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

REPORT NO. 36 - 2023 ACTIVITIES

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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:

Fred Kircheis - State of Maine Fish Biologist/ Executive Director of the Atlantic Salmon Commission

Fred Kircheis, a long time fish biologist with the state of Maine passed away in February of this year. His contributions to fisheries began in the late 1960s after a two year stint in the U.S. Navy, graduating from the University of Maine in 1967. He briefly worked in Rhode Island before moving to Maine and beginning his 35 year career working for Maine Inland Fisheries and Wildlife starting in 1968. While working for Maine, he was a part of the fisheries research unit working on landlocked salmon and brook trout, and ultimately became Maine's leading expert on landlocked Arctic charr. This experience broadened his collaborations beyond his Division and he developed many relationships and friendships which carried on throughout his career. Fred was also heavily involved in many hot-button issues including the evaluation of the effects of anadromous alewives on freshwater ecosystems, in particular, landlocked rainbow smelt in Canaan's Lake George. Fred concluded his career as the executive director for the Atlantic Salmon Commission, starting in 1999. While in this position, he established an office in Augusta and traveled a lot throughout coastal Maine, especially during the ESA listing process when he served as a self-proclaimed "buffer" between fish and other interests. He always tried to side with the fish. Fred's even keeled personality and friendly manner, was a perfect fit during the listing period. He retired in 2003.

Outside of his career, Fred's interests and hobbies were extensive, but most of all involved working on the farm, building and restoring boats, hunting, fishing and foraging. Ed Baum, a colleague and friend of 55 years, fondly remembers their professional bond but also enjoyed many personal moments, from remodeling our old farmhouses together to memorable family camping trips when the children were young. Sue and Fred, and Peggy and Ed also enjoyed many years as avid contract bridge partners.

"Fred's dedication and expertise had a significant impact on the management of Arctic charr and Atlantic salmon in Maine. He will be sincerely missed by those who knew him." - Ed Baum

Thomas F. King - Hatchery Manager of Craig Brook National Fish Hatchery

Tom King, of the Maine Atlantic Salmon Program, passed away in September of 2023 after a long illness. Tom's career with the U.S. Fish and Wildlife Service spanned 32 years, with his final role at the Hatchery Manager of Craig Brook National Fish Hatchery located in East Orland, Maine. Beginning in the late 1990s, Tom oversaw the reconstruction of Craig Brook NFH from a crumbling 1950s era hatchery to a state-of-the-art broodstock facility that remains the keystone of the Maine Atlantic Salmon Program. Tom was a hands-on manager, ever attuned to the needs of the resource and always willing to put on his hippers to join the crew cleaning pools. Following his retirement to Belfast in 2008, Tom took on the roles of Board Member and President of the Belfast Bay Watershed Coalition, bringing Atlantic salmon education and outreach to the local schools. In addition to his passion for Atlantic salmon and Belfast Bay, Tom will always be remembered as a spirited hockey coach at Hampden Academy, an avid curler and kayaker and for his absolute love of apples.

Edward “Peter” Steenstra - Outdoor Recreation Planner at Craig Brook National Fish Hatchery

Peter Steenstra passed away in October 2023 and leaves behind a legacy of positive public engagement and a generation of young conservationists energized by Atlantic salmon. Peter served for four years in the Navy, received his Bachelor’s degree in Secondary Science Education from the University of Southern Maine and his Master’s degree of Education from the University of Maine. Prior to joining the U.S. Fish and Wildlife Service, Peter taught Earth Sciences at Pemetic Junior High School in Southwest Harbor, Maine and shared his love for nature with the public as a Seasonal Naturalist in Acadia National Park in the summers. Peter truly found his calling in 1995, as the Outdoor Recreation Planner at Craig Brook National Fish Hatchery where he blended his love of teaching with his passion for conservation and nature photography. Peter was passionate about bringing Atlantic salmon to the public, particularly engaging children as the future stewards of the environment, as well as sharing the legacy of Craig Brook’s first Superintendent Charles G. Atkins.

1 Executive Summary

1.1 Abstract

Total returns to U.S rivers in 2023 were 1,854 salmon, which is the sum of documented returns to traps and returns estimated by redd counts. Returns to the United States rank 9th out of the 33-year time series (1991-2023) and 20th out of the full 57-year time series (1967-2023). Most returns (1,836; 99.0%) were to the Gulf of Maine Distinct Population Segment (GoM DPS), which includes the Penobscot, Kennebec, Sheepscot and eastern Maine coastal rivers. There were only 18 returns documented outside of the GoM DPS. Documented returns to traps totaled 1,740 and returns estimated by redd counts totaled 96 adult salmon. Overall, 7.0% of the adult returns to the United States were 1SW salmon, 92.5% were 2SW salmon and 0.5% were 3SW or repeat spawners. Most (86.7%) returns were of hatchery smolt origin and the balance (13.3%) originated from either natural reproduction, hatchery fry, or planted eggs. Totals of approximately 3,646,500 juvenile salmon (eggs, fry, parr, and 1 smolt) and 4,120 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 100,631 marks administered in 2023. In 2022, eggs for U.S. hatchery programs were taken from a total of 1,423 females consisting of 252 sea-run females and 1,171 captive/domestic and domestic females. Total egg take was 5,814,000 (1,503,000 sea-run and 4,311,000 captive/domestic).

1.2 Adult Returns to U.S. Rivers

Total returns to U.S. rivers were 1,854 (Table 1.2.1), which is a significant increase from 2022 (1,529, Table 1.2.2). Returns are reported for three distinct population segments (Figure 1.2.1): Long Island Sound (LIS, 0 total returns), Central New England (CNE, 18 total returns), and Gulf of Maine (GOM, 1,836 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 2023. Overall, the majority of the 1,854 adult returns to the U.S. (documented and pro-rated) were 2SW (1,714 = 92.5%), with 1SW (130 =7.0%), 3SW (8 = 0.4%) and repeat spawners (2 = 0.1%) making up the remainder of the total (Table 1.2.2). The percentage of 2SW returns in 2023 (92.5%) was considerably higher than the 10-year average of 72.8%. 86.7% of returns were hatchery smolt origin (13.3% natural origin), which was more than 10% higher than the 10-year average of 75.2%. In 2023, hatchery 2SW adult returns were found in greater proportion than many years in the time series (Figure 1.2.2).

Adult returns were well below conservation spawner requirements (i.e. conservation limit; CL). Returns to 14 monitored rivers represented only 7.6% of the U.S. CL in these populations. In monitored populations, the Kennebec River ranked the highest at 225.4% of CL followed by the Penobscot (21.5%) and Penobscot (15.3%; Table 1.2.3). It should be noted that the U.S. 2SW conservation limits were first reported by Baum (1995) and represent accessible habitat only. Only a small amount of habitat in the Kennebec River was accessible in 1995 and therefore the CL was estimated at 67 2SW spawners. In recent years, pre-spawned adult salmon captured at the lowermost main-stem dam have been trucked around barrier dams and released into the Sandy River, a tributary to the Kennebec, resulting in modest numbers of adult spawners. The Sandy River habitat is not considered within the existing estimated CL for the Kennebec, which is why the ‘percent CL achieved’ is so high for this system. Due to this and other evolving management activities and priorities, the U.S. is working to update our CLs based on the best available information. These updated CLs will be used to track attainment of CLs in the future.

Return Rates:

Marine return rate estimates are calculated based on known smolt migrants (estimated populations of naturally reared, or hatchery stocked) and corresponding adult returns. Until 2020, the return rate for Penobscot River hatchery-origin smolts was based on total smolts stocked and subsequent adult returns by sea age to generate a smolt-to-adult return rate (SAR). Beginning in 2021, 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 U.S. 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. Other rivers reported continue to use the SAR to report return rate data.

Return rates within this and other portions of the USASAC report are only included if appropriate smolt data are available (Figure 1.2.3 and Table 1.2.4). Return (PSAR) rates for two sea-winter Penobscot River salmon from the 2021 smolt cohort equaled 0.26%, which was an increase from the 2020 estimate (0.17%) and greater than the previous five (0.17%) and 10 (0.15%) year means. The 2021 Narraguagus River SAR for the naturally-reared smolt population was 1.20%, which was higher than the previous reported SAR 2019 cohort (0.40%; no smolt data from 2020 due to COVID), but lower than the five (1.64%) and 10 (1.24%) year means. The East Machias River SAR, which included the last year of smolt data, was 1.69%, which was higher than 2019 cohort (1.31%; no smolt data from 2020 due to COVID), but lower than the time series mean of 1.82% (Figure 1.2.3 and Table 1.2.4)

1.3 Description of Fisheries and By-catch in U.S. Waters

All directed fisheries for Atlantic salmon in U.S. waters are closed. The current fishery management plan prohibits their possession as well as any directed fishery or incidental (bycatch) for Atlantic salmon in federal waters. Similar prohibitions exist in state waters. Atlantic salmon found in U.S. 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) Canadian populations (many southern Canadian stocks are classified as Endangered by Canada); or 4) escaped fish from U.S. or Canadian aquaculture facilities. Bycatch and discard of Atlantic salmon are monitored annually by the Northeast Fisheries Science Center using the Standardized Bycatch Reporting Methodology. While bycatch is uncommon, observed events from 1989 through June 2022 are summarized using reports and through September 2023 with supplemental data queries of audited data. Prior to 1993, observers recorded Atlantic salmon as an aggregate weight per haul. Therefore, no individual counts were available for these years, however 8 observed interactions occurred. After 1993, observers recorded Atlantic salmon on an individual basis. Since 1993, monitoring has documented seven observed interactions, with a total count of seven individuals. In total, monitoring has detected Atlantic salmon bycatch and interactions 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. Bycatch of Atlantic salmon is a rare event and monitoring has only detected 15 interactions in the 35-year time series (1989-2022) with the last detection occurring in August 2013.

1.4 Stock Enhancement Programs

During 2023, approximately 3,646,500 juvenile salmon were released into U.S. rivers (Table 1.4.1). Of these, 1,747,000 were hatchery fry; 1,095,000 were planted eyed eggs; 55,600 were parr; and 748,900 were smolts. Most of these restoration stockings were within the GoM DPS with the Connecticut River (LIS) receiving limited allocations of fry (334,000) which continues the legacy program including Salmon-in-Schools program (Table 1.4.1). A significant decrease in parr for the 2023 effort was attributed to the loss of one cohort (>150,000 parr) due to Infectious Pancreatic Necrosis Virus at the Peter Gray Hatchery on the East Machias River. More details are presented in 1.6 (Farm Production and Disease Reporting) of the report.

Besides juveniles, 4,120 adult salmon were released into U.S. rivers, all of which were stocked into the GoM (Table 1.4.2). Of these adults stocked, 1,711 were pre-spawn release, with most stocked into the Machias (300) and Penobscot (1,281) Rivers in support of the Salmon for Maine's Rivers (SFMR) program. The SFMR program aims to use smolt to the adult supplementation to introduce pre-spawn adults into high quality spawning habitat. Planned assessment and monitoring of this program will include telemetry to assess migration behavior for a subset of the released salmon, redd counts and juvenile production via electrofishing.

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 100,631 salmon released into U.S. waters was marked or tagged. Tags and marks for parr, smolts and adults included: PIT, Acoustic, Floy, clips and punches. All marks occurred within the GoM (Table 1.5.1).

1.6 Farmed Salmon Production and Disease Reporting

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). Production of farmed Atlantic salmon is assumed to be similar to previous years as the number of fish stocked into marine cages has remained relatively consistent since 2010.

In August 2023, there were two reported escapes of more than 50,000 postsmolts from adjacent sea cages in Machias Bay, which were determined to be caused by seals. Post-event evaluation of the sites occurred with all indications that seal (predator) exclusion nets were in place. Adjustments to the predator exclusion nets were made following these events. In 2023, no known aquaculture origin Atlantic salmon were captured in Maine rivers.

MDMR was notified of a detection of pathogenic (HPR-deleted) Infectious Salmon Anemia Virus on two occasions (April 13 and June 21, 2023). On each occasion, one Atlantic salmon was detected at each marine net-pen site Swan Harbor Island in Swans Island and East Spectacle Island in Beals Island. For each incident, samples were sent to Kennebec River Biosciences and the United States Department of Agriculture, Animal and Plant Inspection Service National Veterinary Service Laboratory. Confirmatory results, including sequencing, were received from each lab.

Infectious Pancreatic Necrosis Virus (IPNV) was detected during a routine health screening of Atlantic salmon 0+ parr held at the Peter Gray Hatchery, operated by the Downeast Salmon Federation in East Machias, ME. In August 2023 a 60-fish sample from each strain (East Machias and Narraguagus) were sent to the Maine State Fish Health Laboratory in Augusta, Maine. IPNV was detected and samples were shared with Kennebec River Biosciences for confirmation and strain identification. The virus was likely introduced to the hatchery through the influent, which draws raw water directly from the East Machias River.

The decision to depopulate the hatchery was made following deliberation by federal and state agencies. The entire cohorts of the Narraguagus and East Machias strain 0+ parr, totaling 154,000 Atlantic salmon parr, were euthanized using a 15-minute MS-222 bath. The parr were then frozen and buried in a gravel pit off site on private property, away from any waterways, and deep enough to discourage scavengers but shallow enough to allow for a quick decomposition.

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 fish are screened for specific pathogens of concern. In 2023, there were no confirmed pathogen detections.

1.7 Smolt Emigration

NOAA's National Marine Fisheries Service 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 evaluating natural spawning and various restoration stockings by taking measures of length, weight, scale collection and enumerating individuals and/or estimating the population of emigrants via stratified mark-recapture methods (Figure 1.7.1, Table 1.7.1). This platform is also used to facilitate access to smolts in support of tagging and other sample collection. In 2023, two rivers were monitored: Narraguagus and Sandy rivers.

Narraguagus River:

On the Narraguagus River in 2023, MDMR operated smolt traps at two sites including an upper and lower river site to collect size data, scale samples and generate single site mark - recapture population estimates to identify smolt production within these portions of the drainage. Smolt sampling on the Narraguagus River was the 28th year of operation with 24 years of population estimates generated at the lower river site. Naturally-reared (natural spawning, fry stocking and egg planting) and hatchery (fall parr stocking) smolts stocked from the Peter Gray Hatchery (East Machias) in 2021 and 2022, were sampled during the 2023 trapping season.

Lower Site (river km 11.16):

A total of 403 smolts was captured at the lower site (143 naturally reared, 260 hatchery-origin fall parr stocked (classified as ambient parr). The estimate of naturally-reared smolts exiting the system was 525 (95% 411 to 639), hatchery origin 827 (95% 741 to 913) and a total estimate of 1,421 (95% 1,252 to 1,590, Figure 1.7.1, Table 1.7.1). For comparison, the 2022 estimate of emigrating naturally-reared smolts was 1,031 (95% 949 to 1,113; Figure 1.7.1, Table 1.7.1).

Upper Site (river km 47.69):

Project SHARE, in partnership with MDMR, captured 122 smolts of naturally-reared and 138 hatchery-origin smolts at the Route 9 trap site. The Upper Narraguagus River naturally-reared smolt population estimate was 462 (95% 371 to 553). The hatchery-origin population estimate was 525 (95% 419 to 631). The combined estimate (natural and hatchery reared) was estimated 924 (95% 816 to 1,032). For comparison, the 2022 estimate of emigrating naturally-reared smolts was 477 (95% 419 to 535)

Sandy River (Tributary of the Kennebec River):

In 2023, MDMR operated two traps at one site on the Sandy River (river km 27.48) to collect size data, scale samples and generate a single site mark-recapture population estimate to estimate smolt production within this Kennebec River tributary. It was the third year of smolt sampling at this site. Only naturally-reared (natural spawning and egg planting) smolts were present for sampling during the 2023 trapping season. A total of 618 naturally-reared smolts was captured. A population estimate was not generated due to poor trapping conditions caused by high water. For comparison, 1,667 smolts were captured in 2022 and the estimate of emigrating naturally-reared smolts was 9,694 (95% 9,080 to 10,308; Table 1.7.1).

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 the United States by geographic area, 2023. "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	0	0	0	0	0	0
CNE	2	1	7	8	0	0	0	0	18
GOM	113	14	1,478	221	6	2	2	0	1,836
Total	115	15	1,485	229	6	2	2	0	1,854

Table 1.2.2. Estimated Atlantic salmon returns to the USA, 1967-2023. "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

Year	Sea Age 1SW	Sea Age 2SW	Sea Age 3SW	Repeat Spawners	Total	Hatchery Origin	Natural Origin
1991	255	2,289	5	62	2,611	1,602	1,009
1992	1,056	2,255	6	20	3,337	2,678	659
1993	405	1,953	11	37	2,406	1,971	435
1994	342	1,266	2	25	1,635	1,228	407
1995	168	1,582	7	23	1,780	1,484	296
1996	574	2,168	13	43	2,798	2,092	706
1997	278	1,492	8	36	1,814	1,296	518
1998	340	1,477	3	42	1,862	1,146	716
1999	402	1,136	3	26	1,567	959	608
2000	292	535	0	20	847	562	285
2001	269	804	7	4	1,084	833	251
2002	437	505	2	23	967	832	135
2003	233	1,185	3	6	1,427	1,238	189
2004	319	1,266	21	24	1,630	1,395	235
2005	317	945	0	10	1,272	1,019	253
2006	442	1,007	2	5	1,456	1,167	289
2007	299	958	3	1	1,261	940	321
2008	812	1,758	12	23	2,605	2,191	414
2009	243	2,065	16	16	2,340	2,017	323
2010	552	1,081	2	16	1,651	1,468	183
2011	1,084	3,053	26	15	4,178	3,560	618
2012	26	879	31	5	941	731	210
2013	78	525	3	5	611	413	198
2014	110	334	3	3	450	304	146
2015	150	761	9	1	921	739	182
2016	232	389	2	3	626	448	178
2017	363	663	13	2	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
2023	130	1,714	8	2	1,854	1,608	246

Table 1.2.3. 2023 Two sea winter (SW) returns against 2SW Conservation Limits (CL) for select US rivers. The adult return numbers include seven multi sea winter returns (MSW) for the Penobscot River. Although the CL is based on 2SW fish, these MSW fish contribute eggs and contribute 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	0	0.0%
GOM	East Machias	2,145	143	14	9.8%
GOM	Machias	6,685	446	10	2.2%
GOM	Pleasant	1,085	72	11	15.3%
GOM	Narraguagus	6,015	401	17	4.2%
GOM	Union	8,360	557	0	0.0%
GOM	Penobscot	102,575	6,838	1,472	21.5%
GOM	Ducktrap	585	39	2	5.1%
GOM	Sheepscot	2,845	190	8	4.2%
GOM	Kennebec	1,005	67	151	225.4%
GOM	Androscoggin	3,175	212	3	1.4%
CNE	Saco	12,540	836	4	0.5%
CNE	Merrimack	38,980	2,599	11	0.4%
LIS	Connecticut	145,900	9,727	0	0.0%
	Totals	**334,310**	**22,288**	**1,703**	**7.6%**

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 U.S. 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. * Time series average.

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%						
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%		0.90%				
1998	0.12%	0.15%	0.11%	0.28%				
1999	0.10%	0.29%	0.25%	0.53%				
2000	0.10%	0.18%	0.31%	0.17%				
2001	0.23%	0.53%	0.28%	0.85%				
2002	0.13%	0.61%	0.16%	0.46%				
2003	0.17%	0.41%	0.00%	1.01%				

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
2004	0.17%	0.41%	0.08%	0.98%				
2005	0.17%	0.28%	0.08%	0.73%				
2006	0.10%	0.60%	0.24%	0.78%				
2007	0.30%	0.71%	0.09%	1.72%				
2008	0.08%	0.36%	0.34%	0.65%				
2009	0.17%	0.90%	0.44%	1.80%	0.28%	0.84%		
2010	0.30%	0.23%	0.26%	0.61%	0.10%	0.33%		
2011	0.00%	0.12%	0.95%	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%
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%	0.26%	0.49%	1.20%			0.36%	1.69%
2022	0.02%		0.39%					
Previous 5-Year Mean	0.05%	0.17%	0.92%	1.64%				
Previous 10-Year Mean	0.05%	0.15%	0.39%	1.30%	0.16%*	0.58%*	0.51%*	1.82%*

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	32.6

Table 1.4.1. Number of juvenile Atlantic salmon by life-stage stocked in U.S., 2023, 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	-	-	300	-	-	334,000	334,300
LIS	Pawcatuck	-	-	-	-	-	7,000	7,000
CNE	Saco	-	-	-	-	2,000	-	2,000
GOM	Androscoggin	-	-	-	-	-	6,000	6,000
GOM	Dennys	-	-	-	-	-	204,000	204,000
GOM	East Machias	-	-	-	-	-	18,000	18,000
GOM	Kennebec	-	-	98,800	-	654,000	3,000	755,800
GOM	Machias	-	-	-	-	-	212,000	212,000
GOM	Narraguagus	-	-	-	-	-	16,000	16,000
GOM	Penobscot	40,100	-	642,800	-	360,000	754,000	1,796,900
GOM	Pleasant	-	-	-	-		109,000	109,000
GOM	Sheepscot	15,500	-	-	-	79,000	67,000	161,500
GOM	Union	-	-	-	-	-	1,000	1,000
		55,600	0	741,900	-	1,095,000	1,731,000	3,623,500

Table 1.4.2. Stocking summary for sea-run, captive reared domestic adult Atlantic salmon for the U.S. in 2023 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	1,711	1,672	243	494	4,120
Total		1,711	1,672	243	494	4,120

Table 1.5.1. Summary of tagged and marked Atlantic salmon released in the United States, 2023. Includes hatchery and wild origin fish.

Mark Code	Life Stage	CNE	GOM	LIS	Total
Adipose clip	Smolt	-	95,580	-	95,580
Adipose clip	Adult	-	6	-	6
Adipose punch	Adult	-	408	-	408
Upper Caudal Punch	Adult	-	7	-	7
Passive Integrated Transponder (PIT)	Adult	-	4,298	-	4,298
Acoustic Tag	Smolt	-	50	-	50
Acoustic Tag	Adult	-	273	-	273
Floy Tag	Adult	-	9	-	9
		0	100,631	0	100,631

Table 1.6.1. State of Maine – U.S. commercial Atlantic salmon aquaculture production and suspected aquaculture captures to Maine rivers 2000 to 2023. Due to confidentiality statutes in MDMR regulations related to single producer, adult production rates are not available 2011 to 2023 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		16,461	34
2001	4,205,161		13,202	84
2002	3,952,076		67,988	15
2003	2,660,620		6,007	4
2004	1,580,725		8,514	0
2005	294,544		5,263	12
2006	3,030,492	252,875	4,674	5
2007	2,172,690	154,850	2,715	0
2008	1,470,690		9,014	0
2009	2,790,428		6,028	0
2010	2,156,381	128,716	11,127	0
2011	1,838,642	45,188	NA	3
2012	1,947,799	137,207	NA	7
2013	1,329,371	170,024	NA	0
2014	2,285,000	0	NA	0
2015	1,983,850	446,129	NA	0
2016	1,892,511	262,410	NA	3
2017	2,224,348	211,043	NA	0
2018	2,035,690	45,000	NA	0
2019	1,996,662	60,480	NA	0
2020	2,225,000	40,000	NA	0

Year	Total Salmon Stocked (smolt + fall parr + clips)	RV clipped fish stocked	Harvest total (metric tons)	Suspect aquaculture origin captures (Maine DPS Rivers)
2021	2,080,309	31,140	NA	4
2022	1,983,106	54,174	NA	0
2023	1,965,852	3,023	NA	0

Table 1.7.1. Smolt population estimates ± Std. Error (SE) from maximum likelihood estimates for the Narraguagus (NG; 1997 - 2022: natural spawning, fry stocking, egg planting; 2023 - forward: includes ambient parr stocking), Sandy (LKB; egg planting), Sheepscot (SHP; natural spawning, fry stocking, egg planting and parr stocking), East Machias (EM; natural spawning, fry stocking, parr stocking) and Pisctaquis (PI; natural spawning and fry stocking) Rivers, Maine USA. Blank cells indicate that no population estimates were derived during a particular year. **Note:** Specific lifestage estimates have been generated if numbers allow, these data can be found within annual Maine Smolts Update working papers for each year they were run.

Smolt Year	NG SE Lower	NG Pop Est.	NG SE Upper	LKB SE Lower	LKB Pop Est.	LKB SE Upper	SHP SE Lower	SHP Pop Est.	SHP SE Upper	EM SE Lower	EM Pop Est.	EM SE Upper	PI SE Lower	PI Pop Est.	PI SE Upper
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										4,213	5,851	7,489
2009	1,086	1,176	1,266				1,661	1,813	1,965				5,554	6,885	8,216
2010	1,922	2,149	2,376				3,572	3,944	4,316				8,438	9,667	10,896
2011	1,023	1,404	1,785				2,706	3,176	3,646				5,929	8,404	10,879
2012	725	969	1,213				2,132	2,507	2,882				1,513	1,732	1,951
2013	974	1,237	1,500				2,799	3,036	3,273	463	556	649	5,561	5,860	6,159
2014	1,417	1,615	1,813				1,416	1,650	1,884	814	1,019	1224	3,185	3,538	3,891
2015	960	1,201	1,442				1,372	1,558	1,744	212	263	314	4,007	4,278	4,549
2016							2,662	2,924	3,186	916	1,210	1504			
2017							2,149	2,758	3,367	1248	1,501	1754			
2018	483	604	725				1,295	1,652	2,009	863	1,049	1235			
2019	627	829	1,031				1,244	1,442	1,640	1056	1,289	1522			
2020															
2021	1,334	1,426	1,518	11,935	13,229	14,523				714	881	1048			
2022	949	1,031	1,113	9,080	9,694	10,308									
2023	1,252	1,421	1,590												

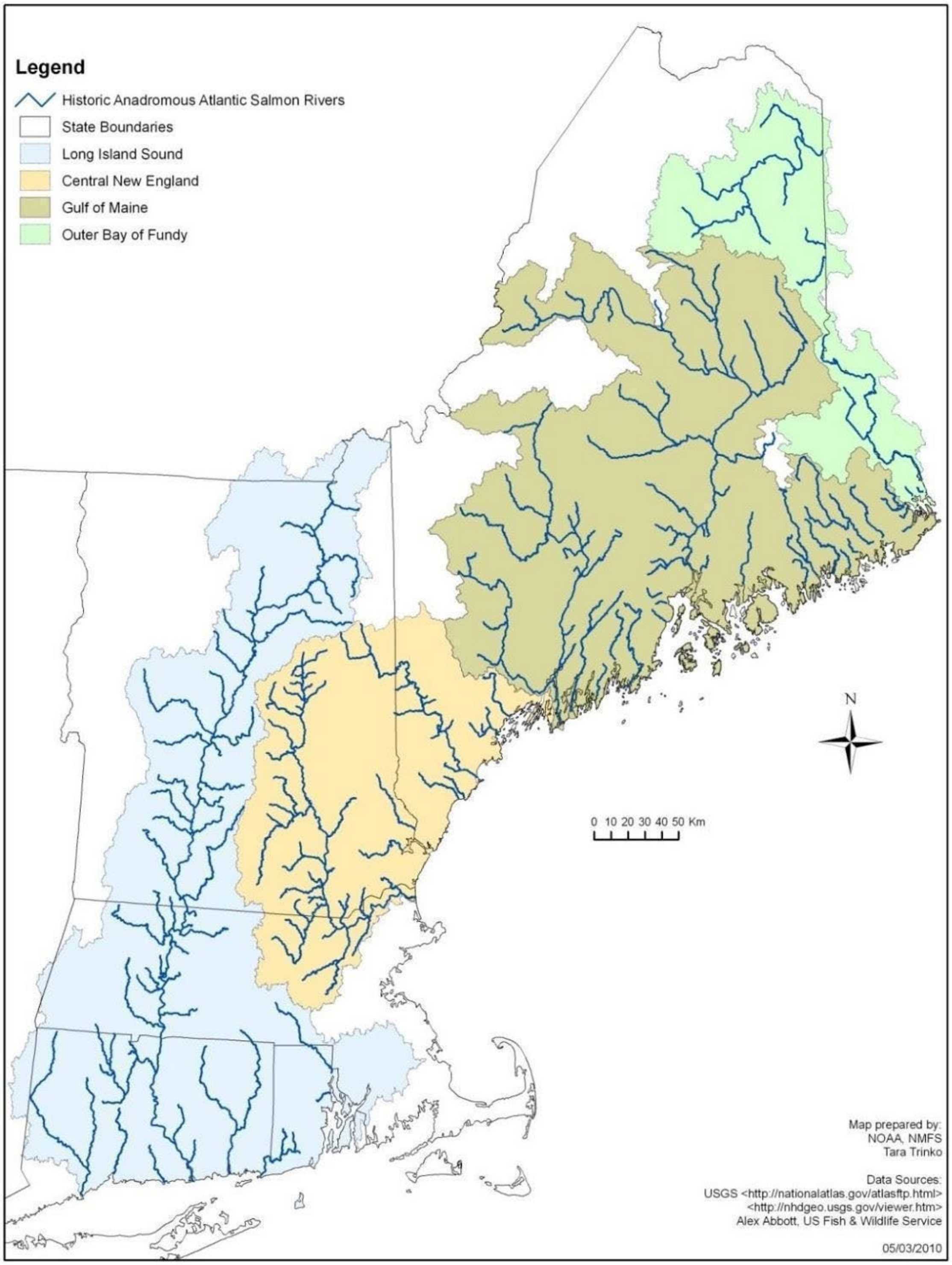

Figure 1.2.1. Map of Distinct Population Segments used in summaries of United States data for returns, stocking, and marking in 2023.

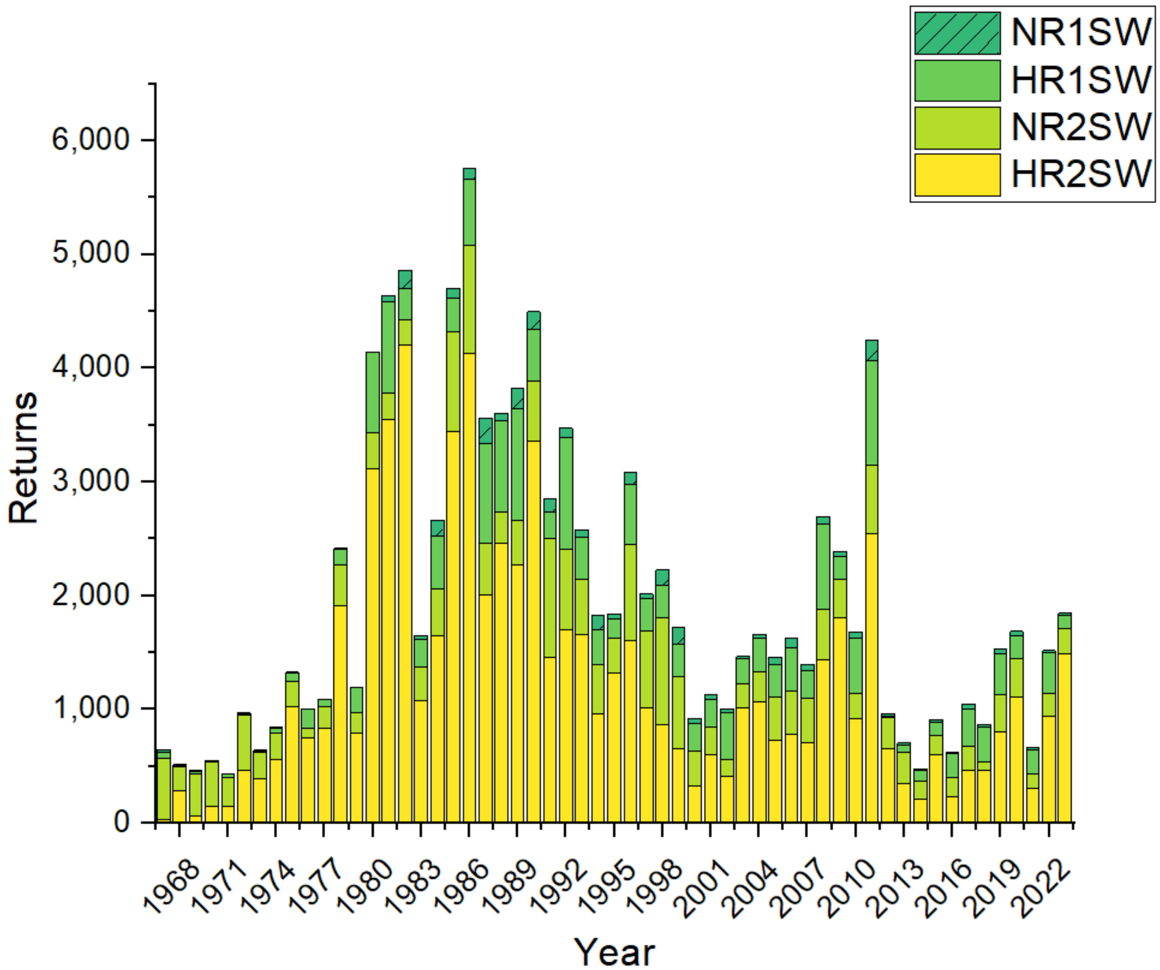

Figure 1.2.2. Origin and sea age (age 1 and 2 only) Atlantic salmon returning to U.S. rivers, 1967 to 2023 (NR1SW = Naturally Reared One Sea Winter; HR1SW = Hatchery Reared One Sea Winter; NR2SW = Naturally Reared Two Sea Winter; HR2SW = Hatchery Reared Two Sea Winter).

