The Atlantic Salmon Ecosystems Forum

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January 17-18, 2018
Orono, Maine USA
University of Maine, Wells Conference Center

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2018 Atlantic Salmon Ecosystems Forum
Schedule At A Glance

Begin	End	January 17, 2018
7:00	8:00	**REGISTRATION** - *Refreshments provided*

Welcome
Mark Renkawitz, Fisheries Biologist, NOAA-Fisheries, Northeast Fisheries Science Center

Session 1: Climate Related Impacts and Resiliency
Carl Wilson, Director, Bureau of Marine Science, Maine DMR, ***Moderator***

8:05	8:25	Atlantic salmon recovery as Ecosystem-Based Fisheries Management *- Jon Hare, Science and Research Director, NOAA-Fisheries, Northeast Fisheries Science Center*
8:25	9:10	Understanding the differences between watershed restoration prioritization methods *- George Pess, Watershed Program Manager, NOAA-Fisheries, Northwest Fisheries Science Center*
9:10	9:25	River flood seasonality in the Northeast United States and trends in annual timing *- Mathias J. Collins, NOAA-Fisheries, NOAA Restoration Center*
9:25	9:40	Climate related changes in the hydrology of New England *- Robert W. Dudley, United States Geological Survey, New England Water Science Cente*r
9:40	9:55	ICNet - Infrastructure and Climate Network *- Charlie Hebson, Environmental Office, Maine Department of Transportation*
9:55	10:10	Reflections on the lack of success of the Connecticut River Atlantic Salmon Restoration Program *- Stephen R. Gephard, Connecticut Department of Energy and Environmental Protection*
10:10	10:50	**BREAK** - *refreshments provided*
10:50	11:20	Climate trends and ecosystem impacts in the Gulf of Maine and Northwest Atlantic *- Andrew Pershing, Chief Scientific Officer, Gulf of Maine Research Institute*
11:20	11:35	Atlantic salmon in a changing climate *- Timothy Sheehan, NOAA-Fisheries, Northeast Fisheries Science Center*

Begin	End	
11:35	11:50	Habitat condition changes and biological implications for Atlantic salmon at sea - *Katherine E. Mills, Gulf of Maine Research Institute*
11:50	12:05	Impacts of a changing ecosystem on Atlantic salmon growth - *Felix Massiot-Granier, Gulf of Maine Research Institute*
		In memorium - Jed Wright, United States Fish and Wildlife Service
12:05	13:20	**LUNCH** - *lunch at the Student Union (not provided)*

Session II: Estuarine and Marine Ecology

Patrick Dockens, Wildlife Biologist, US Fish and Wildlife Service, ***Moderator***

13:20	13:35	Using otolith microchemistry to infer habitat use of American shad prior to dam removal in the Penobscot River, Maine - *Kevin Job, University of Maine, Department of Wildlife, Fisheries and Conservation Biology*
13:35	13:50	Verification of circulus deposition rates in Atlantic salmon (*Salmo salar*) smolts from three Maine rivers - *Erin Peterson, University of Maine, Department of Wildlife, Fisheries and Conservation Biology*
13:50	14:05	Estimating annual consumption rate of Atlantic salmon smolt (*Salmo salar*) by striped bass (*Morone saxatilis*) in the Miramichi Estuary - *Jason Daniels, Atlantic Salmon Federation*
14:05	14:20	The problem may not be where we think it is: A critical review of the critical period hypothesis in salmon - *Marc Trudel, Fisheries and Oceans Canada, St. Andrews Biological Station & University of Victoria, Department of Biology*
14:20	14:35	Relating fluctuations in fish abundance to river restoration efforts and environmental conditions in the Penobscot River, Maine - *Gayle B. Zydlewski (for Constantin C. Scherelis), University of Maine, School of Marine Sciences*
14:35	14:50	Partitioning the big blue box: A synthesis of marine and estuary action team science - *John F. Kocik, ASERT Chief, NOAA-Fisheries, Northeast Fisheries Science Center of Biology*
14:50	15:30	**BREAK** - *refreshments provided*

Session III: Habitat Restoration, Conservation and Management

Patrick Dockens, Wildlife Biologist, US Fish and Wildlife Service, ***Moderator***

Begin	End	
15:30	15:45	Status Update: three years of restoration and project development using the NOAA Penobscot habitat focus area grant - *Jeremy Bell, The Nature Conservancy*
15:45	16:00	Prioritizing barriers to aquatic connectivity in the Penobscot River watershed - *Erik H. Martin, The Nature Conservancy*
16:00	16:15	Restoring riverine habitat in the upper Narraguagus watershed - *Joan G. Trial, Project SHARE*
16:15	16:30	PIT-tagged particle study of bed mobility on the Narraguagus River - *Douglas M. Thompson, Connecticut College, Environmental Studies Program*
16:30	16:45	Maine Atlantic Salmon in-lieu fee program for compensatory mitigation - *Ruth M. Ladd, US Army Corps of Engineers*
16:45	17:00	The Maine Atlantic salmon programmatic (MAP) for transportation projects: a success story for consultation process streamlining and ecological benefits - *Eric Ham, Maine Department of Transportation*
17:00	19:00	**Poster Session and Social** - *refreshments provided, beer and wine are available*
19:00		An evening with George Pess, NOAA-Fisheries, Northwest Fisheries Science Center: An informal presentation and slideshow of the Elwha River Restoration Project - *Black Bear Brewing Co.*

Poster Presentations

Watershed-scale connectivity analysis: An applied GIS model towards the strategic management of barriers to Atlantic salmon migration
- *Michael Arsenault, University of New Brunswick, Department of Biology*

Optimizing strategies to hydraulically plant Atlantic salmon eggs based on fry dispersal patterns
- *Ernie Atkinson, Maine Department of Marine Resources*

International Year of the Salmon
- *Kristen Bronger, Integrated Statistics, Woods Hole, MA (Duty Station is GARFO)*

Incorporating geomorphology and applying large wood science and channel design in habitat restoration
- *Michael Burke, Interfluve*

Lipid content of Atlantic salmon (*Salmo salar* L.) sampled at West Greenland
- *Audrey Dean, University of Waterloo, Department of Biology*

Comparative analysis of estuarine fish diets after restoration of Alewife populations in Penobscot River Watershed
- *Emma Dennison, University of Southern Maine, Department of Environmental Science and Policy*

The effects of post-surgical recovery time and time of day release on the performance and survival of emigrating Atlantic salmon (*Salmo salar* L.) smolts from the Miramichi River
- *Heather J. Dixon (Eric B. Brunsdon presenting), The Atlantic Salmon Federation*

Temporal change and variation in marine growth of North American Atlantic salmon sampled from West Greenland
- *Brandon C. Ellingson, Biologist, Integrated Statistics, Woods Hole, MA*

Getting Over the Dam: Overcoming institutional barriers to the recovery of Atlantic salmon by navigating the social-science/policy interface
- *Melissa E. Flye, University of Maine, Department of Ecology and Environmental Science*

Alternative aging methods for Atlantic Sturgeon: Research to improve management of a pre-historic natural resource
- *Tarren Giberti, University of Maine, School of Marine Sciences*

Prey availability and diet of Sturgeon in the Gulf of Maine
- *Rachel Howland, University of Maine, Department of Marine Science*

Effects of alewife predation on zooplankton communities in three Maine lakes
- *Ericka A. Hutchinson, University of Southern Maine, Department of Environmental Science and Policy*

Evaluating morphometric techniques to determine sex of Shortnose Sturgeon in the Penobscot River, Maine
- *Samantha Nadeau, University of Maine, School of Marine Science*

Developing an ecosystem-based fisheries management framework for the Eastern Maine Coastal Current
- *Joshua Stoll, University of Maine and Maine Center for Coastal Fisheries*

Artificial selection on reproductive timing in hatchery salmon drives potential maladaptation to warming waters
- *Michael D. Tillotson, University of Washington School of Aquatic and Fishery Sciences*

Where did all the salmon go? The combined impacts of acid rain and forestry are preventing Atlantic salmon recovery in Downeast Maine
- *Mark C. Whiting, Downeast Salmon Federation*

Reducing Acidification in Endangered Atlantic Salmon (*Salmo salar*) Habitat
- *Emily Zimmermann, Maine Department of Environmental Protection*

Begin	End	January 18, 2018
7:00	8:00	**REGISTRATION –** *refreshments provided*

Session IV: Emerging Partnerships

Joshua Royte, Senior Conservation Scientist, The Nature Conservancy, ***Moderator***

8:05	8:20	The importance of effective partnerships to aquatic restoration efforts *- Benjamin Naumann, U.S. Department of Agriculture - Natural Resources Conservation Service*
8:20	8:35	An update on the species in the spotlight initiative for Atlantic salmon *- Julie Crocker, Acting Assistant Regional Administrator of Protected Species, NOAA-Fisheries, Greater Atlantic Regional Fisheries Office*
8:35	8:50	The Atlantic salmon research joint venture - "Shaping the future of wild Atlantic salmon science and conservation" *- Patricia Edwards, Department of Fisheries and Oceans, Gulf Region Fisheries Centre*
8:50	9:05	International year of the salmon – why it matters for Maine *- Kimberly Damon Randall, Acting Deputy Regional Administrator, NOAA-Fisheries, Greater Atlantic Regional Fisheries Office*
9:05	9:20	The World Fish Migration Foundation *- Joshua Royte, The Nature Conservancy*
9:20	10:00	Developing, maintaining, and sustaining lasting partnerships (*Discussion*) *- Josh Royte, The Nature Conservancy*
10:00	10:40	**BREAK -** *refreshments provided*

Session V: Tracking and Telemetry

Daniel McCaw, Fisheries Program Manager, Penobscot Indian Nation, ***Moderator***

10:45	11:00	System-wide survival of downstream-migrating Atlantic salmon smolts in the Penobscot River, Maine *- Alejandro Molina-Moctezuma, University of Maine, Department of Wildlife, Fisheries, and Conservation Biology*
11:00	11:15	Behavioral and physical factors influence migratory success of sockeye salmon smolts in a high-risk landscape *- Nathan B. Furey, University of New Hampshire, Department of Biological Sciences*
11:15	11:30	Movement and behavior of acoustic tagged Alewife in the Concord and Merrimack River (*Alosa psuedoharengus*) *- Michael Bailey, US Fish and Wildlife Service – CNE Fishery Resources Office*

Begin	End	
11:30	11:45	Radio-tracking wild and SAS Atlantic salmon in the Northwest Miramichi River - *Ryan Carrow, University of New Brunswick, Canadian Rivers Institute*
11:45	12:00	Space matters: effects of a conservation translocation program on Atlantic salmon size-at-age - *Danielle Frechette, Institute National de Recherche Scientifique, Centre Eau Terre Environnement, Québec*
12:00	12:15	Post-spawned Atlantic salmon (*Salmo salar*) overwinter behaviour and spring migration in relation to the large reservoir of the Mactaquac Generation Station, NB, Canada - *Amanda Babin, University of New Brunswick, Canadian Rivers Institute*
12:10	13:30	**LUNCH** - *lunch at the Student Union (not provided)*

Session VI: Freshwater Ecology

Daniel McCaw, Fisheries Program Manager, Penobscot Indian Nation, ***Moderator***

13:30	13:45	Monitoring the Atlantic Salmon (*Salmo salar*) run in the Miramichi River using imaging sonar – first full monitoring season 2017 - *Jani Helminen, University of New Brunswick, Canadian Rivers Institute and Department of Biology*
13:45	14:00	Habitat selection by juvenile Atlantic salmon (*Salmo salar*) using a functional regression model - *Jeremie Boudreault, Université du Québec, INRS-ETE*
14:00	14:15	Water temperature in a changing climate: the response of juvenile Atlantic salmon populations across Eastern Canada - *Sébastien Ouellet-Proulx , Institut de la 8echerché Scientifique – Centre Eau Terre Environnement, Quebec*
14:15	14:30	Population characteristics of sub-adult Atlantic sturgeon (*Acipenser oxyrhynchus*) in the Penobscot River, Maine - *Catlin Ames, University of Maine, School of Marine Sciences*
14:30	14:45	An overview of 12 Years (2006 – 2017) of sturgeon research on the Penobscot River - *Kevin Lachapelle, University of Maine, School of Marine Science*
14:45	15:00	"Closing the Loop": Anadromous sea lamprey carcasses influence larval conspecifics - *Daniel M. Weaver, University of Maine, Department of Wildlife, Fisheries and Conservation Biology*
15:00	15:35	**BREAK –** *refreshments provided*

