Atlantic Salmon Recovery Framework:

2012 Annual Report

A summary of the collaborative actions undertaken by the State of Maine, US Government, Penobscot Nation, and non-governmental organizations to recover the Gulf of Maine Distinct Population Segment of Atlantic salmon in calendar year 2012.

Prepared by

US Fish and Wildlife Service

Maine Department of Marine Resources

and

National Marine Fisheries Services

Executive Summary

The Stock Assessment Action Team (SAAT) goals are to assess the status and trends of the stocks that comprise the Gulf of Maine Distinct Population Segment (GOM DPS). Estimated total adult Atlantic salmon returns to rivers in the geographic area of the GOM DPS in 2012 were 744. Most of the returns were to rivers in the Penobscot Bay Salmon Habitat Recovery Unit (SHRU). The number of potential spawners in rivers during autumn, known as escapement, was 752. Escapement of all ages to the GOM DPS area was not evenly distributed among the SHRUs. Escapement was at most 29% of the estimated 2SW Conservation Spawner Escapement (CSE) target for rivers in the Downeast Coastal SHRU; 2% of CSE for rivers in the Penobscot Bay SHRU, and 2% of CSE for the rivers in the Merrymeeting Bay SHRU. The current ten-year geometric mean replacement rate, calculated from naturally reared returns with a five year time lag, exceeded 1.0 for both the Merrymeeting Bay SHRU and Downeast Coastal SHRU. Hatchery parr-to-adult survival (PAR), which may include residence from 8 months to two years in freshwater, was similar between the Narraguagus hatchery parr and the accelerated growth parr stocked in the Penobscot River.

In 2012, the Conservation Hatchery Action Team (CHAT) worked collaboratively to implement programs to prevent extinction and to maintain effective population size and genetic diversity of river specific Atlantic salmon populations in Maine. Approximately 3,000,100 salmon fry, 406,800 parr, 686,400 smolts, 486 pre-spawn adults, and 2,085 post-spawn adults were stocked into 10 rivers in Maine throughout the year. The USFWS provided eggs to the Downeast Salmon Federation hatchery facilities on the Pleasant and East Machias rivers. Both Green Lake and Craig Brook National Fish Hatcheries conducted fish health inspections and screenings to ensure high quality, healthy fish for salmon stocking efforts in Maine. Photoperiod was manipulated at Craig Brook to delay spawning of the 481 Penobscot River sea-run broodstock, shift incubation at the hatchery to optimal water temperatures, and improve synchrony of fry development and environmental conditions at the time of release. The CHAT, in collaboration with other Action Teams, reviewed proposals for new actions focused on new stocking strategies, determining fish passage effectiveness at hydropower dams in the Penobscot River watershed, and potential behavioral differences inadvertently created by handling and tagging of hatchery salmon.

Maintaining genetic diversity and preserving the genetic structure present in Atlantic salmon is a critical component of recovery of Atlantic salmon in Maine. The Genetic Diversity Action Team (GDAT) has identified 27 actions in three primary focus areas: monitoring genetic diversity, evaluating hatchery practices and products, and monitoring to detect aquaculture Atlantic salmon. These actions are consistent with current broodstock management and include monitoring and evaluating hatchery management practices, and performance (survival) of hatchery products in the wild. Estimates of genetic diversity within each broodstock, broodstock screening, and genetic parentage assessments of broodstock that are basis for GDAT actions are provided.

Marine ecology of Atlantic salmon has often been equated to a black box, however, new research tools and integrated oceanography and bioenergetics models are providing new insights into the ecology of salmon at sea. During 2012, the Marine and Estuarine Action Team (MEAT) took an interdisciplinary, multiagency, and multinational approach to increase understanding of the structure and function of estuarine and marine communities and migration ecology of Atlantic salmon. This year's activities were primarily research and assessment projects that sought to understand the estuarine and marine ecology and migration of Atlantic salmon. Team members have used broad-based estuary sampling methods to characterize the spatial and temporal distribution of the estuarine community's biomass in the Penobscot system. Efforts are being made to investigate predation impacts in both the estuarine environment (through the use of acoustic telemetry) and in the nearshore marine environment (analyzing stomach contents of ground fish stocks). Additional work related to Atlantic salmon smolts swimming depth and marine distribution was reported in peer reviewed manuscripts furthering our understanding of marine habitat use. For the Penobscot and Downeast SHRUs marine survival for stocks is reported in terms of smolt to adult ratio (SAR); in 2013 members of MEAT drafted a preliminary SAR for the Merrymeeting Bay SHRU. With severely warm ocean conditions in 2012, the working group started evaluations of data from this year to see if anomalies are apparent in smolt behavior or early marine survival.

The mission of the Freshwater Action Team (FWAT) is to increase production of river-reared smolts and by extension, increase wild adult salmon. Strategies for increasing smolt production include identification and restoration of degraded habitat, increasing juvenile salmon survival, and improving the reproductive success of returning adults. Catch per unit effort (CPUE) surveys measuring relative abundance of juvenile salmon (Generalized Random-Tessellated Stratified (GRTS) sampling) were conducted to inform long term population response to management actions and environmental variation. Depletion sampling to obtain juvenile population estimates was conducted to address specific research questions. Spawning inventories (redd counts) were used to monitor the distribution and abundance of adult spawners and potential juvenile recruitment; and adult salmon traps and smolt traps were selectively deployed in all SHRUs to estimate smolt production and adult salmon returns. Severe declines were observed in all age classes of adult returns and resulted in low spawning escapement. Habitat restoration projects undertaken by state and federal agencies and NGOs included removing remnant log drive dams and adding large wood at strategic locations to improve habitat quality in Downeast rivers and in the upper Penobscot River. A collaborative project investigating the buffering capacity and environmental response of adding clam shells to stream reaches was expanded in 2012 following positive results at Dead Stream treatment sites. The relationship between water temperature, habitat suitability, and salmon performance was investigated in the Narraguagus and Machias watersheds. The USFWS also developed an ARC View mapping tool to assist NGOs and state and federal agencies identify areas for habitat restoration and protection. New "Chop and Drop" legislation was passed in 2012 that streamlines the permitting process for large wood addition projects to improve salmonid habitat.

The Connectivity Action Team (CAT) focused on reconnecting headwater areas that are important for salmon spawning and rearing with the Gulf of Maine, highlighting four categories of actions in 2012: 1) Developing a list of barrier priorities for the GOM DPS and implementing connectivity restoration projects in a strategic fashion; 2) Monitoring and reporting on the effectiveness of connectivity restoration projects; 3) Minimizing the effects of existing fish passage barriers (such as dams) and providing incidental take authorization where appropriate; and 4) Increase awareness of the need to co-restore the suite of co-evolved diadromous species. Accomplishments with regards to enhancing the connectivity of seasonally important habitats are included in this report.

The Education and Outreach Action Team (EOAT) worked in 2012 to develop a comprehensive outreach, education and stakeholder engagement strategy; and to do some advanced planning for public outreach when the Revised Atlantic Salmon Recovery Plan will be released for public review in the Federal Register (now estimated for February 2014). To this end, the EOAT met twice and held numerous conference calls among a smaller subset of interested parties to work on the strategy and, later, to help set the development of a new website in motion.

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Strategy

Assess the status and trends of the stocks that comprise the GOM DPS.

Adult Returns

Estimated total adult Atlantic salmon returns to rivers in the geographic area of the Gulf of Maine DPS (73 FR 51415-51436) in 2012 were 744. Most of the returns were to the Penobscot Bay Salmon Habitat Recovery Unit (SHRU) (Figure 1.1). Returns are the sum of counts at fishways and weirs (648) and estimates from redd surveys (96). Counts were obtained at fishway trapping facilities on the Androscoggin, Narraguagus, Penobscot, Kennebec, and Union rivers, and at a new trap on the Pleasant River. Fall conditions were suitable for adult dispersal throughout the rivers and allowed redd counting. Approximately 76 % of documented spawning habitat was surveyed in the Downeast Coastal SHRU. In the other SHRUs, surveys were in selected sub-watersheds resulting in approximately 14 % coverage. The origin of the returns (hatchery or naturally reared) varied among the SHRUs (Figure 1.2), with the lowest percentage of naturally reared salmon in the population occurring in the Penobscot Bay SHRU.

In 2012 the numbers of potential spawners in rivers during autumn, known as escapement, was 752. This includes the 481 pre-spawn captive broodstock stocked in the Dennys, East Machias, Machias, Pleasant and Sheepscot rivers and one captive repeat spawner on the Narraguagus. Escapement to the GOM DPS area was not evenly distributed among the SHRU and was at most 29% of the estimated 2SW Conservation Spawner Escapement for rivers within a SHRU (Table 1.1). Differences in escapement were influenced by broodstock removal, smolt and pre-spawn captive broodstock stocking (Table 1.1).

Table 1.1. Estimated 2012 spawner escapement into rivers within the three geographic areas defined as Salmon Habitat Recovery Units (SHRU) for the GOM DPS. Escapement = Returns – Losses + Stocked pre-spawn adults. Returns = includes sea run returns and captive reared repeat spawners. Losses = broodstock and documented mortalities. Stocked = number of mature captive reared adults released to spawn naturally. CSE = Conservation spawner escapement for rivers within each SHRU (Beland 1984 and Colligan et al. 1999).

SHRU	Returns	Losses	Stocked	Escapement	CSE	% CSE
Downeast Coastal [1]	100		446	546	1,865	29%
Penobscot Bay [2]	624	474		150	6,942	2%
Merrymeeting Bay	21		35	56	3,280	2%
Total	745	474	481	752	12,087	6%

[1] sea run returns, redd estimates + 1 captive reared return

[2] sea run returns, redd estimates - broodstock to CBNFH

For this report, replacement rates were estimated based on naturally reared returns, however, the team is working to integrate estimates of escapement into the calculations. Most of the adults were 2SW salmon that emigrated as 2 year old smolt, thus, cohort replacement rates were calculated assuming a five year lag. These rates were used to calculate the geometric mean for the previous ten years (e.g. for 2000: 1991 to 2000) for the naturally reared component of returns to the GOM DPS overall and in each of three Salmon Habitat Recovery Units (SHRU). From the mid 1990's to 2011, estimated (adult to adult) replacement rate for naturally reared returns to the GOM DPS as a whole did not exceed one (Figure 1.3). In 2012, the ten-year geometric mean replacement rate exceeded 1.0 for the GOM DPS and both the Merrymeeting Bay and Downeast Coastal SHRU.

We also calculated apparent sub-basin redd to redd replacement (2007 to 2012) rates for sea run returns and stocked adults in selected sub watersheds. In 2012, the redd to redd replacement of 0.95 for Old Stream documents true sea run return replacement, as no fry were stocked in the system over the period. The replacement rate for captive reared adults on the Chase Mill Stream in the East Machias River was 0.09, while for Mopang and Hobart streams the rate was 0.0.

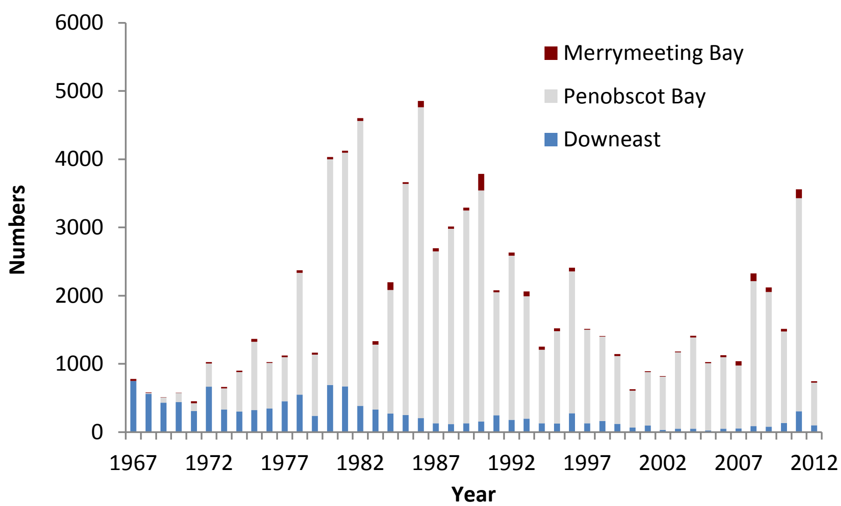

Figure 1.1. Documented returns of Atlantic salmon to the GOM DPS by Salmon Habitat Recovery Units (SHRU). Numbers include angler harvests (up to 1986 on the Pleasant and 1995 on other rivers), trap and weir counts, and redd based estimates (1991 to 2012).

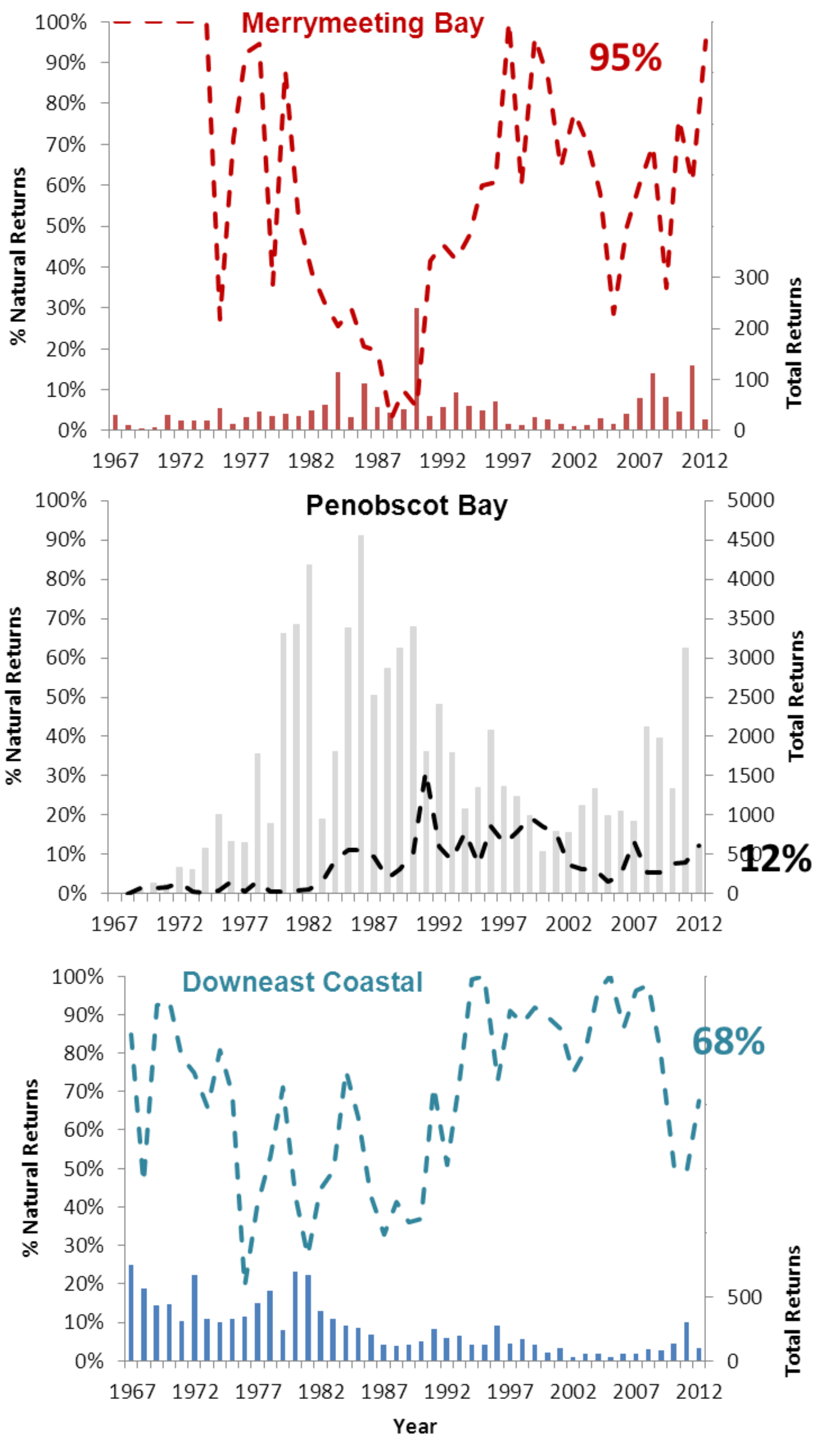

Figure 1.2. Number of returns (bars) that were naturally reared Atlantic salmon in the three Salmon Habitat Recovery Units (SHRU) defined for the GOM DPS and their estimated percentage (dashed line) of total returns. Percent natural returns in 2012 in bold on right of graphs.

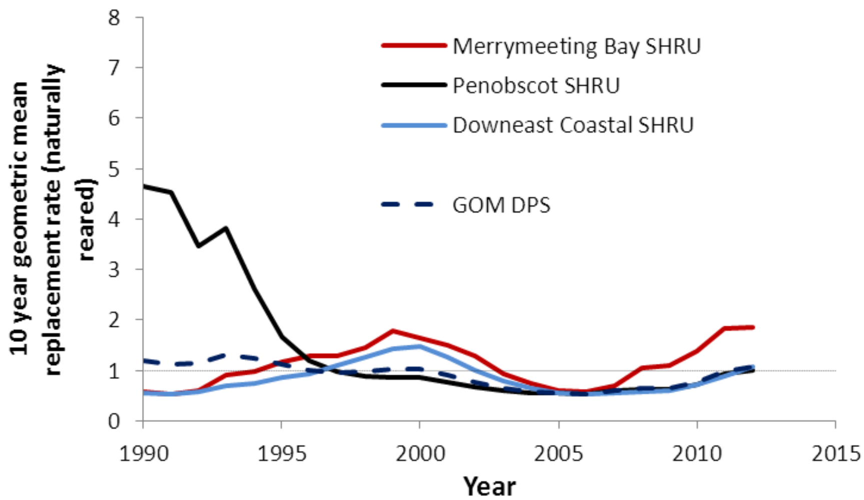

Figure 1.3. Ten year geometric mean of replacement rate for returning naturally reared Atlantic salmon in the GOM DPS and in the three Salmon Habitat Recovery Units (SHRU).

Downeast Coastal SHRU

Sea Run Spawners. Returns in 2012 were based on adult captures at the Cherryfield fishway trap, a fishway trap at Saco Falls on the Pleasant River, and a fishway trap operated by Black Bear Hydro Partners, LLC on the Union River in Ellsworth below Graham Lake. Although the Dennys Weir was operated for a portion of the year, no adult returns were captured. Staff documented 17 sea-run salmon ascending the Narraguagus River fishway and two sea run salmon on the Pleasant River. No salmon were captured in the trap on the Union River.

Estimated returns were extrapolated from redd count data using a return-redd regression based on redd and adult counts from 1991-2009 on the Narraguagus River, Dennys River and Pleasant River (USASAC 2010). In the Machias drainage, 24 redds were attributed to sea run spawners during surveys covering approximately 58% of the spawning habitat area. Six (6) redds attributed to wild returns were counted during the 2012 redd surveys in the East Machias River that included approximately 96% of known spawning habitat area. The 75 redds counted during surveys by canoe and foot covering approximately 76% of Narraguagus River spawning habitat area indicated more salmon had entered the river than were counted at the trap, no fish were seen on video. The same was true on the Pleasant River, where the 9 redds attributed to sea-run returns during surveys of about 84% of spawning habitat area exceeded the 2 returns documented at the trap. Thus, for 2012 the redd estimates for these two rivers were used in estimating returns to the SHRU and GOM DPS.

Captive Reared Spawners. A total of 446 CBNFH captive reared spawners were stocked into rivers in the Downeast Coastal SHRU in 2012. Stockings were all into their river of origin: Dennys River (257), East Machias River (52), Machias River (81), and Pleasant (56). Spawning activity was observed in all rivers where these fish were stocked. Only fourteen (14) redds were counted during the 2012 redd surveys on the Dennys River that included approximately 89% of known spawning habitat area. On the East Machias 36 redds were located in Northern Stream. Forty nine (49) redds were documented in the West Branch of the Machias watershed where adults were stocked. On the Pleasant River 4 redds were attributed to the stocked adults.

Penobscot Bay SHRU

Sea Run Spawners. Adult returns to the SHRU were dominated by captures at the Veazie Dam fishway trap on the Penobscot River. A total of 624 sea run Atlantic salmon were captured during 2012. Of these, 150 were released directly into the Penobscot River upstream of the Veazie Trap, the remaining 474 were retained as broodstock. Thus, total escapement to the Penobscot River above the Veazie Dam in 2012 was 150 Atlantic salmon.

Estimated escapement to the Ducktrap River and Cove Brook was zero (0) based on redd counts. The survey on the Ducktrap River encompassed 70% of the spawning habitat area in the watershed and on Cove Brook 100% of identified Atlantic salmon spawning habitat was surveyed.

Merrymeeting Bay SHRU

Sea Run Spawners. Adult returns were counted at traps on the Androscoggin and Kennebec Rivers. No adult sea run Atlantic salmon were captured at the Brunswick fishway trap on the Androscoggin River. On the Kennebec River, the sea-run Atlantic salmon catch at the Lockwood fish lift was 5 adults; all were trucked and released to the Sandy River. During 2012, no adult Atlantic salmon were captured or observed at the Benton Falls fish lift on the Sebasticook River, a Kennebec River tributary. Redd surveys conducted on the Sheepscot River focused on spawning habitat in the middle portion of the mainstem and West Branch and documented a total of 12 redds.

Captive Reared Spawners. Redds could not be attributed to captive reared adults stocked in the Sheepscot River.

Juvenile Population Status

A Generalized Random - Tessellated Stratified (GRTS) design (Stevens and Olsen 2004) was implemented for the 2012 sampling season. Site lists were developed for the DE SHRU, the Penobscot, and the Sheepscot River and Sandy River in the Merrymeeting Bay SHRU. Selection criteria included stream width and drainage. The sampling frame was selected using a combination of the NHD Flow line feature and the Habitat Model developed by Wright et al. (2011). Analyses based on this sampling design are in progress.

MDMR conducted electrofishing surveys to monitor spatial and temporal abundance of Atlantic salmon juveniles at 295 sites in 2012. One hundred and forty (140) of the sites were randomly selected (GRTS). Two sampling methods were used; the first estimated total abundance at sites and produced density in fish/unit, where one unit equals 100 m^2. The second method was based on standardized wand sweeping protocols for 300 seconds of wand time (catch per unit effort (CPUE) and produced relative abundance in fish/minute. Data aggregated by SHRU (Table 1.2) document the relative low juvenile Atlantic salmon populations throughout the geographic range of the Gulf of Maine DPS in the last six years.

An index of juvenile abundance, calculated using annual densities (log + 0.01 transformed) at sites with more than ten years of data, confirms the relative low densities (Figure 4). A mixed random effects general linear model was used to analyze the data, with years specified as fixed effects; sites within 10 digit HUCs and 10 digit HUCs within years considered random effects. A "no intercept" model was specified. The index is the estimated annual least square means (SE) back transformed from logarithms to density. The index is sensitive to sample size (Figure 1.4), evidenced by the large standard error for

1985 (n = 2) compared to those for 2000 to 2007 (N > 50). Since 1994, the year fry stocking exceeded 11,000,000 and five years after sampling increased, there seems to be an increasing trend (0.1 units/year). A similar index will be produced for relative abundances, when more years of data are available.

Table 1.2. Minimum (min), median, and maximum (max) density (fish/100m2) and relative abundance (fish/minute) of Atlantic salmon juveniles. Data from sampled rivers were aggregated by Salmon Habitat Recovery Unit (SHRU), 2006 to 2012**.**

SHRU	Year	Density fish / unit								CPUE fish / minute							
		Parr				YOY				Parr				YOY			
		N	Min	Median	Max	N	Min	Median	Max	N	Min	Median	Max	N	Min	Median	Max
Downeast Coastal	2006	76	0.0	**2.8**	35.2	73	0.0	**2.8**	51.5	139	0.0	**1.0**	3.5	155	0.0	**1.4**	4.3
	2007	55	0.0	**2.9**	22.3	53	0.4	**7.3**	58.9	133	0.0	**0.6**	5.1	141	0.0	**1.6**	15.3
	2008	43	0.0	**3.6**	20.2	43	0.0	**7.0**	73.8	18	0.0	**0.0**	1.0	18	0.0	**0.3**	8.8
	2009	56	0.0	**3.7**	32.5	56	0.0	**7.7**	36.5	49	0.0	**0.8**	20.4	54	0.0	**1.6**	15.4
	2010	29	0.5	**5.2**	28.0	29	0.0	**8.0**	89.1	91	0.0	**1.0**	8.8	96	0.0	**1.4**	15.5
	2011	19	0.0	**2.8**	94.6	19	0.0	**3.4**	65.7	173	0.0	**0.8**	8.7	173	0.0	**0.6**	6.3
	2012	9	0.6	**2.8**	11.4	9	0.0	0.7	19.9	68	0.0	**0.5**	3.2	69	0.0	**0.2**	5.4
Penobscot Bay	2006	74	0.0	**0.2**	26.9	48	0.0	**0.0**	67.2	24	0.0	**0.0**	1.6	34	0.0	**0.0**	2.2
	2007	49	0.0	**0.0**	33.7	25	0.0	**0.0**	66.8	41	0.0	**0.0**	2.5	53	0.0	**0.0**	1.8
	2008	11	0.0	**6.7**	17.8	11	0.0	**19.9**	47.1	82	0.0	**0.0**	1.5	88	0.0	**0.0**	6.8
	2009	10	0.0	**7.9**	20.4	10	4.1	**29.8**	39.7	161	0.0	**0.0**	2.9	163	0.0	**0.0**	4.5
	2010	7	0.0	**17.0**	22.1	8	0.0	**0.7**	29.5	86	0.0	**0.0**	3.9	95	0.0	**0.8**	16.0
	2011	5	0.0	**7.0**	14.9	5	0.0	**4.1**	49.8	87	0.0	**0.0**	3.8	87	0.0	**0.0**	5.7
	2012	13	0.0	**1.5**	13.0	13	0.0	21.9	69.9	90	0.0	**0.0**	3.1	90	0.0	**0.8**	14.0
Merrymeeting Bay	2006	42	0.0	**1.3**	23.4	41	0.0	**0.3**	25.3	12	0.0	**0.0**	0.6	11	0.0	**0.0**	4.0
	2007	33	0.0	**0.3**	50.3	33	0.0	**4.0**	69.8	37	0.0	**0.0**	2.6	33	0.0	**0.2**	5.0
	2008	26	0.0	**1.6**	21.7	27	0.0	**2.2**	38.9	38	0.0	**0.0**	0.8	39	0.0	**0.0**	1.4
	2009	17	0.0	**6.0**	21.7	17	0.0	**3.1**	28.1	46	0.0	**0.0**	3.3	48	0.0	**0.2**	9.4
	2010	22	0.0	**2.1**	16.6	21	0.0	**3.0**	109.9	110	0.0	**0.0**	2.9	112	0.0	**0.8**	29.4
	2011	17	0.0	**8.7**	44.5	17	0.0	**1.9**	43.3	45	0.0	**0.2**	4.4	45	0.0	**0.2**	9.8
	2012	20	0.0	**2.3**	16.0	20	0.0	**6.6**	77.5	108	0.0	**0.2**	4.9	107	0.0	**0.4**	13.0

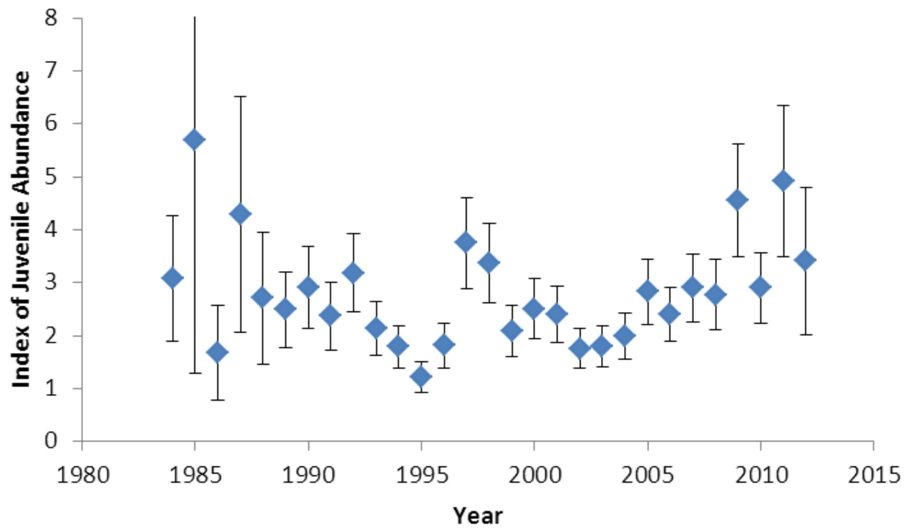

Figure 1.4. Index of parr abundance in the Gulf of Maine DPS, based on juvenile salmon assessments conducted from 1984 to 2012.

Smolt Abundance

MDMR conducted seasonal field activities enumerating smolt populations using Rotary Screw Traps (RSTs) in one river in each SHRU. Scientists generated population estimates from mark recapture data (Bjorkstedt 2005; Bjorkstedt 2010).

Downeast Coastal SHRU

On the Narraguagus River 5,669 smolts were handled, 120 (2.1%) of which were recaptures. During the first week of May, ~ 63,000 age 1+ salmon smolts were stocked, and therefore most (93%) of the smolts captured were hatchery origin. The total estimate and standard error (STDER) of smolts (naturally reared, fall parr and hatchery stocked smolts) exiting the Narraguagus system was 42,261 ± 4,348. Similar to 2010 and 2011, the overall estimate was much lower than the known number of 1+ hatchery smolts that were stocked into the system. The population estimate (STDER) for naturally-reared smolts was 915 ± 232 smolts (Figure 6), considerably less than that of the previous year (1,404 ± 381) and slightly higher than the estimates from 2007-2009.

Penobscot Bay SHRU

Of the 455 naturally reared smolts collected in the Piscataquis River RSTs, 220 were marked and released 3.2 km upstream. Of these marked smolts, 61 (27.7%) were recaptured. The population estimate of emigrating smolts was 2,013 ± 353 (Figure 5), about 38 % of the estimate in 2011 (5,209 ± 1,312).

Merrymeeting Bay SHRU

A total of 375 smolts were captured at the Sheepscot River site, 240 of which were marked with an adipose clip, indicating they were stocked as 0+ parr in 2010 or 2011. The population estimate (STDER) of naturally-reared smolts was 1,101± 252 (Figure 6), about 65% of the 2010 estimate (1,702 ± 370). The estimate of hatchery origin smolts (stocked as fall parr in 2009 and 2010) was 2,102± 429 (STDER).

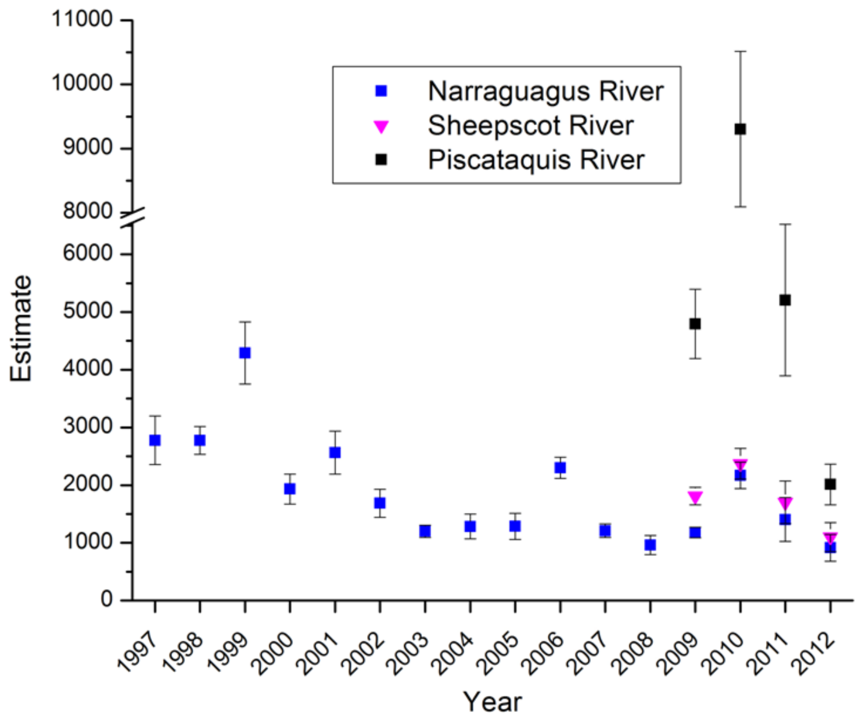

Figure 1.5. Population Estimates (± Std. Error) of emigrating smolts in the Narraguagus River (Downeast Coastal SHRU), Piscataquis River (Penobscot Bay SHRU), and Sheepscot River (Merrymeeting Bay SHRU), Maine from 1997 to 2012 using DARR 2.0.2.

Survival Estimates

Estuarine and Marine

Atlantic salmon survival rates were calculated for marked hatchery stocks and naturally reared stocks for the Narraguagus, Penobscot, and Sheepscot rivers (Table 1.3). Calculations were based on known numbers of stocked salmon, smolt estimates, and adult returns. Smolt-to-adult (SAR) survival rates, the available proxy for marine survival, varied by origin. Hatchery parr stocked on the Narraguagus River had the highest average SAR survival, followed by naturally reared salmon and hatchery smolts, respectively. Hatchery parr-to-adult survival (PAR), which may include from 8 months to two years in freshwater, was similar between the Narraguagus hatchery parr and the accelerated growth parr stocked in the Penobscot River.

