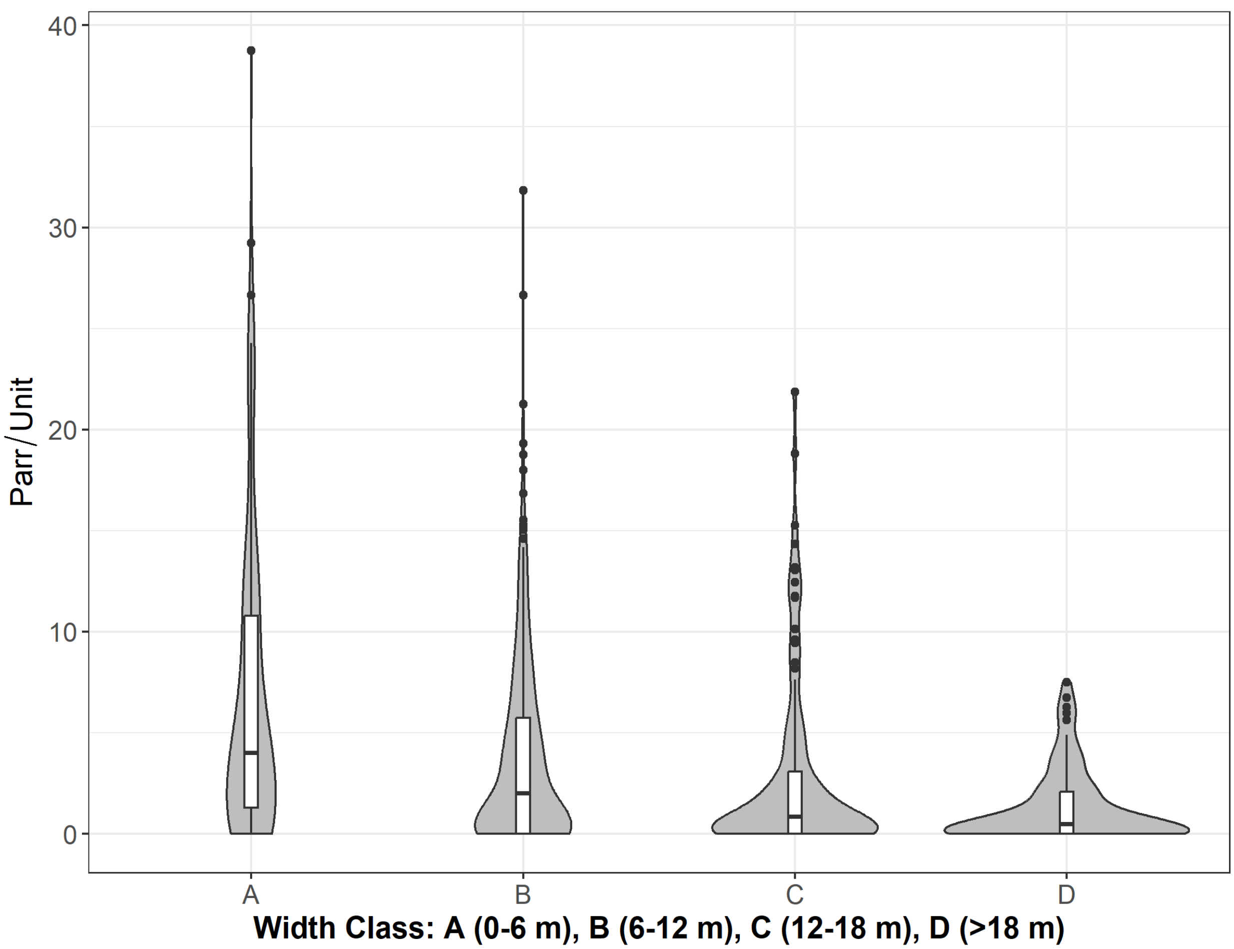

Figure 3.2.4. Violin plots showing abundance as catch per Unit ($100m^2$) for large parr (2017 to 2022) across four width classes. Width classes are as follows: A = 1 – 6 meters, B = 6 -12 meters, C = 12 – 18 meters and D = > 18 meters.

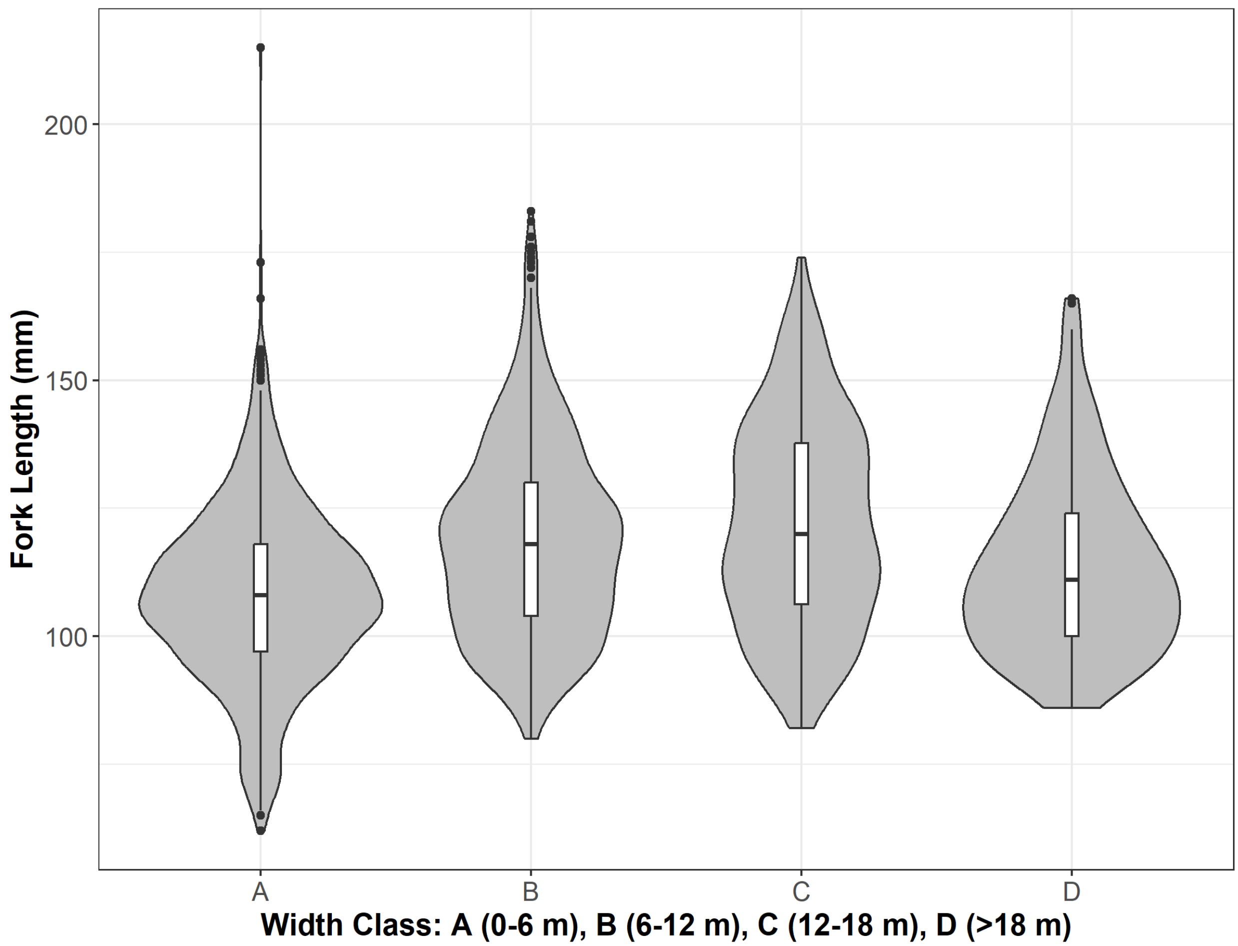

Figure 3.2.5. Violin plots showing fork length (mm) for large parr (2017 to 2022) across four width classes. Width classes are as follows: A = 1 – 6 meters, B = 6 -12 meters, C = 12 – 18 meters and D = > 18 meters.

Smolt Abundance

The following is a summary of smolt trapping activities that occurred in the spring of 2022. The main goals of trapping out-migrating salmon smolts is to estimate the number of migrants, determine age and origin and use this information in determining smolt-to-adult s (SAR) marine survival rates for cohort specific adult returns. A more detailed report on smolt population dynamics is included in Working Paper WP22-02-Smolt Update.

MDMR estimated smolt abundance using Rotary Screw Traps (RSTs) in two Maine rivers, the Narraguagus River (in partnership with Project SHARE) and the Sandy River. A total of 2,271 smolts were unique captures at all sites between 13 April and 31 May 2022 (Table 3.2.6). Smolt trapping operations in the East Machias were suspended in 2022 and there are no plans to continue in the future.

MDMR scientists calculated population estimates using Darroch Analysis with Rank Reduction (DARR) 2.0.2 for program R (Bjorkstedt 2005; R Core Team 2018) for each RST site (Figure 3.2.6 and Table 3.2.7).

Population estimates for each river/site were based on a one-site mark-recapture design. Two sites were operated on the Narraguagus River in 2022. 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 1,113 ±SE 84. The naturally reared smolt population estimate was 1,031 ±SE 82. The hatchery population estimate was 65 ±SE15. At the Narraguagus Route 9 site the naturally reared smolt population emigrating from the upper watershed was estimated at 499 ±SE 61. The population estimate for naturally reared smolts exiting the Sandy River was 9,694 ±SE 614. Further details on age, origin, and other data are presented in Working Paper WP22-02-Smolt Update.

Table 3.2.6 Atlantic salmon smolt trap deployments, total captures, and capture timing by origin in Maine rivers, 2022.

River	Site	Start Date	End Date	Origin	Total Capture	First Capture	Median Capture Date	Last Capture
Narraguagus	Little Falls	12-Apr	27-May	H	27	6-May	13-May	20-May
Narraguagus	Little Falls	12-Apr	27-May	W	373	24-Apr	7-May	24-May
Narraguagus	Route 9	11-Apr	23-May	H	5	6-May	11-May	20-May
Narraguagus	Route 9	11-Apr	23-May	W	184	18-Apr	7-May	20-May
Sandy	Lane Road	12-Apr	3-Jun	W	1,682	13-Apr	13-May	31-May

Table 3.2.7. Maximum likelihood mark-recapture population estimates ± Standard Error for naturally reared and hatchery origin Atlantic salmon smolts emigrating from the Narraguagus and Sandy River (Kennebec tributary).

River	Site	Origin	Estimate ± Standard Error
Narraguagus	Little Falls	Hatchery	65 ± 15
Narraguagus	Little Falls	Naturally reared	1,031 ± 82
Narraguagus	Little Falls	Hatchery and Naturally Reared	1,113 ± 84
Narraguagus	Route 9	Naturally reared	499 ± 61
Sandy	Lane Road	Naturally reared	9,694 ± 614

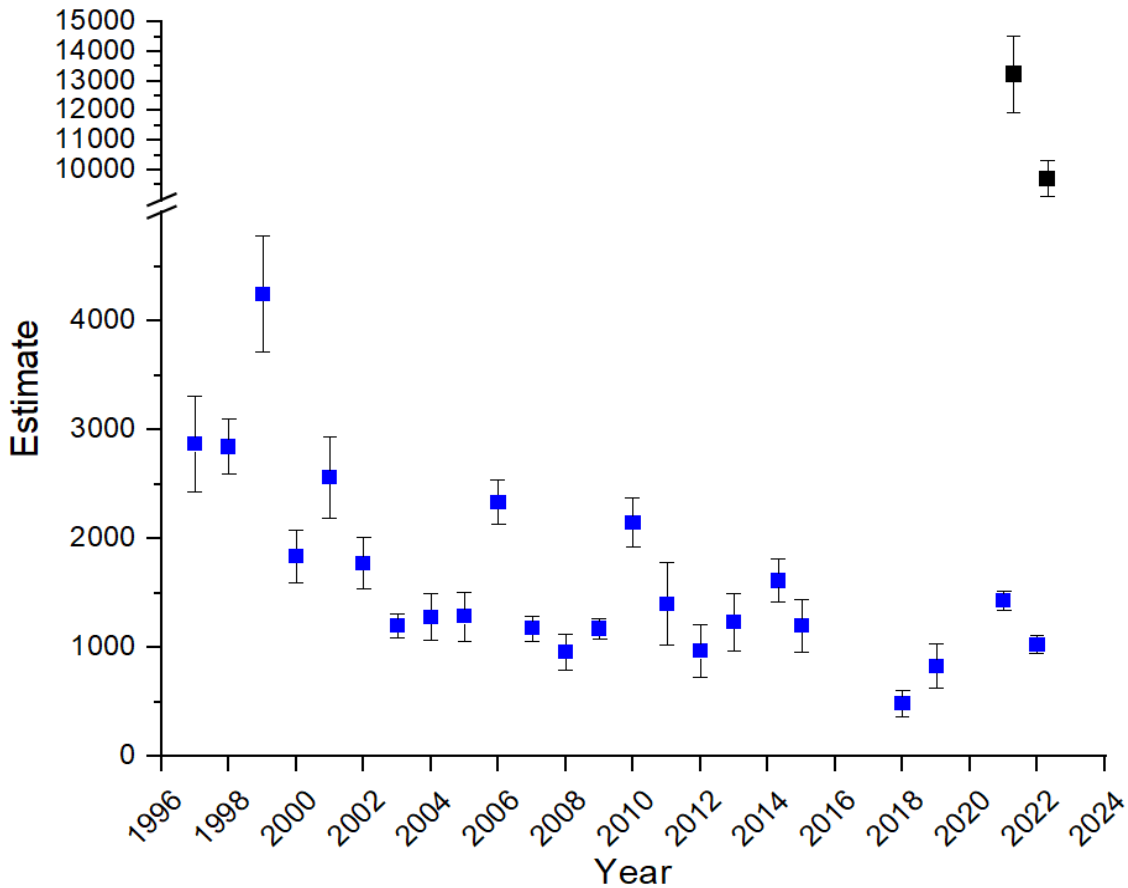

Figure 3.2.6. Population Estimates (± Standard Error) of emigrating naturally reared smolts at active trapping operations on the Narraguagus (Blue Box) and Sandy (Black Box) Rivers in Maine, using DARR 2.0.2.

3.3 Fish Passage and Migratory Fish Habitat Enhancement and Conservation

Habitat Assessment – Various

Quantitative Habitat Surveys

MDMR staff conducted a stream habitat survey in the Carrabassett River, a major tributary to the Kennebec River located in the Merrymeeting Bay SHRU. Staff surveyed from the Kingfield Dam in the town of Kingfield (river kilometer 34.60) to just northeast of the Wire Bridge Rd. in the town of New Portland (river kilometer 26.14). An adjacent survey in the Carrabassett River was completed above the Kingfield dam in 2015. The survey took 4 partial days due to staff training and inclement weather events and/or unsafe river conditions. Approximately 357 units of spawning habitat and 855 units of rearing habitat were documented. Data were geo-referenced and will be appended to the current habitat geo-database. An updated GIS dataset will be issued in March 2023. Survey data could be utilized to establish broodstock requirements, Atlantic salmon management and direct habitat and/or connectivity improvements.

Thermal Refugia Surveys

Maine DMR has been monitoring stream water temperatures to document annual variations across the DPS. DMR has deployed 78 loggers across Maine, covering each SHRU (Figure 3.4.1). These data are provided to the EcoSheds Group (Walker et al. 2020) for use in an air temperature based spatial water temperature model. A challenge has been management of the large amount of data already collected. This challenge and an update on water temperature monitoring will be addressed in 2023.