Session VII: Long Term Strategy and Monitoring

Daniel McCaw, Fisheries Program Manager, Penobscot Indian Nation, ***Moderator***

15:35 15:50 Fish passage at hydropower dams on the Penobscot and Kennebec Rivers: A content analysis of the FERC eLibrary Database
- Sarah Vogel, University of Maine, Department of Wildlife, Fisheries, and Conservation Biology

15:50 16:05 Acid rain mitigation and complementary initiatives lead to encouraging signs of Atlantic salmon recovery
- Edmund A. Halfyard, The Nova Scotia Salmon Association

16:05 16:20 Atlantic salmon in Maine: Assessment of temporal and spatial genetic diversity, and how genetic data is used for to help inform restoration activities in the hatchery and natural environment
- Meredith L. Bartron, US Fish and Wildlife Service - Northeast Fishery Center

16:20 16:35 Applying eDNA tools to salmon ecosystems
- Michael T. Kinnison, University of Maine - School of Biology and Ecology

16:35 16:50 A collaborative model for Atlantic salmon recovery in Fundy National Park of Canada
- Corey Clarke, Parks Canada - Fundy National Park

16:50 16:55 **Student Awards**
- Karen Wilson, Associate Research Professor, Department of Environmental Science and Policy, ***Award Presenter***

Closing Remarks

16:55 17:00 *- Sean Hayes, Protected Species Branch Chief, NOAA-Fisheries, Northeast Fisheries Science Center*

ADJOURN

Session I:
Climate Related Impacts and Resiliency

Moderator: Carl Wilson, Director, Bureau of Marine Science, Maine DMR

Atlantic Salmon recovery as Ecosystem-Based Fisheries Management

Jon Hare[1], John Kocik[2], and Jason Link[3]

[1]*NOAA Fisheries, Northeast Fisheries Science Center, Woods Hole, MA*
[2]*NOAA Fisheries, Northeast Fisheries Science Center, Orono, ME*
[3]*NOAA Fisheries, Office of Science and Technology, Woods Hole, MA*

Ecosystem-based fisheries management is a priority for NOAA Fisheries and an Ecosystem-Based Fisheries Management Roadmap was released in 2016. Although Ecosystem-Based Fisheries Management has been in the agency lexicon for almost 20 years, there is still a lot of uncertainty as to what EBFM looks like in practice. NOAA Fisheries defines EBFM as a systematic approach to fisheries management in a geographically specified area that contributes to the resilience and sustainability of the ecosystem; recognizes the physical, biological, economic, and social interactions among the affected fishery-related components of the ecosystem, including humans; and seeks to optimize benefits among a diverse set of societal goals. This definition intersects with the goals of the Atlantic Salmon Ecosystem Forum and more broadly the recovery efforts for Atlantic Salmon. Thus, Atlantic Salmon recovery efforts are an example of Ecosystem-Based Fisheries Management. Next steps will be defined for both efforts based on an exploration of their conceptual intersection.

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Understanding the differences between watershed restoration prioritization methods

George R Pess[1], Tim Beechie[1], and Phil Roni[2]

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Stream and watershed restoration prioritization is an important and integral part of the restoration planning and implementation process. There are a variety of methods that have been used to prioritize individual stream and watershed restoration projects and conservation actions. Methods can include everything from detailed information about historical and current watershed condition, to simply using expert opinion. In each case, there is a defined methodology that includes goals, objectives, a model, and associated assumptions. We review several methods that have been used in the Pacific Northwest, as well as other areas of the United States, to illustrate the strengths and weaknesses of each restoration prioritization technique. We also identify common, fundamental considerations with respect to prioritization methods that can help cooperating groups in watersheds better define their path to watershed recovery. Finally, we give advice for making a restoration prioritization method clear, transparent, and based upon the best available information.

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River flood seasonality in the Northeast United States and trends in annual timing

Mathias J. Collins[1]

[1]*National Marine Fisheries Service, NOAA, Gloucester, MA, USA*

The New England and Mid-Atlantic regions of the Northeast United States have experienced climate-associated increases in both the magnitude and frequency of floods. However, a detailed understanding of flood seasonality across these regions, and how flood seasonality may have changed over the instrumental record, has not been established. The annual timing of river floods reflects the flood-generating mechanisms operating in a basin and many aquatic and riparian organisms are adapted to flood seasonality, as are human uses of river channels and floodplains. Changes in flood seasonality may indicate changes in flood-generating mechanisms, and their interactions, with important implications for habitats, floodplain infrastructure, and human communities. For example, shifts in the timing of spring floods may negatively or positively affect a vulnerable life stage for a migratory fish (e.g., egg setting) depending on whether floods occur more frequently before or after the life history event. In this study I applied an objective, probabilistic method for identifying flood seasons at a monthly resolution for 90 climate-sensitive watersheds in New England and the Mid-Atlantic (Hydrologic Unit Codes 01 and 02). Historical trends in flood timing during the year were also investigated. Analyses were based on partial duration flood series with an average of 85 years of record. The results show rich detail about annual flood timing across the region with each site having a unique pattern of monthly relative flood frequency. However, a much smaller number of dominant seasonal patterns emerged when contiguous flood-rich months were classified into commonly recognized seasons (e.g., Mar-May, spring). The dominant seasonal patterns identified by manual classification were corroborated by unsupervised classification methods (i.e., cluster analyses). Trend analyses indicate that flood-rich seasons have generally not shifted earlier or later in the year over the period of record, but 65 sites with data from 1941-2013 reveal that strong increasing trends in the number of floods occurring from June through October each year have driven historical changes in Northeast U.S. flood frequency. These months are rarely identified as flood-rich at the sites examined, suggesting warm-season flood potential is changing with possible implications for the region's aquatic and riparian organisms.

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Climate related changes in the hydrology of New England

Robert W. Dudley[1], Glenn A. Hodgkins[1]

[1]*USGS, New England Water Science Center, Augusta, ME*

Historical changes in several components of the water cycle in New England have been documented by a variety of hydrologic studies. The timing of snowmelt-related runoff has become significantly earlier throughout much of New England during the 20th century, with most of the 1- to 2-week change occurring in the last 30 years. Minor flooding has increased significantly at about one-third of stream gages in Maine during the last 50 to 100 years largely driven by increases in heavy precipitation events. Effects of climate-related changes on the occurrence of major floods is more complex and related to antecedent conditions affected by changes in temperature and precipitation. Summer stormflow magnitudes have increased at many rivers, and seasonal groundwater levels also have increased throughout much of New England in response to increased precipitation in recent decades. Long-term projections indicate warmer temperatures and increases in precipitation in the northeastern U.S.

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ICNet - Infrastructure and Climate Network

Charlie Hebson[1]

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Charles Hebson,

The Infrastructure & Climate Network (ICNet), funded by NSF and based at the University of New Hampshire, is a network of academics, students, and practitioners who are dedicated to accelerating climate science and engineering research in the Northeastern United States. The ICNet focuses on climate change and sea level rise impacts and adaptation for sustainable bridges, roads, and transportation networks. Practitioners in ICNet, more so than academics, have commented on the intersecting implications of designing for increased riverine flows as well for aquatic organism passage. Anecdotal evidence indicates that stream crossings designed according to geomorphic principals for fish passage also deliver robust performance under extreme events. Thus, design practices driven by fish passage concerns have inadvertently moved DOT's to a form of climate change adaptation. Sustainability of hydraulic structures, broadly understood, should include survivability as well as the ability to accommodate the environment in which they are placed. Though inherently more expensive than traditional designs and currently a requirement under regulation, geomorphic designs deliver multiple benefits that should ultimately make them more acceptable in the normal course of project development in DOTs.

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Reflections on the Lack of Success of the Connecticut River Atlantic Salmon Restoration Program

Stephen R.Gephard[1]

[1]*Connecticut Dept. Energy and Environmental Protection - Fisheries Division*

The interstate/federal cooperative program to restore Atlantic Salmon to the four-state Connecticut River basin was begun in 1967, over 150 years after the extirpation of the native run of salmon. It was considered the first effort to re-establish a run of Atlantic Salmon to a large watershed that had completely lost its native strain. The program focused on the provision of fish passage at barrier dams and the stocking of hatchery-reared juvenile Atlantic Salmon belonging to a population that originated in Maine. The program produced adult returns that typically numbered in the hundreds annually but experienced a sharp decline in returns after 1992. The program was terminated in 2012 and only a small number of Atlantic Salmon are now stocked in two tributaries in Connecticut as part of that State's Legacy Program. The program benefitted from a great deal of cooperative, supportive research but it was operated as an adaptive management program not a research program. Therefore, it is not possible to list authoritatively the root causes for why the restoration program did not succeed. However, over 35 years of experience with the Connecticut River program and familiarity with other Atlantic Salmon efforts worldwide allow speculation on the top ten factors that contributed to the failure to successful restore the species to the basin.

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Climate trends and ecosystem impacts in the Gulf of Maine and Northwest Atlantic

Andrew Pershing[1]

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Andrew Pershing, Chief Scientific Officer with the Gulf of Maine Research Institute, will be presenting his work on climate trends and ecosystem impacts in the Gulf of Maine and Northwest Atlantic. Dr. Pershing runs the Ecosystem Modeling Lab at the Gulf of Maine Research Institute, where he has been the Chief Scientific Officer since 2014.

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Atlantic Salmon in a Changing Climate

Timothy Sheehan[1]

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Atlantic salmon is a pan-Atlantic species ranging from approximately 42º to 71º North latitude. As an obligate freshwater spawner, productivity is primarily shaped by freshwater factors whereas distribution is primarily defined by marine factors. Despite being a well-studied species, quantifying possible future impacts of changing climate on salmon stock dynamics given the wide range and reliance on a diverse array of habitat types is challenging. As the body of literature on climate impacts grows, some of these potential impact factors can be hypothesized. In response to a question posed by the North Atlantic Salmon Conservation Organization, The International Council for the Exploration of the Seas hosted a Workshop on Potential Impacts of Climate Change on Atlantic Salmon Stock Dynamics (WKCCISAL). The resulting report summarized the current understanding of anthropogenic climate change and explored potential consequences to Atlantic salmon stock dynamics. The Report provides an informative discussion on the characteristics of anthropogenic climate change, the distinction and relatedness between climate and weather, and explains how the residual inertia of climate systems would leave freshwater environments exposed to climate impacts for 50+ years, with ocean effects lasting hundreds of years, even under the most optimistic emission scenarios. The Report also provides an overview of drivers of freshwater, estuarine, and marine Atlantic salmon productivity and discusses the impacts of potential future climate change on these habitat processes and dynamics with specific case studies detailed to support conclusions. This presentation will provide an overview of the WKCCISAL Report with specific focus on factors impacting populations within the Gulf of Maine Distinct Population Segment.