Freshwater

Over the last eight years, survival rates of juvenile Atlantic salmon in freshwater were calculated based on stocking numbers and/or estimates of eggs deposited, 0+ and 1+ parr, and smolt populations for reaches or sub-watersheds. We estimated the survival rate for each freshwater residence period as:

$$\widehat{S_i} = \frac{\widehat{n_j}}{\widehat{n_i}} \text{ or } \frac{\widehat{n_j}}{n_i}$$

where $\widehat{S_i}$ is the life stage specific survival, $\widehat{n_i}$ is the estimated number or number stocked at lifestage *i* and $\widehat{n_j}$ is the estimated number at the following life stage j. To be able to use these rates in population models over varying periods of freshwater residence survival rates were converted to monthly survival based on the number of months encompassed by the transition from one stage to the next (Table 1.4).

$$\widehat{S}_{i_{monthly}} = \widehat{S_i}^{(1/months)}$$

Assessment biologists continue to identify opportunities to estimate survival.

Research Projects

An inventory of recently completed, ongoing, and supported projects is being maintained by the team (Table 1.5).

Table 1.3. Summary table of Atlantic salmon survival rates that include estuarine and marine life stages (a = recent cohorts, b= carried from previous reports) All rates for hatchery origin stocks were based on marked groups. Data represent cohorts where all 2 sea-winter adult returns have been accounted for. Therefore, in some cases, some 3 sea-winter adults may still be at large.

a Cohort Year	Salmon Habitat Recovery Unit	Drainage	Source	Survival From	Survival To	Number Stocked or Estimated	Number of survivors	% Survival
2008	Penobscot Bay	Penobscot	Hatchery Smolts	Smolt	Adult	512500	1005	0.196
2009	Penobscot Bay	Penobscot	Hatchery Smolts	Smolt	Adult	559828	2585	0.462
2010	Penobscot Bay	Penobscot	Hatchery Smolts	Smolt	Adult	567086	1227	0.216
2010	Downeast Coastal	Narraguagus	Naturally Reared	Smolt	Adult	2372	25	1.05
2010	Downeast Coastal	Narraguagus	Hatchery Smolts	Smolt	Adult	62400	76	0.12

b Cohort Year	Salmon Habitat Recovery Unit	Drainage	Source	Survival From	Survival To	Number Stocked or Estimated	Number of survivors	% Survival
2008	Downeast Coastal	Narraguagus	Hatchery Smolts	Smolt	Adult	54116	21	0.0388
2009	Downeast Coastal	Narraguagus	Hatchery Smolts	Smolt	Adult	52829	88	0.1666
2008	Downeast Coastal	Narraguagus	Hatchery Parr	Smolt	Adult	414	5	1.2077
2009	Downeast Coastal	Narraguagus	Hatchery Parr	Smolt	Adult	231	9	3.8961
2006	Downeast Coastal	Narraguagus	Naturally Reared	Smolt	Adult	2300	19	0.8261
2007	Downeast Coastal	Narraguagus	Naturally Reared	Smolt	Adult	1210	9	0.7438
2008	Downeast Coastal	Narraguagus	Naturally Reared	Smolt	Adult	962	7	0.7277
2009	Downeast Coastal	Narraguagus	Naturally Reared	Smolt	Adult	1180	24	2.0339
2006	Penobscot Bay	Penobscot	Hatchery Smolts	Smolt	Adult	169066	409	0.2419
2007	Penobscot Bay	Penobscot	Hatchery Smolts	Smolt	Adult	147619	529	0.3584
2008	Penobscot Bay	Penobscot	Hatchery Smolts	Smolt	Adult	147789	241	0.1631
2009	Penobscot Bay	Penobscot	Hatchery Smolts	Smolt	Adult	178034	673	0.3780
2006	Downeast Coastal	Narraguagus	Hatchery Parr	Parr	Adult	17476	5	0.0286
2007	Downeast Coastal	Narraguagus	Hatchery Parr	Parr	Adult	15687	9	0.0574
2002	Penobscot Bay	Penobscot	Hatchery Accelerated Parr	Parr	Adult	50249	27	0.0537
2003	Penobscot Bay	Penobscot	Hatchery Accelerated Parr	Parr	Adult	72835	26	0.0357
2004	Penobscot Bay	Penobscot	Hatchery Accelerated Parr	Parr	Adult	69719	34	0.0488
2005	Penobscot Bay	Penobscot	Hatchery Accelerated Parr	Parr	Adult	96320	41	0.0426
2006	Penobscot Bay	Penobscot	Hatchery Accelerated Parr	Parr	Adult	100541	54	0.0537
2007	Penobscot Bay	Penobscot	Hatchery Accelerated Parr	Parr	Adult	105577	23	0.0218

Table 1.4. Summary table of Atlantic salmon freshwater survival rates (period and monthly) based on number of hatchery product stocked or estimates of juvenile life stages or eggs spawned ((a = recent cohorts, b= carried from previous reports).

a Initial Life stage Cohort Year	SHRU Drainage	Source	Survival From	Survival To	Number Stocked or Estimated	Number of survivors	Approx. Months	Period % Survival	Monthly % Survival
	Merrymeeting Bay								
2008	Sheepscot	Hatchery	0 Parr	Smolt	13,048	1,618	19	12.4	89.6
2009	Sheepscot	Hatchery	0 Parr	Smolt	17925	1720	19	9.6	88.4
2010	Sheepscot	Hatchery	0 Parr	Smolt	14500	2102	19	14.5	90.3

b Initial Life stage Cohort Year	SHRU Drainage	Source	Survival From	Survival To	Number Stocked or Estimated	Number of survivors	Approx. Months	Period % Survival	Monthly % Survival
	Downeast Coastal								
2010	East Machias	Naturally Reared	Egg	YOY	30,055	1,397	10	4.6	73.6
2010	East Machias	Naturally Reared	Egg	YOY	30,055	370	10	1.2	64.4
2010	East Machias	Naturally Reared	Egg	YOY	15,028	1,356	10	9.0	78.6
2011	East Machias	Naturally Reared	Egg	YOY	26,607	86	10	0.3	56.4
2011	East Machias	Naturally Reared	Egg	YOY	35,476	17	10	0.05	46.6
2011	East Machias	Naturally Reared	Egg	YOY	79,821	4,177	10	5.2	74.5
2010	East Machias	Naturally Reared	YOY	Parr	1,397	410	12	29.3	90.3
2010	East Machias	Naturally Reared	YOY	Parr	370	244	12	65.9	96.6
2010	East Machias	Naturally Reared	YOY	Parr	1,356	1,042	12	76.8	97.8
2006	East Machias	Hatchery	YOY	Parr	1,670	1,077	12	64.5	96.4
2007	Narraguagus	Both	Parr	Smolt	10,213	1,020	8	10.0	75.0
2008	Narraguagus	Both	Parr	Smolt	12,959	750	8	5.8	70.0
2008	Narraguagus	Both	Parr	Smolt	8,245	1,082	8	13.1	77.6

Table 1.4. Continued

b Initial Life stage Cohort Year	SHRU Drainage	Source	Survival From	Survival To	Number Stocked or Estimated	Number of survivors	Approx. Months	Period % Survival	Monthly % Survival
	Merrymeeting Bay								
2009	Sheepscot	Naturally Reared	Egg	YOY	75,000	3,540	10	4.7	73.7
2009	Sheepscot	Naturally Reared	Egg	Parr	75,000	4,959	31	6.6	91.6
2010	Sandy	Hatchery	Egg	YOY	46,160	8,833	8	19.1	81.3
2010	Sandy	Hatchery	Egg	YOY	42,500	5,857	8	13.8	78.1
2010	Sandy	Hatchery	Egg	YOY	55,930	38,518	8	68.9	95.4
2010	Sandy	Hatchery	Egg	YOY	192,920	49,703	8	25.8	84.4
2010	Sandy	Hatchery	Egg	YOY	47,940	24,581	8	51.3	92.0
2010	Sandy	Hatchery	Egg	YOY	104,130	31,301	8	30.1	86.0
2010	Sandy	Hatchery	Egg	YOY	5,825	2,002	8	34.4	87.5
2010	Sandy	Hatchery	Egg	YOY	47,940	32,219	8	67.2	95.2
2004	Sheepscot	Hatchery	0 Parr	Parr	15,600	3,565	11	22.9	87.4
2005	Sheepscot	Hatchery	0 Parr	Parr	15,882	1,206	11	7.6	79.1
2006	Sheepscot	Hatchery	0 Parr	Parr	16,600	7,743	11	46.6	93.3
2007	Sheepscot	Hatchery	Fry	Parr	29,900	409	16	1.4	76.5
2008	Sheepscot	Hatchery	0 Parr	Parr	13,048	4,677	11	35.8	91.1

Table 1.5. Inventory of completed and ongoing assessment and research projects supported during TAC or Framework review, 2001 - 2012.

Contact	Project short title	Watersheds	Study Stocking years	Juvenile Field years	Adult Return years	Status	Reports
O. Cox	Smolt (alternate rearing) stocking	Narraguagus	2008-2012	2008-2012	2009-2014	Analysis	interim updates
E. Atkinson	Whole River Point stocking	Dennys	2007-2010	2008-2012	NA	Analysis	interim updates
J. Kocik	Fry stocking - Smolt & Adult genetics	Narraguagus	ongoing	ongoing	ongoing	Analysis	interim updates
J. van de Sande	East Machias Parr	East Machias	2012-2017	2012-2019	2014-2023	Data	interim updates
E. Atkinson	Single strategy - Captive reared pre-spawn adult stocking	Dennys	2011 - 2015	2012-2017	2014-2021	Data	interim updates
J. Zydlewski	Smolt acoustictag lab study	Penobscot	NA	2012	NA	Data	UM Thesis
J. Zydlewski	Smolt migration	Penobscot	2012 - 2014	2012 - 2014	2013 - 2016	Data	UM Thesis
J. Zydlewski	Smolt salinity lab study	Penobscot	NA	2012 - 2014	NA	Data	UM Thesis
J. Zydlewski	Penobscot PIT Tagging	Penobscot	NA	NA	2012 - 2014	Data	UM Thesis
J. Zydlewski	Al & pH smolt physiology	Narraguagus, Penobscot, Sheepscot	2012 - 2015	2012 - 2014	2013 -2016	Data	UM Thesis
P. Christman	Androscoggin River adults	Androscoggin River	NA	NA	2011-2013	Data	interim updates
J. Burrows	Marsh Stream parr	Marsh Stream	2011-2014	NA	2012 -2016	Data	interim updates
P. Ruksznis	Cove Brook egg planting	Cove Brook	2012 -2016	2012-2018	2015-2020	Data	interim updates
E. Atkinson	Smolt (alternate rearing) stocking	Pleasant River	2011-2013	2011-2013	2012-2015	Data	interim updates
C. Bruchs	Captive reared pre-spawn adult stocking	East Machias	2005 - 2008 & 2009 - 2014	2006 - 2015	2009-2019	Data	interim updates
P Christman	Captive reared pre-spawn adult stocking	Sheepscot	2006-2010	2007-2012	2009-2014	Data	interim updates
C. Bruchs	Captive reared pre-spawn adult stocking	Machias	2006-2010 & 2011 -2013	2007-2012	2009-2014	Data	interim updates
E. Atkinson	Upstream stocking retired Captive broodstock	Narraguagus	2007- ?	NA	2008 - ?	Data	interim updates
P. Christman	Egg planting	Sheepscot, Kennebec	2003-2007	2004-2009	2007-20012	Data	interim updates
P. Christman	Egg planting	Kennebec	2009-strategy	2010-	2014-	Data	interim updates
B. Naumann/SHARE	LWD additions	Machias, East Machias, Narraguagus	2006-2010	2007-2014	NA	Data	interim updates
R. Dill	Wild Veazie returns genetics	Penobscot	NA		2005-2012	Data	interim updates
M. Simpson	Upper drainage smolt assessment	Narraguagus	2003-2008	2005-2010	NA	Data	interim updates
R. Spencer	Upper Piscataquis fry growth	Penobscot	2006-2008	2006-2009	NA	Data	interim updates
R. Spencer	Upper Piscataquis adult transfer	Penobscot	2009-2011	2010-2013	2013-2016	Data	interim updates
J. Trial	Riverine index sites; monitoring juvenile populations	Narraguagus, Dennys, Machias, East Machias, Pleasant, Saco, Kennebec, Lower Penobscot tributaries, Penobscot	NA	NA	NA	Ongoing	Annual reporting USASAC, ICES
J. Trial	Adult trap counts	Penobscot, Kennebec, Narraguagus, Dennys, Androscoggin, Saco, Aroostook, East Branch Penobscot, St. Croix, Union, Pleasant	NA	NA	NA	Ongoing	Annual reporting USASAC, ICES
J. Trial	Redd Counts	Narraguagus, Dennys, Machias, East Machias, Pleasant, Sheepscot, Lower Penobscot tributaries	NA	NA	NA	Ongoing	Annual reporting USASAC, ICES
J. Kocik/Joan Trial	Smolt population estimates and indices	Narraguagus, Sheepscot	NA	NA	NA	Ongoing	Annual reporting USASAC, ICES
M. Bailey	Size selective mortality	Narraguagus, Penobscot	2005-2007	2005-2007	NA	Completed	UM Thesis, 2008
M. Guyette	Marine Derived Nutrients	Piacataquis; Kingsbury Stream	2009-2011	2009-2012	NA	Completed	UM Thesis 2012
W. Ashe	Conectivity and productivity	Machias	NA	2009-2010	NA	Completed	UM Thesis 2012
E. Atkinson	Captive reared pre-spawn adult stocking	Hobart	2006-2010	2007-2012	2009-2014	Completed	Symposium
P. Christman	Streamside incubation	Sheepscot, Kennebec	2002-2006	2003-2008	2006-2011	Completed	Sheepscot - 2008 Kennebec 2006
R. Wathen	Bass salmon interactions	Penobscot; Pollard, Great Works, Hemlock, Hoyt	2008-2009	2008-2009	NA	Completed	2010, 2011
J. Sweka	Fry stocking - habitat & genetics	Sheepscot	2004			Completed	2008, 2012
J. Trial	Stocked fry upstream movements	Machias, East Machias	2007	2007-2008	NA	Completed	2008, 2009
D Macaw	Translocated adults	Kennebec	NA	NA	2006-2009	Completed	2008, 2009
J. Trial	Stocking density	Narraguagus, East Machias, Saco	2002-2006	2002-2007	NA	Completed	2007, 2008
C. Bruchs	Smolt stocking - sites, timing	Dennys	2001-2006	2001-2006	2002-2008	Completed	2013
P. Ruksznis	Smolt timing from stocked Green Lake parr	Pleasant River, Penobscot	2002-2011	2003-2012	2003-2013	Completed	2011
K. Dunham	0+ parr stocking	Narraguagus	2008-2010	2008-2011	2010-2014	Completed	2011
C. Lipsky	Smolt stocking - sites, timing	Penobscot	2002-2006	2002-2006	2003-2007	Completed	2011
G. Mackey	Point stocking, range of sites	Machias, East Machias, Narraguagus, Kennebec	2005-2007	2006-2009	NA	Completed	2009
G. Mackey	Alewife abundance and smolt survival	Narraguagus	Historic data			Completed	2009
P. Christman	0+ parr stocking	Sheepscot	2004-2005	2005-2007	2006-2011	Completed	2008
R. Spencer	Sea run, captive reared comparison	Aroostook	2003-2008	2004-2010	NA	Completed	2007
T. Lindley	Merical Penobscot	Penobscot	2003-2005	2003-2005	2004-2007	Completed?	2008

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Conservation Hatchery Action Team (CHAT)

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Strategy

Increase adult spawners through the conservation hatchery program.

Strategy Objective

To prevent extinction of Atlantic salmon within the Gulf of Maine Distinct Population Segment by maximizing abundance, distribution and genetic diversity through the conservation hatchery program.

Strategy Metric

Adult return per egg equivalent, reported by SHRU (salmon habitat recovery unit)

Background: The Conservation Hatchery Action Team (CHAT) addresses the threat of declining populations and the eventual extirpation of river specific populations and/or the entire Gulf of Maine Distinct Population Segment (DPS). CHAT also addresses the loss of population diversity (genetic, morphological, physiological, and behavioral) throughout the DPS, catastrophic disease contraction and transmission, and catastrophic cohort loss in the wild. The Atlantic salmon conservation hatchery program is a partnership with the USFWS managing two hatcheries (Craig Brook National Fish Hatchery and Green Lake National Fish Hatchery) and the Downeast Salmon Federation managing two hatcheries (East Machias Aquatic Research Center and the Pleasant River Hatchery).

The conservation hatchery program currently implements the following programs:

- Brood stock management: Penobscot River sea-run and domestic brood programs, and the captive brood program for the Sheepscot, Narraguagus, Pleasant, Machias, East Machias, and Dennys Rivers
- Juvenile Production: various life stage and stocking strategies for each population held in the conservation hatchery program
- Fish health management: fish health inspections, screening, diagnostics and treatment and surveillance

Tables 2.1-2.3 highlight juvenile and adult Atlantic salmon stocking accomplishments and sea-run adult returns by river for 2012.

Table 2.1: Juvenile Atlantic salmon stocking summary for Gulf of Maine DPS in 2012

River	Fry	0 Parr	1 Parr	2 Parr	1 Smolt	Total
East Machias	88,000	53,200	0	0	0	141,200
Kennebec	2,000	0	0	0	0	2,000
Machias	231,000	0	1,400	0	0	232,400
Narraguagus	389,000	0	0	0	59,100	448,100
Penobscot	1,073,000	325,700	0	0	555,200	1,953,900
Pleasant	40,000	0	0	0	60,200	100,200
Sheepscot	50,000	15,700	0	0	0	65,700
Union	1,000	0	0	0	0	1,000

Total for Maine Program 2,944,500 (USASAC Annual Report 2012)

Table 2.2: Number of adult Atlantic salmon stocked in Maine rivers in 2012

Captive/Domestic		Sea Run				
Drainage	**Purpose**	**Pre-Spawn**	**Post-Spawn**	**Pre-Spawn**	**Post-Spawn**	**Total**
Dennys	Recovery	257	0	0	0	257
East Machias	Recovery	52	80	0	0	132
Kennebec	Recovery	5	0	0	0	5
Machias	Recovery	81	141	0	0	222
Narraguagus	Recovery	0	297	0	0	297
Penobscot	Recovery	0	1,150	0	469	1,619
Pleasant	Recovery	56	256	0	0	312
Sheepscot	Recovery	35	161	0	0	196

Total for Maine Program 3,040

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.

Table 2.3: Documented Atlantic salmon returns to Maine rivers in 2012

	1 SW		2SW		3SW				
Hatchery Wild	**Hatchery**	**Wild**	**Hatchery**	**Wild**	**Hatchery**	**Wild**	**Repeat**		**Total**
Kennebec	0	0	1	4	0	0	0	0	5
Narraguagus	2	0	9	5	1	0	0	0	17
Penobscot	8	5	531	69	6	0	2	3	624
Pleasant	0	0	0	2	0	0	0	0	2

Total Returns 648

These hatchery programs have been effective in preventing river specific populations from becoming extirpated, and have also maintained minimum river specific effective population size, ensured healthy and disease free hatchery populations, maintained a sustainable source of parr for the captive brood program, and returned sufficient numbers of Penobscot River adults to sustain the sea-run brood program.

In 2012, 624 adult Atlantic salmon returned to the Penobscot River. MDMR biologists released 150 adult salmon into the river due to high flow conditions at the trap at Veazie Dam and to allow sea-run fish to spawn naturally in the river. The remaining 474 adult salmon were transported to Craig Brook National Fish Hatchery for broodstock. The 481 adult salmon transported to Craig Brook were 169 adults short of our target for broodstock management of 650 adults. The reduced numbers of individuals spawned within the broodstock population will likely reduce the diversity and effective population size for the Penobscot River as measured by effective population size and other population genetic parameters monitored by GDAT.

In fall of 2012, MDMR expressed the need to transfer responsibility for transporting adult salmon from the trap at Veazie Dam to CBNFH to the USFWS. A plan was put in place to accept that responsibility and stay within the current budget constraints. To accomplish this, the production of salmon smolts (approx. 100,000 smolts) at Green Lake National Fish Hatchery for the Downeast SHRU was temporarily suspended.

General accomplishments and activities for 2012 and plans for 2013-2016 are highlighted in Appendix 2.1.

In this 5 year implementation plan, the conservation hatchery program continues to provide fish health, broodstock management, and juvenile production programs but begins work towards improving integration of life stage specific assessment and stocking programs to increase adaptive management capacity. CHAT also proposes new projects that move production projects towards realizing greater natural spawning occurrence in the wild. An example for 2011-2012 includes ceasing fry stocking (2012) in the Dennys River and instead releasing pre-spawn captive adults into quality habitat (Fall 2011). The challenge continues to be maintaining viable river specific broodstock that will be able to recolonize marine and freshwater habitats that become suitable and accessible in the future.

The CHAT along with the other action teams reviewed a number of proposals for new actions (research and management) from both internal (agencies) and external partners and collaborators. All of the teams reviewed the proposals for consistency with the framework, lent technical advice, and made recommendations to whether that action should or should not be implemented. The following project summaries are the proposals that were received by CHAT and approved, thus receiving salmon for 2012 and beyond.

2012 Approved and On-going Project Proposals:

The CHAT works in partnership through the framework with state and federal agencies, universities, and non-government organizations to provide fish for the investigation of effectiveness of new stocking techniques and locations, and research that will assist in reaching the goal of maximizing adult Atlantic salmon returns for spawning within the DPS. The following are summaries of proposals received and reviewed by the CHAT in 2012.

Regional effects of acid and aluminum on Atlantic salmon smolts

The acidification of surface waters due to atmospheric pollution remains an ongoing and serious problem in the northeastern region of the United States (Driscoll et al., 2001). Acidified water impacts the physiology of organisms both directly and by increasing the bioavailability of toxic metals especially aluminum (Al). Under acid conditions, Al is particularly harmful to fishes where it accumulates in the gills and impairs their ability to regulate internal ion levels and leads to mortality (Gensemer and Playle 1999). These effects are particularly problematic for anadromous fishes that must migrate between fresh- and sea-water environments. Chronic acid-Al conditions have resulted in the elimination of Atlantic salmon populations in Scandinavian and Canadian rivers.

Most rivers in New England are not chronically acidified, but rather experience episodic events in which pH decreases for days or weeks at a time. Several lines of evidence indicate that episodic acidification and its associated Al toxicity have contributed to declining salmon populations in eastern Maine (National Academy of Sciences, 2004). These poorly characterized impacts may be limiting restoration efforts in many areas of southern New England. It has been known for some time that relatively severe acid-Al levels can compromise the development of seawater tolerance that occurs during the downstream migration of Atlantic salmon smolts. Recent evidence indicates that even short exposures (2-6 days) to moderate levels of acid-Al can compromise smolt development, resulting in reduced gill Na+,K+-ATPase activity (a critical enzyme for salt excretion) and seawater tolerance (Staurnes et al. 1996; Magee et al. 2002; McCormick et al. 2009). Impaired smolt development following acid-Al exposure is linked to substantial reductions in adult return rates of Atlantic salmon (Krogland et al. 2007).

The degree to which smolts are impacted is dependent upon the synergistic effects of both Al and acidity. Exposure of Atlantic salmon smolts to low pH (5.2) and moderate levels of inorganic ('free') aluminum (~ 50 µg/l) results in mortality within several days. Even at less severe conditions (e.g. pH < 6.0 and Ali 10-40 µg/l) smolts experience a detrimental decrease in their seawater tolerance. Because the effect of aluminum under acidic conditions is caused by entry of aluminum into the gill, the amount of aluminum accumulated in the gill exposure can be directly measured. Demonstration of such an effect in nature depends upon linking exposure to performance in a field setting. The proposed work would attempt to do just that.

In order to directly determine the impact of current water chemistry conditions on Atlantic salmon, the researchers will hold hatchery smolts in cages at targeted field sites and subject them to a seawater challenge test after six days of exposure. In late April and early May, Penobscot River origin hatchery smolts will be held in cages (as outlined in McCormick et al. 2009). Cages will be 0.8 x 0.5m x 0.3 m and constructed of 3 cm wooden supports with 1 cm plastic mesh. These structures will be anchored in place, and the well-sealed to prevent unintentional escape if the cage were to move or be overturned in high flow. They will be placed behind large boulders or in side scour pools so that the cages have adequate flow but are protected from high flow events and reduced water levels. After 6 days of exposure 15 fish will be non-lethally sampled and 15 lethally sampled (as above).

Six sites in Maine with known water chemistry representing a range of water chemistry (based on our previous studies) will be chosen. Sites will include at least one experimental liming site (above and below; in collaboration with Steve Koenig; Project SHARE and Scott Craig, (US Fish and Wildlife Service).Our sites will include areas with severe acid conditions (both high and low DOC streams). These studies were conducted in spring 2012, and 2013 and are planned for spring 2014.

Principal Investigator: Joseph Zydlewski   Co- PI: Stephen McCormick

Smolt imprinting study

Hatchery supplementation has been a critical component of Atlantic salmon restoration, and as stated previously has likely prevented extinction in Maine rivers (NRC 2004). The majority of adult salmon returning to the Penobscot are of smolt-stocked origin. The smolt-to-adult return rate (SAR), however, has declined steadily over the past 30 years indicating increased mortality in the river or at sea (Moring et al. 1995; USASAC 2005).

During migration, smolts can incur significant direct or indirect mortality from dams (Ruggles 1980; Coutant and Whitney 2000) and predation (Larsson 1985; Jepsen et al. 1998). Hatchery-reared salmon have been shown to incur higher mortality than their wild counterparts in many systems (Collis et al. 2001; Fresh et al. 2003; Johnsson et al. 2003; Metcalf et al. 2003). Differential performance at seawater entry may also be partly responsible for these differences (Alvarez and Nicieza 2003; Fuss and Byrne 2002; Hockett 1994; Shrimpton et al. 1994). Studies have shown that survival of hatchery smolts may be maximized if hatchery releases coincide with the emigration of wild smolts (Hvidsten and Johnsen 1993; Heinimaa 2003). Survival at seawater entry has been shown to be highest in cohorts that enter the estuary in an evening outgoing tide (Clemens et al., 2009) presumably minimizing predation risk.

The parr-smolt transition is a critical transitional stage in the life history of Atlantic salmon. A territorial, stream-dwelling parr that transforms undergoes a complex suite of behavioral, morphological and physiological changes resulting in a migratory smolt (McCormick and Saunders 1987). Both endogenous and environmental patterns (e.g. photoperiod, temperature, turbidity, and flow) contribute to the timing of these shifts (Hoar 1976; Eriksson and Lundqvist 1982; McCormick et al. 1998). Successful transition into the marine environment is thought to occur during a “window of opportunity,” when physiological condition is optimal for survival (McCormick and Saunders 1987). Poor synchrony can result in high mortality in the estuary (McCormick et al. 1999) or at sea (Virtanen et al. 1991; Staurnes et al. 1993).

In addition to the obvious advantage of surviving emigration, the ability of anadromous salmon to return to a natal stream successfully is pivotal to their reproductive success (McDowall, 2001). Effective homing allows adaptation to local habitats, enhancing the performance of individuals from the local population (Quinn and Dittman, 1990). Straying can be considered an alternate strategy to homing or simply a failure to home effectively. In natural populations, this alternative behavior may be beneficial to the overall persistence of a metapopulation by reducing inbreeding (Heggberget et al. 1988; Quinn, 1993). For hatchery products, straying is an unintended outcome.

Salmon species home to natal rivers via a suite of cues and clues, olfaction being the primary mechanism. During the parr-smolt transformation, enhanced olfactory sensitivity has been documented in Atlantic salmon (Morin et al., 1989a, b). Wild fish may imprint at multiple life stages following cues from the variable environment (Scholtz et al. 1976; Kudo et al., 1994; Dittman and Quinn, 1996), whereas hatchery fish are held in a more constant environment do not experience such cues. For salmon that typically live in their natal stream for years prior to seaward migration, imprinting can also occur during a brief period during the parr-smolt transformation before the initiation of migration (Scholz et al., 1976). Where smolts are imprinted to is clearly important for natural recruitment for broodstock collection. Smolts stocked in the lower river tend to home to the lower river (Power and McCleave 1980; Gorsky 2005), where successful spawning is improbable (or capture as broodstock may be impractical).

A successful stocking strategy balances risks of mortality during migration, with straying risks and the timing of seawater entry such that adult returns are maximized. Gunnerod et al. (1988) stocked Atlantic salmon in the River Surna, its estuary and offshore. Consistent with the hypothesis that in river mortality was a significant factor, SAR's for salmon stocked in the ocean were more than double the returns for in river stocking. Estuary stocking returns were intermediate. Interestingly, stray rates increase with distance downstream; at sea stocking had the highest stray rates, while in river stocking had no known strays. The researchers propose to assess a smolt stocking protocol that would a) allow a period of imprinting in order to minimize straying, b) avoid in river mortality by releasing smolts into the estuary and 3) maximize the probability of rapid seaward migration by stocking at night on an outgoing tide. This proposal represents the first phase of a longer term vision to optimize smolt stocking methodologies.

Figure 3. Aerial image of West Enfield Dam, the three imprinting pools are indicated with the black arrow.

Beginning in 2009, a three year study to asses this methodology was initiated. Approximately 29,000 smolts are marked using an unambiguous VIE tag (as part of National Oceanic Atmospheric Administration's National Marine Fisheries Service (NOAA NMFS) ongoing marking program) and transferred to the West Enfield holding ponds (Figure 3) in order to imprint to the upper Penobscot River for 10 days. Imprinted smolts were removed from the imprinting pools and transported to the Verona Island boat ramp for direct release into seawater. In order to minimize the risk of predation (a goal of this stocking scenario), the smolts were released at the start of the outgoing tide, after dark. Such timing had been shown to reduce the risk of mortality in migrating salmonids (Clemens et al. 2009). Some of these fish (~50) were tagged using acoustic tags in a joint NOAA-Maine Coop Unit-USFWS cooperative assessment for the purpose of assessing survival through Penobscot Bay.

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On river hatchery rearing of 0+ fall parr to increase adult Atlantic salmon returns to the East Machias River:

In its 2007 Review of Atlantic Salmon Hatchery Protocols, Production, and Product Assessment, the Sustainable Ecosystems Institute (SEI) recommendations stated that:

- The Program should adopt the adaptive management approach.
- Hatchery evaluation should be a core element of the recovery program. Assessment and scientific advice should be used in making decisions on hatchery production and release schedules and the use of hatchery supplementation generally.
- Absolute levels of stocking of fry and smolts have been insufficient to retard further declines of adult returns across DPS rivers.
- Assessments have not been conducted in a sufficiently rigorous manner to definitively evaluate fry versus other stage (parr, freshwater smolt and estuarine smolt) stocking tactics.
- One or two rivers within the DPS should be "fully" assessed so that stage specific survivorship can be measured and tracked. "At a minimum one river, designated as an experimental river, should be adequately outfitted (traps, listening receivers) and continuously monitored to assess the success of rearing conditions, capture and handling techniques, and release mechanisms on smolt success." SEI found that Maine's two salmon hatcheries, Craig Brook and Green Lake, were well designed and used "best management practices". But SEI recommended that "a greater emphasis needs to be placed on releasing smolts and parr from the limited number of available fry to increase adult returns" and, due to the rearing limitations at Craig Brook and Green Lake, "other rearing options need to be explored."

The use of hatcheries to restore depleted fish populations has been a popular strategy for decades but the results have generally been disappointing. A draft paper, 'Improving Hatchery Released Parr Survival, (Christman. P. M., Dunham, K. and Rukznis, P.) has summarized much of the literature associated with hatchery performance as well as the recommendations of a 2007 committee to look at this issue. As this paper and literature search revealed, a potential major cause of mortality is the failure of hatchery fish to transition from hatchery feed to live feed (Berg and Jorgensen1991; Fenderson et al. 1968). Other concerns included the failure of hatchery fish to learn predator avoidance, and the effects hatchery coloration and size compared to similar fish in the wild might have on survival. Fortunately, recent, small scale studies have demonstrated that all of these issues can be successfully avoided at the hatchery. Certainly one of the goals of this East Machias project is to grow parr in the hatchery that closely resemble wild fish. East Machias Aquatic Research Center (EMARC) will follow the recommendations in this paper and consult with experts to employ existing and new conditioning techniques.

Goals (bulleted list):

1. To accurately assess the effectiveness of EMARC reared “fall parr” to increase 1+ and 2+ densities in the East Machias River, the number of smolts leaving the river, and ultimately the number of adults returning.

2. To maximize the number of salmon eggs available from CBNFH for the production of “fall parr” at EMARC.

Objectives (bulleted list):

1. To assess the growth and survival of stocked 0+ parr to 1+ and 2+ stage.

2. To compare population densities from “fall parr” stocking to historic fry stocking densities

3. To assess the number of smolts leaving the river for the five years (or more) of the project (2012-2016) (minimum: two years of previous fry stocked fish and three years of “fall parr” stocked fish).

4. To assist the BSFH with adult return assessment, including redd counts and assessment of acoustic imaging techniques.

Methods: (including study design and statistical analyses)

CBNFH will transfer approximately 195,000 eyed eggs to EMARC for the production of fall parr. No fry will be produced at CBNFH for stocking into the East Machias in spring 2013. To mitigate the risk of changing the existing approach to broodstock management in the East Machias River, DSF agrees to assist with broodstock collection during the summer of 2013. Collection of sufficient numbers (approximately 250 individuals) from 1+ and 2+ parr cohorts is expected to maintain the viability and genetic diversity of the broodstock population. If collection efforts do not result in sufficient numbers of 1+ or 2+ parr, 0+ parr from EMARC would be available. It is believed that the “on-river” nature of the hatchery will provide some level of “natural” selection to occur on the broodstock population. Additional fish could be collected during spring smolt trapping efforts and a pilot effort is also proposed to test the feasibility of this alternative.

To increase the number of eggs available for fall parr production at EMARC to approximately 400,000 eyed eggs, it is proposed that suitable post spawn adults be held at CBNFH for future spawning efforts and the number of parr collected in the summer/fall from the east Machias River increases from the current target of 150 to 250 individuals. According to CBNFH staff, increasing the number of adults available to spawn and the number of parr collected for the broodstock population should allow for the production and transfer of approximately 400,000 eyed eggs within two years.

