The 2020 Atlantic Salmon Ecosystems Forum

Time flies – Atlantic salmon as an endangered species twenty years later…

January 14-15, 2020
Orono, Maine USA
University of Maine, Wells Conference Center

Recognizing the International Year of the Salmon (core) in 2019, watch for activities extending into 2020

INTERNATIONAL YEAR OF THE SALMON

2020 Atlantic Salmon Ecosystems Forum
Schedule At A Glance

Begin	End	January 14, 2020
7:00	8:00	**REGISTRATION -** *Refreshments provided*
8:00	8:05	**Housekeeping** *Rory Saunders, NOAA Fisheries*
8:05	8:25	**Welcome to the 2020 ASEF** *Sam Rauch, Deputy Assistant Administrator for Regulatory Programs, NOAA Fisheries*
8:25	9:00	**Sustainability as a framework for rethinking approaches to salmon, society and solutions.** *David Hart, Director, Senator George J. Mitchell Center for Sustainability Solutions*
9:00	9:05	**Session I: 20 Years of Experience Guiding our Future (Part 1 of 2)** *Joshua Royte, The Nature Conservancy, Moderator*
9:05	9:25	**Reflections on Penobscot River Atlantic Salmon: Before and After Listing as an Endangered Species** *Edward T Baum, Maine Atlantic Sea-Run Salmon Commission (Retired)*
9:25	9:45	**From North America to West Greenland and Beyond: management of Atlantic salmon in the North Atlantic** *Martha Jean Robertson, Fisheries and Oceans Canada, Newfoundland and Labrador, Canada*
9:45	10:15	**BREAK** - *refreshments provided*
10:15	10:25	**Science for comfort or conservation- how do we inform and avoid action on fish passage?** *Joseph D Zydlewski, U.S. Geological Survey, Maine Cooperative Fish and Wildlife Research*
10:25	10:35	**Using decision support tools to plan for salmon restoration** *Erik H Martin, The Nature Conservancy*
10:35	10:45	**6 ½ & 19 years Maintaining and Perfecting SHARE's Mission Focus** *Steven D. Koenig, Project SHARE*
10:45	10:55	**Two Decades on the Front Line of Salmon Protection in Maine: A Perspective by the Atlantic Salmon Federation's Andrew Goode** *Andrew Goode, The Atlantic Salmon Federation*
10:55	11:05	**Private forest landowners and aquatic partners getting things done** *Patrick Thomas Sirois, Maine's Sustainable Forestry Initiative Implementation Committee*

Begin **End** **January 14, 2020**

11:05	11:55	**Facilitated Discussion** *Joshua Royte, The Nature Conservancy*
11:55	12:00	**Jed Wright Memorial Fund** *Andy Goode, The Atlantic Salmon Federation* *Kate Dempsey, The Nature Conservancy*
12:00	13:00	**LUNCH** - *lunch at the Student Union (not provided)*
13:00	13:05	**Session II: 20 Years of Experience Guiding our Future (Part 2 of 2)** *Christopher Meaney, US Fish and Wildlife Service, Moderator*
13:05	13:20	**Evaluation of genetic diversity in Maine Atlantic salmon** *Meredith L. Bartron, USFWS Northeast Fishery Center*
13:20	13:35	**20 Years of the Atlantic Salmon Stocking Program** Ernie Atkinson, *Maine Department of Marine Resources*
13:35	13:45	**Marine-phase Atlantic salmon** *Timothy F. Sheehan, NOAA Fisheries Service, Northeast Fisheries Science Center*
13:45	13:55	**Opportunities for More Salmon - Let's Do Some Numbers** *John Kocik, NOAA Fisheries Service, Northeast Fisheries Science Center*
13:55	14:05	**Lost & Found: Communicating the Science of Endangered Species** *Catherine Schmitt, Schoodic Institute, Acadia National Park*
14:05	14:35	**Facilitated Discussion** *Christopher Maeney, US Fish and Wildlife Service*
14:35	15:05	**BREAK** - *refreshments provided*
15:05	15:10	**Session III: Age, Growth, Environmental Stressors** *Daniel McCaw, Fisheries Program Manager, Penobscot Indian Nation*
15:10	15:25	**Linking ocean temperature phenology to migration timing of Atlantic salmon in the Penobscot River** *Katherine Mills, Gulf of Maine Research Institute*
15:25	15:40	**Growing faster but dying younger? Scale analysis of North American Atlantic salmon captured in Greenland suggests increased growth at sea despite declining marine survival.** *Michael D. Tillotson, Gulf of Maine Research Institute*
Begin	**End**	**January 14, 2020**
15:40	15:55	**Linking Ecosystem Change, Growth, and Survival of Penobscot River Atlantic Salmon** *Miguel F Barajas, Gulf of Maine Research Institute*

15:55 16:10 **Marine migration of Atlantic salmon smolt and kelt from a Canadian River (Western Arm Brook, Newfoundland and Labrador).**
Nicholas I. Kelly, Fisheries and Oceans Canada, St. John's, NL, Canada

16:10 16:25 **Assessing the effects of multiple stressors on the estuarine and early marine survival of Atlantic salmon postsmolts**
Brent Wilson, Fisheries and Oceans Canada

16:25 16:40 **Natural transmission routes at sea and influences of coastal aquaculture on infection profiles of wild Atlantic salmon**
Jonathan Carr, Atlantic Salmon Federation, Chamcook, NB

16:40 16:55 **Age structure of non-reproductive, partial migratory populations of sturgeon species in the Penobscot River, Maine**
Catlin Ames, School of Marine Sciences, University of Maine

16:55 17:10 **Aquaculture as a part of the Salmon Ecosystem: NOAA and Sea Grant projects in Maine**
Gayle Zydlewski, Maine Sea Grant

17:10 19:00 **Poster Session and Social -** *refreshments provided, beer and wine are available*

19:00 **An informal gathering at a local brewery to socialize with friends and colleagues from around New England and, Quebec and Atlantic Canada**
Black Bear Brewing Co., 19 Mill St. Orono, ME 04469

Poster Presentations

Distribution and abundance of zooplankton in the Penobscot River estuary
Cody T. Dillingham, School of Biology and Ecology, University of Maine

Working Together For Healthy Streams: the US FWS National Fish Passage Program
Cathy Bozek, US Fish and Wildlife Service

Cost Effective Fish Passage Improvement Tools and Techniques for Community Groups
Amy Weston, Nova Scotia Salmon Association's Adopt a Stream Program

Movements of radio-tagged Atlantic salmon (*Salmo salar*) in the Penobscot River, Maine
Erin Peterson, University of Maine

Science communication: methods, importance, and impact of community engagement during the International Year of the Salmon
Nicole J. Beauchamp, Ocean Tracking Network, Dalhousie University

Growth and habitat use of juvenile alewife in Highland Lake, Windham, Maine
Emma Dennison, University of Southern Maine

Can Clam Shells Reduce the Impacts of Stream Acidification in Eastern Maine?
Emily Zimmermann, Maine DOT

The Maine Water Temperature Working Group: ***Working collaboratively to identify thermal refugia for cold water species***
Graham Goulette, NOAA Fisheries

***R*estoring Stream, Wetland, and Riparian Processes in Third Lake Stream**
Steven D Koenig, Project SHARE

Distribution and abundance of zooplankton in the Penobscot River estuary
Cody T. Dillingham, School of Biology and Ecology, University of Maine

Acid rain and salmon recovery: success and expansion of the West River Acid Rain Mitigation Project
Jillian A. Leonard, Nova Scotia Salmon Association

Evaluating the Efficiency of a Hydropower Bypass for Atlantic Salmon (Salmo salar) in the Tobique River, New Brunswick
Hilary OJ MacLean, Canadian Rivers Institute, University of New Brunswick

Assessment of flow dynamics and fish habitat conditions in Togus Stream in relation to the ongoing restoration of anadromous fish passage into Togus Pond, Chelsea/Augusta, ME.
Carl Merrill, Suffolk University

Baseline Sampling of Penobscot River Sturgeon for Mercury
A. Dianne Kopec, Senator George J. Mitchell Center for Sustainability Solutions, University of Maine

Development of environmental DNA tools for sustainable monitoring of northeast sea-run fishes
Samantha J Silverbrand, University of Maine

Tracking Changes in Atlantic Salmon Habitat Availability using GIS
Christopher M Federico, Project SHARE