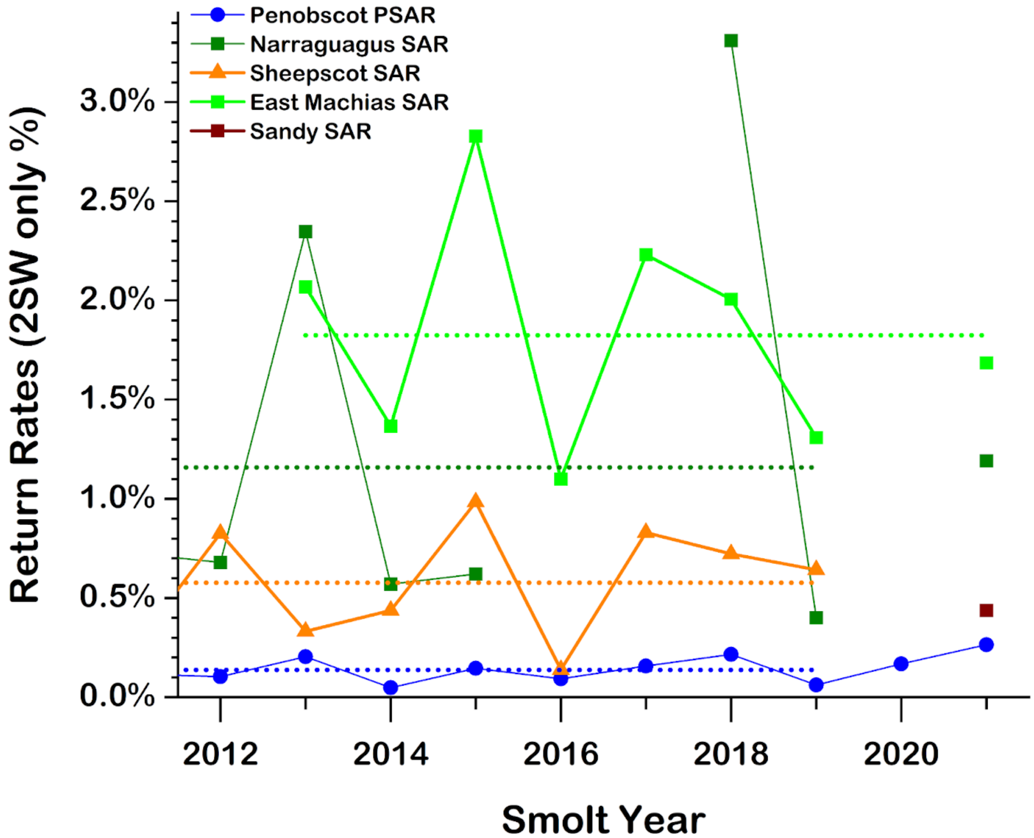

Figure 1.2.3. Smolt to Adult (SAR) and Postsmolt to Adult (PSAR) return rates for 2SW adults for five Maine Rivers: Narraguagus, Sheepscot, East Machias, Penobscot and the Sandy (tributary of the Kennebec) for the 2000 to 2021 Atlantic salmon smolt cohorts. Decadal (or time series) averages expressed as line labeled with percent returns and any gaps in data are due to lack of smolt population data available to generate the summary data.

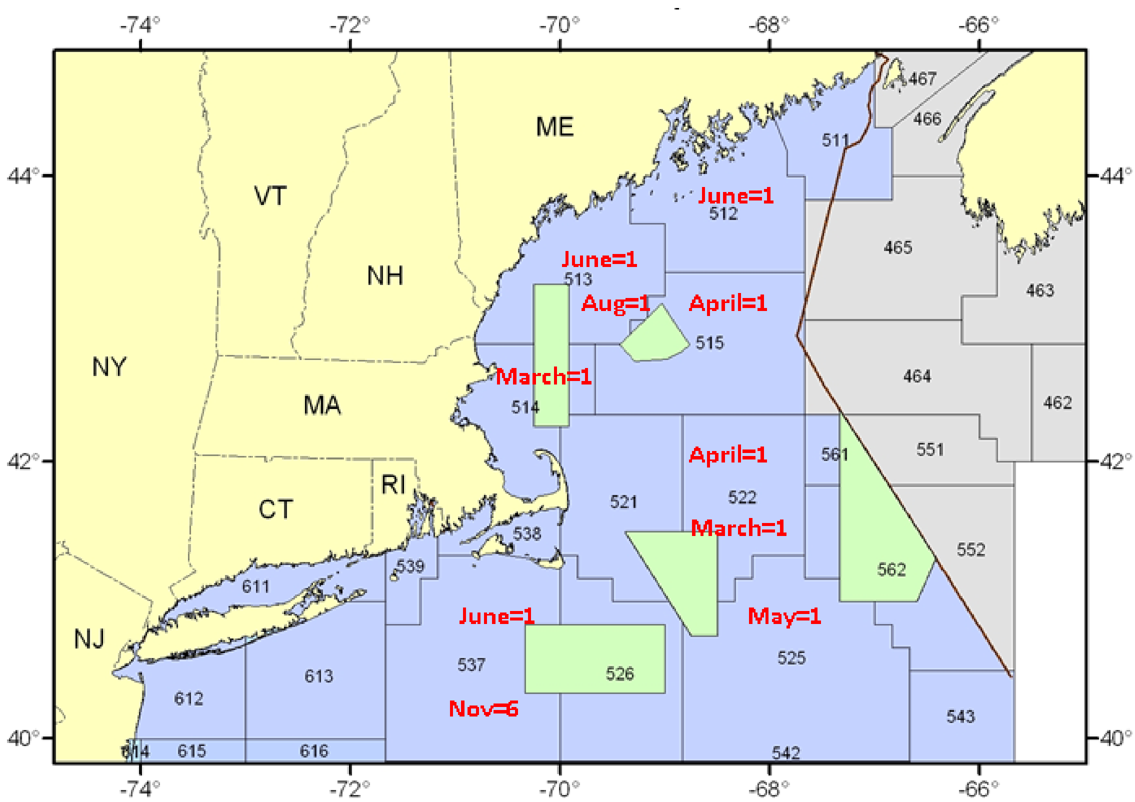

Figure 1.3.1. Map of Gulf of Maine region showing the month and number of Atlantic salmon interactions between 1993 and 202. Blue polygons are U.S. statistical areas, grey zones are in Canada and green-shaded polygons represent regulated access areas. Red text highlights the month and number of individuals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

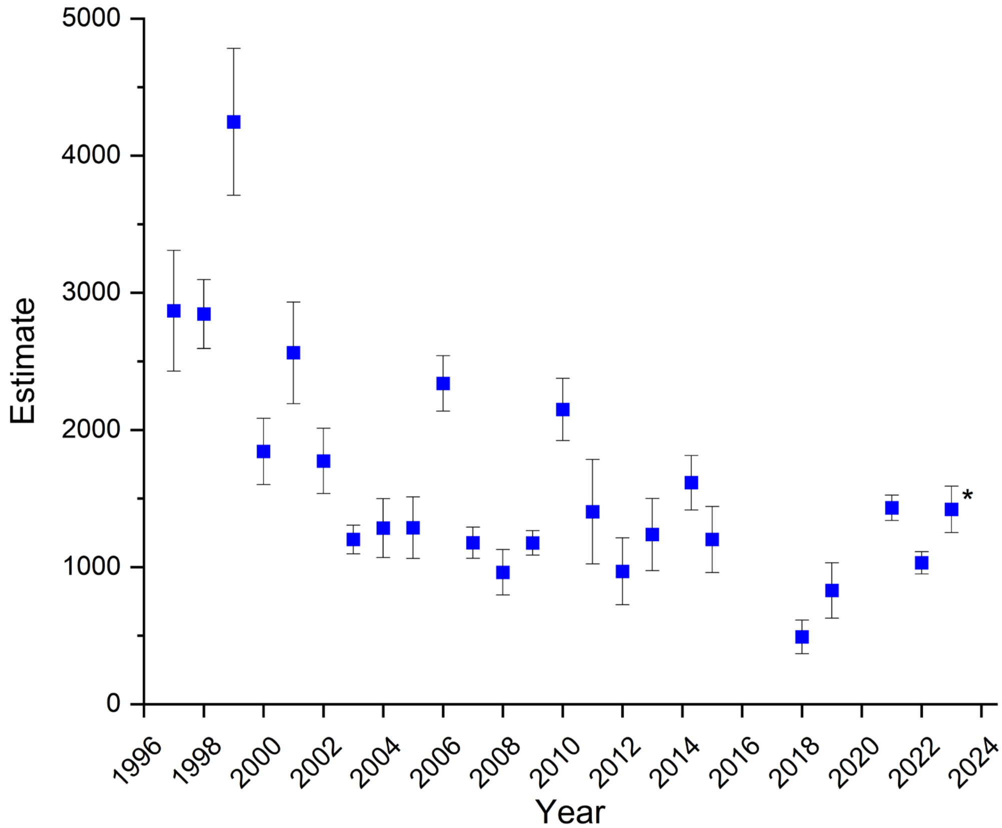

Figure 1.7.1. Population Estimates (± Std. Error) of emigrating naturally-reared smolts on the Narraguagus (natural spawning, egg planting and fry stocking) in Maine U.S. Asterisk (*) indicates a portion of the estimate is made up of ambient parr (stocked) smolts.

End of Chapter 1

2 Viability Assessment - Gulf of Maine Atlantic Salmon

2.1 Executive Summary of DPS and Annual Viability Synthesis 2023

The adult Atlantic salmon **abundance** of the 2023 Gulf of Maine Distinct Population Segment (GOM DPS) spawning run (1,836 estimated adult returns) was ranked 9th out of 33 cohorts since 1991. Hatchery-origin adults (n = 1,599) represented 87% of the returns. Naturally-reared returns remained low across the GOM DPS (237) totaling 116 in Penobscot Bay (PNB), 54 in Downeast Coastal (DEC) and 67 in Merrymeeting Bay (MMB) SHRUs (Salmon Habitat Recovery Unit). Nearly 49% of all 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 22.3% of this target, 1.7-fold higher than returns to the MMB SHRU (13.4%). Returns to the DEC SHRU estimated at 64 were only 10.8% of the target. In 2023, the Ducktrap DIP (Distinct Individual Pop) in the PNB SHRU remains at an elevated extirpation risk with only three estimated returns. In the past decade, biologists documented only 21 returns (median = 1) and in five of the last 10 years, there were no documented returns in the Ducktrap River. The variation in annual adult returns is primarily a function of return rates driven by low marine survival and low natural spawner contributions with relatively consistent conservation hatchery supplementation. These populations remain spawner-limited due to overall adult abundance (returns and hatchery broodstock) remaining below conservation spawning escapement needs.

Population **growth** is monitored by 10-year geometric mean population growth rates of naturally-reared adults (USFWS & NMFS 2018). The GOM DPS rate for 2023 returns was 1.16% CL 0.69-1.93). 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 (Section 2.4.1). These metrics suggest that wild population components have growth rates below 1.0 (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. In the past, we summarized occupancy for cohort production from four sources - wild, egg planted, fry stocked, or parr stocked for core managed and surveyed HUC-12 units (USASAC 2023). Software updates confounded similar occupancy analysis in 2023 where relative density was calculated. However, we enumerated HUC units that were stocked in 2023 and had documented redds in 2022 (binary count). In aggregate, 39 HUC-12 units had documented wild spawning in 2022 or were stocked with eggs, fry and parr in 2023 contributing to the 2023 cohort. An updated occupancy time series is expected to resume with the 2025 assessment. However, given demographic constraints it is likely that most juvenile rearing habitat is vacant and much of the occupied habitat is underutilized. With continued low freshwater abundance, expectations for reaching adult recovery targets should be scaled.

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. The Pleasant River population is consistently on the lower end and Penobscot sea-run and domestic has the most of the 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. Conservation guidance in the broodstock management plan was based on the '50-500 rule' for small populations under short-term supplementation (Franklin 1980). 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 supplementation program for the Penobscot population has been river-specific since 1974, which equates to almost 10 generations (five-year generation time). Of the six coastal river-specific populations, most are nearing seven generations of hatchery intervention. As such, all exceed the definition of short term intervention (five generations). Given current freshwater and marine production, there is an increased urgency to revisiting broodstock collection, hatchery operations, and their impacts on conservation genetics and fish fitness. There is a pressing need to evaluate genetic rescue approaches that have been used successfully elsewhere for endangered salmonids.

2.2 Status Assessment Approach

This section summarizes general trends for the endangered GOM DPS in Maine. These populations represent the majority of US returns. 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). 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. Benchmark assessments are scheduled to be produced and published every 5 years.

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 SHRU for the GOM DPS (NMFS 2009) based on watershed similarities and remnant population structure. The GOM DPS critical habitat ranges from the Dennys River southward to the Androscoggin River (NMFS 2009).

At the time of listing, nine 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 designated at listing, conservation hatchery programs propagate wild-exposed parr or returning adults (Penobscot) to supplement spawning populations in seven DIPs. 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 returns. In general, biologists stock these fish back 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 29,198 adults (Baum 1995). In 2024, Atkinson et al (2024) provided an update of the CL for U.S. populations considering updated habitat estimates, sex ratios and fecundity values. The updated estimate was delineated by DPS and critical versus non-critical habitat. The CL for GOM DPS critical habitat is estimated at 22,134 returns. However, considering ongoing efforts to improve and update habitat area values conservation target reporting will remain unchanged in this document and remain 29,198. The values presented by Atkinson et al (2024) may be considered more fully in the future and are available and can be used for river-specific management targets in the interim.

CL targets represent long-term goals for sustainable population sizes. Given the endangered status of the GOM DPS, the current recovery plan target for down listing from endangered to threatened is at least 1,500 adults originating from wild origin, or hatchery stocked eggs, fry, or parr spawning in the wild, with at least 2 of the 3 SHRUs having a minimum annual escapement of 500 naturally-reared adults. The threshold of 2,000 wild spawners per SHRU, totaling 6,000 wild spawners annually for the GOM DPS, is one of the current recovery targets needed to consider 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 (USFWS & NMFS 2018). 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 marks, 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 2023 were 1,836 adults with 1,599 hatchery-origin fish returning to the East Machias, Penobscot, Sheepscot, Kennebec, and Androscoggin Rivers (Figure 2.3.1 and Table 2.3.1). Because of the abundance of the PNB SHRU smolt-stocked returns (1,476), this SHRU dominated (87%) total abundance with 1,592 returns (includes 116 naturally-reared returns). An additional 123 hatchery returns were documented from the DEC (10) and MMB SHRU (113).

Naturally-reared returns were also highest in PNB at 116 (Table 2.3.1 and Figure 2.3.2). Of these, 22 adults returned to the Ducktrap River or lower Penobscot River tributaries below the Milford and Orono trapping sites. Elsewhere the DEC SHRU had 54 documented naturally-reared returns across all six of monitored river systems while the Merrymeeting Bay SHRU had 67 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 Salmon Habitat Recovery Unit (SHRU) for return year 2023 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	10	54	64	10.8%
Penobscot Bay	1,476	116	1,592	23.2%
Merrymeeting Bay	113	67	180	13.4%
Gulf of Maine DPS	**1,599**	**237**	**1,836**	**-**

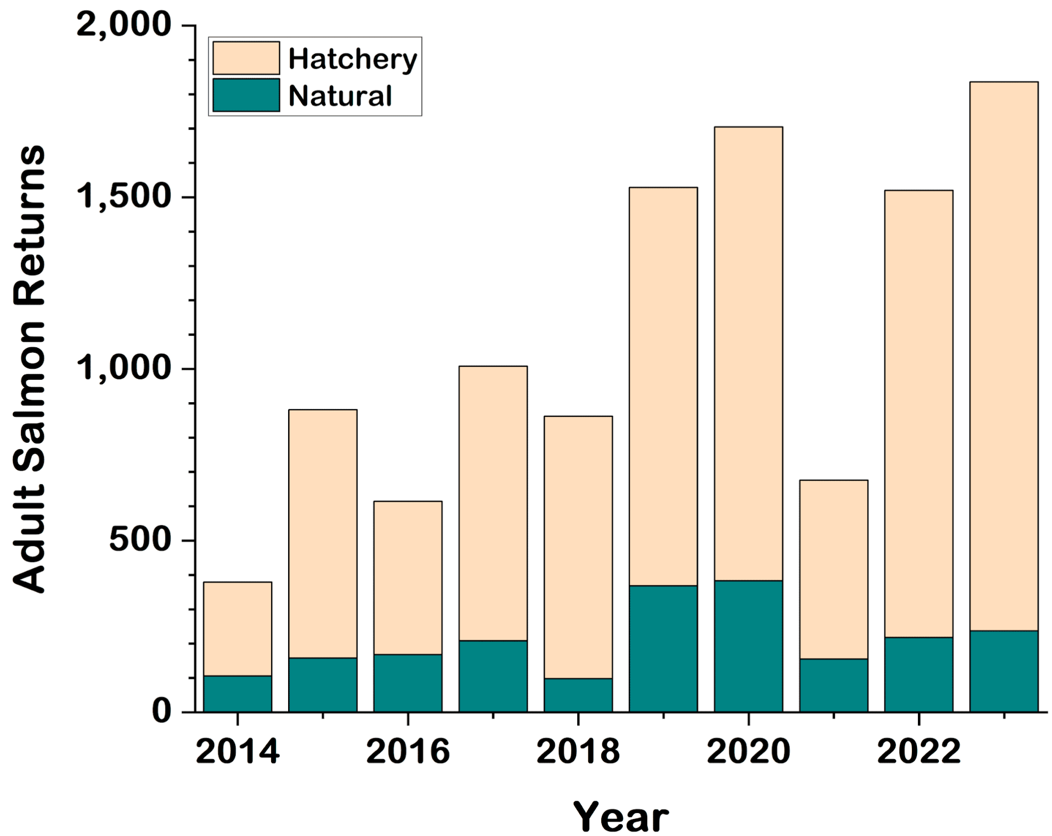

Figure 2.3.1. Time-series of total estimated returns to the GOM DPS of Atlantic salmon for the last decade illustrating the dominance of hatchery reared origin (parr or smolt stocked; tan bars) Atlantic salmon compared to naturally reared (wild, egg stocked, fry stocked; teal bars) origin.

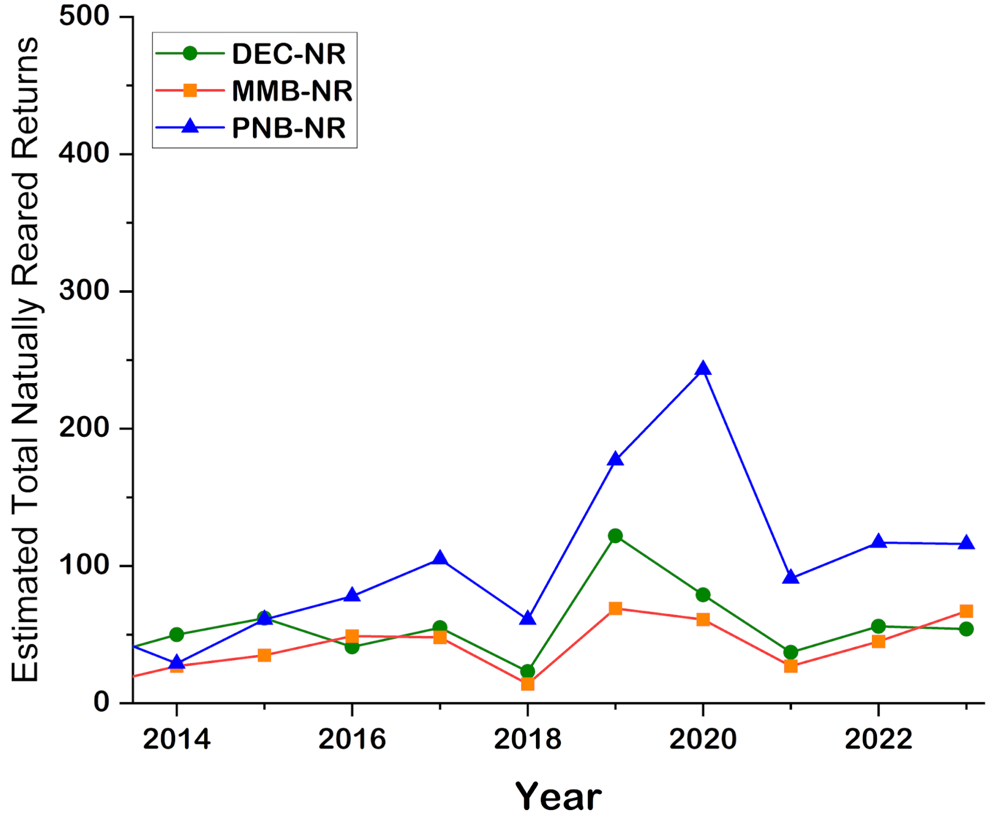

Figure 2.3.2. Time-series of the last decade of naturally-reared adult returns to the Merrymeeting Bay (Orange), Penobscot Bay (Blue), and Downeast Coastal (Green) SHRUs. Note: Naturally-reared target of 500 natural spawners is maximum axis value.

2.3.2 Adult Return Rates

The USASAC updated adult return rate metrics for Penobscot River hatchery-origin smolts based on 2023 returns. For naturally-reared smolts produced in the Narraguagus, Sheepscot, East Machias, and Sandy rivers, metrics for 2SW returns for 2021 cohort were updated after a gap in the 2020 time series as no smolt estimates were available due to the pandemic. Additionally, a naturally-reared smolt population estimate for the Sandy River in 2021 allowed the calculation of SAR for that system for the first time. For all these four populations, we used smolt emigration estimates and subsequent adult returns by sea age 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 ambient parr. The longest time series 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 (salmon can bypass the trap), redd counts are used to estimate total returns. Sheepscot River smolts were monitored from 2009 to 2019. Biologists shifted smolt monitoring to the Sandy River in 2021-2023. East Machias smolt monitoring was conducted from 2013-2019 and 2021. Due to staff capacity and funding constraints, monitoring ended in the Sheepscot (2019), East Machias (2021), and the Sandy River (2023). When biologists estimate adult returns from redd counts, ages are pro-rated by standard methods used by USASAC (2019).

The 1 SW PSAR for the Penobscot 2023 returns was 0.02% and the SAR for the Narraguagus was 0.40%. Trends in the last ten years (smolt cohorts 2012-2021) indicate Penobscot hatchery-reared 1SW population PSAR averaged 0.05%. The Narraguagus River had a higher SAR in the last 10 years averaging 0.45%, with only seven years available because of incomplete estimates in (2016, 2017, and 2020). For the 11-year Sheepscot River time series, the average SAR was 0.16%. The eight-year East Machias grilse SAR 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 than for grilse. In 2023, the 2021 smolt cohort PSAR for the Penobscot was 0.26%, marking the second year of a more than 1.5 fold increase (Figure 2.3.2.1). While these rates are higher than the average of 2SW salmon in the last ten years when the Penobscot PSAR averaged 0.15% (Figure 2.3.2.1), they remain much lower than the 1970 to 1990 average of 1.12%. The average SAR for 2SW returns to the Narraguagus for the past 10 years averaged (1.30%). For completed monitoring, the time-series averages of the Sheepscot (0.58%) and the East Machias (1.82%). While the inter-annual variability is large in these smaller populations, these data suggest consistently 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.

Within the Kennebec River, smolt stocking started in 2020 and 2SW returns of stocked smolts had SAR of only 0.01% in 2022 and 0.09% in 2023. With wild smolt production estimates in the Sandy River starting in 2021, the SAR for 2SW to Lockwood was 0.44% for the 2023 return year. More analysis of returns to this system will occur as the time-series lengthens but assessment of strays to the nearby Androscoggin River should be included in analysis in the future.

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.

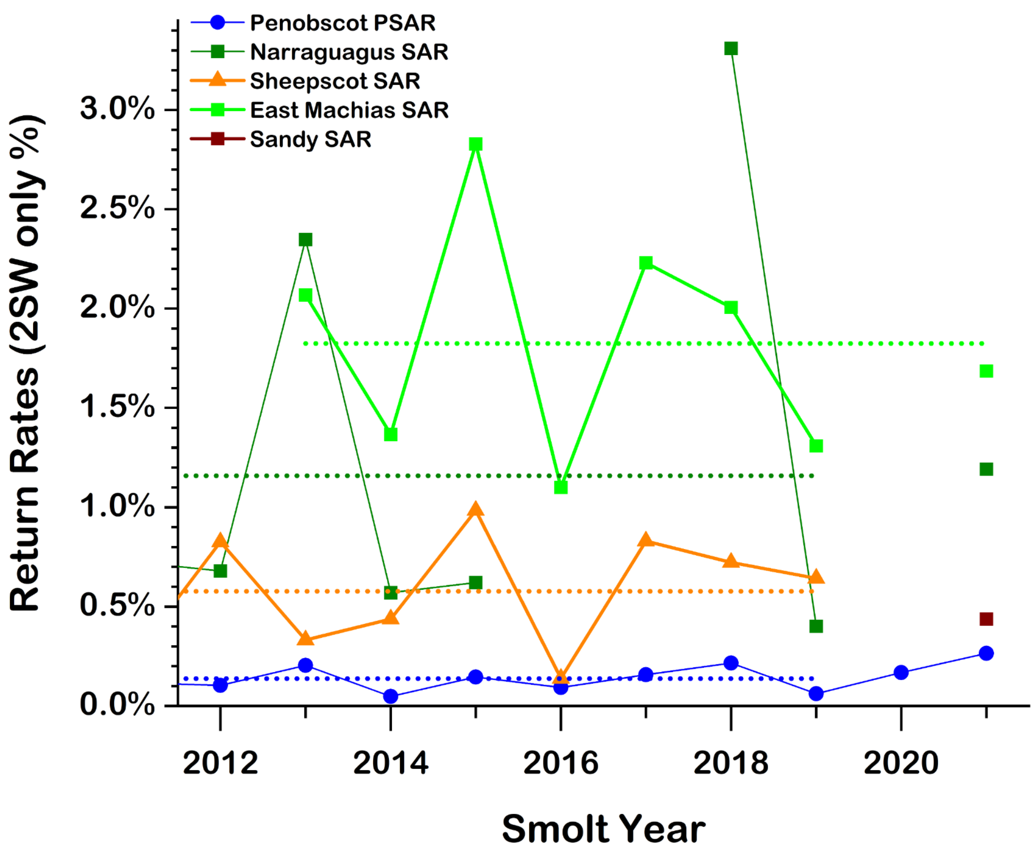

Figure 2.3.2.1. Time series of post-smolt to 2SW adult return rates for the Penobscot hatchery smolts (blue with dashed 0.14% decadal average 2010-2019) and naturally-reared smolt to adult return rates for the Narraguagus (olive with dashed 1.16% decadal average 2010-2019), Sheepscot (orange with dashed 0.58% time series average), East Machias (green with dashed 1.82% time series average), and Sandy (wine) for the 2012-2021 smolt cohorts. This is the first 2SW estimate for the Sandy River (0.44%).

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 N_t is the number of adult returns in year *t* and N_{t-5} is the number of adult returns five years prior. Naturally-reared adult returns 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 returns 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 (USASAC 2009). 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 2.4.1). In 2023, the MMB SHRU had the highest growth rate (1.59; 95% CI: 0.94 – 2.69) and the DEC SHRU had the lowest growth rate (0.95; 95% CI: 0.60 – 1.51). The PNB SHRU had an intermediate growth rate of 1.19 (95% Cl: 0.59-2.39) (Table 2.4.1).

Table 2.4.1. Ten-year geometric mean replacement rates (GM_R) for GOM DPS Atlantic Salmon as calculated for 2023 return year with 95% confidence limits (CL).

RU	GM_R	Lower 95% CL	Upper 95% CL
Downeast Coastal	0.95	0.60	1.51
Penobscot	1.19	0.59	2.39
Merrymeeting Bay	1.59	0.94	2.69
Gulf of Maine DPS	**1.16**	**0.69**	**1.93**

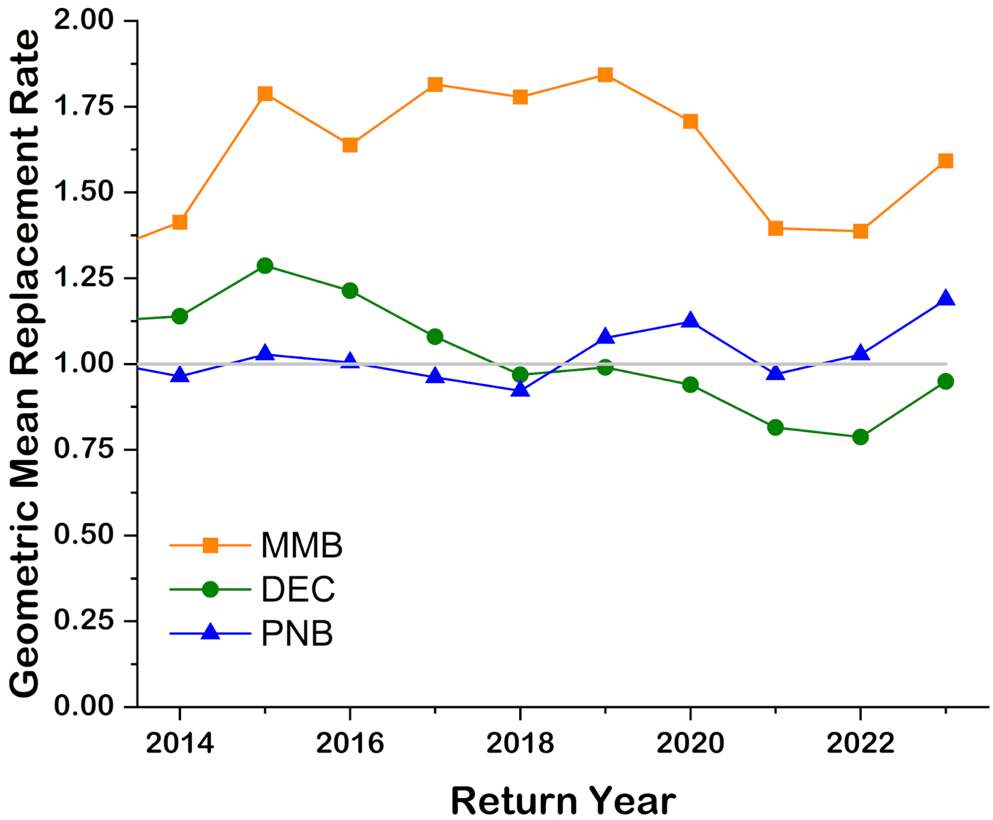

Figure 2.4.1. Annually calculated ten-year geometric mean replacement rates for the GOM DPS of Atlantic salmon for Merrymeeting Bay (orange), Penobscot Bay (blue), and Downeast Coastal (green) for each SHRU individually for the last decade.

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).

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

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

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

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

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

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

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

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

where T = an approximate 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 2014 - 2023 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 naturallyr eared component of returning salmon. Penobscot River broodstock were obtained by trapping adults and transporting them to Craig Brook National Fish Hatchery (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 $(S_{W,t})$ was then

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

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

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

<u>Results</u>

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 for 2021 returns.

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 visualizing habitat 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 typically 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 nursery areas (termed "occupancy") at the HUC-12 level within each SHRU (e.g. Figure 2.5.1.1.). 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, occupancy maps provide 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. However, logical limitations did not allow for a full visual and mapping analysis of 2023 stocking activities see following section.

2.5.1 Modified Summary for 2023 Cohort

Because of software change and updates, the density of redd counts and stocking activities could not be tabulated this year. Standard estimates will be revisited in 2024 with updated tools. As such, we made a binary summary of observed redds or stocking activity in each discrete HUC. We found, redd survey coverage included 17 HUC-12s in 2022 (Figure 2.5.1.2; Section 3) and with stocking there is an aggregate total of 39. 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. A similar summary is presented for egg planing and juvenile stocking (Table 2.5.1).

Table 2.5.1. Summary of number of HUC-12 units in 2023 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 (Egg = EPA, Fry = FPA, and Parr = PPA). Note: because sources overlap (wild plus one or more stocking Products) in some HUC-12 units, the total below (56) exceeds the aggregate total (39) described above. Total HUC-12 units in Critical Habitat are 300- Downeast Coastal (72), Penobscot Bay (154), and Merrymeeting Bay (74).

SHRU	WPA	EPA	FPA	PPA
Downeast Coastal	8	0	15	0
Penobscot Bay	3	1	5	2
Merrymeeting Bay	6	11	4	1
Total Gulf of Maine HUC 12 with Documented Occupancy	**17**	**12**	**24**	**3**

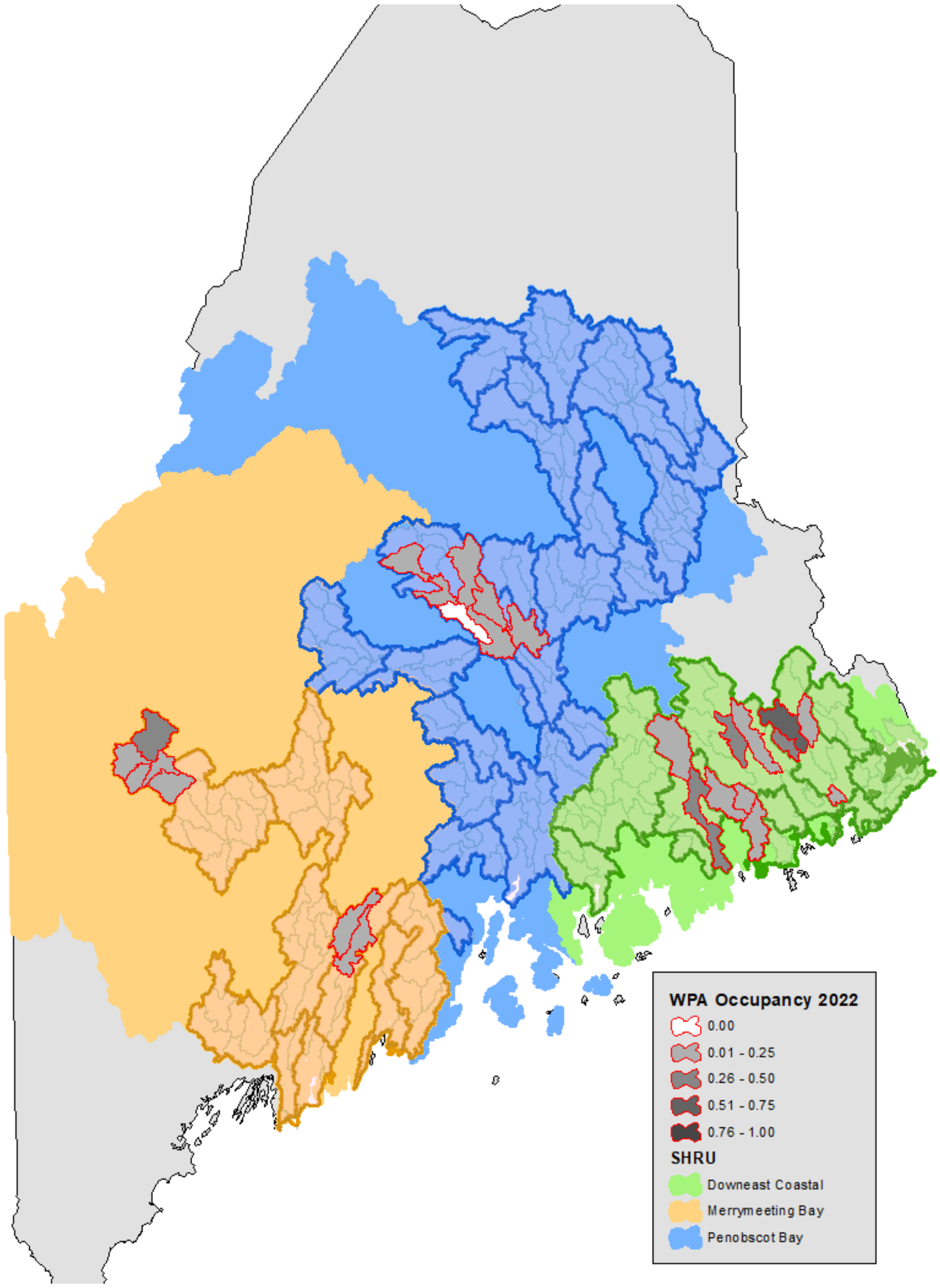

Figure 2.5.1.1.Wild Production Areas 2023. Map highlighting known spawning activity in 2022 at a HUC-12 watershed summary level that visualizes occupancy in HUC-12 units where redd surveys were conducted (red outline of HUC denotes redd surveys conducted (see Table 2.5.1).