This proposal was modified in partnership with the Principal Investigator to recognize the need to continue fry stocking in the East Machias River basin to accommodate the broodstock management approach currently implemented by CBNFH. Proposed stocking densities were also developed in partnership with ME DMR. Principal Investigator: Downeast Salmon Federation

Conclusions and Next Steps

The USFWS is experiencing significant reductions is operating budgets for its federal hatchery facilities. Due to these budget constraints within the USFWS, in addition to those being experienced by our partners, the USFWS is planning to reduce the total number of smolts being raised at Green Lake National Fish Hatchery. The reductions will initially target smolt production for two Downeast rivers. Smolts would be raised solely for the Penobscot River beginning in 2013. Additional reductions to operating budgets for our hatcheries could impact the number of smolts being raised for the Penobscot River.

To make future decisions related to hatchery production as transparent and inclusive as possible, the USFWS has proposed using the Structured Decision Making (SDM) Process to help identify the fundamental objectives for the Atlantic salmon conservation hatchery program. The use of SDM will allow for representation from all state and federal agencies, as well as non-government organizations in the decision and prioritization process.

Genetic Diversity Action Team (GDAT)

Meredith Bartron, US Fish and Wildlife Service
Denise Buckley, US Fish and Wildlife Service
Paul Christman, Maine Department of Marine Resources
Mike Kinnison, University of Maine (adjunct)

Strategy

Maintain the genetic diversity of Atlantic salmon populations in Maine over time.

Strategy Metric

Estimates of genetic diversity (e.g. allelic variation, heterozygosity) based on comparable suites of molecular markers will be assessed and monitored over time.

Background

Maintenance of genetic diversity and the preservation of the genetic structure present in Atlantic salmon is a critical component to the recovery of Atlantic salmon in Maine. The Genetic Diversity Action Team (GDAT) has identified a variety of actions important to include as part of the broader management efforts for Atlantic salmon in Maine. Actions identified by the GDAT relate to three primary focus areas: monitoring genetic diversity, evaluating hatchery practices and products, and monitoring to detect aquaculture Atlantic salmon. Actions identified are consistent with the Broodstock Management Plan (Bartron et al. 2006), and expand to include additional research needs, monitoring of weirs for aquaculture-origin salmon, and to monitor the implementation of the Aquaculture Biological Opinion.

Many of the GDAT actions identified are specified in the Broodstock Management Plan (Bartron et al. 2006). Therefore, most actions are currently undertaken to maintain genetic diversity within the Atlantic salmon program and reduce risks associated with captive breeding programs and are critical to the recovery process. Actions identified by the GDAT provide additional monitoring and evaluation of hatchery management practices, including improving abilities to evaluate performance (survival) of hatchery products in the wild and to aid in evaluation of how hatchery production is contributing to recovery activities. For example, genetic parentage analysis is be used to assess the composition of hatchery versus natural origin individuals within adult and parr broodstock collections. Other actions collate all monitoring activities of aquaculture permits, genetic screening of broodstock for stray aquaculture-origin individuals, and operating weirs on the Dennys River, or in emergency situations in response to an escape event.
The metric used to assess the overall outcome of the actions identified by the GDAT is the maintenance of genetic diversity over time measured by estimates of genetic diversity, including allelic variability (i.e. number of alleles per locus, allelic diversity), and heterozygosity. These estimates are obtained through the use of a comparable suite of molecular markers that are consistently used to monitor diversity over time. Loss of genetic diversity could be due to inbreeding, small population sizes, or artificial selection. Assessment and reporting schedules for most of the GDAT actions are specified as part of the Broodstock Management Plan (Bartron et al. 2006), or are part of the Aquaculture Biological Opinion. Many actions are already part of Atlantic salmon recovery activities. Because the actions identified by the GDAT provide

information and strategies to manage against loss of genetic diversity, implementation of these actions should help to maintain genetic diversity of Atlantic salmon populations in Maine over time.

The GDAT works closely with the other action teams to evaluate and implement management practices that are consistent with maintenance of genetic diversity. Although the GDAT focuses evaluation efforts at the hatchery facilities, genetic methods can be utilized to evaluate of hatchery products in the wild, monitor contribution of natural reproduction by hatchery and wild Atlantic salmon, and as a marking tool to evaluate management practices and habitat utilization.

Monitoring genetic diversity

Genetic monitoring activities involve baseline characterization of potential broodstock to assess estimates of genetic diversity over time. In addition to monitoring genetic diversity over time, information obtained from genetic characterization is used to guide spawning activities, identify individuals for culling, and to track reproduction and recapture of stocked hatchery Atlantic salmon.

Parr collected in 2010 for broodstock purposes were PIT tagged and fin clipped to collect tissue samples prior to transfer to the broodstock building at Craig Brook National Fish Hatchery (CBNFH) in 2011. Fin clips were sent by CBNFH to the USFWS Northeast Fishery Center Conservation Genetics Lab for genetic analysis, with results available prior to the first spawn of the 2010 year class in 2012. Sea-run returning adults to the Penobscot River were trapped at Veazie Dam, PIT tagged, and fin clipped, and individuals identified to be used as broodstock were transported to CBNFH in the summer of 2012.

All individuals (parr and sea-run returning adults) were genotyped at a suite of 18 variable microsatellite loci. Loci analyzed include: 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). Following PCR using conditions described in the primer descriptions, genotypes were visualized using an ABI 3100 (Applied Biosystems, Foster City, CA). Genescan and Genotyper software from Applied Biosystems (Foster City, CA) was used to identify alleles at each of the 18 loci. Genetic characteristics such as allele frequency, number of alleles per locus, observed and expected heterozygosity, within population variability, and allelic richness to standardize the number of alleles per locus per collection for differences in sample size were estimated using FSTAT (Goudet 1995) and GDA (Lewis and Zaykin 2001). Effective population sizes and 95% jackknife-based confidence intervals were estimated using LDNe (Waples 2006).

Estimates of genetic diversity are used to monitor if genetic diversity within each individual broodstock is being maintained over time. Maintenance of genetic diversity is one of the primary goals of the hatchery program: to maintain the genetic characteristics of each individual broodstock, to allow for the diversity to persist for natural selection and adaptation to occur, and to ensure that genetic diversity is not being lost inadvertently due to management practices. Estimates of heterozygosity (observed and expected) compared over time within a broodstock and between broodstocks indicate that similar levels of diversity are present in each broodstock, however for some broodstocks such as the Pleasant River broodstock, have slightly decreased estimates of allelic diversity (N_a=10.6, Table 3.1) relative to other broodstocks, likely a result of decreased broodstock number in the early and mid-1990's. Estimates of effective population size (N_e) also vary between broodstocks, and in general are low relative to conservation targets and cause concern for long-term maintenance of genetic diversity. The largest estimate of effective population size is found in the Penobscot River broodstock (N_e=290.9, 95% CI=265.5-319.9, Table 3.1), due to the larger total broodstock number and overall population size of the Penobscot River population.

Evaluating hatchery practices and products

Information regarding genetic characterization of potential broodstock along with genetic principles is used to guide hatchery practices at Craig Brook National Fish Hatchery and Green Lake National Fish Hatchery. Genetic data on relatedness is used to inform mate selection and determine if spawning between capture years is necessary (Hardy and Vekemans 2002) to reduce the potential for mating related individuals, in combination with using the genetic-based spawning optimization software.

Information about the number of families created is used to guide mixing of fry prior to stocking, stocking practices, and recapture of parr. Genetic determination of parentage is used to determine the hatchery family composition to assess recapture of hatchery produced families (Tables 3.2-3.5). Understanding of the percentage of hatchery produced families is critical to efforts to maintain genetic diversity. The largest proportion of the spawning adults for each population is maintained at CBNFH, and therefore the largest representation of the largest amount of genetic variation within each population is contained within the hatchery. Recapture of the full representation the genetic diversity stocked out of the hatchery is therefore critical to maintaining the overall diversity within each broodstock. Stocking protocols have been implemented to distribute representatives of hatchery families throughout their river-specific habitats, to maximize the potential for recapture of each individual family during subsequent broodstock collection efforts. Broad distribution of families throughout their river-specific habitats should allow for natural selection to be the primary driver for variance in recapture rates opposed to stocking practices or habitat quality. Monitoring the recapture of hatchery families allows for evaluation of both the stocking and broodstock recapture practices.

Individuals not assigned to hatchery families are considered of unknown origin. These individuals could represent offspring of natural reproduction from wild adults or pre-spawn stocked hatchery adults, or from spawning of precious parr (hatchery or wild) spawning with wild (or hatchery stocked) adult females. Although incorporation of offspring from natural reproduction is important to capture the total genetic diversity of the population, these spawning events are likely from a limited number of reproducing individuals compared to the number of adults spawned in the hatchery. Disproportionate incorporation of unknown origin individuals from limited number of parental pairs to future broodstock may limit the maintenance of the total genetic diversity (including that being maintained in the hatchery) of each Atlantic salmon population.

Evaluation of the age structure of the parr being recaptured indicates that for most populations, the greatest proportion of fish are age 1+ parr, with some contribution of 2+ parr (Table 3.4). For the 2010 parr recapture year, no 0+ parr were indicated to be recaptured based on parentage analysis to spawn year (Table 3.4). In the Penobscot River broodstock, 90.7% of the broodstock was from the 2008 spawn year, and assuming that the majority were stocked as age 1+ smolts, these adults would then be 2 sea-winter fish (Table 3.5).

Parentage results indicate variability in the proportion of hatchery families recaptured both between rivers and between years (Table 3.6). In the Penobscot River, the proportion of hatchery families recaptured is generally higher than all other rivers (Table 3.6). The proportion of hatchery families recovered from the 2008 spawn year from the Penobscot River is lower than other years for the Penobscot because not all the year classes from that spawn year have returned to accurately characterize the recapture from that spawn year (Table 3.3). For some broodstocks, the proportion of hatchery families recovered is high (e.g. Pleasant

2006 and 2008 spawn year, Table 3.6) because pedigree lines were implemented from those spawn years (also for the 2006 Dennys spawn year (Table 3.6). Although a goal of the stocking and parr broodstock program is to incorporate offspring of natural reproduction into the hatchery broodstock program, lower proportion of recapture of hatchery fish such as in the Pleasant and Sheepscot rivers (Table 3.3) may result in less of the total genetic diversity being maintained in the hatchery.

For both the adult and parr-based broodstocks, offspring representing each of the families spawned are not being recaptured. For the parr-based broodstocks, evaluation of the proportion of the families spawned in 2008 and recaptured in 2010 indicate that on average, approximately 45.7% of the spawned families were recaptured (Table 3.6), whereas for the Penobscot 2006 spawn year, 85.8% of the families are recaptured (Table 3.6). Long term implications of the reduced recapture of the offspring of parental broodstock include a reduction in genetic diversity and increased inbreeding in future generations. Recapture of families from other spawn years (e.g. 2007 or 2009), is possible due to the presence of multiple age classes of parr present, however based on parentage analysis of the 2010 broodstock, only parr from the 2007 spawn year were in the Dennys, East Machias, Machias, and Narraguagus and none were recaptured from the 2009 spawn year. As a result of the lower than expected recapture of hatchery-stocked families, collection targets for parr broodstock which occur in late summer were been increased in order to increase the proportion of families recaptured. The broodstock collection targets starting in 2013 for the Dennys, East Machias, Pleasant, and Sheepscot will increase to 200 parr and collections for the Machias and Narraguagus will increase to 300 parr.

Monitoring to detect aquaculture Atlantic salmon

To screen potential escapees from aquaculture facilities, or strays from outside the region, a two-phased hierarchical screening process has been established for potential broodstock CBNFH (Bartron et al. 2006). The first phase screens to determine continent-of-origin due to the use of non-North American origin Atlantic salmon for aquaculture purposes, and based on the large differences in allele frequencies between populations from different continents (King et al. 2001).

The second screening phase is based on identifying individuals from the river of origin, or region of origin (Maine), and to allow for natural straying among populations by excluding individuals with low assignment probability to either the population of origin or to other Maine rivers. Individuals may be identified to be culled through either procedure. A two-step hierarchical criterion based on probability of assignment to population of origin was used to classify individuals. First, an individual would be identified for additional analysis if there was a less than 1% probability of assignment to the population an individual putatively originated. For individuals identified for potential removal with the first criteria, only individuals that had a less than 5% probability of assignment to any other Maine population (Narraguagus, East Machias, Dennys, Ducktrap, Penobscot, Kennebec, Machias, Pleasant, and Sheepscot) would be removed from the broodstock. This method was developed to increase the likelihood of correctly identifying individuals belonging to a specific population, while still allowing for the possibility of straying between neighboring drainages. Because other source populations not included in the baseline may have contributed to the unknown group of individuals, the use of the 2-step process and low probability of assignment thresholds would aid in identification to any of the baseline populations used. Therefore, probability of assignment to river or to other Maine populations would identify individuals of unknown origin due to low assignment probabilities.

In total, 11 individuals were screened from the parr-based broodstocks due to not meeting the criteria of assignment to their river of origin or to other Maine rivers (Table 3.7). Three individuals transported to

Craig Brook National Fish Hatchery from the 2012 adult sea-run return to the Penobscot River were also removed prior to use as broodstock based on not meeting the assignment criteria for the river/region screening (Table 3.7).

In 2012, a total of seven Atlantic salmon were identified during trapping activities as potential suspected aquaculture escapees based on physical characteristics. Tissue samples from these individuals (three from the Penobscot River, three from the Union River, and one from the Androscoggin River) were provided to the USFWS Northeast Fishery Center Conservation Genetics Lab for parentage analysis. Of these individuals, two from the Penobscot River were assigned to aquaculture parental pairs spawned in 2008 and 2009 spawn year with no mismatches based on 14 microsatellite loci. Two individuals from the Union River were assigned to the 2009 spawn year, one with no mismatches, and the other with one mismatch. The remaining three individuals were not assigned to Maine aquaculture parents or to CBNFH hatchery broodstock, and none of the individuals failed the culling criteria. Therefore, the origin of the three non-aquaculture assigned individuals was not able to be genetically determined given the data available, although subsequent reading of the scale samples collected from those 3 fish revealed growth patterns consistent with aquaculture rearing (Randy Spencer, Maine DMR). The individuals from the Penobscot River that were assigned to aquaculture parents were not included into the Penobscot River broodstock.

Progress towards recovery

Overall, the results from the genetic monitoring results indicate that genetic diversity is being maintained within the hatchery broodstocks. However, the ability to continue to maintain diversity can be at risk based on the low estimates of effective population sizes in most of the broodstocks, as well as the low percentage of stocked hatchery families being recaptured. Given that for most of the broodstocks, the hatchery populations represent the largest proportion of the existing population of Atlantic salmon, it is important to be able to capture annually a diverse representation of the families stocked in previous years. Maintaining genetic diversity and managing to avoid inbreeding will be critical components of providing the genetic variation for continued and future adaptation necessary for recovery.

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Tables

Table 3.1. Summary results for estimates of genetic diversity from the 2010 parr and 2012 adult (Penobscot) broodstock collection years. Estimates include the number of individuals sampled (N), the number of alleles per locus (N_a), the expected (H_e) and observed (H_o) heterozygosity, inbreeding (f), estimated effective population size (N_e) and the 95% confidence interval, and the number of loci used for the analysis.

Broodstock	Sample Year	Sample Size	N_a	H_e	H_o	Inbreeding (f)	N_e	95% CI	# loci
Dennys	2010	142.0	11.7	0.683	0.709	-0.038	60.4	56.5-64.8	18
East Machias	2010	148.0	12.0	0.669	0.676	-0.011	89.4	82.2-97.6	18
Machias	2010	242.0	12.1	0.672	0.679	-0.010	94.3	87.5-101.8	18
Narraguagus	2010	246.0	12.9	0.680	0.691	-0.016	139.4	129-151	18
Penobscot	2012	478.0	13.3	0.690	0.711	-0.032	290.9	265.5-319.9	18
Pleasant	2010	271.0	10.6	0.674	0.699	-0.038	55.4	52.9-58.0	18
Sheepscot	2010	160.0	11.5	0.681	0.702	-0.032	56.4	52.9-60.3	18

Table 3.2. Identification of hatchery spawn years to compare the 2010 capture year parr broodstock based on potential age at recapture.

Life Stage	Year		
Spawn year	2007	2008	2009
Fry stocked	2008	2009	2010
Parr (0+)	2008	2009	2010
Parr (1+)	2009	2010	2011
Parr (2+)	2010	2011	2012

Table 3.3. Age and estimated spawn year for adults to the Penobscot River given different capture years. Parentage assignment to the 2003 and 2004 return years is limited due to a large number of missing genotypes from many samples, which limited the ability to assign parentage to these two spawn years for returns from 2007 to 2010.

	Estimated age based on spawn year				
Capture Year	2.3/ 1.4	2.2/ 1.3	2.1/ 1.2	2+ parr	1+ parr
2006	2000	2001	2002	2003	2004
2007	2001	2002	2003	2004	2005
2008	2002	2003	2004	2005	2006
2009	2003	2004	2005	2006	2007
2010	2004	2005	2006	2007	2008
2011	2005	2006	2007	2008	2009
2012	2006	2007	2008	2009	2010

Table 3.4. Parentage results for the 2010 capture year parr, identifying the proportion and number of parr assigned to hatchery parents, by spawn year, and the subsequent proportion of the assigned broodstock by age class.

				Number recaptured			Proportion age of assigned		
				age 0+	age 1+	age 2+	age 0+	age 1+	age 2+
Broodstock	Number sampled	Number assigned parents	Prop. assigned	2009	2008	2007	2009	2008	2007
Dennys	142	122	0.859	0	103	19	0.000	0.844	0.156
East Machias	150	100	0.667	0	59	41	0.000	0.590	0.410
Machias	243	55	0.226	0	31	24	0.000	0.564	0.436
Narraguagus	248	140	0.565	0	119	21	0.000	0.850	0.150
Pleasant	376	325	0.864	0	325	0	0.000	1.000	0.000
Sheepscot	166	143	0.861	0	143	0	0.000	1.000	0.000

Table 3.5. Parentage results for the 2012 capture year adults from the Penobscot River, identifying the proportion and number of adults assigned to hatchery parents, by spawn year, and the subsequent proportion of the assigned broodstock by age class.

				Number recaptured			Proportion age of assigned		
				2.1/1.2	2.2/1.3	2.3/1.4	2.1/1.2	2.2/1.3	2.3/1.4
Broodstock	# sampled	# assigned parents	Prop. assigned	2008	2007	2006	2008	2007	2006
Penobscot	481	398	0.827	360	28	10	0.905	0.070	0.025

Table 3.6. The proportion of families recaptured in the 2010 parr broodstock and 2012 adult collection from the spawn years (and earlier spawn years) which those collections would have originated from.

		Number spawned			Proportion recaptured		
Drainage	Spawn year	Total # Families	# female parents	# male parents	% families	% female parents	% male parents
Dennys	2005	85	81	85	0.753	0.790	0.753
Dennys	2006	96	96	90	0.969	0.875	0.889
Dennys	2007	84	84	76	0.643	0.500	0.526
Dennys	2008	105	105	93	0.343	0.343	0.376
East Machias	2005	88	87	65	0.455	0.414	0.446
East Machias	2006	82	74	71	0.549	0.500	0.479
East Machias	2007	78	77	68	0.859	0.558	0.618
East Machias	2008	85	85	72	0.400	0.400	0.472
Machias	2005	160	156	132	0.469	0.449	0.439
Machias	2006	160	153	145	0.325	0.268	0.283
Machias	2007	150	150	138	0.580	0.487	0.507
Machias	2008	141	139	130	0.142	0.144	0.146
Narraguagus	2005	146	136	134	0.342	0.346	0.351
Narraguagus	2006	166	160	136	0.361	0.313	0.368
Narraguagus	2007	186	182	153	0.586	0.516	0.588
Narraguagus	2008	169	169	159	0.355	0.355	0.365
Penobscot	2001	283	282	162	0.304	0.255	0.401
Penobscot	2002	219	218	142	0.393	0.372	0.493
Penobscot	2003	362	361	222	0.572	0.410	0.523
Penobscot	2004	353	334	202	0.714	0.611	0.748
Penobscot	2005	296	284	165	0.882	0.711	0.818
Penobscot	2006	331	313	176	0.858	0.677	0.756
Penobscot	2007	315	313	222	0.822	0.684	0.757
Penobscot	2008	299	299	226	0.625	0.548	0.628
Pleasant	2005	99	98	90	0.273	0.276	0.278
Pleasant	2006	54	54	52	0.907	0.907	0.923
Pleasant	2007	77	75	71	0.416	0.427	0.437
Pleasant	2008	47	47	47	0.872	0.872	0.872
Sheepscot	2005	70	70	57	0.500	0.500	0.561
Sheepscot	2006	83	74	78	0.542	0.514	0.449
Sheepscot	2007	81	81	77	0.654	0.654	0.675
Sheepscot	2008	75	75	74	0.573	0.573	0.568

Table 3.7. Results from the screening for aquaculture origin individuals conducted on the 2010 capture year parr broodstock and 2012 sea-run adult Penobscot broodstock.

Capture Year	Broodstock	CG Lab ID	PIT Tag	Cull reason
2010	East Machias	CBEM-10-014	48780F1767	River/Region
2010	East Machias	CBEM-10-028	486B101C47	River/Region
2010	Machias	CBMA-10-047	4708174139	River/Region
2010	Narraguagus	CBNA-10-128	4708023470	River/Region
2010	Narraguagus	CBNA-10-210	470C323D32	River/Region
2010	Sheepscot	CBSH-10-063	48780C0902	River/Region
2010	Sheepscot	CBSH-10-077	470D693D7F	River/Region
2010	Sheepscot	CBSH-10-114	486B1F0928	River/Region
2010	Sheepscot	CBSH-10-122	48751F342D	River/Region
2010	Sheepscot	CBSH-10-157	487670636A	River/Region
2010	Sheepscot	CBSH-10-158	486B131646	River/Region
2012	Penobscot	CBPN12-256	384.36F2B3C180	River/Region
2012	Penobscot	CBPN12-547	384.36F2B345ED	River/Region
2012	Penobscot	CBPN12-560	384.36F2B345D2	River/Region

Marine and Estuarine Action Team (MEAT)

Richard Dill, Maine Department of Marine Resources
Graham Goulette, NOAA's National Marine Fisheries Service
John Kocik, CHAIR, NOAA's National Marine Fisheries Service
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Michael O' Malley, Integrated Statistics
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Tim Sheehan, NOAA's National Marine Fisheries Service
Daniel Tierney, NOAA's National Marine Fisheries Service
Linda Welch, US Fish and Wildlife Service
Joseph Zydlewski, US Geological Survey

Strategy

Increase marine and estuary survival by increased understanding of these ecosystems and the location and timing of constraints to the marine productivity of salmon

Strategy Objective

To document factors limiting marine and estuarine survival of Atlantic salmon to facilitate informed ecosystem management of these stocks

Strategy Metrics

- Monitor marine survival of hatchery smolts in Penobscot Bay SHRU and decrease uncertainty in estimates (MEAT-M01)
- Monitor marine survival of naturally-reared smolts in Downeast and Merrymeeting Bay SHRU and decrease uncertainty in estimates (MEAT-M02)
- Monitor estuarine and coastal marine survival and identify location and time of mortality events at a population scale using telemetry and pelagic monitoring techniques in Penobscot Bay SHRU (MEAT-M03)
- Increase understanding of Atlantic salmon transition ecology in estuaries, and coastal migrations in US waters and distant waters through active research and cooperatives through partners including universities, marine research institutes, ICES and NASCO resulting in peer-reviewed products (MEAT-M04)

Background: Significant increases (8x) in estuarine and marine survival are needed to increase the number of adult returns (particularly those from wild origin), to achieve self-sustaining populations, maintain genetic diversity, and to maintain and increase the geographic distribution of salmon within the GOM DPS.

The Marine and Estuarine Action Team (MEAT) works in an interdisciplinary, multiagency, and multinational capacity by bringing specialists in marine salmon ecology and experts in associated marine ecosystems together. The MEAT action plan is an integration of priorities identified by regional experts, various workshop committees, and information gaps/needs identified through Team research initiatives. This includes 1) the framework 5-year plan 2) the workshop proceedings of Marine Ecology of Gulf of Maine Atlantic Salmon and 3) ideas and issues identified in team meetings and in independent research. The team meets by teleconference and through email to exchange ideas and information. With presentations and exchanges that occurred at 2012 public meetings, the team has expanded membership and hopes to increase team communication and networking. The primary team project this year was assembling reports, publications, and other information for this Annual Report. This year's activities were primarily research and assessment projects that sought to understand the estuarine and marine ecology and migration of Atlantic salmon. This work was focused on understanding the structure and function of these communities and working towards identifying the factors that may be contributing to current low marine survival. With increased knowledge, we plan to inform management actions with the goal of increasing survival of emigrating smolts, post smolts and ultimately increasing adult returns. Domestic marine and estuary management work currently focuses on permit issuance for Federal, State, and private sector activities (e.g., coastal and marine development, power generation, dredging, etc.) to minimize or eliminate deleterious impacts to Atlantic salmon.

Accomplishments

General accomplishments and activities are highlighted in Appendix 2. While the marine ecology of Atlantic salmon has often been equated to a black box, new research tools and integrating models from oceanography and bioenergetics are providing new insights in many aspects of salmon at sea. Below is a narrative description of accomplishments organized by strategy metric with additional details provided on select activities and emerging topics from 2012.

Marine Survival Metrics (M01 and M02)

Adult returns and smolt outputs for 2012 are presented in SAAT Report. In this section we report the marine survival rates of the 2012 2SW cohort. This is an excerpt of the US Atlantic Salmon Assessment Committee Annual Report (USASAC) (USASAC 2013) with specific details related to each of the three GOM SHRUs. Because only point estimates are available for Penobscot smolt stocking and adult returns, composite indices may mask some of the overall variability in marine survival. For smaller river systems, improvements in mark-recapture designs for smolt estimates and updated redd to spawner models (including total habitat survey ratio) are being studied by DMR and NOAA. Given the relative low proportion of sampling error to interannual variability in overall marine survival, impacts of these improvements may be limited but information gained might help identify important spatial limitations to smolt or adult metrics used to calculate marine survival.

Return rates provide a consistent indicator of marine survival. Previous studies have shown that most of the US stock complexes track each other over longer time-series for return rates (strongest index of marine survival). Median smolt to adult return (SAR- number of adult returns per 10,000 hatchery smolts stocked) over the last 5 years was highest in the Gulf of Maine (23.3) and decreased southward for the Central New England (11.1) and Long Island Sound (1.8) stock indices. Current USASAC Maine return-rate assessments provide both an index for naturally produced fish (fry stocked or wild spawned) in the Narraguagus River and for Penobscot River hatchery smolts—the longest and least variable in release methods and location (Figure ME01). Penobscot average return rates per 10,000 smolts (SAR) for the last five years was 7.1 for 1SW salmon and 23.2 for 2SW fish. The total cohort SAR averaged 31.2. Starting in 1997, naturally-reared smolts in the Narraguagus River have been enumerated. The average cohort SAR for naturally reared Narraguagus River smolt for the past five years was 144.5. That rate was 4.6 times higher than the Penobscot 2SW hatchery cohort average for the same time-period.

In 2012, the SAR for 2SW hatchery smolts released in the Penobscot River was 9.4, ranking 35th in the 42-year record, while the 2012 return rate for 1SW hatchery grilse was 0.1 ranking 42nd in the 43-year record. The 2SW return rate in the Narraguagus River in 2012 was 23.1, more than 2.5 times the SAR observed in the Penobscot River. This was the second lowest return rate in the 14 year Narraguagus time series. It is important to note that total smolt production estimates in the Narraguagus are only about 1,200 smolts annually. This analysis points out a challenge to modern salmon recovery: naturally reared smolts typically have better marine survival than hatchery fish, but the capacity of rivers to produce adequate numbers of smolts, even with the addition of significant hatchery inputs, is generally well below replacement rates, under current marine survival rates.

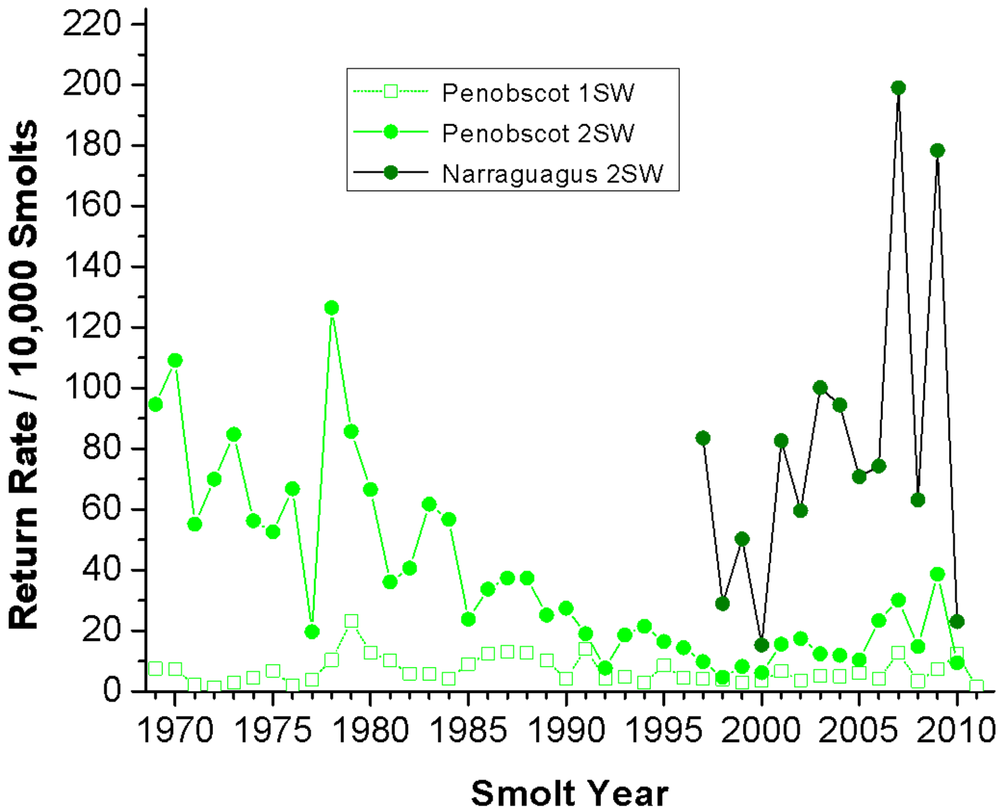


Figure ME01. Return rates of Atlantic salmon per 10,000 smolts from the Narraguagus and Penobscot populations estimated from numbers of stocked smolts for the Penobscot and from estimated smolt emigration from the Narraguagus River population

After the 2013 USASAC, NOAA NMFS staff developed a preliminary SAR index for the Sheepscot River in the Merrymeeting SHRU. This estimate is based on quantitative estimates of smolt emigration (available since 2009) and redd-based estimates of adult returns (available since 1992). While both estimates have important error bounds around them, the index should be compared to metrics for the Penobscot (smolts-based) and Downeast/Narraguagus (naturally reared-based) indices. Because estimates are only available for 2011 and 2012 returns, they should be interpreted with caution and vetted with 2013 estimates at the USASAC in 2014. Preliminarily, because Sheepscot rates in 2012 (low) and 2011 (high), tracked the other two indices suggesting that this index may be useful for comparison but a longer time-series and more analysis is needed to fully understand marine survival of this most southerly population.

Monitoring Short-Term Survival and Migration Routes (M03)

Ultrasonic telemetry studies were conducted to monitor freshwater and nearshore emigration Atlantic salmon juveniles into the ocean. Information collected help describe Atlantic salmon spatial and temporal use of these environments while trying to determine the location and timing of mortality events. Estuary monitoring was again focused in the Penobscot Estuary in 2012. A total of 121 VEMCO receivers (VR) were deployed throughout the Penobscot River estuary and Penobscot Bay as part of a collaborative effort of the University of Maine (UMaine), US Geological Survey (USGS) and NOAA NMFS. UMaine and USGS deployed 25 VR receivers in the upper Penobscot estuary from Graham Station (river km 45.67) to Chipman’s Cove (river km 13.10) and tributaries of the estuary. NOAA NMFS deployed 96 VR receivers from Harriman Cove (river km 10.12) to the outermost marine array (Owls Head, river km -45; Figure ME02). Marine arrays were positioned so all deployed receivers were within 250-600 meters, which, according to range tests provides overlapping coverage for maximum detection efficiency of tagged emigrating smolts. Smolts from two different rearing environments were trucked to the NEFSC Maine Field Station in Orono for surgeries. Naturally reared smolts (ages 2 and 3) were collected using a fish bypass operated by Brookfield power at Weldon dam on the Penobscot River. Hatchery smolts were age-1 Penobscot strain reared at Green Lake National Fish Hatchery (GLNFH) in Ellsworth, Maine. Smolts greater than 145 mm fork length (FL) were tagged following standard operating procedures. Once surgeries were completed, tagged smolts were held in aerated live wells for 0.5 to 5.0 hours before being released at the Brewer Boat ramp in the Penobscot estuary 3.7 km downstream of Veazie Dam. Groups of naturally reared smolts were paired with hatchery smolts when released. At completion of this study phase in 2013, a more comprehensive evaluation of group and individual performance and ecology will be synthesized in a manuscript.