Fish Community Assessment 6 years following dam removal in the Penobscot River, Maine
Kory A Whittum, University of Maine

Beyond Connectivity: Restoring the Upper Narraguagus River Smolt Output Using a Collaborative Process-Based Approach
Joan G. Trial, Project SHARE, Eastport ME

Effects of ocean currents on the migration of Atlantic salmon post-smolts in a semi-enclosed bay
Brady, K, Quinn, Fisheries and Oceans Canada

Integrated conservation planning for priority watersheds within the NS Southern Upland Priority Areas
Fielding A Montgomery, Nova Scotia Salmon Association

		Characterization of in-river plus growth in Atlantic salmon smolt scales *Rachel, Y, Kim, NOAA Fisheries*
		50 years of sampling at West Greenland *Tim Sheehan, NOAA Fisheries*
Begin	**End**	**January 15, 2020**
7:00	8:00	**REGISTRATION –** *refreshments provided*
8:00	8:05	**Session IV: Movement Barriers, Fish Passage, and Ecosystem Response** *Joseph Zydlewski, US Geological Survey and Department of Wildlife, Fisheries, and Conservation Biology, University of Maine, Moderator*
8:05	8:20	**Examining dispersal of point stocked Atlantic salmon (*Salmo salar*) fry relative to habitat qualities in streams in eastern Maine, USA** *Ernest Atkinson, Maine DMR and University of Maine*
8:20	8:35	**Forecasting the downstream migration of adult silver phase American eels** *Dan Weaver, University of Maine*
8:35	8:50	**Establishing criteria to identify Ecologically Significant Areas in freshwater** *Alicia Cassidy, Fisheries and Oceans Canada, Gulf Fisheries Centre, Moncton, New Brunswick*
8:50	9:05	**Penobscot Estuary research, a decade of monitoring restoration and finding surprises** *Justin Stevens, Maine Sea Grant*
9:05	9:20	**Participatory mapping for knowledge co-production and application in Downeast Maine** *Gabriella Marafino, University of Maine*
9:20	9:35	**Dams, death, and delay in the Penobscot River - the complex and cumulative influence of hydropower dams on migrating American eels** *Matthew Mensinger, University of Maine*
9:35	9:50	**Energetic impacts of passage delays in migrating adult Atlantic salmon** *Sarah Rubenstein, University of Maine*
9:50	10:05	**Movement and survival of Atlantic salmon Salmo salar in the Piscataquis River** *Alejandro, Molina-Moctezuma, University of Maine, Department of Wildlife, Fisheries, and Conservation Biology*
10:05	10:35	**BREAK -** *refreshments provided*
10:35	10:50	**Governance of the Atlantic salmon program** *Julie Crocker, Greater Atlantic Regional Fisheries Office, NOAA Fisheries*

10:50	11:05	**Does leadership have a role in collaborative environmental governance?** *Melissa Flye, University of Maine*
11:05	11:20	**Fish passage decision-making during hydropower relicensing in the Kennebec and Penobscot Rivers, Maine** *Sarah K Vogel, University of Maine, Dept of Wildlife, Fisheries, and Conservation*
11:20	11:35	**Maine DOTs Part in Atlantic Salmon Recovery** *Eric Ham, Maine DOT*
11:35	11:50	**Ecosystem implications of restoration evaluated through modeling** *Adrian Jordaan, University of Massachusetts Amherst*
11:50	12:05	**NRCS Aquatic Connectivity Project** *Juan Hernandez, Natural Resources Conservation Service* *Judy Camuso, Maine Department of Inland Fisheries and Wildlife* *Patrick Keliher, Maine Department of Marine Resources*
12:05	13:05	**LUNCH -** *lunch at the Student Union (not provided)*
13:05	13:10	**Session VI: Watershed Restoration and Emerging Recovery Tools** *Carl Wilson, Maine Department of Marine Research, Moderator*
13:10	13:25	**The Anatomy of Watershed Scale Restoration** *Molly Payne Wynne, The Nature Conservancy*
13:25	13:40	**Narraguagus River Conservation Plan: Ecosystem based co-management for the next 20 years?** *Jacob van de Sande, Maine Coast Heritage Trust*
13:40	13:45	**Upper Narraguagus Watershed: Restoring habitat and managing expectations (Part I)** *Joan G. Trial, Project SHARE*
13:45	14:00	**Evaluation of bed mobility using PIT-tagged tracer particles on the Narraguagus River, Maine** *Douglas M. Thompson, Environmental Studies Program, Connecticut College*
14:00	14:15	**Strategic Habitat Conservation in the Upper Narraguagus River: Using best available science to identify high priority restoration areas-actions intended to improve juvenile Atlantic salmon production in a catchment with ideal channel gradients and overall adequate summer time thermal conditions.** *Scott D. Craig, U.S. Fish and Wildlife Service*
14:15	14:30	**Managing for More Productive and Resilient Atlantic Salmon Habitat in the Narraguagus River, Maine** *Christopher M Federico, Project SHARE*
14:30	14:40	**Upper Narraguagus Watershed: Restoring habitat and managing expectations**

(Conclusion)
Joan G. Trial, Project SHARE

14:40 15:10 **BREAK –** *refreshments provided*

15:10 15:25 **The Maine-eDNA EPSCoR program and its ties to Maine's salmon ecosystems**
Michael Kinnison, University of Maine, School of Biology and Ecology, Orono, ME, USA

15:25 15:40 **Comparative assessment of environmental DNA and backpack electrofishing methods for estimating Atlantic salmon occupancy and abundance**
Bradley F. Erdman, University of Maine

15:40 15:55 **Experimental assessment of optimal lotic eDNA sampling and assay multiplexing for Atlantic salmon**
Zachary T. Wood, University of Maine

15:55 16:10 **Untying a Gordian knot: Collective salmon recovery on the East Machias**
Dwayne P. Shaw, Downeast Salmon Federation

16:10 16:25 **Fort Folly First Nation's ambitious plan to restore endangered inner Bay of Fundy Atlantic salmon to the Petitcodiac River**
Tim Robinson, Manager Fort Folly Habitat Recovery program Fort Folly First Nation

16:25 16:40 **Salmon for Maine's Rivers: A New Partnership for Recovery**
Danielle Frechette, MDMR

16:40 16:55 **Using a Keystone Management Species to support Ecosystem Based Management?**
Sean Hayes, NOAA Fisheries

16:55 17:00 **Student Awards, Species in the Spotlight Award and Adjourn**
Jen Anderson, Assistant Regional Administrator for Protected Resources, NOAA Fisheries

ADJOURN

Invited Session (Day 1, Morning):

Time flies – Atlantic salmon as an endangered species twenty years later… (Part 1 of 2)

Moderator:
Joshua Royte, The Nature Conservancy

Reflections on Penobscot River Atlantic Salmon: Before and After Listing as an Endangered Species

Edward T Baum, Maine Atlantic Sea-Run Salmon Commission (Retired)

Modern day Atlantic salmon restoration efforts in the Penobscot River Drainage were initiated approximately 50 years ago, primarily as a result of the passage of federal programs such as the Anadromous Fish Conservation Act of 1965, and the Clean Water Act of 1972. The construction of new or improved upstream fish passage facilities at mainstem and tributary obstructions and the addition of a second federal smolt rearing facility in 1974 (Green Lake NFH), coupled with "conventional" marine survival rates for hatchery-reared salmon and declining rates of exploitation in some distant water commercial fisheries, resulted in escalating adult Atlantic salmon returns to the Penobscot. Liberal State sport fishing regulations in effect during the 1970s and 1980s resulted in widespread interest in and support for angling for "the king of gamefish." The 100-year-old Penobscot Salmon Club, defunct for >20 years, reopened to new members and three additional Atlantic salmon fishing clubs arose to meet an unsustainable demand for accessible Atlantic salmon fishing at bargain prices compared to nearby Canadian rivers. Rapidly declining adult salmon returns beginning in the late 1980s led to a 1993 petition to list Maine Atlantic salmon under the Endangered Species Act. The 7-year period required to list the species under the ESA in 2000 was marked by contentious meetings among stakeholders, a flawed effort by the State to prepare a management plan designed to avert the need for listing and a lengthy legal battle to stop the listing process altogether. Once State efforts to prevent the listing ceased however, and stakeholders potentially impacted by the listing determined that it would not be the economic disaster that had been predicted, a genuine Atlantic salmon recovery plan for the Gulf of Maine Distinct Population Segment (which included the Penobscot River) was prepared utilizing the guidelines of the ESA. Comparisons are made between the first 30 years of salmon restoration efforts, with rising adult salmon returns and sport catches, versus the last 20 years under the Endangered Species Program, with stagnant adult returns and the closure of most sport and commercial fisheries. While significant steps toward salmon recovery have occurred since listing, the lack of improved salmon returns, and the closure of traditional sport fisheries has been disappointing. Recommendations for the future are presented.