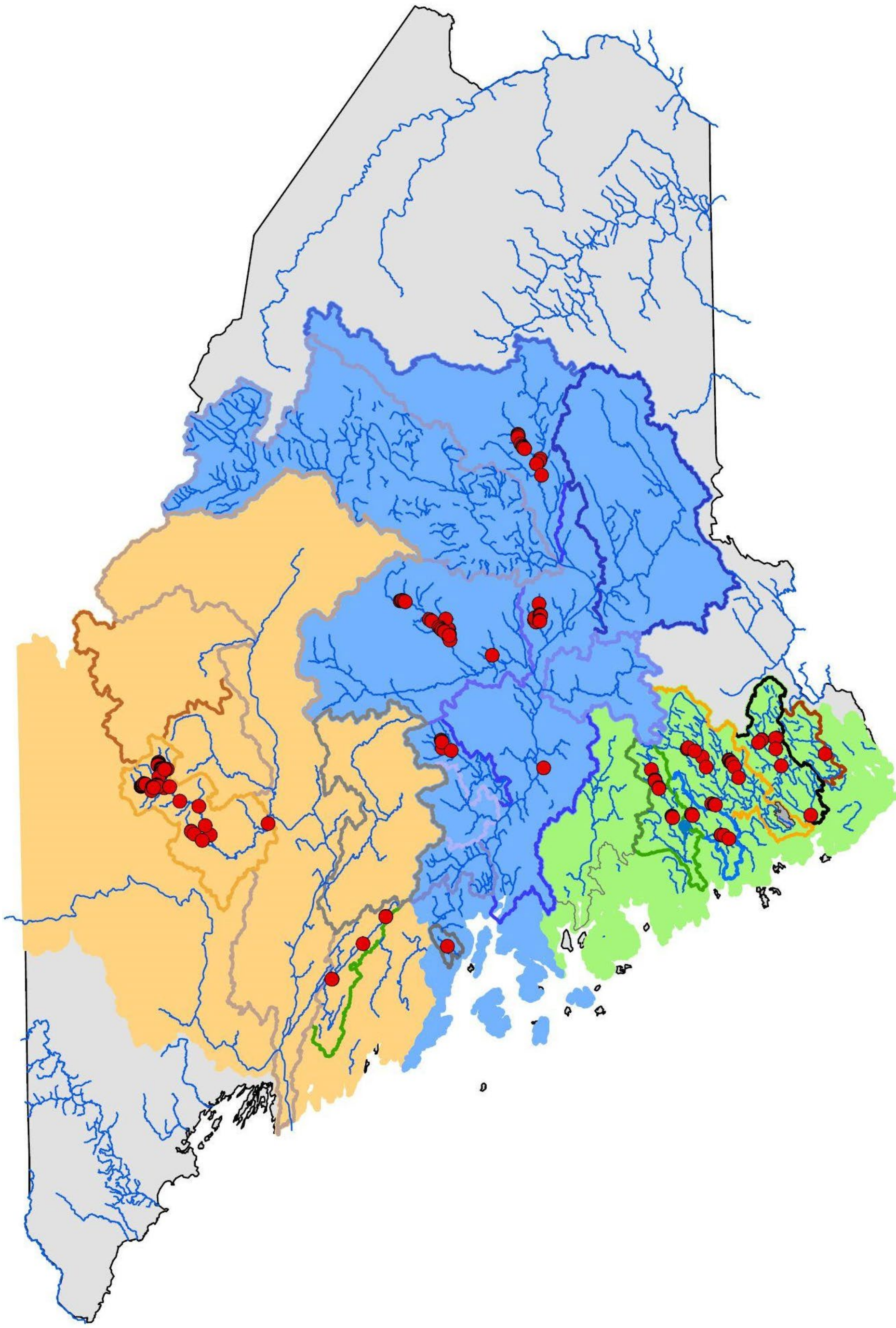

Figure 2.5.1.2. Map of redds (red dots) surveyed in 2023 across the Gulf of Maine DPS. Coverage was expanded in the Penobscot watershed and occupancy density estimates will be provided next year as software upgrades are completed.

2.6 Genetic Diversity

As part of the Atlantic salmon recovery program, maintenance of genetic diversity is a critical component of the process. USFWS monitors genetic diversity for the Atlantic salmon program through assessment of broodstock collected from rivers as parr or returning adults, 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 (Ne) is defined as the size of an ideal population (N) that will result in the same amount of genetic drift as the actual population being considered. Many factors can influence Ne, such as sex ratios, generation time (Ryman et al. 1981), overlapping generations (Waples 2002), reproductive variance (Ryman and Laikre 1991), and gene flow (Wainwright and Waples 1998). Applied to conservation planning, the concept of Ne has been used to identify minimal targets necessary to maintain adequate genetic variance for adaptive evolution in quantitative traits (Franklin and Frankham 1980), or as the lower limit for a wildlife population to be genetically viable (Soulé 1987). Estimation of Ne 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 Ne for a population. In Atlantic salmon, Palstra et al. (2009) identified a range of Ne to N ratios from 0.03 to 0.71, depending on life history and demographic characteristics of populations. Assuming a Ne to N ratio of 0.2 for recovery planning, the Ne 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 Ne 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 the 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 in 2021 and sea-run broodstock collected in 2023. 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 2021 collection year parr, the 2023 collection year Penobscot adult returns and the 2020 Penobscot domestic broodstock. 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 0.695 in the Dennys to 0.714 in the Penobscot domestic broodstock.

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 2021 collection year was estimated for the Dennys broodstock (N_e =50.9, 41.3-63.1 95% CI), and the highest was observed in the Narraguagus broodstock (N_e = 99.4 (79.3-127.5 95% CI). N_e estimates fluctuate annually (Figure 2.6.3.1). Beginning in 2008, average N_e across the parr-based broodstocks ranges from N_e=68.9 in the Dennys to N_e =134.3 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 =402.4. The N_e estimate for the 2023 return the broodstock falls below the average, N_e = 308.3 (276.1-345.7 95% CI). The N_e estimate for the 2020 Penobscot domestic year class (collected from juveniles from a single year class) is N_e =120.4 in (105.9-136.7 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.

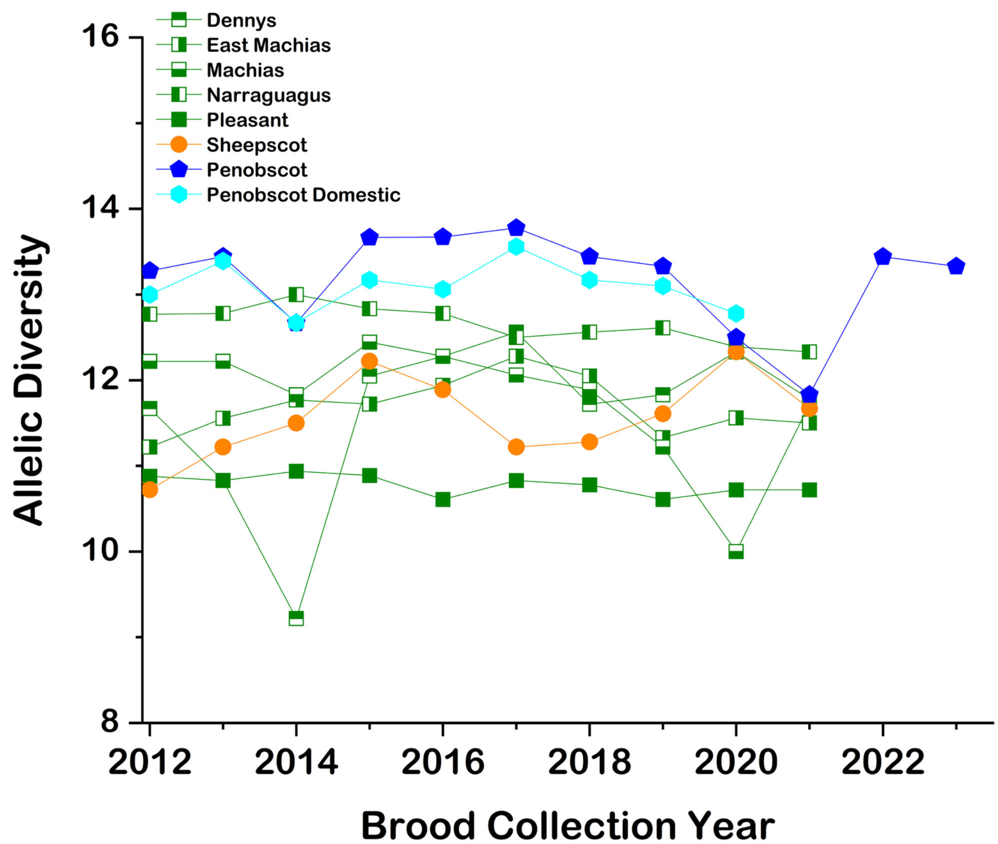

Figure 2.6.1.1. Allelic diversity time series for GOM DPS salmon populations, measured from 18 microsatellite loci for Dennys, East Machias, Machias, Narraguagus, Pleasant, Sheepscot, Penobscot, and Penobscot Domestic populations.

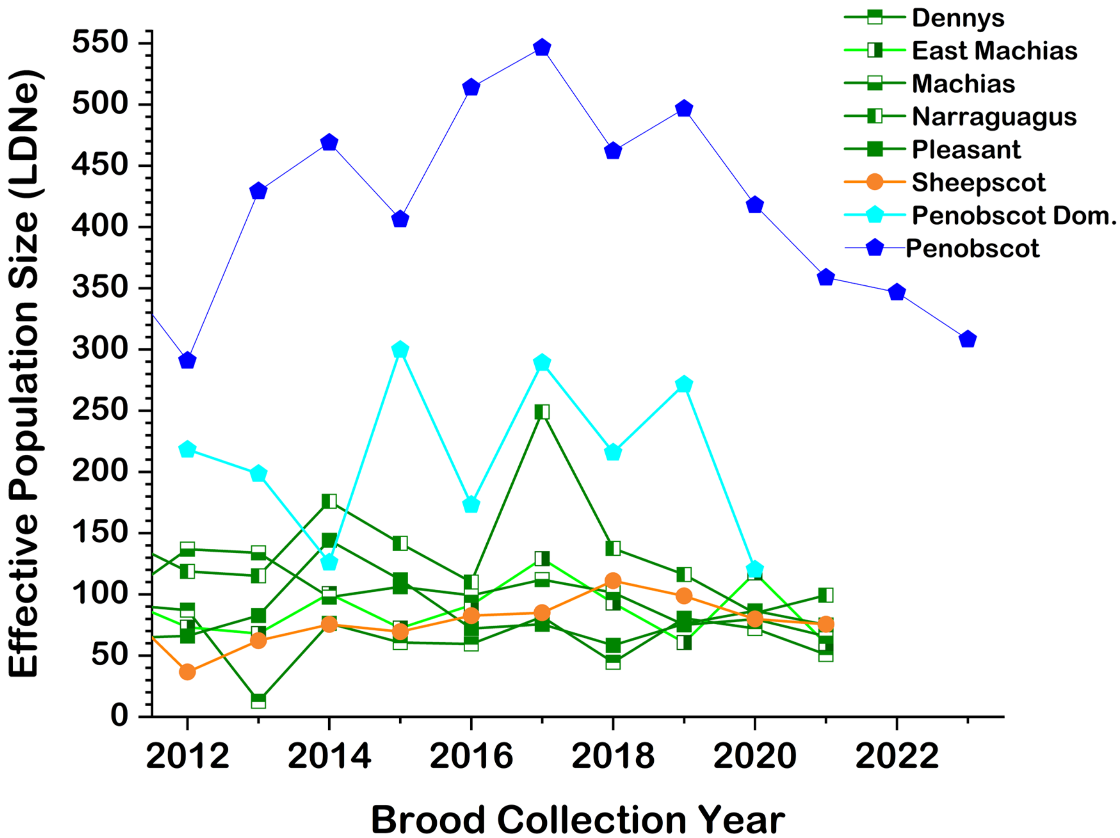

Figure 2.6.3.1 Time series of effective population size for seven GOM DPS distinct individual populations. Estimates for the parr-based broodstock populations (Dennys, East Machias, Machias, Narraguagus, Pleasant, and Sheepscot) approximate the number of breeders, since estimates are obtained from primarily 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 (Penobscot Dom. – Penobscot Domestic Program).

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End of Chapter 2

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 and USFWS 2009) in 2023 was 1,836 salmon (Table 3.0.1). Returns are the sum of counts at fishways and weirs (1,740) and estimates from redd surveys (96). No fish returned "to the rod" because angling for Atlantic salmon is closed statewide. Counts were obtained at fishway trapping facilities on the Androscoggin, Penobscot, Kennebec, and Union rivers.

Total escapement to these same rivers in 2023 was 3,029 salmon (Table 3.0.2). Escapement to the GOM DPS 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 salmon previously released downstream for telemetry studies.

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 3.0.1). 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 2014 to 2023 is 1.16 (0.69 – 1.93) for the DPS. Dividing this further by Salmon Habitat Recovery Unit (SHRU), Merrymeeting Bay experienced the greatest growth rate of 1.59 (0.94 – 2.69), Penobscot Bay was 1.19 (0.58 – 2.39) and Downeast Coastal was 0.95 (0.60 – 1.51). This indicates that the DPS has been slightly above 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 3.0.2). For more detail on population growth rates, see Section 2.3 above.

Table 3.0.1. Returns to the Gulf of Maine in 2023 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 (number of winters spent at sea: 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	0	0	0	0	0	0	0
DEC	East Machias	Redd	2	8	0	0	1	6	0	0	10	7	17
DEC	Machias	Redd	0	0	0	0	2	10	0	0	0	12	12
DEC	Pleasant	Redd	0	0	0	0	3	11	0	0	0	14	14
DEC	Narraguagus	Redd	0	0	0	0	4	17	0	0	0	21	21
DEC	Union	Trap	0	0	0	0	0	0	0	0	0	0	0
PNB	Penobscot	Trap	95	1,356	5	1	2	109	2	0	1,457	113	1,570
PNB	Kenduskeag	Redd	1	10	0	0	0	0	0	0	11	0	11
PNB	Souadabscook	No Survey	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	0
PNB	Great Works	Redd	0	8	0	0	0	0	0	0	8	0	8
PNB	Cove Brook	No Survey	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	0
PNB	Duck Trap	Redd	0	0	0	0	1	2	0	0	0	3	3
MMB	Sheepscot	Redd	1	0	0	0	1	8	0	0	1	9	10
MMB	Kennebec	Trap	9	94	1	1	0	57	0	0	105	57	162
MMB	Androscoggin	Trap	5	2	0	0	0	1	0	0	7	1	8
		Totals	113	1,478	6	2	14	221	2	0	1,599	237	1,836

Table 3.0.2. Sea-run returns and total escapement in 2023 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 (DOA) 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	0	0	0	0	17	0	17
Estimate	DEC	East Machias	17	0	0	17	23	0	40
Estimate	DEC	Machias	12	0	0	12	322	0	334
Trap	DEC	Narraguagus	21	0	0	21	0	0	21
Estimate	DEC	Pleasant	14	0	0	14	41	0	55
Trap	DEC	Union	0	0	0	0	0	0	0
Trap	MMB	Androscoggin	8	0	0	8	0	0	8
Trap	MMB	Kennebec	162	0	1	161	0	0	161
Estimate	MMB	Sheepscot	10	0	0	10	24	0	34
Estimate	PNB	Cove Brook	0	0	0	0	0	0	0
Estimate	PNB	Ducktrap River	3	0	0	3	0	0	3
Estimate	PNB	Great Works	8	0	0	8	0	0	8
Estimate	PNB	Kenduskeag	11	0	0	11	0	0	11
Trap	PNB	Penobscot	1,570	752	3	815	1,275	243	2,333
Estimate	PNB	Souadabscook	0	0	0	0	0	0	0
			1,836	752	4	1,080	1,702	243	3,025

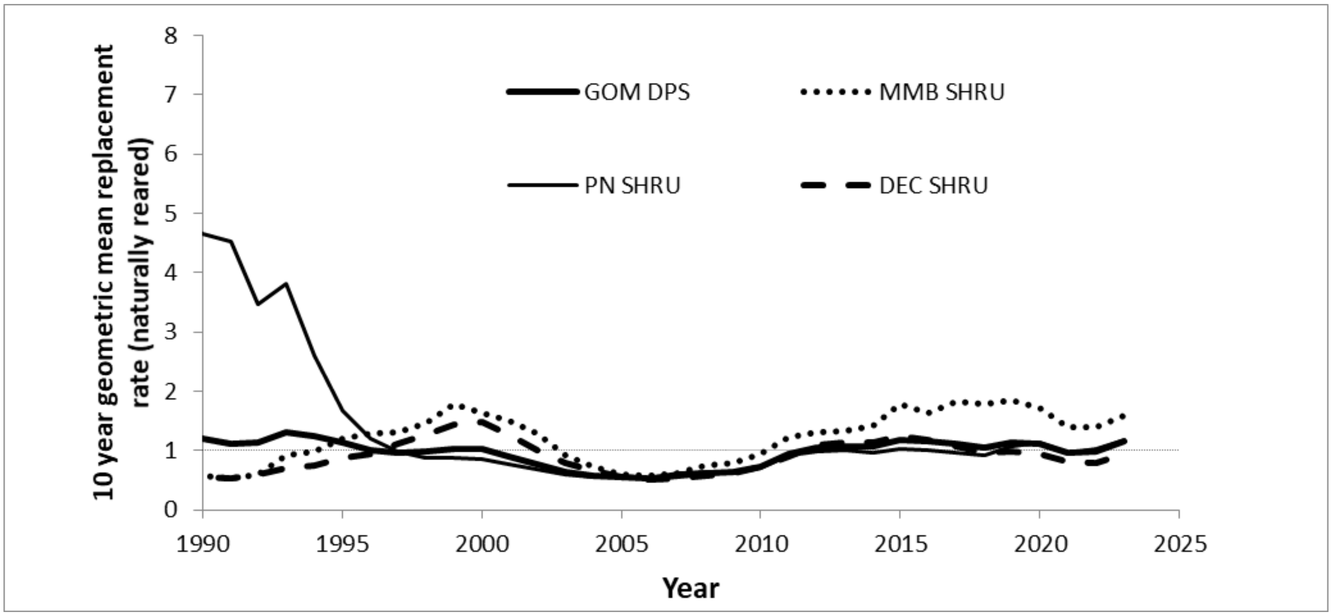

Figure 3.0.1. Ten-year geometric mean of replacement rate for returning naturally reared Atlantic salmon in the Gulf of Maine Distinct Population Segment (GOM DPS) and the three Salmon Habitat Recovery Unit (SHRU) 1990 to 2023. SHRU abbreviations: PNB = Penobscot Bay, MMB = Merrymeeting Bay and DEC = Downeast Coastal

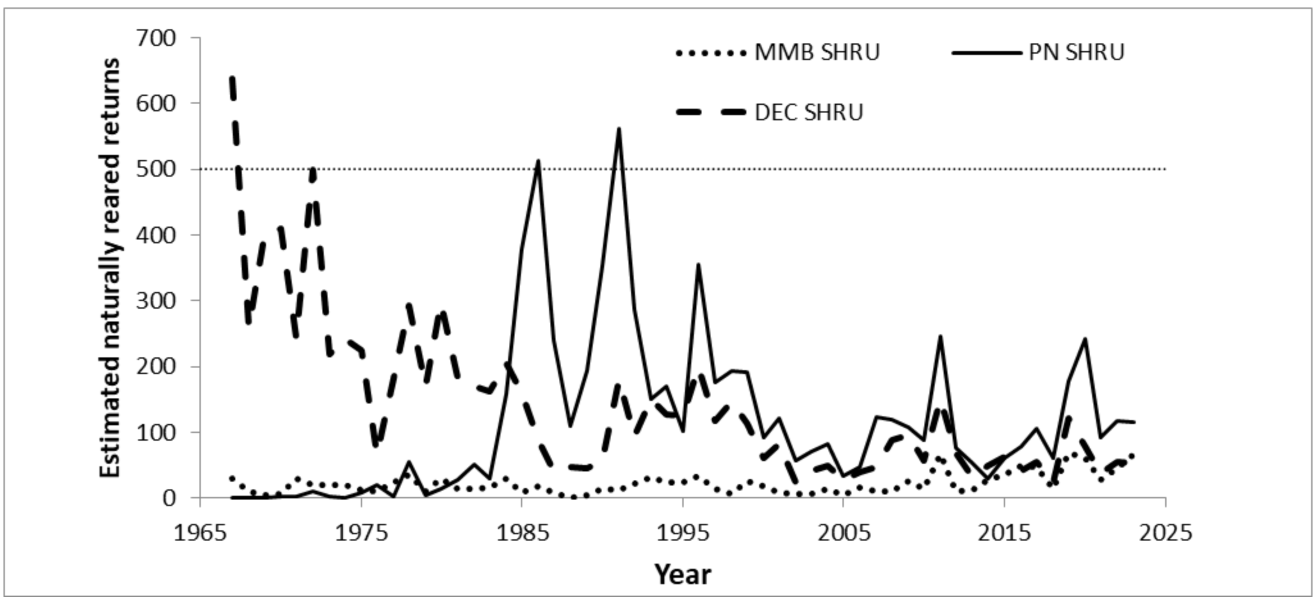

Figure 3.0.2. Estimated Naturally Reared Returns to the Gulf of Maine 1965 to 2023. Naturally reared refers to the egg, and fry lifestages. Salmon Habitat Recovery Unit (SHRU) abbreviations: PNB = Penobscot Bay, MMB = Merrymeeting Bay and DEC = Downeast Coastal.

3.1 Adult returns and escapement

The Maine Department of Marine Resources (MDMR), Bureau of Sea-Run Fisheries and Habitat and its authorized representatives operate counting facilities on several rivers in Maine to capture and count sea-run adult Atlantic Salmon (*Salmo salar*) returning to the GOM DPS. This is done to determine annual returns and estimate escapement, collect biological data, procure sea-run broodstock, and exclude suspected aquaculture Atlantic salmon and invasive species for each river in which salmon are trapped (Table 3.0.1 and 3.0.2). To standardize operations among trapping facilities, MDMR staff developed protocols and methods for tending that considers safe handling and transport as needed. These protocols, which are updated annually, provide site specific guidance on data collection and marking as needed.

Proration of data for returning adult Atlantic salmon.

Data collected from captured adult salmon includes total length to the nearest cm, any noticeable marks, and scale sampling. These data are used to make an initial determination of age and origin followed by confirmation through scale analysis. These data are also used to prorate adults into appropriate categories when data collection is impacted due to sampling challenges (i.e., high temperatures or limited/no handling). 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 potential three Sea-Winter (3SW) fish are assigned first and the remaining Multi Sea-Winter (MSW) subset is prorated as described.

Redd based proration

Starting with 2019 returns, we documented pro-rate methods fully in Working Paper (WP20-03) (USASAC 2020). Briefly, for populations where natural production (wild spawning, egg planting, or fry stocking) is the exclusive source of adult spawners, the proration method is the two-step 80:20 proration. In step 1, the Redds Based Estimate (RBE) is multiplied by 0.8 and rounded to the nearest whole fish to determine the number of large salmon (2SW, MSW, or repeats). In step 2, grilse (1SW) numbers were calculated by subtracting large salmon from the RBE total. For 2019 to 2023 returns to the East Machias and Sheepscot Rivers, a modification was used to enable evaluation of the efficacy of ambient fall parr stocking. All ambient fall parr were marked prior to stocking and hatchery origins were Craig Brook National Fish Hatchery (CBNFH) for the Sheepscot and Peter Gray Hatchery for the East Machias. In both these systems, smolt trapping was used to generate a population estimate of emigrant smolts and measure the proportion of marked fall parr. This pro-ration method assumes equal marine survival between smolts of natural origin (wild, egg-planted, or fry stocked) and fall parr origins. It would be useful to test this assumption in a watershed where returning adults were handled. This is a research need for ambient fall parr evaluations. With the onset of ambient parr stocking in the Narraguagus River some direct adult return evaluation is expected from trap catches. During this period, adult return origin was pro-rated by 0.55 fall parr origin for Sheepscot returns and 0.98 for the East Machias.

The following are drainage summaries of adult returns to the GOM in 2023.

3.1.1. Merrymeeting Bay

Androscoggin River

The Brunswick fishway trap was operated from 12 May to 15 November 2023. Eight adult Atlantic salmon were passed at the Brunswick fishway trap. These consisted of five (62.5%) hatchery reared grilse, two (25.0%) hatchery reared 2SW adults, and one naturally reared adult (12.5%) (Table 3.0.2.). 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 to identify strays from recaptured salmon. Biological data were collected from six trap-captured returning Atlantic salmon in accordance with the 2023 MDMR Adult Trap protocols, and the presence of marks and tags were recorded.

A 0.1 km section of the Little River, where redds have been documented in the past, was surveyed for redd presence, but zero redds were observed in 2023 (Table 3.1.1.).

Kennebec River

The majority of the 162 Atlantic salmon returns to the Kennebec River drainage occurred at the Lockwood Dam (fish lift operated by Brookfield Renewable Power staff from 8 May to 31 October 2023). Of these, 158 were captured at Lockwood (Table 3.0.2.) and one DOA 2SW Atlantic salmon was found downstream and between the Lockwood fish lift and mouth of the Sebasticook River. Additionally, at the Benton Falls fish lift facility (operated by MDMR staff from 01 May to 01 November 2023) located on the Sebasticook River (tributary of the Kennebec), three Atlantic salmon were observed. These adult salmon were pro-rated as hatchery reared based on the lack of a stocking program and few adults returning over the last few years. One was prorated as a 3SW and two were prorated as 2SW based on size.

Of these salmon captured and observed (DOA and Benton), 2SW salmon accounted for 93.2% of the returns. Origins for 2SW returns, 57 were naturally reared and 94 were of hatchery origin. For 1SW returns, all were hatchery reared origin. Hatchery origin salmon made up 64.8% of returns to the Kennebec drainage with naturally reared salmon making up the remaining 35.2%. Thirty-four salmon were recaptured, all likely of hatchery origin (100% of the 18 readable scales were of hatchery origin). The hatchery reared origin returns were likely from stocked smolts raised at the U.S. Fish and Wildlife Service (USFWS) Nashua National Fish Hatchery in New Hampshire.

The dorsal fins of adults returning from smolt stocking in the Kennebec River (hatchery origin adults) tended to be eroded compared to their naturally reared counterparts. Therefore, dorsal score was used to prorate the origin of adults. Out of the four 2SW adults that were prorated as naturally reared, the freshwater ages were prorated based on the known freshwater proportions which were 83% 2-year-olds and 17% 3-year-olds.

Redd surveys in the Kennebec Drainage were limited to the Sandy River, Togus Stream and Bond Brook. Eighty-one redds were observed in the Sandy River and none in Bond Brook or Togus Stream. A drainage total of 103.9 river km were surveyed which covered 34.4% of the surveyed spawning habitat in the Kennebec River drainage. Sandy River surveys covered 96.4 river km. Togus Stream surveys covered 100% of the spawning habitat and the Bond Brook surveys covered 100% of the spawning habitat (Table 3.1.1).

Sheepscot River

There were eight redds observed in the Sheepscot River; all were in the mainstem. Two redds were attributed to captive-reared outplants as they were near the stocking location. A total of 55.6 river km was surveyed which contained 73.4% of the spawning habitat in the drainage (Table 3.1.1.). The Redds Based Returns model estimated that 12 adults returned (95% CI 4 – 31) (Table 3.1.2). Breakdown of returns are as follows: one 1SW hatchery origin, 1 naturally reared 1SW and eight naturally reared 2SW salmon.

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 24 April through 15 November. Biological data including length, sex, scales, genetics, and injury assessment were collected on all fish handled and released. Fish were handled five days per week (Monday through Friday) due to available staffing and at river temperatures < 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 USFWS. Biological data was collected by USFWS staff for all broodstock after fish arrived at CBNFH and provided to MDMR to prevent duplicative data collection between agencies. This workflow also allows for broodstock collection to occur at temperatures exceeding 23°C, as fish are not processed for biological data collection until water can be tempered to safe handling temperatures, thereby reducing stress on fish. Biological data were collected from broodstock on the day of capture when possible. In cases where processing was delayed (typically 1 to 2 days), counts of MSW vs grilse size counts were maintained in daily catch data and morphometric data were backfilled when based on size and numbers.

In addition to the fish lift at Milford Dam, BRP operated a fish lift daily at the Orono Hydro project. BRP staff identify MSW or grilse by size, check for adipose clips (or punches), scan for passive integrated transponder (PIT) tags, and identify fish as male or female when secondary sexual characteristics are obvious. 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 the Orono Hydro facility are included in the Penobscot River totals.

A total of 1,570 sea-run Atlantic salmon returned to the Penobscot River (Table 3.0.1.). Scale samples were collected from 1,145 salmon captured in the Penobscot River and analyzed to characterize the age and origin structure of the run. Origin (natural or naturally reared), sex, and age proportions are applied to salmon that were trapped but not scale-sampled from the seasonal composition.

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. In-season recaptures are reported based on the size, presence of tags or marks observed, and dorsal fin deformity as described previously.

Of returning salmon, seven were 3SW (1%), 1,465 were age 2SW (93.3%), 97 were age 1SW (6.2%), and one was a repeat spawner (<1%). Hatchery origin returns were 92.8% (1,457) of the returning salmon and the remaining 7.2% (113) were naturally reared origin (Table 3.0.1). No aquaculture-suspect salmon were captured.

<u>Video Recapture proration</u>

Because a proportion of returning salmon to the Penobscot is not handled but instead are counted using video (thus are not marked), it is important to estimate “video” recaptures so as not to inflate estimates of returns to the Penobscot. However, obtaining a direct count of “recaptures'' is more complicated without empirical data. Numbers of first capture fish, dead fish, fish removed for broodstock, marked fish, and known recapture fish are recorded daily. The proportions of marked and unmarked fish that are captured and are observed (via telemetry, PIT tag antennae, external tags, or visually observed) are assumed to be the same as the catch proportions during times when staff are not present and/or when fish are not handled. Those proportions are used to 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. The above-referenced proration method for in season recaptures 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 data points used in recapture calculations: (1) total capture events, (2) number of in-season recaptures, (3) known marked fish in the river, and (4) 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 fish recaptured 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 was 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.

Spawner Surveys

Spawner surveys in the Penobscot drainage were limited to the Piscataquis River, East Branch Penobscot River, Kenduskeag Stream, Great Works Stream, Mattamiscontis Stream, and the Ducktrap River. In the Ducktrap, 38.4% of spawning habitat and 1 km of river were surveyed (Table 3.1.1.) with one redd observed. In Kenduskeag Stream, 15.6% of spawning habitat and 7.6 river km was surveyed. There were six redds observed in Kenduskeag Stream. In Great Works Stream, 1.3 river km was surveyed. There were four redds observed in Great Works Stream. In the East Branch Penobscot River, a total 14.8 river km and 36.6% of the spawning habitat were surveyed, with a total of 44 redds observed. Captive-reared adults were released in the East Branch Penobscot River in June and October but assigning origin to the 44 redds was not possible. In the Piscataquis Drainage a total of 28.7 river km and 25.8% of the spawning habitat were surveyed with 102 redds observed. (Table 3.1.1).

Captive-reared adults were released into Mattamiscontis Stream (n = 80) and the Sam Ayers tributary (n= 77) in October 2023 as part of the Salmon for Maine's Rivers program. A total of 14 redds were counted in Sam Ayers Stream and three in Mattamiscontis stream and were all attributed to these captive-reared adults.

The number of redds in the Piscataquis drainage were associated with the release of pre-spawn sea-run adults into the Pleasant River tributary. These salmon were trapped at Milford Dam and transported to CBNFH where they were held until release just before the onset of spawning in October 2023.

3.1.3 Downeast Coastal

Dennys River

One redd was observed in the Dennys River in 2023 and this was attributed to a release of pre-spawn captive reared salmon from CBNFH. Surveys covered 85.2% of the habitat and 19.8 km of stream (Table 3.1.1). Surveys were not conducted in Cathance Stream due to flood conditions affecting visibility. Based on the Redds Based Returns model which uses only sea-run spawners, the estimated escapement was zero (Table 3.1.2.).

East Machias River

A total of 21 redds were counted during the 2023 redd surveys covering 68.5% (15.4 km) of known spawning habitat (Table 3.1.1). Of these redds, six were attributed to a release of pre-spawn captive reared salmon by CBNFH. The sea run returns represent the seventh cohort of adults to return from fall parr stocked as part of the project by the Downeast Salmon Federation (DSF) to raise and release fall parr. There were 226,000 fall parr (2019) associated with the 2SW adult cohort. Based on the Redds Based Returns model, which only uses sea-run spawners, estimated escapement was 17 (95%CI 7 - 45) (Table 3.1.2.).

Machias River

A total of 30 redds were counted in 2023. Of these seven were attributed to a release of pre-spawn captive reared salmon by CBNFH, 15 were attributed to pre-spawn adults released from the Salmon for Maine Rivers program into Old Stream, and eight were from sea-run spawners. Surveys covered 56.9% of the habitat and 68.3 km of stream (Table 3.1.1). Based on the Redds Based Returns model which only uses sea-run spawners, estimated escapement was 12 (95%CI 4 – 31) (Table 3.1.2.).

Pleasant River

There were 11 redds observed in 2023. All from sea-run spawners. The majority of which were located upstream of Saco Falls. Surveys covered 84.1% of the habitat and 18.7 km of stream (Table 3.1.1). Based on the Redds Based Returns model, estimated escapement was 14 (95%CI 5 – 38) (Table 3.1.2.).