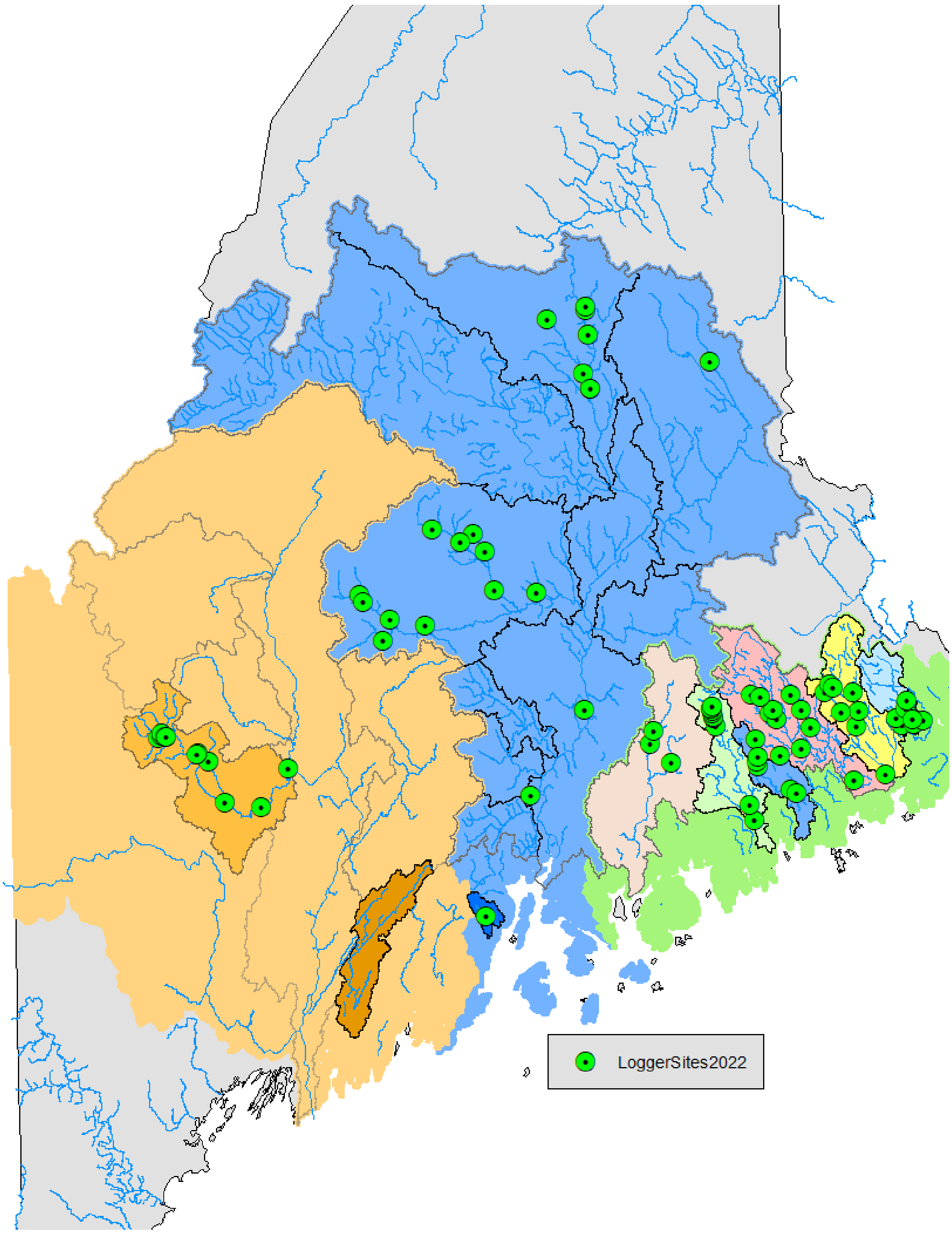

Fig 3.3.1. Map showing locations of Maine DMR stream temperature monitoring sites (78) across the three Salmon Habitat Recovery Units in the Gulf of Maine DPS.

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 coarse wood exist in Maine streams. These barriers include dams and road-stream crossings. All barriers 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. Table 3.3.1. provides a partial list of projects accomplished in 2022

Walton's Mill Dam Removal - Walton's Mill Dam located on Temple Stream, a tributary of the Sandy River in the Kennebec River watershed was removed restoring access to approximately 46 miles of high-quality stream habitat for endangered Atlantic salmon, Brook trout, American eel, and other species. The project also restores natural ecological function and processes to Temple Stream by removing the 1-mile impoundment that was impairing water quality and making habitat unsuitable for Atlantic salmon. Habitat was also enhanced within the historic mill and dam reach with the reconstruction of a natural floodplain, installation of large wood, riparian plantings, and removal of invasive species. Approximately 3.5 acres of riparian zone was also put into conservation easement to help protect the river and provide recreational access to the local community. Atlantic Salmon Federation lead the coalition of partners including but not limited to NOAA Restoration Center, M, USFWS, and the Town of Farmington.

Meddybemps powerhouse – Work was completed on the Meddybemps Powerhouse removal project. This involved installation of two pool weir structures to aid fish over the remnant ledge left from removal of the powerhouse in 2021. Expected results of this project include for the first time in several decades, River herring will be able to access Meddybemps Lake via the main stem channel.

Table 3.3.1. Aquatic Organisim Passage (AOP) projects restoring stream connectivity in Gulf of Maine Distinct Population Segment Atlantic Salmon watersheds, stream name, and distance (miles or km) of stream habitat access above the barrier that was restored. Lead partners are Natural Resource Conservation Service (NRCS) and The Nature Conservancy (TNC).

Lead Partner	Watershed	Stream	Stream Miles	Kilometers
NRCS/TNC	Lower Richardson Lake	Beaver Brook	0.28	0.45
NRCS/TNC	Lower Richardson Lake	Little East Branch Cupsuptic R.	1.17	1.88
NRCS/TNC	Lake Onawa	Barren Mountain Stream	1.25	2.01
NRCS/TNC	Lake Onawa	Un Trib to Long Pond Stream	1.4	2.25
NRCS/TNC	Lake Onawa	Un Trib to Long Pond Stream	3.9	6.28
NRCS/TNC	Lake Onawa	Un Trib to Long Pond	0.7	1.13
NRCS/TNC	Thorn Brook	UN Trib to Bog Brook	0.31	0.5
NRCS/TNC	Silver Lake	UN Trib to Spruce Mountain Brook	1.7	2.74
NRCS/TNC	Silver Lake	UN Trib to Big White Brook	1.1	1.77
NRCS/TNC	Silver Lake	UN Trib to Big White Brook	1.7	2.74
NRCS/TNC	Silver Lake	UN Trib to Big White Brook	0.9	1.45
NRCS	Meadow Brook-Piscataquis River	Daggett Brook	3.77	6.07
NRCS	Great Pond	Elm Brook	2.9	4.67
-	-	**Total**	**21.08**	**33.92**

Habitat Complexity and Suitability

Narraguagus River Restoration Project at Rt 9 Pilot - The restoration project involved the construction of three engineered log jams, construction of a new floodplain to narrow the river, placement of large wood and boulders, and reconnection of two historic side channels with substantial groundwater input from an adjacent esker. These actions were undertaken to restore natural processes to the reach lost by historic log drives that made the river over widened, shallow, simplified, and unable to reconnect with its floodplain. Restoring the river to its natural morphology will improve hyporheic and groundwater exchange, improve shading, increase river depth, and create a diversity of complex habitats, which will convert this reach to climate change refugia for Atlantic salmon, Brook trout, Sea , and many of the other native species living within the riparian corridor. Project SHARE lead the coalition of partners including University of Maine, U.S. Forest Service, MDMR, NOAA Office of Habitat Conservation, Maine Audubon, USFWS) and with substantial donations from private industry.

Figure 3.3.2. Photos of the installation of engineered log jams into the Narraguagus River Restoration Project at Rt 9 Pilot site.

Figure 3.3.3. Drone's eye view of the Narraguagus River Restoration Project at Rt 9 Pilot site showing the engineered log jams in the left photo and the untreated reach immediately upstream of the treatment site.

Water Quality

The Downeast Salmon Federation, in collaboration with the Maine Department of Environmental Protection, continued their multi-year effort which began in 2017 in the East Machias River watershed to investigate the efficacy of using clam shells to lime streams that have been impacted by acid rain. The goal of the project is to increase macroinvertebrate abundance and diversity, and to increase juvenile salmon abundance. Each summer starting in 2019, clam shells have been spread along the bottom of Richardson Brook, as well as along the banks to capture high flow events (i.e., rainfall and snow melt, when episodic acidity is expected). Since the addition of shells in 2020, the pH at the treated site has been 0.4 units higher than during baseline conditions, as well as remaining higher than the upstream control site. Despite the increase in pH, periodic stressful conditions are still occurring in Richardson Brook, including low pH (minimum of 4.75), low calcium (minimum of 1.0 mg/L), and high exchangeable aluminum (maximum of 56 ug/l). Further data analysis is required to determine the extent of seasonal and yearly variations, as well as any impacts to biological communities. As clam shells are added to the target area, monitoring efforts will continue through 2023 to determine the efficacy of using this approach to mitigate acidity.

Fig 3.3.4. Clam shells being spread in and along the banks of Richardson Brook, Township 19 ED BPP, by AmeriCorps member Emily Wilson and Downeast Salmon Federation staff.

3.4 Hatchery Operations

Hatchery operations described below are arranged seasonally, progressing from transfers of 2021 cohort eggs through 2022 juvenile stocking, 2022 adult broodstock collection, 2022 disease sampling, 2022 juvenile broodstock collection and 2022 spawning.

Egg Transfers

Craig Brook National Fish Hatchery (CBNFH) and Green Lake National Fish Hatchery (GLNFH) transferred 2.16M eyed eggs in 2022 to MDMR, DSF and the Fish Friends educational program (Table 3.4.1.). Eyed eggs from each population were allocated for egg planting, fry production, 0+ parr production, and smolt production. Equal aliquots from each family of eyed eggs (one female/one male), when practical, were included in each transfer to ensure equal genetic representation in all life stages.

Table 3.4.1. Eyed egg transfers from Craig Brook National Fish Hatchery (CBNFH) and Green Lake National Fish Hatchery (GLNFH) in 2022. Receiving entities include: Maine Department of Marine Resources (MDMR), Downeast Salmon Federation (DSF), Fish Friends (FF) educational program. Note: Egg numbers rounded to the nearest 1,000.

Hatchery Contribution	Strain	Rearing History	Receiving Entity	Purpose	Number
CBNFH	East Machias	Captive/domestic	DSF	0+ parr production	393,000
CBNFH	Machias	Captive/domestic	GLNFH	Smolt production	17,000
CBNFH	Narraguagus	Captive/domestic	DSF	0+ parr production	202,000
CBNFH	Penobscot	Sea-run	GLNFH	Smolt production	435,000
CBNFH	Pleasant	Captive/domestic	DSF	Fry production	157,000
CBNFH	Sheepscot	Captive/domestic	MDMR	Natal River Egg planting	265,000
CBNFH	Sheepscot	Captive/domestic	GLNFH	0+ parr production	17,000
GLNFH	Penobscot	Captive/domestic	MDMR	Non-natal River Egg planting	438,000
GLNFH	Penobscot	Captive/domestic	FF	Education	14,000
GLNFH	Penobscot	Captive/domestic	CBNFH	Fry production	219,000

Juvenile Stocking and Transfers

CBNFH, GLNFH, Nashua National Fish Hatchery (NNFH), two DSF hatcheries (Pleasant River Hatchery and Peter Gray Hatchery) and the Fish Friends program released 2.88M juveniles (eyed eggs, fry, parr, and smolts) throughout the GOM DPS (Table 5.4.2). Stocking operations are a collaborative effort between MDMR and hatchery management.

As noted in the summary of egg transfer activities, efforts were made to ensure equal distribution of genetic families in all juvenile life stages released in the GOM DPS. Particular attention was paid to stocking fry (or planting eggs) comprised of as many families as feasible into high production habitat areas. In turn, those areas will be targeted for future captive parr broodstock collections the following year [two years post egg-planting]. These actions ensured the broad distribution of genetic material throughout varying habitat conditions.

In addition to the release of juvenile Atlantic salmon into habitat, transfers of age 0+ parr were made from GLNFH to NNFH and an educational rearing aquarium at the Bangor Wastewater Treatment Plant.

Table 3.4.2. Juvenile stocking and transfers of Gulf of Maine Distinct Population Segment populations in 2022. Abbreviations found within the table: CBNFH = Craig Brook National Fish Hatchery, GLNFH = Green Lake National Fish Hatchery, NNFH = Nashua National Fish Hatchery, DSF = Downeast Salmon Federation, CCAR = Center for Collaborative Aquaculture Research, UMO = University of Maine, FF = Fish Friends, BWWTP = Bangor Wastewater Treatment Plant. Note: Juvenile numbers rounded to the nearest 1,000 for values exceeding 10,000.

Hatchery Contribution	Receiving Drainage or Entity	Strain	Action	Parr	Smolt	Eyed Egg	Fry
FF	Androscoggin River	Penobscot	Release	0	0	0	3,700
GLNFH	BWWTP	Penobscot	Transfer	8	0	0	0
CBNFH	Dennys River	Dennys	Release	0	0	0	262,000
DSF/CBNFH	East Machias River	East Machias	Release	165,000	0	0	19,000
NNFH/GLNFH/FF	Kennebec River	Penobscot	Release	0	98,000	438,093	3,200
GLNFH/CBNFH	Machias River	Machias	Release	16,000	938	0	221,000
DSF/CBNFH	Narraguagus River	Narraguagus	Release	90,000	0	0	72,000
GLNFH	NNFH	Penobscot	Transfer	108,000	0	0	0
GLNFH/CBNFH/FF	Penobscot River	Penobscot	Release	11,000	648,000	0	213,000
DSF/CBNFH	Pleasant River	Pleasant	Release	0	0	0	326,000
GLNFH/CBNFH/FF	Sheepscot River	Sheepscot	Release	14,000	0	265,000	19,000
FF	Union River	Penobscot	Release	0	0	0	1,000

Broodstock

Penobscot Domestic Broodstock

Four cohorts of domestic broodstock are maintained at GLNFH: juvenile (age-one), sub-adult (age-two) and adult (ages -three and -four). The combined total of domestic broodstock reared at any given time is approximately 3,600 salmon. GLNFH annually receives Penobscot sea-run eyed eggs CBNFH for smolt production. Egg transfers, in groups divisible by 6,900, are comprised of equal aliquots from each mated pair of Penobscot broodstock. As fry are moved to GLNFH's inside rearing tanks equal aliquots from each tray of 6,900 are combined to populate each tank. Likewise, when larger fry are moved to the outside rearing pools, equal aliquots from each tank are combined to populate each pool. This practice allows for representatives of each sea-run family to be in each pool of future smolts.

To create a domestic broodstock cohort, 960 age-0+ parr are randomly selected from one outside rearing pool. Sixty fish are lethally sampled for fish health monitoring. Nine-hundred brood are reared based on rearing and incubation capacity at GLNFH and the desire to spawn 1:1.

Future brood are tagged in December of their second year with PIT tags and a fin clip is collected for genetic analysis. Following tagging, future brood are transferred to the broodstock holding area to the brood pit and classified as broodstock.

Eyed eggs from age-three females are reserved for egg planting by MDMR in the Sandy River drainage, a tributary to the upper Kennebec River. In the event of a shortfall of Penobscot sea-run eyed eggs, eyed eggs from age-four domestic females are allocated to smolt production in a manner that captures the genetic variability of that cohort to produce a full complement of Penobscot River smolts.

Penobscot Sea-run Broodstock

Penobscot sea-run adults collected for broodstock represent multiple life stages (grilse, multi-sea winter, repeat spawners) of both hatchery- and natural- origin adults returning annually to the Penobscot River. CBNFH is shifting from a 'target' number of broodstock to maintaining an effective population size (N_e) of 500 for the Penobscot River population. The goal is to produce a minimum of 250 individual family groups that will support full smolt production at GLNFH and produce approximately 0.5M fry at CBNFH for release to the Penobscot River and its tributaries. In the event of a strong run of adults more may be collected and released pre-spawn into quality spawning habitat, as determined by MDMR. The minimum number of adults for a pre-spawn release would be 100 (50 females and 50 males), requiring a total adult collection of 600.

CBNFH capped the number of broodstock transported per day at 40 to facilitate disease sample processing [see *Infectious Salmonid Anemia Monitoring* below]. The highest number of fish transported in a single day during 2022 was 36. In 2022 broodstock collections were initiated on May 11th, comprising 63 individual trips to the trap, and concluded on July 7th with 557 adults collected. Of the 557 adults collected one died prior to tagging, eight were removed [released to the river] prior to acceptance into the broodstock population [see *Infectious Salmonid Anemia Monitoring* below], three were culled for genetic reasons prior to spawning, 13 died of natural causes prior to spawning, and two died of natural causes post spawning [see *General Disease Monitoring* below].

Sea-run adults were PIT tagged, sampled for genetics and scales, weighed, measured, and photographed at the hatchery. MDMR and CBNFH biologists collaborated on data collection methods that met the needs of both agencies as well as shared resources such as tags, tagging needles and other materials.

Condition Factor of Penobscot River Sea-Run Adults

As described in (Piper et al. 1982) each fish species has a characteristic range of condition factors depending on growth over time. The condition factor (C) is the ratio of a fish's weight to its length cubed. CBNFH and GLNFH use a C of 0.00035 for Atlantic salmon. Individual weights and lengths have been collected at CBNFH from sea-run adults as part of the broodstock program since 2012 and a declining trend in C is apparent (Figure 3.4.1).

Declines in condition factor (C) have been observed in Atlantic salmon adults and post-smolts on both sides of the Atlantic. These declines may be influenced by poor feed availability (Utne et al. 2021), climate change (Todd et al. 2012; Calado et al. 2021), sea-lice infestation (Susdorf et al. 2018) or potential genetic factors (Bacon et al. 2009). However, the condition factor of sea-run adults captured for use as broodstock demonstrated a marked improvement in 2022. Whether that will have a corresponding increase in fecundity remains to be seen at the time of preparing this report.