Corresponding Author: Edward T Baum, baumeded@roadrunner.com, (207) 949-2971

From North America to West Greenland and Beyond: management of Atlantic salmon in the North Atlantic

Martha Jean Robertson, Fisheries and Oceans Canada, Newfoundland and Labrador, Canada

As Parties to the Convention for the Conservation of Salmon in the North Atlantic (1982) and North Atlantic Salmon Conservation Organization (NASCO) (1984), Canada and the United States of America have committed to the management of Atlantic salmon through international cooperation. Scientific advice to NASCO is requested annually from the International Council for the Exploration of the Sea (ICES) Working Group on North Atlantic Salmon (WGNAS). This request generally includes the status of stocks, salmon catches and landings, new threats to or opportunities for Atlantic salmon, and every three years, catch options for the West Greenland mixed-stock fishery. As the Chair of ICES WGNAS, I will present an overview of the international scientific process and the 2019 advice to NASCO.

Corresponding Author: Martha Jean Robertson, Martha.Robertson@dfo-mpo.gc.ca

Science for comfort or conservation- how do we inform and avoid action on fish passage?

Joseph D Zydlewski, U.S. Geological Survey, Maine Cooperative Fish and Wildlife Research Unit & University of Maine, Dept. of Wildlife, Fisheries, and Conservation Biology

For Atlantic salmon, there is consensus among managers and the science community that: i) the lack of safe, timely and effective dam passage is a fundamental constraint to Atlantic salmon recovery, ii) hatchery supplementation has prevented the abrupt extinction of the population, but not its slow degradation, and iii) the status quo will have a predictable and undesired outcome for recovery. For more than a decade and a half, I have been part of effective collaborations with NOAA, USFWS, PIN, MDMR, UMO and hydropower companies to inform questions of passage for both adult and juvenile Atlantic salmon in the Penobscot River. In some cases, these data have been considered for operational decisions, FERC processes and stocking strategies. In other cases, there was a failure to integrate information into recovery action due to inconvenience and comfort. Because no amount of research can move the species to recovery without influencing management actions, it is worthwhile to reflect, as a community of stakeholders, on the degree to which some research efforts have been integrated or ignored. Have cognitive biases and objectives unrelated to recovery shaped our indecision?

Corresponding Author: Joseph Zydlewski, josephz@maine.edu, (207) 581-2853

Using decision support tools to plan for salmon restoration

Erik H Martin, The Nature Conservancy

Decision support tools can leverage quantitative information to help inform restoration planning and focus scarce resources where they can have the most benefit. The Nature Conservancy, along with multiple partners and funding sources, has recently developed a statewide prioritization tool that can help identify priority restoration options at the barrier scale, including both dams and culverts. Additional related tools and analyses have been produced that can help assess and track progress towards restoration goals, for example by quantifying the number of habitat units in a watershed that are accessible to salmon returning from sea. This presentation will provide a brief overview of these tools and how they can be used by the conservation community.

Corresponding Author: Erik Martin, emartin@tnc.org, (207) 6074826

6 ½ & 19 years Maintaining and Perfecting SHARE's Mission Focus

Steven D. Koenig, Project SHARE

Project SHARE is a non-profit conservation group created in 1994 with a specific mission to improve habitat for Atlantic salmon in the Downeast SHRU. At a time when endangered species listings were highly contentious and litigious, SHARE was inspired as a new model for cooperative conservation. Over the past 25 years SHARE has developed and strengthened relations with landowners, agency biologists, and regulatory staff paving the way for an active habitat restoration program. Successes include implementation of several hundred connectivity and habitat suitability restoration projects framed in a concentrated, process-based focus area approach. SHARE's outreach program features habitat restoration workshops that are regularly attended by practitioners from the New England states and Maritime Provinces. This presentation will provide observations and comments regarding areas where challenges that may impede Atlantic salmon recovery still exist in the Downeast SHRU. These challenges include consistent capacity, communication, and priorities. It will conclude with thoughts on the various future paths Project SHARE and recovery actions in the Downeast SHRU may take.

Corresponding Author: Steven D Koenig, stevenkoenig0@gmail.com, (207) 853-0931

Two Decades on the Front Line of Salmon Protection in Maine: A Perspective by the Atlantic Salmon Federation's Andrew Goode

Andrew Goode, The Atlantic Salmon Federation

The decline of Atlantic salmon has been referred to as 'death by a thousand cuts'. While this is an apt description, significant progress has been made over the past 20 years in salmon's freshwater and saltwater environment to address the worst of these wounds. A shift to holistic river restoration, including dam removals and a multi-species approach, has garnered a positive response from many sea-run fisheries, yet maybe too early for salmon. Reforms in the salmon farming and the blueberry industry have been crucial and the increase in partners and resources bodes well for the future. At the same time, climate change threats are growing and salmon stocks remain depressed. We will need to build upon our past successes, rely on the best science, seek long- term solutions, and implement new laws and regulations that recognize the full range of benefits that Maine rivers provide in order for salmon to have a chance of recovery in the US.

Corresponding Author: Andrew Goode, Atlantic Salmon Federation

Private forest landowners and aquatic partners getting things done

Patrick Thomas Sirois, Maine's Sustainable Forestry Initiative (SFI) Implementation Committee

The recovery plan for Atlantic salmon notes that improvements to stream connectivity are a necessary ingredient to the salmon recovery program. The vast majority of road crossings in headwater areas are privately owned by commercial forests interests. Thus, a necessary component for improving connectivity is a willingness of private landowners to cooperate and collaborate even in the face of potentially contentious issues and political climates. A collaborative model where willing landowners share information and respond to priorities expressed through a cooperative discussion with non-governmental organizations and natural resource agency representatives is a model that could be built upon to further advance connectivity in Maine's watersheds, and thus recovery of endangered Atlantic salmon. I will discuss such an approach that we call the Fisheries Improvement Network (FIN) and provide examples of the types of gains that can be made using such a collaborative model.

Corresponding Author: Patrick Thomas Sirois, psirois@maineforest.org, (207) 837-0101

Invited Session (Day 1, Afternoon):

Time flies – Atlantic salmon as an endangered species twenty years later… (Part 2 of 2)

Moderator:
Christopher Meaney, US Fish and Wildlife Service

Evaluation of genetic diversity in Maine Atlantic salmon

Meredith L. Bartron, USFWS Northeast Fishery Center, Lamar, PA
Shannon E. Julian, USFWS Northeast Fishery Center, Lamar, PA
Jeff Kalie, USFWS Northeast Fishery Center, Lamar, PA
Denise Buckley, USFWS Craig Brook National Fish Hatchery, East Orland, ME
Oliver Cox, USFWS Green Lake National Fish Hatchery, Ellsworth, ME

Recovery of Atlantic salmon in Maine incorporates factors related to abundance, distribution, and diversity. All three components relate in some manner to the genetic diversity that is maintained in each of the remaining Maine Atlantic salmon populations, in addition to how that genetic diversity is partitioned across the populations. Historically, rivers in Maine and other New England states sustained many Atlantic salmon populations, resulting in the greater ability to retain genetic diversity over time. As both population sizes and the number of populations across their range has declined over time, the ability to maintain genetic diversity has been impacted. Reductions in gene flow, the threat of inbreeding, and low numbers of reproducing individuals limit the ability of genetic variation to be retained within populations over time. As a result, contemporary populations rely on hatchery supplementation to sustain populations and maintain the remaining genetic diversity present. Without hatchery intervention, populations would not be able to sustain themselves due to very limited natural reproduction in the wild. Given the importance of the hatchery program to prevent extinction, genetic data is used to monitor genetic diversity, evaluate management practices, and track pedigrees over time. Current practices have been effective at maintaining genetic diversity, but the alteration of selection regimes and long term population declines as well as ongoing population threats continue to impact the maintenance of genetic diversity and subsequently the persistence of Atlantic salmon in Maine. Here we will evaluate how genetic diversity in Maine Atlantic salmon populations has changed over time, how genetic data is used to inform current management strategies to limit further reductions, and challenges to the retention of genetic diversity in the future.