In 2012, we tagged and released naturally reared (n = 81) and age 1 hatchery smolts (n = 121) into the Penobscot River estuary on four dates in April and May. Movements were passively monitored via moored acoustic receivers through the estuarine and near-shore marine environment. Naturally reared smolts were significantly smaller than hatchery stocked smolts (166 vs. 200 mm FL; Kruskal-Wallis: $P < 0.05$). Preliminary estimates of smolt survival to the outer Penobscot Marine Array was estimated to be 0.52 (95% CL 0.29-0.69) for naturally reared and 0.57 (95% CL 0.32-0.74) for hatchery smolts. In most years, both groups partition the bay similarly, in 2012, mid-bay behavior was again similar with little more than half (54%) of naturally reared smolts traveling on the eastern side of Islesboro (Dice Head) as compared to hatchery smolts, of which 63% used this route. Through the outer array, the majority of smolts exited via the western (Owls Head) passage (naturally reared 89% and hatchery 88%) following the pattern of previous years. Naturally reared smolts took less time to exit the array compared to hatchery reared smolts (release to outer array; 5.03 versus 7.43 days). A comparative analysis of multiple years of data is ongoing but 2012 could be characterized generally as having relatively high success rate and migration timing and routes within observed behavior patterns.

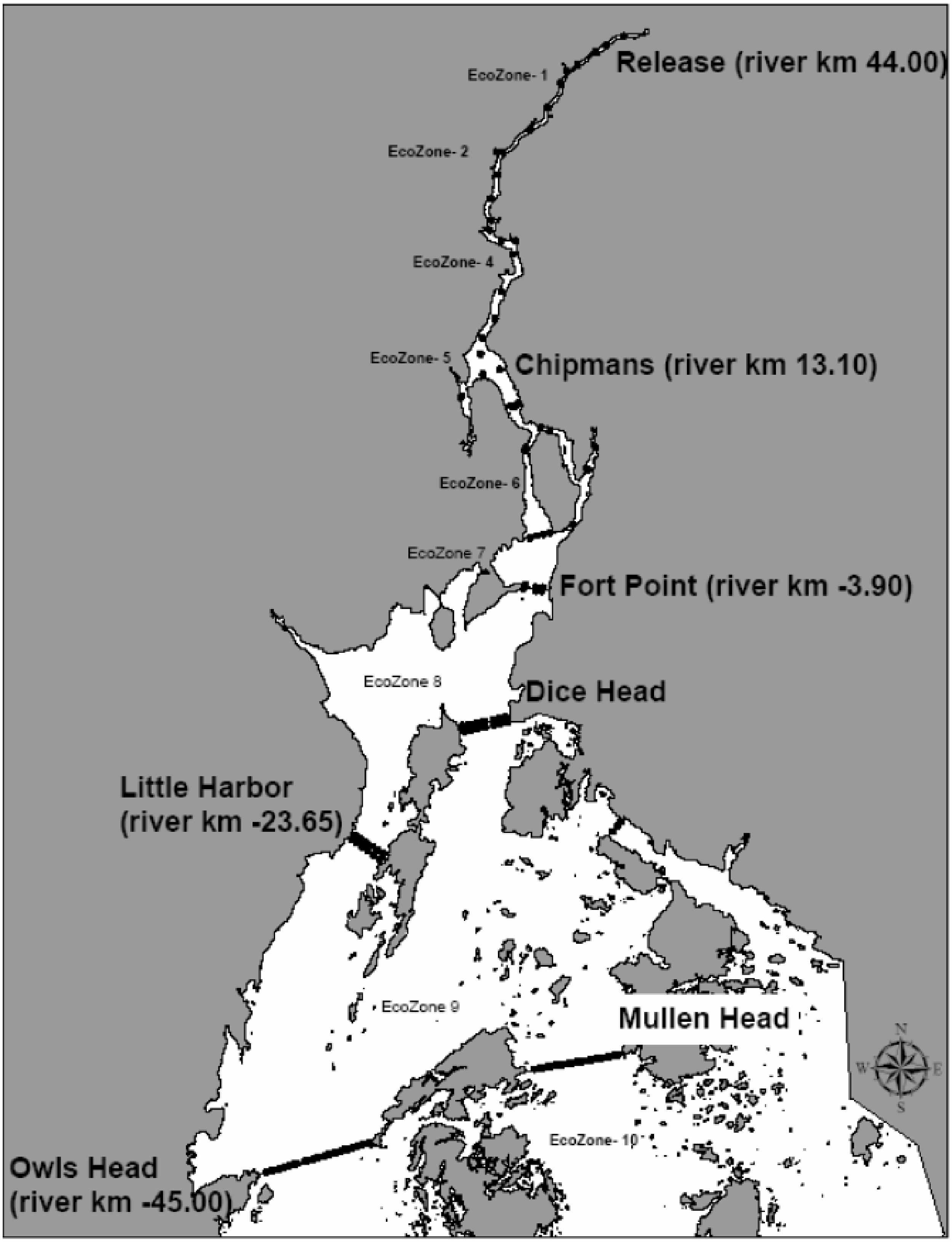


Figure ME02. Map of 2012 Penobscot Estuary and Bay acoustic receiver arrays.

Advances in understanding of Atlantic salmon transition ecology in estuaries, coastal migrations in US waters and distant waters through research (M04)

The balance of work coordinated or consolidated by the MEAT focuses on activities in support of international management, high seas research, and applied estuary and marine research to better understand marine survival, productivity and distribution of GOM Atlantic salmon. Annual summaries are available in several reports and hyperlinked in the international assessment paragraph. A general overview of active projects is provided in the sections below. In these sections, we highlight some recent projects that advanced our knowledge in the marine realm in 2012; these projects enhanced our understanding of habitat use at sea both in depth utilization (Renkawitz et al. 2012) and distribution at sea (LaCroix et al. 2012; Mills et al. 2012).

International Assessment Activities

The work of the MEAT and the SAAT provided essential inputs to international management of Atlantic salmon through International Council for the Exploration of the Sea (ICES) Working Group on North Atlantic Salmon (WGNAS) and North Atlantic Salmon Conservation Organization (NASCO). Active engagement in international science and management both helps to protect all US stocks from fisheries at sea and better manage Atlantic salmon at sea. The output of much of the GOM DPS marine assessment work was vetted through the USASAC. The results of 2012 studies and assessments were published in Annual Report 25: 2012 Activities. These data are then brought forward to international managers through the NASCO Council, North American Commission and West Greenland Commission through the leadership of MEAT member Tim Sheehan. Additionally, the US has a key role in West Greenland monitoring and sampling as Tim Sheehan coordinates this international sampling program. The results of 2012 studies and assessments were folded into North American and North Atlantic level summaries and published in the annual Report of North Atlantic Salmon Working Group.

In addition to core international work, Tim Sheehan participates in NASCO's International Atlantic Salmon Research Board (IASRB). The IASRB was initiated in 2008 with the goal of implementing a major integrated program of marine surveys in the Northeast and Northwest Atlantic, together with enhanced sampling of the fishery at West Greenland under the SALSEA Program and there have been other major research initiatives. Last year we reported much of the breaking US news from the October 2011 Salmon Summit co-convened by NASCO and ICES entitled Salmon at Sea: Scientific Advances and their Implications for Management. US scientists and managers including members of MEAT were authors of several papers that were a result of these efforts and published in a November 2012 special issue of the ICES Journal of Marine Science. Citations with co-authors from our team are listed in the literature cited section of this report and some are highlighted in the narrative as well. We also think it is important to note the key messages from the meeting and symposium according to former NASCO Secretary Malcolm Windsor:

- Because we now know where salmon are at sea, management measures can be implemented to limit impacts on them, such as fisheries for other species.
- A clear message to managers in this challenging global environment is to ensure the maximum number of healthy wild salmon go to sea from their rivers.
- Keeping salmon populations abundant involves addressing impact factors in freshwater, estuarine, and coastal waters. These include degraded freshwater habitat, barriers to migration, over-exploitation, and salmon farming.
- Dr. Windsor continued 'unless we adopt conservation measures identified during the Salmon Summit there is a real risk that southern stocks will become extinct by 2040'.

Select Management and Permitting Highlights
To minimize impacts to listed species, section 7 of the Endangered Species Act (ESA) requires a federal agency to consult with NOAA NMFS and/or the USFWS to ensure federal actions will not jeopardize the existence of ESA listed threatened or endangered species. During this process, NOAA NMFS gathers relevant information on the proposed activities to determine how the action may affect any listed species present in the action area. Members of the MEAT and their parent agencies assist in the consultation process by providing relevant information on the presence of ESA listed species obtained through research conducted by the team and independently. The NEFSC in collaboration with MDMR, UMaine, and USGS also deploys and maintains an array of acoustic receivers in the GOM to obtain information on migration patterns for Atlantic salmon, and Atlantic and shortnose sturgeon. This information is used to describe the behavior and presence of listed species throughout varied action areas. Data collected from telemetry studies being conducted on sturgeon and salmon have provided valuable information on the temporal and spatial aspects of migration; as well as the number of tagged individuals using an area. Furthermore, these data inform the effects analysis to determine any potential effects or take of threatened and endangered species under the jurisdiction of NMFS. If the action has the potential to take a listed species, NMFS will issue a Biological Opinion (BO) that contains an Incidental Take Statement (ITS) to exempt take so that the activity can proceed in compliance with the ESA. If the action has the potential to threaten the existence of any listed species or adversely modify critical habitat then NMFS will recommend reasonable and prudent alternatives (RPAs) to reduce the impact and avoid jeopardy.

This summary focuses on actions in the marine and estuary waters of the Gulf of Maine in areas identified as marine habitat (Figure ME03):

In 2012, the NEFSC provided marine distribution capture and detection locations of Atlantic salmon to the Northeast Regional Office (NERO) to assist with the creation of an online marine spatial planning map (FigureME03). Using NEFSC locations of Atlantic salmon smolt and adult capture/detection locations from near shore trawls, coastal telemetry arrays, and bycatch reporting, NERO created a screening tool for use by action agencies to determine endangered species presence/absence. This tool will increase efficiency for NERO Section 7 biologists, as routine requests for species presence information can be automated. The extent of marine habitat encompassed in this tool far exceeds the surface area of upland watershed and with increasing use of offshore environments this tool is as essential for marine and estuary habitats as it is for freshwater habitats.

Select Management Consultations:
NERO Section 7 biologists regularly use data from acoustic networks and other sources to determine the timing of salmon and sturgeon migrations in project specific action areas. This information is used for the recommendation of time of year work restrictions and to assess the potential for effects due to temporary construction activities. Below we list several examples of consultations and actions in marine and estuary ecosystems that minimized risk not only to Atlantic salmon but other diadromous fish.

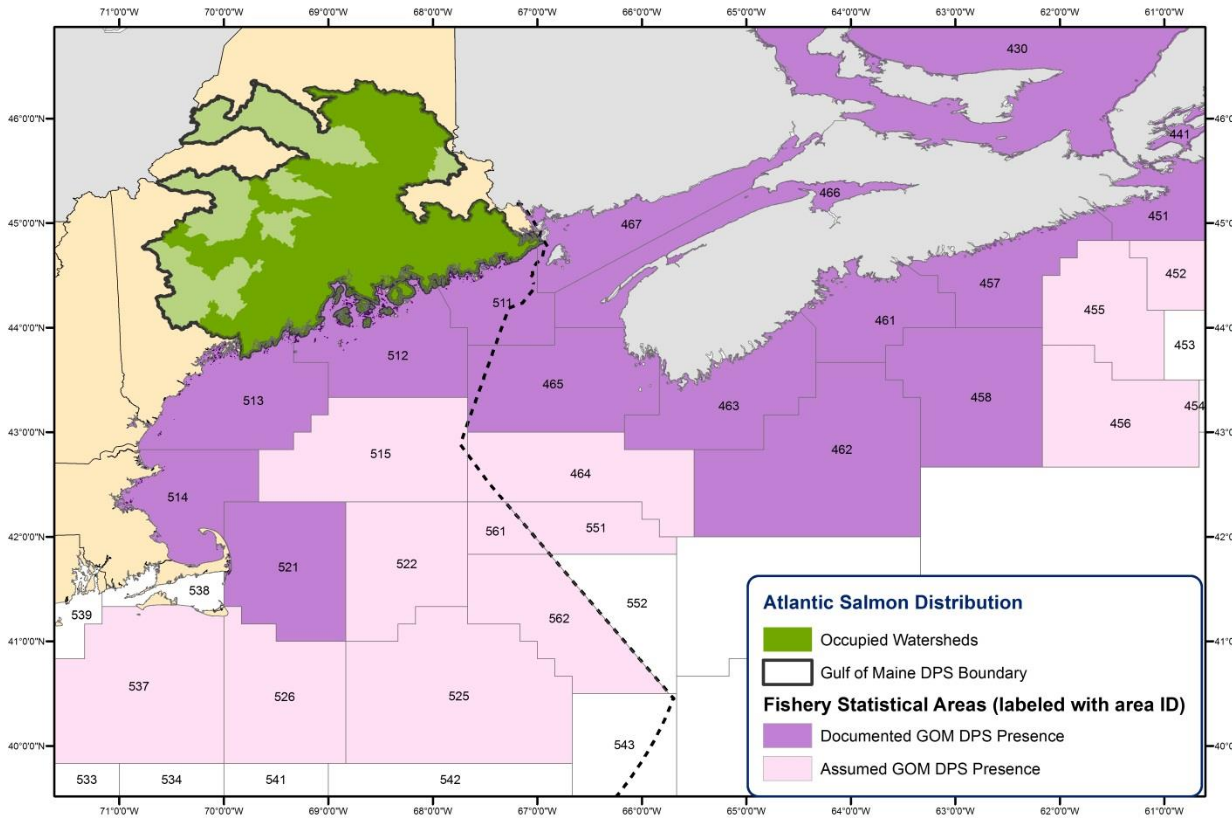
- UMaine proposed the installation of a floating wind turbine in Penobscot Bay near Castine, Maine. Data obtained from an acoustic array deployed off Dice Head provided information on acoustically tagged fish that were migrating through the action area
- The Federal Highway Administration (FHWA) and Army Corps of Engineers (ACOE) received applications for the placement of two bridges over the Picataqua River in southern Maine. Acoustic arrays placed at the entrance to Great Bay provided information on the timing of Atlantic and shortnose sturgeon migrating up the Piscataqua River to Great Bay.
- In June 2012, the Federal Energy Regulatory Commission (FERC) requested our concurrence that

the construction and operations of a liquefied natural gas (LNG) import terminal would not likely adversely affect listed species under our jurisdiction. Based on a variety of sources, including the NEFSC Protected Resources Branch's aerial, ship-board and telemetry tracking data, we concluded that blue, humpback, North Atlantic right, fin, sei and sperm whales, Gray and Harbor seals are known to occur in the action area. Leatherback sea turtles have also been detected in the Gulf of Maine. Atlantic and shortnose sturgeon are known to occur in Passamaquoddy Bay, and the St. Croix River. Tracking data provided by NEFSC and their partners, such as the New England Aquarium, and the Canadian Department of Fisheries and Oceans allowed us to conduct an informed effects analysis on a very complex project.

- In November of 2011, the State of Maine contacted our office regarding an emergency ocean beach nourishment and stabilization project approximately 1 mile from the mouth of the Kennebec River to be conducted over the winter. Based on information provided by the NEFSC, UMaine, and MDMR, we concluded that sturgeon species were only likely to forage in the action area during the spring and summer, and that the prey items would likely re-colonize the action area by the time sturgeon returned. Sturgeon tracking data provided by NEFSC and their partners, allowed us to make a not likely to adversely affect concurrence for this project.

Conclusions

Although major advances in our understanding of marine phase Atlantic salmon have been made in recent years, it is impossible to say if marine and estuarine survival has increased as a result of the Marine and Estuarine Action Team efforts detailed above. It is still unclear what the primary drivers of estuarine and marine Atlantic salmon mortality are and we are therefore unable to counteract these drivers given with our current understand of the dynamics. Continued research and monitoring efforts are required to build a more complete understanding of the ecosystems that Atlantic salmon depend on and the location and timing of constraints on their survival. As our understanding increases, adaptive management projects aimed at testing hypotheses on the causal mechanisms driving the reduced estuarine and marine survival should be developed and pursued.



This figure depicts a best estimate of the distribution of these species in northeast US waters. However, the distribution of these species is not exclusively limited to the areas depicted here. Please contact the NOAA Fisheries Northeast Regional Office for more information.

Figure ME03. Distribution map of Atlantic salmon within the Gulf of Maine and Scotian Shelf Region.

Select Research Highlights

Renkawitz, M. D., Sheehan, T. F., and Goulette, G. S. 2012. *Swimming depth, behavior, and survival of Atlantic salmon postsmolts in Penobscot Bay, Maine. Transactions of the American Fisheries Society. 141: 1219-2012.* To gain information on postsmolt dynamics of emigrating Atlantic salmon through Penobscot Estuary and Penobscot Bay, Maine, we conducted a telemetry experiment in 2005. We implanted 26 salmon smolts with ultrasonic depth tags, and monitored movement activity and fish passage with linear detection arrays through 44.2 km of the estuary and 45.5 km of the bay. During daylight in the bay, greater than 95% of the detections occurred in water depths of 5m or less, but depths to 37 m were recorded (Figure ME04). At night, 99% of the detections were in the top 5 m of the water column and maximum depth was 9 m. Overall survival was 39% and was highest for smaller fish and those released earlier in the smolt run, when river discharge was greater. Rapid emigration (i.e., approximately 1 km/h) and preferential surface orientation improved survival. These results verify that postsmolts are primarily surface oriented in the waters of Penobscot Bay and that they may experience high rates of nearshore mortality despite their short residence time. Detailed emigration and behavioral data such as these allow scientists and managers to delineate areas of high mortality to develop strategies that improve survival, and provide marine spatial planners information to minimize impacts of coastal zone development.

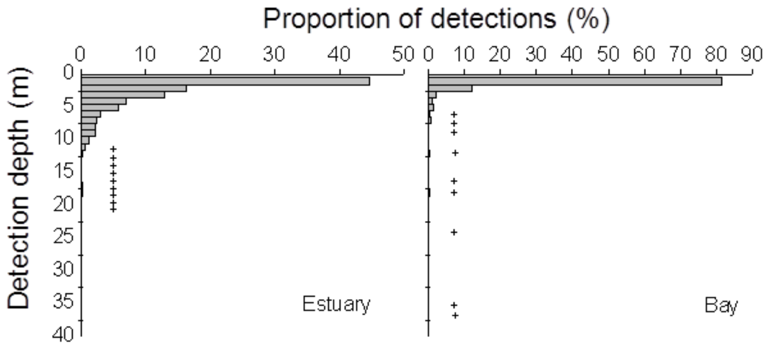


Figure ME04. Detection depths of emigrating Atlantic salmon post-smolts in Penobscot Estuary and Bay in 2005. Proportions are based on 19,217 detections in the estuary and 1,306 detections in the bay. Note the x-axis are different scales. The + symbol denotes the depth detection proportions less than 0.5%.

Lacroix, G. L., Knox, D., Sheehan, T. F., Renkawitz, M. D., and Bartron, M. L. 2012. *Distribution of U. S. Atlantic Salmon Postsmolts in the Gulf of Maine. Transactions of the American Fisheries Society. 141: 934-942.*--- Atlantic salmon of US hatchery origin were captured as postsmolts by surface trawling during spatial surveys in late May to mid-June in the northeastern Gulf of Maine in 2002 and 2003. Most marked and unmarked postsmolts were from the Penobscot River, but some were also from the Dennys and other rivers of the Gulf of Maine (FIGURE ME05). The capture rate of stocked smolts was very low (≤0.01%), and it was highest for marked smolts from known rivers and proportional to numbers stocked. Marked postsmolts were caught 16–43 d after their release as smolts and 89–240 km from their river of origin. The rate of migration from different rivers differed and varied annually, and it accounted for some of the observed differences in capture rate. The weight of postsmolts from known rivers was greater than at smolt stocking and river exit, indicating early marine growth. The distribution of US postsmolts from different rivers was similar, and they were often caught together, as were those from the same river. As a result of this close association during migration, postsmolt catches were aggregated at a few adjacent locations in several areas of the Gulf of Maine. Postsmolts crossing the Gulf of Maine were found east of Jordan Basin and most were along a corridor near shore at the eastern edge of the area surveyed along the southwest coast of Nova Scotia, Canada. Postsmolts of US origin were found in areas used by other salmon populations also leaving the Bay of Fundy during May and June. This seasonal occurrence in a specific coastal area provides an opportunity to manage activities within that corridor to mitigate potential losses of Atlantic salmon from endangered and threatened populations in North America.

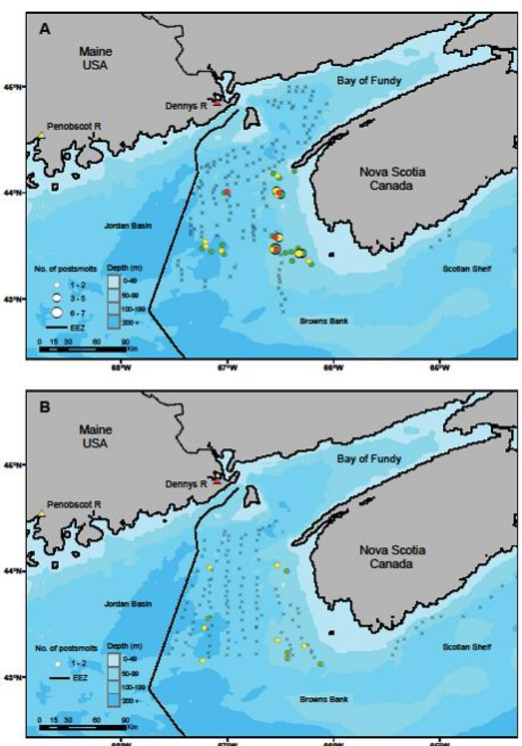


FIGURE ME05. Distribution and abundance of Atlantic salmon postsmolts of US hatchery origin captured in the northeastern Gulf of Maine in (A) 2002, and (B) 2003. Groups represented in pie charts are: Penobscot River (dark fill), Dennys River (gray fill), and unknown rivers (clear). Trawl sites with no US postsmolts (×), the 100-m and 200-m isobaths (differential shading), and the International Boundary (dashed line) are shown

Hawkes, J.P., Saunders, R., Saunders, A.D., and Cooperman, M.S. 2013. *Assessing Efficacy of Non-Lethal Harassment of Double -Crested Cormorants to Improve Atlantic Salmon Smolt Survival. Northeastern Naturalist (20)1-18.*--- Atlantic Salmon smolts are exposed to predation pressure as they migrate from freshwater into the estuary and near-shore marine environment. In particular, double-crested Cormorants are a predator of Atlantic salmon smolts during their estuary and near-shore migration. NOAA NMFS telemetry data collected prior to this study (1997–2003) suggest that smolts are being removed from the Narraguagus River on their downstream out-migration. This removal may be the result of Cormorant predation. We investigated whether smolt survival could be improved by disrupting normal Cormorant foraging activity by integrating passive smolt tracking and active harassment techniques. Smolt movement and usage of various portions of the estuary according to light condition and tidal stage were explored along with concurrent avian harassment. Although harassment only occurred in approximately 33% of available daylight hours during this study, the impacts were easily recognized (Figure ME06). Non-lethal harassment effectively displaced Cormorants from feeding locations and reduced loss of emigrating smolts. In 2004, 83.3% (15 of 18) of all smolt mortalities occurred on days of non-harassment, compared to only 16.7% (3 of 18) on days when harassment occurred. Similarly in 2005, 87.5% (7 of 8) of all smolt mortalities occurred on days of non-harassment, compared to only 12.5% (1 of 8) on days when harassment occurred. Non-lethal harassment appeared to be an effective means to reduce loss of emigrating smolts in the Narraguagus River estuary.

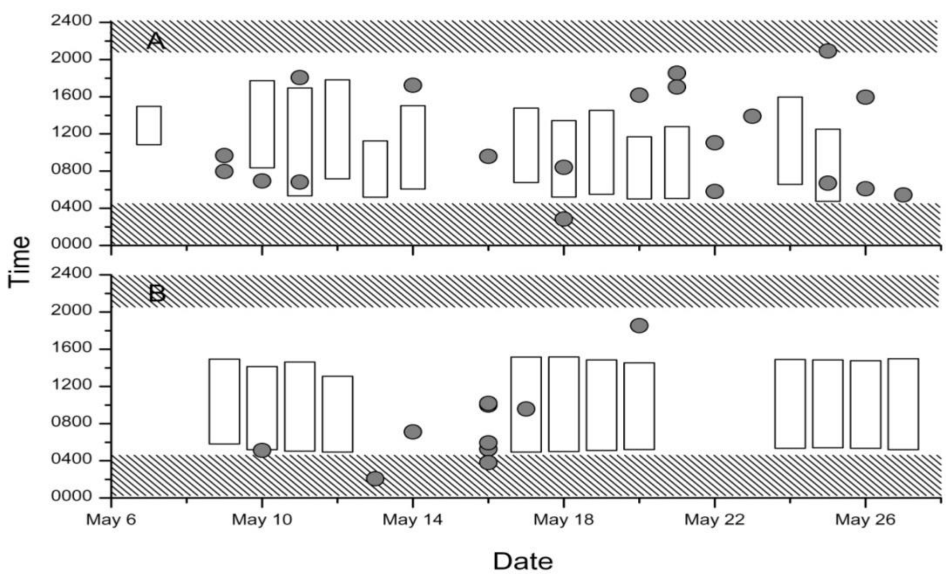


Figure ME06. Harassment period and last detection of unsuccessful smolts (circle) by day in A) 2004 and B) 2005. Open boxes represent periods of harassment (start and stop times) and shaded area (top and bottom of figure) represents low-light level or dark conditions. In 2004, 83.3% (15 of 18) of all smolt mortalities occurred on days of non-harassment, compared to only 16.7% (3 of 18) on days when harassment occurred. Similarly in 2005, 87.5% (7 of 8) of all smolt mortalities occurred on days of non-harassment, compared to only 12.5% (1 of 8) on days when harassment occurred.

O'Malley, M.O., Stevens, J., Dill, R., Saunders, R., and Lipsky, C. 2012. *Overview of Penobscot Estuarine Fish Community and Ecosystem Survey and Examination of River Herring Nursery Habitat. Field Update*-- We tested the feasibility of using multifrequency split-beam hydroacoustic techniques to evaluate the spatial and temporal variability of fish and zooplankton distribution in the Penobscot Estuary, Maine, prior to dam removals. We conducted mobile transects using downward-looking hydroacoustics to provide acoustic target strength and biomass distributions throughout the estuary. We distinguished fish and zooplankton, producing biomass and single target detection target strengths estimates over large spatial and volumetric scales to investigate changes in distribution. Fish biomass and target strength distributions showed variation temporally during the survey period (May–June and Nov-Dec) and spatially through the estuary on survey dates (Figure ME07). Coordinated acoustic and pelagic trawl surveys conducted to perform validation experiments revealed that fish length frequencies and single target detections from hydroacoustics follow similar bi-modal distributions. Target strengths were assigned to sizes of fish and specific species following validation work. For example, in the trawl surveys on 06/21/2011, >90% of trawl catch were made up of alewife, blueback herring and American shad allowing us to assign fish size/species to target strength on that date. Dam-removal upstream will likely cause changes in estuarine communities, and an expansion of methods to investigate changes in fish and zooplankton over larger spatial and temporal scales is warranted. The multifrequency split-beam method can provide fish and zooplankton biomass data over larger scales for relatively small investment over the long term Alewife and blueback herring are two diadromous species of river herring designated by NOAA NMFS as Species of Concern due to their historically low abundance. The Penobscot River currently maintains remnant populations of river herring and is undergoing a large-scale multi-dam removal restoration project aimed at restoring connectivity between freshwater and marine habitats and improving diadromous fish abundance. River herring use of estuarine habitat is poorly understood but it has been characterized as transitional habitat for migrants rather than a significant nursery area. NOAA NMFS initiated a comprehensive fisheries survey of the Penobscot estuary to monitor and describe pre- and post- dam removal conditions using mid-water trawling, seining, fyke nets and hydroacoustics. Sampling from April through October 2011 and 2012 confirmed the presence of river herring in the estuary (Figure ME08). Further analysis indicates that multiple year classes of river herring use the Penobscot estuary including adults and juveniles (ages 0-2) and that juvenile river herring account for a significant portion of the estuarine biomass during the year. These findings provide a baseline for characterizing the dynamics of this habitat for river herring and their role in the ecosystem. Further investigation is required to determine the ecological significance of this habitat for the Penobscot River herring population and how conditions may change as restoration progresses.

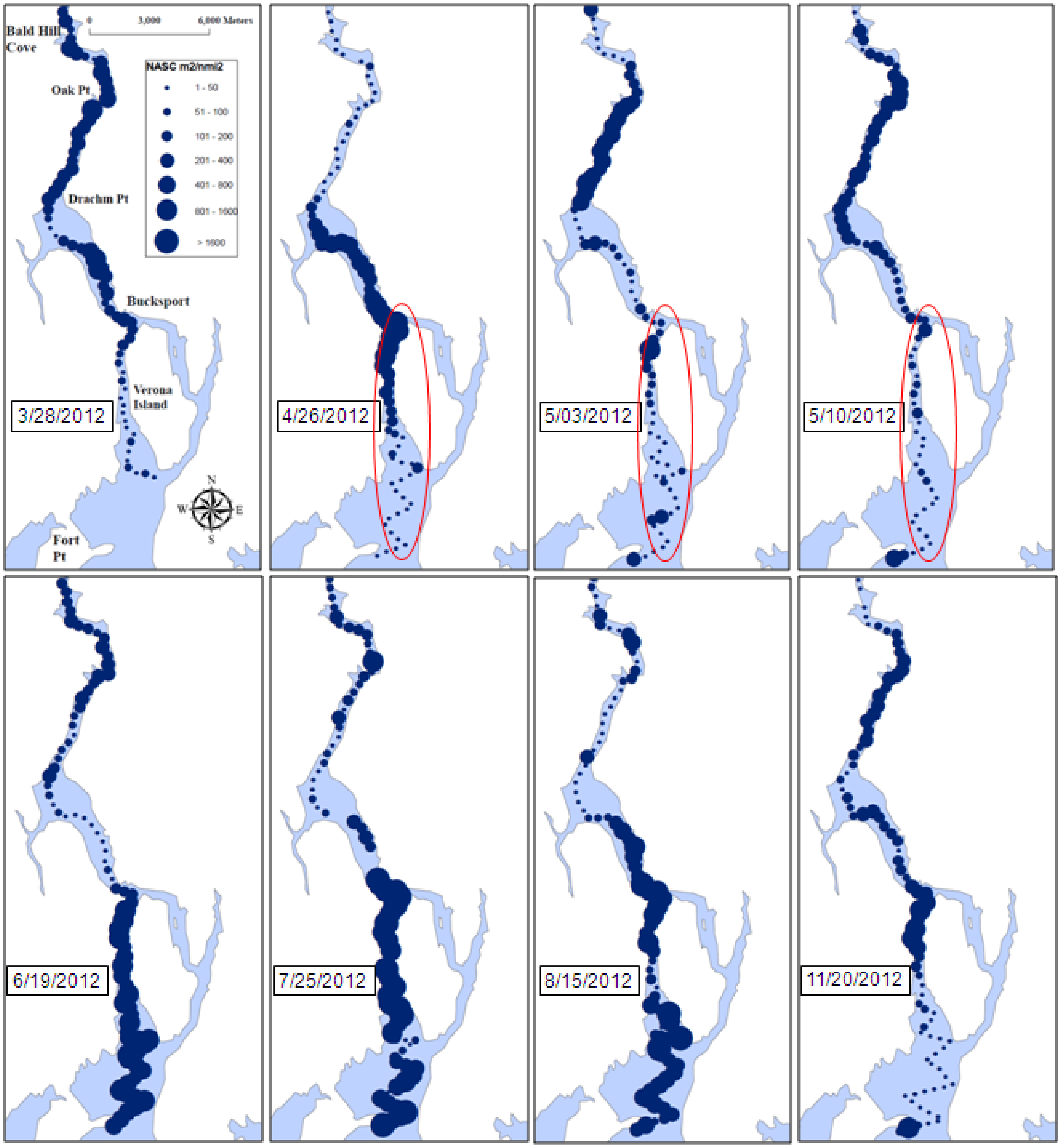


Figure ME07.Penobscot Estuary acoustic fish biomass (NASC - m^2/nmi^2) distributions in 2012. Area highlighted in red is where smolt losses generally begin to increase (NOAA NMFS unpublished data).