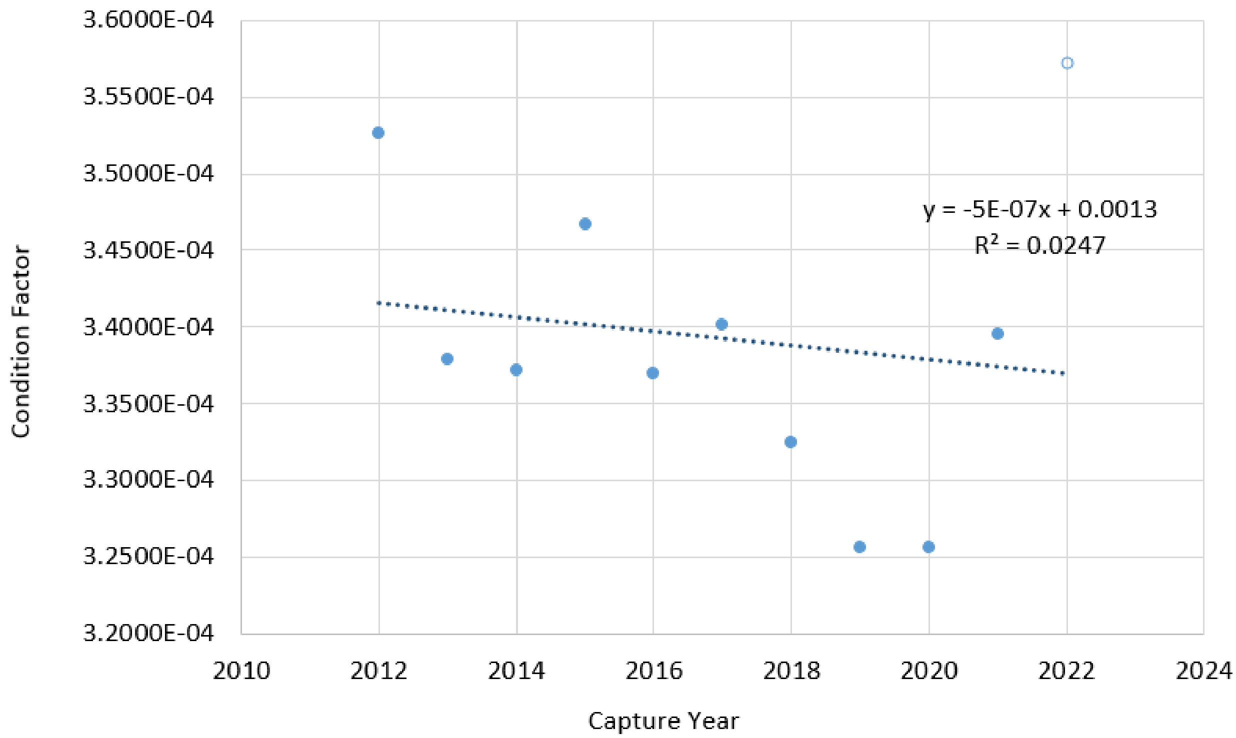

Figure 3.4.1. Condition factor of Penobscot River sea-run broodstock (Atlantic salmon) sampled at Craig Brook National Fish Hatchery from 2012 through 2022.

Data collected on individual adults is feasible due to the trapping facility at Milford and the sea-run broodstock program. In rivers lacking trapping facilities and adequate staff it is impossible to determine whether this trend is repeated in other DPS populations. The decline in C is correlated with a decline in the fecundity of sea-run Atlantic salmon at CBNFH over the same temporal period [see *Egg Production* below]. Should a similar decline in C and fecundity in other DPS populations exist it could affect occupancy and WPA models.

Infectious Salmonid Anemia Monitoring

Infectious Salmonid Anemia (ISA) is an orthomyxovirus first reported among Norwegian salmon farms in the mid-1980s and first reported in the United States in 2000 (Bouchard et al. 2001). 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 from the Penobscot River are monitored for the disease prior to being accepted as broodstock.

Sea-run adults are isolated in a screening facility at CBNFH to undergo ISA sampling. Blood samples are analyzed using Polymerase Chain Reaction (PCR) testing at the USFWS Lamar Fish Health Center (LFHC). Adults which pass the PCR test are accepted into the sea-run broodstock program and transferred to the holding area for future spawning.

In the event of a positive or suspect ISA result, additional tests are conducted on the affected individual. If diagnosed with the non-pathogenic strain (HPRO), the affected individual is released to the Penobscot

River at a location above the Milford dam. Any adults initially isolated in the same room with the HPRO individual, are allowed to join the general hatchery population.

The risk of releasing HPRO positive fish back to the river is negligible as the virus is extant in the population (John Coll, personal communication). The aim of releasing the affected individual is to avoid breeding it in a hatchery setting.

In 2022 nine individuals were diagnosed, via PCR, for HPRO. One died prior to release; the remaining eight were released to the Penobscot River.

In the event a positive diagnosis for a pathogenic strain of ISA is detected, the affected individual is euthanized. Samples of blood and tissue are collected and sent LFHC and the U.S. Department of Agriculture's Animal and Plant Health Inspection Service. Any adults held in the same isolation room as the affected fish are isolated for an additional 28 days and then resampled.

No individuals were identified with pathogenic strains in 2022.

Captive Parr Broodstock

Prior to 2018, captive broodstock targets were based on the number of broodstock required to seed available fry habitat with the equal of 240 eggs per habitat unit (100 m^2). Parr broodstock capture targets increased in the mid-2000s in response to either losses in genetic diversity or from a desire to stock additional juveniles (Table 3.4.3.). An additional number of parr, over the established target, were often collected to account for any losses prior to their first spawn at age-three. The number of additional parr was not established and often led to dramatic increases in broodstock population size, leading to increases in biomass, excess egg production and unplanned gravid broodstock releases.

In 2018, CBNFH equalized the number of age 1+ parr collected for the six captive broodstock populations (Dennys, East Machias, Machias, Narraguagus, Pleasant, and Sheepscot). Parr collection targets for all populations are 200 individuals with up to 15 extra parr to mitigate against potential losses (up to 1,290 total). This cohort size was derived by using average broodstock maturation estimates, broodstock needed to maintain 1:1 spawning protocols, rearing space at the facility and biomass considerations. Collection targets may be adjusted in the future for individual populations based on genetic analysis.

Table 3.4.3. Captive broodstock parr collection targets by population and year. Note: + is allowed variance around collection.

Population	<2006	2008-2017	>2018
Dennys	150	200	200 ± 15
East Machias	150	200	200 ± 15
Machias	250	300	200 ± 15
Narraguagus	250	300	200 ± 15
Pleasant	100	200	200 ± 15
Sheepscot	150	200	200 ± 15

Table 3.4.4. Average number of captive broodstock, per age class, at Craig Brook National Fish Hatchery

Age-1+ Parr	Pre-broodstock Age-2	Broodstock Age-3	Broodstock Age-4	Broodstock Age-5
1,290	1,275	1,250	950	570

The annual average size of each of the six captive broodstock populations is 675 individuals, representing five-year classes. As fish mature and spawn they are released back to their natal river, so each broodstock population is diminished in numbers until the cohort is released at age-five (Table 3.4.4.).

Age-2 future broodstock, collected the prior year as age 1+ parr, are tagged with PIT tags and sampled for genetic characterization annually in June or July. Of the 1,249 age 1+ parr collected in 2021, 1,225 were tagged as age-2 future broodstock and will be genotyped prior to their first spawn in 2023.

In 2022, parr collections totaled 1,277 from the six populations; each population had a minimum of 200 parr collected but some were unable to achieve the ±15.

General Disease Prevention and Monitoring

CBNFH, GLNFH adhere to facility-specific biosecurity plans and water treatments to prevent the introduction of disease to reared fish populations. Surface water sources for CBNFH and GLNFH are mechanically filtered and irradiated before use. Biosecurity measures include the annual fish health sampling, disinfection of eggs from other facilities, disinfection of equipment, the use of footbaths, and keeping populations segregated.

Disease prevention is further achieved through prophylactic formalin treatments on eggs, newly captured age- 1+ parr and sea-run adults, and any fish that display clinical signs of illness or external parasites.

Disease monitoring at CBNFH and GLNFH adhere to protocols established in the USFWS Handbook of Aquatic Animal Health Procedures and Protocols, with some modification to accommodate the endangered status of Atlantic salmon. Service hatcheries collaborate with LFHC and Kennebec River Biosciences for veterinarian services in the event of atypical or unusual disease events requiring either prescriptions or medicated feed.

In accordance with State of Maine aquatic health regulations and as a condition of each facility's National Discharge Elimination System Permit (NPDES) any incidence of disease, and the recommended course of treatment, is reported to the state environmental agency as well as other partners within 24 hours.

The LFHC analyses samples collected from necropsied mortalities, reproductive fluids (ovarian fluid and milt), and lethal whole-body samples collected from each juvenile lot (60 each) prior to stocking. Collection of reproductive fluids, both ovarian fluid and milt, is done in lieu of lethally sampling adult broodstock at CBNFH.

Atlantic salmon mortalities and those lethally sampled are screened for a suite of salmonid viruses and bacteria including, but not limited to: Furunculosis (*Aeromonas salmonicida)*, Enteric Redmouth (*Yersinia ruckeri*)*,* Bacterial Kidney Disease (*Renibacterium salmoninarum),* Infectious Hematopoietic Necrosis virus, Infectious Pancreatic Necrosis virus, Viral Hemorrhagic Septicemia virus, Infectious Salmonid Anemia virus.

No positive disease findings were made in 2022 except the nine ISA diagnoses discussed above.

Spawning Activities and Egg Production

Spawning Activities

A total of 317 Penobscot sea-run origin females, 466 captive females, and 597 Penobscot-origin domestic females was spawned in November and December 2022 to provide eggs for egg planting, fry, parr and smolt production, domestic broodstock and educational programs. Spawning protocols for Atlantic salmon broodstock at CBNFH and GLNFH prioritized first time spawners and utilized 1:1 paired matings.

CBNFH experienced reduced maturation of age-three and age-four female broodstock in 2022 as compared to the previous three years. The overall female maturation was reduced by 6% for age-three broodstock and 7% for age-4 four. The East Machias, Narraguagus and Sheepscot populations experienced the greatest reduction in age-three female maturation of 11%, 12% and 11%, respectively. The Dennys population experienced the highest reduction of age four-female maturation at 11%. The mechanism behind the reduction is currently unknown. The decrease in female maturation as well as the decrease in parr broodstock collections since 2018 led to a low egg take in 2022 [see Egg Production].

In addition to reduced maturation in 2022 CBNFH and GLNFH, as well as several other hatcheries, experienced an unexpected delay in the onset of spawning [see Photoperiod Manipulation] that was not related to changes in photoperiod treatments. Cooke Aquaculture, National Cold Water Marine Aquaculture Center, and several State of Maine hatcheries also experienced delays in spawning (Mike Pietrak, personal communication). Lake Trout spawning at Berkshire National Fish Hatchery was similarly delayed (Aubrey Curley, personal communication). Spawning of Penobscot Atlantic salmon sea-run broodstock was delayed by a full week; Atlantic salmon domestic broodstock at GLNFH was delayed nearly two-weeks as were captive Atlantic salmon broodstock at CBNFH.

Photoperiod Manipulation

Photoperiod manipulation is used at CBNFH to mitigate against the effects of warm water temperatures (>10°C), typically experienced in late October, on early egg and fry survival. The practice was first applied to Penobscot Atlantic Salmon sea-run adult broodstock in response to an observed shift in spawn timing to earlier in October and decrease in egg quality and survival. Photoperiod manipulation entails providing 16 hours of artificial light beginning on June 20th for one month; ambient light is not restricted during this period. On or about July 20th the amount of artificial light is gradually reduced until the amount of ambient and artificial light is equalized in early November. Not only does the practice delay spawning towards more favorable water temperature conditions, but it also allows greater flexibility during the spring release season when river conditions and road accessibility can affect fry stocking activities.

The use of photoperiod manipulation, using standard linear fluorescent tubes delivering approximately 2,900 lumens in the Screening Building and Swedish pools, has successfully delayed spawning of sea-run broodstock by approximately 10 days (Figure 3.4.2) and allowed eggs to be collected and incubated in more favorable water temperatures (<10°C). As noted in Spawning Activities, an additional delay in the onset of spawning was experienced for sea-run, domestic, and captive broodstock that was not associated with changes in the photoperiod treatment.

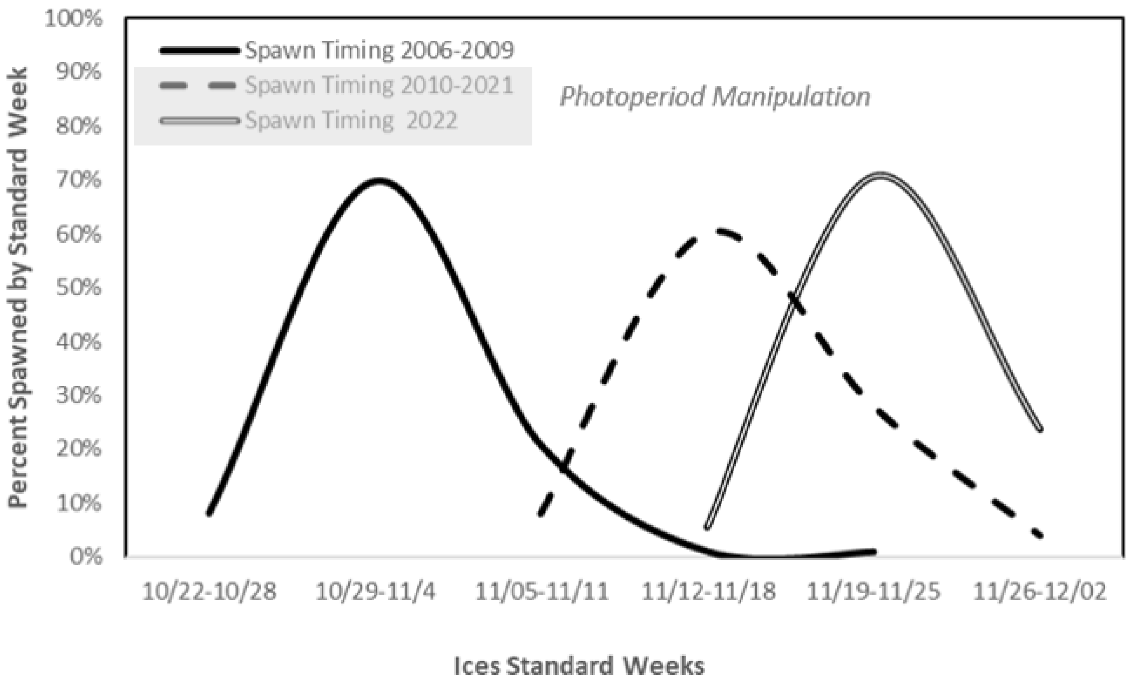

Figure 3.4.2. Spawn timing of Penobscot sea-run broodstock (2006 – 2022). Photoperiod manipulation at Craig Brook National Fish Hatchery began in 2010.Years with manipulation are highlighted within the figure legend.

In 2018, the practice was extended to the Machias and Narraguagus broodstock. New LED (light emitting diode) lighting systems were installed, delivering approximately 7,200 lumens, in the Machias and Narraguagus broodstock modules. The use of higher intensity lighting in 2018 delayed spawning for the Machias and Narraguagus broodstocks approximately an additional week beyond the Penobscot sea-runs even though the same treatment was applied for the same period of time. In 2019, some of the lights in those two modules were turned off which shifted spawning ahead slightly to be more in line with the Penobscot brood.

In 2020, the practice was extended to the remaining captive broodstocks. New LED lighting, delivering approximately 5,700 lumens, was installed in the remaining broodstock modules. This level of light, delivered over the same time period, performed similarly to the standard fluorescent lights used for Penobscot brood area. In 2022, the 7,400 lumen lights were moved to the Dennys and Sheepscot broodstock modules. The effect of photoperiod manipulation on the spawn timing of captive broodstock is demonstrated in Figure 3.4.3.

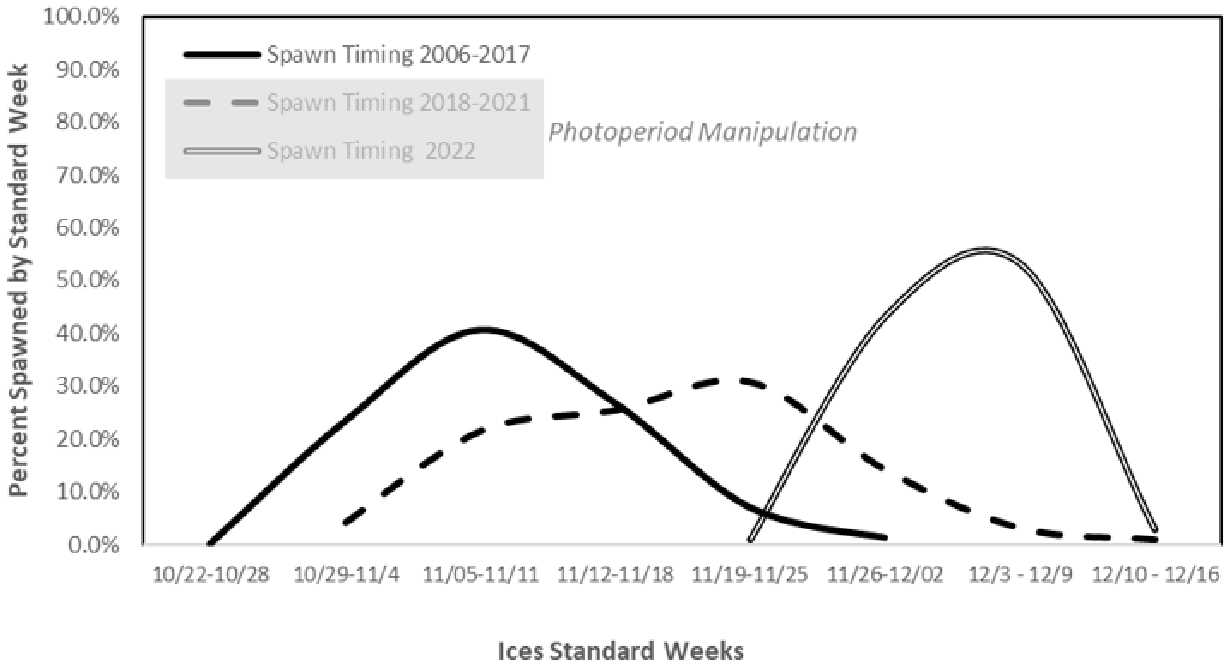

Figure 3.4.3. Spawn timing of captive brood at Craig Brook National Fish Hatchery, 2006 – 2022. Photoperiod manipulation at Craig Brook National Fish Hatchery began in 2018 and was used on two captive populations in 2018 and 2019, all populations in 2020-2022. Years with manipulation are highlighted within the figure legend.