Corresponding Author: Meredith L Bartron, meredith_bartron@fws.gov, (570) 726-4247

20 Years of the Atlantic Salmon Stocking Program

Ernie Atkinson, *Maine Department of Marine Resources*
Justin R. Stevens, *Maine Sea Grant College Program*
Denise Buckley, *US Fish and Wildlife Service, Craig Brook National Fish Hatchery*

Stock enhancement has been at the heart of the Atlantic Salmon program in Maine since Commissioner Atkins opened the first federal hatchery for Atlantic Salmon in the late 1800's. Since then, Maine's rivers have seen 100's of millions of hatchery products released with the hope of positively affecting salmon populations. These products have increased the amount of occupied habitat, increased in-stream densities, and supplemented populations in Maine's rivers. Looking back over the past 20 years, the salmon program has seen some of its largest advances in husbandry techniques and stocking strategies. The program has also continually adapted to shifting management landscapes to accomplish these stocking strategies. We'll explore the evolution of river-specific stocking in Maine from a fry dominated program to the more diverse portfolio of strategies including eggs, parr, smolts and adults. Further, we will provide insight into strategy evaluation and adaptive management decisions addressing challenges and successes. Although population recovery is still the unmet goal being pursued, the stocking program has succeeded in preventing extinction and improving the genetic diversity of the DPS. In addition, the program has a broad suite of life stages available to meet manager's desires for particular habitat. Fry stocking techniques have been improved through the addition of extensive habitat data. Egg stocking reduces the hatchery influence and allows the most natural exposure for hatchery products. Smolt stocking has improved through the application of telemetry studies to inform survival patterns. Parr life stages have enabled marginal quality habitat to support juveniles. Adult stocking has allowed habitat modification and mate selection in Maine rivers while sea-run returns remain low. Looking to the future, we know have the largest selection of tools and information available to effectively and efficiently manage salmon but will this help move toward recovery of this long imperiled species? Perhaps, but in the iconic words of Winston Churchill "*Those who fail to learn from history are condemned to repeat it.*" Therefore the program must ensure that strategic evaluation and adaptation be implemented into the stocking to position the program for its best opportunity at meeting recovery goals.

Corresponding Author: Ernie Atkinson, Ernie.atkinson@maine.gov, (207) 434-5921

Marine-phase Atlantic salmon

Timothy F. Sheehan, *NOAA Fisheries Service, Northeast Fisheries Science Center*

Conceptually, managing Atlantic salmon is easy. We can define the ecological needs of the species to support robust populations and we generally have the tools to mitigate threats to salmon productivity with the exception of increased natural marine mortality due to a changing climate. Over the past few decades, large declines in abundance have been noted across the species range, in particular the multi-sea winter components of the southern stock complexes. These declines have largely been attributed to factors acting on survival at sea. Survival at sea has been demonstrated to have a disproportionate influence on population productivity, but despite decades of research we still have an incomplete mosaic of the species' marine ecology, especially compared to freshwater. Our current understanding of the marine ecology of Atlantic salmon represents a cumulative progression of work performed over six decades by countless individuals from numerous countries and institutions across the species range. During the late 1950's a number of tagging programs were initiated, which were followed by numerous marine surveys that prompted and supported many novel investigations. The culmination of decades of work has resulted in a few seminal papers that have begun to disentangle the ecosystem drivers of salmon marine productivity. Research efforts continue to combine archived datasets, samples, and existing technologies with new techniques, approaches and processes to answer important questions about feeding migrations, marine distribution and trophic ecology. Many multidisciplinary collaborations are supporting the development of more complex and realistic models that continue to advance our understanding of the mechanisms driving marine survival. The culmination of these efforts support the hypothesis that in its current state the North Atlantic Ocean is not able to support Atlantic salmon populations at historical levels. This could be a cyclic phenomenon, but temperatures are expected to increase over the next century and the prospectus for Atlantic salmon in the North Atlantic is expected to be challenging with the potential for both northerly range expansion and southerly retraction. This however is not a call to surrender. Improved understanding of the marine ecology of Atlantic salmon is needed to more clearly define the drivers of marine productivity to more effectively guide and gauge the efficacy of our recovery program and the actions undertaken.

Corresponding Author: Timothy F. Sheehan, 508-495-2215, Tim.Sheehan@noaa.gov

Opportunities for More Salmon - Let's Do Some Numbers

John Kocik, NOAA Fisheries Service, Northeast Fisheries Science Center

For over 300 years, Atlantic salmon populations have been impacted by freshwater habitat loss, dams, fisheries, and pollution throughout Maine. With modern (1970) recovery efforts, abundance trajectories were upward until about 1990. At that point, marine survival declined precipitously and has remained at a lower baseline for more than 25 years. While a better understanding of marine ecology is important, an outcome of a multi-year NASCO effort on survival at sea recommended that managers "maximise the number of healthy wild salmon that go to sea from their home rivers, since management options in the ocean are limited." Some have suggested that Gulf of Maine populations can not be viable under current marine survival regimes. To examine management options under marine conditions of the past 25 years, I retrospectively examined potential of interventions based on historical data and current literature. My approach was to 1) examine existing data from the modern era, 2) assess current science on a potential management action, and 3) simulate the potential impact of an action to illustrate changes in spawner abundance and the expected level of marine variation. I examined two actions targeted on marine survival (genetic diversity and improved hatchery smolt performance at sea) and two focused on increased freshwater production (increasing occupancy of vacant habitat and increased habitat quality). Simulations suggest that successful implementation of these management actions could increase baseline populations but the impact of low and variable marine survival is still evident.

Corresponding Author: John F Kocik, John.Kocik@noaa.gov, (207) 866-7341

Lost & Found: Communicating the Science of Endangered Species

Catherine Schmitt, Schoodic Institute, Acadia National Park

Communication with public audiences is needed to gain support for endangered species recovery. Yet as wild Atlantic salmon have declined from historic highs, New England residents and visitors have lost collective or social memory of a culturally and economically important animal, complicating information exchange about the species and the science of saving salmon. Efforts seeking to restore watershed connections to the sea draw upon stories from the past about communities and their historic commercial, recreational, and subsistence fisheries. Scientists are called upon to explain research and management measures. How effective are these different approaches? Much has changed in the 20 years since Endangered Species Act listing—have related communications reflected these changes? This presentation will review the challenges of endangered species communication, and encourage participants to consider other ways and means of talking and writing about salmon.

Corresponding Author: Catherine Schmitt, cschmitt@schoodicinstitute.org, (207) 9441587

Contributed Session I (Day 1, Afternoon):

Age, Growth, Environmental Stressors

Moderator:
Dan McCaw, Penobscot Indian Nation

Linking ocean temperature phenology to migration timing of Atlantic salmon in the Penobscot River

Katherine Mills, Gulf of Maine Research Institute
John Kocik, NOAA Fisheries, Northeast Fisheries Science Center, Atlantic Salmon Ecosystems Research Team
Owen Mulvey-McFerron, University of North Carolina, Institute of Marine Sciences
Jason Valliere, Maine Department of Marine Resources
Andrew Thomas, University of Maine, School of Marine Sciences
Miguel Barajas, University of Maine, School of Marine Sciences

The migration phenology of Atlantic salmon (*Salmo salar*) adults returning to the Penobscot River, Maine, has changed substantially over recent decades. The median date of the returning run of Atlantic salmon has advanced by over a month since 1978, with even stronger advances in dates of later portions of the run. As such, the majority of the run (between 5th and 95th percentiles of returning fish) now occurs earlier and in a much more condensed period of time than it has in the past. These seasonal advances in run timing are associated with shifting ocean temperature phenology—particularly the length of winter—in Atlantic salmon overwintering habitat around Newfoundland. In this area, calculations with daily Optimum Interpolation Sea Surface Temperature time series using a location-specific temperature threshold (*i.e.*, Thomas *et al.* 2017) show the duration of winter has become shorter since 2000. These shorter winters are associated with earlier returns of Penobscot River Atlantic salmon. The advance in migration timing and loss of late-returning fish has potential consequences for the population, as trait diversity may be narrowed with the loss of unique traits and growth patterns in late-returning fish.