Narraguagus River

The Narraguagus Fishway Trap located at the Cherryfield ice control dam was operated from 24 April to 27 October 2023. There were six returns to the fishway trap in 2023. Redd surveys observed 21 redds originating from sea-run spawners with surveys covering 90.1% and 69.2 km of known spawning habitat (Table 3.1.1). The redds based estimate was used to determine returns to the Narraguagus because it was greater than the trap count. Data collected at the trap were used to prorate the breakdown of age and origins. The Redds Based Returns model of the estimated return was 21 (95%CI 8 – 56) (Table 3.1.2.). All returning adults were naturally reared origin with 17 2SW (81%) and 4 1SW (19%) 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 MDMR. The trap was operated from 1 May to 31 October 2023. No salmon were captured in 2023. (Table 3.0.1.)

Table 3.1.1. Results of redd surveys by Salmon Habitat Recovery Unit (SHRU), Drainage and Stream for 2023 by redd origin. Origins are: Captive Reared Freshwater (CRF), Captive Reared Marine (CRM), and Sea-run Redds (Sea-run). Effort is shown by both total kilometers surveyed and the proportion of the spawning habitat surveyed for Drainage and individual stream. Percent stream survey values of N/A signify that habitat data were unavailable for this analysis. Bolded drainage totals may not equal the sum of the individual stream totals since not all streams in a drainage may be surveyed. 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		CRF	CRM	Sea-run	Total Redds	% Stream Spawn Habitat Surveyed	Stream Total KM Surveyed
DEC/Dennys River	Dennys River	1	0	0	1	85.3	19.8
Dennys River Drainage Total	**All Surveyed**	**1**	**0**	**0**	**1**	**85.2**	**19.8**
DEC/East Machias River	Barrows	0	0	2	2	100.0	2.2
DEC/East Machias River	Beaverdam Stream	0	0	0	0	100.0	2.2
DEC/East Machias River	Chase Mill Stream	0	0	6	6	100.0	0.6
DEC/East Machias River	East Machias River	0	0	3	3	45.9	5.6
DEC/East Machias River	Northern Stream	6	0	4	10	99.3	4.8
East Machias River Drainage Total	**All Surveyed**	**6**	**0**	**15**	**21**	**68.5**	**15.4**
DEC/Machias River	Crooked	0	0	0	0	N/A	0.6
DEC/Machias River	Holmes Brook	0	0	0	0	100.0	0.9
DEC/Machias River	Machias River	0	0	2	2	51.6	8.7
DEC/Machias River	Mopang Stream	0	0	4	4	47.8	12.2
DEC/Machias River	Old Stream	0	15	2	17	80.0	34.9
DEC/Machias River	West Branch Machias River	7	0	0	7	93.3	11.0
Machias River Drainage Total	**All Surveyed**	**7**	**15**	**8**	**30**	**56.9**	**68.3**
DEC/Narraguagus River	Baker Brook	0	0	0	0	12.4	0.6
DEC/Narraguagus River	Gould Brook	0	0	0	0	5.3	0.5
DEC/Narraguagus River	Narraguagus River	0	0	21	21	97.4	64.2
DEC/Narraguagus River	West Branch Brook	0	0	0	0	100.0	3.9
Narraguagus River Drainage Total	**All Surveyed**	**0**	**0**	**21**	**21**	**90.1**	**69.2**
DEC/Pleasant River	Pleasant River	0	0	11	11	84.7	18.7
Pleasant River Drainage Total	**All Surveyed**	**0**	**0**	**11**	**11**	**84.1**	**18.7**
MMB/Androscoggin River	Little River	0	0	0	0	100.0	0.1

SHRU/Drainage		CR F	CR M	Sea-run	Total Redds	% Stream Spawn Habitat Surveyed	Stream Total KM Surveyed
Lower Androscoggin River Drainage Total	**All Surveyed**	**0**	**0**	**0**	**0**	**N/A**	**0.1**
MMB/Kennebec River	Avon Valley Brook	0	0	0	0	N/A	1.0
MMB/Kennebec River	Barker Brook	0	0	1	1	N/A	1.0
MMB/Kennebec River	Bond Brook	0	0	0	0	100	3.9
MMB/Kennebec River	Conant Stream	0	0	0	0	N/A	0.0
MMB/Kennebec River	Cottle Brook	0	0	2	2	N/A	0.3
MMB/Kennebec River	Mt Blue Stream	0	0	0	0	N/A	1.4
MMB/Kennebec River	Orbeton Stream	0	0	21	21	97.2	12.8
MMB/Kennebec River	Perham Stream	0	0	5	5	84.1	2.3
MMB/Kennebec River	Saddleback Stream	0	0	0	0	N/A	0.1
MMB/Kennebec River	Sandy River	0	0	41	41	95.9	69.4
MMB/Kennebec River	South Branch Sandy River	0	0	6	6	100.0	2.6
MMB/Kennebec River	Temple Stream	0	0	5	5	N/A	5.4
MMB/Kennebec River	Togus Stream	0	0	0	0	100.0	3.6
MMB/Kennebec River	Valley Brook	0	0	0	0	N/A	0.1
Lower Kennebec River Drainage Total	**All Surveyed**	**0**	**0**	**81**	**81**	**34.4**	**103.9**
MMB/Sheepscot River	Sheepscot River	0	0	8	8	75.8	29.1
MMB/Sheepscot River	West Branch Sheepscot River	0	0	0	0	94.3	26.6
Sheepscot River Drainage Total	**All Surveyed**	**0**	**0**	**8**	**8**	**73.4**	**55.6**
PNB/Ducktrap River	Ducktrap River	0	0	1	1	39.2	1.0
Ducktrap River Drainage Total	**All Surveyed**	**0**	**0**	**1**	**1**	**38.4**	**1.0**
PNB/East Branch Penobscot River	Big Seboeis River	0	4	0	4	36.2	5.6
PNB/East Branch Penobscot River	East Branch Penobscot River	0	40	0	40	42.4	9.2
East Branch Penobscot River Drainage Total	**All Surveyed**	**0**	**44**	**0**	**44**	**36.6**	**14.8**
PNB/Penobscot River	Cove Brook	0	0	0	0	91.6	4.1
PNB/Penobscot River	French Stream	0	0	1	1	62.2	1.8
PNB/Penobscot River	Great Works Stream	0	0	4	4	N/A	1.3
PNB/Penobscot River	Kenduskeag Stream	0	0	6	6	15.6	7.6
PNB/Penobscot River	Mattamiscontis Stream	0	3	0	3	N/A	4.8
PNB/Penobscot River	Pollard Brook	0	0	0	0	N/A	0.5

SHRU/Drainage		CR F	CR M	Sea-run	Total Redds	% Stream Spawn Habitat Surveyed	Stream Total KM Surveyed
PNB/Penobscot River	Sam Ayers Stream	0	0	14	14	N/A	6.8
PNB/Penobscot River	Souadabscook Stream	0	0	0	0	29.3	2.7
Penobscot River Drainage Total	**All Surveyed**		**3**	**25**	**28**	**6.4**	**29.5**
PNB/Piscataquis River	East Branch Pleasant River	0	0	6	6	24.4	2.6
PNB/Piscataquis River	Houston Brook	0	0	11	11	N/A	2.1
PNB/Piscataquis River	Middle Branch Pleasant River	0	0	2	2	N/A	1.0
PNB/Piscataquis River	Piscataquis River	0	0	0	0	10.7	4.6
PNB/Piscataquis River	Pleasant River	0	0	8	8	84.7	7.4
PNB/Piscataquis River	Schoodic Stream	0	0	9	9	N/A	0.9
PNB/Piscataquis River	West Branch Pleasant River	0	0	66	66	88.5	10.3
Piscataquis River Drainage Total	**All Surveyed**	**0**	**0**	**102**	**102**	**25.8**	**28.7**

Redd Based Returns to Small Coastal Rivers

Estimated returns to Maine are based on the total number of adult Atlantic salmon returning to traps on the 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, Souadabscook, Machias River, Pleasant River, and the Sheepscot River based on observed redd counts. Estimated returns based on redd counts are computed using the equation: $\ln Adults = 1.1986 + 0.6098(\ln Redds)$.

A total of 70 redds were surveyed in Dennys, East Machias, Machias, Pleasant, Narraguagus, Sheepscot, Cove Brook, Ducktrap, Kenduskeag, and Souadabscook Rivers. The predicted redds based estimate of returns for 2023 is 90 adults (95%CI 34 to 236; Table 3.1.6). Total Redd numbers across the GOM DPS were similar to 2022 with 70 to 90 estimated returns to un-trapped drainages (Figure 3.1.1.). Trends in estimated returns across surveyed drainages followed similar negative trajectories from 2022 to 2023 (Figure 3.1.2).

Table 3.1.2. Redds based regression estimates and 95% confidence intervals of total Atlantic salmon escapement to the Dennys, East Machias, Machias, Pleasant, Narraguagus, Sheepscot, Cove Brook, Ducktrap, Kenduskeag, and Souadabscook Rivers for 2023.

SHRU	Drainage	Total Spawn Habitat ($100m^2$)	Surveyed Habitat ($100m^2$)	Surveyed Redds	Predicted Returns	L95	U95
DEC	Dennys	238.5	203.2	0	0	NA	NA
DEC	East Machias	58.9	40.4	15	17	7	45
DEC	Machias	449.8	255.8	8	12	4	31
DEC	Narraguagus	265.8	239.4	21	21	8	56
DEC	Pleasant	141.4	119.0	11	14	5	38
MMB	Sheepscot	325.4	238.7	8	12	4	31
PNB	Cove Brook	7.3	6.7	0	0	NA	NA
PNB	Ducktrap	43.8	16.8	1	3	1	9
PNB	Kenduskeag Stream	66.0	10.3	6	10	4	26
PNB	Souadabscook Stream	51.1	15.0	0	0	NA	NA
	Grand Total	1,647.9	1,145.2	70	90	34	236

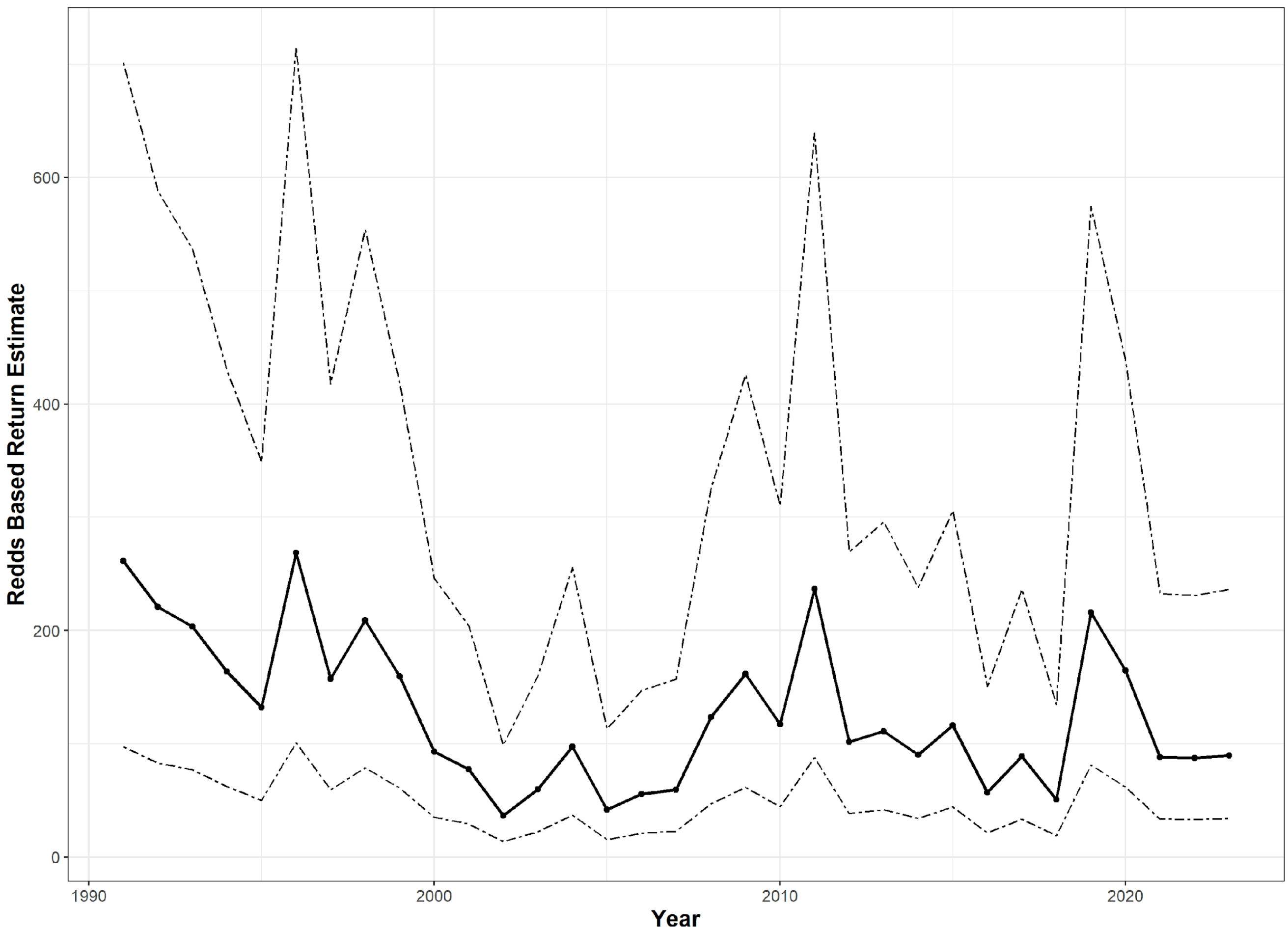

Figure 3.1.1. Annual total redds based estimates for Cove Brook, Dennys, Ducktrap, East Machias, Kenduskeag, Machias, Narraguagus, Pleasant, Sheepscot and Souadabscook Rivers through 1991 – 2023.

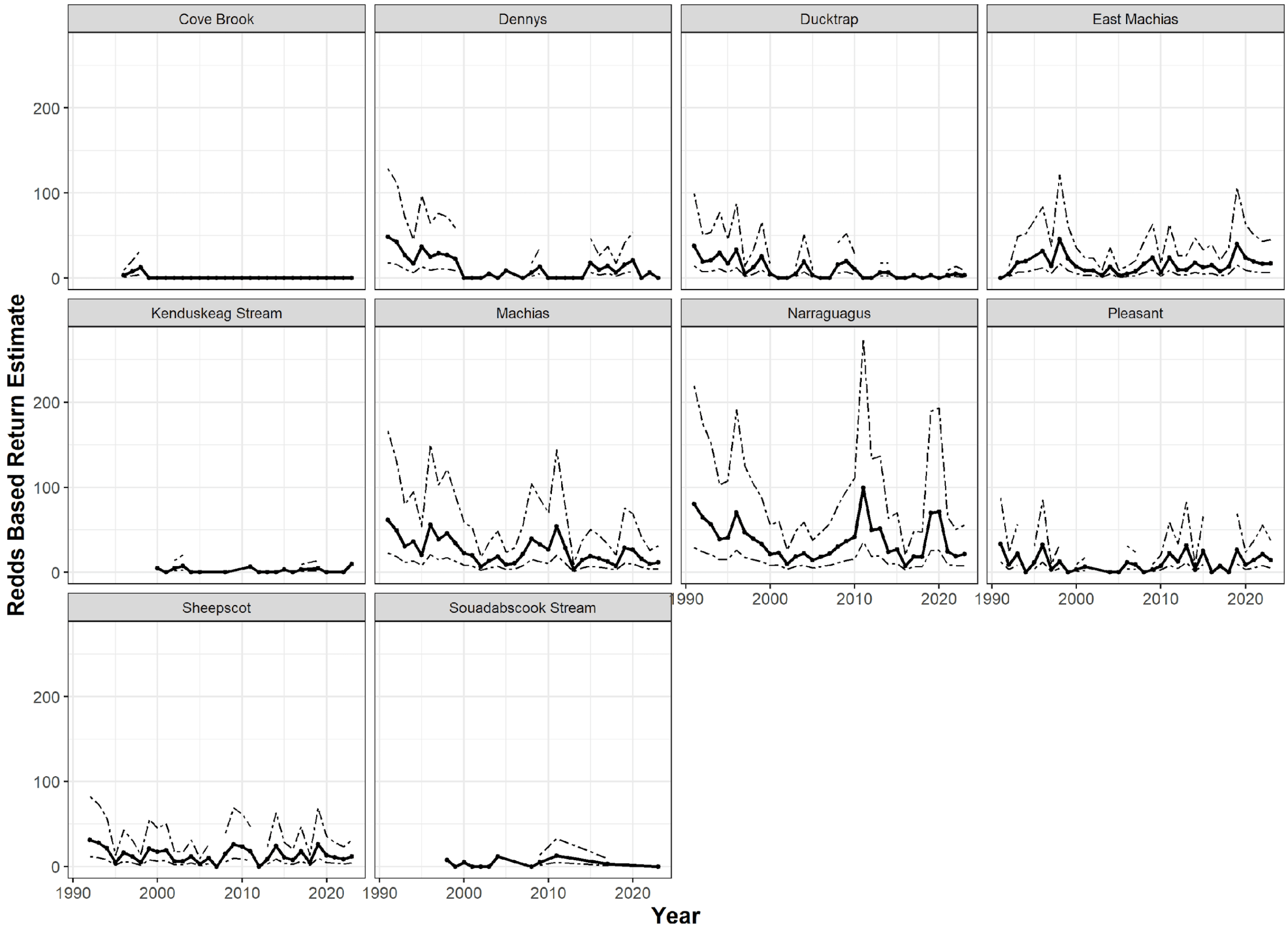

Figure 3.1.2. Individual annual redds based estimate of adult returns to drainages included in the redds based regression estimate for the Gulf of Maine Distinct Population Segment, 1991 - 2023.

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; (NMFS 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 techniques described in (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 Monitoring Station (LCMS) and these drainages receive the greatest focus for GRTS sites (see below for a description).

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	33,836.2	2,098.0	121.3
DEC	East Machias	80,797.3	6,951.0	238.0
DEC	Machias	129,072.7	19,602.0	537.9
DEC	Narraguagus	63,496.3	7,180.0	203.0
DEC	Pleasant	32,845.7	2,580.0	90.9
MMB	Sandy River	153,567.5	36,790.8	1,567.8
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 148 sites were surveyed between July 17th and October 5th, using single pass electrofishing survey techniques across all three SHRUs. Of these, 64 sites were either GRTS selected sites (35) or index sites (29) used to track status and trends. Additional electrofishing efforts were used to evaluate spawner success for hatchery products (WPA), habitat improvements and parr broodstock 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 2023 by project Type. Broodstock are sites where parr broodstock was collected, GRTS sites are used for long term trend analysis, Index sites are sites associated with explicit management projects such as coarse wood additions, Other sites are sites that don't fit in with management such as culvert replacement fish removals, SFMR sites are site surveyed for the Salmon for Maine Rivers project, and WPA are wild production areas determined by redd locations in the previous fall. Abbreviations for Salmon Habitat Recovery Units (SHRUs): DEC = Downeast Coastal, MMB = Merrymeeting Bay and PNB = Penobscot Bay.

SHRU	Drainage	Broodstock	GRTS	Index	Other	SFMR	WPA	Totals
DEC	Dennys	5						5
DEC	East Machias	4		2				6
DEC	Machias	6				4		10
DEC	Narraguagus	3	12	6				21
DEC	Pleasant	4			2			6
MMB	Lower Androscoggin			2				2
MMB	Sandy River		23	5	4		3	35
MMB	Sheepscot	16		10	1		5	32
PEN	Ducktrap			2			1	3
PEN	Cove Brook			2				2
PEN	East Branch					10		10
PEN	Piscataquis				16			16
	Totals	38	35	29	23	14	9	148

Mean parr densities (parr / 100m^2) for GRTS and Index sites surveyed in 2023 ranged from a high of 8.5 parr/100m^2 in the East Machias Drainage to a low of 0 parr / 100m^2 in the Lower Kennebec Drainage (Table 3.2.3).

Life Cycle Monitoring and Juvenile Assessment

The Sandy and Narraguagus Rivers have been established as Life Cycle Monitoring Stations to observe trends in each drainage and attempt to tie trends to management actions. Both systems have extensive sampling programs in place to monitor multiple life stages across the salmon life cycle, including smolt and adult traps, fall juvenile assessment using electro-fishing, and spawner survey sampling plan. Since this section is focused on juvenile assessment, the following will describe trends and observations from fall juvenile electrofishing surveys.

Table 3.2.3. Summary of Single density (Parr/100m^2) results for Index and Generalized Randomized Tessellated Stratification sites across sampled drainages for 2023. Abbreviations for Salmon Habitat Recovery Units (SHRUs): DEC = Downeast Coastal, MMB = Merrymeeting Bay and PNB = Penobscot Bay.

SHRU	Drainage	Year	n	Mean	SD	Low 95	Up 95
DEC	East Machias	2023	2	8.5	0.0	8.5	8.5
DEC	Machias	2023	4	3.2	2.2	1.1	5.4
DEC	Narraguagus	2023	16	2.9	3.6	1.2	4.7
MMB	Lower Kennebec	2023	4	0.0	0.0	0.0	0.0
MMB	Middle Sandy River	2023	10	0.2	0.4	0.0	0.5
MMB	Sheepscot	2023	15	1.2	1.3	0.5	1.8
MMB	Upper Sandy River	2023	17	1.8	1.9	0.8	2.7
MMB	Cove Brook	2023	2	1.2	0.1	1.0	1.4
PNB	Ducktrap	2023	3	0.2	0.3	0.0	0.5
PNB	Penobscot	2023	2	3.8	3.2	0.0	8.2

Within each drainage, sites were selected using the GRTS selection tool as described above (Stevens and Olsen 2004). These sites are sampled annually with a target of 12 GRTS sites sampled in the Narraguagus and 30 sampled in the Sandy River (Table 3.2.2). The Sandy River is divided into two management reaches: the Upper Sandy River (20 sites) and the Middle Sandy River (10 sites) due to differences in management actions and geomorphic characteristics. These sites are stratified by stream width classes as follows; A = 0 to 6 meters, B = 6 to 12 m, C = 12 to 18 m and D = > 18 m. This stratification allows for better comparison of habitat types based on the assumption that cumulative drainage areas, thermal conditions etc. would be similar within width classes. Challenges posed by stream flow, fishing conditions, or weather have prevented full sampling of GRTS sites, however, over the six-year period (2017 to 2023), an average of 39 sites, 10 in the Narraguagus and 29 in the Sandy, were surveyed (Table 3.2.4).

Within the LCMS GRTS selected sites in the Sandy and Narraguagus Drainages, catch-per-unit ($100m^2$) of large parr over the period 2017 to 2023 ranged from 0.23 ± 0.27 to 7.45 ± 4.57 parr/unit (Table 3.2.4). Trends in densities over the period of 2017 to 2023 decline over time but there is much variation within drainages. Densities differed among management reaches with the Narraguagus having higher densities than the Middle Sandy River reach. The Upper Sandy reach had higher densities than the Middle Sandy River. Figure 3.2.3 illustrates that the Narraguagus and Upper Sandy River reaches have similar densities (ANOVA, $F_{(2,400)} = 11.837$, $p < 0.05$). Densities also differed among Width Classes with A class sites having higher abundances than all other Width Classes. B class sites had higher densities than D class sites, but C class sites had similar abundances to B or D class sites (ANOVA, $F_{(3,400)} = 11.804$, $p < 0.05$) (Figure 3.2.3).

During fall juvenile surveys, captured parr are measured for fork length to the nearest millimeter and weighed to nearest 0.1 gram. A total of 1,056 parr were measured across the 272 sites surveyed between 2017 and 2023 (Table 3.2.7). Comparisons of condition across sites and width classes were performed using the methods outlined in (Cone 1989) where the slope of the relationship between log length and log weight are compared to other sites. Parr captured in sites within the C or 12–18-meter width class had a higher condition than the other width classes ($p = 0.01$). Figure 3.2.5 illustrates the relative condition between width classes.

When reviewing electrofishing data collected between 2017 and 2023 in the Sandy and Narraguagus Rivers and comparing across width classes, there were higher densities in the A class or 0-to-6-meter sites but the parr had better condition in the C class or 12-to-18-meter sites. Thermal conditions or lack of predators e.g., Smallmouth Bass (*Micropterus dolomieui*) may explain greater abundances in the small order streams. But greater primary productive potential may explain larger better conditioned parr in the larger width stream reaches. These results influence 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 (Elliott and Elliott 2010) and habitat complexity play a role (Finstad et al. 2007; Johnston et al. 2004). Use of the GRTS methods in combination with the establishment of Life Cycle Monitoring Stations 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 continues to be a priority of the Maine Atlantic Salmon combined group; National Oceanic and Atmospheric Administration (NOAA), USFWS, MDMR, Penobscot Indian Nation, and Non - Government Organizations NGOs.

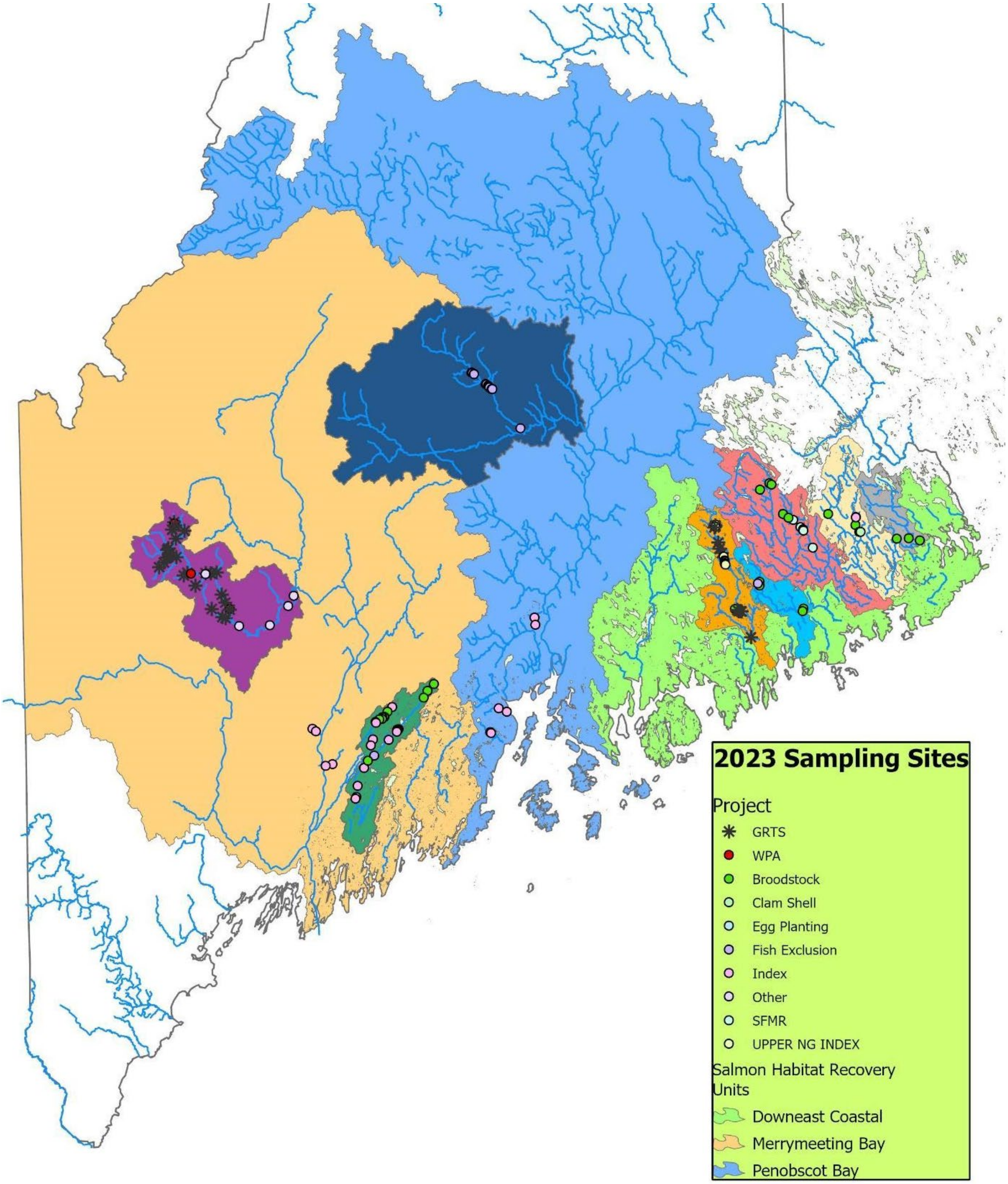

Figure 3.2.1. Location of sites (148) surveyed in 2023 for juvenile abundance and distribution estimates within the Gulf of Maine Distinct Population Segment of Atlantic salmon.

Table 3.2.4. Annual mean catch-per-unit ($100m^2$) ± 95% CI of large parr for all Lifecycle Monitoring Stations, 2017 to 2023.

LCMS	Year	n	Mean Parr/$100m^2$ ± 95CI
Narraguagus	2017	8	7.5 ± 4.6
Narraguagus	2018	12	3.6 ± 2.4
Narraguagus	2019	10	2.7 ± 1.6
Narraguagus	2020	7	3.0 ± 1.6
Narraguagus	2021	12	1.5 ± 0.9
Narraguagus	2022	12	3.5 ± 2.6
Narraguagus	2023	12	2.2 ± 2.1
Middle Sandy River	2017	13	1.8 ± 1.3
Middle Sandy River	2018	13	1.0 ± 0.7
Middle Sandy River	2019	10	0.6 ± 0.7
Middle Sandy River	2020	10	2.8 ± 2.4
Middle Sandy River	2021	10	1.2 ± 1.1
Middle Sandy River	2022	11	1.3 ± 1.2

LCMS	Year	n	Mean Parr/100m^2 ± 95CI
Middle Sandy River	2023	9	0.23 ± 0.27
Upper Sandy River	2017	14	2.4 ± 1.2
Upper Sandy River	2018	19	1.8 ± 0.8
Upper Sandy River	2019	20	3.8 ± 1.4
Upper Sandy River	2020	18	4.6 ± 1.9
Upper Sandy River	2021	20	0.7 ± 0.3
Upper Sandy River	2022	18	3.2 ± 1.6
Upper Sandy River	2023	14	1.9 ± 1.0

Table 3.2.5 Mean catch-per-unit (100m^2) ± 95% CI of large parr across width classes and Management reaches 2017 to 2023 for Life cycle Monitoring Stations in the Narraguagus and Sandy Rivers. 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.

SHRU	Reach	Width Class	N	Mean Parr/100m^2 ± 95CI
DEC	Narraguagus	A	27	5.9 ± 1.9
DEC	Narraguagus	B	27	2.5 ± 1.0
DEC	Narraguagus	C	9	0.7 ± 0.7
DEC	Narraguagus	D	10	0.5 ± 0.5
MMB	Middle Sandy River	A	9	2.7 ± 1.1
MMB	Middle Sandy River	B	28	1.1 ± 0.9
MMB	Middle Sandy River	C	12	2.0 ± 1.6
MMB	Middle Sandy River	D	27	0.8 ± 0.4
MMB	Upper Sandy River	A	9	2.88 ± 2.11
MMB	Upper Sandy River	B	56	3.0 ± 0.9
MMB	Upper Sandy River	C	18	3.2 ± 1.3
MMB	Upper Sandy River	D	40	1.8 ± 0.7

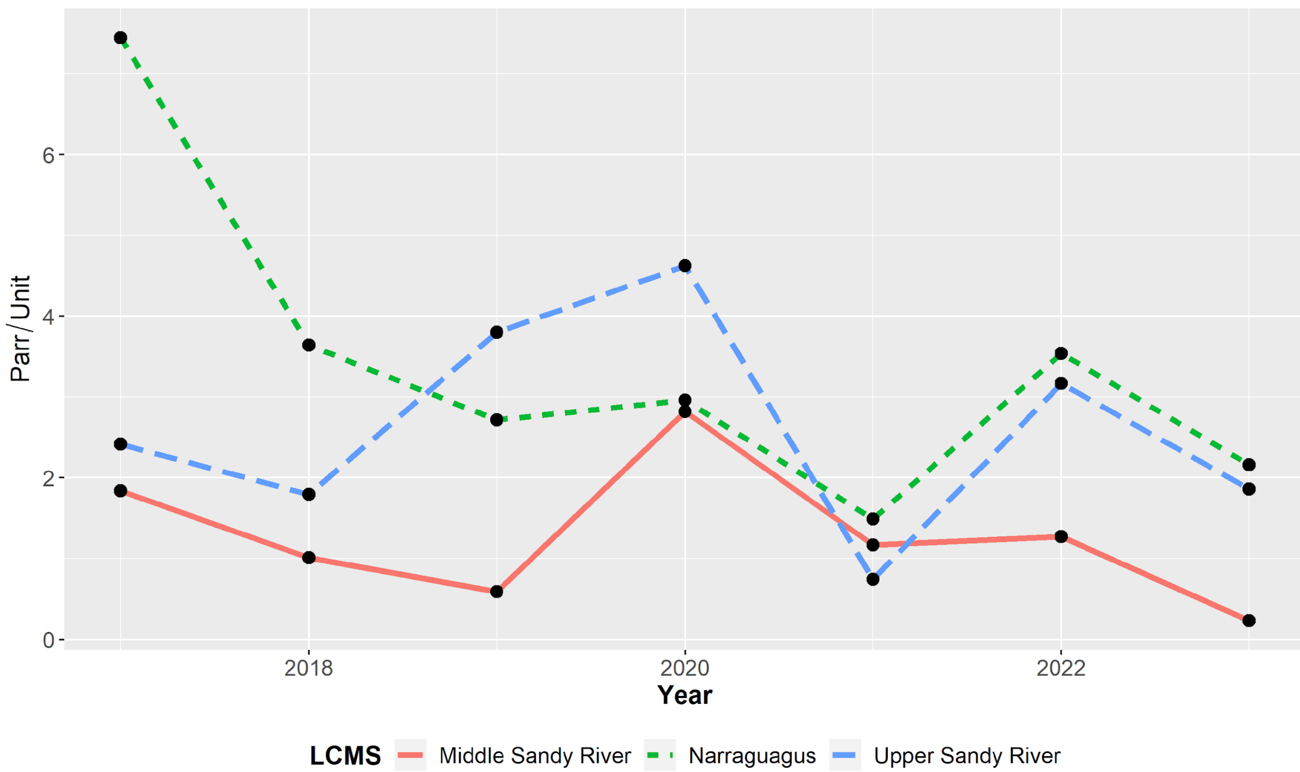

Figure 3.2.2. Trends of mean catch per unit ($100m^2$) by drainage 2017 to 2023 for Life Cycle Monitoring Station in the Sandy and Narraguagus Rivers.