Mate Matcher Software

CBNFH and GLNFH use “Mate Matcher”, a proprietary software program for real-time pairing of mating individuals through optimization of all possible pairings for minimization of genetic relatedness. The software uses broodstock inventory and genotype data to calculate the proportion of shared alleles, which is the count of identical alleles shared by individuals selected for spawning; the lower the shared proportion, the less likely the individuals share common ancestry (Coombs and Nislow 2019). The software then creates data records for each successful pairing including the PIT tag identification of each male and female, their relatedness value, a unique family number and other pertinent information. CBNFH uses the optimization feature of the software for all spawning, and it is anticipated within the next five years GLNFH will also begin optimizing pairing between age-three females and age-four males.

Egg Production

Sea-run, captive and domestic broodstock spawned in 2022 at CBNFH and GLNFH produced 4,677,489 green eggs for the Maine program: 2,072,333 eggs from Penobscot sea-run broodstock; 1,025,717 eggs from domestic broodstock; 1,579,439 eggs from captive broodstock populations Table 3.4.5).

Egg production from CBNFH and GLNFH contribute towards river-of-origin and out-of-basin egg planting, fry production, educational programs, private rearing (fry and parr production), parr and smolt production.

Table 3.4.5. Atlantic salmon egg production in 2022 for the Maine program by drainage, parent origin, the number of females used and fecundity. Parent origin are from the captive reared parr, sea-run adults, or domestic brood raised entirely in captivity.

Drainage	Parent Origin	Females	Egg	Fecundity
Dennys	Captive	85	276,965	3,258
East Machias	Captive	79	318,088	4,026
Machias	Captive	87	321,148	3,691
Narraguagus	Captive	63	205,875	3,268
Penobscot	Sea Run	320	2,072,333	6,476
Penobscot	Domestic	597	1,025,717	1,718
Sheepscot	Captive	64	219,023	3,422
Pleasant	Captive	77	238,340	3,095
-	Totals	1,372	4,677,489	3,409

Adult Stocking

A total of 2,832 adults were stocked into GOM drainages (Table 3.4.6). The Salmon for Maine's Rivers program released 40 Machias adults and 305 Penobscot adults to their natal rivers prior to spawning. In addition, eight Penobscot sea-run adults were released in June, July, and August from CBNFH following diagnosis of non-pathogenic ISA (see *Infectious Salmonid Anemia Monitoring)*.

CBNFH releases spent age-three and age-four broodstock while retaining a small cohort of age-three to spawn in future years as needed. The entire age-five year class is released following their final spawn. GLNFH releases spent age-three broodstock at the entire age-four year class following spawning. All Penobscot sea-run broodstock are released post-spawning. In 2022, the University of Maine released 50 spent sea-run broodstock into the East Branch Penobscot River for research purposes.

Spent broodstock are released to the rivers-of-origin within a week or two following spawning. All broodstock are PIT tagged and have either a double upper caudal fin punch or a double adipose punch to identify them. Releases of spent broodstock are coordinated with MDMR biologists, as well as state and federal game wardens.

Table 3.4.6. Adult broodstock released pre- and post-spawn from Craig Brook National Fish Hatchery (CBNFH), Green Lake National Fish Hatchery (GLNFH), Salmon for Maine's Rivers (SFMR) and the University of Maine (UMO) in 2022.

Originating Entity	Receiving Drainage	Strain	Pre/Post Spawn	Lot	Number Stocked
CBNFH	Dennys	Dennys	Post-Spawn	Captive/Domestic	213
CBNFH	East Machias	East Machias	Post-Spawn	Captive/Domestic	177
SFMR	Machias	Machias	Pre-Spawn	Captive/Domestic	40
CBNFH	Machias	Machias	Post-Spawn	Captive/Domestic	196

Originating Entity	Receiving Drainage	Strain	Pre/Post Spawn	Lot	Number Stocked
CBNFH	Narraguagus	Narraguagus	Post-Spawn	Captive/Domestic	171
SFMR	Penobscot	Penobscot	Pre-Spawn	Captive/Domestic	305
GLNFH	Penobscot	Penobscot	Post-Spawn	Captive/Domestic	867
CBNFH	Penobscot	Penobscot	Pre-Spawn	Sea-run	8
UMO	East Branch Penobscot	Penobscot	Post-Spawn	Sea-run	50
CBNFH	Penobscot	Penobscot	Post-Spawn	Sea-run	480
CBNFH	Pleasant	Pleasant	Post-Spawn	Captive/Domestic	184
CBNFH	Sheepscot	Sheepscot	Post-Spawn	Captive/Domestic	141

3.5 General Program Information

GOM DPS Recovery Plan

The Recovery Plan for the Gulf of Maine Distinct Population Segment of Atlantic Salmon has been completed by the USFWS and NOAA in close collaboration with MDMR and the Penobscot Indian Nation and was released on February 12th, 2019. This document is available at: https://www.fisheries.noaa.gov/action/final-atlantic-salmon-recovery-plan?utm_medium=email&utm_source=govdelivery

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4 Non-Gulf of Maine Distinct Population Segments

The document has been re-organized for the 2022 report. It will separately report on the activities of the Recovery Plan for the Gulf of Maine Distinct Population Segment (DPS), which is found in section 4, and the activities related to Atlantic salmon in the other three DPSs identified in the United States, which is found in this section.

4.1 Long Island Sound

This DPS has been identified as being extinct and includes the Connecticut and the Pawcatuck rivers.

4.1.1 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. CRASC and its partners continued to work on other diadromous fish restoration. The following is a summary of work on Atlantic salmon.

4.1.1.2 Adult returns

Four sea-run Atlantic salmon adults were observed returning to the Connecticut River watershed. Three were observed by video passing up the Rainbow Fishway on the Farmington River and not handled. One was observed by an experienced salmon biologist while snorkeling below the Leesville Fishway on the Salmon River and not handled. An angler subsequently caught and released a male kelt in the Salmon River in the fall. These return numbers (3 + 1= 4) are identical to 2021.

4.1.1.3 Hatchery operations

A total of 656,295 green eggs was produced (2021= 650,646). Only the Kensington State Fish Hatchery (KSFH) in CT maintained domestic broodstock. Contributing broodstock included 118 females and 118 males. Both males and females were a mix of 3+ and 4+ year old fish. Those eggs will be used for fry stocking for the Connecticut Legacy Program including the Salmon-in-Schools program.

4.1.1.4 Juvenile Atlantic salmon releases
A total of 304,335 juvenile Atlantic salmon was stocked into the Connecticut River watershed, all in Connecticut (2021= 33,585). Selected stream reaches in the Farmington River were stocked with fed fry (N= 227,523) and selected reaches in the Salmon River were stocked with both fed (N= 46,930) and unfed (N= 29,882) fry. All fed fry were produced at the Kensington State Fish Hatchery (KSFH) and all of the unfed fry were produced at the Tripp Streamside Incubation Facility (TSIF). The TSIF received eyed eggs from the KSFH. In addition, unfed 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. An estimated 10,523 fry were released by the school program.

4.1.1.5 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.

4.1.1.6 Juvenile population monitoring
None was conducted.

4.1.1.7 Fish passage developments relevant to Atlantic salmon
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. Many diadromous fish species were observed and counted using this technology but salmon were observed only at the Rainbow Fishway.

A new fishway was completed during 2021 at the Upper Collinsville Dam Fishway on the Farmington River in the town of Canton, CT. This fishway is a license requirement as part of a FERC license issued to Canton Hydro, LLC. It will benefit Atlantic salmon since the Legacy program stocks fry upstream of this dam and smolts migrate downstream. A Denil fishway and counting facility and a downstream passage facility were designed and approved by the CTDEEP and the USFWS. It was hoped that it would be operational during the 2022 fish passage season but that did not occur due to other construction delays. The fishway was completed during the summer of 2022 but unusually dry conditions on the river resulted in no hydro operation and thus no fishway operation. The fishway was run for a few hours during the fall for hydraulic inspection but it will not begin routine operation for fish passage until April of 2023.

4.1.1.8 Educational activities
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 14,750 eggs for 52 tanks in 42 schools in Connecticut.

4.1.2 Pawcatuck River

Although a small portion of the watershed lies in Connecticut, all activities involving Atlantic salmon have been conducted solely by Rhode Island Department of Environmental Management (RIDEM) within the state of Rhode Island. The program to restore Atlantic salmon to the Pawcatuck River has ended but RIDEM still produces some salmon eggs from domestic broodstock at a State hatchery for the purposes of providing eggs for a school program. It also monitors the Potter Hill Fishway for the passage of all anadromous fishes. The following is a summary of available information.

4.1.2.1 Adult returns

No Atlantic salmon adults were observed returning to the Pawcatuck River.

4.1.2.2 Hatchery operations

RIDEM's Lafayette Trout Hatchery produced 6,600 eggs from its Sebago Lake broodstock. All of the eggs were used to support the Salmon-in-the-Classroom program.

4.1.2.3 Juvenile Atlantic salmon releases

A total of 4,900 fry were stocked into the watershed by participating schools in the Salmon-in-the-Classroom program.

4.1.2.4 Juvenile population monitoring

None was conducted.

4.1.2.5 Fish passage developments relevant to Atlantic salmon

None.

4.1.2.6 Educational activities

The salmon in the Classroom program supported 29 schools participating in the 2021-22 season, totaling 33 tanks (2020= 16).

4.2 Central New England DPS

This DPS has been identified as being extinct and includes the Merrimack and the Saco rivers.

4.2.1 Merrimack River

The salmon restoration program for this watershed ended in 2013.

4.2.1.1 Adult returns

No Atlantic salmon adults were observed returning to the Merrimack River.

4.2.1.2 Hatchery operations

Previously, the Nashua National Fish Hatchery (NNFH) took eggs and raised salmon for release into the Merrimack River. Such activities have now shifted to the Kennebec River in Maine. There were no hatchery activities supporting salmon management in the Merrimack River watershed.

4.2.1.3 Juvenile Atlantic salmon releases

No salmon of any life stage were released into the Merrimack River.

4.2.1.4 Juvenile population monitoring

None was conducted.

4.2.1.5 Fish passage developments relevant to Atlantic salmon
There are no such developments to report.

4.2.1.6 Educational activities
None reported.

4.2.2 Saco River
There was not a formal, inter-agency restoration program that targeted this river in the past. However, salmon from the NNFH and other sources were stocked into this river in the past and the Saco River Salmon Club operated a volunteer hatchery for years. Fish passage for salmon and other anadromous fishes have been provided at lower dams.

4.2.2.1 Adult Returns
Five Atlantic salmon adults were observed returning to the Saco River. Two were grilse (presumed male) and one female 2SW and two male 2SW fish were reported. All fish were passed upstream.

4.2.2.2 Hatchery Operations
The Saco Salmon Restoration Alliance & Hatchery (SSRA) has ceased receiving eggs or broodstock from NNFH. They now relay on a partnership with University of New England (UNE) to assist in rearing broodstock and spawning. Naturally-reared parr are collected in the wild and reared to adulthood at the SSRA hatchery and then transferred to UNE for spawning. UNE currently is holding 185 adults.

In the fall of 2022, the UNE staff spawned 11 adult salmon (six males and five females) and the eggs were transferred to the SSRA Hatchery. The eggs will be used to supplement the Saco River as well as support the Salmon in Schools Program.

To continue the captive broodstock line, 86 naturally reared and wild parr were taken from Swan Pond Stream, a tributary to the Saco River, in October 2022 as future broodstock. They will be reared at the SSRA hatchery until maturity.

4.2.2.3 Juvenile Atlantic salmon releases
A total of 2,400 fry and 2,000 eggs were stocked into the Saco River watershed.

4.2.2.4 Juvenile population monitoring
None was reported.

4.2.2.5 Fish passage developments relevant to Atlantic salmon
There were no such developments to report.

4.2.2.6 Educational activities

None reported.

4.3 Outer Bay of Fundy

Several tributaries of the St John River (Aroostook River, Prestile Stream, and the Meduxnekeag River) as well as the St Croix River historically contributed to the Outer Bay of Fundy stock of Atlantic salmon. Abundance and distribution of this stock is substantially reduced compared to historic levels. In November of 2010, the Committee on the Status of Endangered Wildlife in Canada assessed the status of the Outer Bay of Fundy stock as 'endangered'. For a species assessed as 'endangered', the Minister of Fisheries and Oceans must decide whether or not to list the species under the Species at Risk Act. To inform this decision a recovery potential assessment was completed in 2016 (Gibson et al. 2016).

4.3.1 St. Croix River

This river is the boundary between the U.S. and Canada. There have been no U.S. activities regarding Atlantic salmon in this watershed for many years. The activities described below reflect only U.S. activities. No activities by Canada Department of Fisheries and Oceans (DFO) are included.

4.3.1.1 Adult Returns

No Atlantic salmon adults were observed returning to the St. Croix River.

4.3.1.2 Hatchery Operations

There were no hatchery activities supporting salmon management in this watershed.

4.3.1.3 Juvenile Atlantic salmon releases

No salmon of any life stage were released into the St. Croix River.

4.3.1.4 Juvenile population monitoring

None was conducted.

4.3.1.5 Fish passage developments relevant to Atlantic salmon

The Milltown Dam (first at tidewater) is scheduled to be removed in 2024. Funding provided by the National Fish and Wildlife Foundation and by NOAA are jumpstarting efforts to improved fish passage at Woodland Dam and Grand Falls Dam as well. Feasibility analyses for improvements at these facilities are now well underway.

4.3.1.6 Educational Activities

None reported.

4.3.2 Meduxnekeag River

This river flows mostly in Maine but enters New Brunswick shortly before flowing into the St. John River. Any adult fish that ascend the Meduxnekeag River from the St. John must first pass the Mactaquac Dam, which lies wholly within Canada. U.S. salmon management activities in this watershed have been sporadic and relatively minor in past years. All activities reported herein are U.S. activities without any reference to activities undertaken by DFO.

4.3.2.1 Adult returns

No Atlantic salmon adults were observed returning to the Meduxnekeag River.

4.3.2.2 Hatchery operations

There were no hatchery activities that supported Atlantic salmon management in this watershed.

4.3.2.3 Juvenile Atlantic salmon releases

No salmon of any life stage were released into the Meduxnekeag River.

4.3.2.4 Juvenile population monitoring

None was conducted.

4.3.2.5 Fish passage developments relevant to Atlantic salmon

Tribal, federal, and academic scientists recently completed an analysis of fish passage alternatives for the Mactaquac Dam finding that, absent dam removal, a fish lift or multiple fish lifts was the best option for upstream passage of most species (Stover et al. 2022). They also reviewed the potential alternatives for downstream passage, which resulted in the ranking of various potential options for downstream passage with no clear preferred alternative, but rather a number of potential options to be further considered. This analysis has been presented to the Government of Canada.

4.3.2.6 Educational activities

None reported.

4.3.3 Prestile Stream

This river flows mostly in Maine but enters New Brunswick shortly before flowing into the St. John River. Any adult fish that ascend Prestile Stream from the St. John must first pass the Mactaquac Dam, which lies wholly within Canada. U.S. salmon management activities in this watershed have been sporadic and relatively minor in past years. All activities reported herein are U.S. activities without any reference to activities undertaken by DFO.

4.3.3.1 Adult returns
No Atlantic salmon adults were observed returning to Prestile Stream.

4.3.3.2 Hatchery operations
There were no hatchery activities that supported Atlantic Salmon management in this watershed.

4.3.3.3 Juvenile Atlantic salmon releases
No salmon of any life stage were released into Prestile Stream.

4.3.3.4 Juvenile population monitoring
None was conducted.

4.3.3.5 Fish passage developments relevant to Atlantic salmon
Tribal, federal, and academic scientists recently completed an analysis of fish passage alternatives for the Mactaquac Dam finding that, absent dam removal, a fish lift or multiple fish lifts was the best option for upstream passage of most species (Stover et al. 2022). They also reviewed the potential alternatives for downstream passage, which resulted in the ranking of various potential options for downstream passage with no clear preferred alternative, but rather a number of potential options to be further considered. This analysis has been presented to the Government of Canada.

4.3.3.6 Educational activities
None reported.

4.3.4 Aroostook River
This river flows mostly in Maine but enters New Brunswick shortly before flowing into the St. John River. The Tinker Dam is located a short distance downstream of the international boundary. Any adult fish that ascend the Aroostook River from the St. John must first use pass the Mactaquac Dam and Tinker Dam, both of which lie wholly within Canada and both have fishways. U.S. salmon management activities in this watershed have been sporadic and relatively minor in past years. All activities reported herein are U.S. activities without any reference to activities undertaken by DFO.

4.3.4.1 Adult returns
No Atlantic salmon adults were observed returning to the Aroostook River.

4.3.4.2 Hatchery operations
There were no hatchery activities that supported Atlantic salmon management in this watershed.

4.3.4.3 Juvenile Atlantic salmon releases
No salmon of any life stage were released into the Aroostook River.

4.3.4.4 Juvenile population monitoring
None was conducted.

4.3.4.5 Fish passage developments relevant to Atlantic salmon
None.

4.3.4.6 Educational activities
None reported.

References:

Gibson, A.J.F., Jones, R.A. and MacAskill, G.J. 2016. Recovery Potential Assessment for Outer Bay of Fundy Atlantic salmon (Salmo Salar): Population Dynamics and Viability. DFO Can. Sci. Advis. Sec. Res. Doc. 2016/032. v + 87 p.