Corresponding Author: Katherine Mills, kmills@gmri.org, (207) 228-1657

Growing faster but dying younger? Scale analysis of North American Atlantic salmon captured in Greenland suggests increased growth at sea despite declining marine survival.

Michael D. Tillotson, Gulf of Maine Research Institute
Katherine E. Mills, Gulf of Maine Research Institute
Timothy F. Sheehan, NOAA Fisheries
Ruth E. Haas-Castro, NOAA Fisheries

Atlantic salmon populations throughout their distribution have experienced generally low productivity since the early 1990s. Given the broad geographic scale of this phenomenon and the apparent stability of freshwater production in populations where it has been assessed, the working hypothesis continues to be that a shift towards unfavorable conditions at sea is responsible for reduced lifetime survival. Accompanying the decline in marine survival has been an apparent shift in the age composition of the returning adults with increasing prevalence of 1SW in returns. While several plausible mechanisms may account for this trend, the simplest seems to be a proportionally larger decline in survival during the second year at sea. Retrospective analyses of growth based on scale or otolith samples have helped to illuminate the mechanisms of recruitment variation in salmon populations. Growth histories read from scales reflect the integrated environmental and trophic conditions experienced by an individual and, in aggregate, can indicate how harsh or favorable conditions were for salmon at sea. As such, growth may serve as a suitable proxy for partitioning marine survival between years at sea. Using growth increments from over 5,000 scales of North American Atlantic salmon – primarily captured in the Greenland fishery – between 1968 and 2018, we sought to describe long-term trends in growth and evaluate support for the hypothesis that conditions experienced during the second year at sea caused a decline in growth and survival during the early 1990s. To this end, we partitioned each scale into three periods based on growth markers: freshwater, freshwater entry to first marine annulus (first-year) and after the first marine annulus (second-year). Freshwater growth generally declined over time for smolt of most ages. First year marine growth was relatively low from the mid-1980s to mid-1990s compared to earlier and later years. Finally, and contrary to expectation, second-year marine growth increased over the time series. We provide alternative hypotheses for this unexpected trend and emphasize the complex interactions that can occur between growth, size-selective mortality and size-dependent maturation.

Corresponding Author: Michael D. Tillotson, mtillotson@gmri.org

Linking Ecosystem Change, Growth, and Survival of Penobscot River Atlantic Salmon

Miguel F Barajas, Gulf of Maine Research Institute
Katherine E Mills, Gulf of Maine Research Institute
Timothy F Sheehan, Northeast Fisheries Science Center
Ruth E Haas-Castro, Northeast Fisheries Science Center

Beginning in the 1980s, return rates of Atlantic salmon to the Penobscot River, Maine U.S.A. declined and have persisted at critically low levels. The timing of this decline coincided with similar widespread declines of North American and European Atlantic salmon stocks as well as with major physical and biological shifts in the Northwest Atlantic ecosystem. Prior studies using scale pattern increment analysis suggest that the declines of European stocks are related to decreased post-smolt growth whereas declines of North American stocks have not shown the same relationship, suggesting that marine survival of North American salmon stocks is somewhat growth-independent. We constructed a time series of growth data based on scales of Atlantic salmon returning to the Penobscot River for smolt-years spanning four productivity periods—1978-1980, 1986-1988, 1998-2000, and 2012-2014. The growth data were analyzed to determine if and how growth patterns have changed over the four productivity periods and to identify seasons during which the changes have occurred. Preliminary results indicate that the declining growth during late marine stages and the loss of slow-growing fish are associated with reduced marine survival in this population.

Corresponding Author: Miguel F Barajas, mbarajas@gmri.org, (207) 577-5087

Marine migration of Atlantic salmon smolt and kelt from a Canadian River (Western Arm Brook, Newfoundland and Labrador).

Nicholas I. Kelly, Fisheries and Oceans Canada, St. John's, NL, Canada
Martha Robertson, Fisheries and Oceans Canada, St. John's, NL, Canada
Steven Duffy, Fisheries and Oceans Canada, St. John's, NL, Canada
Jon Carr, Atlantic Salmon Federation, Chamcook, NB, Canada
Glenn T. Crossin, Dalhousie University, Halifax, NS, Canada

Marine survival continues to be the primary factor influencing trends in abundance of adult Atlantic salmon (*Salmo salar*) in Newfoundland and Labrador, Canada. Improving our understanding of the temporal and spatial distribution of different life stages of Atlantic salmon during their marine migration is critical in order to predict how physical and biological factors impact their behaviour and survival at sea. In 2018 and 2019, we captured and tagged Atlantic salmon during their downriver migration on Western Arm Brook. Smolts were tagged with acoustic transmitters (VEMCO V8 and V9) and kelts with both acoustic transmitters (VEMCO V9 and V13) and Passive Integrated Transponder (PIT) tags (Oregon RFID, 25 mm). Acoustic receivers deployed nearshore in St. Barbe Bay, across the Strait of Belle Isle and off of Port Hope Simpson, Labrador, provided detection data to estimate survival and migration timing of salmon leaving Western Arm Brook, through St. Barbe Bay (~ 5 km), the Gulf of St. Lawrence (~ 30 km) and into the South Labrador Sea (~ 160 km). Combining detection data from acoustic receivers in the marine environment and a PIT station on Western Arm Brook provided estimates of kelt survival and migration duration. Temperature and depth data were collected by acoustic receivers throughout the study area from acoustic tags (V13TP) implanted in 22 kelt in 2019. The thermal occupancy of kelt in the Gulf of St. Lawrence and South Labrador Sea was concentrated around 7 to 8˚C. Kelt occupied surface waters with an average individual depth of 3.2 to 7.1 m and maximum depths ranged from 4 to 87 m. Together, these data provide valuable information that can inform future modeling efforts to understand how environmental factors influence the spatial and temporal distribution, behavior and survival of these fish during their marine migration.

Corresponding Author: Nicholas I Kelly, Nicholas.Kelly@dfo-mpo.gc.ca, (709) 772-4553

Assessing the effects of multiple stressors on the estuarine and early marine survival of Atlantic salmon postsmolts

Brent Wilson, Fisheries and Oceans Canada
Marc Trudel, Fisheries and Oceans Canada
Claire Rycroft, Dalhousie University
Jon Carr, Atlantic Salmon Federation
Jason Daniels, Atlantic Salmon Federation
David Hardie, Fisheries and Oceans Canada
James Hawkes, NOAA Fisheries
Chris McKindsey, Fisheries and Oceans Canada
Fred Page, Fisheries and Oceans Canada
Shawn Robinson, Fisheries and Oceans Canada
Émilie Simard, Fisheries and Oceans Canada
Fred Whoriskey, Ocean Tracking Network
Glenn Crossin, Dalhousie University

Atlantic salmon have been extirpated from several of their native rivers and often fail to meet conservation requirements, particularly populations in the Bay of Fundy and northeastern United States. Although multiple factors likely contributed to these declines, such has habitat destructing, overfishing, and climate change, the cumulative effects of multiple stressors on the survival of Atlantic salmon is poorly understood. Here, we present the results of an acoustic telemetry project to assess the population response of Atlantic salmon to multiple stressors during a critical period of their life cycle, including passage through a hydropower system and bycatch mortality associated with in-river fisheries. We also assessed their migration routes and survival rates during their early marine life and whether there is any interactions with aquaculture. For this project, a total of 160 smolts were tagged with pressure and temperature sensor acoustic tags and released above and below a hydropower dam, before and during a commercial alewife fishery. A total of 129 acoustic receivers were placed in the river and estuary of the Magaguadavic River (New Brunswick, Canada), at all passages in Passamaquoddy Bay, as well as at twenty-three salmon aquaculture sites located in three Bay Management Areas (stocked with year 1 or year 2 fish, or in fallow). It is anticipated that this research will provide information necessary to develop effective mitigation strategies to limit associated threats, and aid in the recovery of wild salmon populations.