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Habitat condition changes and biological implications for Atlantic salmon at sea

Katherine E. Mills[1], and Timothy F. Sheehan[2], Felix Massiot-Granier[1]

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[2]*NOAA Fisheries Service, Northeast Fisheries Science Center, 166 Water St., Woods Hole, MA 02543*

The Northwest Atlantic has been warming more rapidly than many oceanic regions over the past 30 years, and ocean temperature has been identified as an important factor contributing to declines in the abundance and productivity of North American Atlantic salmon populations. Tracking physical changes that shape conditions experienced by Atlantic salmon during their marine life stages is essential for understanding how ecosystem conditions may affect population processes. In this presentation, we will examine (1) whether the location of marine habitat areas used by Atlantic salmon have changed, (2) how temperature trends and seasonal cycles have changed within the habitat areas, and (3) the biological implications of shifts in habitat usage patterns and their physical conditions. Linkages from physical habitat changes to population dynamics will be explored with a particular focus on growth as one biological mechanism through which ecosystem conditions shape population outcomes. This framework will be used to pose hypotheses regarding how growth is expected to be affected by ecosystem conditions, and these hypotheses can then be evaluated against growth increment measurements obtained from various salmon populations.

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Impacts of a changing ecosystem on Atlantic salmon growth

[1]Felix Massiot-Granier, Katherine E. Mills[1], and Timothy F. Sheehan[2]

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[2]NOAA Fisheries Service, Northeast Fisheries Science Center, 166 Water St., Woods Hole, MA 02543

Atlantic salmon populations have declined throughout North America and Europe in recent decades. These declines have exhibited similar patterns over broad geographic areas, and previous studies have shown correlations between salmon declines and changing marine ecosystem conditions. These analyses have specifically identified warming ocean conditions and changes in the prey base as closely linked with Atlantic salmon population trends. The observed ecosystem changes have likely increased the energy requirements of Atlantic salmon and reduced the energy available to them through their prey. However, the mechanisms behind these relationships remain undiagnosed and are therefore not accounted for in Atlantic salmon population dynamic models. Based on growth patterns observed in archived scales of Atlantic salmon of the Penobscot River, we investigated the hypothesis that ecosystem changes have influenced the energy needed by and available to Atlantic salmon and thereby have affected salmon growth and survival during their marine phase. The dynamic energy budget (DEB) model we developed aims to provide a better understanding of how marine ecosystem conditions affect Atlantic salmon growth and population dynamics, which is valuable information for evaluating recovery prospects and constraints.

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Session II:
Estuary and Marine Ecology

Moderator: Patrick Dockens, Wildlife Biologist, US Fish and Wildlife Service

Using otolith microchemistry to infer habitat use of American shad prior to dam removal in the Penobscot River, Maine

Kevin Job[1], Joseph Zydlewski[2,1], Jason Schaffler[3]

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[3]*Muckleshoot Indian Tribe, Auburn, WA*

Prior to 2013, upstream passage of American Shad through the lowest dam (Veazie) was extremely poor, limiting spawning - and juvenile rearing - to 15 km of estuarine habitat. Removal of two main-stem dams (Great Works and Veazie) was completed in 2013 as part of the Penobscot River Restoration Project. These removals and other improvements to passage have begun to reconnect this species to upriver habitat, much of which is upstream of Milford Dam. In order to understand how these changes may influence juvenile estuarine use, otoliths were collected from juveniles (126) sampled from the lower river and estuary in 2011-2013 and from adults (491) representing pre-dam removal spawning cohorts (2013-2017). Additionally, juveniles (170) were also collected representing the first post-dam removal cohorts (2014-2017). We analyzed otolith cross sections along a transect extending from the core to the edge of the otolith using laser ablation coupled with inductively coupled plasma mass spectrometry (ICPMS). For each sample, ablated material provided data on ^{25}Mg, ^{55}Mn, ^{85}Rb, ^{88}Sr, ^{138}Ba and ^{48}Ca relative to otolith annuli. We used this information to infer the degree to which juvenile shad utilize the freshwater and saline habitats prior to and following, the removal of Veazie and Great Works Dams. Preliminary data indicate complex patterns of habitat use in this spatially restricted population.

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Verification of circulus deposition rates in Atlantic salmon *Salmo salar* smolts from three Maine rivers

Erin Peterson[1], Timothy F. Sheehan[2], and Joseph D. Zydlewski[1,3]

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[2]*National Marine Fisheries Service, Northeast Fisheries Science Center, 166 Water Street, Woods Hole, MA*
[3]*U.S. Geological Survey, Maine Cooperative Fish and Wildlife Research Unit, and Department of Wildlife, Fisheries, and Conservation Biology, University of Maine, Orono, ME*

Scale circuli yield valuable information about the life history, age, and growth of a fish. Annual patterns of growth are proportionally back-calculated from scale growth rates, but this depends on an assumption that the formation of circuli are constant over time. Because circuli formation can be influenced by somatic growth, this assumption is a source of error for this method. In order to characterize the formation of circuli in Atlantic salmon during their ocean phase, smolts reared from brood-stock collected on the Dennys, Machias, and East Machias rivers were obtained and reared in marine net pens. Fish from each stock were sampled 13 times over a period of 25 months. On each occasion, length and mass were recorded. Multiple scales were collected from each fish at every sampling event. We used scales from 162 of these fish to calculate circulus deposition rate between known sampling dates. These rates were compared between rearing sites and among rivers of origin. The influence of water temperature was also assessed. Lastly, age estimates were also compared among scales collected from the same fish to characterize individual variation. The results from this project will inform research that uses scale circuli patterns as a standardized method of investigating growth.

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Estimating annual consumption rate of Atlantic salmon smolt (*Salmo salar*) by striped bass (*Morone saxatilis*) in the Miramichi River estuary

Jason Daniels[1], Gerald Chaput[2] and Jonathan Carr[1]

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Differentiating detections of a telemetered fish from those of predators which may have consumed that telemetered fish presents problems and opportunities. Efforts to quantitatively classify predation events have had to rely on data from unknown states of fish (i.e. unsupervised learning techniques). Therefore, model performance can not be refined or compared to alternate models. We circumvent this limitation by having acoustic telemetry data (2013 to 2016) from the Miramichi River estuary on striped bass (*Morone saxitilis*) behaviours and a subset of Atlantic salmon (*Salmo salar*) smolt behaviours of known states. This information was used to guide a random forest classification model (i.e. supervised learning technique). Model predictions were applied to Atlantic salmon smolt to provide an index of striped bass predation-derived mortality. The optimized random forest model suggests that minimal predation by striped bass was highly variable between years for two smolt stocks, ranging between 1.9% to 17.5%. Spatial and temporal overlap is a likely factor behind the between stock and annual variation of predation estimates.

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The problem may not be where we think it is: A critical review of the critical period hypothesis in salmon

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In a seminal paper published over one hundred years ago, Hjort hypothesized that for Norwegian herring and cod stocks, year-class strength, defined as the abundance of a given cohort, was determined during a critical period very early in the fishes life history. More recently, Beamish and Mahnken applied the critical period concept to salmon, proposing two marine critical periods: an early predation-based mortality that occurs during the first few weeks following ocean entry, and a starvation-based mortality period during the first fall and winter at sea. Here we present a systematic review of the literature on the application of acoustic telemetry on Atlantic salmon smolts to evaluate the critical period hypothesis. There are currently no data to assess the importance of the first winter at sea for salmon recruitment dynamics. Our analysis demonstrates there is little evidence to date, that year class strength is regulated by early marine mortality for Atlantic salmon. As a result, the poor performance of Atlantic salmon observed over a broad geographic range during the last 2-3 decades may due to mortality experienced later in their marine life.

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Relating fluctuations in fish abundance to river restoration efforts and environmental conditions in the Penobscot River, Maine

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Quantifying how fish abundance changes after a significant portion of their natural habitat becomes re-accessible is critical to gauge the success of large restoration efforts. Because fish abundance also changes with naturally fluctuating environmental conditions, examining abundance relative to these conditions can indicate fish responses to both anthropogenic and natural river variation. A side-looking hydroacoustic system was used to estimate fish abundance in the Penobscot River, ME from 2010-2016, where 2010-2013 were pre-dam removal conditions, and 2014-2016 were post-dam removal conditions. The river was monitored during non-ice condition periods, roughly April to November annually. Automated data processing enabled continuous abundance estimates from fish tracks. A fourfold increase in median fish abundance occurred in the fall compared to spring and summer, regardless of dam presence. Concurrent with restoration activities, fish abundance increased approximately twofold pre- to post-dam removal. We examined the influence of natural environmental conditions including tide, discharge, temperature, diurnal cycle, day length, moon phase, as well as restoration activities (focusing on dam presence) on variability in fish abundance. Day length (or photoperiod) was the most important predictor in all eight time-series analyzed. During the fall migration, abundance was generally higher during outgoing tides, at night, and during relatively high river discharge. In the early fall, when day length was between 11.3 h and 12 h (September 24th to October 6th) and water temperature was above 12.0 °C, an eightfold increase in fish abundance was recorded in post-dam removal years. Alewife stocking numbers increased post-dam removal relative to pre-dam removal years and likely contributed to the increased fish abundance detected. This is one of the first validated tools to continuously examine the response of fish abundance to a major river restoration activity. In this application, it significantly increased our understanding of how fish abundance changed in the Penobscot River as result of major restoration efforts and provides a basic understanding of fish responses to naturally fluctuating environmental conditions.

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Partitioning the Big Blue Box: A Synthesis of Marine and Estuary Action Team Science

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A major threat to Gulf of Maine (GoM) Atlantic salmon is mortality in the estuary and ocean. The Marine and Estuary Action Team identified four critical areas of research needs: 1) estuary transition; 2) predation risk in estuary and coastal systems, 3) adult fishing mortality; and 4) climate change related ecosystem shifts. We characterize our understanding of these risks based on annual assessments and recently published manuscripts to describe ecology from smolt emigration to adult returns. Smolts are migrating and entering the ocean earlier than in the past and estuary mortality is high compared to other regions. We also found latent effects of successful dam passage that resulted in increased mortality during estuary transition. Upon seawater entry, postsmolt diets suggests differential feeding between wild and hatchery fish in coastal waters. Results from tagging and tracking studies demonstrate that postsmolts are migrating relatively quickly towards the Labrador Sea residing in the GoM for less than a month. Once on the Scotian Shelf, postsmolts begin to mix with populations from Canada and migrate relatively close to shore in colder and fresher water masses. At summer feeding grounds off West Greenland (WG), diets have changed over the last decades likely related to climate driven shifts in the Northwest Atlantic. A phase shift in the 1990s diminished prey quality and availability and remains a constraint on the productivity and recovery of many Atlantic salmon populations. US Atlantic salmon are also harvested in distant water fisheries and international teams monitor WG fisheries. Our ability to determine catch of US fish has expanded from tag recovery to genetic techniques. Precision of molecular techniques has also increased from continent-of-origin, to regional, and now river-specific resolution. Insights into return migration routes are being enhanced by satellite tagging work at WG. Finally, home water returns have shifted earlier in the spring and run duration has narrowed- fewer late summer/fall run fish are observed. Combined, these findings suggest localized population bottlenecks, global level shifts in productivity, and temporal population resiliency. This body of work informs steps to both to manage and recover salmon populations in the GOM.

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Session III:
Habitat Restoration, Conservation, and Management

Moderator: Patrick Dockens, Wildlife Biologist, US Fish and Wildlife Service

Status Update: Three Years of Restoration and Project Development using the NOAA Penobscot Habitat Focus Area Grant

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Since 2014, The Nature Conservancy in Maine has partnered with NOAA via their Penobscot Habitat Blueprint Project. Through this project, The Conservancy with partners have implemented on the ground projects, project monitoring as well as outreach and education events in the watershed to promote improved river connectivity for diadromous fish habitat. The presenter will describe the goals and strategies of the overall grant and provide case study project areas to highlight continued work in the watershed to build on the success of the Penobscot River Restoration Project.