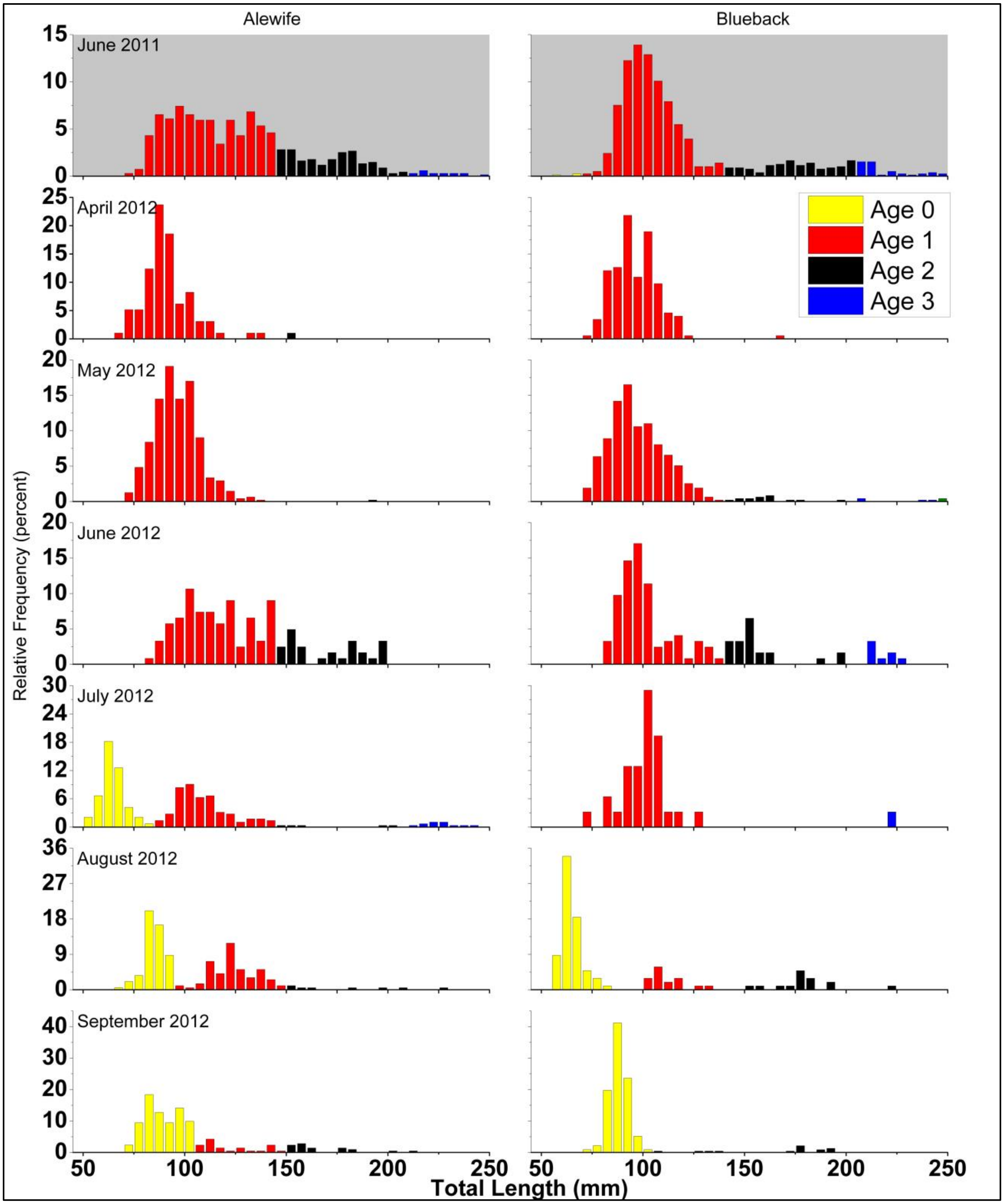


Figure ME08. Total Length frequency for alewife (left) and blueback herring (right) during 2011-2012 trawl sampling depicting multiple size classes present throughout the time-series. Age classes were assigned based on length at age keys developed from NEFSC age analysis and literature.

Grote, A.B. 2012. *Migration and spawning behavior of a remnant population of American shad (Alosa sapidissima) prior to dam removal. MS Thesis Extended Abstract*
The Penobscot River is currently the subject of an intensive river restoration effort. The impact of this effort toward the restoration of the diadromous community is hypothesized to have synergetic impacts on Atlantic salmon recovery. American shad are one species that may serve as a barometer to the restoration of a healthy diadromous species complex. This thesis examined the migratory movements, and age and spawning structure of American shad prior to dam removal. Although shad were historically abundant in the system, little is known about the current-day population which was presumed to be small. This decline is attributed to a lack of migratory connectivity and accessible habitat; American shad do not pass the Veazie fishway, and freshwater spawning habitat (15 rkm) and brackish rearing habitat (~50 rkm) are limited below the dam. It is anticipated that the Penobscot River shad will benefit from restored connectivity and access to upriver freshwater habitats. In the spring of 2011, a Dual-Frequency Identification Sonar (DIDSON) was used to record footage of fish approaching the entrance of the Veazie Dam fishway. Fork lengths (FLs) from high-quality images were measured, and the resulting FL distributions were compared against known length distributions of river herring, American shad, and Atlantic salmon using a Bayesian mixture model. The model classified over 76 % of fish observations as American shad, and attributed 16 % to Atlantic salmon and 8 % to river herring. These results indicate shad were present at the base of dam. However, because the imaged fish were not uniquely identifiable and may have been imaged repeatedly, abundance at the base of the dam cannot be inferred from these proportions. A combination of radio and acoustic telemetry was used to investigate the movements of migratory American shad in the springs of 2010 and 2011. Radio telemetry results indicate that few tagged shad (5 – 8 %) approached the Veazie Dam, but that those who did investigated the dam on at least two days. Tagged fish exhibited three main movement patterns in freshwater: using the upper end of the radio array above rkm 43, using the lower end of the array near rkm 34, or using the entire array. Mean freshwater residence time in freshwater ranged from 9.1 to 14.0 days. "Hotspots" where shad congregated included Eddington Bend (rkm 47) and the Bangor Dam head pond (rkm 44), and spawning activity was observed at the latter site. Freshwater survival and survival to the estuary were at least 71%. The high survival rate was confirmed the ageing and spawning histories obtained from shad scales, which indicated that 75 – 95 % of the sampled fish were repeat spawners, and that adult migrants ranged from age 4 – 9. Acoustic tagged fish exhibited a series of upstream and downstream reversals upon entering the lower estuary. These movements were previously unreported for American shad, and may be related to osmoregulatory acclimatization for re-entry into saltwater, to the resumption of post-spawn feeding activity or both.

Overview of 2012 Temperatures in the Gulf of Maine
Given the extensive press coverage of the warm ocean temperatures in the GOM last year, we decided a brief synopsis would be useful. As this report was going to press, a comprehensive research communication became available that provides this overview. We suggest that interested readers review the article - Mills, K. E., Pershing, A. J., Brown, C. J., Chen, Y., Chiang, F. S., Holland, D. S. and Wahle, R. A. (2013). Fisheries management in a changing climate: Lessons from the 2012 ocean heat wave in the Northwest Atlantic. Oceanography, 26(2). With record warm sea surface temperatures in the GOM, we think their conclusions bear repeating as they are relevant to Atlantic salmon marine management.
"The 2012 ocean heat wave serves as a preview of the types of changes that are likely to occur in marine ecosystems as ocean temperatures warm and become more variable. The events associated with this heat wave brought both unanticipated challenges and opportunities to fisheries in the Gulf of Maine and likely in other areas that were affected by the extremely warm temperatures. The 2012 experience also provides a rare case study that can be used to develop a deeper understanding of how ecosystems

respond to warming and to identify ways in which management can prepare for changes that will occur under future climate conditions. Drawing lessons from events like the 2012 heat wave is critical for developing adaptation strategies that will enhance existing capacities to sustain marine ecosystems and fisheries in the context of climate change."

Future Directions

Given the recent increase of marine research findings for Atlantic salmon overall and GOM Atlantic salmon in particular, the MEAT has decided to revisit our strategies during 2013 and suggest some changes. We will be developing these potential ideas as a team and present these to Action Team Chairs and the Management Board during 2013 for inclusion in 2014 Plans. However, some agency actions that will be relevant to better understanding marine ecology have already started and are outlined below.

Groundfish predation on diadromous fishes in coastal Maine: Quantifying a suspected trophic interaction - Sheehan, T. F., Lipsky, C., O'Malley, M. and Renkawitz, M. D. --- In 2009, a joint project between the NEFSC and NERO was initiated with the objective to quantify the presence of diadromous fishes in the stomachs of groundfishes in coastal waters near the mouths of the Kennebec and Penobscot rivers in Maine. Preliminary work consisted of four sampling events conducted in 2010 and 2011 and found that the trophic interactions between diadromous fish and piscivorous groundfish of the Northwest Atlantic have been largely indeterminate. Within this region, Link et al. found evidence for marine predation on migratory spawners such as river herrings (Alosa spp.), American eel, Atlantic salmon, and rainbow smelt has been limited or, at best, reported anecdotally. The objectives of this work were to quantify the presence of diadromous fishes in the stomachs of groundfish in coastal waters near the mouths of the Kennebec and Penobscot rivers in Maine. Preliminary results showed that diadromous fishes were detectable and observed in the diets of several predators for every season sampled (only river herrings were observed and with low frequencies of occurrence). Even though diadromous fishes were not the most abundant prey, they accounted for ~5-10% of the diet by mass for several predators. Furthermore, statistical comparisons of these data with food habits data from the Northeast Fisheries Science Center (NEFSC) suggest the frequency of this trophic interaction was significantly higher within the targeted sampling areas of the present study. Odds ratios of diadromous predation were as much as 100 times higher in the targeted sampling as compared to the NEFSC sampling. Diadromous predation events were more concentrated in the near-coastal waters compared to the consumption of a similar but more widely distributed species, the Atlantic herring (Clupea harengus). Within the context of ecosystem-based fisheries management, our results suggest that even low-frequency events may be locally important; exactly how important remains an intriguing issue.

Starting in 2012 (spring), NOAA NMFS Northeast Salmon Team (NEST) continued this sampling program in collaboration with the Maine DMR inshore survey program. Sampling effort continues to be focused on the coastal waters near the mouths of the Kennebec and Penobscot rivers. In conjunction with the spring and falls surveys, NOAA NMFS NEST personnel participate on the Maine DMR inshore trawl for two weeks (one week in the Kennebec River region and one week in the Penobscot River region) collecting stomach samples from potential predators of diadromous fishes. Stomach samples are processed by the Northeast Fisheries Science Center/Population Biology Branch's Food Web Dynamics Program in Woods Hole, MA. Approximately 200 samples were collected in 2012 and sampling was continued in 2013. Long term plans are to continue this sampling.

Auditing of Department of Fisheries and Oceans Canada historical marine survey database - - Renkawitz, M. D. and Sheehan, T. F. Given insights gained from modernizing tagging databases (Miller et al. 2012), NEFSC staff felt it important to modernize and preserve data from marine surveys that encounter US

Atlantic salmon. The Department of Fisheries and Oceans Canada (DFO) has been conducting marine surveys for Atlantic salmon in the nearshore waters of eastern Canada and the Labrador Sea since 1962. A large and robust database has been developed over the decades, but database and software technology have evolved to the point where the archived DFO Atlantic salmon databases require auditing and updating to facilitate their contemporary use. DFO personnel changes have left a knowledge gap in terms of database structure and content and resources were not available to audit and modernize these databases. Staffs from NOAA NMFS NEST familiar with the DFO marine surveys have been working with current DFO staff to facilitate this process. Initial audits have been conducted and results provided to DFO. Once the database audit is complete, a finalized modern database will be available to US and Canadian researchers. This database will be a valuable tool for Atlantic salmon marine researchers investigating the marine ecology of the species in the Northwest Atlantic. Approximately 25,000 individual fish records, including tag release and recapture records are contained within the database.

Selected Recent 2012 Publications, Presentations, and Reports

Journal Publications

1. Dixon, H., Power, M., Dempson, J.B. Sheehan, T.F., and Chaput G., 2012. Characterizing trophic status and shift in Atlantic salmon, Salmo salar, from freshwater to marine life cycle phases. ICES Journal of Marine Science. 69(9):1646–1655. doi:10.1093/icesjms/fss122.

2. Hawkes, J.P., Saunders, R., Saunders, A.D., and Cooperman, M.S., 2013. Assessing Efficacy of Non-Lethal Harassment of Double -Crested Cormorants to Improve Atlantic Salmon Smolt Survival. Northeastern Naturalist (20):1-18.

3. Lacroix, G. L., Knox, D., Sheehan, T.F., Renkawitz, M.D., and Bartron, M.L., 2012. Distribution of U. S. Atlantic Salmon Postsmolts in the Gulf of Maine. Transactions of the American Fisheries Society. 141:934-942.

4. Miller, A. S., Sheehan, T.F., Spencer, R.C., Renkawitz, M.D., Meister, A.L., and Miller, T.J., 2012. Revisiting the marine migration of US Atlantic salmon with historic Carlin tag data. ICES Journal of Marine Science. 69(9):1609-1615. doi:10.1093/icesjms/fss039.

5. Reddin, D. G, Hansen, L. P., Bakkestuen, V., Russell, I., White, J., Potter, E.C.E. , Sheehan, T. F., Ó Maoiléidigh, N., Dempson, J. B., Smith, G. W., Isaksson, A., Fowler, M., Jacobsen, J. A., Mork, K. A., and Amiro, P., 2012. Distribution of Atlantic salmon (Salmo salar L.) at Greenland, 1960s to present. ICES Journal of Marine Science. 69(9):1589–1597. doi:10.1093/icesjms/fss087.

6. Renkawitz, M. D., Sheehan, T. F., and Goulette, G. S., 2012. Swimming depth, behavior, and survival of Atlantic salmon postsmolts in Penobscot Bay, Maine. Transactions of the American Fisheries Society. 141:1219-2012.

7. Sheehan, T. F., Reddin, D. G., Chaput, G., and Renkawitz, M. D., 2012. SALSEA North America: A pelagic ecosystem survey targeting Atlantic salmon in the Northwest Atlantic. ICES Journal of Marine Science. 69(9):1580-1588. doi:10.1093/icesjms/fss052.

Presentations

8. Collins, M. J., Clarke, G. A., Baeder, C., McCaw, D., Royte, J., Saunders, R., and Sheehan, T. F., 2012. Large-scale dam removal in the northeast United States: documenting ecological responses to the Penobscot River Restoration Project. American Geophysical Union 2012 Fall Meeting. San Francisco, CA.

9. Goulette, G.S., Hawkes, J.P., O'Malley, M.B., Music, P.A., Stevens, J.R., Stich, D.S., and Lipsky, C.A. 2012. Estuarine community and emigration ecology of Atlantic salmon in the Penobscot Estuary, Maine. Talk (Symposium); Teaming up Atlantic and Pacific salmonid biologists to enhance recovery of endangered salmon in North America. American Fisheries Society, Minneapolis/St. Paul, Minnesota, Aug 19-23, 2012.

10. Goulette, G.S., Hawkes, J.P., O'Malley, M.B., Kocik, J.F., Music, P.A., Stevens, J.R. and Lipsky, C.A., 2012. Predation and prey buffer potential for Atlantic salmon smolts emigrating the Penobscot Estuary, Maine. 38th Annual Meeting of the Atlantic International Chapter of the American Fisheries Society. Averill, Vermont.

11. Goulette, G.S., Hawkes, J.P., O'Malley, M.B., Kocik, J.F., Music, P.A., Stevens, J.R. and Lipsky, C.A. 2012. Predation and prey buffer potential for Atlantic salmon smolts emigrating the Penobscot Estuary, Maine. NOAA – DMR Co-op Meeting October 2012. Bangor, ME.

12. Hawkes, J.P., Zydlewski, G., Zydlewski, J., Goulette, G., and Kocik, J., 2012. Telemetry: An established monitoring tool for assessing pre-dam removal conditions for diadromous fishes of the Penobscot River [abstract]. Presented at: 2012 Maine Water Conference; Augusta ME; 14 Mar 2012.

13. Hawkes, J.P., Sheehan, T.F., Music, P., Stich, D., Atkinson, E., 2012. Assessing estuarine and coastal migration performance of Age-1 hatchery reared Atlantic salmon smolts from the Dennys River, Maine (USA) [abstract]. Presented at: 2012 Atlantic Salmon Forum; Maine Atlantic Salmon and their Ecosystems; Bangor ME; 10-11 Jan 2012. NEFSC Ref Doc. 12-12; p 184.

14. Hawkes, J. P., Sheehan, T. F., Music, P., Stich, D. and Atkinson, E. 2012. Assessing estuarine and coastal migration performance of age-1 hatchery reared Atlantic salmon smolts released into the Dennys River. Atlantic Salmon and their Ecosystems Forum. Bangor, ME.

15. King, T. L., Sheehan, T. F., Waples, R., and Moran, P., 2012. Insightful Connections and Contrasts in the Conservation Genetics of Atlantic and Pacific Salmon - A Synthesis. American Fisheries Society 2012 Annual Meeting. St. Paul, MN.

16. Kocik, J. F., Goulette, G. S., Hawkes, J. P., and Sheehan, T. F., 2012. Telemetry-based estimates of Atlantic salmon survival in estuaries and bays of Maine. Atlantic Salmon and their Ecosystems Forum. Bangor, ME.

17. Lipsky, C., and Saunders, R., 2013. Evidence of successful spawning of American shad in the Penobscot River, Maine. Poster; DSRRN Science Meeting, January 2013.

18. Miller, A. S., Miller, T. J., Sheehan, T. F., and Renkawitz, M. D., 2012. Retrospective analysis of Atlantic salmon marine growth parameters in the northwest Atlantic based on tag-recovery data. Atlantic Salmon and their Ecosystems Forum. Bangor, ME.

19. Miller, A. S., Sheehan, T. F., Renkawitz, M. D., Meister, A. L., and Miller, T. J., 2012. Revisiting the marine migration of US Atlantic salmon using historic Carlin tag data. Atlantic Salmon and their Ecosystems Forum. Bangor, ME. [Poster].

20. Mills, K. E., Pershing, A., Sheehan, T. F., and Mountain, D., 2012. Marine Ecosystem Conditions Affect North American Atlantic Salmon Populations. American Fisheries Society 2012 Annual Meeting. St. Paul, MN.

21. Mills, K., Pershing, A., Mountain, D., and Sheehan, T. F., 2012. The influence of environmental, oceanographic, and low trophic level conditions on marine survival of Atlantic salmon. Atlantic Salmon and their Ecosystems Forum. Bangor, ME.

22. O'Malley, M., Stevens, J., Saunders, R., Lipsky, C., and Kocik, J., 2012. Pre-dam Removal Monitoring of Penobscot Estuarine Fish and Zooplankton using Mobile Split-Beam Hydroacoustic Methods. Talk (Session E); Evaluating Restoration Outcomes of the Penobscot River Restoration Project: An Assessment of Pre-dam Removal Conditions. Maine Water Conference, Augusta Civic Center, Augusta, Maine, March 14, 2012.

23. O'Malley, M., Stevens, J., Saunders, R., Lipsky, C., and Kocik, J., 2012. Using Hydroacoustics to Investigate Prey Buffering during Atlantic Salmon Smolt Migration in the Penobscot Estuary, Maine, USA. Talk (Symposium); Standardization in Hydroacoustic Assessments: Fundament or Folly? American Fisheries Society, Minneapolis/St. Paul, Minnesota, Aug 19-23, 2012.

24. O'Malley, M., Stevens, J., Saunders, R., Lipsky, C., and Kocik, J., 2012. Describing the Penobscot Estuary during Atlantic Salmon Smolt migration using Hydroacoustics. Talk; DMR Meeting October, 2012.

25. O'Malley, M., Stevens, J., Saunders, R., Lipsky, C., and Kocik, J., 2012. The Penobscot Estuarine Fish Community and Ecosystem Survey. Newsletter; Penobscot River Research Newsletter, Vol. 2 (1).

26. O'Malley, M., Saunders, R., and Stevens, J., 2013. Using Hydroacoustics to Investigate Prey Buffering during Atlantic Salmon Smolt Migration in the Penobscot Estuary, Maine, USA. [Poster] DSRRN Science Meeting, January 2013.

27. Renkawitz, M. D., Sheehan, T. F., Reddin, D., Chaput, G., and Saunders, R., 2012. Trophic ecology of Atlantic salmon in the northwest Atlantic. Atlantic Salmon and their Ecosystems Forum. Bangor, ME.

28. Sheehan, T. F., Renkawitz, M. D., and Brown, R., 2012. Surface trawl survey for US origin Atlantic salmon (Salmo salar) in Penobscot Bay, Maine. Atlantic Salmon and their Ecosystems Forum. Bangor, ME.

29. Stevens, J., O'Malley, M., Saunders, R., Lipsky, C., and Kocik, J., 2012. What's in the Water? - Penobscot Estuary Fish Community Survey Preliminary Results. Talk; AIC Meeting, Vermont, Sept 22-24, 2012.

30. Stevens, J., and Dill, R., 2013. Evidence of the Penobscot River Estuary Providing River Herring Nursery Habitat. Poster; DSRRN Science Meeting, January 2013.

Reports and Working Papers

1. Goulette, G.S., Hawkes, J.P., and Kocik, J.F. 2013. *Update on NOAA Fisheries Service Coastal Maine River Atlantic Salmon Smolt Telemetry Studies: 2012*. Working Paper 2013-04. US Atlantic Salmon Assessment Committee Meeting. Turner Falls, MA. 15 pp.

2. Miller, A. S., Sheehan, T. F., Spencer, R. C., Renkawitz, M. D., Friedland, K. D., and Meister, A. L., 2012. Description of the Historic US Atlantic Salmon (Salmo salar L.) Tagging Programs and Subsequent Databases. Northeast Fisheries Science Center Reference Document 12-13. 56 pp.

3. Sheehan, T. F., Reddin, D.G., Nygaard, R., and King, T.L., 2012. The International Sampling Program, Continent of Origin and Biological Characteristics of Atlantic Salmon Collected at West Greenland in 2011. Working Paper 01. International Council for the Exploration of the Seas Working Group on North Atlantic Salmon Annual Meeting. Copenhagen, Denmark.

4. Sheehan, T. F., Assunção, M. G. L., Chisholm, N., Deschamps, D., Dixon, H., Renkawitz M.D., Rogan, G., Nygaard, R., King, T. L., Robertson, M. J., O'Maoiléidigh, N., 2012. The international sampling program, continent of origin and biological characteristics of Atlantic salmon (Salmo salar) collected at West Greenland in 2011. US Dept. Commer. Northeast Fish. Sci. Cent. Ref. Doc. 12-24; 27 pp.

5. Sheehan, T. F., 2011. Tag recaptures at Greenland (2003-2010). Working Paper 02. International Council for the Exploration of the Seas Working Group on North Atlantic Salmon Annual Meeting. Copenhagen, Denmark.

6. Trial, J., Sweka, J., Kocik, J., and Sheehan, T. F., 2012. National Report for the United States, 2011. Working Paper 7. International Council for the Exploration of the Seas Working Group on North Atlantic Salmon Annual Meeting. Copenhagen, Denmark.

7. Watson, D. S., and Sheehan, T. F., 2012. Archived Documents of the International Council for the Exploration of the Sea (ICES) Working Group on North Atlantic Salmon (WGNAS). Working Paper 2. International Council for the Exploration of the Seas Working Group on North Atlantic Salmon Annual Meeting. Copenhagen, Denmark.

Freshwater Action Team (FWAT)

Colby Bruchs, Maine Department of Marine Resources
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Jim Hawkes, NOAA's National Marine Fisheries Service
Dan Kircheis, NOAA's National Marine Fisheries Service
Fred Seavey, US Fish and Wildlife Service
Randy Spencer, CHAIR, Maine Department of Marine Resources
Jed Wright, US Fish and Wildlife Service

Strategy

Increase adult spawners through the freshwater production of smolts

Strategic Objectives

- Increase juvenile Atlantic salmon survival.
- Increase our understanding of factors limiting juvenile Atlantic salmon survival.
- Develop a process and infrastructure to identify and implement habitat restoration projects.
- Protect and conserve productive Atlantic salmon Habitat.

Strategic Metrics

- Population estimates of smolt production at index rivers
- Catch-per-unit-effort of parr based on a stratified random sampling design
- Distribution and abundance of redds (Stock Assessment action)
- Counts of wild adult returns at index rivers (Stock Assessment action)

Background: The goal of the Freshwater Action Team (FWAT) is to increase the production of wild smolts and wild adult returns. This can be accomplished by reducing the threats to Atlantic salmon in freshwater and improving habitat. It is also important to maximize the production potential of each returning adult Atlantic salmon. There are three objectives in support of our primary goal; 1) increase our knowledge and understanding of factors that limit juvenile production; 2) develop a structured system to identify habitat restoration projects; and 3) protect productive Atlantic salmon habitat and restore/enhance degraded habitat.

Accomplishments

The form and function of the framework and action teams is an evolving and adaptive process. We recognize that developing and implementing FWAT management priorities within the current staff and budget restrictions is challenging. The FWAT met in 2012 to discuss and clarify our team's responsibilities and potential strategies to increase our effectiveness within these constraints. A creative approach will be required to develop partnerships and focus additional interest and resources to support fresh water priorities identified through the FWAT and framework. A first step was taken by expanding FWAT membership with three additional members representing the NMFS (Jim Hawkes) and the USFWS (Jed Wright, Fred Seavey) and to invite a representative from the DSF (Jacob van de Sande) to our FWAT meeting. The FWAT will continue to meet in 2013 to refine and expand this process.

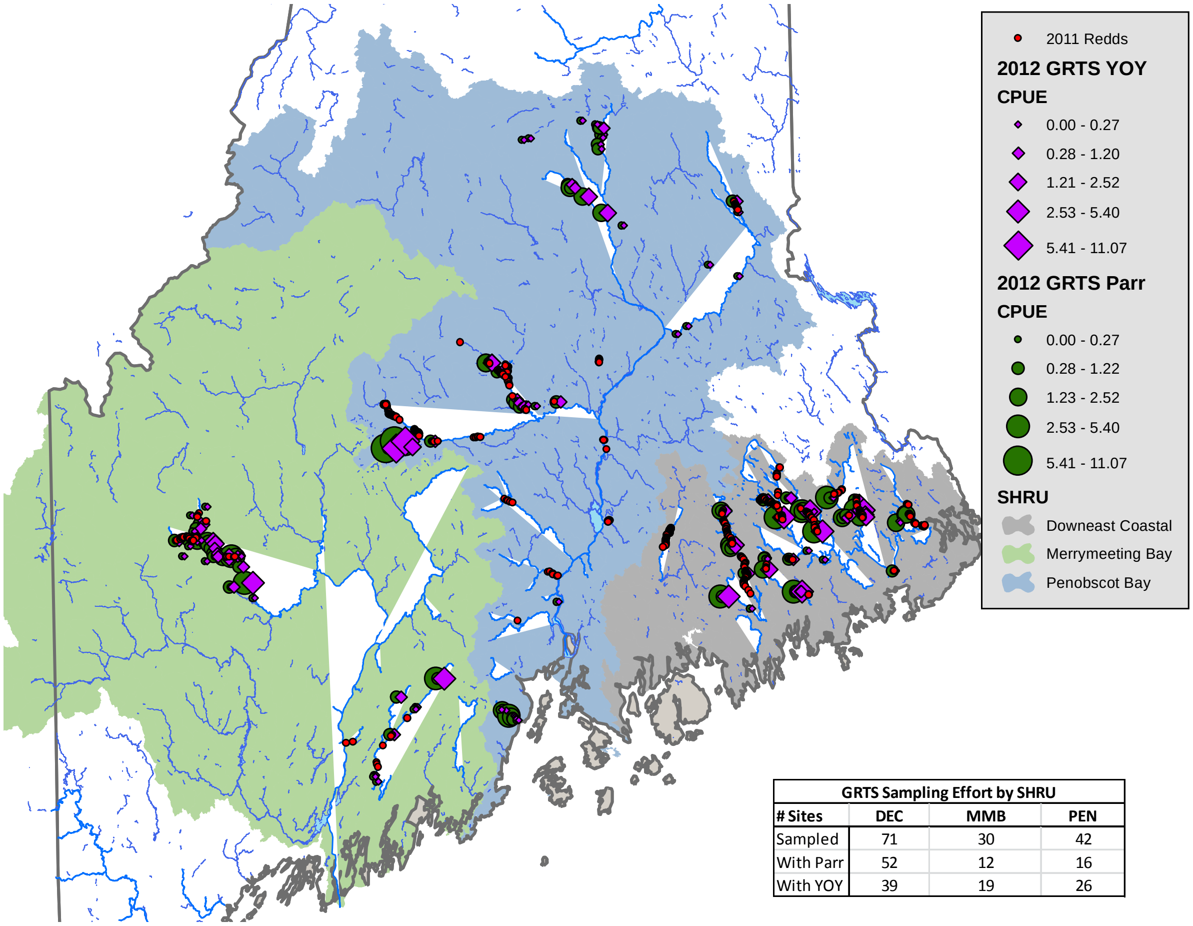
Updates on each action are summarized in Table 5.7. Some FWAT action items are sequential, some independent, and others are implemented opportunistically. Consequently not all listed actions are pursued each year. This was the second year (2012) of implementation of FWAT strategies and progress was made in core areas. Increasing freshwater production is an ongoing process and our intention is to refine actions as necessary to best match our strategic objectives, resources, and cooperative efforts within the Atlantic salmon community.

Juvenile Assessment

Stream residents

FWAT action 1 is implementation of a state-wide juvenile salmon monitoring program based on a statistically valid sampling methodology. As in 2011, DMR monitored the relative abundance of juvenile salmon through CPUE electrofishing surveys based on a state-wide Generalized Random - Tessellated Stratified design (GRTS, Stevens and Olsen 2004). The GRTS sampling frame was selected using the NHD Flow line feature for the DE SHRU and the Habitat Model developed by Wright et al. (2011) for the Penobscot and Sandy Rivers. A total of 143 randomly selected sites (selection filters included stream width and drainage) were sampled representing the Downeast Coastal, Penobscot Bay, and Merrymeeting Bay Salmon Habitat Recovery Units (SHRU, Figure 5.2).

Relatively low juvenile abundance was observed throughout the Gulf of Maine DPS. Young-of-the-Year salmon (age0+) were present at 63% of Merrymeeting Bay SHRU sites, 62% of Penobscot Bay SHRU sites, and 55% of Downeast Coastal SHRU sites. Salmon parr (>age0+) were present at 73% of Downeast Coastal SHRU sites, at 40% of Merrymeeting Bay SHRU sites, and 38% of Penobscot Bay SHRU sites. State-wide relative abundance ranged from 0.00-11.07 yoy/minute and 0.00-4.00 parr/minute (Figure 5.2). Analysis of data from sites where salmon were present indicates SHRU medians of YOY abundance (0.40 to 0.79 YOY/minute) and parr abundance (0.50 to 0.77 parr/minute) decreased relative to 2011. Juvenile abundance and density data are presented in greater detail in the Stock Assessment section of this report (Table 1.2). Additional analysis will be presented in DMR's bi-annual July report "Atlantic Salmon Freshwater Assessments and Research of Mutual Interest to Maine DMR and NOAA Fisheries".



GRTS Sampling Effort by SHRU

# Sites	DEC	MMB	PEN
Sampled	71	30	42
With Parr	52	12	16
With YOY	39	19	26

Figure 5.2. 2012 Juvenile Atlantic salmon abundance (fish/minute) and previous year redd locations by SHRU, within the Gulf of Maine DPS.

Smolt Assessment

The FWAT's strategic objective to "Increase our understanding of factors limiting juvenile salmon survival" (in freshwater) included an investigation of smolt behavior and survival during downstream migration in the Penobscot River. University of Maine researchers (Dan Stitch and Joe Zydlewski) partnered with Brookfield Power and the Penobscot River Restoration Trust to acoustically tag and monitor 167 smolts during downstream migration in 2012. A primary study objective was to identify potential sources of mortality and provide strategic insight for improving smolt survival.

To increase our understanding of juvenile salmon survival and smolt production, the DMR deployed and operated rotary screw traps (RST) at three established index sites in 2012 (Table 5.2). Data collected and analyzed from these sites were used to assess management strategies that target river-reared "wild" smolt production; and to extend the time series for production estimates (Figure 1.6). In 2012 DMR assumed responsibility for daily operations at the Narraguagus and Sheepscot sites although NOAA NMFS continues to assist with data analysis for those sites. DMR maintained responsibility for all aspects of smolt trapping and data analysis for the Piscataquis River site (Table 5.3). Mark-recapture data and "DARR for R, v2.0.2" software were used to produce a maximum likelihood estimate of smolt abundance at all sites (Figure 1.6).

Smolt catches in 2012 declined relative to 2011 on all rivers but high river flows and poor trapping conditions during the peak of the smolt migration reduced capture efficiency in 2012. Traps could not be fished safely for extended periods and a substantial number of smolts may have passed undetected and been excluded from the 2012 population estimates (Table 5.3).

Table 5.2. Total captures of Atlantic salmon smolts, by origin, and dates of rotary screw trap operations for three drainages in Maine.

Drainage	Deployment window		Origin	Total Catch	First Catch	Last Catch	Median Catch
Narraguagus	12-Apr	29-May	Wild	312	20-Apr	24-May	1-May
			Hatchery	5,357	22-Apr	20-May	1-May
Upper Piscataquis	16-May	22-May	Wild	513	17-Apr	20-May	23-Apr
Sheepscot	29-Mar	31-May	Wild	171	17-Apr	30-May	6-May
			Hatchery	245	15-Apr	15-May	5-May

Table 5.3. 2012 naturally reared Atlantic salmon smolt population estimates and standard error (se) from rivers in gulf of Maine DPS.

SHRU	Drainage	Estimate	SE
Downeast Coastal	Narraguagus River	969	244
Penobscot Bay	Upper Piscataquis River	2,013	353
Merrymeeting Bay	Sheepscot River	1,101	252

Adult Assessment

Increasing wild smolt production is a primary goal of the FWAT. Currently wild smolt production is estimated directly using rotary screw traps, and indirectly by monitoring wild adult returns. Adult salmon return data collected at fishway traps indicate extremely low marine survival rates for both the 1SW and 2SW cohorts in 2012. On the Penobscot, wild returns (77 total) declined by 69% relative to 2011 and hatchery returns (547) declined by over 80% (Table 5.4). The state-wide declines in both river-reared and hatchery origin adults implicate marine rather than freshwater survival problems. Variation in marine survival can mask short term patterns of smolt production and escapement (as it did in 2012) but long term trends in smolt abundance will be reflected in the number of returning wild adults. Detailed analysis of adult salmon return data are presented in the Stock Assessment section.

Table 5.4. Total 2012 captures of Atlantic salmon adults, by origin, and dates of trap operations for six drainages in Maine.