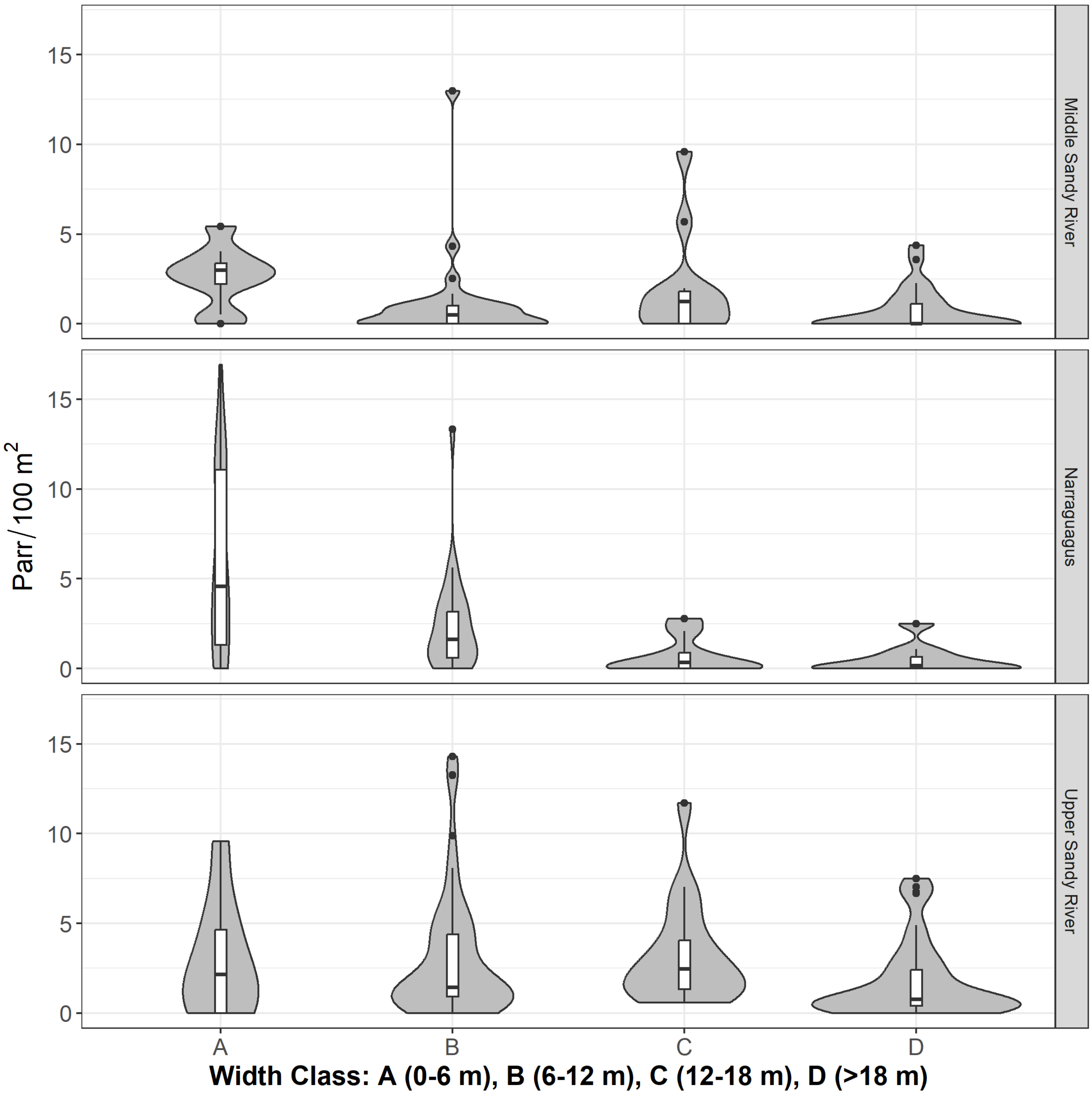

Figure 3.2.3. Violin plots showing abundance as catch per Unit ($100m^2$) for large parr (2017 to 2023) across four width classes for Life Cycle Monitoring Stations in the Sandy and Narraguagus Rivers. Width classes are as follows: A = 1 – 6 meters, B = 6 -12 meters, C = 12 – 18 meters and D = > 18 meters.

Table 3.2.7. Mean large parr fork length (mm) ± 95% CI and mean weight (g) ± 95%CI across width Classes for sites sampled from 2017 to 2023 in the Narraguagus and Sandy Rivers, ME. Width classes are as follows: A = 1 – 6 meters, B = 6 -12 meters, C = 12 – 18 meters and D ≥18 meters.

Width Category	n	Mean Fl (mm) ± 95%CI	Mean Weight (g) ± 95%CI
A	312	109 ± 2	16.5 ± 1.0
B	424	110 ± 2	16.8 ± 1.0
C	108	110 ± 3	16.9 ± 1.6
D	212	107 ± 2	15.4 ± 1.2

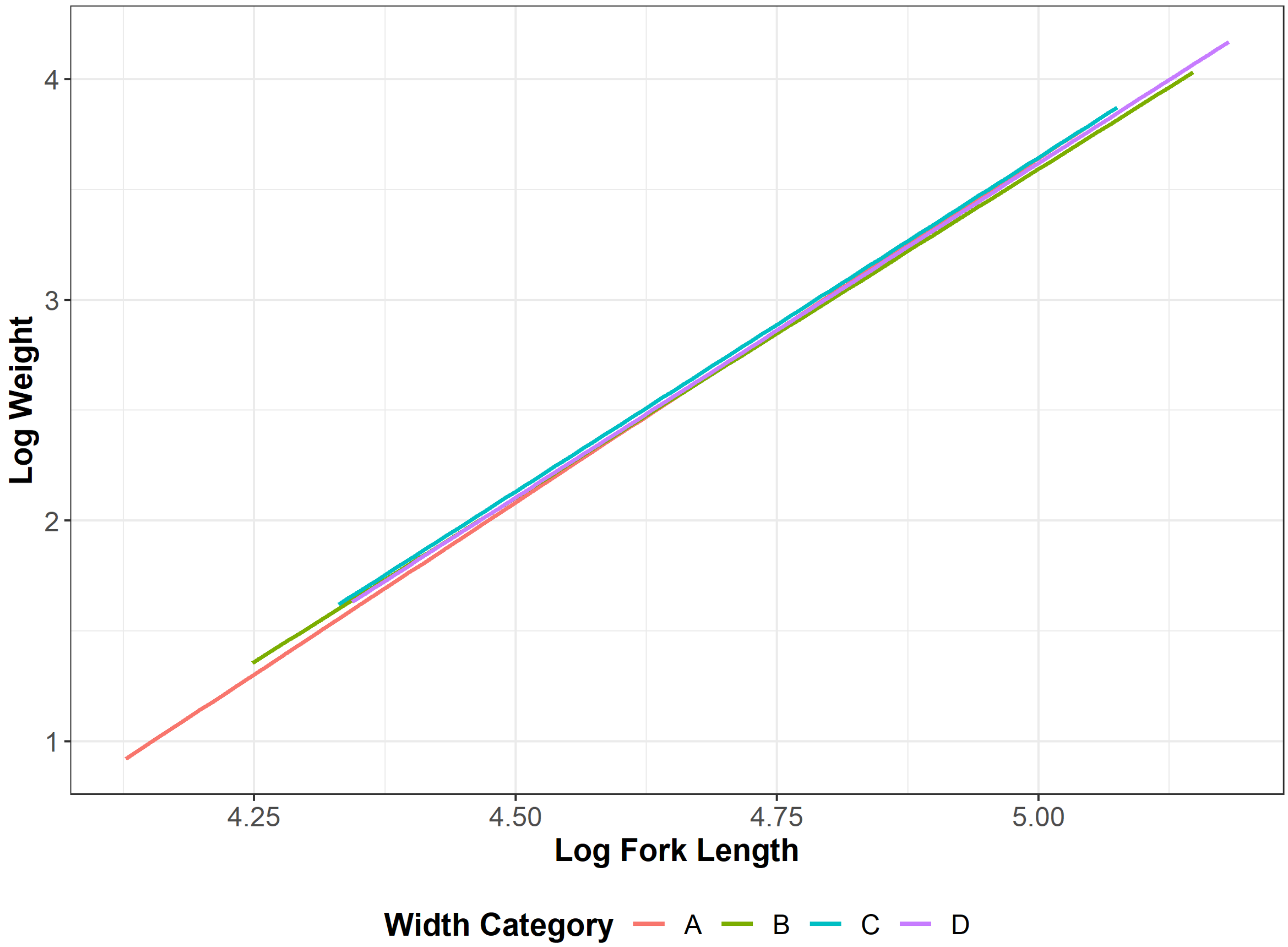

Figure 3.2.5. Plot of large parr condition across width classes determined by the relationship of log length and log weight of parr sampled from 2017 to 2023 based on methods outlined by (Cone 1989). Width classes are as follows: A = 1 – 6 meters, B = 6 -12 meters, C = 12 – 18 meters and D ≥18 meters.

Smolt Abundance

The following is a summary of smolt trapping activities that occurred in the spring of 2023. The main goal 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 (SAR) marine survival rates for cohort specific adult returns. A more detailed report on smolt population dynamics is included in Working Paper WP24-12-Smolt Update.

MDMR estimated smolt abundance using Rotary Screw Traps in two Maine rivers, the Narraguagus River (in partnership with Project SHARE) and the Sandy River. A total of 1,281 smolts were unique captures at all sites between 14 April and 1 June 2023 (Table 3.2.6).

MDMR scientists calculated population estimates using Darroch Analysis with Rank Reduction (DARR) 2.0.2 for program R (Bjorkstedt 2005; Team 2022) for each site (Figure 3.2.6 and Table 3.2.7).

Population estimates (± SE) for each river/site were based on a one-site mark-recapture design. Two sites were operated on the Narraguagus River in 2023. 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 1,421 ± 169. The naturally reared smolt population estimate was 525 ±114. The hatchery population estimate was 827 ± 86. At the Narraguagus Route 9 site total population estimate for all smolts emigrating from the upper sub-watershed was estimated at 924 ± 108. The naturally reared smolt population estimate was 462 ± 91. The hatchery population estimate was 525 ± 106. High flow conditions prevented continuous sampling on the Sandy River in 2023, therefore, no population estimate was generated. Further details on age, origin, and other data are presented in Working Paper WP24-12-Smolt Update.

Table 3.2.6 Atlantic salmon smolt trap deployments, total captures, and capture timing by origin in Maine rivers, 2023.

River	Site	Start Date	End Date	Origin	Total Capture	First Capture	Median Capture Date	Last Capture
Narraguagus	Little Falls	17-Apr	27-May	H	260	21-Apr	7-May	24-May
				W	143	23-Apr	7-May	30-May
Narraguagus	Route 9	14-Apr	26-May	H	138	18-Apr	1-May	23-May
				W	122	18-Apr	30-Apr	23-May
Sandy*	Lane Road	8-May	20-May	W	618	9-May	N/A	20-May
*Limited sampling period due to high flows								

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) in 2023, using DARR 2.0.2.

River	Site	Origin	Estimate ± Standard Error
Narraguagus	Little Falls	Hatchery	827 ± 86
Narraguagus	Little Falls	Naturally reared	525 ± 114
Narraguagus	Little Falls	Hatchery and Naturally Reared	1,421 ± 169
Narraguagus	Route 9	Hatchery	525 ± 106
Narraguagus	Route 9	Naturally reared	462 ± 91
Narraguagus	Route 9	Hatchery and Naturally Reared	924 ± 108
Sandy	Lane Road	Naturally reared	N/A

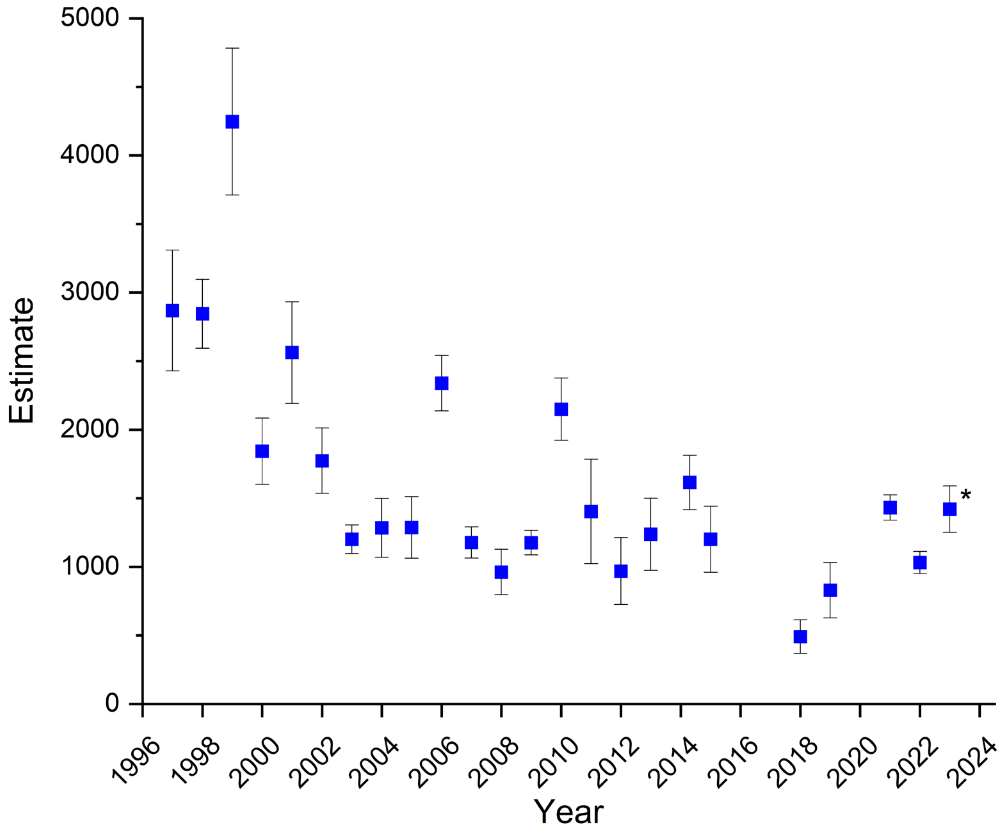

Figure 3.2.6. Population Estimates (± Std. Error) of emigrating naturally-reared smolts on the Narraguagus River (Little Falls trapping site - river km 11.16) in Maine, using DARR 2.0.2. Contributing to the migrating cohort of smolts are the product of natural spawning, egg planting and fry stocking. Asterisk (*) indicates a portion of the estimate is made up of ambient parr (stocked) smolts which were from the Peter Gray Hatchery on the East Machias River.

3.3 Fish Passage and Migratory Fish Habitat Enhancement and Conservation

Narraguagus River Temperature Monitoring

The USFWS Maine Fish and Wildlife Conservation Office (MeFWCO) has been collecting water temperature data in the Upper Narraguagus River since 2011. The monitoring site is in a high priority mapped Atlantic salmon rearing habitat at River Kilometer (RKM) 48.20 (44.84817 -68.07058). All data has been collected with Onset Inc. HOBO TidbiT V2 loggers at 30-minute intervals preset to start at the top of each hour. HOBO TidbiT V2 loggers record with ±0.2°C accuracy. The logger is checked each spring and downloaded/reset each fall. During downloads (normally late September), a data check with a reliable handheld thermometer confirmed the logger recorded within 0.2°C of the last reading. Data collected from May 2011 to September 2022, has been uploaded to the USGS Spatial Hydro Ecological Decision System (SHEDS) (Walker et al. 2020) and water temperature is provided in one continuous file that is publicly available.

Over the 10-year period of 2012-2021, mean annual water temperature varied greatly but increased from lows around 9^{o}C in 2013 and 2014 to slightly above 10^{o}C in 2021 at this site. A preliminary look at these years suggests a possible 0.3^{o}C increase. However, because of high interannual variation, further work is needed to examine this trend since thermal conditions will become increasingly challenging for salmon if they do not have access to adequate cold-water refuge. The warmest month, July, showed no obvious indication of any trend. The month of May suggests a slight decrease over the time period. Warming trends over the four seasons suggest summer months (1^{o}C /decade) have been warming faster than fall (0.2^{o}C /decade). Winter temperatures show little change and spring may have cooled by 0.2^{o}C /decade. More data is needed to determine if any significant annual water temperature trends are occurring at the standard week nominal scale. Continuation of MeFWCO staff gauge measurements at Rt. 9 (RKM 47.60) will allow future analysis to evaluate possible relationships with discharge and water temperature at RKM 48.20.

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 2023. Additional barrier removal project summaries are provided below:

Branch Pond Fishway - Branch Pond is the largest alewife pond in the West Branch of the Sheepscot River, which has significant high-quality spawning and rearing habitat for Atlantic salmon (Figure 3.3.2). The historic 1817 dam at the outlet of the pond blocked 325 acres of alewife spawning habitat and in 2014, the Maine Emergency Management Agency (MEMA) concluded that the dam was in poor condition and unable to safely pass a 100-year flood event. In 2023, partners worked together to restore passage into the pond through the installation of an Alaskan Steep pass Fishway and repaired the dam to meet MEMA safety standards and improve water level management of the pond. The suite of community benefits includes the construction of a hand-carry boat launch with a removable bollard allowing emergency services access into the pond, a new dry hydrant for the local fire departments, and new parking area. Project partners include the Atlantic Salmon Federation (ASF), Midcoast Conservancy, The Nature Conservancy (TNC), the local camp owners Branch Pond Association, Town of China, Town of Palermo, Natural Resources Conservation Service (NRCS), MDMR, NOAA Restoration Center, National Fish and Wildlife Foundation, and USFWS.

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.

Crooked Brook Flowage Fishway – In 2017, MDMR and the ASF, began working with several partners including the Town of Danforth and the local fishway advisory committee, NOAA, USFWS, Baskahegan Dam Company, NRCS, and TNC on efforts to reconnect the Baskahegan Lake and the Crooked Brook Flowage to the Mattawamkeag River. The dam (located in the Town of Danforth) blocked access into Crooked Brook Flowage and Baskahegan Lake (8,960 total surface acres) and Baskahegan Stream and its tributaries (137 stream miles) that were historically used by Atlantic salmon, alewives, blueback herring, American shad, American eel, and sea lamprey. Achieving fish passage at Crooked Brook Dam is identified as a high priority in the State of Maine's 2009 Operational Plan for the Restoration of Diadromous Fishes to the Penobscot River. Installation of the fishway at Crooked Brook Dam will contribute to lasting local, regional, and national benefits to Atlantic salmon and co-evolved diadromous species, including access to an estimated 557 units of Atlantic salmon habitat. Over time, an alewife run of 3.5 million adults produced from the Crooked Brook Flowage and Baskahegan Lake is anticipated, doubling the current run into the entire Penobscot River. Restoring this and the suite of co-evolved diadromous species is identified as a recovery action and is recognized as a primary constituent element of designated critical habitat. MDMR, ASF, and USFWS conducted extensive outreach and engagement work in the local community that ensured the project was understood and ultimately supported by residents and stakeholders. For over 4 years, project proponents met with the local fishway advisory committee and discussed a variety of issues related to fish passage design options, water flows and water levels, sea-run fish biology and ecology, and interactions with other species. Work on the new fishway (a pool and weir) began in the summer of 2023 and will be finalized in the Spring of 2024, with a goal to allow alewife and other migratory fish to again migrate up the river and enter Baskahegan Lake. Several years of monitoring upstream migrating alewives is planned to begin in the Spring of 2024.

Table 3.3.1. Aquatic Organism Passage 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 the Atlantic Salmon Federation (ASF), Maine DMR, Mid-Coast Conservancy (MCC), Natural Resource Conservation Service (NRCS), The Nature Conservancy (TNC) and Project SHARE.

Lead Partner	Watershed	Stream	Stream Miles	Kilometers
ASF/MDMR	Mattawamkeag	Crooked Brook/Baskahegan	96.5	155.3
MCC/ASF	Sheepscot	W. Branch Sheepscot	9.0	14.5
NRCS/TNC	Casco Bay – Frontal Atlantic Ocean	Dam Cove Creek	0.7	1.0
NRCS/TNC	Middle W. Branch Penobscot	Unnamed Trib to Nollesemic Lake	0.6	1.0
NRCS/TNC	Pleasant (Penobscot)	Unnamed Trib to Mooresville Brook	1.9	3.0
NRCS/TNC	Seboeis	Oak Knoll Brook	2.6	4.1
NRCS/TNC	Stillwater	Unnamed Trib to Rollins Brook	0.8	1.2
Project SHARE	Narraguagus	Narraguagus River	6.3	10.1
Project SHARE	Narraguagus	West Branch	7.0	11.2
Project SHARE	Pleasant	Colonel Brook	2.5	4.0
		Total	**127.8**	**205.4**

Figure 3.3.2. Branch Pond dam fishway, located on the West Branch Sheepscot River, prior to construction (left) and post construction (right). *Photo credit: Melissa Cote, Midcoast Conservancy.*

Figure 3.3.3. Strategic wood addition, Thirty-Five Brook, Upper Narraguagus Watershed, Maine, 2023. *Photo credit: Colby Bruchs – MDMR*

Figure 3.3.4. Aquatic Organism Passage project before (left) and after (right), Deer Lake Outlet, Upper Narraguagus Watershed, Maine, 2023. *Photo credit: Chris Federico, Project SHARE.*

Habitat Complexity and Suitability

Large Wood Additions – Project SHARE continued wood addition projects throughout the Narraguagus, Machias, and East Machias River watersheds in 2023. These actions were undertaken to restore natural processes to stream reaches that were likely changed by historic log drives that made the river over widened, shallow, simplified, and unable to reconnect with its floodplain. Wood additions are implemented to create a diversity of complex habitats for Atlantic salmon, brook trout, other native sea-run fish, as well as terrestrial species living within the riparian corridor.

Three wood addition projects were completed in support of the Upper Narraguagus Watershed Restoration Project. Approximately 167 units ($100m^2$) of rearing habitat were treated with 238 trees using strategic and self-placing methods in the mainstem and Thirty-Five Brook (Figure 3.3.3 and Table 3.3.2). Rearing habitat in two tributaries (35 units) of the Machias River and one tributary (14 units) of the East Machias River were treated with 71 and 24 trees, respectively.

Table 3.3.2. Wood additions completed by Project SHARE in Downeast Coastal rivers, Maine, 2023.

Watershed	Stream	Method	Wood Pieces	Habitat Units ($100m^2$)
East Machias	Northern Stream	Strategic	24	14
Machias Machias	Old Stream West Branch	Strategic Strategic	55 16	27 8
Narraguagus	Mainstem	Self-placing	120	39
Narraguagus	Mainstem	Strategic	54	106
Narraguagus	Thirty-Five Brook	Strategic	64	22
-		**Total**	**333**	**216**

Water Quality

The DSF, in collaboration with the Maine Department of Environmental Protection, completed a seven-year study in the East Machias River watershed investigating the efficacy of using clam shells to lime streams that have been impacted by acid rain. The following is a brief description of (Zimmerman 2023). The goal of the project was to increase macroinvertebrate abundance and diversity, and to increase juvenile salmon abundance. Clam shells were spread along the bottom and banks (to capture high flow events from rainfall and snow melt) of Richardson Brook every summer from 2019-2022 (Figure 3.3.5). Shell treatment increased the pH at the treated site by 0.5 units compared with baseline conditions, as well as remaining on average 0.4 units higher than the upstream control site. Following shell additions, the treated site was above the optimal minimum pH (6.5) for the protection of the most sensitive salmon life stages 15% of the time, compared with only 0.1% of the time pre-treatment (and never at the upstream control site). Despite the increased pH, periodic stressful conditions are still occurring in Richardson Brook, including low pH (minimum of 4.5), low calcium (minimum of 1.0 mg/L), and high exchangeable aluminum (maximum of 376 ug/l). However, maximum duration of stressful acidic events was reduced by 22 days following shell additions, indicating that shells have increased the buffering capacity at the treatment site, allowing recovery to less stressful pH levels to occur more quickly. The biggest improvement in buffering capacity occurred during summer baseflow, with higher concentrations of calcium and acid neutralization capacity at the treatment site. No significant changes to macroinvertebrate or salmon abundance were observed. Combined with other potential stressors such as warm temperatures and low dissolved oxygen during summer baseflow, the improvements to water quality from the addition of clam shells may not be sufficient to elicit measurable change in the salmon population.

Fig 3.3.5. Clam shells remaining along the stream bank one year after final treatment, Richardson Brook, Township 19 ED BPP, Maine, 2023.

3.4 Hatchery Operations

Hatchery operations described below are arranged seasonally, progressing from transfers of 2022 cohort eggs through 2023 juvenile and adult stocking, 2023 adult broodstock collection, 2023 disease sampling, 2023 juvenile broodstock collection and 2023 spawning.

Egg Transfers

Craig Brook National Fish Hatchery (CBNFH) and Green Lake National Fish Hatchery (GLNFH) transferred 2.58M eyed eggs in 2023 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. 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 2023. 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.

Originating Entity	Strain	Rearing History	Receiving Entity	Purpose	Number
CBNFH	East Machias	Captive/domestic	DSF	0+ parr production	217,000
CBNFH	Narraguagus	Captive/domestic	DSF	0+ parr production	162,000
CBNFH	Penobscot	Sea-run	GLNFH	Smolt production	952,000
CBNFH	Pleasant	Captive/domestic	DSF	Fry production	123,000
CBNFH	Sheepscot	Captive/domestic	MDMR	Natal River Egg planting	79,000
CBNFH	Sheepscot	Captive/domestic	GLNFH	0+ parr production	18,000
CBNFH	Sheepscot	Captive/domestic	FF	Education	1,000
CBNFH	Penobscot	Sea-run	FF	Education	3,000
CBNFH	Dennys	Captive/domestic	FF	Education	<1,000
GLNFH	Penobscot	Captive/domestic	MDMR	Natal River Egg planting	360,000
GLNFH	Penobscot	Captive/domestic	MDMR	Non-natal River Egg planting	654,000
GLNFH	Penobscot	Captive/domestic	FF	Education	11,600

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 3.3M juveniles (eyed eggs, fry, parr, and smolts) throughout the GOM DPS (Table 3.4.2). Stocking operations are a collaborative effort between MDMR and hatchery management.

As noted in the summary of egg transfer activities, efforts are made to ensure equal distribution of genetic families in all juvenile life stages released in the GOM DPS. Particular attention is paid to providing groups of juvenile Atlantic salmon comprised of as many families as feasible for release 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 ensure 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 2023. 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, 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.

Originating Entity	Receiving Drainage or Entity	Strain	Action	Parr	Smolt	Eyed Egg	Fry
FF	Androscoggin River	Penobscot	Release	0	0	0	6,000
GLNFH	BWWTP	Penobscot	Transfer	8	0	0	0
CBNFH	Dennys River	Dennys	Release	0	0	0	204,000
DSF/CBNFH	East Machias River	East Machias	Release	0	0	0	17,000
NNFH/GLNFH/FF	Kennebec River	Penobscot	Release	0	99,000	654,000	3,000
CBNFH	Machias River	Machias	Release	0	0	0	212,000
DSF/CBNFH	Narraguagus River	Narraguagus	Release	0	0	0	16,000
GLNFH	NNFH	Penobscot	Transfer	90,000	0	0	0
GLNFH/CBNFH/FF/UMO	Penobscot River	Penobscot	Release	40,000	643,000	360,000	777,000

Originating Entity	Receiving Drainage or Entity	Strain	Action	Parr	Smolt	Eyed Egg	Fry
DSF/CBNFH	Pleasant River	Pleasant	Release	0	0	0	109,000
GLNFH/CBNFH/FF	Sheepscot River	Sheepscot	Release	16,000	0	79,000	70,000
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, which represent each family created during spawning at CBNFH for smolt production. To create a domestic broodstock cohort, 960 age-0+ parr are randomly selected from one outside rearing pool. Each pool of parr represents a mix of each family of eggs created during the previous spawn year. Sixty fish are lethally sampled for fish health monitoring.

Nine-hundred age-one future broodstock are reared annually at GLNFH and the need to spawn broodstock at a sex ratio of 1:1. Broodstock are spawned at ages 3 and 4.

Future broodstock are tagged in December of their second year with PIT tags and a fin clip is collected for genetic analysis. Following tagging, future broodstock are transferred from 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.

The highest number of fish transported in a single day during 2023 was 54. In 2023, broodstock collections were initiated on May 14th, comprising 32 individual trips to the trap, and concluded on June 27 with 754 adults collected and transported to CBNFH. Of these CBNFH captive fish: 234 were returned to the river as 'pre-spawn releases'; nine tested positive to Infectious Salmonid Anemia virus (non-pathogenic) and released back to the river; four were pre-spawn mortalities; three were post-spawn mortalities; 432 were released, post-spawn, by CBNFH; 62 were released, post-spawn by University of Maine; and 10 were tank mortalities during transportation.

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

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 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 (Calado et al. 2021; Todd et al. 2012), sea-lice infestation (Susdorf et al. 2018) or potential genetic factors (Bacon et al. 2009). Despite a marked improvement in condition factor of Penobscot sea-run broodstock observed in 2022, the condition factor of the 2023 cohort fell back into line with the previously noted declining trend.

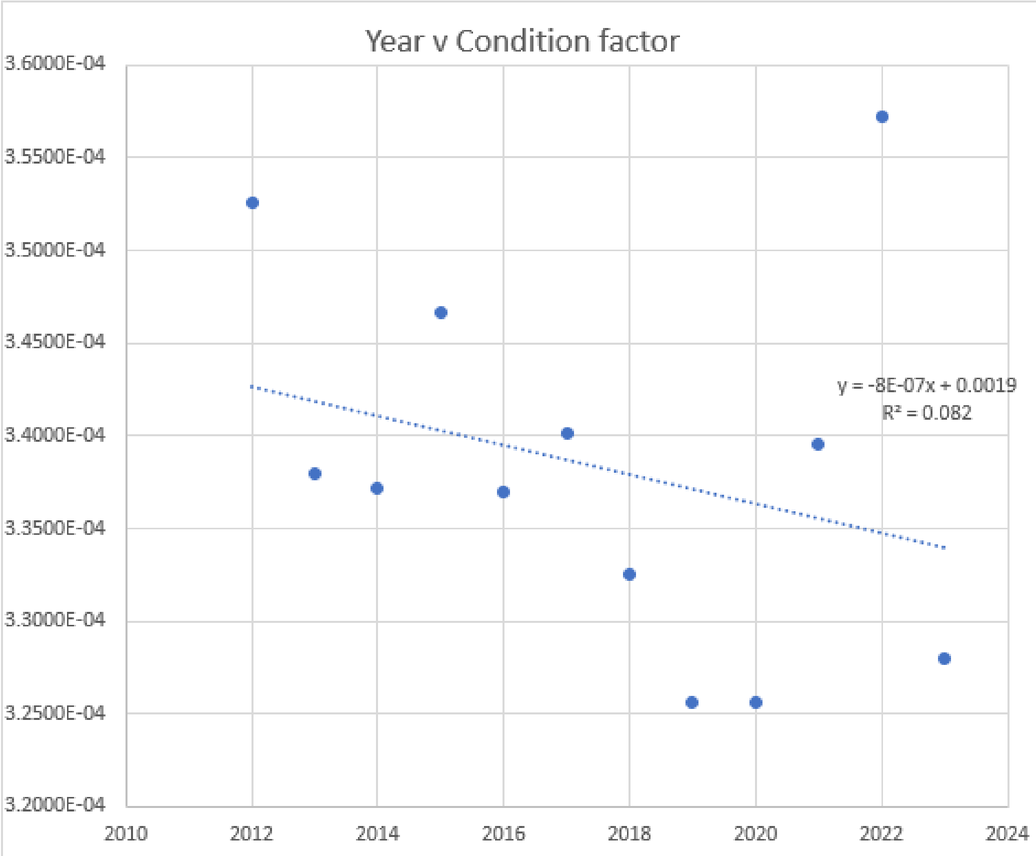

Figure 3.4.1. Condition factor of Penobscot River sea-run broodstock (Atlantic salmon) sampled at Craig Brook National Fish Hatchery from 2012 through 2023.

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 section]. 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 screening. Blood samples are analyzed using Polymerase Chain Reaction (PCR) testing at the USFWS Lamar Fish Health Center (LFHC). Adults that do not test position to ISA are accepted into HPR 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 fish. 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, USFWS, LFHC, personal communication). The aim of releasing the affected individual is to avoid breeding it in a hatchery setting.

In 2023, nine individuals were diagnosed, via PCR, for HPRO and 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 to the USFWS's 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 2023.

Infectious Pancreatic Necrosis Virus at the Peter Gray Hatchery during the 2023 rearing season.

Infectious Pancreatic Necrosis Virus (IPNV) was detected during a routine health screening of Atlantic salmon 0+ parr held at the Peter Gray Hatchery (PGH), operated by the DSF in East Machias, ME. In August 2023 a 60-fish sample from each strain (East Machias and Narraguagus) to the Maine State Fish Health Laboratory in Augusta, Maine. IPNV was detected and samples were shared with Kennebec River Biosciences for confirmation and strain identification. The virus was likely introduced to the hatchery through the influent, which draws raw water directly from the East Machias River.

The decision to depopulate the hatchery was made following deliberation by federal and state agencies. The entire cohorts of the Narraguagus and East Machias strain 0+ parr, totaling 154,000 Atlantic salmon parr, were euthanized using a 15-minute MS-222 bath. The parr were then frozen and buried in a gravel pit off site on private property, away from any waterways, deep enough to discourage scavengers but shallow enough to allow for a quick decomposition.

Once the hatchery was depopulated the facility underwent a deep cleaning process. The entire facility, including influent and effluent areas, was disinfected with a bleach solution. The hatchery was then left fallow to completely dry. To mitigate future incidents DSF sourced whole hatchery filtration and ultraviolet irradiation technology to be installed in January 2024.

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 were set at 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 protocol, rearing space at the facility and biomass considerations.

In 2023, parr collection targets were increased to 250 for each population (up to 1,500 cohort total). This action was undertaken to attempt to reduce biomass from older year classes of adult brood as a strategy to reduce total phosphorus discharge. See Spawning section for additional details.

Table 3.4.3. Captive broodstock parr collection targets by population and year. Note: ± was allowed variance around collections between 2018 and 2022.

Population	**<2006**	**2008-2017**	**2018-2022**	**2023**
Dennys	150	200	200 ± 15	250
East Machias	150	200	200 ± 15	250
Machias	250	300	200 ± 15	250
Narraguagus	250	300	200 ± 15	250
Pleasant	100	200	200 ± 15	250
Sheepscot	150	200	200 ± 15	250

Table 3.4.4. Average number of captive broodstock, per age class, at Craig Brook National Fish Hatchery in 2023.