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Prioritizing barriers to aquatic connectivity in the Penobscot River watershed

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The fragmentation of aquatic habitats by dams and road-stream crossings is a primary threat to aquatic species. Road-stream crossings also limit the ability of water to flow freely during extreme storm events which can result in culvert failures and road washouts. The strategic removal of dams and upgrade of road-stream crossings can both increase habitat connectivity and enhance the resiliency of road infrastructure. With funding from NOAA's Penobscot Habitat Focus Area project, The Nature Conservancy has developed the Aquatic Barrier Prioritization tool, a web-based decision support tool which can be used to assess dams and road-stream crossings for their potential to benefit diadromous fish species if removed or upgraded. Through both consensus-based prioritization scenarios as well as data visualization tools, users can identify high priority potential fish passage projects and understand what drives them to be high priorities. Beyond identifying potential stream restoration projects, the results can be used to support funding applications, to help inform funding allocation decisions, and for communication and outreach.

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Restoring Riverine Habitat in the Upper Narraguagus Watershed

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In 2014 Project SHARE assembled a team to develop a project that had the potential to significantly increase smolt production in the Upper Narraguagus River watershed. The project area was selected because it is the top priority Atlantic salmon sub-watershed in the Narraguagus River and produces approximately 75% of smolts in the watershed annually. The project hypothesis was that by reconnecting habitat, improving habitat suitability, and reintroducing salmon to unoccupied habitat; the number of smolts leaving the sub-watershed will increase. Since 2014, habitat actions have focused on restoring altered riverine processes within the habitat for freshwater life stages of Atlantic salmon, including: culvert and bridge replacements or removals, remnant log dam removals, and large wood additions. Change in the amount of accessible habitat has been chronicled since 2001 and changes in summer temperature conditions and habitat complexity in the focus area are being examined. The cumulative effect of habitat restoration at the sub-watershed scale will be based on trends in annual Atlantic salmon parr and smolt population assessments produced by NOAA Fisheries and the State of Maine.

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PIT-tagged particle study of bed mobility on the Narraguagus River.

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Results from an on-going study on the Narraguagus River in Maine. Laser total station cross-sectional surveys and tracking of passive integrated transponder (PIT) tags embedded in glass spheres were used to document changes in channel-bed characteristics associated with additions of post-assisted log structures (PALS) and natural spawning activities. In 2016, work was initiated to monitor changes in bed elevation and sediment mobility with the addition of PALS to the Narraguagus River as part of a restoration effort. Ten cross-sections, spaced 5-m apart, were established and surveyed with a laser total station in each of three different study reaches. The study sites include a control reach, a section with anticipated spawning activities and a site with ongoing PALS placement. A grid of 200 glass spheres embedded with PIT tags, with twenty alternating 25-mm and 40-mm size particles equally spaced along each of the ten transects, were placed to serve as point sensors to detect sediment mobilization within each reach. In 2017, the site was revisited to determine if differences in PIT-tagged tracer particle mobilization reflect locations where PALS was added and places where Atlantic salmon (*Salmo salar*) and sea lamprey (*Petromyzon marinus*) construct spawning redds. The positions of 555 of 595 seeded PIT-tagged tracer particles was recorded (93.3% recovery rate), but particles were not disturbed or uncovered to permit study of potential reworking of buried tracer particles the following year. Only 30.0% of particles showed evidence of movement more than 1.0 m despite a 1.4-year magnitude flood event. The lack of bed mobility could be increasing embeddedness with an associated loss of interstitial habitat. Full tracer particle recovery will be determined in 2018 to determine if depths of tracer burial and changes in bed elevation vary among places near redds, PALS and main channel locations. The data will be used to determine if salmon and lamprey redds are preferentially located in either places with greater evidence of sediment reworking or alternatively in stable areas? The study will help determine the degree of bed disruption associated with spawning activities and whether PALS placement encourages similar sediment mobilization processes.

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Maine Atlantic Salmon In-lieu Fee Program for compensatory mitigation

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Many of the rivers in Maine provide current or potential habitat for the endangered Atlantic Salmon. Many existing stream crossings preclude fish passage for all or part of the year. Some new and modified crossings are unable to provide 100% passage because of construction constraints, topography in relation to the road, costs, etc. The vast majority of these projects require authorization by the Corps of Engineers under Section 404 of the Clean Water Act and there may be adverse impacts to salmon for which the U.S. Fish and Wildlife Service and/or National Marine Fishery Service and the State of Maine would like compensation in the form of replacing undersized or hanging culverts or providing some other form of habitat enhancement.

The Salmon In-lieu Fee program uses an RFP process to solicit projects that compensate for these individually small but cumulatively large impacts. One of the challenges encountered in the development of the program was how to assess fees in general and for crossings of various widths that impair but do not eliminate salmon access. The presentation will focus on the fee schedule development but will include a summary of the program's process, determination of service areas, and performance measures for mitigation projects as well as other challenges encountered and how they were resolved.

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The Maine Atlantic Salmon Programmatic (MAP) for transportation projects: a success story for consultation process streamlining and ecological benefits

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Due to endangered species act consultations, MaineDOT projects were delayed for up to a year at times because of a backlog of work for MaineDOT and USFWS staff. In 2013, MaineDOT received an FHWA Eco-logical grant to help aid in the development of a programmatic approach to solving the delay issues. Maine Department of Transportation (MaineDOT), the Maine Division of the Federal Highway Administration (FHWA), and the Maine office of the Army Corps of Engineers (ACOE) worked with the United States Fish and Wildlife Service (USFWS) to develop a programmatic biological assessment and biological opinion for project effects to endangered Atlantic salmon (*Salmo salar).*

Almost four years later, on January 23, 2017, USFWS issued the biological opinion. Now, processing individual consultations commonly occurs in less than one business day, and more MaineDOT projects are meeting Atlantic Salmon recovery standards. The agreement is a great example of a mutually beneficial situation that has resulted in a very positive relationship between the various government agencies who were involved.

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Session IV:
Strategic Communication Partnerships for Diadromous Fish Restoration

Moderator: Joshua Royte, Senior Conservation Scientist, The Nature Conservancy

The importance of effective of partnerships to aquatic restoration efforts

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Partnering on aquatic restoration projects large or small always requires partnering. Better projects draw on people and organizations with various experiences/disciplines, funding, and connections to local users. NRCS has been doing conservation projects since the dust bowl and without the strong partnerships created through building trust, relationships and sound communication most projects would not have been easy or even possible. In Maine NRCS partners with various restoration practitioners (Federal, State, and municipal, NGO, business and private landowners) to identify and remediate road stream crossing barriers, add habitat complexity into streams resulting in hundreds of miles restored streams and rivers and lake access around the state.

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An update on the species in the spotlight initiative for Atlantic salmon

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The "Species in the Spotlight: Survive to Thrive" initiative, is a concerted agency-wide effort to spotlight and save eight at-risk species. Our 5-year action plan, built largely on the draft recovery plan, details the focused efforts needed to reduce threats and stabilize population declines of the Gulf of Maine Distinct Population Segment of Atlantic Salmon. The plan highlights four key areas: reconnecting the Gulf of Maine with headwater habitats; increasing the number of fish successfully entering the marine environment; reducing international fishery mortality in West Greenland; and increasing our understanding and ability to improve survival in the marine environment. Since the initiative began in 2016, we have funded six projects through two Federal Funding Opportunities directed at projects that align with the four areas highlighted in the action plan. The Species in the Spotlight initiative allows us to highlight the critical needs of Atlantic salmon recovery efforts, the importance of partnerships to achieving recovery goals and has helped us convey the successes and challenges in recovering salmon and their ecosystems here in Maine.

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The Atlantic Salmon Research Joint Venture - "Shaping the future of wild Atlantic salmon science and conservation."

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The formation of the Atlantic Salmon Research Joint Venture (ASRJV) was initiated by the Canadian Federal Department of Fisheries and Oceans as a direct response to the catastrophic declines in wild Atlantic salmon populations witnessed in 2014. The Ministerial Advisory Committee on Atlantic Salmon (MACAS) Report released in July 2015 that provided recommendations to protect, conserve, and rebuild Atlantic salmon stocks across eastern Canada, among them, the idea to form a research Joint Venture was born. The partnership represents a collaboration between scientists from the Department of Fisheries and Oceans, Provincial and Territorial Fisheries and Natural Resource Departments, Indigenous Research Groups, Non-Governmental Conservation Organizations, Academia, and the Northeast Fisheries Service of the National Oceanic & Atmospheric Administration.

The ASRJV has established a suite of objectives for the partnership: the coordination of cooperative and collaborative data collection, data and information sharing, and jointly designed and executed research activities to address urgent knowledge gaps affecting wild Atlantic salmon throughout their life stages and geographic range. Joint Venture research projects have been collaboratively funded by partners for the first year and half of the Joint Venture on a broad range of topics ranging from at-sea tracking, freshwater temperature studies, review of existing data, development of new tracking technology, and; life history modelling. Recently however members of the Joint Venture met to develop a Science Plan to more strategically guide the development of science initiatives through the Joint Venture. Priorities identified within the plan will inform the future investment of resources by Joint Venture partners toward the highest priority research questions, particularly those related to the questions surrounding At-Sea Survival of wild Atlantic salmon.

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International Year of the Salmon – Why it matters for Maine

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In 2016, the Parties to the North Atlantic Salmon Conservation Organization (NASCO) and the North Pacific Anadromous Fish Commission (NPAFC) agreed that the International Year of the Salmon (IYS) could provide a very good opportunity to raise awareness of the factors driving salmon abundance, the environmental and anthropogenic challenges they face, and the measures being taken to address these. A proposal for the IYS initiative, entitled "Salmon and People in a Changing World," has now been accepted by NASCO and the NPAFC. In short, the goals of IYS are to improve scientific understanding; generate further support for strategies to conserve salmon; improve understanding and awareness of the ecological, social, cultural and economic values of salmon; among others. Efforts to advance these goals are now underway at the local, regional, hemispheric, and "salmospheric" scales. Here in Maine, we must now use the energy and increased attention to turn these lofty goals into action to conserve Atlantic salmon and the ecosystem upon which they rely.

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The World Fish Migration Foundation

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The World Fish Migration Foundation is a NGO focusing on protecting and restoring free-flowing rivers by connecting people to waterways, the fish that migrate through them, and connecting people working on stream connectivity projects to one another. They do this through four key projects, the foremost being the bi-annual World Fish Migration Day where in 2016 over 2,000 organizations independently developed 450 events in 63 countries reaching 82,000 people in person and 15 Million people through social media. The Foundation also publishes "From Sea to Source" global guidance for fish passage, it supports a global networking platform, and is developing a status report and atlas of the planets migratory fish. All of these projects take collaboration and many people in Maine have participated on behalf of searun fish, we're looking for more to join this effort this April.

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Strategic Communication Partnerships for Diadromous Fish Restoration

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Restoration efforts around the region and around the world generally rely on partnerships to implement projects and to raise the awareness needed to support projects and also to connect people to the resources that have often been disarticulated from their community's awareness. This session explores five partnerships that do just that; raise awareness of the plight of diadromous fish, develop knowledge needed to understand species life-history, threats to their survival, and restoration strategies and how those are working, and also to garner needed support from grass roots public supporters, program managers and governments at all levels that make decisions about funding for projects and programs. Attendees at the forum will be asked to reflect on where they are already engaged in partnerships and what they could do to create better enabling conditions globally, in Washington DC, in our agencies and organizations, and the communities in which we live and work.

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Session V:
Tracking and Telemetry

Moderator: Dan McCaw, Fisheries Biologist, Penobscot Indian Nation

System-wide survival of downstream-migrating Atlantic salmon smolts in the Penobscot River, Maine

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A hierarchical multistate model was developed to estimate system-wide survival of downstream-migrating Atlantic salmon (*Salmo salar*) smolts in the Penobscot River, Maine, for 2017. A multi-release approach with six release sites and two release dates was used. A total of 450 fish were released, 160 fish were released in the Piscataquis River, 240 in the main-stem Penobscot River, and 50 fish in the Stillwater branch. This model allows for the estimation of path choice, around Marsh Island (Stillwater Branch v. main-stem), reach specific mortalities and the influence of previous experience. This multi-release approach also allowed us to estimate delays caused by nine dams in the system. As has been previously reported, high mortality rates were observed at dams while lower probabilities of mortality were associated with un-impounded river reaches. Passage survival at the Howland bypass is greatly increased over survival estimates prior to the construction of the nature like fish way. We detected additive effects of passing multiple dams, resulting in lower survival. Increased rates of mortality at a given dam were associated with upstream delays.