SHRU Drainage	Open date	Median capture	Close date	Origin	Sea-run Salmon	Aquaculture escapees
Downeast Coastal SHRU						
Dennys	14-Aug	na	4-Oct	Wild	0	0
				Hatchery	0	
Narraguagus	27-Apr	22-Jun	30-Oct	Wild	5	0
				Hatchery	12	
Union	5-May	na	13-Nov	Wild	0	3
				Hatchery	0	
Penobscot SHRU						
Penobscot	30-Apr	30-May	25-Oct	Wild	77	3
				Hatchery	547	
Merrymeeting Bay SHRU						
Androscoggin	7-May	na	29-Oct	Wild	0	1
				Hatchery	0	
Kennebec	1-May	18-Jun	26-Oct	Wild	4	0
				Hatchery	1	
Non GOM DPS						
Saco	1-May	14-Jun	26-Oct	Wild	0	0
				Hatchery	12	
Total					658	7

Redd Surveys

Atlantic salmon spawning surveys focused on rivers with established salmon populations within the GOM DPS. DMR conducted redd surveys within each SHRU from early October to ice-in with the assistance of NGO partners (Figure 4). Redds were documented in each SHRU (Table 5.5) but counts in all SHRUs were much lower than 2011. Only 20 redds were counted in Old Stream (Machias watershed), a 65% decline relative to 2011 (58 redds) and 47% below the conservation spawning escapement (CSE) for that habitat. Captive- reared adult salmon were used to supplement wild spawners in the Downeast Coastal SHRU (Table 5.5) and adult returns from hatchery smolt stocking contributed to spawning in the Narraguagus River.

In the Penobscot, termination of the adult translocation study combined with low overall returns reduced escapement and contributed to a sharp decline in redds in 2012. Spawning escapement and redds in the GOM DPS declined to the critically low levels observed prior to 2008 (Figure 5.5).

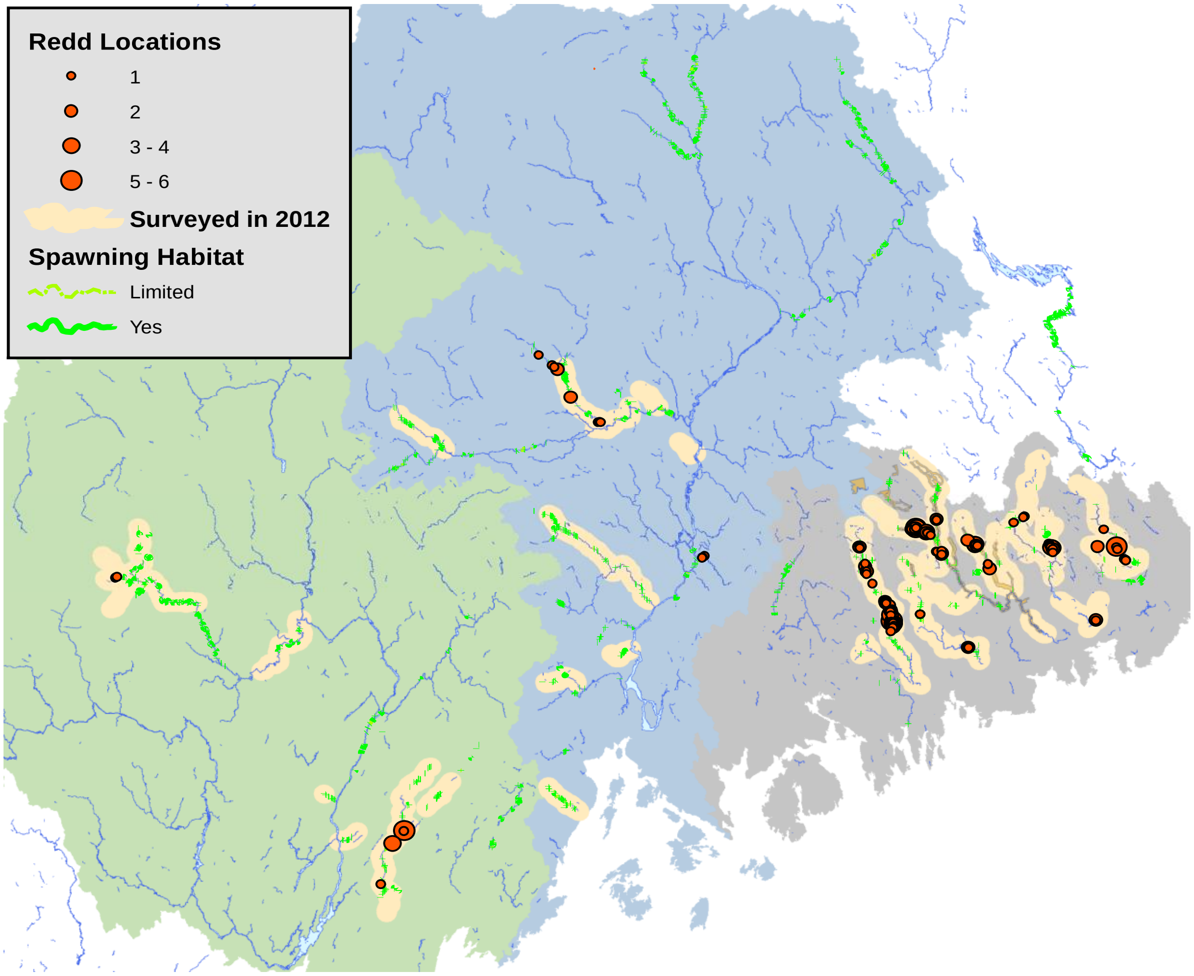


Figure 5.4. Mapped spawning habitat, spawning inventory coverage, and redd locations by SHRU, 2012.

Table 5.5. Summary of documented redds and survey effort by SHRU and drainage 2012.

SHRU	Drainage	Redds	% Spawning Habitat Surveyed
Downeast Coastal	Dennys*	14	97.1
	East Machias*	42	95.9
	Hobart	0	53.5
	Machias*	84	58.2
	Narraguagus	86	82.0
	Pleasant*	13	84.1
Merrymeeting Bay	Ducktrap	0	69.7
	Lower Kennebec	2	1.5
	Sheepscot	12	77.0
Penobscot	Mattawamkeag	0	1.5
	Penobscot	3	1.9
	Piscataquis	10	8.8

*Redds from captive reared adult outplants included in total

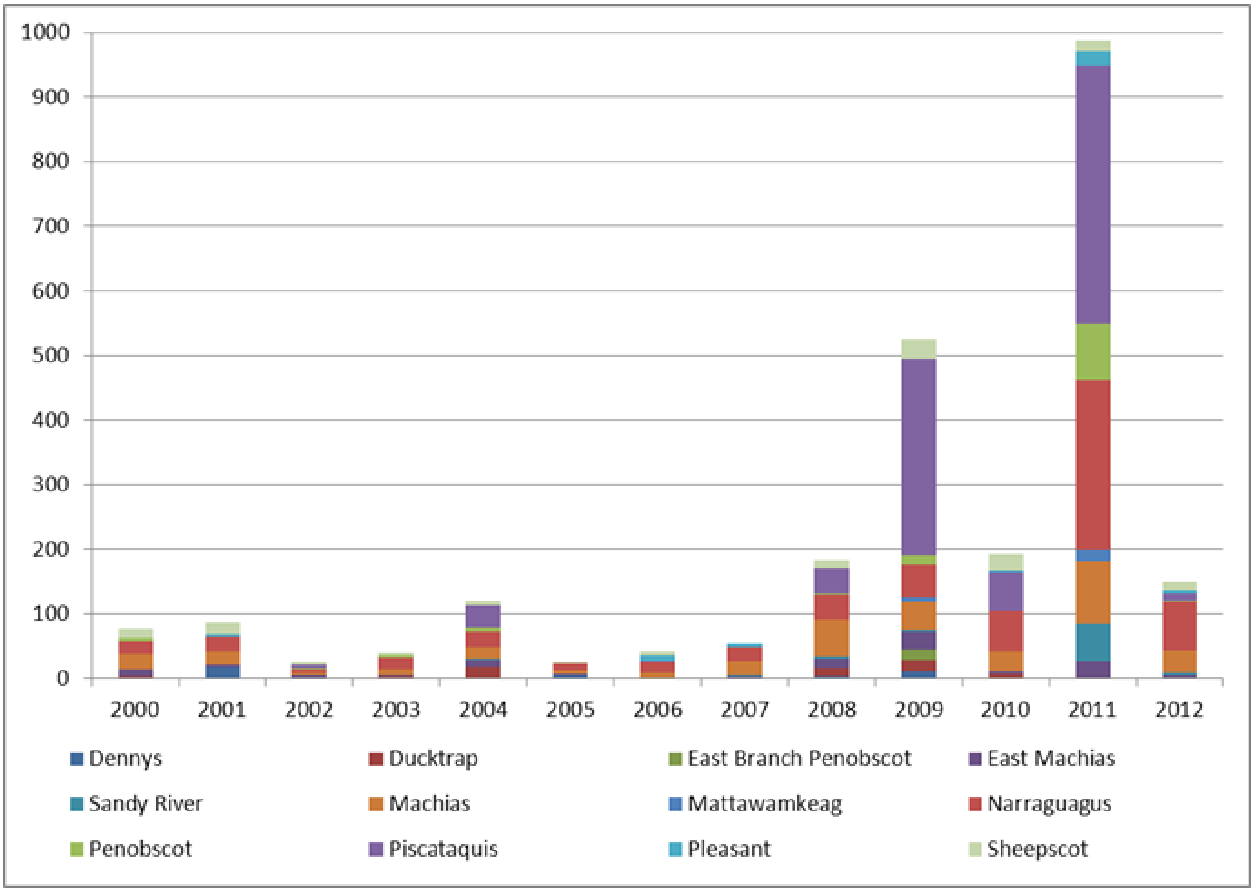


Figure 5.5. Total number of redds, by drainage, within the Gulf of Maine DPS, 2000 - 2012. Redds in reaches wherein pre-spawn adults are outplanted are not included.

Habitat enhancement and monitoring.

Water Temperature Studies.

In 2012, several water temperature studies were conducted in the Downeast Coastal River SHRU. These projects include a comparison of a groundwater versus non-groundwater influenced catchment in the Machias River, a study in the Upper Narraguagus River (Beddington Lake HUC12) and a similar study in the East Machias River.

The Machias River study compared water temperature in groundwater influenced Old Stream versus the non-groundwater influenced mainstem Machias River at Route 9 over a two year period (2011-2012). Water temperature in Old Stream did not exceed the feeding threshold for salmon (>22.5 °C , Elliot 1991) in 2011 and exceeded it for only 1 hour in 2012; no daily mean temperatures exceeded the feeding threshold. Water temperature was much warmer in the mainstem Machias River (non-groundwater influenced) and exceeded the feeding threshold on 21 days in 2011 and 34 days in 2012. A comparison of hatchery versus in-stream egg incubation temperatures suggest warmer winter water temperatures at CBNFH increased developmental rates by 4-10 days over natural river conditions in 2011 and 2012. Contact scott_craig@fws.gov for more information.

A water temperature monitoring study was concluded in the Upper Narraguagus River in 2012 (Figure 5.6). Eight loggers were deployed in the mainstem between Beddington Lake (river km 41.4) and the outlet of Eagle Lake (river km 78.2). Fourteen loggers were placed in tributaries just above the mainstem confluence, and eighteen more were located upstream at accessible locations. Lethal (high) water temperatures for salmon were observed in the mainstem river at Eagle Lake but a general cooling trend occurred downstream to Beddington Lake. The most suitable mainstem thermal regimes for juvenile salmon occurred from Baker Brook to Beddington Lake. Upper Narraguagus River tributaries were typically much cooler and more suitable for salmon than mainstem habitats (Figure 5.7).

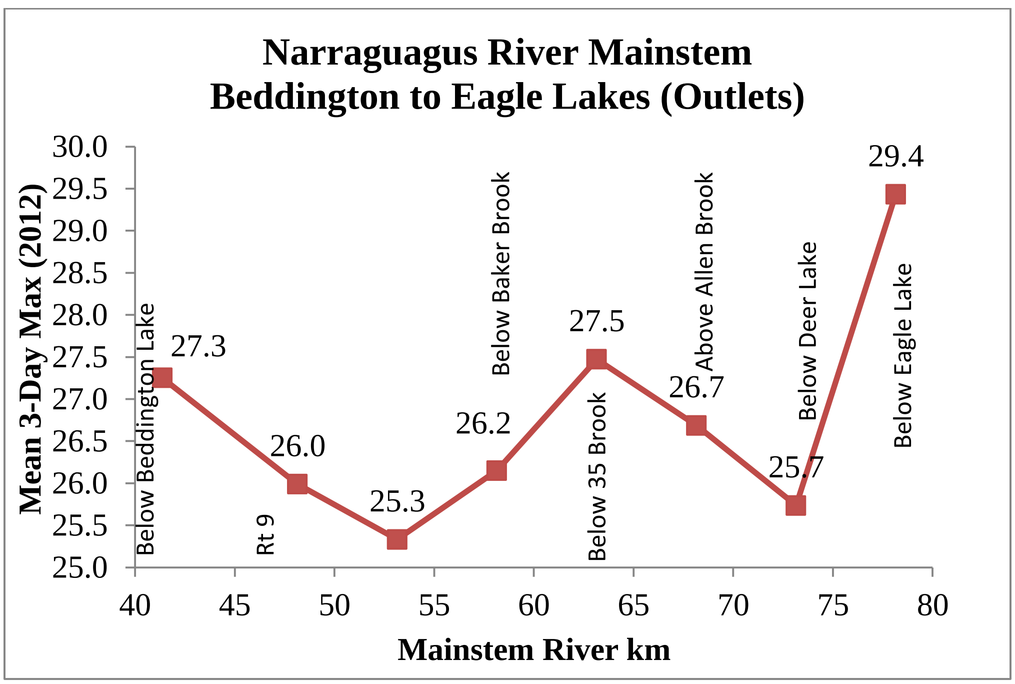


Figure 5.6 Maximum water temperatures at mainstem sites in the Narraguagus River, 2012.

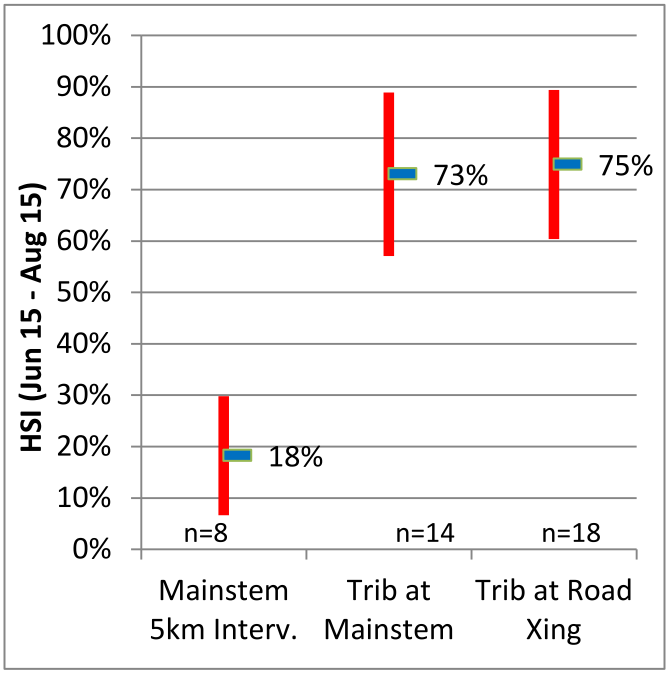


Figure 5.7. Frequency (mean and 95% C.I.) of water temperature suitability for Atlantic salmon in Narraguagus mainstem and tributary habitat during the summer of 2012.

The coolest tributaries were Bobcat, Barrel, Rocky, Sinclair and Shorey Brooks and the warmest were Little Narraguagus, Allen, 35, and W.B. Narraguagus. Contact scott_craig@fws.gov for more information.

In 2012, a watershed wide water temperature monitoring study was initiated in the East Machias River. Loggers were placed in riffle type habitats in the mainstem river (n=8), major tributaries (n=8), and smaller tributaries (n=32). Contact scott_craig@fws.gov or kyle@mainesalmonrivers.org for more information.

New Maine Forestry Rule Streamlining Permits for Adding Wood into Streams.
In December 2012, the Maine State legislature amended Maine Forest Service Chapter 25 regulations through rule 2012-350 regarding "Standards for Placing Wood into Stream Channels to Enhance Cold Water Fisheries Habitat". The intent of the rule is to increase landowner participation in habitat improvement projects (large wood additions) by streamlining the permitting process. The rule eliminates the requirement for a state permit for habitat improvement projects provided they are supervised by a Maine licensed forester (certified in the appropriate techniques) and adheres to a plan approved by DMR/DIFW biologists. Certification relating to this new rule is in progress. For further information, contact: Keith.Kanoti@Maine.gov

Large Wood Addition Projects
Four new large wood (LW) addition projects were completed in the Downeast Coastal SHRU in 2012. Since 2007, there are now 36 stream reaches that have been augmented with LW in the East Machias (10), Machias (12), Narraguagus (13), and Pleasant (1) Rivers (Table 5.6). Production type sites have been averaging 50-100 meters in length as compared to 150-200 meters for study sites. Both types maintain similar wood loading rates of about one tree per 10 meters of stream. All four sites completed

in 2012 were treated using the non-motorized grip hoist method, with tree selection of >15cm diameter breast height. This hand type method involved cutting key roots and pulling the tree into the stream, thus minimizing erosion and sedimentation into the stream.

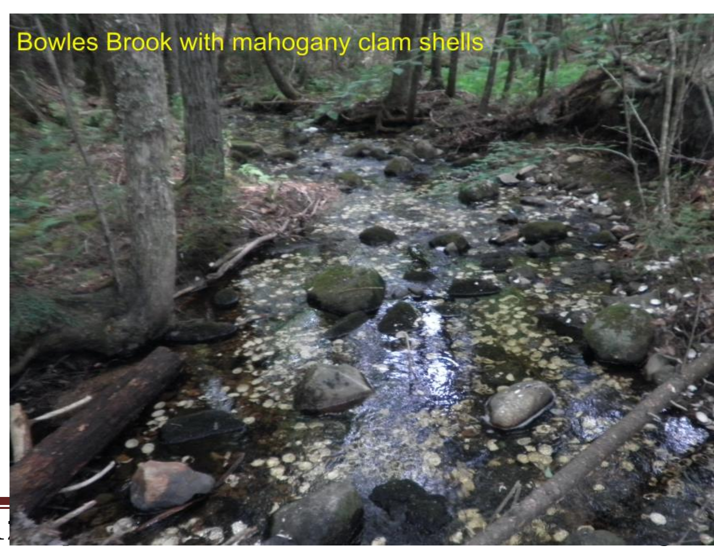
The grip hoist method allows for a crew of three staff to fell 10-20 trees in a day, depending on a site. The equipment is mobile and there is no environmental impact other than the trees being felled as part of the study. Overall, this method is efficient and cost effective by allowing more flexible scheduling for agency staff and volunteers to participate, so there is no need to contract a wood cutter to fell trees. In 2013, several "production" type sites are expected to occur and ongoing LW "project" monitoring is scheduled. Contact Colby.W.B.Bruchs@maine.gov or kyle@mainesalmonrivers.org for more information.

Table 5.6. Large wood addition projects in the Downeast Coastal SHRU, 2007-2012.

Year	Production	Study	Total
2007		4	4
2008		2	2
2009		7	7
2011	10	9	19
2012	4		4
Total	14	22	36

Juvenile Production in Small tributaries
In 2010 and 2011 juvenile salmon biomass, survival, and growth was quantified in small tributaries to the Machias River and compared to physical and biotic variables. Salmon metrics were similar for both years despite near drought conditions in 2010. Physical habitat variables were the primary predictors of fry performance in 2010 due to low summer flow. Improved fry performance was associated with water depth (deeper), abundant large wood, reduced detritus substrate, increased drainage area, and seasonal optimums for water temperature and velocity. In 2011, physical factors returned to normal ranges and the biotic factors like brook trout *Salvelinus fontinalis* abundance and the seasonal abundance of insects and invertebrates were better predictors of fry performance. More information: Wes Ashe (Wesley.Ashe@maine.gov)

Water Quality Related Projects
In 2012, results of a three year study investigating the use of clam shell additions to improve low pH observed in salmon streams were reported. Discarded (shucked and air dried over several years) marine based shells of *Mya arenaria* (common softshell or steamer clam), *Arctica islandica* (mahogany clam or black quahog), and to a lesser extent, *Mytilus edulis* (blue mussel) were used as a calcium carbonate input to mitigate chronically low pH, low alkalinity, and



high aluminum concentrations. In 2012, three new study streams were added to the two existing locations; all sites were located in the Old Stream tributary to the Machias River. Monitoring included a suite of *abiotic* factors: pH, conductivity, acid neutralizing capacity , calcium, sodium, potassium, magnesium, dissolved organic carbon , total aluminum, organic aluminum, exchangeable aluminum (Alx), stream discharge and depth; and *biotic* factors: algae, leaf detritus processing (leaf pack), macro invertebrates, and fish community.
Clam shell additions corresponded to improved pH and calcium concentrations, and reduced Alx at all project sites. Biotic effects are more difficult to interpret, but overall fish abundance and species diversity has increased, especially at the two originally treated study sites. Leaf pack processing (degradation) was twice as high in the treatment area versus the control area. For more information, contact mark.whiting@maine.gov or skoenig@salmonhabitat.org.

2013 Implementation and Conclusions

FWAT will continue to work with NGOs and interested partners to convey habitat restoration priorities identified in the SHRU specific arc viewer mapping tool. The objective will be to focus attention and promote action in those priority areas. The process will be adaptive by necessity, with focus on established priorities but capitalizing on opportunistic projects as they arise. The FWAT will continue the effort to develop meaningful, quantitative metrics to evaluate program progress and focus actions in priority areas. The FWAT will also establish an annual meeting schedule to address these issues, respond to new issues, and track within- year progress.

DMR met the strategic objective of monitoring the relative abundance of juvenile salmon state-wide using a GRTS sampling design. However, salmon densities decreased in all SHRUs relative to 2011 suggesting an environmentally mediated decrease in freshwater survival. Reallocation of stocking products to alternative river reaches will be considered in 2013 in an effort to improve survival. DMR met the strategic objective of assessing adult returns in all SHRUs through trap catches and redd counts. The steep state-wide declines observed in both river-reared and hatchery origin adult returns in 2012 implicate marine rather than freshwater survival problems. Cause for these declines has not been identified. The strategic objective of assessing factors that may influence juvenile survival was addressed through telemetry studies of migrating smolts USGS, Univ. of Maine), monitoring population response to large wood additions (DMR), intensive water temperature monitoring programs (USFWS, DMR, DESF), and alternative stocking strategies (DMR).   Habitat enhancement strategies were pursued in 2012 through assessment of clam shell additions to mitigate for impaired water quality (DEP, SHARE); and passage and implementation of new legislation streamlining the permitting process for large wood additions (MFS,DMR) that will enhance habitat suitability for salmon.   The USFWS worked on development of an ARC Viewer application to meet the strategic objectives of identifying priority areas for habitat enhancement projects.

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Connectivity Action Team (CAT)

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Strategy:

Enhanced connectivity between the ocean and freshwater habitats important for salmon recovery

Strategy Objectives:

Provide full access to 30,000[1] habitat units (100m^2) with a habitat quality score of 2 or 3[2] in the Merrymeeting Bay SHRU;

Provide full access to 30,000 habitat units with a habitat quality score of 2 or 3 in the Penobscot Bay SHRU;

Provide full access to 30,000 habitat units with a habitat quality score of 2 or 3 in the Downeast SHRU.

Strategy Metrics

- Number of fully accessible habitat units in Merrymeeting Bay SHRU;
- Number of fully accessible habitat units in Penobscot Bay SHRU;
- Number of fully accessible habitat units in Downeast SHRU;

Background

Atlantic salmon require a diverse array of well-connected habitat types in order to complete their life cycle. Historically, the upstream extent of anadromy extended well into the mountainous headwaters of

[1] In order for habitat to be considered fully accessible, it must be in an area where:

1. There are no anthropogenic barriers (dam, culvert, etc.) downstream (to the Gulf of Maine), OR
2. Anthropogenic barriers have the following characteristics:
    a. Cumulative downstream fish passage efficiencies of all barriers are 95% or greater unless site-specific demographic studies demonstrate other targets are sufficient to allow for recovery, AND
    b. Cumulative upstream fish passage efficiencies of all barriers are 95% or greater unless site-specific demographic studies demonstrate other targets are sufficient to allow for recovery.

[2] Habitat quality scores are derived from NMFS (2009) figure 1.6.1 and summarized in tables 2.3b, 3.3b, and 4.3b.

even the largest watersheds of Maine including the West Branch of the Penobscot River, the Carrabasset River in the Kennebec drainage and the Swift River in the Androscoggin basin as well as all the smaller coastal rivers. Today, the migrations of juvenile and adult Atlantic salmon are substantially limited by dams and road crossings that block or impair access to many of the most productive areas for spawning and rearing.

The focus of the connectivity action team is reconnecting headwater areas that are important for salmon spawning and rearing with the Gulf of Maine and provide a safe migration corridor for emigrating smolts. More specifically, there are four categories of actions highlighted as urgently needed:

1. Develop a list of barrier priorities for the GOM DPS and begin implementing connectivity restoration projects in a strategic fashion.
2. Monitor and report on the effectiveness of connectivity restoration projects.
3. Minimize the level of impact and provide incidental take authorization for existing fish passage barriers (such as dams) when appropriate.
4. Increase awareness of the need to co-restore the suite of co-evolved diadromous species.

2012 Connectivity Accomplishments

In 2012 proactive efforts (Table 6.1, 6.2 & 6.3) improved connectivity to approximately 272,000 units of Atlantic salmon spawning and nursery habitat, and approximately 16,500 acres of lakes and ponds that serve as spawning and nursery habitats for alewives. The removal of Great Works Dam on the Penobscot River accounts for over 260,000 units of improved access to salmon spawning and nursery habitat. Though the removal of Great Works dam only directly opened up access to 40 units of Atlantic salmon habitat, its removal eliminates related direct and indirect mortality of all migrating smolts and adults that would otherwise pass over the dam during their migration; and reduces the cumulative mortality of adults and smolts associated with passing over or through multiple dams. Furthermore, the removal of Great Works is anticipated to significantly improve survival and migration success for all other diadromous species that use the Penobscot as a migratory corridor. Most of these benefits are expected to be realized upon the 2013 removal of Veazie Dam, the lowermost dam on the mainstem of the Penobscot River.

Among the other proactive efforts (not including Great Works), were:

- ten barrier removal projects that opened up access to 754 units of salmon habitat, and 383 acres of alewife habitat;
- one new fish passage project that improved passage to 1,969 units of salmon habitat, and 5,102 acres of alewife habitat;
- four fish passage improvement projects that improved connectivity to 9,107 units of salmon habitat, and 11,129 acres of alewife habitat; and

- four remnant dam removals that improved the quality and availability of 321 units of salmon habitat.

Among all proactive projects, 226 units of spawning and nursery habitat were opened up that have no known manmade barriers below them.

For regulatory projects, thirteen projects are known to have been completed in 2012 upon which NMFS and the USFWS completed consultations (Table 6.4 & 6.5). When an agency engages in consultation on a connectivity related project there is no guarantee that the project outcome will lead to improved connectivity. Subsequently, we report on the outcome of a consultation relative to losses and gains of salmon habitat, or projects where the level of connectivity remained the same. Of the thirteen projects, passage remained the same at eleven of the thirteen projects, and improved from partial barrier to no barrier at two projects. At the two sites where passage was improved from partial barrier to no barrier, there are approximately 0.26 units of Atlantic salmon spawning and nursery habitat and no alewife habitat above them (Table 6.4).

Related to hydro-projects, NMFS issued a Biological Opinion to FERC analyzing the effects to listed Atlantic salmon regarding their proposal to amend the licenses for the Stillwater, Orono, Milford, West Enfield, and Medway Hydroelectric Projects in the Penobscot River in Maine (owned and operated by Black Bear Hydro LLC) to incorporate provisions of an Species Protection Plan (SPP). NMFS also issued Opinions to the FERC on the impacts to listed species from Interim Species Protection Plans (ISPPs) being proposed by Brookfield Renewable Power for the Hydro-Kennebec Project, Topsham Hydro Partners for the Pejepscot Project, and Miller Hydro Group for the Worumbo Project, respectively (*See section* "FERC Related Projects" on Page 14).

Table 6.1: Summary of benefits to Atlantic salmon from connectivity projects in 2012.

Atlantic salmon	Barrier Removal projects		New fish passage Projects		Fish passage improvement Projects		Habitat improved by Remnant Dam Removals		Salmon Habitat Opened with no downstream Barriers
	#	Units	#	Units	#	Units	#	Units	
Downeast	5	503			3	7,039	3	19	19
Merrymeeting Bay	1	207							207
Penobscot Bay	4	4	1	1,969	1	2,068	1	302	
Greatworks*	1	40				260,168			
Total	**11**	**754**	**1**	**1,969**	**4**	**269,275**	**4**	**321**	**226**

Table6.2: Summary of benefits to alewives from connectivity projects in 2012

River Herring	Barrier Removal projects		Fish passage Projects		Passage improvement Projects	
	#	Acres	#	Acres	#	Acres
Downeast	5	383			3	10,049
Merrymeeting Bay						
Penobscot Bay			1	5,102	1	1,080
Total	**5**	**383**	**1**	**5,102**	**4**	**11,129**

Barrier Removal: Projects where a barrier or partial barrier was completely removed

New Fish Passage: Projects at sites where fish passage was installed where fish passage did not occur previously

Fish Passage Improvement Projects: Projects at sites where existing fish passage was improved

Remnant Dams: Though remnant dams may or may not block or impair the physical migration of salmon, their removal improves access and restores previously impounded habitats

***** Great Works is within the Penobscot SHRU but is kept separate given the scale of benefits relative to smaller projects within the SHRU

Table 6.3: Overview of proactive connectivity projects completed in 2012

Project Name	Project Manager (e.g. Project SHARE, ASF, NOAA, etc…)	Project Funder	SHRU	Project Type (Dam, culvert, other)	Barrier removal/passage improvement
Barrel Brook Arch Culvert	Project SHARE	NOAA	Downeast	Culvert	Barrier Removal
Barrel Brook Bridge 1	Project SHARE	NOAA	Downeast	Crossing - Bridge	Barrier Removal
Barrel Brook Bridge 2	Project SHARE	NOAA	Downeast	Crossing - Bridge	Barrier Removal
Barrel Brook remnant Dam 1	Project SHARE	NOAA	Downeast	Remnant dam removal	Remnant Dam Removal
Barrel Brook remnant Dam 2	Project SHARE	NOAA	Downeast	Remnant dam removal	Remnant Dam Removal
Maple Brook (Hobart Stream)	Project SHARE/USFWS (Moosehorn Refuge)	NOAA, USFWS	Downeast	Modern dam removal	Barrier Removal
Middle Brook (Hobart Stream)	Project SHARE/USFWS (Moosehorn Refuge)	NOAA, USFWS	Downeast	Modern dam removal	Barrier Removal
Flanders Stream Culvert Replacement	Town of Sullivan, ME	NOAA, USFWS + others	Downeast	Open Bottom Arch	Passage Improvement
Grovers Mills Remnant Dam	Project SHARE	Project SHARE, USFWS	Downeast	Remnant dam removal	Remnant Dam Removal
Narraguagus Ice Control Dam	DMR	DEP-SEP	Downeast	Fishway Repair	Passage Improvement
Meddybemps Fishway	ASF, DMR, USFWS	ASF, USFWS	Downeast	Fishway Repair	Passage Improvement
Jam Black Brook	TU	NRCS, TU, USFWS	Merrymeeting B	Open Bottom Arch	Barrier Removal
Pushaw Lake Fishway	Atlantic Salmon Federation	NOAA, USFWS + others	Penobscot	Fishway	Fish Passage
Great Works Dam Removal	Penobscot River Restoration Trust	NOAA, USFWS	Penobscot	Modern dam removal	Barrier Removal
Mattamiscontis Lake Outlet	Penobscot Indian Nation	NRCS, ASF, PIN	Penobscot	Fishway - Rock ramp	Passage Improvement
East Branch Barrier Removals	Atlantic Salmon Federation/USFWS (GOMCP)	ASF, USFWS, NFWF, EPI	Penobscot	Road crossing removal	Barrier Removal
East Branch Barrier Removals	Atlantic Salmon Federation/USFWS (GOMCP)	ASF, USFWS, NFWF, EPI	Penobscot	Crossing - Bridge	Barrier Removal
East Branch Barrier Removals	Atlantic Salmon Federation/USFWS (GOMCP)	ASF, USFWS, NFWF, EPI	Penobscot	Crossing - Bridge	Barrier Removal
East Branch Barrier Removals	Atlantic Salmon Federation/USFWS (GOMCP)	ASF, USFWS, NFWF, EPI	Penobscot	Crossing - Bridge	Barrier Removal
Roaring Brook Remnant Dam	NRCS	NRCS, DMR, USFWS	Penobscot	Remnant dam removal	Remnant Dam Removal

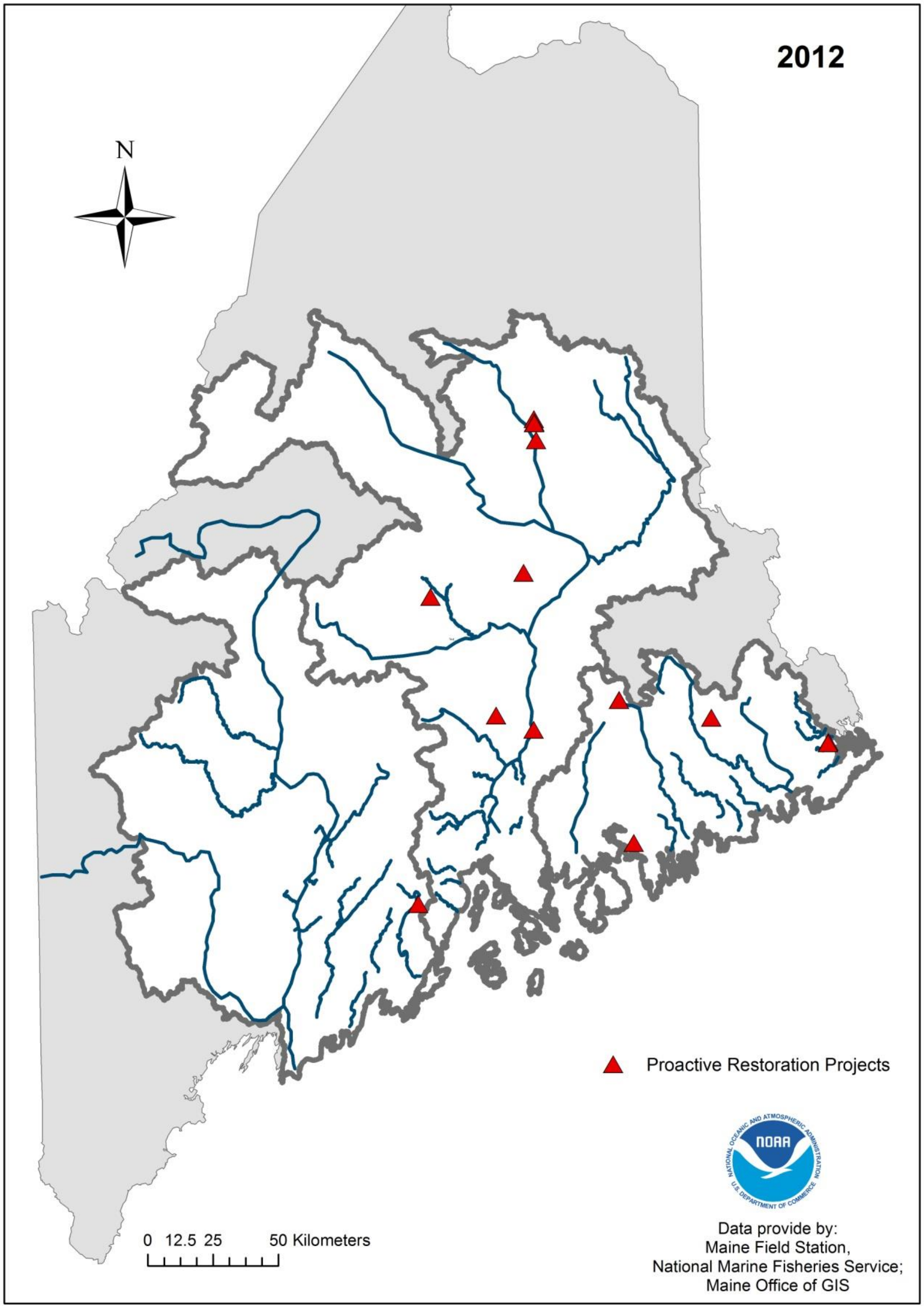

Figure 6.1 Locations of proactive restoration projects within the GOM ATS DPS.