Corresponding Author: Brent M Wilson, brent.wilson@dfo-mpo.gc.ca, (506) 529-5910

Natural transmission routes at sea and influences of coastal aquaculture on infection profiles of wild Atlantic salmon

Amy K. Teffer, Department of Forest and Conservation Sciences, University of British Columbia, Vancouver, BC
Jonathan Carr, Atlantic Salmon Federation, Chamcook, NB
Amy Tabata, Pacific Biological Station, Fisheries and Oceans Canada, Nanaimo, BC
Angela Schultze, Pacific Biological Station, Fisheries and Oceans Canada, Nanaimo, BC
Ian Bradbury, Salmonids Section, Fisheries and Oceans Canada, St. John's, NF
Denise Deschamps, Ministère des Ressources naturelles et de la Faune du Québec, Direction de la recherche sur la faune, QC
Carole-Anne Gillis, Gespe'gewaq Mi'gmaq Resource Council, Listuguj, QC
Eric B. Brunsdon, Atlantic Salmon Federation, Chamcook, NB
Gideon Mordecai, Department of Earth and Ocean Sciences, University of British Columbia, Vancouver, BC
Kristina M. Miller, Pacific Biological Station, Fisheries and Oceans Canada, Nanaimo

Infective agents are key components of animal ecology and drivers of host population dynamics. As such, a firm knowledge of their diversity and transmission in the wild is necessary for host species management and conservation. Infective agent transmission among wild Atlantic salmon (*Salmo salar*) is hypothesized to occur during population mixing at sea and as a result of aquaculture exposure during spawning migration. We tested these hypotheses using a molecular approach that identified infective agents and transmission potential among sub-adult Atlantic salmon at marine feeding grounds and returning adults in three eastern Canadian rivers with varying aquaculture influence. We used high-throughput qPCR to quantify infection profiles and next generation sequencing to measure genomic variation among viral isolates. We identified 14 agents, including seven not described in peer reviewed literature as occurring in eastern Canada. Infection profiles varied relative to environmental conditions, life stage, and host origin. Our findings identify research opportunities regarding transmission dynamics and associated pathologies among wild fishes.

Corresponding Author: Jonathan Carr, 506-754-5079, jcarr@asf.ca

Age structure of non-reproductive, partial migratory populations of sturgeon species in the Penobscot River, Maine

Catlin Ames, School of Marine Sciences, University of Maine, Orono, ME
Gayle Zydlewski, School of Marine Sciences, University of Maine, Orono, ME
Michael Kinnison, School of Biology and Ecology, University of Maine, Orono, ME
Joseph Zydlewski, US Geological Survey - Maine Cooperative Fish and Wildlife Research Unit and Department of Wildlife, Fisheries, and Conservation Biology, University of Maine, Orono, ME

Age structure of recovering populations of anadromous Atlantic (*Acipenser oxyrinchus*) and Shortnose sturgeon (*A. brevirostrum*) are not well understood in the Gulf of Maine. Historically, the Penobscot River supported large populations, suggesting cohorts with successful recruitment, but both species were thought to be extirpated from the system due to overharvest and loss of essential habitat from the construction of dams in the early 1900s. In 2006, both species were observed in the Penobscot River and, after a decade of research on movement patterns, it was suggested that these individuals were partial migrants from the Kennebec system. Extensive efforts to determine if reproduction is occurring in the Penobscot River have been inconclusive, but telemetry studies have shown evidence of fidelity to the Penobscot by both species. Currently, population sizes and habitat use are fairly well understood in the Penobscot River, but age structure is unknown. Our goal was to address this question by developing an age-at-length model for these species. Over the last decade, gill netting surveys were used to obtain pectoral fin spine samples from Atlantic (n=22) and Shortnose sturgeon (n=102). For comparison of readability and application of a less deleterious method, a subset (n=12) of individuals had the second marginal fin ray removed. Individual fork lengths ranged from 70.4 – 173.5 cm (Atlantic) and 60.4 – 110.4 cm (Shortnose). Analyses are ongoing, but preliminary results suggest that Atlantic Sturgeon captured in the Penobscot River average 14 ± 5 (SD) years old and Shortnose sturgeon are closer to 10 ± 3 years. Individuals under age 4 of either species were not observed, supporting the hypothesis that Penobscot River sturgeon are partial migrants from other systems. Second fin rays were easy to obtain, but difficult to read with 60% of all samples either unreadable or difficult to differentiate annuli. Age estimates of Shortnose Sturgeon were similar to historical records from the Kennebec River, and Atlantic Sturgeon were generally younger than individuals found in higher latitudes (e.g. Bay of Fundy). These data are being used to address critical research demographic characteristics of imperiled sturgeon species in the Gulf of Maine portion of their range.

Corresponding Author: Catlin Ames, catlin.ames@maine.edu, (207) 581-4372

Aquaculture as a part of the Salmon Ecosystem: NOAA and Sea Grant projects in Maine

Gayle Zydlewski, Maine Sea Grant
Dana Morse, Maine Sea Grant
Christopher Bartlett, Maine Sea Grant
Jaclyn Robidoux, Maine Sea Grant

Maine Sea Grant sponsors scientific research informed by those who depend on Maine's coastal and marine resources. Our contributions to aquaculture research, outreach, and education over nearly four decades include support for applied research and technology transfer initiatives that have advanced and improved culture methods, infrastructure, and collaboration in the shellfish and sea vegetable aquaculture industry. The program has supported research and provided networking and coordination for efforts to address finfish and shellfish disease and related management issues, playing a leadership role in the state's efforts to develop aquaculture education and training opportunities for K-12 audiences, undergraduate and graduate students, and professionals seeking to enter the aquaculture industry. These and current efforts will be discussed.

In Sep 2019 National Sea Grant announced $16 million in federal funding awards to support 42 research projects and collaborative programs aimed at advancing sustainable aquaculture in the United States. Maine Sea Grant and researchers at the University of Maine, other institutions, and partner organizations received $1.6 million to lead four of the projects in collaboration with aquaculture industry, management and community partners. One funded project established the Maine Aquaculture Hub, coordinated by Maine Sea Grant, with the goal of building capacity for industry-driven innovation, diversification and workforce development. The Maine Hub is intended to help the aquaculture industry overcome barriers associated with commerce, permitting and policies, new species, production systems, and seafood safety and quality with a sustainable approach. The award will also help train entrants to the aquaculture industry and support workforce development for existing aquaculture businesses through an expansion of the Aquaculture in Shared Waters training program, established by the project collaborators in 2013. Maine Sea Grant is involved in two other established collaborative hubs. One being led by Maryland Sea Grant to build capacity of land-based Atlantic salmon aquaculture in the U.S with the intent of establishing a coordinated national effort to review and identify challenges and bottlenecks, and develop a road map and comprehensive strategic plan to address and overcome them. Finally, Connecticut Sea Grant is establishing the National Sea Grant Seaweed Hub, to provide stakeholders with information to make better-informed decisions. Maine Sea Grant staff are involved in all of these hubs. Planned activities for all of the hubs will be discussed.

Corresponding Author: Gayle B Zydlewski, gayle.zydlewski@maine.edu, (207) 581-1422

Contributed Session II (Day 2, Morning):

Movement Barriers, Fish Passage, and Ecosystem Response

Moderator:

Joseph Zydlewski, US Geological Survey - Maine Cooperative Fish and Wildlife Research Unit and Department of Wildlife, Fisheries, and Conservation Biology, University of Maine

Examining dispersal of point stocked Atlantic salmon (*Salmo salar*) fry relative to habitat qualities in streams in eastern Maine, USA

Ernest Atkinson, Maine DMR and University of Maine
Joseph, Zydlewski, U.S. Geological Survey, Maine Cooperative Fish and Wildlife Research Unit, University of Maine Department of Wildlife, Fisheries, and Conservation Biology

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, but risks domestication effects. Egg planting and fry stocking replicate the natural spawning process in streams and provide a natural experience which can be important to maintaining wild traits. However, survival and dispersal behavior of salmon fry immediately after emergence from eggs planted in artificial nests is poorly characterized with respect to spatial distribution and the influence of habitat quality. To address these uncertainties, dispersal of salmon fry planted as eyed eggs during the winter of 2019 was observed during the first year of growth across nine, two-kilometer reaches. These reaches represent “high”, “medium” and “low” quality rearing habitat. At the end of the first growing season, there was no observed difference in abundance throughout the study reaches indicating substantial movements post-emergence for some individuals. Growth was greater for those found further from planting locations. Both growth and abundance were greater in higher quality habitats. We anticipate that the results of this study will inform decisions related to stocking intervals, habitat use, and stocking rates by the creation of an index of suitability based on juvenile salmon presence and abundance.