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Behavioral and physical factors influence migratory success of sockeye salmon smolts in a high-risk landscape

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To better understand migration ecology, a series of studies were conducted on juvenile sockeye salmon smolts emigrating from Chilko Lake, which supports one of the largest populations in British Columbia. Acoustic telemetry identified the first migratory segment within the Chilko River to be a high-risk landscape associated with poor survival. Bull trout, a native char of conservation concern, opportunistically exploit the smolt migration by binge-feeding where prey congregate. Further work assessed behavioral and physical influences on smolt survival in this high-risk landscape. First, pseudo-experimental releases of acoustic-tagged smolts revealed smolt survival was dramatically increased when travelling downstream with large densities of co-migrant conspecifics. This result provides rare evidence for swamping to effectively reduce individual predation risks in a migrant animal. Second, molecular comparisons of predated and non-predated smolts indicated that individuals infected with a specific virus experienced more than a ten-fold increase in predation risk by bull trout. Together, these results have implications for not only ecological theory but also management of diadromous species, including those on the Atlantic coast, such as the utility of predator control, the use of telemetry-based survival estimates, and hatchery release strategies.

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Movement and behavior of acoustic tagged Alewife in the Concord and Merrimack River (*Alosa psuedoharengus*)

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Telemetry is a quickly advancing tool for fisheries biologists. Advances in technology have improved efficacy in coastal marine waters and increased tag life now enables multi-season studies. Alewife are often the focus of upstream and downstream fish passage studies on the East coast of North America. River herring in general are easily stressed from handling and gastric insertion of a transmitter is considered the standard method for tagging for both radio and acoustic telemetry studies. However, gastric tagging is not considered a viable long term methodology as fish will regurgitate or pass transmitters. In 2017, we implemented a study on the Concord River to look at movement and behavior of adult migrating Alewife into inaccessible river habitat blocked by a dam. We observed how fish moved in relation to dams on the system and the extent of their upstream movement. This information will be included in plans to open up the watershed with improvements to fish passage and potential dam removal. It also represents one of the first studies on Alewife where surgical tagging is used to maximize opportunity to learn about coastal and marine movements.

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Radio-tracking wild and SAS Atlantic salmon in the Northwest Miramichi river.

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It is well known that Atlantic salmon populations in Atlantic, Canada, and more specifically the Miramichi River are steadily decreasing. A popular management tool used to limit population decline is fish supplementation or stocking. However, traditional stocking programs are not considered to be beneficial when trying to recover a salmon population due to decreased fitness between wild and hatchery fish. The smolt-to-adult supplementation (SAS) program is a relatively new approach to supplementation. This strategy captures outward migrating wild salmon smolts and raises them to mature adults in a hatchery. The mature adults will be released back to their native stream to spawn naturally. It is hypothesized, that the SAS program will be a beneficial management strategy to aid in recovering the Miramichi River salmon population which has high at-sea mortality. Compared to traditional juvenile stocking methods based on broodstock collections, the benefits of the SAS strategy are well known, however the risks are not completely understood. Over the next two years this project aims to provide information regarding the risks of using SAS as a supplementation strategy by tracking Atlantic salmon in the Miramichi river. In the fall of 2017, twenty-eight wild adult Atlantic salmon were captured, externally tagged with a radio transmitter, and released back into the Little Southwest Miramichi River (LSWM). Two salmon life events will be tracked. First, spawning movements and behavior will be monitored to better understand spawning rigor of LSWM salmon. Second, winter behavior, survival, and migration during kelt out-migration will provide an estimate for the number of wild fish that become multi-year spawners. Salmon will be tracked using passive monitoring stations placed at key locations throughout the main stem of the LSWM. Active tracking will be utilized to locate specific habitats and locations used by wild salmon during the spawning and post-spawning periods. In 2018, an estimate of repeat-spawners will be collected on wild fish from the proportion of radio-tagged fish returning to the LSWM. This will also provide an estimate for at-sea survival of wild post-spawned fish. In June 2018, fifty wild and fifty SAS salmon from LSWM and Northwest Miramichi (NWM) will be captured, externally tagged, and released back to their native river. The same life events will be monitored for NWM salmon. In addition, summer behavior will be monitored, and thermal habitat will be located. Similar, tracking methods will be used on NWM.

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Space matters: effects of a conservation translocation program on Atlantic salmon size-at-age

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Density-dependent effects on growth and survival during freshwater rearing is well documented in salmonid species. Release from the effects of density-dependent growth can increase growth rates, creating greater niche separation and reduced competition among cohorts. Faster growth rates may enable salmon parr to attain size thresholds for smoltification at younger ages, further reducing inter-cohort competition while reducing the time that juveniles are subject to sources of in-river mortality. The concept of density-dependent effects on growth and survival provides the rational for a population enhancement strategy on the Sainte-Marguerite River in Quebec. Between 2014 and 2016, a subset of returning adult salmon were captured at river kilometer 7 and transported upstream of a pair of impassible waterfalls. Our objectives were to assess whether the transport program succeeded in reducing adult spawning density and produced expected: (1) increase in size-at-age, (2) habitat shifts, and (3) reduced age at smolt outmigration. We compared density of adults and redds in the river sectors upstream and downstream of the impassible falls via acoustic telemetry and spawning ground surveys during 2015 and 2016. We conducted electro-fishing at identified spawning sites toward the end of the summer growth period during 2016 and 2017 to compare juvenile density, size-at-age, and habitat use and conducted smolt trapping during 2016 to compare age at outmigration between the two river sectors. Logistics prevented a complete spawning survey in the downstream sector during 2015, however, at the time of spawning 18 adults (7 females) were present upstream and 71 adults were present downstream. During 2016, 22 adults (8 females) were present upstream, 190 adults were present downstream, and redds were more clustered downstream than upstream. Juvenile salmonid densities were greater downstream than upstream during both years. At the end of the 2016 growth season, upstream YOY were larger and were in habitat with greater velocity than downstream YOY. Age analysis is in progress for juveniles captured during 2017, however, smolts emigrated from the upstream habitat at age-2+, whereas long-term trends indicate that the majority of smolts in this system emigrate at age-3+. It is therefore evident that the transport program on the Sainte-Marguerite River has succeeded in reducing juvenile rearing densities with subsequent effects on size-age, habitat use, and age-at-outmigration.

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Post-spawned Atlantic salmon (*Salmo salar*) overwinter behaviour and spring migration in relation to the large reservoir of the Mactaquac Generation Station, New Brunswick, Canada

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Atlantic salmon post-spawned adults (kelts) must migrate through reservoirs and dams along the Saint John River (SJR) to complete their lifecycle. As part of the Mactaquac Aquatic Ecosystem Study (MAES), fish movements through the reservoir upstream of the Mactaquac Generation Station (MGS) were investigated. This large reservoir has minimal water current ($\bar{x}$=3.5 km/d), restricting natural environmental cues for salmon movement. Acoustic telemetry was used to track kelts (2014/5 n=25, 2015/6 n=20) through the river and reservoir, with ten tags in each year having depth and temperature sensors. Winter survival was higher among females (66-87%) and multi-sea-winter fish (70-91%) than males (0-50%) and one-sea-winter fish (53-56%). Fish undertook non-directional movements before their directed downstream migration which was interpreted as a reconditioning period potentially involving feeding and increased muscle activity. Kelts were equally likely to enter the reservoir in the fall or spring, but those who waited until spring had a greater chance of successfully reaching the river mouth than those who used the reservoir as overwintering habitat (67-80% vs. 0-40%). Initiation of migration tended to coincide with the spring freshet, although some late migrants were also successful in reaching the lower SJR. Within the reservoir, 36% of their time was spent moving upstream instead of downstream so that the fish swam up to 10 times the distance necessary to traverse the reservoir. Dam passage was most often attempted at night (58-73%). Those which were delayed for longer (18.5-44.5 h) than the median delay of 10-11 h were ultimately unsuccessful in reaching the lower SJR. Migration rates were significantly lower in the reservoir (5-15 km/d) than in the river section downstream of the MGS (18-27 km/d; K-W $p<0.00$). Results indicate that the MGS reservoir and dam causes migratory delay of kelts, potentially impacting survival and future spawning success.

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Session VI:
Freshwater Ecology

Moderator: Dan McCaw, Fisheries Biologist, Penobscot Indian Nation

Monitoring the Atlantic Salmon (*Salmo salar*) run in the Miramichi River using imaging sonar – first full monitoring season 2017

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ARIS (Adaptive Resolution Imaging Sonar) technology was used for monitoring the adult Atlantic Salmon run in the Miramichi River, New Brunswick, from May to November 2017. The sonars were collecting acoustic data continuously (24/7) at two locations: Main Southwest Miramichi River and Little Southwest Miramichi River. Improvements to sonar study sites were made during the season to ensure continuous data recording over changing weather conditions. The sonars allow near real-time reporting of the numbers of fish passing the study sites up- and downstream. The fish can be measured from the sonar image, but distinguishing species is still a challenge. Information about migration timing is recorded when analyzing the sonar videos. Most fish were detected in June and in October, and the fish were more active at night than during the day. 2017 was the first full season for monitoring the salmon run using sonars in the Miramichi River, while mark-recapture method has been used for monitoring the population since 1992. The two methods are compared to develop better understanding of the salmon run in the Miramichi River.

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Habitat selection by juvenile Atlantic salmon (Salmo salar) using a functional regression model

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Juvenile salmon habitat is impacted by human activities such as dams and road construction. Also, climate change may cause increased soil erosion, higher stream temperature and habitat destruction that could result in a decrease of salmon population. Hence, models to access habitat quality and/or quantity must be developed. In the literature, fish habitat is studied by different approaches: Physical habitat simulation model (PHABSIM), habitat sustainability index (HSI), habitat probabilistic index (HPI) and classical regression models like the generalized linear model (GLM) and the generalized additive model (GAM). In the regression approaches, a linear (GLM) or smooth (GAM) effect of a physical predictor variable (typically depth, velocity and substrate size) is linked to fish abundance/density/presence-absence. In its natural habitat, salmon is not strictly exposed to a single (mean) value of each habitat characteristic, but rather to a complete range of values, summarized by a distribution of frequency. However, classical regression models use a single value for each predictor, thereby causing an important loss of information. Hence, functional regression models appear naturally more adapted in this context since they are able to represent a variable by functions or curves. In our case, juvenile salmon abundance can be modelled using smoothed histograms of available depths, velocities and substrate sizes that fully describe the fish habitat. Moreover, functional regression handles naturally heterogonous habitat (i.e. bimodal distribution) compared to classical approaches. To test the proposed approach, several sites were studied along two salmon rivers of the province of Quebec (Canada) during the summer of 2017: The Petite-Cascapedia River (30 sites) and the Sainte-Marguerite River (27 sites). For each site, 30 patches were physically characterized and surveyed by electrofishing for the 0+, 1+ and 2+ age stage of juvenile Atlantic salmons. The functional regression model will then be compared to other approaches commonly used to model fish abundance and validated through performance criteria.