Age-1+ Parr	**Pre-broodstock Age-2**	**Broodstock Age-3**	**Broodstock Age-4**	**Broodstock Age-5**
1,500	1,275	1,250	940	480

The annual average size of each of the six captive broodstock populations in 2023 was 650 individuals, representing five-year classes. As fish mature and spawn, they are released back to their natal river, so each year class is diminished in numbers until the cohort is released at age-five (Table 3.4.4.). The number of age five and four broodstock was reduced in 2023 to manage total phosphorus discharge. See Adult Stocking section.

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 1,277 age 1+ parr collected in 2022, 1,223 were tagged as age-2 future broodstock and will be genotyped prior to their first spawn in 2024.

In 2023, parr collections totaled 1,402 from the six populations; each population had a minimum of 232 parr collected but some were unable to achieve the 250 targets.

General Disease Prevention and Monitoring

CBNFH and 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 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, ovarian fluid, and lethal whole-body samples collected from each juvenile lot (60 each) prior to stocking.

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 2023 except the nine ISA diagnoses discussed above.

Spawning Activities and Egg Production

Spawning Activities

Totals of 252 Penobscot sea-run origin females, 563 captive females, and 482 Penobscot-origin domestic females were spawned at CBNFH and GLNFH in November and December 2023 to provide eggs forplanting, fry, parr and smolt production, domestic broodstock and educational programs. Spawning protocols for Atlantic salmon broodstock at CBNFH and GLNFH prioritize first time spawners and uses 1:1 paired crosses.

CBNFH and GLNFH experienced a delay, similar to that experienced in 2022, in the onset of spawning [see Photoperiod Manipulation] that was not related to changes in photoperiod treatments. Spawning of Penobscot Atlantic salmon sea-run broodstock was delayed by a full week and domestic broodstock at GLNFH was delayed nearly two-weeks. The mechanism of delay is currently unknown but thought to be environmental.

Cryopreservation Activities

Cryopreservation is a process in which a living cell can be frozen, stored, thawed, and remain viable for future growth. The cryopreservation lab at the USFWS' Warm Springs Fish Technology Center (WSFTC) in Georgia focuses on developing and implementing cryopreservation techniques to secure the remaining genetic diversity of endangered species, reduce issues caused by non-coincident mating, improve control in artificial spawning programs, and transfer wild genetics into hatchery stocks. Cryopreserved sperm can also assist reproductive efforts by allowing spawning to take place whenever females are ready. For vulnerable species with limited populations, this reduces the need to hold males for long periods of time and can increase the flexibility and genetic diversity in future generations (https://www.fws.gov/project/cryopreservation-lab).

CBNFH is exploring the option of cryopreservation to potentially lower the amount of total phosphorus discharged into Alamoosook Lake. Using cryopreservation may lower the amount of biomass needed to successfully spawn in any given year resulting in less food being fed and lowering the amount of total phosphorus. In addition, it may allow CBNFH to create more diverse families by having milt from different generations readily available. This process has the possibility of improving eye up by ensuring sterile milt is not being used. Cryopreservation techniques are widely used in the aquaculture industry (Yang et al. 2018).

To collect samples, only gravid males, those freely expressing milt, were used. For captives [Dennys and Narraguagus] age-five broodstock were used. For sea-runs only 2SW males were used. If milt could not be easily expressed another male was selected. The urogenital opening was patted dry with a clean paper towel to avoid any water entering the sample. The initial portion of milt was expressed into the tank to avoid collecting either urine or feces. The milt was collected into a 50 mL test tube and placed on wet ice to help extend the life of the milt. A 1mL sample of milt was pipetted to a second 50 mL test tube containing Storfish ® extender. Oxygen was added by injecting it into the tube, using a low pressure, being careful not to touch the sample. Both the undiluted and diluted samples were either refrigerated or on wet ice until they were shipped, it was important the samples were not frozen.

Upon receiving milt samples, motility of diluted [with Storfish ® extender] and undiluted samples were checked at WSFTC (Figure 3.4.2). Diluted samples were drawn into 0.5 mL straws and either Methanol (MeOH) or Dimethyl sulfoxide (DMSO) were added at different concentrations (Agarwal 2011), as cryoprotectants. The straws were frozen in liquid nitrogen for 24 hours and then thawed, in different thicknesses of polystyrene platforms. Motility was re-checked post-thaw to determine survivability of the milt through the process. Varying thaw times were also investigated.

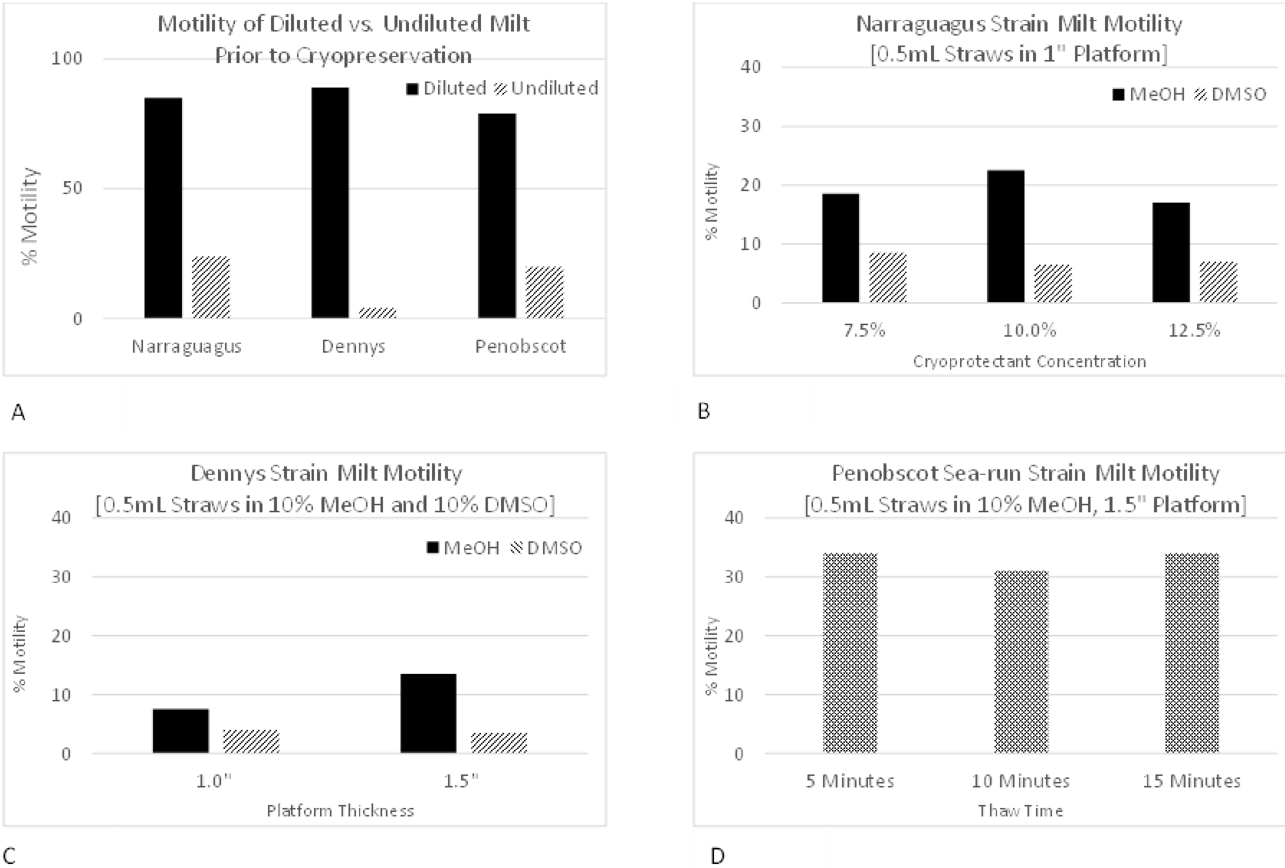

Figure 3.4.2. Percent motility of Atlantic salmon sperm: (A) diluted with Storfish ® or undiluted, (B) following cryopreservation in 0.5mL straws using cryoprotectants methanol (Me0H) and Dimethyl sulfoxide (DMSO) at different concentrations, (C) thawing straws with 10% MeOH and 10% DMSO on 1" and 1.5" Styrofoam platforms, and (D) motility over varying thaw times. Note the higher overall motility of Penobscot sea-run milt (D) as compared with milt collected from captive broodstock (B, Narraguagus and C, Dennys).

Different methods of protecting, storing and thawing milt samples was the focus in 2023 as cryopreservation is not widely performed either for conservation purposes or at the WSFTC. Using these results, refined protocols will be developed for the 2024 season as well as a small trial using the cryopreserved milt.

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 3.4.3) 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 and domestic broodstock that was not associated with changes in the photoperiod treatment.

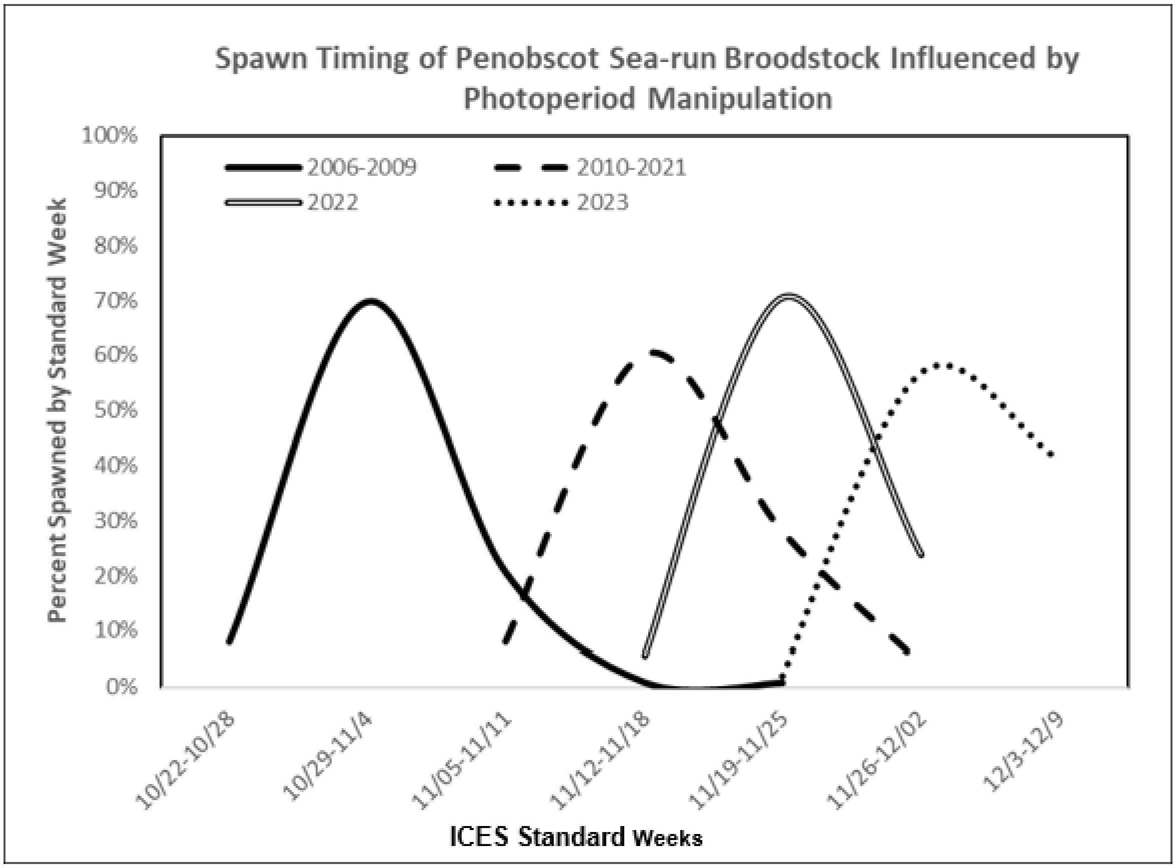

Figure 3.4.3. Spawn timing of Penobscot sea-run broodstock (2006 – 2023). Photoperiod manipulation at Craig Brook National Fish Hatchery began in 2010.

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 broodstock by 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. The effect of photoperiod manipulation on the spawn timing of captive broodstock is demonstrated in Figure 3.4.4.

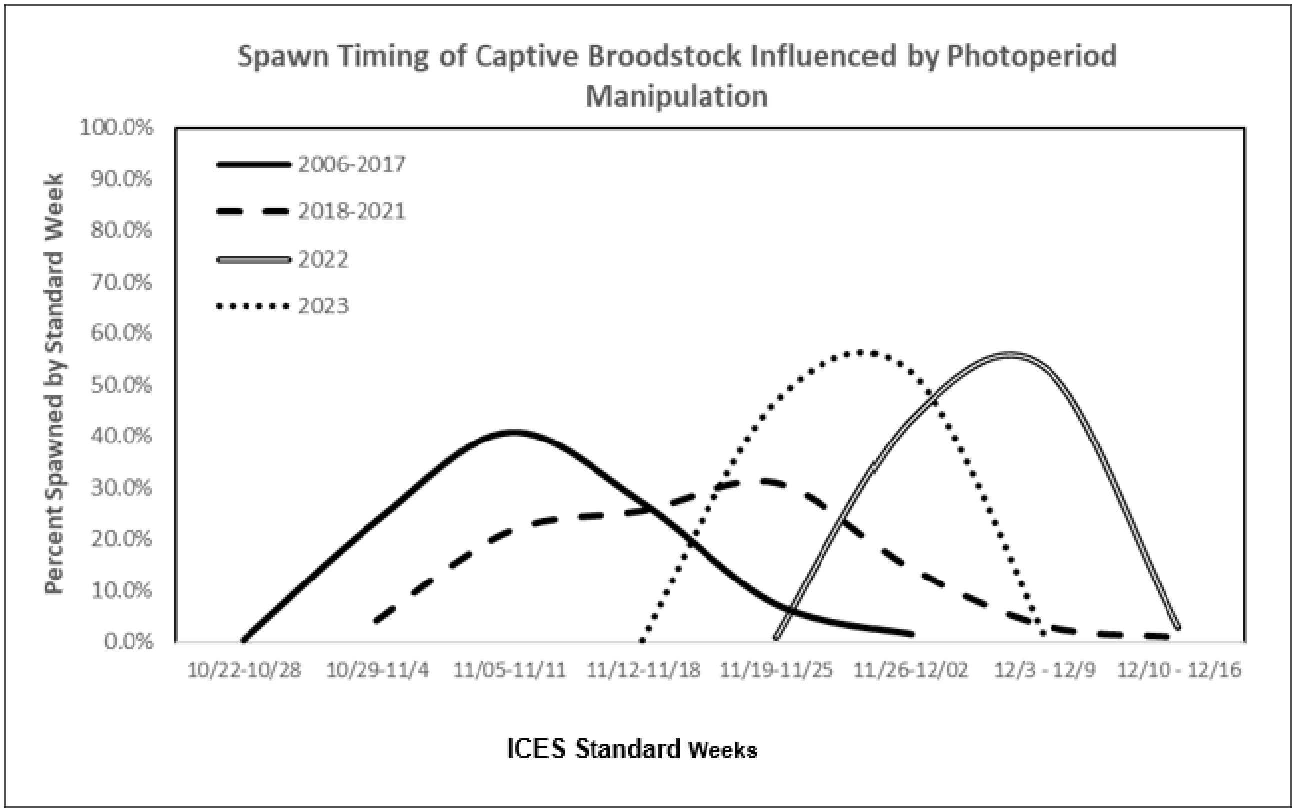

Figure 3.4.4. Spawn timing of captive brood at Craig Brook National Fish Hatchery, 2006 – 2023. Photoperiod manipulation at Craig Brook National Fish Hatchery began in 2018 and was used on two captive populations in 2018 and 2019, all populations in 2020-2023.

CBNFH will be considering continued use of photoperiod manipulation on sea-run broodstock during 2024 given the trend of delayed spawning experienced in 2022 and 2023.

In 2023, CBNFH began instituting a change in spawning procedures that will rely solely on first-time spawners and only age-3 and age-4 broodstock in effort to reduce total phosphorus discharge at the facility (Table 3.4.5.). In 2023, any age-5 adult that had spawned previously was released pre-spawn and only first-time age-5 adults were spawned. No age-3 broodstock were retained, as has been past practice, as insurance against anticipated poor future egg takes. These changes will reduce total egg production since CBNFH will no longer be spawning the higher fecund age-5 females. CBNFH increased parr collections for the captive broodstock program from 200 ± 15 to 250 per river strain in 2023 (Table 3.4.3.) to offset the decrease in egg production. The increase in captive broodstock is not expected to replace all of the lost production. The change is expected to increase the effective population size of the hatchery population.

Table 3.4.5. Broodstock inventory, family groups, anticipated egg production and anticipated phosphorus discharge using average maturation, fecundity, egg survival and phosphorus removal. Each capture year is represented by a color: 2023, orange; 2022, yellow; 2021, green; 2020, white; 2019, grey; etc.

	2023		2024		2025		2026 - onward	
	Status Quo		Transition Year		Transition Year		Anticipated Result	
Age	Brood No.	Families	Brood No.	Families	Brood No.	Families	Brood No.	Families
1	1500	0	1500	0	1500	0	1500	0
2	1229	0	1455	0	1455	0	1455	0
3	1169	351	1217	364	1440	432	1440	432
4	926	186	819	163	615	123	672	138
5	541	64						
Est Phosphorus	127		98		90		98	
Est Green Eggs	2,358,900		1,866,250		1,880,250		1,951,500	

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 by 2027 GLNFH will also begin optimizing pairing between age-three females and age-four males.

Egg Production

Sea-run, captive and domestic broodstock spawned in 2023 at CBNFH and GLNFH produced 5.07M green eggs for the Maine program: 1.5M eggs from Penobscot sea-run broodstock; 1,26M eggs from domestic broodstock; 2.3M 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 2023 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**	**Green Egg**	**Fecundity**
Dennys	Captive	69	283,000	4,101
East Machias	Captive	119	454,000	3,815
Machias	Captive	81	335,000	4,135
Narraguagus	Captive	113	539,000	4,770
Penobscot	Sea Run	252	1,503,000	5,954
Penobscot	Domestic	482	1,264,000	2,622
Sheepscot	Captive	88	289,000	3,284
Pleasant	Captive	93	405,000	4,355
	Totals	**1,297**	**5,072,000**	

Adult Stocking

A total of 4,120 adults was stocked into GOM drainages (Table 3.4.6). The Salmon for Maine's Rivers program (SFMR) released 297 Machias adults and 1,277 Penobscot adults into their natal rivers pre-spawn. Two salmon released into the Penobscot River were subsequently caught and killed by anglers, resulting in an escapement of 1,275 captive reared salmon from the SFMR. CBNFH pre-spawn releases included: 234 Penobscot sea-run adults (West Branch Piscataquis River) and 9 adults that tested positive to non-pathogenic ISA (see *Infectious Salmonid Anemia Monitoring)*. A total of 494 Penobscot sea-run adults was released post-spawn, 62 of which were tagged with acoustic transmitters by the University of Maine for research purposes.

Traditionally, CBNFH annually releases spent age-three, spent age-four captive broodstock, and the entire age-five year class. A small cohort of age-three spent broodstock has been typically retained to spawn in future years as needed. In 2023, in effort to control the discharge of total phosphorus via biomass reduction, CBNFH pre-spawn released 130 age-four and age-five captive broodstock that had previously spawned. Additionally, CBNFH released all spent age three and the entire age-four year class following spawning (Table 3.4.6). This action will eliminate age-five broodstock moving into the future.

GLNFH releases some spent age-three broodstock and the entire age-four year class following spawning. All Penobscot sea-run broodstock are released post-spawning.

Spent broodstock are typically released to the rivers-of-origin within a week or two following spawning. All released 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. Due to poor weather and river conditions CBNFH was unable to release spent captive broodstock from the Pleasant, East Machias, and Machias rivers. These broodstock will be released in the spring of 2024.

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 2023.

Originating Entity	Receiving Drainage	Strain	Pre/Post Spawn	Lot	Number Stocked
CBNFH	Dennys	Dennys	Pre-Spawn	Captive/Domestic	17
CBNFH	Dennys	Dennys	Post-Spawn	Captive/Domestic	179
CBNFH	East Machias	East Machias	Pre-Spawn	Captive/Domestic	23
CBNFH	Machias	Machias	Pre-Spawn	Captive/Domestic	25
CBNFH	Narraguagus	Narraguagus	Post-Spawn	Captive/Domestic	318
CBNFH	Penobscot	Penobscot	Pre-Spawn	Sea-run	243
CBNFH	Penobscot	Penobscot	Post-Spawn	Sea-run	432
CBNFH	Pleasant	Pleasant	Pre-Spawn	Captive/Domestic	41

Originating Entity	Receiving Drainage	Strain	Pre/Post Spawn	Lot	Number Stocked
CBNFH	Sheepscot	Sheepscot	Pre-Spawn	Captive/Domestic	24
CBNFH	Sheepscot	Sheepscot	Post-Spawn	Captive/Domestic	321
GLNFH	Penobscot	Penobscot	Post-Spawn	Captive/Domestic	854
SFMR	Machias	Machias	Pre-Spawn	Captive/Domestic	300
SFMR	Penobscot	Penobscot	Pre-Spawn	Captive/Domestic	1,281
UMO	East Branch Penobscot	Penobscot	Post-Spawn	Sea-run	62

3.5 General Program Information

GOM DPS Recovery Plan

The Recovery Plan for the Gulf of Maine Distinct Population Segment of Atlantic Salmon was completed in 2019. Work plans designed to support the recovery plan were developed by the Collaborative Management Strategy SHRU coordinating committees and approved in 2023. These plans reference key actions for each SHRU that will help increase connectivity, habitat function, and stock enhancement.

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End of Chapter 3

4 Non-Gulf of Maine Distinct Population Segments

This part of the document was re-organized for the 2022 report. It now reports on the activities of the Recovery Plan for the Gulf of Maine Distinct Population Segment (DPS), which are found in section 3, and the activities related to Atlantic salmon in the other three DPSs identified in the U.S., which are found in this section.

Long Island Sound DPS

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

4.1 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 Adult Returns

No sea-run Atlantic salmon adults were observed returning to the Connecticut River watershed. Salmon fry were previously stocked into the Farmington and Salmon rivers and during the past few years, small numbers have returned to those streams. However, the Rainbow Dam Fishway on the Farmington River was not operated in 2023 due to its poor physical condition and if salmon returned to the river, there was no way to observe and document them. The Leesville Dam Fishway on the Salmon River was operated but with no trap or video system, the only way to observe returning salmon is by snorkeling below the dam or receive angler reports. No such reports were received in 2023. This does not mean that no salmon returned to the watershed, but that none were documented.

4.1.2 Hatchery Operations

A total of 742,451 green eggs was produced (2022= 656,295). Only the Kensington State Fish Hatchery (KSFH) in CT maintained domestic broodstock. Contributing broodstock included 126 females and 126 males. Both males and females were a mix of 3+ and 4+ year old fish. All fish were spawned twice. During the first spawn each female was crossed with four separate males, followed several days later with a single second spawn cross (1 female x 1 male). Those eggs will be used for fry stocking for the Connecticut Legacy Program including the Salmon-in-Schools program.

4.1.3 Stocking

4.1.3.1 Juvenile Atlantic Salmon Releases

A total of 334,738 juvenile Atlantic salmon was stocked into the Connecticut River watershed, all in Connecticut (2022= 304,335). Selected stream reaches in the Farmington River were stocked with fed fry (N= 194,978) and selected reaches in the Salmon River were stocked with both fed (N= 45,404) and unfed (N= 94,356) fry. All fed fry were produced at the 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. An additional 300 smolts were stocked into the Salmon River, not as a part of a deliberate smolt stocking program but as a means to reduce fish density at the KSFH.

4.1.3.2 Surplus Adult Salmon Releases

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

4.1.4 Juvenile Population Status

4.1.4.1 Smolt Monitoring

No videography monitoring of the smolt migration at the viewing window at the Rainbow Dam Fishway (Farmington River) occurred in 2023 due to staff shortages. A new hydro project was developed at the upstream Upper Collinsville Dam and the FERC license required construction and operation of upstream and downstream passage, documented by videography. Such monitoring documented the downstream passage of 43 smolts in the Denil fishway. The unmonitored downstream fish passage facility covers 98% of the river flow compared to the 2% passed by the Denil. If smolt passage was commensurate with the volume of passed water, the total smolt run could be estimated at 2,205.

4.1.4.2 Index Station Electrofishing Surveys

No electrofishing surveys of juvenile salmon populations were conducted in 2023.

4.1.5 Fish Passage

4.1.5.1 Hydropower Relicensing

Similar to the past several years, State and federal resource agencies continued to spend considerable time on FERC-related processes for the relicensing of four mainstem dams and one pumped storage facility. Some agreements relevant to relicensing have been agreed while others remain under discussion. Since no salmon are stocked upstream of the Holyoke Dam, such agreements have little relevance to Atlantic salmon.

4.1.5.2 Fish Passage Monitoring

Salmonsoft® computer software was again used with lighting and video cameras to monitor passage at Turners Falls, Vernon, Bellows Falls, Wilder, Rainbow, Upper Collinsville 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 no adult salmon were observed. Smolts were observed passing the Upper Collinsville Dam (see 3.1.4.1).

4.1.5.3 New Fishways

The recently completed Upper Collinsville Dam Fishway on the Farmington River in the town of Canton, CT was reported last year but 2023 was its first operational season. No adult salmon were passed due to the presence of the Lower Collinsville Dam, a barrier planned for removal, and the closure of the Rainbow Dam Fishway. Many resident species of fish ascended this fishway and it will be ready to pass anadromous fish as soon as the two lower obstacles are addressed.

4.1.5.4 Dam Removals

None to report.

4.1.5.4 Culvert Fish Passage Projects

None to report.

4.1.6 Genetics

The genetics program previously developed for the Connecticut River program has been terminated. Best accepted broodstock management practices are attempted at the KSFH.

4.1.7 General Program Information

The use of salmon egg incubators in schools as a tool to teach about salmon continued in Connecticut. The Connecticut River Salmon Association, in cooperation with CTDEEP, maintained its Salmon-in-Schools program, providing 18,623 eggs for 65 tanks in 46 schools in Connecticut.

The Connecticut River Atlantic Salmon Commission (CRASC) was formed through an act of Congress in 1983 to continue the work of anadromous fish restoration that had begun with a different governing framework in 1967. The interstate effort to restore Atlantic salmon to the basin ended in 2012 but the work to rebuild the runs of other diadromous species continues. The CRASC was up for reauthorization in 2023 but instead the State and federal partners chose to sunset the organization and reconvene the efforts under a newly created organization called the Connecticut River Migratory Fish Cooperative (CRMFC). The partners, organizational structure, and activities will remain very similar to those of CRASC but without any salmon-related activities. The Legacy Program which stocks salmon fry in a few areas in Connecticut is strictly a State of Connecticut program and not under the CRMFC.

4.1.8 Migratory Fish Habitat Enhancement and Conservation

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

4.2 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. 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.

4.2.1 Adult Returns

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

4.2.2 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.

4.2.3 Stocking

A total of 5,200 fry were stocked into the watershed by participating schools in the Salmon-in-the-Classroom program.

4.2.4 Juvenile Population Status

There is no report of any electrofishing surveying being conducted in 2023.

4.2.5 Fish Passage

No additional work in 2023.

4.2.6 Genetics

No genetics program relative to the broodstock program was reported.

4.2.7 Migratory Fish Habitat Enhancement and Conservation

No special fishway or dam removal projects were reported.

4.2.8 General Program Information

The Salmon in the Classroom program supported 31 schools participating in the 2022-23 season, totaling 35 tanks (2022= 33).

The USASAC noted that this watershed has not reported any sea-return adults or significant stockings of juvenile salmon in many years. In addition, all eggs in this program are taken from adults of landlocked salmon not sea-run origin and are produced exclusively for the school program. Therefore, the decision was made to drop this program from the standard New England database and reporting process. This would follow the treatment of other rivers such as the Cocheco and Salmon Falls rivers that previously had salmon programs that were terminated. If an adult salmon is observed in the Pawcatuck River in the future, it will be reported under an "Other Rivers" category but the Pawcatuck River line in the standing annual database will be discontinued.

4.3 Central New England DPS

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

4.3.1 Merrimack River

The salmon restoration program for this watershed ended in 2013.

4.3.1.1 Adult Returns

Fourteen Atlantic salmon adults were observed returning to the Merrimack River and were lifted at the Essex Dam fish lift. The fish were not handled by biologists but lifted by power company staff. Many were only observed from the lift videography system. The following demographic data are estimates based upon prorating the observations with scale reading data obtained from adult returns to the Kennebec River.

Table 4.3.1.1. Estimates of age and origin breakdown of returning Adult Atlantic salmon to the Merrimack River at the Essex Dam fish lift.

Hatchery	Hatchery	Hatchery	Hatchery	Naturally Reared
1SW	2SW	3SW	Repeat	2SW
2	7	1	0	4

4.3.1.2 Hatchery Operations

There were no hatchery activities supporting salmon management in the Merrimack River watershed.

4.3.1.3 Juvenile Atlantic salmon releases

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

4.3.1.4 Juvenile Population Monitoring

None was conducted.

4.3.1.5 Fish Passage developments relevant to Atlantic salmon

There are no such developments to report.

4.3.1.6 Educational activities

None reported.

4.3.2 Saco River

4.3.2.1 Adult returns

Brookfield Renewable Energy Partners operated three fish passage-monitoring facilities on the Saco River. The Cataract fish lift, located on the East Channel in Saco was operated until July 17 and shut down for repairs. The Cataract Denil fishway located on the West Channel in Saco and Biddeford, operated from 1 May to 29 October 2023 and the Skelton fish lift was operated from 1 May to 29 October 2023. Four Atlantic salmon were documented in the Saco River in 2023. However, the count could exceed this due to the possibility of adults ascending Cataract without passing through one of the counting facilities.

Pro-ration of data for Saco returns to Cataract Fishways

On the mainstem Saco River, adult Atlantic salmon are typically counted at one of two of the first dams encountered on either side of an island: East Cataract fishlift or the West Channel fishway. Atlantic salmon are not handled at the East Channel fishway, but viewed through a window; therefore, fork lengths are estimated and no scales are taken. Fish passage in the West Channel Denil is volitional. The facility is only checked daily for debris, so it is unlikely that Atlantic salmon are viewed at this facility. Skelton dam fishlift, located approximately 20 river km upstream is where Atlantic salmon are typically biologically sampled. Typically, when sampling fish, 8-10 scales are taken as part of the standard biological sampling. One Atlantic salmon was viewed at the East Channel of Cataract; estimated being 71 cm (prorated as 2SW) (Table 4.3.2.1). Four 2SW Atlantic salmon were caught at Skelton, biologically sampled, and were determined to be W2:2 (wild, 2 freshwater years, 2 sea-winter years). One of these fish could have been viewed at East Cataract prior to reaching Skelton. Therefore, a minimum of four 2SW returned to the Saco River. The 2SW that was viewed at East Cataract after the second 2SW arrived at Skelton was prorated also as a W2:2, based on in season captures at Skelton. The Atlantic salmon captured at Skelton on 7/2 has similar metrics – fork length, fin scores are the fish viewed at the East Channel Cataract on 6/16, so they are likely the same fish. Therefore, the salmon captured on 6/16 was prorated for sex as a female based on this assumption.

Table 4.3.2.1. Corresponding fishway, date, sex, fork length, dorsal score, sea-winter age, freshwater age data for all documented adult salmon on the mainstem Saco River. The Atlantic salmon captured on June 16 at the East Channel Cataract is likely the same capture at Skelton. PR = prorated.*Likely recaptured at Skelton.

Fishway	Date of Capture	Sex	Fork Length (cm)	Dorsal Score	FW age	SW age	Prorated Origin	Prorated FW age
Skelton	1-Jun	M	71	0	2	2	W	N/A
Skelton	22-May	M	70	0	2	2	W	N/A
Skelton	2-Jul	M	70	0	2	2	W	N/A
E. Cataract*	16-Jun	F	71	1	-	2-PR	W	2
Skelton	10-Jun	F	71	0	2	2	W	N/A

4.3.2.2 Hatchery Operations

Egg collection

The Saco Salmon Restoration Alliance & Hatchery (SSRA) has ceased receiving eggs or broodstock from Nashua National Fish Hatchery (NNFH). The broodstock program will now rely on annual naturally reared parr collections from the drainage. In the fall of 2023, the University of New England (UNE) staff spawned 15 adult salmon (7 males and 8 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.

Broodstock Collections

In October 2023, 30 naturally-reared and wild parr were taken from Swan Pond Stream and Cooks Brook tributaries to the Saco River.

4.3.3.3 Stocking

Juvenile Atlantic Salmon Releases

In 2023, the Saco River Salmon Restoration Alliance planted 2,100 eyed-eggs Swan Pond Stream.

Adult Salmon Releases

In 2023, no adult Atlantic salmon were stocked into the Saco River drainage.

4.3.3.4 Juvenile Population Status

Maine Department of Marine Resources did not conduct any electrofishing surveys in the Saco River watershed in 2023.

Smolt Monitoring

There was no smolt monitoring in 2023.

Tagging

No salmon released into the Saco River drainage were tagged or marked in 2023.

4.3.3.5 Fish Passage

The only change to passage in 2023 was the temporary repair shutdown of the fishlift on the East Channel Cataract.

4.3.3.6 Genetics

All adult returns captured at Skelton Dam are tissue sampled. Samples are preserved and kept at Maine Department of Marine Resources in Augusta. Currently no plans have been made to characterize them genetically.

4.3.3.7 General Program Information

In 2019 the SSRA began a partnership with the UNE. The partnership relies on the UNE to rear broodstock and assist the SSRA with spawning.

In addition, to maintain a source of broodstock the SSRA collects parr. The parr are taken annually from the Saco River drainage, reared at the SSRA hatchery and then transferred to the UNE for spawning in the fall.

4.3.3.8 Migratory Fish Habitat Enhancement and Conservation

No habitat enhancement or conservation projects directed solely towards Atlantic salmon were conducted in the watershed during 2023.

4.4 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).

4.4.1 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.

4.4.1.1 Adult Returns

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

4.4.1.2 Hatchery Operations

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

4.4.1.3 Juvenile Atlantic Salmon Releases

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

4.4.1.4 Juvenile Population Monitoring

None was conducted.

4.4.1.5 Fish Passage Developments Relevant to Atlantic Salmon

The Milltown Dam (first barrier, at tidewater) was removed in 2024. Funding provided by the National Fish and Wildlife Foundation and NOAA are jumpstarting efforts to improve fish passage at the next two upstream dams, Woodland Dam and Grand Falls Dam. Feasibility analyses for improvements at these facilities are now underway.

4.4.1.6 Educational Activities

None reported.