Stover, M. (editor). 2022. Wolastoq International Watershed Restoration Collaboration Fish Passage Workgroup Report Analysis of Fish Passage Alternatives at Mactaquac Generating Station. U.S. Environmental Protection Agency. Boston, Massachusetts. 31pp.

5 Emerging Issues in US Salmon and Terms of Reference

5.1 Summary
This section provides an overview of information presented or developed at the committee meeting that identified 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 routine updates that are typically included in other sections. This section reviews select working papers, ensuing discussions, and ad-hoc topics to provide information on discussions and decisions made by the USASAC.

5.2 Scale Archiving and Inventory Update
The USASAC noted that the lack of dedicated resources and capacity has delayed an 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 and Bioscale Databases. However, storage details and the condition of fish scales has not been adequately summarized. The USASAC supported continued efforts of an ad-hoc committee to work towards identifying funding

sources and drafting a proposal to add capacity to inventory and archive historic scale samples throughout New England. NOAA supported travel time and supplies to advance this effort led by Steve Gephard.

In 2022, Gephard made trips to Roxbury, VT, Conte Lab in Turners Falls, MA, Sunderland, MA, Old Lyme, CT, Nashua, NH and another trip to Maine. Scales were collected and returned to Deep River, CT during all of the trips except the trip to Maine and the trip to Nashua. The trip to Maine was to inventory newly discovered scales at the Augusta office (not previously seen) and the trip to Nashua was to get a sense of how many boxes were stored at the federal hatchery so that a subsequent collection trip could be planned. All scales collected in 2022 were sorted, inventoried, entered into the database, and repackaged for archival storage before the end of the year. The first leg of the trip to Maine included the transfer of six bins to storage. Rendezvous was made with Tim Sheehan in eastern Massachusetts (to save time) and he transported the scales to NOAA storage in Pocasset, MA. Similar to last year with Maine scales, data for these scales were entered into an Excel spreadsheet that included: agency, location, sample type, life stage, year, location, box descriptions, number of samples per box, disposition, and comments. Additional supplies for archiving were purchased and forwarded to Deep River. Early in 2023, additional scales that had been previously collected were packaged for storage and five bins were transported to Pohasset for storage. After leaving Pocasset, the scales that were stored at the Nashua National Fish Hatchery were picked up and transferred to Deep River, CT to await inventory.

A constructive discussion ensued at this year's meeting further developing plans and procedures moving forward in 2023. Additionally, there was discussion regarding the re-labeling of samples due to deterioration of previous label methodologies. The ad hoc group will continue with inventory and archiving activities and provide further reporting in 2023 to be reported in the TOR for 2024.

5.3 Juvenile Assessment Update

Over the past twenty years juvenile abundance efforts have been determined based on individual studies or larger scale basin wide estimates. Sampling locations were often picked based on likelihood of a successful catch or proximity to a road at a time when equipment was heavy and cumbersome. The use of multiple-pass depletion methods was used to estimate juvenile salmon production. While providing a closer estimate of the true population size with error around the estimates, these methods take more time to perform and reduce the number of locations a field crew can sample in a season. Additionally, these methods increase the risk of electrofishing injuries. More recently the use of a single pass Catch per Unit Effort has been adopted. The main advantages single-pass has over multiple-pass methods is it reduces injuries, and more sites can be surveyed in each time frame and over a larger geographical area within a drainage.

With the ability to sample more locations managers can examine the spatial distribution and abundance of salmon across the drainages and regions. However, to do this objectively can be an additional challenge. The method outlined by (Stevens and Olsen, 2004) has been applied to select biological sampling locations based on a Generalized Random – Tessellation Design (GRTS) for a linear resource. Besides removing objectiveness from sampling site selection, use of this selection method can allow for other spatial relationships to be examined such as temperature, physical stream habitat variables, water quality, and land uses, all which could be used in development of a species distribution and habitat model (SDHM).

Plans for 2023 include continuing the use of GRTS to break down sampling needs to cover long term trends (GRTS Index), wild production (WPA) and project-based sampling (Project), a strong base of data will exist for current and future management needs. Future work within GRTS selected site could include specific habitat monitoring or long-term water temperature monitoring. These data can be paired with site biological data to inform Species Distribution Habitat Model that would aid in optimizing rearing strategies and habitat restoration projects across the Maine DPS. An update on 2022 sampling activities were included in Chapter Three of the USASAC 2023 annual report. For 2023, the sampling plan will not differ greatly. A document summarizing the current sampling plan and describing results and trends will be prepared for committee review in 2024.

5.4 Conservation Limits for U.S. Atlantic salmon

Conservation limits (CLs) for U.S. Atlantic salmon were first proposed by Baum in 1995 (Baum (1995). Given evolving management activities and priorities since that time, the USASAC determined that an update to our CLs based on the best available information was warranted. Progress has been made in developing these updated CLs, but further work is needed before a final proposal is available for review by the USASAC in 2024.

Emerging Issues

5.5 Need for Accurate and Consistent Reporting on Habitat Connectivity gains

In 2021, the USASAC discussed increasing needs for accurate reporting of habitat accessibility data at the international and domestic level. These goals are reported annually in the U.S. Annual Progress Report to NASCO. Additionally, at the national level, a database is needed to report on progress towards attainment of the habitat metric in the recovery plan. The final recovery plan states that a minimum of 90,000 units of accessible (as defined in the recovery plan) and suitable habitat must be obtained before delisting is considered. The determination of suitable habitats are left to the discretion of scientists and managers. Although the Critical Habitat Final Rule (74 FR 29300, 2019) identified watersheds that were known to contain the most abundant, suitable habitats for Atlantic salmon, the scale that suitable habitats were identified are too coarse for reporting progress towards meeting the recovery criteria in the recovery plan. To accurately report on progress towards the habitat criterion, there needs to be a standardized definition of what constitutes suitable habitat, where suitable habitats are located in the DPS, the relative productivity of suitable habitats, and a method to calculate how much suitable habitat meets the criteria as accessible each year.

In an effort to address these needs, a small team from ME-DMR, Maine Sea Grant and NOAA – Fisheries began a series of meetings and workshops to address the challenge of identifying, quantifying and mapping suitable Atlantic salmon habitat. The team convened the first of these workshops in December 2022. The primary goal of the workshop was to review existing information that we have available pertaining to salmon habitat and habitat quality. This included a review of the Atlantic salmon habitat model, and review of the habitat quality scoring methods used in identifying critical habitat. The workshop also provided an opportunity to learn from experts about what factors they believe are most influential in determining habitat suitability. In conclusion, the participants in the workshop generally agreed that temperature was the most important factor driving habitat productivity that was not adequately considered in existing models.

A second meeting was held during the 2023 assessment committee meeting. During this meeting, the participants reached consensus that water temperatures are the an important factor driving productivity and should be a key indicator in informing habitat suitability. We also discussed whether to update the existing habitat model, and the spatial scale needed to achieve the objectives. Participants unanimously agreed that the model should be updated, recognizing that advances in the NHDPlus and the inclusion of LIDAR would considerably improve the accuracy of the model, which in turn will be valuable for assessment and management. As for the spatial scale, even though a reach scale is not necessary for reporting on progress towards recovery, participants agreed that the habitat suitability model will be useful in informing other efforts, and therefore, should be modelled at the smallest possible scale. In conclusion, participants agreed that a working group should be established along with a terms-of-reference to advance the next steps to update the habitat model and incorporate water temperature to inform habitat suitability.

Literature Cited:

NASCO. 2003. Resolution by the Parties to the Convention for the Conservation of Salmon in the North Atlantic Ocean, The Williamsburg Resolution. Adopted at the Twentieth Annual Meeting of North Atlantic Salmon Conservation Organization in June 2003, as amended.

SEI. 2007. Review of Atlantic Salmon Hatchery Protocols, Production, and Product Assessment. Sustainable Ecosystems Institute, Portland Oregon.

U.S. Fish and Wildlife Service and NMFS. 2018. Recovery plan for the Gulf of Maine Distinct Population Segment of Atlantic salmon (*Salmo salar*). 74 pp.

5.9 Draft Terms of Reference for 2023 Meeting

The purpose of this section is to outline terms of reference identified at the USASAC annual meeting in March 2023. These draft Terms of Reference are meant to be revisited during our summer 2023 teleconference and intersessional work. These draft TOR will be integrated with requests and needs that emerge from the ICES WGNAS (April 2023); NASCO Meetings (June 2023), and the Maine Collaborative Management Strategy Annual Report (April 2023) to develop Final 2023 TOR and an agenda for the 2024 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 annual 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

Compilation of Tag releases

In **support of the 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 at SHRU level 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

Diversity Metric

Hatchery production

Connectivity

Distribution - occupancy maps and data

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. It is anticipated that this project will be completed during 2023.

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 the 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 (Furey), approaches for index rivers, and complementary efforts that address specific restoration questions (e.g. dispersion from artificial redds, fry vs. parr etc.).

Biological characteristics of US Atlantic salmon. 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 given the development of expected adoption of the new Life Cycle Modeling (LCM) approach. The new LCM has the ability to incorporate detailed information on age-specific adult abundance, estimates of annual escapement, annual smolt ages, annual fecundities, sea age-specific sex distribution of adult returns etc. The LCM is scheduled to be formally reviewed by ICES in 2023 and if approved will become the official assessment model for the WGNAS in 2024. In support of this, the USASAC will work towards developing these time series data-streams in 2023 and 2024 to be available for use within the LCM.

Conservation Limits. Continue refinement of Conservation Limits especially within the Gulf of Maine DPS. Review and update the number of rivers with conservation limits and the monitored time series.

Redds-based and pro-rate returns. Update redd-based and pro-rate working paper- consider additional years for the regression, appropriateness of adding new data, double check language on post-hoc adjustments to returns based on the presence of YoY after zero observed redds.

Connectivity Reporting. Pursuant to accurate reporting of habitat accessibility gains, the U.S. Atlantic Salmon Assessment Committee agreed to review protocols and database structures as they are developed and recommend any necessary changes to data management in support of domestic or international management needs.

6 List of Attendees, Working Papers, and Glossaries

6.1 List of Attendees

Participants for the 2023 USASAC meeting. On site (O), Virtual (V), and Not participating (-)

Last Name	First Name	Email	Agency	Location	2/28	3/1	3/2
Hawkes	Jim	James.Hawkes@noaa.gov	NOAA	Orono, ME	O	O	O
Kocik	John	John.Kocik@noaa.gov	NOAA	Orono, ME	O	O	O
Atkinson	Ernie	Ernie.Atkinson@maine.gov	MDMR	Jonesboro, ME	O	O	O
Gephard	Steve	sgephard@gmail.com	CTDEEP-retired	Deep River, CT	O	O	O
Sweka	John	John_Sweka@fws.gov	USFWS	Lamar, PA	O	O	O
Sheenan	Tim	Tim.Sheehan@noaa.gov	NOAA	Woods Hole, MA	V	V	V
Haas-Castro	Ruth	Ruth.Haas-Castro@noaa.gov	NOAA	Woods Hole, MA	O	O	O
Kircheis	Dan	Dan.Kircheis@noaa.gov	NOAA	Orono, ME	O	O	O
Valliere	Jason	jason.valliere@maine.gov	MDMR	Bangor, ME	V	V	V
Noll	Jennifer	Jennifer.B.Noll@maine.gov	MDMR	Hallowell, ME	-	O	V
Simpson	Mitch	Mitch.Simpson@maine.gov	MDMR	Bangor, ME	V	V	V
Bean	David	David.Bean@noaa.gov	NOAA	Orono, ME	-	V	-
Christman	Paul	Paul.Christman@maine.gov	MDMR	Hallowell, ME	-	-	O
Cox	Oliver	Oliver_Cox@fws.gov	USFWS	Ellsworth, ME	V	V	V
Danielle	Frechette	Danielle.Frechette@maine.gov	MDMR	Augusta, ME	O	O	O
Graham	Goulette	Graham.Goulette@noaa.gov	NOAA	Orono, ME	V	V	-
Abbott	Alex	alexoabbott@hotmail.com	National Audubon Society	Falmouth, ME	-	-	V
Bennett	Bill	William_Bennett@fws.gov	USFWS	Falmouth, ME	-	-	V
Ouellet	Valliere	Valerie.Ouellet@noaa.gov	NOAA	Orono, ME	-	-	V
Stevens	Justin	Justin.Stevens@maine.edu	ME SeaGrant	Orono, ME	-	-	O

6.2 List of Program Summaries and Technical Working Papers (WP) and PowerPoint Presentation Reports (PPT)

Number	Author(s)	Title
WP23-01	S. Gephard	Long Island Sound: Connecticut River and Pawcatuck & Central New England Area: Merrimack River (PPT)
WP23-02	E. Atkinson	Central New England (Saco River) PPT
WP23-03	E. Atkinson	Gulf of Maine DPS Program Summary (PPT)
WP23-04	E. Atkinson	Outer Bay of Fundy (Aroostook and St. Croix Rivers) Summary (PPT)
WP23-05	T. Sheehan	2023 WGNAS ToRs overview for USASAC (PPT)
WP23-06	T. Sheehan	Summary of US data to WGNAS (PPT)
WP23-07	D. Kircheis	NASCO - Meeting and Annual Progress Report (PPT)
WP23-08	J. Kocik, C. Tholke and T. Sheehan	Annual Bycatch Update for Atlantic Salmon, 1989 through February 2023 (WP)
WP23-09	D. Bean	Maine and neighboring Canadian Commercial Aquaculture Activities and Production (WP)
WP23-10	R.E. Haas-Castro, B. Ellingson, G.S. Goulette, C. Bruchs and J. Noll	Review of Atlantic salmon age & image analysis studies: 2022 (Part 1) & Work plan for 2023 (Part 2) (WP)
WP23-11	R.E. Haas-Castro, B. Ellingson, G.S. Goulette, C. Bruchs and J. Noll	Review of Atlantic salmon age & image analysis studies: 2022 (Part 1) & Work plan for 2023 (Part 2) (PPT)
WP23-12	C.W.B. Bruchs, J. Noll, J.P. Hawkes, C. Federico, E.J. Atkinson, P. Christman, R.E. Haas-Castro, and G. Goulette	Update on Maine River Atlantic Salmon Smolt Studies: 2022 (WP)
WP23-13	J. Noll and C.W.B Bruchs	Maine Smolt Summary:2022 (PPT)
WP23-14	John Kocik and Justin Stevens	Marine Metrics SAR PSAR and COVID Impacts 2022 (PPT)
WP23-15	J. Valliere	Covid Impacts: Penobscot - Milford Ops - USFWS processing fish (ppt)
WP23-16	S. Gephard and R.E. Haas-Castro	Update on the Inventory and Archiving of Atlantic Salmon Scale Collections of New England (WP)
WP23-17	S. Gephard and R.E. Haas-Castro	Scale Archiving Activity Update (PPT)
WP23-18	R.E. Haas-Castro	Faded Labels Slides - Sample archiving (PPT)

Number	Author(s)	Title
WP23-19	T. Sheehan	The ‘new’ ICES WGNAS Life Cycle Model (PPT)
WP23-20	D. Frechette	Smolt-to-Adult Supplementation for the GOM DPS: Salmon For Maine's Rivers (PPT)
WP23-21	E. Atkinson, J. Kocik and T. Sheehan	2023 Review and Update of USA Atlantic Salmon Conservation Limits (PPT)
WP23-22	J. Stevens	Atlantic Salmon Habitat Work Group (PPT)
WP23-23	St.Croix Waterway Comm	Anadromous Fish Counts at Milltown Dam
WP23-24	G. Goulette	Overview of NOAA-Fisheries Service, Atlantic Salmon Ecosystems Research Team Water Temperature Report: 2016-2022 (WP)

6.3 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
Virtual	March 1-4, 2021	Jim Hawkes	NOAA
Virtual	February 28 - March 2, 2022	Jim Hawkes	NOAA
Portland, ME	February 28 - March 2, 2023	Jim Hawkes	NOAA

6.4 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
PGH – Peter Gray Hatchery

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

6.5 Glossary of Definitions

Term	Definition
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.

Term	Definition
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.

Term	Definition
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, Age 0 parr stocking, 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 not include 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.

Term	Definition
Reconditioned Kelt	A kelt that has been restored to a feeding condition in captivity.
Repeat Spawner	A salmon that returns numerous times to the river for the purpose of reproducing. Previous spawner.

Appendix 1. Juvenile Atlantic salmon stocking summary for New England in 2022.

United States

Number of fish stocked by lifestage

River	Egg	Fry	0 Parr	1 Parr	2 Parr	1 Smolt	2 Smolt	Total
Connecticut	0	304,000	0	0	0	0	0	304,000
Total for Connecticut Program								**304,000**
Androscoggin	0	4,000	0	0	0	0	0	4,000
Dennys	0	262,000	0	0	0	0	0	262,000
East Machias	0	19,000	164,700	0	0	0	0	183,700
Kennebec	438,000	3,000	0	0	0	97,500	0	538,500
Machias	0	221,000	15,600	0	0	900	0	237,500
Narraguagus	0	72,000	89,700	0	0	0	0	161,700
Penobscot	438,000	213,000	11,400	0	0	648,300	1,000	1,311,700
Pleasant	0	326,000	0	0	0	0	0	326,000
Saco	2,000	2,000	0	0	0	0	0	4,000
Sheepscot	265,000	19,000	13,600	0	0	0	0	297,600
Union	0	1,000	0	0	0	0	0	1,000
Total for Maine Program								**3,327,700**
Pawcatuck	0	5,000	0	0	0	0	0	5,000
Total for Pawcatuck Program								**5,000**
Total for United States								**3,636,700**
Grand Total								**3,636,700**

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 in 2022.