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Water Temperature in a Changing Climate: the Response of Juvenile Atlantic Salmon Populations Across Eastern Canada

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Water temperature in river environment exerts a central control on the geographical distribution of Atlantic salmon (*Salmo salar*). It is also known to strongly affect juvenile salmon growth and survival at all life stages. River temperatures are expected to increase in future climate, thus intensifying magnitude and frequency of thermal stress episodes. The ongoing project aims to investigate linkages between river temperature characteristics and growth of juvenile Atlantic salmon. More specifically, it targets the establishment of reliable empirical relationships between size-at-age, age-at-smoltification, and water temperature metrics, with a special emphasis being put on the effect of thermal stress events on growth. These relationships are examined for five rivers (Québec, New-Brunswick, Newfoundland and Labrador) selected to cover a wide range of water temperature conditions observed in eastern Canadian salmon rivers. Analyses are also conducted within the range of river temperature conditions observed in each river system. At each river, juvenile salmon (0+, 1+ and 2+) were collected by electrofishing at the end of the growth season, measured, and sampled for scales, at 5-7 locations where a thermograph had been recording water temperature every 15 min during the entire 2017 summer growth period. In this presentation, different metrics are extracted from this thermal record and tested for their potential association with salmon growth. The expected benefits of this project include the creation of knowledge to infer potential impacts of climate change on Atlantic salmon distribution from at both a watershed and a regional perspective.

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Population characteristics of sub-adult Atlantic Sturgeon (*Acipenser oxyrhynchus*) in the Penobscot River, Maine

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ABSTRACT: Atlantic Sturgeon (*Acipenser* oxyrinchus) is an anadromous species listed as federally threatened in the Gulf of Maine (GOM). Overharvest for caviar, and loss of habitat by the construction of dams led to the eventual closure of the fishery in 1998 by the Atlantic States Marine Fisheries Commission (ASMFC). In 2017, the ASMFC stated critical research needed for the species included regional abundance estimation and growth information as these questions remain poorly understood. Our goal was to address these questions by determining the population size and demographic characteristics such as growth and condition in the Penobscot River, Maine. Over the last decade, gill netting surveys resulted in the capture of 224 individuals that were uniquely marked (PIT and external) generating 19 recaptures. Ten percent of the fish were implanted with acoustic tags to estimate immigration/emigration rates for population abundance estimation using mark/recapture techniques. Changes in relative condition, growth (length and mass), and stock structure were evaluated. Sizes of individuals captured ranged 55 – 166 cm in fork length, and modelled growth demonstrated L_∞ = 149 cm, representing the Penobscot stock consists of primarily sub-adults. Growth averaged 0.12 cm per year, average mass gained was 250 g per year. Growth was positively correlated with days at large, with a growth coefficient of K = 0.2. Annual population estimates for 2007 – 2016 were 605 - 708 individuals, and the overall superpopulation of sub-adults available for all years ranged from 1657 – 5468. These data address critical research demographic characteristics of Atlantic Sturgeon in a portion of their range. The presence of only sub-adults that range widely in the GOM suggest the need for more explicit efforts to describe the metapopulation dynamics of this population within the GOM.

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An Overview of 12 Years (2006 – 2017) of Sturgeon Research on the Penobscot River, ME

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In July 2005, an angler fishing for striped bass at Fisherman's Park in Brewer, Maine caught a sturgeon. This incidental capture led to an intensive and ongoing sturgeon research program at the University of Maine. Initial objectives were focused on obtaining baseline information since nearly no information existed on sturgeon presence or use of the Penobscot River during modern times (post WWII). In the first year of study (2006) both Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) and shortnose sturgeon (*Acipenser brevirostrum*) were documented in the river. Since then, more detailed and complex questions regarding these sturgeons and their relationships to the Penobscot River, other coastal waterways of Maine, and the greater Gulf of Maine have been explored. Since 2006 we have documented over 1350 shortnose sturgeon and 245 Atlantic sturgeon in the Penobscot River, plus over 530 recaptures of shortnose sturgeon and 20 recaptures of Atlantic sturgeon. Estimates of sturgeon numbers in the Penobscot River based on mark/recapture data have ranged from 231 to 3250 shortnose sturgeon and 605 to 751 Atlantic sturgeon. A subset of 147 shortnose and 55 Atlantic sturgeon have had acoustic transmitters surgically implanted, resulting in over a decade of telemetry data demonstrating that shortnose sturgeon travel between the Merrimack, Saco, Kennebec, and Penobscot rivers; and Atlantic sturgeon travel from the Penobscot north to the inner Bay of Fundy, and south to the Hudson River. Telemetry data has also allowed for the examination of seasonal habitat use and possible critical habitat in the Penobscot River. Shortnose sturgeon have been documented moving into the newly available habitat above the former Veazie dam site, and several have been captured at the Milford Dam fish lift. Habitats above and below the former Veazie dam site have been evaluated and monitored for spawning. Shortnose sturgeon wintering aggregations have been documented annually in the Penobscot, and overwintering sturgeon numbers have been estimated using sonar imaging. Overwintering estimates have ranged from 539 to 1186 individuals. Sturgeon research at UMaine has produced five Masters and one Ph.D. degree, over 20 undergraduate research projects, and multiple scientific publications. The research program has grown to be a collaborative effort with multiple academic, state, federal, international, and non-governmental organizations. This research has resulted in a wealth of knowledge concerning two federally protected species that were not known to even previously exist in the Penobscot, and has given us many more questions that we hope to address in the future.

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“Closing the Loop”: Anadromous sea lamprey carcasses influence larval conspecifics

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Migrations of anadromous sea lamprey (*Petromyzon marinus*) from marine ecosystems serve as vectors of nutrients into recipient freshwater food webs. Larval sea lamprey, which reside in streams for 6–8 years, function as filter feeding detritivores before metamorphosing and migrating to the ocean. Previous work has demonstrated that carcass nutrients increase stream productivity and are incorporated by pre-metamorphic larvae. This delivery may increase growth rates and permit earlier metamorphosis. We examined the sensitivity of life history parameters and influence of sea lamprey carcass nutrients on the age and growth of larval conspecifics with a deterministic stock recruitment model. We hypothesized that growth variability among larval populations represents the influence of productivity-mediated growth. We compared simulated populations in which larvae receive added growth benefits from carcass nutrients to populations that do not receive these benefits. Our work exemplifies two potential alternative ecosystem states, one in which larval sea lamprey benefit from adult conspecifics, and another in which the larvae do not. Our simulation demonstrated that increased larval growth (and lower age-at-metamorphosis) led to increased spawner abundance.

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Session VII:
Long Term Strategies and Monitoring

Moderator: Dan McCaw, Fisheries Biologist, Penobscot Indian Nation

Fish Passage at Hydropower Dams on the Penobscot and Kennebec Rivers: A Content Analysis of the FERC eLibrary Database

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Hydropower dams represent a significant challenge for the successful migration of diadromous fish, many species of which are in decline. Measures to assist migration through dams such as fishways can differ greatly in scope and performance and are often mandated on a case-by-case basis. The Federal Energy Regulatory Commission (FERC) regulates most hydropower dams and grants 30-50 year licenses to projects. Thus, the process of licensing represents the chief opportunity for resource agencies to influence fish passage. It is notable that nearly 25 percent of active hydropower projects will require relicensing in the next decade. Licensing involves a multitude of stakeholders, many working from differing timeframes, varying levels of authority, and within the bounds of a complex legal system. Understanding how decisions are made during this crucial time is important to informing future relicensing processes and ensuring the effective prescription of fish passage measures. We are studying the regulatory processes for projects in the Kennebec and Penobscot River watersheds to assess abiotic, biotic and social correlates with regulatory outcomes. Data from the FERC eLibrary Database provides detailed correspondences, comments, and official documents relating to hydropower energy projects. A targeted content analysis of these sources will be used to characterize the roles of resource agencies and tribal entities, entity participation, and agency decision-making behaviors. Knowledge of these patterns may inform future relicensing efforts.

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Acid rain mitigation and complementary initiatives lead to encouraging signs of Atlantic Salmon recovery.

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Acid rain has been greatly reduced relative to the 1980s, however along the Atlantic coast of Nova Scotia, Canada and northeastern Maine, USA, a legacy of acid rain persists; impacting soils, forests, and the aquatic ecosystem health. The Atlantic Salmon, *Salmo salar*, is a species which has been particularly negatively impacted with total abundance reduced by 88-99% along Nova Scotia's Atlantic coast. At least 2/3rds of the known populations are suspected to now be extirpated. Beginning in 2005, the not-for-profit Nova Scotia salmon association initiated a demonstration acid rain mitigation project on a small coastal river 80 km northeast of Halifax. An automated lime doser continuously administers powdered limestone to the acidic river water to raise pH, reduce the concentration of toxic monomeric (labile) aluminum, and ultimately, increase the survival and abundance of Atlantic Salmon and other acid-sensitive aquatic species. The freshwater production of juvenile Atlantic Salmon has increased by > 300% in treated areas whereas untreated areas remain at low abundance with occasional year class failure. Water chemistry is above target levels in portions of the watershed; however, a large area of important habitat remains under-treated and limits the full recovery of the population. A major expansion of the project is underway including the installation of a second lime doser, an evaluation of helicopter-applied terrestrial liming, physical habitat restoration to compliment chemical mitigation and concerted research projects to inform development of a regional recovery strategy for acid-stressed Atlantic Salmon populations.

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Atlantic salmon in Maine: Assessment of temporal and spatial genetic diversity, and how genetic data is used for to help inform restoration activities in the hatchery and natural environment

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Given the endangered status of Atlantic salmon in Maine, conservation efforts are focused on restoration actions that will lead to establishment of self-sustaining populations. Genetic data is used in many ways to help inform restoration activities: to monitor genetic diversity, to assess hatchery activities such as spawning and broodstock collection, and to evaluate survival in the wild after stocking. The primary goal guiding the genetic-based management at the current stage of restoration is to limit loss of genetic diversity, and to maintain the genetic variation currently present in the populations. Given the limited population size for Atlantic salmon within the DPS, and especially given limited natural reproduction, any action that could reduce genetic diversity within the DPS could further reduce the ability of the population to persist. Although concerns about adverse impacts due to adaptation to the hatchery environment and artificial selection exist, hatcheries enable larger populations (both in census size and number of spawning individuals) to be maintained than what would be possible if solely relying on natural reproduction. These larger population sizes enable a greater portion of genetic diversity to be retained from one generation to the next. Therefore, due to the current population status, reliance on hatcheries for production and maintenance of the populations is critical to sustain genetic diversity, in order to provide the basis for future adaptation. To facilitate use of genetic monitoring, estimates such as allelic diversity, heterozygosity, effective population size, and the proportion of families recaptured for broodstock are evaluated annually. Genetic monitoring allows us to evaluate actions related to hatchery management to limit adverse impacts to genetic diversity. The current genetic status of the Atlantic salmon DPS will be discussed: spatially across the various populations, and temporally to assess changes in diversity over time.

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Applying eDNA Tools to Salmon Ecosystems

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Living and dead organisms shed fragments of DNA into their environments. Detecting these fragments of environmental DNA, or 'eDNA', is quickly emerging as a powerful new tool for species and community monitoring in aquatic systems. We have developed, and are continuing to develop, eDNA assays for species inhabiting salmon ecosystems, ranging from native trout, salmon, and other diadromous species to exotic species. We will present a findings from eDNA studies in Maine, that demonstrate: how eDNA tools are developed, how they are vetted in the lab and field, the importance of proper field survey designs, and the strengths and weaknesses of eDNA for different monitoring objectives. Studies include testing the limits of detection and quantification for juvenile salmon (*Salmo salar*) in streams, testing detection of sea run smelt (*Osmerus mordax*), demarking the limits of invasion for exotic pike and musky (*Esox* spp.), confirming Maine angler reports of exotic bass (*Micropterus* spp.) and crappy (*Pomoxis nigromaculatus*), and collaborating with agency biologists and NGOs to quantify brook trout (*Salvelinus fontinalis*) and Arctic charr (*S. alpinus oquassa*) abundances in lakes. We believe that eDNA, used properly, can be a useful, even transformative, addition to our monitoring toolkit. Although the planning and sampling effort for effective eDNA surveys are not trivial, this high-tech tool places monitoring capacity into the hands of far more individuals and groups, and thus, can facilitate unprecedented levels of collaborative monitoring of salmon ecosystems.