4.4.2 Meduxnekeag River

This river flows mostly in Maine but enters New Brunswick shortly before flowing into the St. John River. 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.

4.4.2.1 Adult Returns

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

4.4.2.2 Hatchery Operations

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

4.4.2.3 Juvenile Atlantic Salmon Releases

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

4.4.2.4 Juvenile Population Monitoring

None was conducted.

4.4.2.5 Fish Passage Developments Relevant to Atlantic Salmon

None.

4.4.2.6 Educational Activities

None reported.

4.4.3 Prestile Stream

This river flows mostly in Maine but enters New Brunswick shortly before flowing into the St. John River. 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.

4.4.3.1 Adult Returns

No Atlantic salmon adults were observed returning to Prestile Stream.

4.4.3.2 Hatchery Operations

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

4.4.3.3 Juvenile Atlantic Salmon Releases

No salmon of any life stage were released into Prestile Stream.

4.4.3.4 Juvenile Population Monitoring

None was conducted.

4.4.3.5 Fish Passage Developments Relevant to Atlantic Salmon

None.

4.4.3.6 Educational Activities

None reported.

4.4.4 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 ascends the Aroostook River from the St. John must use the fishway at the Tinker Dam. U.S. salmon management activities in this watershed have been sporadic and relatively minor in past years.

4.4.4.1 Adult Returns

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

4.4.4.2 Hatchery Operations

Dug Brook Hatchery is operated by Atlantic Salmon for Northern Maine.

4.4.4.3 Juvenile Atlantic Salmon Releases

The Mactaquac Biodiversity Facility supplies roughly 40,000 eyed eggs to the Dug Brook Hatchery annually (e.g., 38,478 in 2023). The eggs are raised to the parr stage and released the following year. In 2023, roughly 200 parr were released into a tributary of the Aroostook River

4.4.4.4 Juvenile Population Monitoring

None was conducted.

4.4.4.5 Fish Passage Developments Relevant to Atlantic Salmon

None.

4.4.4.6 Educational Activities

None reported.

End of Chapter 4

5 Emerging Issues in US Salmon and Proposed Terms of Reference

Summary

This section provides an overview of information presented, identified and/or developed at the committee meeting related to 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.

5.1 Reporting on 2023 USASAC Terms of Reference

In support of NASCO, we provided reporting on the following TORs in 2023 for Atlantic salmon in the United States.

Term of Reference	Section within the report
Describe the key events of the annual fisheries bycatch (targeted fisheries are closed) and aquaculture production	1
Update age-specific stock conservation limits based on new information as available including updating the time-series of the number of river as available including updating the time-series of the number of river stocks with established CL's by jurisdiction.	1 and 5
Describe the status of the stocks including updating the time-series of trends in the number of river stocks meeting CL's by jurisdiction.	1
Identification of significant new or emerging threats to, or opportunities for, salmon conservation and management;	1, 3 and 5
Compilation of Tag releases	1

In support of CMS, we provided reporting on the following TORs in 2023 for Atlantic salmon in the United States.

Term of Reference	Section within the report
Status of US Populations for the Gulf of Maine DPS at SHRU level	1, 3 and 4
Adult Returns Estimate (Hatchery and Naturally Reared)	1, 3 and 4
Freshwater Production Summaries – Smolts and pre-smolt production CPUE	1 and 3
Marine Survival – hatchery index Penobscot and naturally-reared Narraguagus	1 and 2
Diversity Metric	2

Hatchery production	1, 3 and 4
Connectivity	3 and 5
Distribution - occupancy maps and data	3

Beyond the support of ICES, NASCO and CMS, the USASAC develops their own TORs and emerging issues. These are variable scope, but are all deemed important to bring forward, with these topics identified prior to, or during each of the annual meetings. We report on 2023 TORs below.

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.

Discussion on the scale archiving project highlighted both the successful progress to date and the importance of documenting location of all the scales. Currently all of Southern New England and the Vermont and New Hampshire watersheds that undertook salmon restoration efforts since the 1960s are stored in a climate-controlled area by the NOAA NEFSC. These scales are stored in archival materials and organized by numbered bins with up to six boxes in each bin. Additionally, a master database in Excel documents this information and summaries through 2020 collections from the State of Maine. Maine collections are currently stored at MDMR offices in Jonesboro (Downeast Collections) and Augusta (Merrymeeting Bay and Penobscot Bay) archives. The group concurred that the ideal situation would be to have all archived samples in one location As such the committee suggests working with Maine leadership to move archive scales into that secure and safe location. Additionally, the Excel data table will be evaluated for optimizing these data in an Access Database by USASAC analysts. Once completed these data will be publically available through the USASAC portal housed by NOAA NEFSC. Additionally discussion of recent data collections from 2001 forward in Maine highlighted the need to combine an automated process with the physical archival storage and box numbering system and database. Work on this project will continue through 2024 and likely part of 2025 to resolve archive issues and build standard protocols for moving forward annually.

The ad hoc group will continue with inventory and archiving activities and provide further reporting in 2024.

Conservation Limits for U.S. Atlantic salmon

Conservation limits (CLs) for U.S. Atlantic salmon were first proposed by Baum in 1995 (Baum (1995). Since that time, US management activities and priorities have changed greatly with both the ESA listing of Gulf of Maine Atlantic salmon and the end of US Atlantic salmon restoration efforts outside of Maine. As such, 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, this resulted in a working paper presentation at the 2024 meeting that updated best available habitat, fecundity, and sex ratio data. The Baum US CL was 29,198 and the team's revised estimate for historic CLs was 58,332. However, the working paper presents a CL of 20,941 for critical habitat within the GOM DPS. Given ongoing work on revisiting habitat suitability with higher resolution elevation data, groundwater richness, and other environmental metrics, the USASAC recommends using the working paper as a reference for a) the evolution of calculation methods of US CLs over time and b) the best available data for ongoing evaluations of population production potential. These CLs are benchmarks beyond ESA listing actions and represent lower limit reference points assuming full access to and restoration of all Critical Habitat.

Internationally, within the West Greenland and North American Commissions of NASCO, the stated management objective for Atlantic salmon stocks in the U.S. remains at 4,549 2SW adult returns (NASCO 2013); see NAC(13)4. This rebuilding objective was established considering the extremely depleted state of these endangered populations and was developed to align with the recovery criteria for the remnant stocks currently under protection of the ESA. This objective also incorporated U.S. demographic data in the management of the Greenland fishery and aligns with

U.S. federal obligations and NASCO guidance. It is important to note that the federal designated recovery target is 6,000 total returns per year as the NASCO management objective (4,549 2SW) does not include grilse. It is also important to note that this is just one of the criteria that needs to be met before considering downlisting. As stock status improves and the remnant stocks are down-listed or removed from the ESA, this management objective could be revised and would be moving towards the CLs listed above.

Need for Accurate and Consistent Reporting on Habitat Connectivity gains

In 2021, the USASAC discussed the increasing need for accurate reporting of habitat accessibility data at both the international and domestic level. At the international level, the U.S. identifies habitat accessibility goals as part of their NASCO Implementation Plan. Progress towards attaining these goals need to be reported to NASCO annually as part of the U.S.'s Annual progress Report. At the domestic level, the Recovery Plan for Atlantic Salmon 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. The Critical Habitat Rule (74 FR 29300, 2019) identified watersheds that were known to contain the most abundant, suitable habitats for Atlantic salmon, although the scale at which these habitats were identified are too coarse for reporting requirements noted above. To accurately report on progress towards these habitat criterion, a standardized definition of what constitutes suitable habitat is required. Once defined, an inventory should be created that identifies where suitable habitats are located in the DPS, the relative productivity of these suitable habitats and a method to calculate how much suitable habitat meets the criteria as accessible each year. Ultimately, a database, which tracks all of these metrics, is needed and this database needs to be consistently maintained.

In an effort to address theis need, 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 in late 2022 and provided an update to the USASAC in March 2023. Based on these efforts, it was concluded that the current habitat model was inadequate to track progress of recovery goals through connectivity projects as important variable that drive habitat productivity (e.g. water temperature) were not adequately considered in existing models.

Following the March 2023 meeting, the team developed a terms-of-reference to the next steps to update the habitat model for more spatial precision necessary for reporting while also incorporating water temperature to inform habitat suitability. External funding was obtained for a contractor at NEFSC to support model development and dissemination. The team will continue to evaluate newly available spatial data layers and will work to develop the most spatially accurate model possible. Once built, the team will validate and refine as appropriate necessary and will work to develop a habitat suitability definition for Critical Habitat and evaluate habitat-related mechanisms that drive juvenile productivity. An update of progress to date was provided to the USASAC and work will continue through 2025. An update will be provided to the USASAC in 2025.

5.2 Emerging Issues

Cryopreservation Activities of broodstock milt

This investigation was presented to the USASAC members at this year's meeting within Section 3 (GoM reporting) and discussion. Cryopreservation is a process in which a living cell can be frozen, stored, thawed, and remain viable for future growth. The Cryopreservation Lab at the U.S. Fish and Wildlife Service's Warm Springs Fish Technology Center in Georgia focuses on developing and implementing cryopreservation techniques to secure the remaining genetic diversity of endangered species, reduce issues caused by non-coincident mating, improve control in artificial spawning programs, and transfer wild genetics into hatchery stocks. Cryopreserved sperm can also assist reproductive efforts by allowing spawning to take place whenever females are ready. For vulnerable species with limited populations, this reduces the need to hold males for long periods of time and can increase the flexibility and genetic diversity in future generations. Craig Brook National Fish Hatchery is exploring the option of cryopreservation to potentially lower the amount of total phosphorus discharged into Alamoosook Lake. Using cryopreservation may lower the amount of biomass needed to successfully spawn in any given year resulting in less food being fed and lowering the amount of total phosphorus. In addition, it may allow Craig Brook National Fish Hatchery to create more diverse families by having milt from different generations readily available. This process has the possibility of improving eye up by ensuring sterile milt is not being used. Cryopreservation techniques are widely used in the aquaculture industry (Yang et al. 2018).

Updates or progress on activities related to this will be presented at the USASAC meeting in 2025.

Inclusion of parr in "naturally reared" USASAC reporting

In 2020 the USASAC discussed inclusion of parr-stocked fish within the classification of "naturally reared" to be consistent with the language within the status review (2019). The intent was not to go backwards and recalculate abundance estimates, but go forward with this classification starting in 2021. No progress has been made on this topic to date. This topic will be revisited during the 2024 summer meeting and program summaries provided in 2025 will be expected to incorporate this change. A short working paper will be developed for the 2025 meeting to outline these changes and to document the changes made to the USASAC database to accommodate.

Evaluation of lifestage specific contributions to restoration stocking efforts

The primary goal of the recovery program is to maximize the production of naturally reared smolts. This is accomplished through the supplementation of perennially low sea-run escapement with hatchery origin juveniles. Historically, age-1 smolts raised at Green Lake National Fish Hatchery have been used to maximize the number of smolts entering the ocean and the number of sea -run returns. These hatchery-origin, sea-run returns have been the staple of the Penobscot River broodstock for decades and since the expanded Listing in 2009, the source of broodstock for the Kennebec River program. In the other DPS rivers, smolt stocking has been accomplished by rotating river-specific egg allotments from captive broodstock at Craig Brook National Fish Hatchery to Green Lake to raise as smolts. Stockings have rotated from the Denny's (50k per year 2001-2007), Narraguagus (50k per year 2008-12), Machias (50 k in 2013), Pleasant (60k per year 2011-2013), and again to the Narraguagus (100k per year 2016-2019). In an effort to increase sea-run returns to the Kennebec, approximately 100k smolts were stocked into the Kennebec River in 2020-2022.

The premise that hatchery-origin smolts boost adult returns has been realized with mixed results. Indeed total abundance of hatchery-origin adult returns has averaged ~1,000 from 2000-2024 in the Penobscot as the result of 500-600k smolts stocked annually, however hatchery-origin returns to the other rivers has varied from 1-5 (Dennys), 11 Machias, 24-96 Narraguagus, and 2-21 Pleasant from the stocking of 50-100k smolts annually (USASAC 2024). All these returns fall well below conservation spawning escapement goals for these rivers.

In contrast the contribution of other hatchery products (egg, fry, parr) to naturally-reared origin returns is also relatively small and fails to meet conservation objectives. However, the numeric output of 2-3 million salmon (all eggs, fry, and parr) are well below stocking requirements to fill unoccupied habitat .Given the goal of these adult returns is to produce naturally reared smolts, the evaluation of production is critical in evaluating the management strategy.

Compounding the uncertainty of past stocking effectiveness is the projection of 20% decrease in egg allocations to all DPS watersheds beginning in 2024 as the result of strategic decreases in captive broodstock biomass to address phosphorus discharge at Craig Brook NFH. This decrease is in addition to the general trend of reduced egg production compared to the 2000's. A suggestion was made at this years' USASAC meeting to evaluate the contributions of specific stocking strategies (smolts, parr, fry, eggs) to smolt populations within the GoM DPS. This effort will help to provide a context of what some of these efforts have and are providing in terms of naturally-reared smolts annually, but also how hatcheries can better utilize resources (time, feed, energy, discharge) within the hatchery operations.

A working paper will be presented at the 2025 meeting.

5.3 Data Deficiency and Data Needs

Directionality using pit tags -

During the 2023, season PIT monitoring was in place at Mattaseunk (Weldon) dam on the Penobscot River, which was used to track passage of various species of PIT tagged sea-run fish. During the USASAC meeting it was brought to the attention of many that this was the only array in place on the river and that there was no means of determining directionality of fish movement. The unfortunate issue with this, is that more than 1,000 PIT adult Atlantic salmon are in the river presently as a part of the Salmon For Maine's River project. Despite many being acoustically tagged, it is unfortunate that there was no additional infrastructure to track movements. It was suggested that this array be expanded (additional array(s)) to justify continued tagging of animals at Milford and evaluate efficiency of passage, but also to support the Salmon For Maine's Rivers project.

Citations:

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.

Yang, H., E. Hu, J. T. Buchanan, and T. R. Tiersch. 2018. A Strategy for Sperm Cryopreservation of Atlantic Salmon, Salmo salar, for Remote Commercial-scale High-throughput Processing. J World Aquac Soc 49(1):96-112.

5.4 Draft Terms of Reference for 2025 Meeting

The purpose of this section is to outline terms of reference identified at the USASAC annual meeting in March 2024. These draft Terms of Reference will be revisited during our summer 2024 teleconference to support or organize intersessional work on the topics. These draft TORs will be integrated with requests and needs that emerge from the Maine Collaborative Management Strategy Annual Report (April 2024) and the NASCO Annual Meeting (June 2024) to develop Final 2024 TOR and an agenda for the 2025 USASAC Meeting.

In **support of 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.

- Identification of significant new or emerging threats to, or opportunities for, salmon conservation and management2;
- Compilation of Tag releases

In **support of the Maine Collaborative 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

In **support of the USASAC**, we propose the following Terms of Reference:

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. Provide an update of all activities at the 2025 USASAC Annual Meeting.

Need for Accurate and Consistent Reporting on Habitat Connectivity gains. 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.

End of Chapter 5

6 List of Attendees, Working Papers, and Glossaries

6.1 List of Attendees

Participants for the 2024 USASAC meeting. On site (O), Virtual (V), and Not participating (-).

Last Name	First Name	Email	Agency	Location	3/5	3/6	3/7
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	ME DMR	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	V	V	V
Sheehan	Tim	Tim.Sheehan@noaa.gov	NOAA	Woods Hole, MA	O	O	-
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	-
Valliere	Jason	jason.valliere@maine.gov	ME DMR	Bangor, ME	O	O	O
Noll	Jennifer	Jennifer.B.Noll@maine.gov	ME DMR	Augusta, ME	O	-	O
Simpson	Mitch	Mitch.Simpson@maine.gov	ME DMR	Bangor, ME	V	V	-
Bean	David	David.Bean@noaa.gov	NOAA	Orono, ME	V	-	-
Christman	Paul	Paul.Christman@maine.gov	ME DMR	Augusta, ME	-	O	O
Cox	Oliver	Oliver_Cox@fws.gov	USFWS	East Orland, ME	-	V	V
Danielle	Frechette	Danielle.Frechette@maine.gov	ME DMR	Augusta, ME	O	-	O
Stevens	Justin	Justin.Stevens@maine.edu	ME Sea Grant	Orono, ME	O	O	O
Buhyoff	Matt	matt.buhyoff@noaa.gov	NOAA	Orono, ME	O	O	O
O'Regan	Emily	emily.oregan@noaa.gov	NOAA	Orono, ME	O	O	O

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

Number	Author(s)	Title
WP24-01	S. Gephard	Long Island Sound: Connecticut River and Pawcatuck & Central New England Area: Merrimack River (PPT)
WP24-02	E. Atkinson	Central New England (Saco River) PPT
WP24-03	E. Atkinson	Gulf of Maine DPS Program Summary (PPT)
WP24-04	E. Atkinson	Outer Bay of Fundy (Aroostook and St. Croix Rivers) Summary (PPT)
WP24-05	T. Sheehan	2023 WGNAS TORs overview for USASAC (PPT)
WP24-06	T. Sheehan	Summary of US data to WGNAS (PPT)
WP24-07	D. Kircheis	NASCO - Meeting and Annual Progress Report (PPT)
WP24-08	J. Kocik, C. Tholke and T. Sheehan	Annual Bycatch Update for Atlantic Salmon, 1989 through February 2023 (WP)
WP24-09	D. Bean	Maine and neighboring Canadian Commercial Aquaculture Activities and Production (WP)
WP24-10	R. Haas-Castro	Scale studies (WP)
WP24-11	R. Haas-Castro	Scale Studies (PPT)
WP24-12	Bruchs, Noll et al.	Update on Maine River Atlantic Salmon Smolt Studies: 2024 (WP)
WP24-13	E. Akinson, J. Kocik and T. Sheehan	Progress Towards Updating USA Atlantic Salmon Conservation Limits (WP)
WP24-14	E. Akinson, J. Kocik and T. Sheehan	Progress Towards Updating USA Atlantic Salmon Conservation Limits (PPT)
WP24-15	J. Noll and C.W.B Bruchs	Update on Maine River Atlantic Salmon Smolt Studies: 2024 (PPT)
WP24-16	D. Frechette	Smolt-to-Adult Supplementation for the GOM DPS: Salmon For Maine's Rivers (PPT)
WP24-17	D. Frechette	Mattaceunk PIT reader Data Summary (PPT)
WP24-18	SCIWC	Anadromous Fish Counts - Milltown 2023 (WP)
WP24-19	J. Sweeka	Escapement and Natural Returns (PPT)
WP24-20	S. Gephard and R.E. Haas-Castro	Scale Archiving Activity Update (WP)
WP24-21	S. Gephard and R.E. Haas-Castro	Scale Archiving Activity Update (PPT)
WP24-22	J. Stevens	Atlantic Salmon Habitat Work Group (PPT)
WP24-23	S. Gephard	Report on the Use of Video at the Milford Fishlift - 2023 (PPT)
WP24-24	S. Gephard	Report on the Use of Video at the Milford Fishlift - 2023 (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

Location	Meeting Date	Committee Chair	Affiliation
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
Portland, ME	March 5-7, 2024	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
CMS - Collaborative Management Strategy
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
GOM - Gulf of Maine
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

P8 - Parr 8
P20 - Parr 20
P32 - Parr 32
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
2SW - Two sea winter adult salmon
3SW - Three sea winter adult salmon
4SW - Four sea winter adult salmon
SCIWC - St. Croix International Waterway Commission
SHRU – Salmon Habitat Recovery Unit
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
Conservation Limit	Management target defined as the number of spawners to achieve long-term average maximum sustainable yield
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.
Escapement (Natural)	Natural escapement is calculated using the equation = Returns - broodstock take - known mortalities.
Escapement (Total)	Total Escapement is calculated using the equation = Natural escapement + pre-spawn Stocking
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.

Term	Definition
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.
Pre-spawn Stocking	Domestic fish released prior to spawning season AND Sea Run fish that were taken to the hatchery, not used as broodstock, and released prior to spawning season.
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.
Salmon Habitat Recovery Units	The critical habitat rule divided the DPS range into three recovery units, termed Salmon Habitat Recovery Units, or SHRUs: (1) The Merrymeeting Bay SHRU, which covers the Androscoggin and Kennebec basins, and extends east to include the Sheepscot, Pemaquid, Medomak, and St. George watersheds; (2) the Penobscot Bay SHRU, which covers the entire Penobscot basin and extends west to and includes the Ducktrap watershed; and (3) the Downeast SHRU, including all coastal watersheds from the Union River east to the Dennys River. Federal Register, 117, 29300–29341. Retrieved from https://federalregister.gov/a/E9-14268
Captive Broodstock	Adults produced from naturally reared parr that were captured and reared to maturity in the hatchery.
Sea-run Broodstock	Atlantic salmon that return to the river, are captured alive, and held in confinement for the purpose of providing eggs for fish culture activities.
Strategy	Any action or integrated actions that will assist in achieving an objective and fulfilling the goal.
Life History related	
Green Egg	Life stage from spawning until faint eyes appear.

Term	Definition
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 with the appearance of “parr marks” on each side of the juvenile Atlantic salmon, until the commencement of migration to the sea as smolts.
Age 0 Parr	Life stage occurring during the period from when “parr marks” appear, often referring to fish that are stocked from a hatchery during this time. The two most common parr hatchery products are (1) accelerated parr and (2) ambient parr (see definitions below).
Accelerated Parr	Parr reared as part of a 1-year smolt program that incubates eggs and fry utilizing heated water.
Ambient Parr	Parr reared under ambient hatchery water conditions that does not involve utilizing heated water to advance egg and fry development.
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	(P8) A parr stocked at age 0 that migrates as 1 Smolt (8 months spent in freshwater).
Parr 20	(P20) A parr stocked at age 0 that migrates as 2 Smolt (20 months spent in freshwater).

Term	Definition
Parr 32	(P32) A parr stocked at age 0 that migrates at 3 Smolt (32 months spent in freshwater).
Smolt	An actively migrating young salmon that has undergone the physiological changes to survive the transition from freshwater to saltwater.
Wild Smolt	A wild smolt is an Atlantic salmon which is the product of natural spawning, emerged from a redd and was reared in the river prior to emigrating to the ocean.
Hatchery Smolt	A hatchery smolt is a product of hatchery spawning which has spent nine months (or more) of its life within a hatchery prior to stocking. These include fall parr origin (i.e. fingerlings, parr 8, parr 20, or parr 32), Age 1 and Age 2 smolts. This definition was modified by the 2019 Status Review. See Naturally Reared Smolt below.***
Naturally Reared Smolt	A naturally reared smolt is the product of wild spawning, 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 sea-run 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.

Term	Definition
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	(2SW) A salmon that survives past December 31 twice since becoming a smolt.
3SW Salmon	(3SW) A salmon that survives past December 31 three times since becoming a smolt.
4SW Salmon	(4SW) A salmon that survives past December 31 four times since becoming a smolt.
Kelt	Life stage after a salmon spawns. For domestic salmon, this stage lasts until death. For wild fish, this stage lasts until it returns to home waters to spawn again.
Reconditioned Kelt	A kelt that has been restored to a feeding condition in captivity.
Repeat Spawner	A salmon that returns numerous times to the river for the purpose of reproducing. Previous spawner.

End of Chapter 6

Appendix 1. Juvenile Atlantic salmon stocking summary for New England in 2023.

United States

Number of fish stocked by lifestage

River	Egg	Fry	0 Parr	1 Parr	2 Parr	1 Smolt	2 Smolt	Total
Connecticut	0	334,000	0	0	0	300	0	334,300
Total for Connecticut Program								**334,300**
Androscoggin	0	6,000	0	0	0	0	0	6,000
Dennys	0	204,000	0	0	0	0	0	204,000
East Machias	0	18,000	0	0	0	0	0	18,000
Kennebec	654,000	3,000	0	0	0	98,800	0	755,800
Machias	0	212,000	0	0	0	0	0	212,000
Narraguagus	0	16,000	0	0	0	0	0	16,000
Penobscot	360,000	777,000	40,100	0	0	642,800	0	1,819,900
Pleasant	0	109,000	0	0	0	0	0	109,000
Saco	2,000	0	0	0	0	0	0	2,000
Sheepscot	79,000	67,000	15,500	0	0	0	0	161,500
Union	0	1,000	0	0	0	0	0	1,000
Total for Maine Program								**3,305,200**
Pawcatuck	0	7,000	0	0	0	0	0	7,000
Total for Pawcatuck Program								**7,000**
Total for United States								**3,646,500**
Grand Total								**3,646,500**

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 2023.

Drainage	Purpose	Captive/Domestic Pre-Spawn	Captive/Domestic Post-Spawn	Sea Run Pre-Spawn	Sea Run Post-Spawn	Total
Dennys	Restoration	17	179	0	0	196
East Machias	Restoration	23	0	0	0	23
Machias	Restoration	322	0	0	0	322
Narraguagus	Restoration	0	318	0	0	318
Penobscot	Restoration	1,275	854	243	494	2,866
Pleasant	Restoration	41	0	0	0	41
Sheepscot	Restoration	24	321	0	0	345
Total		1,702	1,672	243	494	4,111

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 2023 .

Marking Agency	Age	Life Stage	H/W	Stock Origin	Primary Mark or Tag	Number Marked	Secondary Mark or Tag	Release Date	Release Location
UMO/USGS	1	1_Smolt	H	Penobscot	PING	50		May	Penobscot
USFWS	1	1_Smolt	H	Penobscot	AD	95,580		Apr	Penobscot
MEDMR		Adult	W	Androscoggin	UCP	7		Jun	Androscoggin
USFWS	3	Adult	H	Dennys	PIT	36	DUCP	Nov	Dennys
USFWS	5	Adult	H	Dennys	PIT	101	DUCP	Nov	Dennys
USFWS	5	Adult	H	Dennys	PIT	17	DUCP	Jun	Dennys
USFWS	4	Adult	H	Dennys	PIT	142	DUCP	Nov	Dennys
USFWS	5	Adult	H	East Machias	PIT	23	DUCP	Jun	East Machias
MEDMR		Adult	W	Kennebec	AP	33	UCP	Jun	Kennebec
MEDMR		Adult	W	Kennebec	AP	371		Jun	Kennebec
MEDMR		Adult	H	Machias	PING	50	AP, PIT	Oct	Machias
MEDMR		Adult	H	Machias	PIT	200	AP	May	Machias
MEDMR		Adult	H	Machias	PING	49	AP, PIT	May	Machias
USFWS	5	Adult	H	Machias	PIT	25	DUCP	Jun	Machias
MEDMR		Adult	W	Narraguagus	AD	6		Jun	Narraguagus
USFWS	3	Adult	H	Narraguagus	PIT	48	DUCP	Dec	Narraguagus
USFWS	4	Adult	H	Narraguagus	PIT	174	DUCP	Dec	Narraguagus
USFWS	5	Adult	H	Narraguagus	PIT	96	DUCP	Dec	Narraguagus
MEDMR		Adult	H	Penobscot	PIT	626	AD	Jun	Penobscot
MEDMR		Adult	H	Penobscot	PING	36	AD, PIT	Oct	Penobscot
MEDMR		Adult	H	Penobscot	PING	73	AD, PIT	Jun	Penobscot
MEDMR		Adult	W	Penobscot	PIT	355	AP	Jun	Penobscot
MEDMR		Adult	W	Penobscot	PIT	1	DAP	Jun	Penobscot
MEDMR		Adult	W	Penobscot	PIT	4	UCP	Jun	Penobscot
MEDMR		Adult	H	Penobscot	PIT	544	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/USGS		Adult	W	Penobscot	PING	25	AP, PIT	Dec	Penobscot
UMO/USGS		Adult	W	Penobscot	PING	37	AP, PIT	Nov	Penobscot
USFWS		Adult	W	Penobscot	PIT	391	AP	Dec	Penobscot
USFWS		Adult	W	Penobscot	PIT	40	DAP	Dec	Penobscot
USFWS	4	Adult	H	Penobscot	PIT	628	DAP	Dec	Penobscot
USFWS		Adult	W	Penobscot	FLOY	1	DAP, PIT	Jun	Penobscot
USFWS		Adult	W	Penobscot	PIT	7	DAP	Oct	Penobscot
USFWS		Adult	H	Penobscot	PIT	1	AD, UCP	Dec	Penobscot
USFWS		Adult	W	Penobscot	PIT	226	AP	Oct	Penobscot
USFWS		Adult	W	Penobscot	PIT	1	AD, UCP	Oct	Penobscot
USFWS		Adult	W	Penobscot	FLOY	5	AP. PIT	Jun	Penobscot
USFWS		Adult	W	Penobscot	FLOY	3	AP, PIT	Jun	Penobscot
USFWS	3	Adult	H	Penobscot	PIT	226	DAP	Dec	Penobscot
USFWS	4	Adult	H	Pleasant	PIT	20	DUCP	Jun	Pleasant
USFWS	5	Adult	H	Pleasant	PIT	21	DUCP	Jun	Pleasant
MEDMR		Adult	W	Saco	AP	4		Jun	Saco
USFWS	5	Adult	H	Sheepscot	PIT	24	DUCP	Jun	Sheepscot
USFWS	3	Adult	H	Sheepscot	PIT	58	DUCP	Dec	Sheepscot
USFWS	4	Adult	H	Sheepscot	PIT	165	DUCP	Dec	Sheepscot
USFWS	5	Adult	H	Sheepscot	PIT	98	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 2023.

Origin	Total External Marks	Total Adipose Clips	Total Marked
Hatchery Adult	3,381	1,170	3,481
Hatchery Juvenile	95,580	95,580	95,630
Wild Adult	1,454	6	1,517
Total			**100,628**

Appendix 4. Estimates of Atlantic salmon returns to New England in 2023 from trap counts and redd surveys. (N.R. represents naturally reared origin.)

	Assessment Method	1SW Hatchery	1SW N.R.	2SW Hatchery	2SW N.R.	3SW Hatchery	3SW N.R.	Repeat Hatchery	Repeat N.R.	Total	2019-2023 Average
Androscoggin	Trap	5	0	2	1	0	0	0	0	**8**	7
Connecticut	Trap	0	0	0	0	0	0	0	0	**0**	2
Cove Brook	Redd Est	0	0	0	0	0	0	0	0	**0**	0
Dennys	Redd Est	0	0	0	0	0	0	0	0	**0**	9
Ducktrap	Redd Est	0	1	0	2	0	0	0	0	**3**	2
East Machias	Redd Est	2	1	8	6	0	0	0	0	**17**	23
Great Works Stream	Redd Est	0	0	8	0	0	0	0	0	**8**	2
Kenduskeag Stream	Redd Est	1	0	10	0	0	0	0	0	**11**	7
Kennebec	Trap	9	0	94	57	1	0	1	0	**162**	77
Machias	Redd Est	0	2	0	10	0	0	0	0	**12**	19
Merrimack	Trap	2	1	7	4	0	0	0	0	**14**	4
Narraguagus	Redd Est	0	4	0	17	0	0	0	0	**21**	59
Pawcatuck	Trap	0	0	0	0	0	0	0	0	**0**	0
Penobscot	Trap	95	2	1356	109	5	2	1	0	**1,570**	1,218
Pleasant	Redd Est	0	3	0	11	0	0	0	0	**14**	17
Saco	Trap	0	0	0	4	0	0	0	0	**4**	4
Sheepscot	Redd Est	1	1	0	8	0	0	0	0	**10**	14
Souadabscook Stream	Redd Est	0	0	0	0	0	0	0	0	**0**	1
Union	Trap	0	0	0	0	0	0	0	0	**0**	1
Total		**115**	**15**	**1,485**	**229**	**6**	**2**	**2**	**0**	**1,854**	**1,466**

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 2023.

Source River	Origin	Females Spawned	Total Egg Production
Connecticut	Domestic	126	742,000
Penobscot	Domestic	482	1,261,000
Dennys	Captive	69	283,000
East Machias	Captive	119	454,000
Machias	Captive	81	335,000
Narraguagus	Captive	113	539,000
Pleasant	Captive	93	405,000
Sheepscot	Captive	88	289,000
Total	**Captive/Domestic**	**1,171**	**4,308,000**
Penobscot	Sea Run	252	1,503,000
Total	**Sea Run**	**252**	**1,503,000**
Grand Total for Year	**2023**	**1,423**	**5,811,000**

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															
1993-2013	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															
1977-2013	2,071	21,264,000	7,600	33,559	207,521,000	5,900	0	0		2,395	28,935,000	9,900	38,025	257,720,000	6,300
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
2023	0	0		126	742,000	5,900	0	0		0	0		126	742,000	5,900
Total Connecticut	2,071	21,264,000	7,600	34,627	214,146,000	6,400	0	0		2,395	28,935,000	9,900	39,093	264,345,000	6,400
Dennys															
1939-2013	26	214,000	7,600	125	687,000	4,600	1,370	5,789,000	4,200	40	330,000	7,700	1,561	7,020,000	4,800
2014	0	0		0	0		40	148,000	3,700	0	0		40	148,000	3,700
2015	0	0		0	0		78	447,000	5,700	0	0		78	447,000	5,700
2016	0	0		0	0		27	155,000	5,700	0	0		27	155,000	5,700
2017	0	0		87	392,000	4,500	95	328,000	3,500	0	0		182	721,000	4,000

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
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
2023	0	0		0	0		69	283,000	4,100	0	0		69	283,000	4,100
Total Dennys	26	214,000	7,600	212	1,079,000	4,600	2,158	8,874,000	4,082	40	330,000	7,700	2,436	10,498,000	4,200
East Machias															
1995-2013	0	0		0	0		1,466	5,961,000	4,100	0	0		1,466	5,961,000	4,100
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
2023	0	0		0	0		119	454,000	3,800	0	0		119	454,000	3,800
Total East Machias	0	0		0	0	0	2,574	10,427,000	4,055	0	0		2,574	10,427,000	4,100
Kennebec															
1979-2013	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
1992-2013	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															
1941-2013	456	3,263,000	7,300	0	0		2,623	10,678,000	4,100	8	52,000	6,400	3,087	13,994,000	5,700
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
2023	0	0		0	0		81	335,000	4,100	0	0		81	335,000	4,100
Total Machias	456	3,263,000	7,300	0	0	0	3,692	14,627,000	3,736	8	52,000	6,400	4,156	17,943,000	3,900
Merrimack															
1983-2013	1,582	12,306,000	7,900	11,687	57,862,000	4,600	0	0		540	5,709,000	10,800	13,809	75,877,000	5,900
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
Total Merrimack	1,582	12,306,000	7,900	13,169	62,838,000	3,500	0	0		540	5,709,000	10,800	15,291	80,853,000	3,700

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
Narraguagus															
1962-2013	0	1,303,000		0	0		2,739	10,860,000	4,000	0	0		2,739	12,163,000	4,000
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
2023	0	0		0	0		113	539,000	4,800	0	0		113	539,000	4,800
Total Narraguagus	0	1,303,000		0	0	0	3,809	14,973,000	3,836	0	0		3,809	16,276,000	3,800
Orland															
1967-2013	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															
1992-2013	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															
1871-2013	20,833	177,932,000	7,900	9,184	26,637,000	3,000	329	1,400,000	4,300	0	0		30,346	205,969,000	7,200
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

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
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
2023	252	1,503,000	6,000	482	1,261,000	2,600	0	0		0	0		734	2,764,000	3,800
Total Penobscot	23,027	192,966,000	7,000	15,152	42,057,000	2,600	329	1,400,000	4,300	0	0		38,508	236,422,000	4,000
Pleasant															
2001-2013	0	0		123	468,000	5,900	568	2,161,000	4,400	0	0		691	2,630,000	4,600
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
2023	0	0		0	0		93	405,000	4,400	0	0		93	405,000	4,400
Total Pleasant	0	0		123	468,000	5,900	1,376	5,233,000	3,845	0	0		1,499	5,702,000	3,900
Sheepscot															
1995-2013	18	125,000	6,900	0	0		1,371	5,245,000	3,700	45	438,000	9,900	1,434	5,809,000	4,100

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

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

Note: Connecticut data are preliminary prior to 1990.