		Captive/Domestic		Sea Run		
Drainage	**Purpose**	**Pre-Spawn**	**Post-Spawn**	**Pre-Spawn**	**Post-Spawn**	**Total**
Dennys	Restoration	0	213	0	0	213
East Machias	Restoration	0	177	0	0	177
Machias	Restoration	40	196	0	0	236
Narraguagus	Restoration	0	171	0	0	171
Penobscot	Restoration	305	867	8	530	1,710
Pleasant	Restoration	0	184	0	0	184
Sheepscot	Restoration	0	141	0	0	141
Total		345	1,949	8	530	2,832

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 2022 .

Marking Agency	Age	Life Stage	H/W	Stock Origin	Primary Mark or Tag	Number Marked	Secondary Mark or Tag	Release Date	Release Location
DSF	0	0_Parr	H	Narraguagus	AD	89,677		Oct	Narraguagus
UMO/USGS	1	1_Smolt	H	Penobscot	PING	148		Apr	Penobscot
USFWS	1	1_Smolt	H	Penobscot	AD	36,575		Apr	Penobscot
MEDMR		Adult	W	Androscoggin	UCP	13		Jun	Androscoggin
USFWS	3	Adult	H	Dennys	PIT	57	DUCP	Dec	Dennys
USFWS	4	Adult	H	Dennys	PIT	36	DUCP	Dec	Dennys
USFWS	5	Adult	H	Dennys	PIT	120	DUCP	Dec	Dennys
USFWS	3	Adult	H	East Machias	PIT	53	DUCP	Dec	East Machias
USFWS	5	Adult	H	East Machias	PIT	89	DUCP	Dec	East Machias
USFWS	4	Adult	H	East Machias	PIT	35	DUCP	Dec	East Machias
MEDMR		Adult	W	Kennebec	AP	81		Jun	Kennebec
MEDMR		Adult	W	Kennebec	AP	1	UCP	Jun	Kennebec
MEDMR		Adult	W	Kennebec	PING	17		Jun	Kennebec
MEDMR	3	Adult	H	Machias	PIT	10	AD	Oct	Machias
UMO/MEDMR		Adult	H	Machias	PING	30	PIT, AD	Oct	Machias
USFWS	3	Adult	H	Machias	PIT	52	DUCP	Dec	Machias
USFWS	5	Adult	H	Machias	PIT	105	DUCP	Dec	Machias
USFWS	4	Adult	H	Machias	PIT	39	DUCP	Dec	Machias
MEDMR		Adult	W	Narraguagus	AP	18		Jun	Narraguagus
MEDMR		Adult	W	Narraguagus	AP	1	UCP	Jun	Narraguagus
USFWS	4	Adult	H	Narraguagus	PIT	60	DUCP	Dec	Narraguagus
USFWS	5	Adult	H	Narraguagus	PIT	76	DUCP	Dec	Narraguagus
USFWS	3	Adult	H	Narraguagus	PIT	35	DUCP	Dec	Narraguagus
MEDMR		Adult	W	Penobscot	AP	224		Jun	Penobscot
MEDMR	3	Adult	H	Penobscot	PIT	1,276	AD	Oct	Penobscot

Marking Agency	Age	Life Stage	H/W	Stock Origin	Primary Mark or Tag	Number Marked	Secondary Mark or Tag	Release Date	Release Location
UMO/MEDMR		Adult	H	Penobscot	PING	29	PIT, AD	Oct	Penobscot
UMO/USGS		Adult	W	Penobscot	PING	50	PIT, AP	Nov	Penobscot
USFWS	3	Adult	H	Penobscot	PIT	710	DAP	Dec	Penobscot
USFWS		Adult	W	Penobscot	PIT	8	AP	Jul	Penobscot
USFWS	4	Adult	H	Penobscot	PIT	157	DAP	Dec	Penobscot
USFWS		Adult	W	Penobscot	PIT	480	AP	Dec	Penobscot
USFWS	3	Adult	H	Pleasant	PIT	52	DUCP	Dec	Pleasant
USFWS	4	Adult	H	Pleasant	PIT	50	DUCP	Dec	Pleasant
USFWS	5	Adult	H	Pleasant	PIT	82	DUCP	Dec	Pleasant
Brookfield		Adult	W	Saco	AP	2		Jun	Saco
USFWS	4	Adult	H	Sheepscot	PIT	40	DUCP	Dec	Sheepscot
USFWS	5	Adult	H	Sheepscot	PIT	80	DUCP	Dec	Sheepscot
USFWS	3	Adult	H	Sheepscot	PIT	21	DUCP	Dec	Sheepscot

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 2022.

Origin	Total External Marks	Total Adipose Clips	Total Marked
Hatchery Adult	3,235	1,286	3,294
Hatchery Juvenile	126,252	126,252	126,400
Wild Adult	828	0	895
Total			**130,589**

Appendix 4. Estimates of Atlantic salmon returns to New England in 2022 from trap counts and redd surveys. (N.R. represents naturally reared origin.)

	Assessment Method	1SW		2SW		3SW		Repeat			2018-2022
		Hatchery	N.R.	Hatchery	N.R.	Hatchery	N.R.	Hatchery	N.R.	Total	Average
Androscoggin	Trap	8	0	9	0	0	0	0	0	**17**	6
Connecticut	Trap	0	0	0	4	0	0	0	0	**4**	3
Cove Brook	Redd Est	0	0	0	0	0	0	0	0	**0**	0
Dennys	Redd Est	0	1	0	5	0	0	0	0	**6**	10
Ducktrap	Redd Est	0	1	0	4	0	0	0	0	**5**	1
East Machias	Redd Est	3	0	13	1	0	0	0	0	**17**	23
Kenduskeag Stream	Redd Est	0	1	0	4	0	0	0	0	**5**	6
Kennebec	Trap	34	2	12	39	0	0	0	0	**87**	47
Machias	Redd Est	0	2	0	8	0	0	0	0	**10**	19
Narraguagus	Trap	0	7	1	11	0	0	0	0	**19**	63
Pawcatuck	Trap	0	0	0	0	0	0	0	0	**0**	0
Penobscot	Trap	308	0	898	105	6	2	5	0	**1,324**	1,058
Pleasant	Redd Est	0	4	0	17	0	0	0	0	**21**	14
Saco	Trap	2	0	0	3	0	0	0	0	**5**	4
Sheepscot	Redd Est	1	1	4	3	0	0	0	0	**9**	13
Union	Trap	0	0	0	0	0	0	0	0	**0**	1
Total		**356**	**19**	**937**	**204**	**6**	**2**	**5**	**0**	**1,529**	**1,268**

Note: The origin/age distribution for returns to the Merrimack and Connecticut Rivers 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 2022.

Source River	Origin	Females Spawned	Total Egg Production
Connecticut	Domestic	118	656,000
Pawcatuck	Domestic	1	7,000
Penobscot	Domestic	597	1,026,000
Dennys	Captive	85	277,000
East Machias	Captive	79	318,000
Machias	Captive	87	321,000
Narraguagus	Captive	63	206,000
Pleasant	Captive	77	238,000
Sheepscot	Captive	64	219,000
Total	**Captive/Domestic**	**1,171**	**3,268,000**
Penobscot	Sea Run	320	2,072,000
Total	**Sea Run**	**320**	**2,072,000**
Grand Total for Year 2022		**1,491**	**5,340,000**

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.

Year	Sea-Run			Domestic			Captive			Kelt			TOTAL		
	No. females	Egg production	Eggs/ female	No. females	Egg production	Eggs/ female	No. females	Egg production	Eggs/ female	No. females	Egg production	Eggs/ female	No. females	Egg production	Eggs/ female
Cocheco															
1993-2012	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															
1977-2012	2,025	20,939,000	7,700	33,482	206,965,000	5,900	0	0		2,395	28,935,000	9,900	37,902	256,839,000	6,300
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
2020	0	0		116	630,000	5,400	0	0		0	0		116	630,000	5,400
2021	0	0		123	651,000	5,300	0	0		0	0		123	651,000	5,300
2022	0	0		118	656,000	5,600	0	0		0	0		118	656,000	5,600
Total Connecticut	2,071	21,264,000	7,400	34,501	213,404,000	6,500	0	0		2,395	28,935,000	9,900	38,967	263,603,000	6,500
Dennys															
1939-2012	26	214,000	7,600	125	687,000	4,600	1,324	5,678,000	4,300	40	330,000	7,700	1,515	6,909,000	5,000
2013	0	0		0	0		46	111,000	2,400	0	0		46	111,000	2,400
2014	0	0		0	0		40	148,000	3,700	0	0		40	148,000	3,700
2015	0	0		0	0		78	447,000	5,700	0	0		78	447,000	5,700
2016	0	0		0	0		27	155,000	5,700	0	0		27	155,000	5,700

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
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
2019	0	0		0	0		109	353,000	3,200	0	0		109	353,000	3,200
2020	0	0		0	0		100	429,000	4,300	0	0		100	429,000	4,300
2021	0	0		0	0		90	380,000	4,200	0	0		90	380,000	4,200
2022	0	0		0	0		85	277,000	3,300	0	0		85	277,000	3,300
Total Dennys	26	214,000	7,600	212	1,079,000	4,600	2,089	8,591,000	3,936	40	330,000	7,700	2,367	10,215,000	4,000
East Machias															
1995-2012	0	0		0	0		1,396	5,709,000	4,100	0	0		1,396	5,709,000	4,100
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
2019	0	0		0	0		108	344,000	3,200	0	0		108	344,000	3,200
2020	0	0		0	0		137	653,000	4,800	0	0		137	653,000	4,800
2021	0	0		0	0		119	500,000	4,200	0	0		119	500,000	4,200
2022	0	0		0	0		79	318,000	4,000	0	0		79	318,000	4,000
Total East Machias	0	0		0	0	0	2,455	9,973,000	4,036	0	0		2,455	9,973,000	4,000
Kennebec															
1979-2012	5	50,000	10,000	0	0		0	0		0	0		5	50,000	10,000
Total Kennebec	5	50,000	10,000	0	0	0	0	0		0	0		5	50,000	10,000
Lamprey															

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

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

Note: Connecticut data are preliminary prior to 1990.

Year	Sea-Run			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
1992-2012	6	32,000	4,800	0	0		0	0		0	0		6	32,000	4,800
Total Lamprey	6	32,000	4,800	0	0	0	0	0		0	0		6	32,000	4,800
Machias															
1941-2012	456	3,263,000	7,300	0	0		2,509	#########	4,100	8	52,000	6,400	2,973	13,652,000	5,700
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
2019	0	0		0	0		127	405,000	3,200	0	0		127	405,000	3,200
2020	0	0		0	0		106	439,000	4,100	0	0		106	439,000	4,100
2021	0	0		0	0		91	371,000	4,100	0	0		91	371,000	4,100
2022	0	0		0	0		87	321,000	3,700	0	0		87	321,000	3,700
Total Machias	456	3,263,000	7,300	0	0	0	3,611	14,293,000	3,636	8	52,000	6,400	4,075	17,608,000	3,800
Merrimack															
1983-2012	1,577	12,270,000	8,000	11,392	57,009,000	4,600	0	0		540	5,709,000	10,800	13,509	74,988,000	6,000
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

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

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

Note: Connecticut data are preliminary prior to 1990.

Year	Sea-Run No. females	Sea-Run Egg production	Sea-Run Eggs/ female	Domestic No. females	Domestic Egg production	Domestic Eggs/ female	Captive No. females	Captive Egg production	Captive Eggs/ female	Kelt No. females	Kelt Egg production	Kelt Eggs/ female	TOTAL No. females	TOTAL Egg production	TOTAL Eggs/ female
Total Merrimack	1,582	12,306,000	7,600	13,169	62,838,000	3,400	0	0		540	5,709,000	10,800	15,291	80,853,000	3,600
Narraguagus															
1962-2012	0	1,303,000		0	0		2,621	#########	4,000	0	0		2,621	11,728,000	4,000
2013	0	0		0	0		118	434,000	3,700	0	0		118	434,000	3,700
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	501,000	3,700	0	0		134	501,000	3,700
2018	0	0		0	0		102	401,000	3,900	0	0		102	401,000	3,900
2019	0	0		0	0		81	314,000	3,900	0	0		81	314,000	3,900
2020	0	0		0	0		140	591,000	4,200	0	0		140	591,000	4,200
2021	0	0		0	0		89	366,000	4,100	0	0		89	366,000	4,100
2022	0	0		0	0		63	206,000	3,300	0	0		63	206,000	3,300
Total Narraguagus	0	1,303,000		0	0	0	3,696	14,433,000	3,736	0	0		3,696	15,736,000	3,700
Orland															
1967-2012	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															
1992-2012	20	157,000	7,700	556	8,000	700	0	0		13	76,000	5,400	589	241,000	6,000
2022	0	0		1	7,000	6,600	0	0		0	0		1	7,000	6,600
Total Pawcatuck	20	157,000	7,700	557	15,000	3,600	0	0		13	76,000	5,400	590	248,000	6,300
Penobscot															
1871-2012	20,659	176,674,000	7,900	8,667	24,924,000	3,000	329	1,400,000	4,300	0	0		29,655	202,999,000	7,300
2013	174	1,258,000	7,200	517	1,713,000	3,300	0	0		0	0		691	2,971,000	4,300

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

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

Note: Connecticut data are preliminary prior to 1990.

Year	Sea-Run No. females	Sea-Run Egg production	Sea-Run Eggs/female	Domestic No. females	Domestic Egg production	Domestic Eggs/female	Captive No. females	Captive Egg production	Captive Eggs/female	Kelt No. females	Kelt Egg production	Kelt Eggs/female	TOTAL No. females	TOTAL Egg production	TOTAL Eggs/female
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	1,572,000	5,600	647	1,726,000	2,700	0	0		0	0		927	3,298,000	3,600
2020	122	927,000	7,600	704	1,898,000	2,700	0	0		0	0		826	2,825,000	3,400
2021	77	489,000	6,300	622	1,657,000	2,700	0	0		0	0		699	2,146,000	3,100
2022	320	2,072,000	6,500	597	1,026,000	1,700	0	0		0	0		917	3,098,000	3,400
Total Penobscot	22,775	191,463,000	7,100	14,670	40,796,000	2,700	329	1,400,000	4,300	0	0		37,774	233,659,000	4,100
Pleasant															
2001-2012	0	0		119	439,000	5,600	490	1,899,000	4,400	0	0		609	2,339,000	4,700
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	288,000	3,300	0	0		87	288,000	3,300
2020	0	0		0	0		91	422,000	4,600	0	0		91	422,000	4,600
2021	0	0		0	0		96	388,000	4,000	0	0		96	388,000	4,000
2022	0	0		0	0		77	238,000	3,100	0	0		77	238,000	3,100
Total Pleasant	0	0		123	468,000	6,400	1,283	4,828,000	3,755	0	0		1,406	5,297,000	3,800
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.