Table 6.4: Overview of non-FERC related Atlantic salmon projects requiring ESA consultation by NOAA NMFS or USFWS completed in 2012.

# of Projects	Habitat affect as a result of the project						
	# of Projects			Units of salmon habitat		acres of alewife habitat	
	Net Loss	Neutral	Gain	loss	gain	loss	gain
13	0	11	2	0	0.26	0	0

Before and After Consultation Status	Before	After
Barrier	0	0
Partial Barrier	4	2
No Barrier	9	11

Table 6.5: Summary of completed non-FERC related projects in 2012 requiring Atlantic salmon ESA consultation by NOAA NMFS or USFWS*

2012 Connectivity Related Consultations							
Action Agency	Consulting agency (USFWS, NMFS, Joint)	SHRU	Project Type (Dam, culvert, other)	Consultation response (e.g. no affect, not likely to adversely affect, etc..)	Critical habitat (Not designated CH, no affect, etc..)	Connectivity status before consultation (no barrier, partial barrier, barrier)	Connectivity status after consultation (no barrier, partial barrier, barrier)
NRCS	USFWS	Downeast	bridge, agriculture	NLAA	CH	no barrier	no barrier
FEMA	USFWS	Downeast	arch culvert	NLAA	NLAA	partial barrier	no barrier
MMB	NMFS	Merrymeeting Bay	bridge	authorized take	no affect	no barrier	no barrier
ACOE	NMFS	Merrymeeting Bay	Box culvert	NLAA	NLAA	partial barrier	partial barrier
NRCS	USFWS	Merrymeeting Bay	bridge, agriculture	NLAA	CH	partial barrier	no barrier
NRCS	USFWS	Merrymeeting Bay	bridge, agriculture	NLAA	CH	no barrier	no barrier
ACOE	USFWS	Merrymeeting Bay	arch culvert	NLAA	NLAA	no barrier	no barrier
NRCS	USFWS	Merrymeeting Bay	bridge, agriculture	NLAA	NLAA	no barrier	no barrier
NRCS	USFWS	Merrymeeting Bay	bridge, forestry	NLAA	NLAA	no barrier	no barrier
NRCS	USFWS	Merrymeeting Bay	bridge, forestry	NLAA	NLAA	no barrier	no barrier
FHWA	USFWS	Merrymeeting Bay	five culverts on small tribs t	NLAA	NLAA	partial barriers	partial barrier
FHWA	USFWS	Penobscot Bay	culvert replacement	NLAA	CH	no barrier	
FHWA	USFWS	Penobscot Bay	bridge	no jeopardy	no adverse mod	no barrier	no barrier

NLAA = "Not Likely to Adversely Affect"

*This list is likely incomplete and will be revised as needed.

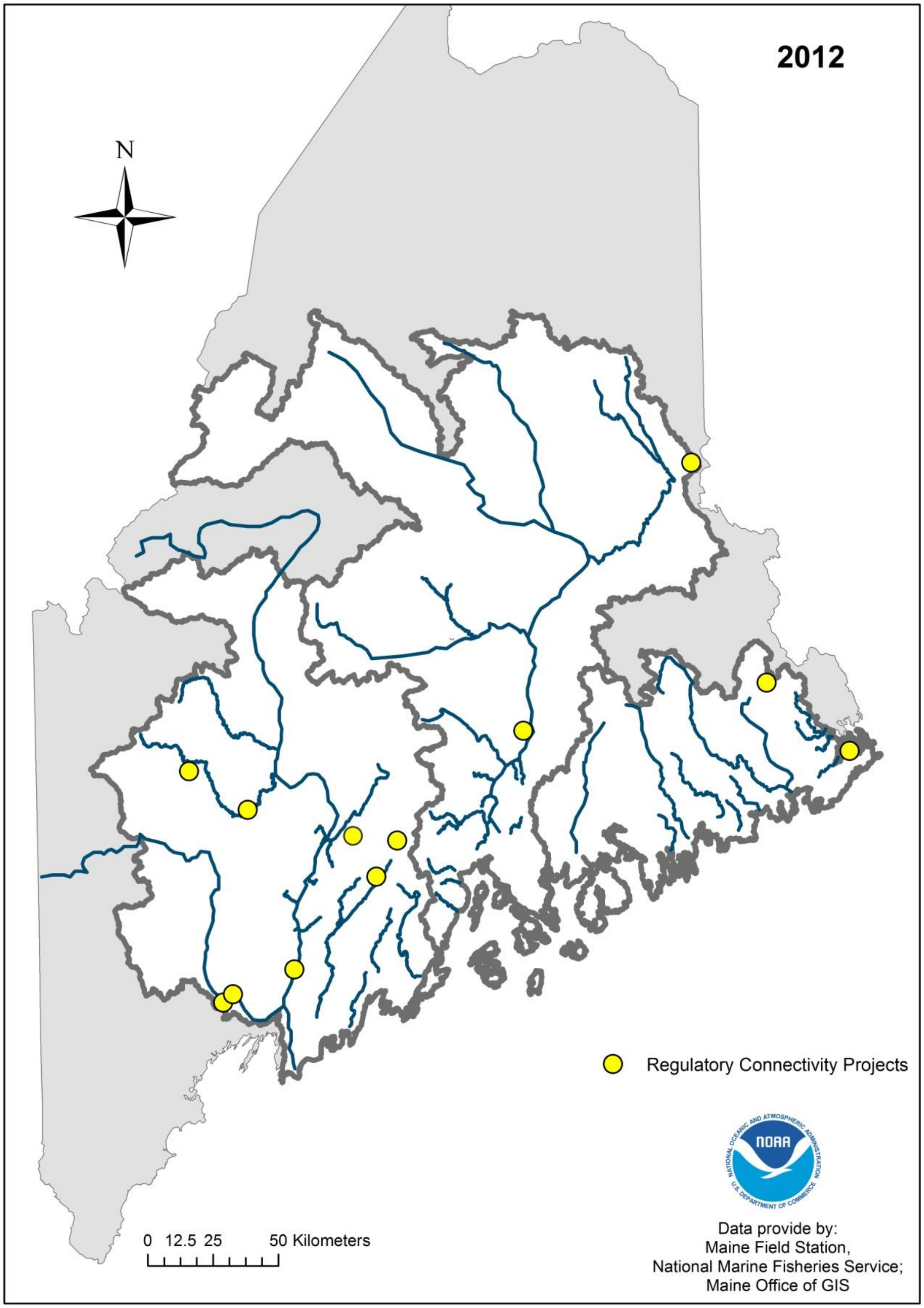

Figure 6.2 Locations of regulatory driven connectivity projects.

2012 Connectivity Metrics

The interim recovery criteria for the GOM DPS take a geographically explicit approach to ensure that "recovery" (a GOM DPS that is demographically secure, no longer requiring the protections of the Endangered Species Act) is not limited to one or a few rivers. Each of the three salmon habitat recovery units (SHRUs) must meet each of the recovery criteria. This includes providing access to a minimum of 30,000 units of suitable habitats in a manner that allows for Atlantic salmon's continued survival and recovery. Watershed areas that contain the most abundant and most suitable habitats are described fully in NMFS' critical habitat designation (74 Fed. Reg. 29300; June 19, 2009). Accessible Habitats that allow for survival and recovery will be defined in the Atlantic salmon recovery plan, but for now accessible habitats are those habitats where there are no downstream barriers to fish passage or, where there are barriers, passage has been determined adequate to allow for survival and recovery through consultation with the services.

For 2012, we estimate that fewer than 39,000 suitable habitat units across the DPS are unimpeded by dams. It is important to note, however, that these estimates are extremely optimistic. They do not fully include the effects of culverts. Road-stream crossing surveys have only been conducted in roughly half of the freshwater range of the GOM DPS. Thus, our estimates are very imprecise. However as a result of the survey effort we now have inventories of ongoing connectivity remediation projects, results of dam surveys, and accumulating road/stream crossing surveys to refine these estimates in future years.

Accessibility also varies greatly in each SHRU. The Downeast SHRU is better connected than either the Penobscot or Merrymeeting Bay SHRU, largely because there are fewer dams in Downeast Maine.

Within the Merrymeeting Bay SHRU, 248 dams block or impair access to the vast majority of salmon habitat. Those dams include 35 FERC regulated dams; 2 FERC-exempt dams; and 211 non-regulated dams. Of the FERC dams, five are equipped with upstream passage facilities (DMR and DEP, 2008). Of the 211 known non-regulated dams, 16 are equipped with upstream fish passage facilities. Of the 29,000 units of habitat unimpeded by dams, approximately 7,000 units are in areas considered suitable for spawning and rearing, while the remaining 22,000 are in areas considered marginally suitable for spawning and rearing.

Within the Penobscot SHRU, 140 dams block or impair access to the vast majority of salmon habitat. Those dams include 23 dams regulated, by the Federal Energy Regulatory Commission (FERC); 6 FERC exempt dams; and 111 non-regulated dams. Of the FERC dams, 13 have upstream anadromous fish passage, and 10 have a structure or measures for downstream passage (DMR and DEP, 2008). Of the 111 non-regulated dams, 16 have upstream fish passage. Of the 21,000 units of habitat unimpeded by dams, all are located below Veazie Dam. Approximately 8,500 units are in areas considered suitable for spawning and rearing while approximately 12,500 units are in areas considered marginally suitable for spawning and rearing. These marginal habitats are mostly in mainstem areas that include habitats with abundant predators and competitors, and habitats with water quality and substrate conditions that often impair Atlantic salmon survival.

Within the Downeast SHRU, 75 dams block or impair access to considerable amounts of habitat. Of those dams, there are three FERC-regulated dams and 72 non-regulated dams. Of the three FERC dams, one is equipped with an upstream passage facility. Of the 72 non-regulated dams, sixteen are equipped with upstream passage facilities. Of the remaining 37,500 units of habitat unimpeded by dams, approximately 23,300 units are in areas considered suitable for Atlantic salmon spawning and rearing while 14,200 units are in areas considered marginally suitable for spawning and rearing.

Thus, there is much work to be done to meet the goal of connecting 30,000 units of suitable habitat in each SHRU. Fortunately, there is considerable effort on the part of each agency and many partner agencies, non-governmental organizations, and private industry. Following is a brief synopsis of several efforts that are ongoing to address these high priority recovery actions.

Updates on connectivity projects within GOM-DPS

The list of NGO's, public and private entities involved in connectivity projects for the benefit of Atlantic salmon and other diadromous species is extensive. Project SHARE, the Atlantic Salmon Federation, the Penobscot Nation, the Penobscot River Restoration Trust, and Trout Unlimited are among the most active NGO's in fund raising and implementing proactive on-the-ground connectivity projects. In addition to these efforts, there are numerous efforts underway throughout the Gulf of Maine DPS directed at improving connectivity for Atlantic salmon and other aquatic organisms. These range from large public-private partnerships to improve awareness, coordination and project management of smaller-scale individual projects with municipal or private landowners. The following is a brief summary of some of these efforts. It is important to note that the four agencies represented on the Atlantic salmon connectivity team are involved in most of the following efforts.

Stream-Smart Road Crossing Workshops– Workshops were held around the state in 2012 to educate professionals responsible for road-stream crossings on how to improve stream habitat by creating better crossings. The workshops cover road-stream crossing projects from site assessment to permitting and installation. Maine Audubon, and other partners, including US Fish and Wildlife Service, Maine Forest Service, Maine Department of Inland Fisheries and Wildlife, Maine Department of Environmental Protection, Sustainable Forestry Initiative, Maine Coastal Program, USDA Natural Resources Conservation Service, National Marine Fisheries Service, US Army Corps of Engineers, Casco Bay Estuary Partnership, and Project SHARE held the workshops in 2012. The group held six *Stream-Smart Road Crossing Workshops* in Augusta (2), Bangor, Caribou, and Falmouth (2), to inform public and private road owners about opportunities to replace aging and undersized culverts with designs that last longer, improve stream habitat, save money on maintenance, and can reduce flooding. Over 300 people attended these workshops including town road commissioners, public works directors, contractors, forest landowners, foresters, engineers, conservation commissions, land trusts, and planning board members.

Aquatic Resource Management Strategy (ARMS) – Maine Department of Transportation is leading an effort to develop a statewide Aquatic Resource Management Strategy. The ARMS goal is to develop networks of properly functioning watersheds that support populations of fish and other aquatic and riparian dependent organisms across Maine. The strategy will focus on maintenance and restoration of ecological processes responsible for creating and sustaining habitats over broad landscapes as opposed to individual projects or small watershed scales. This plan will consist of four components: broad scale passive restoration via standards and guidance; active restoration strategically focused on watershed analysis; partnerships; and education and outreach.

Northeast Aquatic Connectivity Project – The Nature Conservancy has led an effort to undertake an ecoregional assessment of fish passage barriers through the development of a regional database and specific tools and analysis. The work is being developed by the Northeast states to reconnect fragmented river, stream, coastal, reservoir, lake, and estuarine habitat by removing or bypassing key barriers to fish passage thereby enhancing fish populations.

Maine Forest Service – The Maine Forest Service (MFS), in partnership with numerous state and federal agencies and nongovernmental organizations, has surveyed thousands of culverts at road-stream crossings throughout Maine. In addition, MFS provides extensive outreach and education efforts to private landowners on the importance of fish-friendly stream crossings. MFS also initiates and serves as project manager on many culvert replacement and removal projects throughout the Gulf of Maine DPS.

Maine Forest Products Council – In Maine, the Sustainable Forestry Initiative (SFI) represents 7 million acres of certified forest lands and the American Tree Farm represents in excess of 800,000 acres of certified family forests. In addition, under the SFI umbrella, nearly all of the largest forest products manufacturers have SFI certified procurement programs which have extensive responsibilities for wood sourced from lands outside of the SFI and Tree Farm systems. Nearly every harvest that takes place in Maine provides some wood to an SFI facility that in turn creates an opportunity to back-feed information through that relationship. SFI has, and will continue to make use of this networking apparatus to educate forest resource professionals on fish passage and stream connectivity issues. The SFI Implementation Committee is also committed to work with state and federal agencies, and other relevant interest, to establish the Fisheries Improvement Network (FIN). FIN continues to facilitate a non-regulatory approach in providing landowners tools, training, and other assistance that is currently available through agency programs and projects to improve long-term stream connectivity while being flexible and adaptable to various landowner capabilities and approaches.

Natural Resource Conservation Service – Natural Resource Conservation Service (NRCS) provides extensive technical and financial support to barrier removal efforts within the Gulf of Maine DPS. In 2011, a fisheries biologist was hired with support from Maine Department of Inland Fisheries and Wildlife and Maine Department of Marine Resources, to work directly with private landowners in the Penobscot River watershed. The work is focused on fish passage barriers identified through watershed scale surveys. In 2012, the program supported connectivity projects the Pleasant River Watershed (Penobscot Basin), and on tribal lands in the Penobscot watershed. NRCS also supported a connectivity project in the St. George River watershed.

Keeping Maine's Forest - Keeping Maine's Forests is an effort to maintain the state's land base as forest. The initiative's focus is on helping landowners find practical solutions for keeping their lands undeveloped, open, and productive. KMF is interested in protecting biodiversity (such as rare, threatened, and endangered species recognized at the federal, state, and tribal level, unique and exemplary natural areas, late successional forest features in working forests, and others similar, as well as maintaining, and where practicable, restoring viable populations of game and non-game wildlife). In addition their goals include maintaining or enhancing existing public access for the full spectrum of existing recreational uses, and attracting an increased number of recreational users by selective investments in improved recreation facilities and facilitating the adaptation of forest systems to a changing climate particularly by maintaining large contiguous and interconnected areas of forest. KMF has identified restoring aquatic habitat connectivity as a primary initial focus for the organization. A variety of partners are contributing to this effort by assisting with identifying biological priorities, providing datasets on potential barrier removals, identifying funding mechanisms and through technical assistance for specific barrier removal projects.

<u>Maine Stream Connectivity Work Group</u> - The Maine Stream Connectivity Work Group was convened in 2009 as an informal effort to grapple with the practical and technical challenges that hinder the re-establishment of aquatic connectivity in Maine. The Work Group is currently coordinated by the Maine Coastal Program (State Planning Office) with oversight from the Coastal Program and Maine Department of Marine Resources. Populated by recovery practitioners affiliated with state, federal and tribal agencies, non-government organizations, forest products companies, and engineering firms, the Work Group has evolved to act as a forum and increasingly as a mechanism for coordination. The group is concentrating much of its work on the development of prioritization tools and online barrier data access. The Work Group is focused on completing the following objectives:

- Identify alternatives for a dedicated ecological restoration program that focuses on improving aquatic connectivity statewide.
- Increase resources to support priority, on-the-ground barrier removal needs at specific sites and regions throughout Maine.
- Provide incentives and tools for owners of dams and roads to integrate ecological considerations into the operation and maintenance of infrastructure.
- Provide technical support for the development of stream crossing regulatory rules that compliment statewide aquatic restoration and conservation efforts.
- Support development of objective, ecologically-based prioritization approaches that allow a starting point for sequencing restorative action.
- Provide the restoration community and other users relevant to restoration with efficient access to barrier data.
- Continue barrier inventories in priority watersheds throughout Maine.
- Identify alternatives for streamlining regulatory requirements that apply to restoration projects.
- Update and maintain the Maine Stream Habitat Viewer.

<u>Maine Stream Habitat Viewer</u> - The Stream Habitat Viewer was created to enhance statewide stream restoration and conservation efforts. The Viewer provides a starting point for towns, private landowners, and others to learn more about stream habitats across the state.

The Viewer displays habitats for several stream-dependent species and it also displays locations of dams and public road crossings, which can act as barriers to the movements of fish and wildlife. The Viewer helps bring people together to restore and conserve Maine's natural heritage that can also ease financial burdens of road and dam owners. Financial burdens can be eased by reducing or removing liability associated with unwanted structures, and designing alternatives that improve fish passage but also increase resilience to storm events.

The Viewer allows users to:

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

Convened by the State of Maine's Coastal Program and Department of Marine Resources, the Maine Stream Connectivity Work Group is a partnership of over 25 industry, state, federal, and non-government organizations working to improve Maine's stream restoration efforts.

http://mapserver.maine.gov/streamviewer/index.html

FERC Regulated Dams

Dam impact analysis:

In 2012, the NEFSC completed a Dam Impact Analysis (DIA) model that facilitated the determination of the effects of operating multiple hydroelectric projects on Atlantic salmon survival and recovery in the Penobscot Bay SHRU. Using estimates of smolt survival at dams provided by Alden Research Lab Inc., the NERSC's DIA model estimated survival (both survival of downstream migrating smolts, as well as passage success of upstream migrants) at every FERC licensed dam in the Penobscot River watershed. The DIA model (NMFS 2012) also predicted the effect that the dam removals will have on the distribution of Atlantic salmon in the Penobscot River.

The NEFSC Model evaluated the relative effect that changes in various inputs could have on the abundance of returning 2SW female Atlantic salmon to the Penobscot River under the survival and recovery conditions. The DIA model uses the following inputs in its analysis:

- Initial number of 2SW females spawners
- Eggs per female
- Freshwater Survival (Egg to smolt)

- In-River Survival (Outmigration)
- Smolt production caps
- Hatchery Stocking Levels and Location
- Downstream passage estimates (Alden)
- Downstream passage estimate correlation
- Path choice
- Hatchery discount
- Marine Survival
- Broodstock collection
- Natural Straying Rate
- Dam mortality
- Dam-induced Straying Rate
- Pre-spawn adult upstream passage efficiencies

The model compares baseline survival and recovery conditions to what would be anticipated with the implementation of the Atlantic salmon survival performance standards contained in a Species Protection Plan prepared by Black Bear Hydro Partners, LLC. This important effort, which, took several years to complete, will be presented in a Lab Reference Document. Going forward, the DIA Model will continue to help inform section 7 consultations for Atlantic salmon in the Penobscot River.

Species Protection Plans:

In recent years, NMFS has encouraged the owners of FERC licensed hydroelectric projects in the GOM DPS to seek take coverage for Atlantic salmon. Subsequently, project owners have sought coverage through the development of Species Protection Plans (SPPs). In general, SPPs outline an adaptive management strategy to minimize the effect of each project on Atlantic salmon and critical habitat. The agreed upon fish passage measures and activities are laid out within an adaptive management framework, with integration of management and research in order to provide feedback and the ability to adapt measures, as necessary, for further protection and enhancement of Atlantic salmon. If study results indicate that a given fishway is not highly efficient at passing Atlantic salmon, the owner will coordinate with us and modify operations at the Project as appropriate to avoid and minimize effects to Atlantic salmon to the extent practicable. To that end, we will coordinate with the owners often and meet at least annually to discuss study results, potential modifications to the study design and/or potential changes to the operation of the facility that may be necessary to reduce adverse effects to the species.

On August 30, 2012, NMFS issued a Biological Opinion to FERC analyzing the effects to listed Atlantic salmon regarding their proposal to amend the licenses for the Stillwater, Orono, Milford, West Enfield, and Medway Hydroelectric Projects in the Penobscot River in Maine (owned and operated by Black Bear Hydro LLC) to incorporate provisions of an SPP (Table 6.6). The SPP requires that the Stillwater, Orono, Milford, and West Enfield Projects achieve 96% downstream passage survival for Atlantic salmon. The SPP also requires 95% upstream passage survival of Atlantic salmon at the Milford and West Enfield Projects. At Medway, the SPP requires Black Bear Hydro to meet with NMFS every five years to ensure that the project is being operated in a way that is consistent with recovery objectives for listed species. In the Opinion, we conclude that the proposed project may adversely affect but is not likely to jeopardize the continued existence of the GOM DPS of Atlantic salmon or result in adverse modification or destruction of Atlantic salmon critical habitat. In our August 2012 Opinion, we modeled the anticipated effects of amending the licenses of Black Bear Hydro's projects on the Penobscot River. Our model compared baseline conditions with the conditions of the river once the proposed actions have been implemented. The model results predicted a growth in the annual return rate of 2SW female Atlantic salmon by 11% in the tenth generation over the baseline conditions of the PRRP. As the metric being assessed is the change in the abundance of pre-spawn 2SW female Atlantic salmon, we assume that the increase in abundance corresponds with an increase in reproduction.

On September 17, 2012, September 19, 2012, and October 18, 2012 we issued Opinions to the FERC on the impacts to listed species from Interim Species Protection Plans (ISPPs) being proposed by Brookfield Renewable Power for the Hydro-Kennebec Project, Topsham Hydro Partners for the Pejepscot Project, and Miller Hydro Group for the Worumbo Project, respectively (Table 6.6). The purpose of these ISPPs is to avoid and minimize impacts to listed Atlantic salmon and collect information on passage efficiency and survival of Atlantic salmon adults and smolts attempting to migrate past the Projects. The incidental take statements exempt take for proposed studies, fishway improvements, and ongoing operation of these projects for five year interim periods (2012-2016). In 2016, Brookfield, Topsham Hydro, and Miller Hydro will develop final SPPs that contain additional protection measures for listed fish, if necessary, and FERC will reinitiate formal consultation in order to obtain take authorization for the remainder of each projects' license term. The final SPPs will contain performance standards for downstream survival and upstream passage efficiency.

Table 6.6. Status and duration of Species Protection Plans (SPP's) and Interim Species Protection Plans (ISPP's) for Hydro Projects in the GOM DPS

River	Project	FERC ID #	Type	Duration	Opinion Issued
Kennebec	Lockwood	2574	ISPP	2013-2019	July 19, 2013
	Hydro-Kennebec	2611	ISPP	2012-2016	September 17, 2012
	Shawmut	2322	ISPP	2013-2019	July 19, 2013
	Weston	2325	ISPP	2013-2019	July 19, 2013
Androscoggin	Brunswick	2284	ISPP	2013-2019	July 19, 2013
	Pejepscot	4784	ISPP	2012-2016	September 19, 2012
	Worumbo	3428	ISPP	2012-2016	October 18, 2013
	Lewiston Falls	2302	ISPP	2013-2019	July 19, 2013
Penobscot	Milford	2534	SPP	2012-2038	August 31, 2012
	West Enfield	2600	SPP	2012-2024	August 31, 2012
	Mattaceunk	2520	ISPP	2013-2018	June 20, 2013
	Stillwater	2712	SPP	2012-2048	August 31, 2012
	Orono	2710	SPP	2012-2048	August 31, 2012
	Medway	2666	SPP	2012-2029	August 31, 2012

Connectivity progress and next steps

The agencies in partnership with NGO's, private companies, and other state and federal agencies have made considerable progress in implementing the strategy objectives of the Connectivity Action Team. Surveys of culverts, remnant dams, dams and dam owners has given all stakeholders a clear understanding of the connectivity challenges before us. These surveys have provided agencies and NGO's with decision-making tools to seek out connectivity projects that provide the greatest conservation benefit to anadromous fish. The surveys have also provided NGO's, federal and state agencies the tools to educate the public on the breadth of the connectivity problems for anadromous fish. All the stakeholders have stepped up to the challenge of seeking out and implementing connectivity projects, and educating landowners on fish passage solutions.   This includes Project SHARE's monumental effort to replace more than 70 undersized culverts over the last 5 years in Downeast Maine with bottomless arch culverts as well as remove nearly as many other barriers and remnant dams; and the work of the Penobscot River Restoration Trust and all the partners involved that lead to the successful removal of the Veazie and Great Works Dams on the Penobscot River.   On the regulatory front, NMFS and the USFWS have made considerable inroads in negotiating fish passage solutions at FERC projects in both the Penobscot and Merrymeeting Bay SHRU's.

Next Steps:

The agencies will continue to work with partners to provide technical assistance, coordination, and funding for dam removal, improved fish passage at dams, and improved passage at road crossings. In addition to these activities, agencies anticipate being involved with the following connectivity efforts over the next five years:

- Conduct post monitoring in the Penobscot River to evaluate the ecosystem response to the removal of the Veazie and Great Works Dam.
- Continue working with hydro-developers and FERC to develop final species protection plans for projects in the Penobscot, Androscoggin and Kennebec Rivers.
- Continue to work with FERC to evaluate whether hydro developers in the Penobscot are meeting or exceeding their performance standards as required under their Species Protection Plans
- Continue to negotiate with FERC and Hydro developers on the Union River to develop a species protection plan with performance measures necessary to allow for safe and effective passage of Atlantic salmon within the Union River watershed.
- Develop and start implementing a SHRU level connectivity strategy within each SHRU
- Continue to work with private landowners, Maine DOT, municipalities and to develop conservation goals, in relation to culvert replacements, that will help move the species towards recovery.
- Continue to work with the Natural Resources Conservation Service to identify and fund connectivity projects that will contribute to recovery of Atlantic salmon while streamlining interagency ESA section 7 consultations using existing programmatic approaches.
- Work with the Corps of Engineers to develop a programmatic ESA section 7 consultation to facilitate installation of both new and replacement road-stream crossings that are accessible to Atlantic salmon and promote natural stream function (this would be for all projects other than Maine DOT).

- Work with the Maine DOT, Federal Highway Administration, and Corps of Engineers to develop a programmatic ESA section 7 consultation to facilitate installation of both new and replacement road-stream crossings that are accessible to Atlantic salmon and promote natural stream function.
- Continue support of Stream Smart, Fisheries Improvement Network (FIN), and Maine Stream Connectivity Work Group
- Work with the town of Cherryfield and the Army Corp of Engineers to find a reasonable alternative to the Narraguagus Ice Control Dam that will provide the necessary protections to the properties within the town of Cherryfield while restoring safe, timely and effective passage of Atlantic salmon.
- Develop the Connectivity Action Team page on the new Atlantic salmon website and keep the information up-to-date
- Continue to work with the Penobscot Nation and Atlantic Salmon Federation on lake outlet dam fish passage projects in support of diadromous fish restoration in the Penobscot River watershed, including projects at Etna Pond, East Branch Lake, South Branch Lake, and Boyd Lake.
- Continue to partner with the Maine DOT and Atlantic Salmon Federation to address fish passage issues on Blackman Stream at the Route 178 road-stream crossing and at Chemo Pond.
- Continue efforts with the Penobscot Indian Nation and the Atlantic Salmon Federation to provide accessible replacement road-stream crossings in the Mattasmiscontis Stream watershed.
- Develop a connectivity project tracking system, with clearly defined terminology, that allows integration of other types of restoration projects (like LWD additions) and facilitates future decisions on stocking locations.
- Continue to hold technical training for tribes, agencies, NGOs and private landowners on Stream Simulation methodology.
- Continue development of online habitat and barrier viewer tools.
- Complete barrier inventories in high value habitat within the GOM-DPS.

Atlantic Salmon Recovery Outreach, Education and Stakeholder Engagement Group

Team contacts invited to participate in outreach planning:
Dwayne Shaw, Edward Steenstra, Jacob van de Sande, Janet Kennedy, John Kocik, Meredith Bartron, Randy Spencer, John Burrows, Antonio Bentivoglio, Laury Zicari, Meagan Racey, Peter Lamothe, Cheryl Daigle, Rory Saunders, Alan Kane, Alex Abbott, Alyson Saunders, Andy Goode, Barbara Arter, Barbara Charry, Barry Burgason, Ben Naumann, Brandon Kulik, Dan Bassett, Dan McCaw, Don Sprangers, Gayle Zydlewski, George Clarke, Gerry Zegers, Jay Clement, Jed Wright, Jeff Reardon, John Gilbert, Josh Royte, , Kathy Libby, Keith Kanoti, Landis Hudson, Laura RoseDay, Mao Lin, Marci Caplis, Mark Leathers, Merry Gallagher, Oliver Cox, Pat Sirois, Paul Christman, Scott Craig, Slade Moore, Stephen Coghlan, Steve Koenig, Tara Trinko-Lake, and Ted Shina. Our apologies to anyone whom we may inadvertently have left out.

The Framework State and Federal agencies and Penobscot Indian Nation formed action teams to develop recovery strategies and one of the teams was devoted to outreach. From the beginning, it was thought that education and outreach activities should not be isolated into a group separate from the other actions but instead should be integrated into the recovery actions.

As the planning continued towards major revisions to the recovery plan, non-governmental organizations, the State of Maine, Federal and Tribal agencies, and interested members of the public identified a need to reengage in more active and coordinated outreach and education. It was also acknowledged that there are a great number and diversity of outreach and education needs – those that directly support the Framework by making others aware of the activities being undertaken by the agencies; those that are intended to change the behavior of an individual or industry to minimize impacts on salmon and their habitat; or to encourage collaboration by other agencies, academia, conservation organizations or other interested parties.

Much work had been done and was underway and/or planned for the future, but it was not yet fully coordinated in a way to be most effective. To this end, in late 2012, an *ad hoc* group of former members of Framework recovery outreach group, the Framework action team chairs, and a team of facilitators got together to draft an outline for how to proceed. This is only a first step in development of a cohesive and detailed outreach plan that will articulate what we believe to be key communication actions needed over the next several years.

The group had two charges: to investigate developing a comprehensive outreach, education and stakeholder engagement strategy; and to do some advanced planning for public outreach when the revised Atlantic Salmon Recovery Plan will be released for public review in the Federal Register (now estimated for February 2014). To this end, we met twice and held numerous conference calls among a smaller subset of interested parties, to work on the strategy and, later, to help set the development of a new website in motion.

In the future, every effort will be made to engage as many stakeholders as are interested in developing a more comprehensive outreach, education and stakeholder engagement plan and in participating in coordinated recovery efforts.