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A **collaborative model for Atlantic salmon recovery in Fundy National Park of Canada**

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For over a decade, Parks Canada, Department of Fisheries and Oceans (DFO) and First Nation partners have worked to monitor and maintain a portion of the remnant endangered wild Inner Bay of Fundy (IBoF) salmon population in Fundy National Park's (FNP) 2 salmon rivers. Live gene banking efforts succeed in preventing extirpation through capture of remnant juveniles from the wild, rearing to maturity, spawning, and releasing at different stages back to the wild to maintain native local stocks. Subsequent monitoring programs detected different phenotypes in migrating smolts attributed to the stage in which individuals were released. More recent work showed that smolts with increased early-life exposure to the wild exhibited higher measures of wild-fitness.

Wild juveniles collected in excess of those required for FNP's live gene banking program are now transferred as smolts to what is considered to be the first dedicated marine farm for rearing wild Atlantic salmon. Juveniles are reared until maturity. Then, they are transferred back to native rivers in FNP to spawn naturally. Considering the IBoF population depends on supplementation to avoid extinction, migrating smolts from this program are hoped to provide optimally fit individuals going out to sea as well as optimal samples for perpetuating live gene banking activities.

Since 2016, Mature native adults are released back to FNP in October. Numbers of individuals released are targeted to exceed estimated minimum viable effective population size of 475 individuals. Early results show wild-produced juveniles were found throughout the study river in 2017 and other research on this program shows significant increases in river primary productivity resulting from the presence of mature adult salmon. This experimental model could be applicable to other depressed Atlantic salmon populations.

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Poster Session:

Watershed-scale connectivity analysis: An applied GIS model towards the strategic management of barriers to Atlantic salmon migration

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Barriers to connectivity are often associated with culverts and beaver dams. With increasing logging efforts, roads and stream crossing are more prevalent and beaver densities have also increased over the last century causing habitat loss to Atlantic salmon in the Restigouche watershed. The main objective of this applied research project aims to develop a watershed-scale connectivity analysis using a GIS model and spatial analysis tools. The results of this project will help to strategically manage issues impeding upstream migration of Atlantic salmon and to cost-effectively prioritize restoration efforts towards increasing access to productive upstream habitats and conservation requirements needed for an adaptive and integrated management plan.

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Optimizing strategies to hydraulically plant Atlantic salmon eggs based on fry dispersal patterns

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Abstract
The Gulf of Maine Distinct Population Segment of Atlantic salmon has suffered from habitat loss and exploitation over the last century. Hatchery supplementation has unquestionably prevented the extirpation of the species over the last decades. Stocking older life history stages minimizes early life history mortality, but does so at a cost of limiting exposure to a natural freshwater environment. Egg planting is a process by which fertilized eggs from the hatchery are injected into the gravel in the fall, replicating the natural spawning process in streams and provides a natural experience which can be important for adaptation. This methodology has been used experimentally within the region, but significant uncertainties exist in developing the effective implementation of this method at a greater scale. Specifically, the habitat dependent distribution of juveniles after emergence from the gravel would provide information necessary to apply the technique to meet conservation hatchery goals with respect to fall parr densities. We propose to characterize the dispersal pattern of egg planted Atlantic salmon as a function of habitat and use these data to construct a GIS based tool to inform stocking. This work, if successful, can help to optimize the application of egg planting at a management level.

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International Year of the Salmon

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The North Atlantic Salmon Conservation Organization (NASCO) and the North Pacific Anadromous Fish Commission (NPAFC) are collaborating to celebrate salmon restoration and recovery with an International Year of the Salmon in 2019. The overall theme is *Salmon and people in a changing world.* During the International Year of the Salmon, our outreach efforts will raise awareness of what people can do to better to ensure salmon and their varied habitats are conserved and restored in light of increasing environmental variability. The International Year of the Salmon will also stimulate an investment in research and leave a legacy of knowledge, data/information systems, tools and a generation of scientists better equipped to provide timely advice to inform rational management of salmon. The countries who are participating include the U.S., Canada, Norway, EU, Russia, Japan and Korea.Planning, promotion and outreach has begun and will continue through 2018. Over 2018 – 2022, research will be conducted, analyzed, results published and then findings disseminated.

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Howland Fish Bypass Channel Physical Monitoring

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The last of the three major fish passage enhancements forming the Penobscot River Restoration Project to be implemented, the Howland bypass channel is a notably large nature-like fishway whose design and construction included several novel elements. Following completion of the project in 2016, an effectiveness monitoring program is ongoing. One element of the program includes monitoring the physical and hydraulic characteristics of the channel, including channel stability and adjustments, and flow-field characteristics including velocities and depths. The poster will present the physical monitoring framework, review selected logistical and technological challenges, and discuss preliminary results.

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Lipid content of Atlantic salmon (*Salmo salar* L.) sampled at West Greenland

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Lipids serve as important energy reserves to sustain Atlantic salmon (*Salmo salar*) on themigration from summer feeding grounds in the North Atlantic to their natal streams to spawn and are important determinants of spawning success. Therefore, it is likely that fish that have higher percentages of lipids in their muscle tissue at their summer feeding grounds off West Greenland will be more likely to survive migration and reproduce than those fish with lower percentages of lipids. We sought to examine the lipid content of Atlantic salmon with two objectives: 1) to analyze the lipid content of summer feeding Atlantic salmon captured at West Greenland and 2) to assess the accuracy of using C:N ratios to estimate percent lipid in the muscle tissue of Atlantic salmon. Lipid content was found to be spatially and temporally variable ($p < 0.05$), but no significant relationships between size, sex, trophic position, sea surface temperature, condition, δ13C, and δ15N were found ($p > 0.05$). These findings may be indicative of a selection event occurring in the Labrador Sea in the winter prior to migration to West Greenland for summer feeding, i.e. suggestive of condition related to or other mortality occurring before arrival at West Greenland. Considering the lack of correlation between C:N ratio and percent lipid, we suggest that C:N measures are poor predictors of lipid content for salmonid fishes given the findings of this and other studies. Given the paucity of information regarding the overwintering of Atlantic salmon in the Labrador Sea and the findings of this study, future research conducted in the Labrador Sea could better elucidate the impacts of marine feeding and growth on lipid content and marine productivity.

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Comparative analysis of estuarine fish diets after restoration of Alewife populations in Penobscot River Watershed

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Recent reintroduction of alewife to their native spawning habits in Maine has led to a dramatic increase in numbers, although still far less than the populations present 200 years ago. The sudden increase of a particular species often shifts the balance of predation and competition in ecological communities. This project investigates possible diet overlap among alewife and other juvenile fish using the Penobscot Estuary as a nursery habitat. Alewife, Blueback Herring, Atlantic Herring, Atlantic Mackerel, and Rainbow Smelt were collected in the Penobscot Estuary in October, 2017 as part of the Penobscot Estuary Monitoring Trawl (NOAA). Individual fish were weighed, measured, and the stomach dissected and preserved with F-13 preservative. Tissues were preserved for stable isotope analyses to estimate length of time the fish were in the estuary. Diet contents were identified to genus when possible. Preliminary results indicate that most fish were actively feeding when captured, and that the mackerel were feeding on fish. These data will be important in determining the value of the Penobscot Estuary as a nursery habitat.

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The effects of post-surgical recovery time and time of day release on the performance and survival of emigrating Atlantic salmon (*Salmo salar* L.) smolts from the Miramichi River

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Acoustic telemetry, commonly involves surgically implanting transmitters inside the abdominal cavity of a fish that will be detected by receivers along migration routes. However, the surgical procedure can reduce the growth and performance of tagged fish, biasing migration and survival estimates for the population. Therefore, it is important to develop tagging methodologies and protocols that will reduce bias within estimates. In this study, we used Atlantic salmon (*Salmo salar L.*) smolts to test the hypothesizes that tagging smolts months prior to release, and releasing smolts during the night, will affect survival and performance. Smolts were divided into four treatment groups for two separate populations: 1) wild smolts tagged two months prior to release but overwintered in a hatchery (winter tagged); 2) wild smolts tagged on the day of release but overwintered in a hatchery (spring tagged); 3) wild smolts tagged on the day of release and released during the day (day release); and 4) wild smolts tagged on the day of release and released during the night (night release). After release, survival and migration time was calculated to head of tide, river exit, bay exit and Strait of Belles Isle gates. In both populations, winter tagged smolt survival was higher than spring tagged. No difference in survival between fish released during the day and night were detected. Between all treatment groups and populations there was a high amount of variation in migration speeds to each gate. This study is one of the first to describe how post surgery holding time can affect survival and migration timing and holds important implications for tagging studies.
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Temporal change and variation in marine growth of North American Atlantic salmon sampled from West Greenland

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Concurrent declines in Atlantic salmon abundance and productivity have been demonstrated for North American populations since the 1980's and 1990's. These trends were driven by the segment of the population that spends two years in the marine environment before returning to spawn. These two-sea-winter (2SW) spawners are a primary driver of overall population productivity and abundance as they are often larger and have higher fitness metrics than one-sea-winter conspecifics. This suggests that biological processes, such as growth, during the second half of the marine phase may be important factors governing overall abundance. West Greenland is the primary feeding ground for North American salmon stocks in their second summer. To investigate the relationship between marine growth and population productivity, we extracted growth data from scales sampled from Atlantic salmon harvested at West Greenland from 1980-2015. Using these growth measurements, we described temporal trends and variability of key marine growth metrics. We compared the temporal trends in marine growth metrics with annual estimates of population productivity and abundance to identify metrics with strong correlation to population outcomes. Our results will help inform subsequent analyses investigating relationships between ecosystem variables, marine growth, and the productivity and abundance of North American 2SW Atlantic salmon stocks. Identifying relationships between marine growth metrics and Atlantic salmon abundance and productivity will further our understanding of how marine growth mediates survival.

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Getting Over the Dam: Overcoming institutional barriers to the recovery of Atlantic salmon by navigating the social-science/policy interface

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The Atlantic salmon population in Maine remains critically low despite extensive hatchery supplementation and habitat improvement efforts over the past four decades. In 2000 the Gulf of Maine Distinct Population Segment (DPS) was listed as endangered under the Endangered Species Act (ESA) with listing authority jointly shared by the National Oceanic and Atmospheric Administration (NOAA) and the United States Fish and Wildlife Service (USFWS). Because, regulators and managers from federal, State, and Penobscot Nation context operate with independent authorities, recovery decisions depend upon effective communication and coordination. From 1980 to 2005 management and regulatory bodies, non-profit organizations, and citizens met as a single group, the Maine Technical Advisory Committee (TAC). The dissolution of TAC in 2005 resulted in reduced coordination across authorities until 2011 when the Atlantic Salmon Recovery Framework (ASRF) was formed. This alternative structure was built on five areas: stock assessment, marine/estuarine survival, connectivity, genetic diversity, and freshwater survival. Each area is addressed by an interagency action team. Within ASFR the processes by which these isolated action teams' recommendations are incorporated are poorly characterized and efforts to innovate are often stifled by an inability to effectively evaluate large scale tradeoffs when entities perceive biological, functional, or political risk. We intend to assess these social factors using a mixed methods case study approach involving i) semi-structured interviews, ii) Q-sort techniques, and iii) document analysis. We contend that an evaluation of the interactions among entities in the face of uncertainty may inform the processes by which recovery policies and actions are implemented. Specifically, we hope to characterize institutional barriers and factors that currently impact Atlantic salmon recovery decision making in Maine.