Corresponding Author: Ernest J Atkinson, ernest.atkinson@maine.edu, (207) 271-7195

Forecasting the downstream migration of adult silver phase American eels

Dan Weaver, University of Maine
Douglas B. Sigourney, NOAA Fisheries
Mari-Beth Delucia, The Nature Conservancy
Joseph D. Zydlewski, U.S. Geological Survey

American Eel (Anguilla rostrata) is a catadromous species ubiquitous in coastal waters of the eastern United States. Beginning in late summer, silver phase eels migrate from freshwater systems out to the Sargasso Sea to spawn. During downstream migration they face substantial injury and mortality passing through hydroelectric facilities. Improved predictions as to the timing and magnitude of eel migrations may inform mitigation actions (e.g., operational shutdowns) to reduce injury and mortality. We used a 30-year data set consisting of daily eel catch and environmental variables (discharge, temperature, moon phase, ordinal date) among several Northeastern US rivers. We constructed generalized additive models and generalized linear mixed models with a Bayesian hierarchical framework to describe the relationships between variables and the migration of silver eels. A Bayesian hierarchical approach effectively estimated parameters and error structure across multiple systems. This work represents a step towards the development of an auto-regressive integrated moving average (ARIMA) forecasting model to predict silver eel movement using forecasted environmental covariates.

Corresponding Author: Dan M Weaver, daniel.weaver@maine.edu, (207) 7459683

Establishing criteria to identify Ecologically Significant Areas in freshwater

Alicia Cassidy, Fisheries and Oceans Canada, Gulf Fisheries Centre, Moncton, New Brunswick, Canada
Cindy Breau, Fisheries and Oceans Canada, Gulf Fisheries Centre, Moncton, New Brunswick, Canada
Nathalie Brodeur, Fisheries and Oceans Canada, Gulf Fisheries Centre, Moncton, New Brunswick, Canada

The term Ecologically Significant Areas (ESAs) was included in the Canadian Fisheries Act in 2012 and 2019 and refers to areas of high ecological importance to fish, including areas that are sensitive, highly productive, rare or unique habitats. The objectives of this project are to identify and validate criteria that can be used to define ESAs in freshwater. The criteria used were uniqueness, aggregation, fitness consequence, and important physical features of the habitat. To assess these criteria, biotic and abiotic data from long-term georeferenced electrofishing surveys (~20 years) were analyzed for rivers in New Brunswick. Electrofishing sites were scored based on factors within each criterion such as species richness, function of a site for a life history process, elevation of the site, presence of a species at risk, etc. From these scores, areas of relative ecological importance were identified, which could be considered ESAs by managers. Using New Brunswick as a case study for establishing criteria for ESAs was useful in identifying future needs for data collection. For example, since these data are based on electrofishing for stock-assessment of diadromous fish, sampling was primarily conducted in riffles of rivers (prime habitat for Atlantic Salmon). Therefore, one priority is to collect biotic and abiotic data from different parts of the streams (riffles, runs, flats and pools) to assess different habitat types and characterize habitats important for all fish, not only salmon. Additional information is needed for proper assessments of ESAs in freshwater in Canada using an ecosystem-based approach, including riparian zone, predator-prey interactions, water quality and river connectivity, etc. Ecologically Significant Areas are potentially an important tool for habitat managers, and will be used to manage activities in areas with characteristics having high ecological significance to fish, as well as place objectives for conservation and protection of fish and fish habitat within these areas. ESAs could also be useful for prioritizing areas for offsetting and habitat banking, or for identifying possible restoration sites that are subject to cumulative effects.

Corresponding Author: Alicia Cassidy, alicia.cassidy@dfo-mpo.gc.ca, (506) 380-0783

Penobscot Estuary research, a decade of monitoring restoration and finding surprises

Justin Stevens, Maine Sea Grant
Gayle Zydlewski, Maine Sea Grant, University of Maine
Rory Saunders, NOAA Fisheries, Greater Atlantic Fisheries Office

The Penobscot River Restoration Project (PRRP) aimed to restore native sea-run fish through the removal of two main-stem dams and improved fish passage at a third dam on the Penobscot River. Thus, the PRRP provided some unique opportunities to monitor changes to a broad suite of ecological patterns in the Penobscot River and Estuary. Initial aspirations included a potential evaluation of the "prey buffer" hypothesis that suggests that restoration of Alosines to the estuary and lower river may enhance smolt survival during their transition to the marine environment.

In 2010 NOAA Fisheries initiated a long-term, estuary ecosystem survey to describe the spatial and temporal distribution of the fish community, avian and marine mammal predators, and environmental conditions in part to provide baseline understanding of ecosystem linkages prior to dam removals. These evaluations revealed a dynamic system with diverse habitats requiring a variety of gear to sample the intertidal mudflats (fyke nets), sandy beaches (seines) and pelagic (trawl and hydroacoustics) habitats. Pre-dam removal surveys revealed most native diadromous species were present in the system. Beach seine sampling demonstrated successful spawning of American Shad. Trawling revealed prolonged estuary use of age- 1 and 2 Alewife, Blueback Herring, and American Shad. Trawl surveys also suggest that the pelagic fish community was dominated by clupeids and Rainbow Smelt. Rainbow Smelt appeared to be abundant in spring and fall and juvenile size distributions suggested a long period of spawning activity in the system. Predator surveys suggested consistent concentrations of seals and cormorants in the lower estuary. Hydroacoustic surveys revealed higher biomass typically in the middle of the estuary, in the area of highest turbidity and salinity transition and in late-spring each year. After dam removals, hydroacoustic surveys revealed higher fish biomass densities over a wider area of the estuary and overall higher biomass in the estuary coincident with increasing River herring runs.

After 10 years of sampling, it is apparent that the Penobscot Estuary has a diverse fish community that continues to change post- restoration. These studies have provided novel observations and established baselines to evaluate long-term changes to the system during restoration. Lastly, results from sampling in the estuary have provided an integrated approach to assessing recovery of sea-run fish in Penobscot watershed. As fish passage improvements continue to accrue in the watershed, sampling in the estuary offers unique possibilities to answer questions related to recovery of complex ecological interactions.

Corresponding Author: Justin R Stevens, justin.stevens@Maine.edu, (207) 581-1434

Participatory mapping for knowledge co-production and application in Downeast Maine

Gabriella Marafino, University of Maine
Jessica Jansujwicz, University of Maine
Tora Johnson, University of Maine at Machias
Gayle Zydlewski, Maine Sea Grant and University of Maine

Local and traditional ecological knowledge are valuable sources of information, but can be difficult to present in a way that is useful to decision-makers. On the flip side, scientific data is often not accessible to a broader audience. The resulting knowledge gaps among data users was addressed in the context of understanding challenging, turbulent, and high flow systems in eastern Maine. We will report on applying an engaged research approach and community engagement processes to better integrate different sources of knowledge in a way that is useful to diverse stakeholder groups. To gather sources of local knowledge, recreational, commercial, and traditional fishers were engaged in collaborative meetings to discuss their stories and memories about this ecosystem. Separate meetings were used to engage recreational and commercial fishers in Eastport, ME and traditional fishers from the Passamaquoddy tribe in two-way dialogue about their experiences. To foster dialogue, a participatory mapping activity was used to document spatial and temporal changes directly on hard-copy nautical charts. Data on these charts were digitized using geographic information systems (GIS), allowing these data to be combined with other datasets. This offered a way to include local community knowledge and human dimensions research in decision-making processes. Separate meetings were held to work directly with managers, industry representatives, a tribal environmental department, and community members to understand what makes different types of information useful and accessible. Participants at these meetings identified two data integration approaches that would be helpful: (1) spatial information integrated on an interactive mapping application and (2) non-spatial data and documents organized in a central data repository. Taking an engaged research approach allowed data integration strategies to be tailored to different stakeholder groups to develop user-focused decision-support tools. In response to the need for an interactive map accessible on both computers and mobile phones, ArcGIS Online was selected as the platform to visualize spatial datasets. Participants also noted that peer-reviewed papers and other documents can be difficult to access, and therefore these sources were added to the central google folder. This is an iterative process and data integration strategies are being revised based on stakeholder input and feedback. These edits include adding direct links in the metadata to streamline how users locate information in the central data repository for decision-making.