	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
1995-2012	18	125,000	6,900	0	0		1,290	5,015,000	3,800	45	438,000	9,900	1,353	5,579,000	4,100
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	278,000	3,500	0	0		80	278,000	3,500
2020	0	0		0	0		106	417,000	3,900	0	0		106	417,000	3,900
2021	0	0		0	0		104	464,000	4,500	0	0		104	464,000	4,500
2022	0	0		0	0		64	219,000	3,400	0	0		64	219,000	3,400
Total Sheepscot	18	125,000	6,900	0	0	0	2,164	7,818,000	3,327	45	438,000	9,900	2,227	8,382,000	3,400
St Croix															
1993-2012	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															
1974-2012	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	34,501	213,404,000	6,500	0	0		2,395	28,935,000	9,900	38,967	263,603,000	6,500
Dennys	26	214,000	7,600	212	1,080,000	4,600	2,089	8,591,000	3,900	40	330,000	7,700	2,367	10,215,000	4,000
East Machias	0	0		0	0		2,455	9,973,000	4,000	0	0		2,455	9,973,000	4,000
Kennebec	5	50,000	10,000	0	0		0	0		0	0		5	50,000	10,000
Lamprey	6	32,000	4,800	0	0		0	0		0	0		6	32,000	4,800
Machias	456	3,263,000	7,300	0	0		3,611	14,293,000	3,600	8	52,000	6,400	4,075	17,608,000	3,800
Merrimack	1,582	12,306,000	7,600	13,169	62,837,000	3,400	0	0		540	5,709,000	10,800	15,291	80,852,000	3,600
Narraguagus	0	1,303,000		0	0		3,696	14,433,000	3,700	0	0		3,696	15,736,000	3,700
Orland	39	270,000	7,300	0	0		0	0		0	0		39	270,000	7,300
Pawcatuck	20	157,000	7,700	557	15,000	3,700	0	0		13	76,000	5,400	590	248,000	6,300
Penobscot	22,775	191,463,000	7,100	14,670	40,794,000	2,700	329	1,400,000	4,300	0	0		37,774	233,657,000	4,100
Pleasant	0	0		123	468,000	6,400	1,283	4,828,000	3,800	0	0		1,406	5,296,000	3,800
Sheepscot	18	125,000	6,900	0	0		2,164	7,818,000	3,300	45	438,000	9,900	2,227	8,381,000	3,400
St Croix	39	291,000	7,400	0	0		0	0		0	0		39	291,000	7,400
Union	600	4,611,000	7,900	0	0		0	0		0	0		600	4,611,000	7,900
Grand Total	**27,640**	**235,370,000**	**8,500**	**63,232**	**318,598,000**	**5,000**	**15,627**	**61,336,000**	**3,900**	**3,041**	**35,540,000**	**11,700**	**109,540**	**650,844,000**	**5,900**

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								
2001-2012	0	14,000	0	0	0	0	0	14,000
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
2020	0	2,000	0	0	0	0	0	2,000
2021	0	1,000	0	0	0	0	0	1,000
2022	0	4,000	0	0	0	0	0	4,000
Totals:Androscoggin	**0**	**27,000**	**0**	**0**	**0**	**500**	**0**	**27,500**
Aroostook								
1978-2012	0	5,751,000	317,400	38,600	0	32,600	29,800	6,169,400
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								
1988-2012	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								
1967-2012	0	146,669,000	2,846,500	1,836,700	64,700	3,771,300	1,728,600	156,916,800
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
2020	0	222,000	0	1,000	0	0	0	223,000
2021	0	34,000	0	0	0	0	0	34,000
2022	0	304,000	0	0	0	0	0	304,000
Totals:Connecticut	**0**	**150,467,000**	**2,858,200**	**1,837,700**	**64,700**	**3,771,900**	**1,828,100**	**160,827,600**
Dennys								
1975-2012	0	3,964,000	225,400	7,300	0	532,700	30,000	4,759,400
2014	0	84,000	0	0	0	0	0	84,000
2015	0	110,000	0	0	0	0	0	110,000
2016	0	343,000	0	0	0	0	0	343,000
2017	0	126,000	0	0	0	0	0	126,000
2018	0	234,000	0	300	0	0	400	234,700
2019	0	175,000	10,000	0	0	0	0	185,000
2020	40000	149,000	0	0	0	0	0	189,000

	Number of fish stocked by life stage							
	Egg	**Fry**	**0 Parr**	**1 Parr**	**2 Parr**	**1 Smolt**	**2 Smolt**	**Total**
2021	43000	313,000	0	0	0	0	0	356,000
2022	0	262,000	0	0	0	0	0	262,000
Totals:Dennys	**83,000**	**5,760,000**	**235,400**	**7,600**	**0**	**532,700**	**30,400**	**6,649,100**
Ducktrap								
1986-2012	0	68,000	0	0	0	0	0	68,000
Totals:Ducktrap	**0**	**68,000**	**0**	**0**	**0**	**0**	**0**	**68,000**
East Machias								
1973-2012	0	3,717,000	60,700	42,600	0	108,400	30,400	3,959,100
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
2020	0	0	68,000	0	0	0	0	68,000
2021	0	19,000	171,600	0	0	0	0	190,600
2022	0	19,000	164,700	0	0	0	0	183,700
Totals:East Machias	**0**	**3,834,000**	**1,641,200**	**42,600**	**0**	**108,400**	**30,400**	**5,656,600**
Kennebec								
2001-2012	2810000	322,000	0	0	0	200	0	3,131,653
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
2020	679000	3,000	0	0	0	89,000	0	770,600
2021	759000	2,000	0	0	0	100,000	0	861,290
2022	438000	3,000	0	0	0	97,500	0	538,593
Totals:Kennebec	**9,978,000**	**339,000**	**0**	**0**	**0**	**287,300**	**0**	**10,603,492**
Lamprey								
1978-2012	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								
1970-2012	0	6,398,000	99,300	124,300	0	191,300	44,100	6,857,000
2013	0	172,000	800	1,400	0	59,100	0	233,300
2014	27000	210,000	400	0	0	0	0	237,387
2015	49000	503,000	500	0	0	0	0	552,732
2016	40000	186,000	0	0	0	0	0	226,348
2017	61000	187,000	0	0	0	0	0	247,800
2018	84000	145,000	0	0	0	0	0	229,500

	Number of fish stocked by life stage							
	Egg	**Fry**	**0 Parr**	**1 Parr**	**2 Parr**	**1 Smolt**	**2 Smolt**	**Total**
2019	91000	183,000	0	0	0	0	100	274,100
2020	102000	181,000	16,000	0	0	0	0	299,000
2021	40000	290,000	17,200	0	0	0	0	347,200
2022	0	221,000	15,600	0	0	900	0	237,500
Totals:Machias	**494,000**	**8,676,000**	**149,800**	**125,700**	**0**	**251,300**	**44,200**	**9,741,867**
Merrimack								
1975-2012	0	41,664,000	431,800	617,000	0	1,940,600	638,100	45,291,500
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								
1970-2012	0	6,632,000	117,100	14,600	0	400,200	84,000	7,247,900
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
2020	66000	164,000	0	0	0	0	0	230,000
2021	283000	280,000	112,800	0	0	0	0	675,672
2022	0	72,000	89,700	0	0	0	0	161,700
Totals:Narraguagus	**494,000**	**8,532,000**	**372,400**	**15,000**	**0**	**791,700**	**84,700**	**10,289,817**
Pawcatuck								
1979-2012	0	6,288,000	1,209,200	268,100	0	127,500	500	7,893,300
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
2021	0	3,000	0	0	0	0	0	3,000
2022	0	5,000	0	0	0	0	0	5,000
Totals:Pawcatuck	**0**	**6,343,000**	**1,209,200**	**268,100**	**0**	**128,700**	**500**	**7,949,500**
Penobscot								
1970-2012	353000	26,056,000	6,470,800	1,394,400	0	17,172,800	2,508,200	53,954,979
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

	Number of fish stocked by life stage							
	Egg	**Fry**	**0 Parr**	**1 Parr**	**2 Parr**	**1 Smolt**	**2 Smolt**	**Total**
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
2020	498000	614,000	70,000	0	0	648,000	0	1,830,000
2021	306000	242,000	112,200	0	0	620,400	0	1,280,847
2022	438000	213,000	11,400	0	0	648,300	1,000	1,311,793
Totals:Penobscot	**3,942,000**	**32,388,000**	**7,965,500**	**1,394,400**	**0**	**22,828,600**	**2,509,200**	**71,027,542**

Pleasant

1975-2012	0	1,398,000	16,000	1,800	0	184,600	42,400	1,642,800
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
2020	85000	89,000	0	0	0	0	0	174,000
2021	178000	165,000	0	0	0	0	0	343,248
2022	0	326,000	0	0	0	0	0	326,000
Totals:Pleasant	**646,000**	**2,779,000**	**16,000**	**1,800**	**0**	**246,900**	**42,400**	**3,731,061**

Saco

1975-2012	0	7,127,000	463,800	232,000	0	396,200	9,500	8,228,500
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
2020	24000	0	0	0	0	0	0	24,000
2021	9000	0	0	0	0	0	0	8,600
2022	2000	2,000	0	0	0	0	0	4,000
Totals:Saco	**277,000**	**9,526,000**	**518,900**	**232,000**	**0**	**444,100**	**9,500**	**11,007,410**

Sheepscot

1971-2012	97000	3,304,000	209,000	20,600	0	92,200	7,100	3,730,069
2013	122000	18,000	14,000	0	0	0	0	154,476
2014	118000	23,000	15,000	0	0	0	0	155,668
2015	118000	19,000	14,200	0	0	0	0	150,868
2016	209000	20,000	15,400	0	0	0	0	244,170
2017	371000	18,000	15,400	0	0	0	0	404,829
2018	131000	23,000	13,100	0	0	0	0	167,130
2019	215000	9,000	17,000	0	0	0	0	241,000
2020	163000	28,000	0	0	0	0	0	191,000
2021	264000	28,000	19,300	0	0	0	0	311,300
2022	265000	19,000	13,600	0	0	0	0	297,564
Totals:Sheepscot	**2,073,000**	**3,509,000**	**346,000**	**20,600**	**0**	**92,200**	**7,100**	**6,048,074**

	Number of fish stocked by life stage							
	Egg	**Fry**	**0 Parr**	**1 Parr**	**2 Parr**	**1 Smolt**	**2 Smolt**	**Total**
St Croix								
1981-2012	0	1,268,000	498,000	158,300	0	808,000	20,100	2,752,400
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								
1971-2012	0	552,000	371,400	0	0	379,700	251,000	1,554,100
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
2020	0	2,000	0	0	0	0	0	2,000
2021	0	1,000	0	0	0	0	0	1,000
2022	0	1,000	0	0	0	0	0	1,000
Totals:Union	**0**	**660,000**	**371,400**	**0**	**0**	**379,900**	**251,000**	**1,662,300**
Upper StJohn								
1979-2012	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	26,000	0	0	0	500	0	**26,200**
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	150,466,000	2,858,200	1,837,700	64,800	3,771,900	1,828,200	**160,762,000**
Dennys	83,000	5,760,000	235,400	7,600	0	532,800	30,400	**6,649,600**
Ducktrap	0	68,000	0	0	0	0	0	**68,000**
East Machias	0	3,833,000	1,641,200	42,600	0	108,400	30,400	**5,655,700**
Kennebec	9,977,000	339,000	0	0	0	287,400	0	**10,603,800**
Lamprey	0	1,593,000	427,700	58,800	0	201,400	32,800	**2,313,700**
Machias	495,000	8,677,000	149,700	125,600	0	251,400	44,200	**9,742,300**
Merrimack	0	41,797,000	431,700	658,100	0	1,981,400	638,300	**45,506,500**
Narraguagus	494,000	8,532,000	372,400	15,000	0	791,900	84,700	**10,290,400**
Pawcatuck	0	6,343,000	1,209,200	268,100	0	128,700	500	**7,949,100**
Penobscot	3,942,000	32,387,000	7,965,600	1,394,400	0	22,828,600	2,509,200	**71,026,100**
Pleasant	645,000	2,780,000	16,000	1,800	0	247,000	42,400	**3,732,100**
Saco	277,000	9,526,000	518,800	232,000	0	444,000	9,500	**11,007,000**
Sheepscot	2,073,000	3,510,000	345,900	20,600	0	92,200	7,100	**6,048,600**
St Croix	0	1,270,000	498,000	158,300	0	808,000	20,100	**2,754,200**
Union	0	659,000	371,400	0	0	379,900	251,000	**1,661,200**
Upper StJohn	0	2,165,000	1,456,700	14,700	0	5,100	27,700	**3,669,200**
TOTALS	**17,986,000**	**288,589,000**	**18,865,400**	**4,884,400**	**64,800**	**32,898,500**	**5,586,200**	**368,809,600**

Summaries for each river vary by length of time series.

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

Estimated returns include rod and trap caught fish as well as returns estimated from redd counts. Returns are unknown where blanks occur. Returns from juveniles of hatchery origin include age 0 and 1 parr, and age 1 and 2 smolt releases. Returns of 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									
1983-2012	57	599	6	2	10	106	0	1	**781**
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**
2020	0	3	0	0	0	2	0	0	**5**
2021	4	0	0	0	0	1	0	0	**5**
2022	8	9	0	0	0	0	0	0	**17**
Total for Androscoggin	69	615	0	2	10	119	0	0	**822**
Cocheco									
1992-2012	0	0	1	1	6	10	0	0	**18**
Total for Cocheco	0	0	0	1	6	10	0	0	**18**
Connecticut									
1974-2012	58	3,608	28	2	131	2,233	14	3	**6,077**
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**
2020	0	0	0	0	0	0	0	0	**0**
2021	0	0	0	0	0	4	0	0	**4**
2022	0	0	0	0	0	4	0	0	**4**
Total for Connecticut	58	3,612	16	2	140	2402	16	16	**6,261**
Cove Brook									
2018	0	0	0	0	0	0	0	0	**0**
2019	0	0	0	0	0	0	0	0	**0**
2020	0	0	0	0	0	0	0	0	**0**
2021	0	0	0	0	0	0	0	0	**0**

	HATCHERY ORIGIN				NATURALLY REARED ORIGIN				
	1SW	2SW	3SW	Repeat	1SW	2SW	3SW	Repeat	Total
2022	0	0	0	0	0	0	0	0	**0**
Total for Cove Brook	0	0	0	0	0	0	0	0	**0**
Dennys									
1967-2012	42	350	0	1	77	910	6	35	**1,421**
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**
2020	0	0	0	0	4	17	0	0	**21**
2021	0	0	0	0	0	0	0	0	**0**
2022	0	0	0	0	1	5	0	0	**6**
Total for Dennys	42	350	6	1	95	987	6	6	**1,516**
Ducktrap									
1985-2012	0	0	0	0	59	259	0	0	**318**
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**
2020	0	0	0	0	0	0	0	0	**0**
2021	0	0	0	0	0	2	0	0	**2**
2022	0	0	0	0	1	4	0	0	**5**
Total for Ducktrap	0	0	0	0	63	280	0	0	**343**
East Machias									
1967-2012	22	254	1	2	73	574	1	10	**937**
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**
2020	4	18	0	0	0	2	0	0	**24**
2021	3	15	0	0	0	1	0	0	**19**
2022	3	13	0	0	0	1	0	0	**17**
Total for East Machias	46	360	1	2	83	617	1	1	**1,120**
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**
2022	0	0	0	0	1	4	0	0	**5**
Total for Kenduskeag Stream	0	0	0	0	4	16	0	0	**20**
Kennebec									
1975-2012	24	255	6	7	9	74	0	0	**375**
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**
2020	0	0	0	0	4	49	0	0	**53**
2021	4	0	0	0	4	17	0	0	**25**
2022	34	12	0	0	2	39	0	0	**87**
Total for Kennebec	64	274	2	7	36	357	2	2	**747**
Lamprey									
1979-2012	10	17	1	0	13	16	0	0	**57**
Total for Lamprey	10	17	0	0	13	16	0	0	**57**
Machias									
1967-2012	40	363	9	2	154	2,082	41	131	**2,822**
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**
2020	0	0	0	0	6	23	0	0	**29**
2021	0	0	0	0	3	13	0	0	**16**
2022	0	0	0	0	2	8	0	0	**10**
Total for Machias	43	374	41	2	184	2201	41	41	**2,985**
Merrimack									
1982-2012	499	1,746	51	9	153	1,192	39	0	**3,689**
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**

	HATCHERY ORIGIN				NATURALLY REARED ORIGIN				
	1SW	2SW	3SW	Repeat	1SW	2SW	3SW	Repeat	Total
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**
2020	0	0	0	0	1	3	0	0	**4**
2021	0	0	0	0	0	0	0	0	**0**
Total for Merrimack	504	1,788	40	12	155	1227	40	40	**3,779**
Narraguagus									
1967-2012	195	807	25	58	134	2,583	72	168	**4,042**
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	21	16	0	0	1	3	1	0	**42**
2019	58	18	0	2	9	35	1	0	**123**
2020	11	76	3	1	2	15	0	0	**108**
2021	2	17	0	0	3	3	0	0	**25**
2022	0	1	0	0	7	11	0	0	**19**
Total for Narraguagus	314	981	74	61	163	2708	74	74	**4,505**
Pawcatuck									
1982-2012	2	151	1	0	1	23	1	0	**179**
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**
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	0	0	0	**0**
2020	0	0	0	0	0	0	0	0	**0**
2021	0	0	0	0	0	0	0	0	**0**
2022	0	0	0	0	0	0	0	0	**0**
Total for Pawcatuck	2	151	1	0	1	25	1	1	**181**
Penobscot									
1968-2012	13,307	50,910	299	739	834	4,319	37	102	**70,547**
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**

	HATCHERY ORIGIN				NATURALLY REARED ORIGIN				
	1SW	2SW	3SW	Repeat	1SW	2SW	3SW	Repeat	Total
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**
2020	177	998	16	5	18	221	3	1	**1,439**
2021	194	270	5	1	13	73	2	3	**561**
2022	308	898	6	5	0	105	2	0	**1,324**
Total for Penobscot	15,305	55,897	44	757	919	5188	44	44	**78,568**
Pleasant									
1967-2012	11	33	0	0	51	365	3	2	**465**
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**
2020	0	0	0	0	2	7	0	0	**9**
2021	0	0	0	0	3	11	0	0	**14**
2022	0	0	0	0	4	17	0	0	**21**
Total for Pleasant	21	76	3	0	68	435	3	3	**605**
Saco									
1985-2012	179	702	5	7	50	118	6	0	**1,067**
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**
2020	0	0	0	0	2	4	0	0	**6**
2021	0	0	0	0	0	0	0	0	**0**
2022	2	0	0	0	0	3	0	0	**5**
Total for Saco	185	716	6	7	55	132	6	6	**1,106**
Sheepscot									
1967-2012	22	87	0	0	71	492	13	0	**685**
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**

	HATCHERY ORIGIN				NATURALLY REARED ORIGIN				
	1SW	2SW	3SW	Repeat	1SW	2SW	3SW	Repeat	Total
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**
2020	2	6	0	0	1	5	0	0	**14**
2021	1	5	0	0	1	4	0	0	**11**
2022	1	4	0	0	1	3	0	0	**9**
Total for Sheepscot	38	151	13	0	84	540	13	13	**826**
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									
1981-2012	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									
1973-2012	274	1,841	9	28	1	16	0	0	**2,169**
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**
2020	0	2	0	0	0	1	0	0	**3**
2022	0	0	0	0	0	0	0	0	**0**
Total for Union	274	1,844	0	28	1	21	0	0	**2,177**

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	69	615	6	2	10	119	0	1	**822**
Cocheco	0	0	1	1	6	10	0	0	**18**
Connecticut	58	3,612	28	2	140	2,402	16	3	**6,261**
Cove Brook	0	0	0	0	0	0	0	0	**0**
Dennys	42	350	0	1	95	987	6	35	**1,516**
Ducktrap	0	0	0	0	63	280	0	0	**343**
East Machias	46	360	1	2	83	617	1	10	**1,120**
Kenduskeag Stream	0	0	0	0	4	16	0	0	**20**
Kennebec	64	274	6	7	36	357	2	1	**747**
Lamprey	10	17	1	0	13	16	0	0	**57**
Machias	43	374	9	2	184	2,201	41	131	**2,985**
Merrimack	504	1,788	53	12	155	1,227	40	0	**3,779**
Narraguagus	314	981	28	61	163	2,708	74	176	**4,505**
Pawcatuck	2	151	1	0	1	25	1	0	**181**
Penobscot	15,305	55,897	351	757	919	5,188	44	107	**78,568**
Pleasant	21	76	0	0	68	435	3	2	**605**
Saco	185	716	5	7	55	132	6	0	**1,106**
Sheepscot	38	151	0	0	84	540	13	0	**826**
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	1,844	9	28	1	21	0	0	**2,177**

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 2017 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 2017 and earlier).