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Alternative aging methods for Atlantic Sturgeon: Research to improve management of a pre-historic natural resource

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Gulf of Maine (GOM) is home to a federally threatened population of Atlantic Sturgeon (*Acipenser oxyrhynchus oxyrhynchus*) due to overharvest and degradation of habitat. Under current population trends, the population is predicted, by the Atlantic States Marine Fisheries Commission, to become endangered by 2025. Population status and stock trends are currently plagued with considerable data gaps. One way to better understand the status of this population is to describe the population's age structure for stock demographic analyses which would be useful to managers. However, the most widely used method of aging sturgeon (pectoral fin spines) has high potential to be deleterious, especially upon recapture in gill nets. The goal of this study is to assess the use of alternative parts that may be less deleterious to the individual. We will compare the standard fin spine approach with the use of alternative structures: the second pectoral fin ray, dorsal scute, and in some cases an otolith (salvaged carcasses). Both the second pectoral fin ray and dorsal scutes have less potential for negative affects to the individual. Eight known-age Atlantic Sturgeon will be sampled (pectoral fin spine, second pectoral fin ray, dorsal scute) from the USGS Conte Anadromous Fish Research Center in Massachusetts. Four additional known-age samples from individuals kept at the University of Maine Aquaculture Research Center (including otolith) and eight wild unknown age GOM Atlantic Sturgeon will also be sampled (pectoral fin spine, second pectoral fin ray, dorsal scute). Each hard part (3-4 from each fish) will be processed and aged by three different people. The age determined for each individual hard part will be matched back to the individual. We expect all hard parts to reveal the same age. If successful, this research could lead to a less harmful approach to better understanding GOM Atlantic Sturgeon age structure and aid in management of the species.
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Prey availability and diet of Sturgeon in the Gulf of Maine

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Maine's two native species of sturgeon move extensively between the Kennebec and Penobscot river systems. Both species use the Kennebec system for spawning, but this has not been observed in the Penobscot and warrants further investigation into why both species use the Penobscot seasonally. One explanation could be linked to foraging behavior and prey availability at each location. The goal of this research is to analyze and compare the diets of Shortnose Sturgeon (*Acipenser brevirostrum*) and Atlantic Sturgeon (*Acipenser oxyrhichus oxyrhynchus*) as well as prey resources in the Penobscot and Kennebec Rivers. Results will be used to assess whether these two species are selectively feeding on different prey and if interspecific competition could be occurring. To assess prey availability, we used PONAR benthic samplers and Hester-Dendy invertebrate samplers, standard techniques used to characterize benthic invertebrate communities. Twenty-seven Hester-Dendy samplers were deployed for four weeks in both rivers in locations with salinities ranging from 0.0ppt to 19.0ppt, mimicked in both rivers for comparison. In addition, we collected temperature, salinity and dissolved oxygen data at all sampling locations. These data will be used to assess prey availability, and characterization of critical habitat. To determine diets, sturgeon were collected using 6-inch stretch gill nets and their stomach contents were extracted using gastric lavage. In total, 87 lavage samples were collected, 21 from Atlantic and 69 from Shortnose Sturgeon. Preliminary observations suggest that Kennebec prey samplers have greater abundance of invertebrates than those in the Penobscot. Stomach samples and the samplers still need to be processed and analyzed. This research could be beneficial to understanding the foraging habits of these two species of sturgeon that currently live in the Penobscot and Kennebec rivers. These data will be used to characterize environmental predictors of prey occurrence, which can be used to further establish critical foraging habitat for both species.

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Effects of alewife predation on zooplankton communities in three Maine lakes

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Predation by alewives on large zooplankton has been shown to influence zooplankton communities and primary producer biomass. The absence of larger herbivorous zooplankton could result in an increase in abundance of phytoplankton and possibly lead to nuisance algal blooms. Alternatively, other studies have argued that the presence of alewives influence the bottom-up control of phytoplankton by increasing nutrient loading via import of marine-derived nutrients or decreasing nutrient loading via export of freshwater-derived nutrients. In order to examine the relative influence on these two mechanisms, we need a good understanding of changes in phytoplankton and zooplankton communities, in addition to nutrients and chlorophyll-a. For this poster we focused on zooplankton communities in mid-July, August, and October, 2017, in Cobbossee Lake, Pleasant Pond, and China Lake. Zooplankton were identified to genus and sorted into three size bins: $\leq$ 0.5 mm, 0.5-1 mm, and $\geq$ 1 mm. This data will add to the existing body of knowledge on phytoplankton control, and may help lake associations and others as they consider the reintroduction of anadromous alewife into their lakes.

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Evaluating morphometric techniques to determine sex of Shortnose Sturgeon in the Penobscot River, Maine.

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Shortnose Sturgeon were identified as an endangered species in 1967 and have maintained this status range-wide under the U.S. Endangered Species Act. Reasons for this status include anthropogenic factors like overfishing, pollution, and the construction of dams. Currently, all techniques for sexing sturgeon are invasive and can be injurious. In an attempt to find a non-invasive technique, we are applying a protocol adapted from work with lake sturgeon, where morphometric measurements from photos have been used to determine sex. For lake sturgeon, relationships between head width and depth correlate directly with whether an individual is male or female. To validate this method, I will use blood samples to analyze and compare the circulating reproductive hormones, testosterone and 17β-estradiol, in individuals captured from the Penobscot River. Sturgeon are captured with bottom-set gillnets. Upon capture, individuals are then measured (for length and weight), internally and externally tagged, fin clipped (for genetics), blood is sampled, and multiple pictures are taken from different perspectives. In addition, a boroscope is used to look at the morphology of the gonads in each individual to determine females by egg presence and development stage (early versus late). We are aiming to sample fish, preferably 20 late stage females, 10 early stage females, and 20 individuals of unknown sex, all initially determined using internal observations of gonads using the boroscope. Data collected from the three methods, boroscope, hormones, and head morphometics, will be compared for an overall consensus on sex. Ideally, all three metrics will reveal the same sex ratio for the totality of individuals examined. These data will also be used to determine the sex ratio of Shortnose Sturgeon present in the Penobscot River to further demographic inquiries. In addition, if head morphometrics provide positive sex determination (confirmed with blood samples), this method could eliminate the need for invasive techniques like blood samples, surgery or endoscopy. Because Shortnose Sturgeon are still endangered, non-invasive examining techniques are desirable. If this method proves successful, it could potentially be used for other sturgeon species.

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Developing an ecosystem-based fisheries management framework for the Eastern Maine Coastal Current

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Maine Center for Coastal Fisheries, NOAA Fisheries' Northeast Fisheries Science Center, and the Maine Department of Marine Resources have entered into a cooperative research and development agreement to develop a scientific framework capable of supporting ecosystem-based approaches to fisheries management. Within this context, EBFM is defined as a systematic approach to fisheries management in a geographically specified area that contributes to the resilience and sustainability of the ecosystem by recognizing the physical, biological, economic, and social interactions among the affected fishery-related components of the ecosystem, including humans. Our interest in EBFM is motivated by our collective view that traditional approaches to studying marine systems are often not well suited for dealing with the heterogeneity or complexity of riverine, coastal, or ocean environments, especially in the face of rapid change and uncertainty. In contract, EBFM represents an adaptive process by which we can learn, adapt, and evolve our approaches to management in a continual process. The new partnership will strengthen relationships between the three principal institutions as well as collaborations among all stakeholders invested in the Eastern Maine Coastal Current region. Importantly, it will include active collaboration from coastal stakeholders. This poster focuses on the first steps in the partnership and provides a set of frequently asked questions about the initiative and how individuals and institutions can be involved.

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Artificial selection on reproductive timing in hatchery salmon drives potential maladaptation to warming waters

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Reproductive phenology – the timing of spawning and associated events such as migration – is an important trait that links generations and substantially influences individual fitness. In salmonids, phenological events including return to freshwater and spawning occur during predicable periods within a given population suggesting local adaptation of these traits to prevailing environmental conditions. Changing reproductive phenology has been observed in many populations of Atlantic and Pacific salmon, potentially reflecting an adaptive response to climate change, but the mechanisms by which change occurs are seldom well understood. The sockeye salmon spawning in the Cedar River near Seattle, Washington have displayed dramatic changes in spawn timing over the past 50 years, trending generally later through the early 1990s, and then, approximately concurrent with the initiation of an integrated hatchery program, changing course and again becoming earlier. During the more recent period, and in spite of substantial hatchery production, the abundance of Cedar River sockeye has declined markedly. In this study we explored the question of whether artificial selection in the hatchery has resulted in maladaptation to ongoing environmental changes in the Lake Washington basin including warming waters and lower late-summer flow. We found that prior to the mid-1990s median spawning date in Cedar River sockeye was well correlated with Cedar River flow and Lake Washington temperature, but in the most recent 20 years these relationships have deteriorated. Since it's initiation in 1991 that hatchery has on average imposed directional selection for earlier spawning, and, depending on trait heritability, would be expected to have advanced spawning by 1-3 weeks over this period. We estimated heritability of spawning date to be high ($h^2 \sim 0.8$), and so the upper end of this range is not improbable. Recent observations of increased prespawning mortality in early spawners and relatively lower survival of early emerging juveniles, suggest that artificial and natural selection are acting in opposite directions. Because both of the apparent fitness costs of early spawning are expected to be exacerbated by future warming, we conclude that artificially altered phenology is a likely contributor to reduced productivity of Cedar River sockeye salmon, and may limit the capacity of the population to adapt to climate change.

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Where did all the salmon go? The combined impacts of acid rain and forestry are preventing Atlantic salmon recovery in Downeast Maine

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Water quality surveys and an experimental liming project in Downeast Maine have shown that pH, calcium and toxic aluminum are at/or exceed threshold levels for Atlantic salmon survival. In general, calcium appears to be more limiting than pH or aluminum. Other fish species and macroinvertebrate assemblages are also impaired. In most streams, even brook trout are near survival thresholds. The result is that many streams are one of the following: (1) without fish, (2) support only brook trout, or (3) have only limited fish species diversity. Restoration requires a transition from fossil fuels to sustainable energy (a decision forced on us by Climate Change), but in the short term, liming is a cost-effective management strategy.

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Reducing acidification in endangered Atlantic salmon (Salmo salar) habitat

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Despite restored access to historic Atlantic salmon (Salmo salar) habitat in eastern Maine, population sizes have remained low. Most waters in this region are chronically (headwaters) and/or episodically (main stems) acidic, experiencing pH levels below 6.5. Loss of fish populations due to acidification of surface waters (low pH, low calcium and high aluminum ion concentrations), primarily due to acid precipitation, has been well documented in the North Atlantic region. Even episodic acidity can have detrimental impacts when it coincides with key salmon life stages during snow melt and spring runoff. Adding lime to acidic waters, through application of agricultural lime or lime slurry, has increased salmon populations in Scandinavia and Nova Scotia, and has been a recommended restoration action for Maine's acidic rivers and streams. A 2009 MEDEP pilot study investigating the efficacy of using clam shells to lime small streams suggested a trend towards improved habitat quality. To further investigate the efficacy of this mitigation method, a multi-year liming project in the East Machias River watershed will be conducted in collaboration with the Downeast Salmon Federation. Clam shells will be spread along treatment reaches both along the stream bottom and along the banks to capture high flow events (during which episodic acidity events are expected). The goal of the study is to increase macroinvertebrate abundance and diversity, and increase juvenile salmon abundance. The first year of the project was used to characterize baseline conditions by monitoring water quality between May and November using continuous monitoring devices and periodic grab samples. Preliminary data analysis indicates periodic stressful conditions for juvenile salmon, with pH ranging from 4.99 to 6.88 with the lowest stream mean of 5.3, temperature ranging from 8.94 to 26.06°C, with the highest stream mean of 18°C, dissolved oxygen ranging from 5.81 to 10.80 mg/L with the lowest stream mean of 8.9 mg/L, calcium ranging from 1.32 to 5.98 mg/L with the lowest stream mean of 1.44 mg/L, and exchangeable aluminum ranging from 6.27 to 53 ug/L with the highest stream mean of 35.3 ug/L. The dry summer of 2017 resulted in extremely low stream flows, likely causing further stress to salmon in addition to affecting water quality. As clam shells are added to the target area, monitoring efforts will continue for at least five years to determine the efficacy of using this approach to mitigate acidity.

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