Statement of overall purpose of an outreach, education and stakeholder engagement strategy outline:

This outline is a guide for helping the State, Federal, Tribal, NGO and other stakeholders engaged in Atlantic salmon conservation and recovery activities continue to make coordinated strategic investments in education and outreach toward our shared goals of salmon recovery as is outlined in the recovery plan. In addition, this strategy will create a framework for communication among the stakeholders and the Atlantic Salmon Framework action teams and management board. Atlantic salmon recovery cannot be achieved without active and continued collaboration with State, Federal, Tribal and NGO partners. Only through a well-coordinated collaborative process will we be successful. Further, the future of Atlantic salmon is inexorably bound to the fate of the whole community of sea-run fish of the North Atlantic. Thus our outreach and stakeholder engagement activities will encompass ecosystem restoration with Atlantic salmon recovery being a component of that.

This Strategy Outline includes seven action categories that build upon each other and which, collectively provide a pathway to enhance awareness and knowledge of Atlantic salmon recovery, the sea-run fish community, and the significance of ecosystem restoration, and will help stakeholders develop skills to conduct recovery activities.

As outreach planning continues, additional action categories may be developed; additional goals and objectives may be identified; more key messages and more specific messages may be written; more diverse audiences will be identified and audiences will be described in greater detail; many, many more delivery mechanisms will be strategized, developed, implemented and assessed; expected outcomes will be identified in greater detail, and alternative funding sources will be utilized.

Action Category #1. Improving stakeholder and public knowledge of ecosystem restoration, sea-run fish resources in Maine.

Improving stakeholder and public awareness of sea-run fish resources in Maine is the foundation upon which we can build support for species ecosystem recovery. Many Mainers are unaware of what has happened to aquatic habitats in Maine, and the efforts to restore them, including restoration of the community of sea run fish.

Action Category #2. Enhancing awareness of stakeholders and the public at large for Atlantic salmon recovery actions.

These participants are doing many types of recovery activities, from: egg, parr and smolt rearing in hatcheries; restoring habitat by adding large woody debris to streams lacking it; conducting outreach and education programs; stocking fish, assessing fish stocks, and tracking fish movements; assessing the effectiveness of fish passage facilities; and reestablishing connections between spawning and rearing habitat and the open ocean.

Action Category #3: Connecting Atlantic Salmon Recovery Framework action teams with stakeholders and other members of the public.

Stakeholders have expressed concern about the level of engagement with them and other members of the public, by Federal, state and tribal scientists working in Atlantic Salmon Recovery Framework activities. We believe that significant gains can be made towards fixing this, through active involvement of stakeholders in the Outreach Group which acts as the liaison with the Framework action teams for sea-run fish restoration outreach activities, use of social media and more.

Action Category #4: Coordinating recovery actions. Example: replacing barriers to fish migration to reestablish habitat connectivity.

Natural resource professionals, NGOs, and researchers will provide a clear message about what recovery looks like, how recovery activities are prioritized and why, and how the entire effort is coordinated and organized. Communities, neighbors, natural resource professionals, conservation advocates and landowners will become engaged in what will become the growing network of stream connections, with attention to how they can be involved and contribute.

Action Category #5: Sharing resources and coordinating outreach projects among interested stakeholders, coordinate funding opportunities and publicize all actions that help Atlantic salmon.

Action Category #6: Providing training for stakeholders and others, for Atlantic salmon recovery activities, (e.g., how to build fish-friendly road/stream crossings).

Action Category #7: Explaining Endangered Species requirements to those who need to know.

Development of a new website was the most significant of all potential tools discussed to engage the public, each other, and to advance sea-run fish recovery in Maine. We explored teaming up with the North Atlantic Landscape Conservation Cooperative (NALCC) which had envisioned "adopting" other groups on their website, (http://www.northatlanticlcc.org/) groups with shared objectives and vision for conservation into the future. The webmaster of the NALCC worked with US Fish and Wildlife Service (Service) staff and developed a scope of work for the website's contractor, and the Service and NOAA NMFS found funding for the contractor. An initial meeting at the Service Northeast Regional Office with the web contractor took place in late July, 2013 and we look forward to website development and training for interested members of the outreach group, in early fall, 2013, timed well for the release of the revised recovery plan. We are grateful to the Maine Department of Marine Resources for hosting the current website; this new website, however, will be more interactive, easier to update, and will utilize web-tools developed for the NALCC "mother" site.

A full copy of the outreach, education and stakeholder engagement strategy outline will be appended to the Revised Atlantic Salmon Recovery Plan and available for public comment. The Plan will include initial estimates of the cost and timing of important outreach and education activities.

Appendix 1 RESEARCH and ASSESSMENT

Inventory of completed and ongoing assessment and research projects supported during TAC or Framework review, 2001 - 2012.

Contact	Project short title	Watersheds	Study Stocking years	Juvenile Field years	Adult Return years	Status	Reports
J. Zydlewski	Smolt acoustictag lab study	Penobscot	NA	2012	NA	Data	UM Thesis
J. Zydlewski	Smolt migration	Penobscot	2012 - 2014	2012 - 2014	2013 - 2016	Data	UM Thesis
J. Zydlewski	Smolt salinity lab study	Penobscot	NA	2012 - 2014	NA	Data	UM Thesis
J. Zydlewski	Penobscot PIT Tagging	Penobscot	NA	NA	2012 - 2014	Data	UM Thesis
J. Zydlewski	Al & pH smolt physiology	Narraguagus, Penobscot, Sheepscot	2012 - 2015	2012 - 2014	2013 -2016	Data	UM Thesis
M. Brown	Androscoggin River adults	Androscoggin River	NA	NA	2011	Data	interim updates
J. Burrows	Marsh Stream parr	Marsh Stream	2011-2014	NA	2012 -2016	Data	interim updates
J. van de Sande	East Machias Parr	East Machias	2012-2017	2012-2019	2014-2023	Rearing	interim updates
P. Ruksznis	Cove Brook egg planting	Cove Brook	2012 -2016	2012-2018	2015-2020	Pending	interim updates
M. Guyette	Marine Derived Nutrients	Piacataquis; Kingsburry Stream	2009-2011	2009-2012	NA	Ongoing	UM Thesis
R. Wathen	Bass salmon interactions	Penobscot; Pollard, Great Works, Hemlock, Hoyt	2008-2009	2008-2009	NA	Completed	2010, 2011
W. Ashe	Conectivity and productivity	Machias	NA	2009-2010	NA	Ongoing	UM Thesis
P. Ruksznis	Smolt timing from stocked Green Lake parr	Pleasant River, Penobscot	2002-2011	2003-2012	2003-2013	Completed	2011
O. Cox	Smolt (alternate rearing) stocking	Narraguagus	2008-2012	2008-2012	2009-2014	Analysis	interim updates
J. Trial	Smolt (alternate rearing) stocking	Pleasant River	2011-2013	2011-2013	2012-2015	Data	interim updates
P. Christman	0+ parr stocking	Sheepscot	2004-2005	2005-2007	2006-2011	Complete	2008
O. Cox	0+ parr stocking	Narraguagus	2008-2010	2008-2011	2010-2014	Analysis	2011
E. Atkinson	Captive reared pre-spawn adult sto cking	Hobart	2006-2010	2007-2012	2009-2014	Data	interim updates
E. Atkinson	Single strategy - Captive reared pre-spawn adult stocking	Dennys	2011 - 2015	2012-2017	2014-2021	Stocking	interim updates
C. Bruchs	Captive reared pre-spawn adult stocking	East Machias	2005 - 2008 & 2009 - 2014	2006 - 2015	2009-2019	Data	interim updates
P Christman	Captive reared pre-spawn adult stocking	Sheepscot	2006-2010	2007-2012	2009-2014	Data	interim updates
C. Bruchs	Captive reared pre-spawn adult stocking	Machias	2006-2010 & 2011 -2013	2007-2012	2009-2014	Data	interim updates
E. Atkinson	Upstream stocking post-spawn Captive broodstock	Narraguagus	2007- ?	NA	2008 - ?	Data	interim updates
P. Christman	Egg planting	Sheepscot, Kennebec	2003-2007	2004-2009	2007-20012	Data	interim updates
P. Christman	Egg planting	Kennebec	2009-strategy	2010-	2014-	Data	interim updates
P. Christman	Streamside incubation	Sheepscot, Kennebec	2002-2006	2003-2008	2006-2011	Complete	Sheepscot 2008 Kennebec 2006
B. Naumann	LWD additions	Machias, East Machias, Narraguagus	2006-2010	2007-2014	NA	Data	interim updates
O. Cox	Wild Veazie returns genetics	Penobscot	NA		2005-2012	Data	interim updates
M. Simpson	Upper drainage smolt assessment	Narraguagus	2003-2008	2005-2010	NA	Data	interim updates
E. Atkinson	Whole River Point stocking	Dennys	2007-2010	2008-2012	NA	Data	interim updates
G. Mackey	Point stocking, range of sites	Machias, East Machias, Narraguagus, Kennebec	2005-2007	2006-2009	NA	Analysis	2009
R. Spencer	Sea run, captive reared comparison	Aroostook	2003-2008	2004-2010	NA	Complete	2007
R. Spencer	Upper Piscataquis fry growth	Penobscot	2006-2008	2006-2009	NA	Data	interim updates
R. Spencer	Upper Piscataquis adult transfer	Penobscot	2009-2011	2010-2013	2013-2016	Data	interim updates
R. Dill	Smolt stocking - sites, timing	Dennys	2001-2006	2001-2006	2002-2008	Complete	2010
C. Lipsky	Smolt stocking - sites, timing	Penobscot	2002-2006	2002-2006	2003-2007	Complete	2011
T. Lindley	Merical Penobscot	Penobscot	2003-2005	2003-2005	2004-2007	Completed?	2008
J. Sweka	Fry stocking - habitat & genetics	Sheepscot	2004			Completed	2008, 2012
J. Kocik	Fry stocking - Smolt & Adult genetics	Narraguagus	ongoing	ongoing	ongoing	Analysis	interim updates
G. Mackey	Alewife abundance and smolt survival	Narraguagus	Historic data			Completed	2009
J. Trial	Stocking density	Narraguagus, East Machias, Saco	2002-2006	2002-2007	NA	Completed	2007, 2008
J. Trial	Stocked fry upstream movements	Machias, East Machias	2007	2007-2008	NA	Completed	2008, 2009
D Macaw	Translocated adults	Kennebec	NA	NA	2006-2009	Completed	2008, 2009
M. Bailey	Size selective mortality	Narraguagus, Penobscot	2005-2007	2005-2007	NA	Completed	UM Thesis, 2008
J. Trial	Riverine index sites; monitoring juvenile populations	Narraguagus, Dennys, Machias, East Machias, Pleasant, Saco, Kennebec, Lower Penobscot tributaries, Penobscot	NA	NA	NA	Ongoing	Annual reporting USASAC, ICES
J. Trial	Adult trap counts	Penobscot, Kennebec, Narraguagus, Dennys, Androscoggin, Saco, Aroostook, East Branch Penobscot, St. Croix, Union, Pleasant	NA	NA	NA	Ongoing	Annual reporting USASAC, ICES
J. Trial	Redd Counts	Narraguagus, Dennys, Machias, East Machias, Pleasant, Sheepscot, Lower Penobscot tributaries	NA	NA	NA	Ongoing	Annual reporting USASAC, ICES
J. Kocik/Joan Trial	Smolt population estimates and indices	Narraguagus, Sheepscot	NA	NA	NA	Ongoing	Annual reporting USASAC, ICES

Appendix 2 Tables of Actions in 2012.

Appendix 2.1: CHAT five year implementation plan.

Action	2012	2013	2014	2015	2016	Comments
Current Program: review and implement biosecurity plan	X	X	X	X	X	Ongoing
Current Program: Provide therapeutic and prophylactic treatment recommendations for optimum fish health	X	X	X	X	X	Ongoing
Current Program: conduct USFWS annual Fish Health Inspections	X	X	X	X	X	Ongoing
Current Program: fish health diagnostics	X	X	X	X	X	Ongoing
Current Program: screen all non-fry mortality for pathogens at Craig Brook NFH	X	X	X	X	X	Ongoing
Current Program: screen all gametic fluids taken during broodstock spawning	X	X	X	X	X	Ongoing
Current Program: produce Penobscot F2 eggs as backup source	X	X	X	X	X	Ongoing
Current Program: maintain captive brood for Machias	X	X	X	X	X	Ongoing
Current Program: maintain captive brood for Narraguagus	X	X	X	X	X	Ongoing
Current Program: maintain captive brood for Dennys	X	X	X	X	X	Ongoing
Current Program: maintain captive brood for Sheepscot	X	X	X	X	X	Ongoing
Current Program: maintain captive brood for East Machias	X	X	X	X	X	Ongoing
Current Program: maintain captive brood for Pleasant	X	X	X	X	X	Ongoing
Current Program: maintain Penobscot domestic brood	X	X	X	X	X	Ongoing
Current Program: conducts surveillance of ISA Virus in sea-run brood	X	X	X	X	X	Ongoing
Current Program: maintain use of Penobscot sea-run brood	X	X	X	X	X	Ongoing

Action	2012	2013	2014	2015	2016	Comments
Current Program: release spent broodstock into river of origin	X	X	X	X	X	Ongoing
Current Program: 50,000 1+ smolt / 1+ parr into the Narraguagus	X					Program temporarily discontinued due to budget constraints
Current Program: 50,000 1+ smolt / 1+ parr into the Machias		X	?	?	?	Program temporarily discontinued due to budget constraints
Current Program: 550,000 1+ smolt into the Penobscot	X	X	X	X	X	On-going
Current Program: 350,000 0+ parr into the Penobscot	X	X	X	X	X	Ongoing – these fish are a byproduct of smolt production for the Penobscot
Culture & Stocking: 50,000 1+ smolt / 1+ parr into the Pleasant	X	X	?	?	?	Program temporarily discontinued due to budget constraints
Current Program: stock 15K parr in Sheepscot	X	X	X	X	X	On-going
Current Program: stock 1 million fry in Penobscot	X	X	X	X	X	On-going; final numbers dependent on number of adult returns to the Penobscot
Culture & Stocking: stock 750K fry in Penobscot; balance of sea run adult spawn naturally		X	X	X	X	On-going
Current Program: stock 500K fry in Machias	X	X	X	X	X	On-going
Current Program: stock 500K fry in Narraguagus	X	X	X	X	X	On-going
Current Program: stock 400K fry in Dennys						Program discontinued due to poor survival rate
Culture & Stocking: stock gravid adults (no fry) in Dennys	X	?				Results from this stocking approach are being evaluated

Current Program: stock 200K fry in Sheepscot	X	X	X	X	X	On-going
Current Program: stock 100K fry in East Machias	X	X	X	X	X	On-going
Current Program: supply eggs to East Machias Aquatic Research Center (EMARC) to stock 50k parr in East Machias	X	X	X	X	X	Current plan is to provide up to 400,000 eggs to the facility for fall parr production
Current Program: stock 100K fry in Pleasant	X	X	X	X	X	On-going
Tools & Assess: mark significant number of parr releases		?	X	X	X	On-going; as resources are available
Culture & Stocking: smolt release utilizing imprinting and seawater acclimation	X	X	?			On-going
Culture & Stocking: artificial redd / egg stocking in Kennebec (Sandy River)	X	X	?	?	?	Dependent on availability of eggs from the domestic brood for the Penobscot
Tools & Assess: develop and implement in-hatchery product assessment program		X	X	X	X	On-going
Tools & Assess: in-stream fry and parr assessment program	X	X	X	X	X	On-going
Tools & Assess: smolt migration / production assessment program	X	X	X	X	X	On-going

Appendix 2.2 GDAT implementation plan.

Action Number	Action Name and Description	Evaluation of Action	Timeline	Status
	Genetic monitoring			
G-1	Use genetic methods to annually characterize parr and sea-run adults (fundamental action). This action must be accomplished to allow many of the other actions listed to be carried out because it provides the genetic data necessary for further analyses.	Follow procedures outlined in Broodstock Management Plan	ongoing	A total of 1209 parr broodstock from the 2010 collection year and 478 sea-run adult broodstock from the 2012 return year were genotyped.
G-2	Monitor broodstocks for evidence of genetic diseases or deleterious genetic traits	Follow procedures outlined in Broodstock Management Plan	ongoing	Broodstock are evaluated for physical deformities which may indicate genetic abnormalities, as well as genetic estimates of inbreeding.
G-3	Genetically assess consequences of alternate stocking strategies for multiple life history stages	Follow procedures outlined in Broodstock Management Plan	ongoing	Various life stages were stocked in 2012: egg planting, fry, parr, smolts, and pre-spawn adults to allow for natural selection at multiple life stages.
G-4	Prioritize current genetic data analysis needs with respect to current and long-term management goals	Follow procedures outlined in Broodstock Management Plan	ongoing	Genetic analysis of broodstock continues to be evaluated annually.
G-5	Evaluate if certain program components are missing (gap analysis) in regards to genetic goals of the program.	Follow procedures outlined in Broodstock Management Plan	ongoing	
G-6	Monitor estimates of genetic diversity of the wild or naturally reproducing Atlantic salmon (for currently defined hatchery program/DPS and Penobscot)	Follow procedures outlined in Broodstock Management Plan	ongoing	Estimates of genetic diversity such as mean number of alleles per locus, observed heterozygosity, effective population size, and inbreeding estimates are calculated for all broodstocks.

G-7	Use genetic determination of parentage to identify percentage of families recovered from stocking events, and monitor yearly to evaluate broodstock collection practices	Follow procedures outlined in Broodstock Management Plan	ongoing	Parentage analysis is conducted annually to determine hatchery contribution to the parr and adult broodstock collections.
G-8	Improve management of data resulting from production, stocking, and genetic evaluation to facilitate program assessment and monitoring	Follow procedures outlined in Broodstock Management Plan	ongoing	Access-based databases are used to manage spawning, broodstock tracking, genetic data, and genetic results.
G-9	Continually monitor critical trait variation (quantitative, morphometric, other physical trait) to assess risks of inadvertent selection	Follow procedures outlined in Broodstock Management Plan	ongoing	Annual assessment of traits has not occurred due to staffing limitations.
G-10	Use 2-phased criteria to assess if spawning optimization program effectively reduces potential for inbreeding	Follow procedures outlined in Broodstock Management Plan	ongoing	Individuals that are likely to spawn in a given year are identified annually by staff at CBNFH and that information is sent to NEFC for analysis of inbreeding potential.
G-11	Use 3-phased criteria (relatedness, inbreeding, and limited population size) to determine if spawning populations within or between capture years is needed	Follow procedures outlined in Broodstock Management Plan	ongoing	Both the 2 and 3-phased criteria are evaluated prior to spawning. Starting in 2012, crosses between capture years within broodstocks were initiated.
	Evaluation of hatchery practices and product			
G-12	Optimize practices to reduce risks of inadvertent selection that might reduce fitness in the wild	Follow procedures outlined in Broodstock Management Plan	ongoing	Hatchery staff work to minimize activities that could result in artificial selection.
G-13	Utilize broodstock database to track spawning history for all salmon held for broodstock purposes and implement spawning protocols described in the Broodstock Management Plan	Follow procedures outlined in Broodstock Management Plan	ongoing	The broodstock database is used annually to document spawning, stocking, and other related actions.
G-14	Implement stocking practices that broadly distribute genetic groups (families) throughout the stocking sites	Follow procedures outlined in Broodstock Management Plan	ongoing	CBNFH works to batch families based on developmental stage and mix batches for prior to stocking.

G-15	Implement pedigree lines if demographic, family recovery, aquaculture escape event, or other parameter limits the potential collection of a broodstock year class	Genetic diversity within each broodstock will be monitored to determine if pedigree lines should be continued	ongoing	No pedigree lines were implemented in 2012.
G-16	Maintain and enhance as applicable the genetic viability of river-specific broodstocks for supplementation according to the Broodstock Management Plan	Follow procedures outlined in Broodstock Management Plan	ongoing	Estimates of genetic diversity are monitored annually for each river-specific broodstocks.
G-17	Link hatchery production parameters (i.e.. Changes in fecundity, broodstock reproducing, etc.) to genetic characteristics of the broodstocks to assist in monitoring of fitness	Follow procedures outlined in Broodstock Management Plan	ongoing	Individuals not previously spawned are given priority to allow all adults to reproduce.
G-18	Implement collection practices that obtain representative genetic variation (i.e. majority of artificial and wild spawned families), including widespread field collection-Juveniles for DPS parr collections for current parr program	Follow procedures outlined in Broodstock Management Plan	ongoing	Based on results from genetic parentage analysis, fry stocking and parr broodstock collection practices are being evaluated to increase the number of hatchery families recovered.
G-19	Evaluate the genetic implications of collecting adult fish for captive propagation versus wild reproduction	Follow procedures outlined in Broodstock Management Plan	ongoing	Given the current low return rates, collection of adult fish is not practical at this time.
G-20	Evaluate and optimize grading practices to reduce genetic selection (initial emphasis on grading for smolt production)	Follow procedures outlined in Broodstock Management Plan	ongoing	Planning for a study to evaluate grading practices for the Penobscot River smolts is underway, to begin with the 2013 spawn year class.
G-21	Implement collection practices that obtain representative genetic variation (i.e. majority of artificial and wild spawned families), including widespread field collection-Adults for collection of adult returns to the Penobscot for broodstock	Follow procedures outlined in Broodstock Management Plan	ongoing	Evaluation of hatchery family composition in the broodstock collections resulted in an increase in parr broodstock targets starting with the 2013 parr broodstock collections.

G-22	Experimental genetic analyses and projects for increased hatchery evaluation	Follow procedures outlined in Broodstock Management Plan	ongoing	No new studies were implemented in 2012.
G-23	Consider options to evaluate, improve, and enhance the hatchery product and broodstock management practices in experimental environments outside of hatchery production requirements	Follow procedures outlined in Broodstock Management Plan	ongoing	Working with DSF, the EMARC facility is rearing juveniles from the East Machias broodstock for stocking.
	Monitoring of aquaculture			
G-24	**Screen incoming parr** and adults for aquaculture escapees	Follow procedures outlined in Broodstock Management Plan	ongoing	Screening identified a total of 11 parr-broodstock and 3 Penobscot River adult broodstock to be removed from the broodstocks in accordance with the BMP.
G-25	Monitor effectiveness of Aquaculture Biological Opinion (including site inspections, audits, etc.)	Ensure that permits, inspections, and audits are proceeding according to schedule.	ongoing	Annual inspections of aquaculture sites, adherence to permit conditions, and audits are conducted per the ABO.
G-26	Prevent aquaculture adults from entering rivers with existing trapping facilities and using emergency methods when large escapes occur and trapping is possible.	If escape occurs, assess number of aquaculture origin individual in rivers	ongoing	Protocols are in place to utilize existing trapping facilities if needed.
G-27	Operate the Denny's weir for the preemptive purpose of excluding aquaculture Atlantic salmon	Assessment of number of adults that were able to pass the weir when it was in place or prior to when the weir was put in place	ongoing	The Dennys River trap was not operated in 2012.

Appendix 3. FWAT implementation plan.

Action Number	Action Name and Description	Evaluation of Action	Timeline	Status
FWAT1	Design and implement a state-wide juvenile salmon sampling plan based on statistical sampling with fully standardized methods	Review of sampling design and data quality (variance) of the Parr Production Index (%CV ≤ 35)	Ongoing	Maine DMR developed and implemented a state-wide juvenile sampling plan. The sampling scheme has been used 2011and 2012. Results are presented in the FWAT and SAAT sections of this report. Efforts to refine methodology and improve utility will continue in 2013.
FWAT2	Evaluate smolt production on selected rivers (i.e. Narraguagus, Penobscot, and Sheepscot Rivers)	Calculated smolt estimates and evaluate smolt production in association with large parr production	Ongoing	Atlantic salmon smolt production was estimated at three locations, Narraguagus River, Upper Piscataquis River, and the Sheepscot River. Results are presented in the FWAT and SAAT sections of this report.
FWAT3	Monitor reaches for natural re-colonization	Contrast tends in natural re-colonization to adult Atlantic salmon abundance, distribution, and changes in connectivity	Ongoing	Redd counts were conducted within each SHRU and results are presented in the FWAT and SAAT sections of this report.
FWAT4	Monitor water temperatures in selected salmon river systems	Data will be used by manages when evaluating juvenile production and juvenile production potential	Ongoing	Water temperature was monitored at 19 locations by Maine DMR in the GOM DPS. In 2012, several water temperature studies were conducted in the Downeast Coastal River SHRU. These projects include a comparison of a groundwater versus non groundwater influenced catchment in the Machias River, a study was completed in the Upper Narraguagus River (Beddington Lake HUC12) and a similar study was initiated within the East Machias River.
FWAT5	Develop habitat based productivity estimates and identify key elements of productive salmon habitat and limiting factors	Data used as inputs for the Atlantic salmon production model	2012-2015	Data on fry density, parr density, and water temperature were collected to evaluate site specific productivity. Growth rates there were classified as medium to slow, possibly due to high fry densities and intraspecific competition.
FWAT6	Develop a GIS model to predict Atlantic salmon production, based on abiotic and biotic parameters	Completion of the model is used to develop a model to predict habitat suitability for Juvenile Atlantic salmon	2012-2015	Following a review of USFWS and NGOs modeling efforts, this action will be reevaluated to better align the action with the goal of focusing restoration efforts
FWAT7	Conduct surveys to validate GIS Atlantic salmon production model (e.g. substrate quality, complexity etc.)	Model successfully predicts Atlantic salmon production	2014-2015	None
FWAT8	Map riparian zones and activities (e.g., harvest practices, ATVs, development etc.) that may impact Atlantic salmon (sedimentation, flow, etc.)	Completed map of riparian zones that can inform restoration prioritization	2012-2013	Statewide mapping is in progress by the Nature conservancy of Active River Areas (ARA).

FWAT9	Identify areas for riparian forest improvement and pursue resources for improvements	Map of riparian areas that could be targeted for restoration and number of grant applications filed	2013-2014	See action FWAT 8
FWAT10	Support riparian zones management practices for water quality and habitat	Number of consultation and acres of riparian zones in conservation	Ongoing	None
FWAT11	Prioritize and evaluate habitat restoration strategies based on system connectivity, habitat quality, and the expected Atlantic salmon production and pursue resources for improvements	The development of a list	2014-2015	The concept of re-focusing habitat restoration and enhancement measures at HUC 12 level resolution was implemented by NOAA NMFS in 2012. An "ARC Viewer" tool was developed and deployed by the USFWS with input from DMR regional biologists. Its purpose is to clearly identify high priority Atlantic salmon habitat and focus restoration resources in those areas.
FWAT12	Increase escapement of adult salmon to the Penobscot River	Increasing % of wild origin trap catch	Ongoing	Low number of 2SW salmon and unprecedented low returns of 1SW salmon to the Penobscot occurred in 2012, reducing escapement to spawning habitat. The likelihood of even lower 2SW returns in 2013 influenced spawning escapement goals. Staff from the DMR, CBNFH, and GDAT discussed alternative strategies to minimize negative impacts to the salmon program if the anticipated shortfall in sea-run adult returns should occur in 2013. The consensus was that spawning escapement in the Penobscot River would remain at zero until sufficient broodstock had been acquired to meet production goals at CBNFH; or until demolition of the Veazie Dam commences (July 15, 2013).
FWAT13	Trap and truck adult salmon from Lockwood Dam to the Sandy River drainage, Kennebec basin	A positive association between the number of female Atlantic salmon transported upstream and redd counts and juvenile CPUE is expected	Ongoing	Five Atlantic salmon were transported from Lockwood to the Sandy River.
FWAT14	Sample all Aquaculture suspects captured for disease	Review of pathogen reports and management SOPs as necessary	Ongoing	Aquaculture origin was confirmed for three suspects captured in the Penobscot River, three in the Union River, and one in the Androscoggin River during 2012. The standard suite of tissue samples was collected for disease screening and forwarded to the USFWS, no reportable diseases were detected?
FWAT15	Investigate recruitment from natural spawning and various hatchery stocking strategies as tools to repopulate vacant habitat with Atlantic salmon to facilitate future adult returns	Comparison of fry and large parr recruitment	2012-2015	Eyed eggs were planted in the Penobscot Bay SHRU: 56,000 in Cove Brook, 320,000 in the West Branch Pleasant River; and in the Merrymeeting Bay SHRU: Sandy River 920,000 eggs, Sheepscot River 40,330 eggs. Results of egg stocking, fry stocking, parr Stocking, and adult stocking were assessed through electrofishing surveys (CPUE and depletion) smolt trapping, and adult trapping programs.

FWAT16	Evaluate the impacts of sedimentation and changes to stream channel geomorphology on habitat quality/quantity	Data was used to inform habitat modeling efforts	2012-2015	None
FWAT17	Retain large woody debris in streams and rivers to support salmon habitat quality and quantity	Number of river kilometers where land owners have made a committed to maintain LWD inputs	Ongoing	Four new large wood (LW) addition projects were completed in the Downeast Coastal SHRU in 2012. Each of these sites covers 100-150m of stream. A willing land owner for large wood additions has been identified on the Sheepscot River and funding is being sought to complete the project
FWAT18	Implement habitat manipulations adding large wood to streams	Number of river kilometers treated and juvenile Atlantic salmon response	2012-2015	In 2012 the Maine State legislature amended Maine Forest Service Chapter 25 regulations through rule 2012-350 regarding "Standards for Placing Wood into Stream Channels to Enhance Cold Water Fisheries Habitat". This rule streamlines the permitting process for implementing cold water fisheries habitat enhancement projects. From 2007 through 2012 juvenile salmon response has been assessed at 22 large wood treatment study sites in the Downeast Coastal SHRU.
FWAT19	Perform experimental habitat manipulations to reduce sedimentation (i.e. embeddedness/armoring) and evaluate the effect on the biological function of streams	Number of river kilometers treated and juvenile Atlantic salmon response	2012-2015	Geomorphic effects of large wood additions are being evaluated. Correctly sized culvert replacements (see CAT) reduce sedimentation from catastrophic loss.
FWAT20	Assess avian, fish, and mammal predation in freshwater-all life stages	Report on Atlantic salmon predation issues that leads to a reduction in salmon predation	2012-2015	NOAA NMFS (Music et al) conducted an avian and marine mammal census (AMMC) in the Penobscot River estuary to investigate the relationships between avian and mammalian predators and the fish community.
FWAT21	Evaluate the ecological role and importance of diadromous fish (alewives, shad, smelt etc.) contributions to the freshwater production of smolts	Report on nutrient additions	2011-2015	In addition to several monitoring efforts being conducted in the Kennebec and Penobscot estuaries, DMR counted river herring, shad, and sea lamprey at many adult salmon trapping facilities. University of Maine (Stephan Coghlin and students) continues to investigate the ecology of sea lamprey and their contribution to habitat productivity in Sedgeunkedunk Stream in the Penobscot SHRU.

FWAT22	Investigate natural spawning performance of translocated adult salmon	Transporting Atlantic salmon into superior headwater habitat increased juvenile production relative to free-swim and low river spawning.	2011-2013	Maine DMR translocated pre-spawn adults to the Upper Piscataquis River from 2009-2011 to improve their reproductive success. Recruitment is assessed annually at smolt traps and through depletion sampling at eight electrofishing index sites. High river flows in 2012 reduced sampling effort Preliminary analysis indicates a 30fold in 0+parr production may be realized (relative to inferior low river spawning habitat).
FWAT23	Capture and captive-rear, in sea-cages, wild and/or naturally-reared Penobscot smolts for release as sexually mature adults in selected river reaches	Increased adult escapement, juvenile production, and "return" rates relative to treatment controls.	Ongoing	This action is postponed pending evaluation of recent staff attrition and competing needs for the limited resources available.
FWAT24	Assess overwinter survival of juvenile salmon using best available data initially, and design and undertake further research as needed	Report on overwinter survival in Maine	Ongoing	No specific work was conducted on overwinter survival; however, FWS and NOAA NMFS have been working on updating life history models. Both of those agency efforts are working to better understand how passage inefficacies at FERC Hydro projects can influences population dynamics.
FWAT25	Support and implement studies that provide managers with information on abundance, distribution, and habitat utilization of Atlantic salmon	Increased knowledge of Atlantic salmon distribution and habitat utilization that can be incorporated with passage and juvenile production data	Ongoing	GRTS sampling strategies, rotary screw traps, and adult traps were operated in all SHRU to inform distribution and abundance of Atlantic salmon.
FWAT26	Review existing water quality standards for salmon rivers to determine adequacy to meet the needs of Atlantic salmon	Report on the adequacy of water quality standards in Maine to protect Atlantic salmon	Ongoing	In 2012, a comprehensive report detailing the third year of activities pertaining to the use of clam shells to mitigate acid rain type water quality issues was completed.
FWAT27	Ensure that water withdrawal permit requirements protect stream flows required for the recovery and conservation of Atlantic salmon. Enforce all appropriate permits for water withdrawals	Report on the adequacy of water withdrawal permits in Maine to protect Atlantic salmon	Ongoing	Maine DMR reviewed LURC irrigation permits
FWAT28	Evaluation of permit requests associated with incidentally take of Atlantic salmon	Number of permit requests reviewed	Ongoing	The USFWS requested guidance from the FWAT regarding prioritization of permit reviews based on habitat suitability for Atlantic salmon.
FWAT29	Review existing stocking programs (various trout spp, bass spp, or any other species) and assess the potential impacts of these introductions on Atlantic salmon populations	Identification of stocking programs that have the potential to reduce Atlantic salmon survival.	Ongoing	None
FWAT30	Minimize by catch of Atlantic salmon through closure of adult Atlantic salmon holding areas to fishing and angler education	Areas closed and/or posted	Ongoing	No new closures were enforced this year.

FWAT31	Continue to enforce commercial freshwater fisheries regulations/permits where the potential for incidental take of Atlantic salmon exists	Reducing Atlantic salmon bycatch	Ongoing	At this time, we do not have any documentation reporting bycatch of Atlantic salmon.