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

Appendix 12.2: Return rates for Atlantic salmon that were stocked as fry in the Connecticut (basin) River .

Year	Total Fry (10,000s)	Total Returns	Returns (per 10,000)	Age class (smolt age.sea age) distribution (%)										Age (years) dist'n (%)				
				1.1	1.2	1.3	2.1	2.2	2.3	3.1	3.2	3.3	4.2	2	3	4	5	6
1974	2	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1975	3	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1976	3	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	5	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	5	7	1.400	0	0	0	0	100	0	0	0	0	0	0	0	100	0	0
1979	5	3	0.561	0	100	0	0	0	0	0	0	0	0	0	100	0	0	0
1980	29	18	0.630	0	0	0	0	100	0	0	0	0	0	0	0	100	0	0
1981	17	19	1.129	0	0	0	11	89	0	0	0	0	0	0	11	89	0	0
1982	29	46	1.565	0	0	0	0	89	11	0	0	0	0	0	0	89	11	0
1983	19	2	0.108	0	100	0	0	0	0	0	0	0	0	0	100	0	0	0
1984	58	3	0.051	0	0	0	0	33	33	0	33	0	0	0	0	33	66	0
1985	42	47	1.113	0	0	0	0	100	0	0	0	0	0	0	0	100	0	0
1986	18	28	1.592	0	0	0	4	96	0	0	0	0	0	0	4	96	0	0
1987	117	51	0.436	0	18	0	0	67	2	0	14	0	0	0	18	67	16	0
1988	131	108	0.825	0	0	0	0	97	1	0	2	0	0	0	0	97	3	0
1989	124	67	0.539	0	22	0	7	69	0	0	1	0	0	0	29	69	1	0
1990	135	68	0.505	0	19	0	0	79	0	0	1	0	0	0	19	79	1	0
1991	221	35	0.159	0	17	0	0	63	0	0	20	0	0	0	17	63	20	0
1992	201	118	0.587	0	5	0	0	82	1	0	12	0	0	0	5	82	13	0
1993	415	185	0.446	0	4	0	3	87	0	0	6	0	0	0	7	87	6	0
1994	598	294	0.492	0	5	0	2	88	0	0	5	0	0	0	7	88	5	0

Means includes year classes with complete return data (year classes of 2017 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	0	0	100	0	0
2015	39	3	0.077	0	0	0	0	100	0	0	0	0	0	0	0	100	0	0
2016	6	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2017	19	4	0.207	0	0	0	0	100	0	0	0			0	0	100	0	
2018	20	4	0.203	0	0	0	0	100		0				0	0	100		
2019	34	0	0.000	0	0		0							0	0			

Means includes year classes with complete return data (year classes of 2017 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 .

2020	22	0	0.000	0										0				
Total	**15,000**	**2,558**																
Mean			**0.336**	**0**	**11**	**0**	**4**	**68**	**2**	**0**	**4**	**0**	**0**	**0**	**15**	**68**	**5**	**0**

Means includes year classes with complete return data (year classes of 2017 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 2017 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	0	0	0
2015	27	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2016	4	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2017	11	3	0.282	0	0	0	0	100	0	0	0			0	0	100	0	
2018	11	3	0.272	0	0	0	0	100		0				0	0	100		
2019	21	0	0.000	0	0		0							0	0			
2020	15	0	0.000	0										0				
Total	**2,462**	**382**																
Mean			**0.223**	**0**	**20**	**0**	**4**	**52**	**0**	**0**	**6**	**0**	**0**	**0**	**23**	**52**	**6**	**0**

Means includes year classes with complete return data (year classes of 2017 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 2017 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	0	0	100	0	0	0
2015	0	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2016	0	3	7.528	0	0	0	0	100	0	0	0	0	0	0	0	100	0	0
2017	0	1	5.405	0	0	0	100	0	0	0	0			0	100	0	0	
Total	**4,183**	**1,422**																
Mean			**2.003**	**0**	**2**	**0**	**11**	**64**	**4**	**2**	**7**	**0**	**0**	**0**	**13**	**66**	**11**	**1**

Means includes year classes with complete return data (year classes of 2017 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 2017 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	0	0	0
2015	1	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2016	1	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2017	0	0	0.000	0	0	0	0	0	0	0	0			0	0	0	0	
2019	2	0	0.000	0	0		0							0	0			
Total	**635**	**27**																
Mean			**0.102**	**0**	**3**	**1**	**1**	**28**	**0**	**0**	**4**	**0**	**0**	**0**	**4**	**28**	**4**	**0**

Means includes year classes with complete return data (year classes of 2017 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 2017 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	0	0	0
2015	12	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2016	2	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2017	7	1	0.140	0	0	0	0	100	0	0	0			0	0	100	0	
2018	9	1	0.115	0	0	0	0	100		0				0	0	100		
2019	13	0	0.000	0	0		0							0	0			
2020	7	0	0.000	0										0				
Total	**601**	**124**																
Mean			**0.198**	**0**	**15**	**0**	**4**	**54**	**0**	**0**	**0**	**0**	**0**	**0**	**20**	**54**	**0**	**0**

Means includes year classes with complete return data (year classes of 2017 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 2017 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 2017 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 2017 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	0	0	15	74	11	0
2015	52	196	3.786	0	1	0	5	79	2	2	12	0	0	0	6	81	14	0
2016	102	209	2.040	0	0	0	1	94	1	0	3	0	0	0	1	94	4	0
2017	41	102	2.493	0	0	0	18	65	2	1	15			0	18	66	17	
2018	114	101	0.884	0	0	0	11	89		0				0	11	89		
2019	63	1	0.016	100	0		0							100	0			
2020	61	0	0.000	0										0				
Total	**3,180**	**5,674**																
Mean			**4.375**	**0**	**0**	**0**	**15**	**74**	**1**	**3**	**8**	**0**	**0**	**0**	**15**	**76**	**9**	**0**

Means includes year classes with complete return data (year classes of 2017 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		3.786
2016	7.528	0.000	0.000		0.000	0.000		2.040
2017	5.405	0.000	0.207		0.140	0.282		2.493
2018			0.203		0.115	0.272		0.884
2019		0.000	0.000		0.000	0.000		0.016
2020			0.000		0.000	0.000		0.000
Mean	**1.869**	**0.106**	**0.344**	**0.452**	**0.205**	**0.229**	**0.174**	**4.442**
StDev	**4.915**	**0.368**	**0.435**	**0.684**	**0.251**	**0.293**	**0.168**	**6.070**

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	12	0	4	78	2	0	4	0	0	0	16	78	6	0
Farmington	0	22	0	4	66	0	0	7	0	0	0	27	66	7	0
Merrimack	0	3	0	14	69	4	2	8	0	0	0	17	71	12	1
Pawcatuck	0	8	2	2	78	0	0	10	0	0	0	10	80	10	0
Penobscot	3	0	0	15	74	1	2	8	0	0	3	15	76	9	0
Salmon	0	19	0	5	75	0	0	0	0	0	0	24	75	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**	**17**	**75**	**7**	**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 2022.

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	17	0	0	17	0	0	17
Cove Brook	0	0	0	0	0	0	0
Dennys	6	0	0	6	0	0	6
Ducktrap	5	0	0	5	0	0	5
East Machias	17	0	0	17	0	0	17
Kenduskeag Stream	5	0	0	5	0	0	5
Kennebec	87	0	0	87	0	0	87
Machias	10	0	0	10	40	0	50
Narraguagus	19	0	0	19	0	0	19
Penobscot	1,324	557	3	764	305	8	1,077
Pleasant	21	0	0	21	0	0	21
Saco	5	0	0	5	0	0	5
Sheepscot	9	0	0	9	0	0	9
Union	0	0	0	0	0	0	0
Totals	**1525**	**557**	**3**	**965**	**345**	**8**	**1,318**

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 - 2012**	**781**	**0**	**0**	**781**	**0**	**0**	**781**
	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**
	2020	**5**	**0**	**0**	**5**	**0**	**0**	**5**
	2021	**5**	**0**	**0**	**5**	**0**	**0**	**5**
	2022	**17**	**0**	**0**	**17**	**0**	**0**	**17**
Cove Brook	**2018**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
	2019	**0**	**0**	**0**	**0**	**0**	**0**	**0**
	2020	**0**	**0**	**0**	**0**	**0**	**0**	**0**
	2021	**0**	**0**	**0**	**0**	**0**	**0**	**0**
	2022	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Dennys	**1967 - 2012**	**1421**	**0**	**5**	**1416**	**299**	**0**	**1715**
	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**
	2020	**21**	**0**	**0**	**21**	**0**	**0**	**21**
	2021	**0**	**0**	**0**	**0**	**0**	**0**	**0**
	2022	**6**	**0**	**0**	**6**	**0**	**0**	**6**
Ducktrap	**1985 - 2012**	**318**	**0**	**0**	**318**	**0**	**0**	**318**

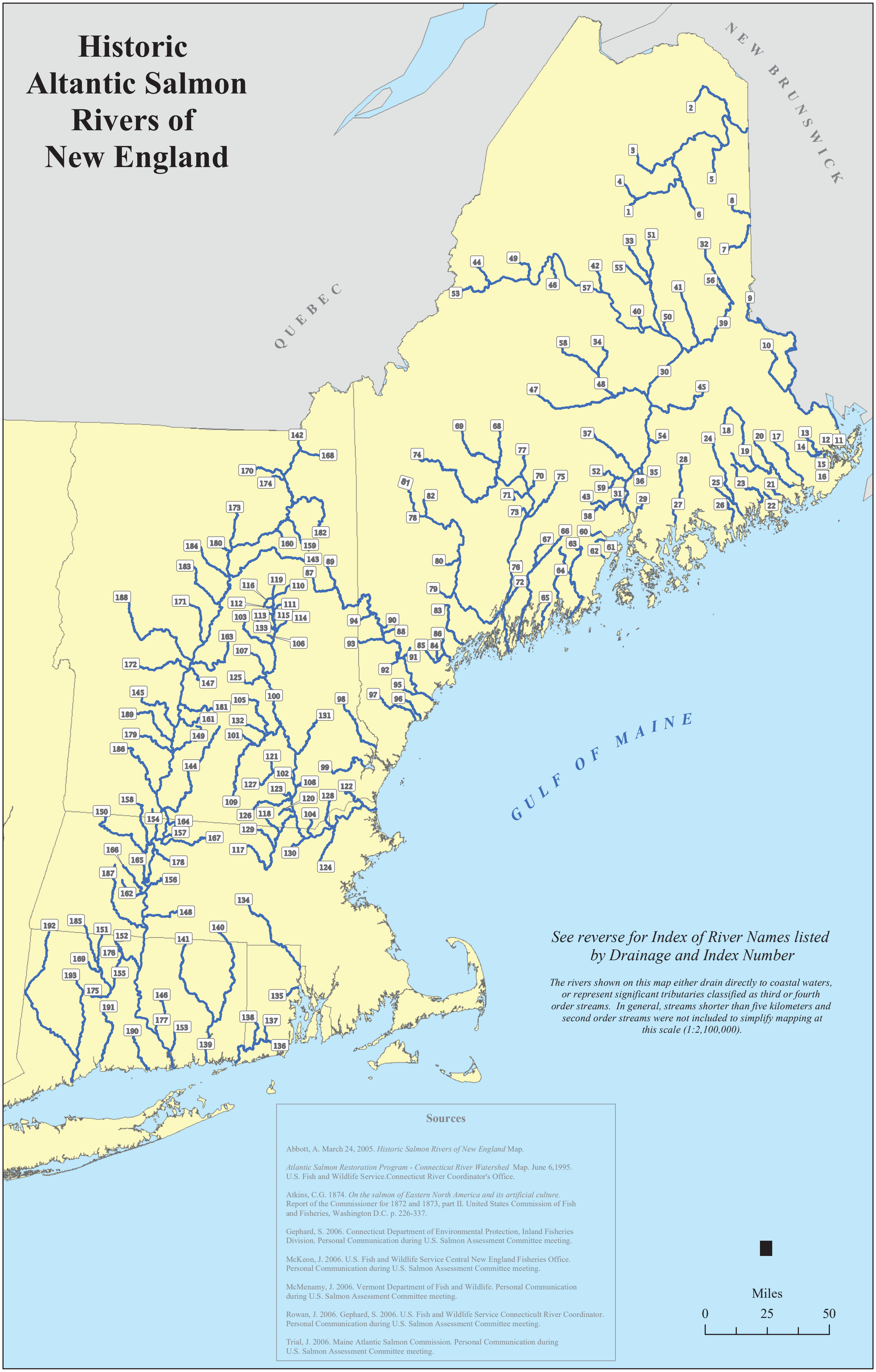
Drainage	Year	Estimated Returns	Broodstock Take	Observed Mortalities	Natural Escapement	Pre-Spawn Stocking Captive/ Domestic	Pre-Spawn Stocking Sea Run	Total Escapement
Ducktrap	2013	7	0	0	7	0	0	7
	2014	7	0	0	7	0	0	7
	2017	4	0	0	4	0	0	4
	2018	0	0	0	0	0	0	0
	2019	0	0	0	0	0	0	0
	2020	0	0	0	0	0	0	0
	2021	2	0	0	2	0	0	2
	2022	5	0	0	5	0	0	5
East Machias	1967 - 2012	937	0	0	937	374	0	1311
	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
	2020	24	0	0	24	0	0	24
	2021	19	0	0	19	0	0	19
	2022	17	0	0	17	0	0	17
Kenduskeag Stream	2017	9	0	0	9	0	0	9
	2019	6	0	0	6	0	0	6
	2022	5	0	0	5	0	0	5
Kennebec	1975 - 2012	375	0	7	368	196	0	564
	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
	2020	53	0	0	53	0	0	53
	2021	25	0	0	25	0	0	25
	2022	87	0	0	87	0	0	87
Machias	1967 - 2012	2822	0	0	2822	451	0	3273

Drainage	Year	Estimated Returns	Broodstock Take	Observed Mortalities	Natural Escapement	Pre-Spawn Stocking Captive/ Domestic	Pre-Spawn Stocking Sea Run	Total Escapement
Machias	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
	2017	14	0	0	14	0	0	14
	2018	9	0	0	9	136	0	145
	2019	29	0	0	29	0	0	29
	2020	29	0	0	29	0	0	29
	2021	16	0	0	16	0	0	16
	2022	10	0	0	10	40	0	50
Narraguagus	1967 - 2012	4042	0	1	4041	0	0	4041
	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
	2020	108	0	0	108	0	0	108
	2021	25	0	0	25	0	0	25
	2022	19	0	0	19	0	0	19
Penobscot	1968 - 2012	70547	18223	217	52107	0	417	52524
	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
	2020	1439	221	8	1210	0	2	1212
	2021	561	147	1	413	0	1	414
	2022	1324	557	3	764	305	8	1077
Pleasant	1967 - 2012	465	0	0	465	56	0	521
	2013	31	0	0	31	0	0	31

Drainage	Year	Estimated Returns	Broodstock Take	Observed Mortalities	Natural Escapement	Pre-Spawn Stocking Captive/ Domestic	Pre-Spawn Stocking Sea Run	Total Escapement
Pleasant	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
	2019	26	0	0	26	0	0	26
	2020	9	0	0	9	0	0	9
	2021	14	0	0	14	0	0	14
	2022	21	0	0	21	0	0	21
Saco	1985 - 2012	1067	0	5	1062	0	0	1062
	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
	2020	6	0	0	6	0	0	6
	2021	0	0	0	0	0	0	0
	2022	5	0	0	5	0	0	5
Sheepscot	1967 - 2012	685	0	0	685	337	0	1022
	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
	2020	14	0	0	14	0	0	14
	2021	11	0	0	11	0	0	11
	2022	9	0	0	9	0	0	9
Souadabscook Stream	2017	4	0	0	4	0	0	4
	2019	3	0	0	3	0	0	3
St Croix	1981 - 2012	4227	0	0	4227	0	0	4227
Union	1973 - 2012	2169	0	32	2137	0	0	2137

Drainage	Year	Estimated Returns	Broodstock Take	Observed Mortalities	Natural Escapement	Pre-Spawn Stocking Captive/ Domestic	Pre-Spawn Stocking Sea Run	Total Escapement
Union	**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**
	2020	**3**	**0**	**0**	**3**	**0**	**0**	**3**
	2022	**0**	**0**	**0**	**0**	**0**	**0**	**0**

Historic Altantic Salmon Rivers of New England



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

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

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