Year	Sea-Run No. females	Sea-Run Egg production	Sea-Run Eggs/ female	Domestic No. females	Domestic Egg production	Domestic Eggs/ female	Captive No. females	Captive Egg production	Captive Eggs/ female	Kelt No. females	Kelt Egg production	Kelt Eggs/ female	TOTAL No. females	TOTAL Egg production	TOTAL Eggs/ female
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
2023	0	0		0	0		88	289,000	3,300	0	0		88	289,000	3,300
Total Sheepscot	18	125,000	6,900	0	0	0	2,252	8,107,000	3,364	45	438,000	9,900	2,315	8,671,000	3,400
St Croix															
1993-2013	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															
1974-2013	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	7,600	34,627	214,147,000	6,400	0	0		2,395	28,935,000	9,900	39,093	264,346,000	6,400
Dennys	26	214,000	7,600	212	1,080,000	4,600	2,158	8,874,000	4,100	40	330,000	7,700	2,436	10,498,000	4,200
East Machias	0	0		0	0		2,574	10,427,000	4,000	0	0		2,574	10,427,000	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		3,692	14,628,000	3,700	8	52,000	6,400	4,156	17,943,000	3,900
Merrimack	1,582	12,306,000	7,900	13,169	62,837,000	3,500	0	0		540	5,709,000	10,800	15,291	80,852,000	3,700
Narraguagus	0	1,303,000		0	0		3,809	14,972,000	3,800	0	0		3,809	16,275,000	3,800
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	23,027	192,966,000	7,000	15,152	42,055,000	2,600	329	1,400,000	4,300	0	0		38,508	236,421,000	4,000
Pleasant	0	0		123	468,000	5,900	1,376	5,233,000	3,800	0	0		1,499	5,701,000	3,900
Sheepscot	18	125,000	6,900	0	0		2,252	8,107,000	3,400	45	438,000	9,900	2,315	8,670,000	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	**27,892**	**236,873,000**	**8,500**	**63,840**	**320,602,000**	**5,000**	**16,190**	**63,641,000**	**3,900**	**3,041**	**35,540,000**	**11,700**	**110,963**	**656,656,000**	**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								
2001-2013	0	15,000	0	0	0	500	0	15,500
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
2023	0	6,000	0	0	0	0	0	6,000
Totals:Androscoggin	**0**	**33,000**	**0**	**0**	**0**	**500**	**0**	**33,500**
Aroostook								
1978-2013	0	6,331,000	317,400	38,600	0	32,600	29,800	6,749,400
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								
1988-2013	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								
1967-2013	0	148,526,000	2,849,700	1,836,700	64,700	3,771,900	1,828,100	158,877,100
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
2023	0	335,000	0	0	0	300	0	335,300
Totals:Connecticut	**0**	**150,802,000**	**2,858,200**	**1,837,700**	**64,700**	**3,772,200**	**1,828,100**	**161,162,900**
Dennys								
1975-2013	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
2021	43000	313,000	0	0	0	0	0	356,000

	Number of fish stocked by life stage							
	Egg	**Fry**	**0 Parr**	**1 Parr**	**2 Parr**	**1 Smolt**	**2 Smolt**	**Total**
2022	0	262,000	0	0	0	0	0	262,000
2023	0	204,000	0	0	0	0	0	204,000
Totals:Dennys	**83,000**	**5,964,000**	**235,400**	**7,600**	**0**	**532,700**	**30,400**	**6,853,100**
Ducktrap								
1986-2013	0	68,000	0	0	0	0	0	68,000
Totals:Ducktrap	**0**	**68,000**	**0**	**0**	**0**	**0**	**0**	**68,000**
East Machias								
1973-2013	0	3,737,000	138,300	42,600	0	108,400	30,400	4,056,700
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
2023	0	18,000	0	0	0	0	0	18,000
Totals:East Machias	**0**	**3,852,000**	**1,641,200**	**42,600**	**0**	**108,400**	**30,400**	**5,674,600**
Kennebec								
2001-2013	3464000	324,000	0	0	0	800	0	3,788,335
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	88,800	0	770,400
2021	759000	2,000	0	0	0	100,100	0	861,390
2022	438000	3,000	0	0	0	97,500	0	538,593
2023	654000	3,000	0	0	0	98,800	0	755,476
Totals:Kennebec	**10,632,000**	**342,000**	**0**	**0**	**0**	**386,000**	**0**	**11,358,868**
Lamprey								
1978-2013	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								
1970-2013	0	6,570,000	100,100	125,700	0	250,400	44,100	7,090,300
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
2019	91000	183,000	0	0	0	0	100	274,100

	Egg	Fry	0 Parr	1 Parr	2 Parr	1 Smolt	2 Smolt	Total
	Number of fish stocked by life stage							
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
2023	0	212,000	0	0	0	0	0	212,000
Totals:Machias	**494,000**	**8,888,000**	**149,800**	**125,700**	**0**	**251,300**	**44,200**	**9,953,867**

Merrimack

	Egg	Fry	0 Parr	1 Parr	2 Parr	1 Smolt	2 Smolt	Total
1975-2013	0	41,775,000	431,800	658,200	0	1,981,500	638,100	45,484,600
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

	Egg	Fry	0 Parr	1 Parr	2 Parr	1 Smolt	2 Smolt	Total
1970-2013	0	6,920,000	117,100	14,600	0	400,200	84,000	7,535,900
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
2023	0	16,000	0	0	0	0	0	16,000
Totals:Narraguagus	**494,000**	**8,548,000**	**372,400**	**15,000**	**0**	**791,700**	**84,700**	**10,305,817**

Pawcatuck

	Egg	Fry	0 Parr	1 Parr	2 Parr	1 Smolt	2 Smolt	Total
1979-2013	0	6,296,000	1,209,200	268,100	0	127,500	500	7,901,300
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
2023	0	7,000	0	0	0	0	0	7,000
Totals:Pawcatuck	**0**	**6,350,000**	**1,209,200**	**268,100**	**0**	**128,700**	**500**	**7,956,500**

Penobscot

	Egg	Fry	0 Parr	1 Parr	2 Parr	1 Smolt	2 Smolt	Total
1970-2013	586000	26,778,000	6,684,800	1,394,400	0	17,725,800	2,508,200	55,677,172
2014	89000	815,000	0	0	0	557,700	0	1,461,360
2015	89000	518,000	257,800	0	0	375,600	0	1,240,580
2016	473000	1,025,000	263,200	0	0	569,300	0	2,330,673
2017	575000	409,000	253,300	0	0	569,700	0	1,806,821
2018	397000	1,143,000	219,900	0	0	559,100	0	2,319,033
2019	491000	631,000	92,900	0	0	554,700	0	1,769,263

	Number of fish stocked by life stage							
	Egg	Fry	0 Parr	1 Parr	2 Parr	1 Smolt	2 Smolt	Total
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
2023	360000	754,000	40,100	0	0	642,800	0	1,797,341
Totals:Penobscot	**4,302,000**	**33,142,000**	**8,005,600**	**1,394,400**	**0**	**23,471,400**	**2,509,200**	**72,847,883**

Pleasant

	Egg	Fry	0 Parr	1 Parr	2 Parr	1 Smolt	2 Smolt	Total
1975-2013	0	1,578,000	16,000	1,800	0	246,900	42,400	1,885,100
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
2023	0	109,000	0	0	0	0	0	109,000
Totals:Pleasant	**646,000**	**2,888,000**	**16,000**	**1,800**	**0**	**246,900**	**42,400**	**3,840,061**

Saco

	Egg	Fry	0 Parr	1 Parr	2 Parr	1 Smolt	2 Smolt	Total
1975-2013	0	7,446,000	473,900	232,000	0	408,300	9,500	8,569,700
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
2023	2000	0	0	0	0	0	0	2,100
Totals:Saco	**279,000**	**9,526,000**	**518,900**	**232,000**	**0**	**444,100**	**9,500**	**11,009,510**

Sheepscot

	Egg	Fry	0 Parr	1 Parr	2 Parr	1 Smolt	2 Smolt	Total
1971-2013	219000	3,322,000	223,000	20,600	0	92,200	7,100	3,884,545
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
2023	79000	67,000	15,500	0	0	0	0	161,748
Totals:Sheepscot	**2,152,000**	**3,576,000**	**361,500**	**20,600**	**0**	**92,200**	**7,100**	**6,209,822**

	Number of fish stocked by life stage							
	Egg	**Fry**	**0 Parr**	**1 Parr**	**2 Parr**	**1 Smolt**	**2 Smolt**	**Total**
St Croix								
1981-2013	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								
1971-2013	0	554,000	371,400	0	0	379,700	251,000	1,556,100
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
2023	0	1,000	0	0	0	0	0	1,000
Totals:Union	**0**	**661,000**	**371,400**	**0**	**0**	**379,900**	**251,000**	**1,663,300**
Upper StJohn								
1979-2013	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	31,000	0	0	0	500	0	**31,800**
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	150,801,000	2,858,200	1,837,700	64,800	3,772,200	1,828,200	**161,097,000**
Dennys	83,000	5,965,000	235,400	7,600	0	532,800	30,400	**6,854,100**
Ducktrap	0	68,000	0	0	0	0	0	**68,000**
East Machias	0	3,851,000	1,641,200	42,600	0	108,400	30,400	**5,673,300**
Kennebec	10,631,000	342,000	0	0	0	386,000	0	**11,359,100**
Lamprey	0	1,593,000	427,700	58,800	0	201,400	32,800	**2,313,700**
Machias	495,000	8,888,000	149,700	125,600	0	251,400	44,200	**9,954,000**
Merrimack	0	41,797,000	431,700	658,100	0	1,981,400	638,300	**45,506,500**
Narraguagus	494,000	8,549,000	372,400	15,000	0	791,900	84,700	**10,306,800**
Pawcatuck	0	6,349,000	1,209,200	268,100	0	128,700	500	**7,955,700**
Penobscot	4,302,000	33,140,000	8,005,700	1,394,400	0	23,471,400	2,509,200	**72,823,200**
Pleasant	645,000	2,889,000	16,000	1,800	0	247,000	42,400	**3,841,000**
Saco	279,000	9,526,000	518,800	232,000	0	444,000	9,500	**11,009,100**
Sheepscot	2,152,000	3,577,000	361,500	20,600	0	92,200	7,100	**6,210,300**
St Croix	0	1,270,000	498,000	158,300	0	808,000	20,100	**2,754,200**
Union	0	660,000	371,400	0	0	379,900	251,000	**1,662,600**
Upper StJohn	0	2,165,000	1,456,700	14,700	0	5,100	27,700	**3,669,200**
TOTALS	**19,081,000**	**290,320,000**	**18,921,000**	**4,884,400**	**64,800**	**33,640,200**	**5,586,200**	**372,433,600**

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									
1983-2013	57	600	6	2	10	107	0	1	**783**
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**
2023	5	2	0	0	0	1	0	0	**8**
Total for Androscoggin	74	617	0	2	10	120	0	0	**830**
Cocheco									
1992-2013	0	0	1	1	6	10	0	0	**18**
Total for Cocheco	0	0	0	1	6	10	0	0	**18**
Connecticut									
1974-2013	58	3,612	28	2	134	2,318	14	3	**6,169**
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**
2023	0	0	0	0	0	0	0	0	**0**
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**
2023	0	0	0	0	0	0	0	0	**0**
Total for Cove Brook	0	0	0	0	0	0	0	0	**0**
Dennys									
1967-2013	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**
2023	0	0	0	0	0	0	0	0	**0**
Total for Dennys	42	350	6	1	95	987	6	6	**1,516**
Ducktrap									
1985-2013	0	0	0	0	60	265	0	0	**325**
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**
2023	0	0	0	0	1	2	0	0	**3**
Total for Ducktrap	0	0	0	0	64	282	0	0	**346**
East Machias									
1967-2013	22	254	1	2	75	583	1	10	**948**
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**
2023	2	8	0	0	1	6	0	0	**17**

	HATCHERY ORIGIN				NATURALLY REARED ORIGIN				
	1SW	2SW	3SW	Repeat	1SW	2SW	3SW	Repeat	Total
Total for East Machias	48	368	1	2	84	623	1	1	**1,137**
Great Works Stream									
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**
2023	0	8	0	0	0	0	0	0	**8**
Total for Great Works Stream	0	8	0	0	0	0	0	0	**8**
Kenduskeag Stream									
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	1	5	0	0	**6**
2022	0	0	0	0	1	4	0	0	**5**
2023	1	10	0	0	0	0	0	0	**11**
Total for Kenduskeag Stream	1	10	0	0	4	16	0	0	**31**
Kennebec									
1975-2013	24	256	6	7	9	81	0	0	**383**
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**
2023	9	94	1	1	0	57	0	0	**162**
Total for Kennebec	73	368	2	8	36	414	2	2	**909**
Lamprey									
1979-2013	10	17	1	0	13	16	0	0	**57**
Total for Lamprey	10	17	0	0	13	16	0	0	**57**
Machias									
1967-2013	40	363	9	2	155	2,085	41	131	**2,826**
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**

	HATCHERY ORIGIN				NATURALLY REARED ORIGIN				
	1SW	**2SW**	**3SW**	**Repeat**	**1SW**	**2SW**	**3SW**	**Repeat**	**Total**
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**
2023	0	0	0	0	2	10	0	0	**12**
Total for Machias	43	374	41	2	186	2211	41	41	**2,997**
Merrimack									
1982-2013	499	1,752	51	12	153	1,204	39	0	**3,710**
2014	4	25	1	0	0	10	0	0	**40**
2015	0	8	1	0	0	3	1	0	**13**
2016	1	1	0	0	0	3	0	0	**5**
2017	0	0	0	0	1	4	0	0	**5**
2018	0	2	0	0	0	0	0	0	**2**
2019	0	0	0	0	0	0	0	0	**0**
2020	0	0	0	0	1	3	0	0	**4**
2021	0	0	0	0	0	0	0	0	**0**
2022	0	0	0	0	0	0	0	0	**0**
2023	2	7	0	0	1	4	0	0	**14**
Total for Merrimack	506	1,795	40	12	156	1231	40	40	**3,793**
Narraguagus									
1967-2013	202	840	25	58	134	2,592	72	168	**4,091**
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**
2023	0	0	0	0	4	17	0	0	**21**
Total for Narraguagus	314	981	74	61	167	2725	74	74	**4,526**
Pawcatuck									
1982-2013	2	151	1	0	1	25	1	0	**181**
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**

	HATCHERY ORIGIN				NATURALLY REARED ORIGIN				
	1SW	2SW	3SW	Repeat	1SW	2SW	3SW	Repeat	Total
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**
2023	0	0	0	0	0	0	0	0	**0**
Total for Pawcatuck	2	151	1	0	1	25	1	1	**181**
Penobscot									
1968-2013	13,361	51,185	302	741	837	4,363	37	102	**70,928**
2014	82	153	2	2	1	21	0	0	**261**
2015	110	552	7	1	9	52	0	0	**731**
2016	208	218	2	1	10	68	0	0	**507**
2017	301	451	9	0	9	79	0	0	**849**
2018	276	434	0	1	15	45	0	1	**772**
2019	288	738	2	0	7	161	0	0	**1,196**
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**
2023	95	1,356	5	1	2	109	2	0	**1,570**
Total for Penobscot	15,400	57,253	46	758	921	5297	46	46	**80,138**
Pleasant									
1967-2013	16	53	0	0	52	370	3	2	**496**
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**
2023	0	0	0	0	3	11	0	0	**14**
Total for Pleasant	21	76	3	0	71	446	3	3	**619**
Saco									
1985-2013	179	704	5	7	50	119	6	0	**1,070**
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**

	HATCHERY ORIGIN				NATURALLY REARED ORIGIN				
	1SW	2SW	3SW	Repeat	1SW	2SW	3SW	Repeat	Total
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**
2023	0	0	0	0	0	4	0	0	**4**
Total for Saco	185	716	6	7	55	136	6	6	**1,110**
Sheepscot									
1967-2013	23	92	0	0	72	495	13	0	**695**
2014	3	12	0	0	2	8	0	0	**25**
2015	1	6	0	0	1	4	0	0	**12**
2016	1	4	0	0	1	3	0	0	**9**
2017	2	9	0	0	2	6	0	0	**19**
2018	1	2	0	0	1	2	0	0	**6**
2019	3	11	0	0	2	10	0	0	**26**
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**
2023	1	0	0	0	1	8	0	0	**10**
Total for Sheepscot	39	151	13	0	85	548	13	13	**836**
Souadabscook Stream									
2017	0	0	0	0	1	3	0	0	**4**
2019	0	0	0	0	1	2	0	0	**3**
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**
2023	0	0	0	0	0	0	0	0	**0**
Total for Souadabscook Stream	0	0	0	0	2	5	0	0	**7**
St Croix									
1981-2013	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									
1973-2013	274	1,841	9	28	1	17	0	0	**2,170**
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**

	HATCHERY ORIGIN				NATURALLY REARED ORIGIN				
	1SW	2SW	3SW	Repeat	1SW	2SW	3SW	Repeat	Total
2021	0	0	0	0	0	0	0	0	**0**
2022	0	0	0	0	0	0	0	0	**0**
2023	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	74	617	6	2	10	120	0	1	**830**
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	64	282	0	0	**346**
East Machias	48	368	1	2	84	623	1	10	**1,137**
Great Works Stream	0	8	0	0	0	0	0	0	**8**
Kenduskeag Stream	1	10	0	0	4	16	0	0	**31**
Kennebec	73	368	7	8	36	414	2	1	**909**
Lamprey	10	17	1	0	13	16	0	0	**57**
Machias	43	374	9	2	186	2,211	41	131	**2,997**
Merrimack	506	1,795	53	12	156	1,231	40	0	**3,793**
Narraguagus	314	981	28	61	167	2,725	74	176	**4,526**
Pawcatuck	2	151	1	0	1	25	1	0	**181**
Penobscot	15,400	57,253	356	758	921	5,297	46	107	**80,138**
Pleasant	21	76	0	0	71	446	3	2	**619**
Saco	185	716	5	7	55	136	6	0	**1,110**
Sheepscot	39	151	0	0	85	548	13	0	**836**
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 2018 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 2018 and earlier).

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

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

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

Means includes year classes with complete return data (year classes of 2018 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	0	0	100	0	0
2018	20	4	0.203	0	0	0	0	100	0	0	0			0	0	100	0	
2019	34	0	0.000	0	0	0	0	0		0				0	0	0		

Means includes year classes with complete return data (year classes of 2018 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		0							0	0			
2021	3	0	0.000	0										0				
Total	**15,003**	**2,558**																
Mean			**0.333**	**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 2018 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 2018 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	0	0	100	0	0
2018	11	3	0.272	0	0	0	0	100	0	0	0			0	0	100	0	
2019	21	0	0.000	0	0	0	0	0		0				0	0	0		
2020	15	0	0.000	0	0		0							0	0			
2021	3	0	0.000	0										0				
Total	**2,465**	**382**																
Mean			**0.225**	**0**	**19**	**0**	**4**	**53**	**0**	**0**	**6**	**0**	**0**	**0**	**23**	**53**	**6**	**0**

Means includes year classes with complete return data (year classes of 2018 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 2018 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	0	0	100	0	0	0
Total	**4,183**	**1,422**																
Mean			**2.082**	**0**	**2**	**0**	**13**	**62**	**3**	**2**	**7**	**0**	**0**	**0**	**15**	**64**	**11**	**0**

Means includes year classes with complete return data (year classes of 2018 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 2018 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	0	0	0
2019	2	0	0.000	0	0	0	0	0		0				0	0	0		
2021	0	0	0.000	0										0				
Total	**635**	**27**																
Mean			**0.099**	**0**	**3**	**1**	**1**	**27**	**0**	**0**	**3**	**0**	**0**	**0**	**4**	**27**	**3**	**0**

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 2018 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	0	0	100	0	0
2018	9	1	0.115	0	0	0	0	100	0	0	0			0	0	100	0	
2019	13	0	0.000	0	0	0	0	0		0				0	0	0		
2020	7	0	0.000	0	0		0							0	0			
Total	**601**	**124**																
Mean			**0.196**	**0**	**15**	**0**	**4**	**55**	**0**	**0**	**0**	**0**	**0**	**0**	**19**	**55**	**0**	**0**

Means includes year classes with complete return data (year classes of 2018 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 2018 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 2018 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 2018 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	0	0	18	66	17	0
2018	114	117	1.024	0	0	0	9	77	2	0	12			0	9	77	14	
2019	63	96	1.521	1	0	0	0	99		0				1	0	99		
2020	61	2	0.033	0	0		100							0	100			
2021	24	0	0.000	0										0				
Total	**3,204**	**5,787**																
Mean			**4.324**	**0**	**0**	**0**	**15**	**73**	**1**	**3**	**8**	**0**	**0**	**0**	**15**	**76**	**9**	**0**

Means includes year classes with complete return data (year classes of 2018 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		1.024
2019		0.000	0.000		0.000	0.000		1.521
2020			0.000		0.000	0.000		0.033
2021		0.000	0.000			0.000		0.000
Mean	**2.003**	**0.102**	**0.336**	**0.452**	**0.198**	**0.223**	**0.174**	**4.375**
StDev	**4.932**	**0.362**	**0.433**	**0.684**	**0.250**	**0.292**	**0.168**	**5.996**

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	0	0	0	17	74	1	2	8	0	0	0	17	77	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 2023.

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. Natural and total escapement estimates do not incorporate any information on age distribution or sex ratios and should be used with caution in any other analyses.

					Pre-Spawn Stocking		
Drainage	**Estimated Returns**	**Broodstock Take**	**Observed Mortalities**	**Natural Escapement**	**Captive/ Domestics**	**Sea Run**	**Total Escapement**
Androscoggin	8	0	0	8	0	0	8
Cove Brook	0	0	0	0	0	0	0
Dennys	0	0	0	0	17	0	17
Ducktrap	3	0	0	3	0	0	3
East Machias	17	0	0	17	23	0	40
Great Works Stream	8	0	0	8	0	0	8
Kenduskeag Stream	11	0	0	11	0	0	11
Kennebec	162	0	1	161	0	0	161
Machias	12	0	0	12	322	0	334
Narraguagus	21	0	0	21	0	0	21
Penobscot	1,570	752	3	815	1,275	243	2,333
Pleasant	14	0	0	14	41	0	55
Saco	4	0	0	4	0	0	4
Sheepscot	10	0	0	10	24	0	34
Souadabscook Stream	0	0	0	0	0	0	0
Union	0	0	0	0	0	0	0
Totals	**1840**	**752**	**4**	**1084**	**1702**	**243**	**3,029**

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. Natural and total escapement estimates do not incorporate any information on age distribution or sex ratios and should be used with caution in any other analyses.

						Pre-Spawn Stocking		
Drainage	**Year**	**Estimated Returns**	**Broodstock Take**	**Observed Mortalities**	**Natural Escapement**	**Captive/ Domestic**	**Sea Run**	**Total Escapement**
Androscoggin	1983 - 2013	783	0	0	783	0	0	783
	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
	2023	8	0	0	8	0	0	8
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
	2023	0	0	0	0	0	0	0
Dennys	1967 - 2013	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
	2023	0	0	0	0	17	0	17

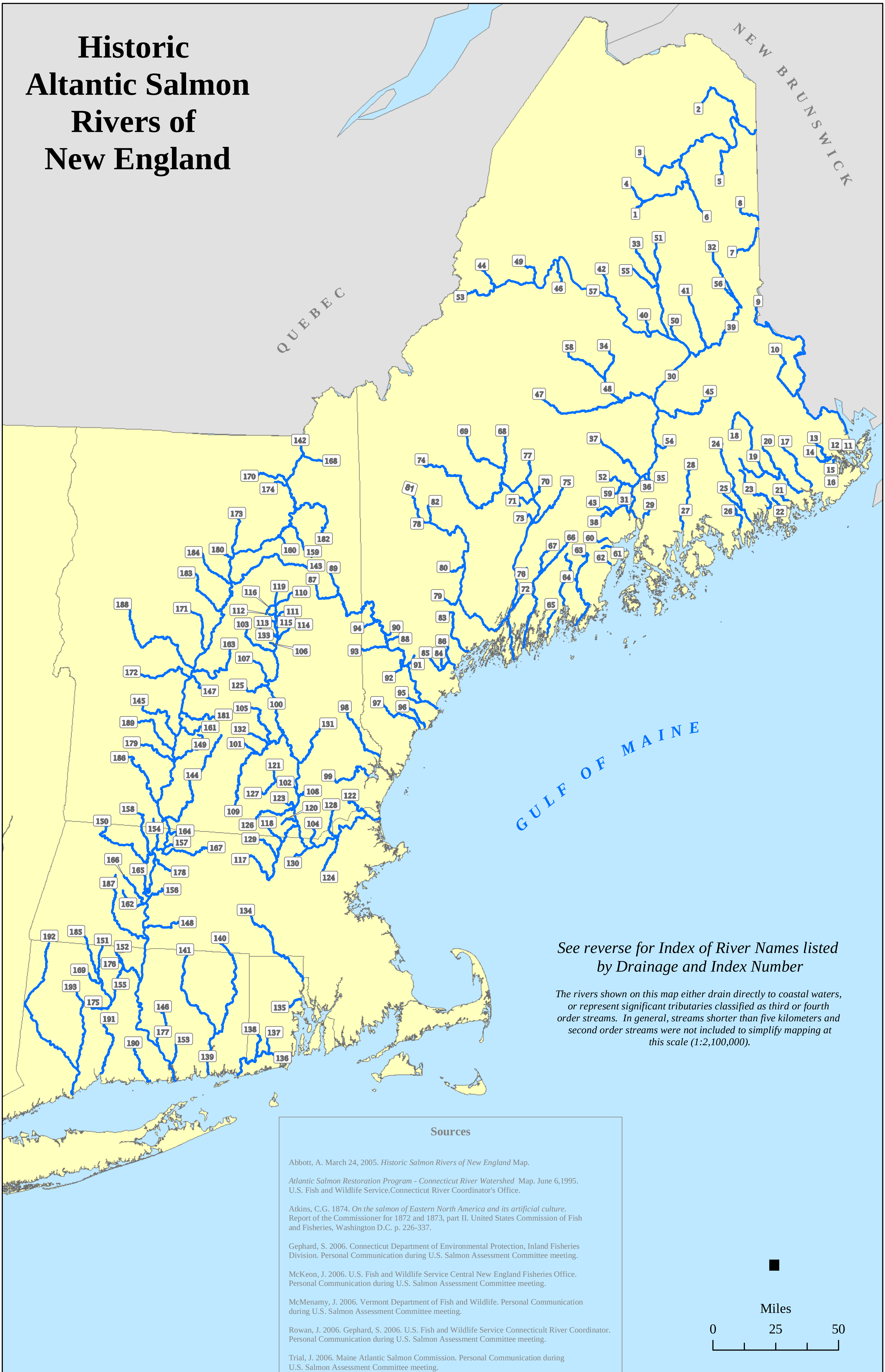
Drainage	Year	Estimated Returns	Broodstock Take	Observed Mortalities	Natural Escapement	Pre-Spawn Stocking Captive/ Domestic	Pre-Spawn Stocking Sea Run	Total Escapement
Ducktrap	1985 - 2013	325	0	0	325	0	0	325
	2014	7	0	0	7	0	0	7
	2017	4	0	0	4	0	0	4
	2018	0	0	0	0	0	0	0
	2019	0	0	0	0	0	0	0
	2020	0	0	0	0	0	0	0
	2021	2	0	0	2	0	0	2
	2022	5	0	0	5	0	0	5
	2023	3	0	0	3	0	0	3
East Machias	1967 - 2013	948	0	0	948	374	0	1322
	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
	2023	17	0	0	17	23	0	40
Great Works Stream	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
	2023	8	0	0	8	0	0	8
Kenduskeag Stream	2017	9	0	0	9	0	0	9
	2018	0	0	0	0	0	0	0
	2019	6	0	0	6	0	0	6
	2022	5	0	0	5	0	0	5
	2023	11	0	0	11	0	0	11
Kennebec	1975 - 2013	383	0	7	376	196	0	572
	2014	18	0	0	18	0	0	18
	2015	31	0	0	31	0	0	31
	2016	39	0	0	39	0	0	39

Drainage	Year	Estimated Returns	Broodstock Take	Observed Mortalities	Natural Escapement	Pre-Spawn Stocking Captive/ Domestic	Pre-Spawn Stocking Sea Run	Total Escapement
Kennebec	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
	2023	162	0	1	161	0	0	161
Machias	1967 - 2013	2826	0	0	2826	451	0	3277
	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
	2023	12	0	0	12	322	0	334
Narraguagus	1967 - 2013	4091	0	1	4090	0	0	4090
	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
	2023	21	0	0	21	0	0	21
Penobscot	1968 - 2013	70928	18595	217	52116	0	417	52533
	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

Drainage	Year	Estimated Returns	Broodstock Take	Observed Mortalities	Natural Escapement	Pre-Spawn Stocking Captive/ Domestic	Pre-Spawn Stocking Sea Run	Total Escapement
Penobscot	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
	2023	1570	752	3	815	1275	243	2333
Pleasant	1967 - 2013	496	0	0	496	56	0	552
	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
	2023	14	0	0	14	41	0	55
Saco	1985 - 2013	1070	0	5	1065	0	0	1065
	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
	2023	4	0	0	4	0	0	4
Sheepscot	1967 - 2013	695	0	0	695	337	0	1032
	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

Drainage	Year	Estimated Returns	Broodstock Take	Observed Mortalities	Natural Escapement	Pre-Spawn Stocking Captive/ Domestic	Pre-Spawn Stocking Sea Run	Total Escapement
Sheepscot	2020	14	0	0	14	0	0	14
	2021	11	0	0	11	0	0	11
	2022	9	0	0	9	0	0	9
	2023	10	0	0	10	24	0	34
Souadabscook Stream	2017	4	0	0	4	0	0	4
	2019	3	0	0	3	0	0	3
	2020	0	0	0	0	0	0	0
	2021	0	0	0	0	0	0	0
	2022	0	0	0	0	0	0	0
	2023	0	0	0	0	0	0	0
St Croix	1981 - 2013	4227	0	0	4227	0	0	4227
Union	1973 - 2013	2170	0	32	2138	0	0	2138
	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
	2021	0	0	0	0	0	0	0
	2022	0	0	0	0	0	0	0
	2023	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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Historic Atlantic Salmon Rivers of New England – Index

Drainage	River Name	Index
Aroostook	Aroostook River	1
	Little Madawaska River	2
	Big Machias River	3
	Mooseleuk Stream	4
	Presque Isle Stream	5
	Saint Croix Stream	6
St. John	Meduxnekeag River	7
	North Branch Meduxnekeag River	8
St. Croix	Saint Croix River	9
	Tomah Stream	10
Boyden	Boyden Stream	11
Pennamaquan	Pennamaquan River	12
Dennys	Dennys River	13
	Cathance Stream	14
Hobart	Hobart Stream	15
Orange	Orange River	16
East Machias	East Machias River	17
Machias	Machias River	18
	Mopang Stream	19
	Old Stream	20
Chandler	Chandler River	21
Indian	Indian River	22
Pleasant	Pleasant River	23
Narraguagus	Narraguagus River	24
	West Branch Narraguagus River	25
Tunk	Tunk Stream	26
Union	Union River	27
	West Branch Union River	28
Penobscot	Orland River	29
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	Cove Brook	31
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	East Branch Pleasant River	34
	Eaton Brook	35
	Felts Brook	36
	Kenduskeag Stream	37
	Marsh Stream	38
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	Millinocket Stream	40
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	Souadabscook Stream	52
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	West Branch Mattawamkeag River	56
	West Branch Penobscot River	57
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	West Branch Souadabscook Stream	59
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Little	Little River	61
Ducktrap	Ducktrap River	62
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Medomak	Medomak River	64
	Pemaquid River	65
Sheepscot	Sheepscot River	66
	West Branch Sheepscot River	67
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Androscoggin	Androscoggin River	78
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Presumpscot	Presumpscot River	84
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	Ellis River	89
	Hancock Brook	90
	Josies Brook	91
	Little Ossipee River	92
	Ossipee River	93
	Shepards River	94
	Swan Pond Brook	95
Kennebunk	Kennebunk River	96
Mousam	Mousam River	97
Cocheco	Cocheco River	98
Lamprey	Lamprey River	99
Merrimack	Merrimack River	100
	Amey Brook	101
	Baboosic Brook	102
	Baker River	103
	Beaver Brook	104
	Blackwater River	105
	Bog Brook	106
	Cockermouth River	107
	Cohas Brook	108
	Contoocook River	109
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	Eastman Brook	111
	Glover Brook	112
	Hubbard Brook	113
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	Mill Brook (Merrimack)	115
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	Nissitissit River	118
	Pemigewasset River	119
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	Piscataquog River	121
	Powwow River	122
	Pulpit Brook	123
	Shawsheen River	124
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	South Branch Piscataquog River	127
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Pawtuxet	Pawtuxet River	135
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	Shetucket River	141
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	Ammonoosuc River	143
	Ashuelot River	144
	Black River	145
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	Paul Stream	174
	Pequabuck River	175
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	Upper Ammonoosuc River	182
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	Wells River	184
	West Branch Farmington River	185
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	White River	188
	Williams River	189
Hammonasset	Hammonasset River	190
Quinnipiac	Quinnipiac River	191
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