Corresponding Author: Gabriella A Marafino, gabriella.marafino@maine.edu, (703) 4027642

Dams, death, and delay in the Penobscot River - the complex and cumulative influence of hydropower dams on migrating American eels

Matthew Mensinger, University of Maine
Erik, Blomberg, University of Maine, Department of Fisheries, Wildlife, and Conservation Biology, Orono, ME.
Joseph, Zydlewski, U.S. Geological Survey, Maine Cooperative Fish and Wildlife Research Unit and University of Maine, Department of Wildlife, Fisheries, and Conservation Biology, Orono, ME

Each fall, adult American eels, Anguilla rostrata, travel from freshwater systems across eastern North American to spawn in the Sargasso Sea. In impounded watersheds, many migrating adults must navigate hydroelectric dams. Downstream passage is commonly associated with mortality and delay for diadromous fish species. To understand the consequences of dam passage in the Penobscot River, Maine, we captured and implanted acoustic transmitters into adult eels from 2016–2019 (n=355). Tagged eels were released upstream of West Enfield and Milford Dams and tracked with an extensive acoustic array (60 fixed receivers). We used a Cormack-Jolly-Seber mark-recapture framework to estimate survival as eels continued downstream migration. Survival through dams varied among years (0.88–0.99), but was lower than free-flowing river sections (0.98–0.99). We found evidence of a compounding effect of dam passage where survival at a future passage event was reduced by an additional 4-10% for individuals that had previously encountered a dam during their migration. Detections were also used to calculate movement speeds throughout the river. Eels moved slower in impounded reaches when compared to free flowing river sections. The observed mortality and delay associated with dam passage in the Penobscot River underscores the complex negative influence hydropower dams have on this species.

Corresponding Author: Matthew A Mensinger, matthew.mensinger@maine.edu, (218) 355-1662

Energetic impacts of passage delays in migrating adult Atlantic salmon

Sarah Rubenstein, University of Maine
Joseph Zydlewski, U.S. Geological Survey, Maine Cooperative Fish and Wildlife Research Unit; University of Maine, Department of Wildlife, Fisheries, and Conservation Biology
Nishad Jayasundara, University of Maine, Department of Marine Sciences
Paul Christman, Maine Department of Marine Resources

New England Atlantic salmon runs in the Penobscot and Kennebec Rivers of central Maine face critical endangerment, but despite extensive restoration efforts, inefficient fishways at dams continue to act as barriers to fish movement. Passage delays expose upstream migrating fish to elevated water temperatures causing increased metabolic demand, but there currently exists no clear quantification of metabolic costs and fitness risks. Using temperature logging radio tags and a Distell Fish Fatmeter, we radio tagged, tracked, and measured 66 Atlantic salmon over two years on both the Penobscot and Kennebec Rivers. We captured and gastrically tagged fish at fish sorting facilities on Milford Dam and Lockwood Dam and released tagged fish back downstream in their respective rivers. We used radio telemetry to monitor salmon as they returned upstream to ascend the dams a second time, at which point we were able to recapture the tagged fish. Mobile and stationary telemetry data has shown us patterns of delays at dams ranging from weeks to months. Using the Fish Fatmeter to estimate lipid content of individual salmon at both first capture and recapture, we have correlated fat loss to time spent delayed below the dam. Salmon recaptured at Milford Dam were sent to Craig Brook National Fish Hatchery as brood stock, where we followed up for a third Fatmeter reading. Data from this field work will inform bioenergetics modeling, allowing us to characterize specific energetic costs of delays to upstream migrating adult salmon with the intention of informing future fish passage and relicensing decisions.

Corresponding Author: Sarah Rubenstein, sarah.rubenstein@maine.edu, (518) 796-5035

Movement and survival of Atlantic salmon Salmo salar in the Piscataquis River

Alejandro, Molina-Moctezuma, University of Maine, Department of Wildlife, Fisheries, and Conservation Biology
Erin Peterson, University of Maine, Department of Wildlife, Fisheries, and Conservation Biology
Joseph D. Zydlewski, U.S. Geological Survey, Maine Cooperative Fish and Wildlife Research Unit & University of Maine, Department of Wildlife, Fisheries, and Conservation Biology

Movement, delays, and survival of hatchery Atlantic salmon Salmo salar smolts were evaluated through the Piscataquis River, a tributary of the Penobscot River, in Maine, USA. We explored the effects of the four dams (Guilford, Dover, Brown's Mill, and Howland) from 2005-2019. During this period, the downstream-most dam (Howland Dam) transitioned from full hydropower generation to seasonal turbine shutdowns, and then to the decommission and construction of a nature-like fish bypass in 2016. We estimated survival through open river reaches, and at each dam using acoustic telemetry (n = 1,536). Dams decreased survival, with per rkm apparent survival averages of 0.972, 0.951, and 0.990 for Guilford, Dover, and Brown's Mill, compared to a per-rkm survival of 0.999 for open river reaches. Turbine shutdowns increased survival in Howland Dam, and further increased it following the construction of the nature-like fish bypass. We used radio telemetry in 2019 (n = 75) to demonstrate that approximately about 1/3 of the fish using this alternative downstream path, while the remaining fish used alternative routes. Smolts successfully passing upstream dams had lower apparent survival through Howland Dam than smolts released upstream of Howland Dam, but downstream of the next dam in the system. While smolts passing through Brown's Mill Dam had high survival, the dam caused extended delays, with median delay times surpassing 48 hours in most years. Surprisingly, most of the delays caused by Brown's Mill Dam occurred after fish had passed the dam, and may indicate a sub lethal effect of passage. Overall, while survival through Howland Dam has improved, in aggregate, passage and delays caused by the three upstream dams represent a critical impediment to the effective use of the high spawning habitat found upstream.

Corresponding Author: Alejandro Molina-Moctezuma, alejandro.molina@maine.edu, (207) 907-0655

Governance of the Atlantic salmon program

Julie Crocker, Greater Atlantic Regional Fisheries Office, Protected Resources Division, National Marine Fisheries Service, 55 Great Republic Drive, Gloucester, MA
Dan McCaw, Penobscot Indian Nation, Department of Natural Resources, 12 Wabanaki Way, Indian Island, Maine
Sherry White, U.S. Fish and Wildlife Service, 300 Westgate Center Drive, Hadley, MA
Carl Wilson, Bureau of Marine Science, Maine Department of Marine Resources, McKown Point Road, West Boothbay Harbor, ME

Over the last year, program leaders from Maine DMR, NOAA, USFWS and Penobscot Indian Nation have been working very hard to develop an improved governance strategy. This "Collaborative Management Strategy for the Gulf of Maine Atlantic Salmon Recovery Program" promotes communication, collaboration, accountability, transparency and improved decision making for the Atlantic salmon recovery program. The new strategy will be implemented as a pilot through the end of 2020. Kick-off meetings for the new teams are being scheduled right now, and the new structure will be fully staffed by the New Year. We view the implementation of the strategy as a step in the right direction, building on the many things that the Atlantic salmon recovery program does well, while taking steps towards improving those areas where we can do better.

Corresponding Author: Julie Crocker, Julie.Crocker@noaa.gov

Does leadership have a role in collaborative environmental governance?

Melissa Flye, University of Maine
Carly C. Sponarski, University of Maine
Joseph, D. Zydlewski, United States Geologic Survey, University of Maine
Bridie McGreavy, University of Maine

Environmental managers are moving toward more holistic approaches to the complex natural resource issues that face our natural world. Agencies, organizations, and managers around the world are finding themselves in need of additional resources to achieve their management and policy goals. To address these challenges, they are working to form collaborative governance structures. While studies have assessed the conditions and structures under which collaborative action occurs, little emphasis has been placed on the role that leadership may play in joint-jurisdictional systems. Management of species under the United States Endangered Species Act offers an opportunity to assess the collaboration and coordination of federal, state, and tribal resource agencies. The critically endangered Gulf of Maine Distinct Population Segment of Atlantic salmon (Salmo salar) are managed under a joint-jurisdictional governance structure; the Atlantic Salmon Recovery Framework (ASRF). We used the ASRF as a case study to examine the influence that different types of leadership may have on perceived program efficacy, member buy-in, and lived experience through semi-structured interviews. 28 interviews with members of the ASRF revealed three major thematic concepts which members felt were inadequate with respect to leadership; 1) shared goals/approach to recovery, 2) transparency, and 3) trust. We propose that collaborative leadership approaches which foster the creation of shared goals, transparency, and trust will increase adaptive capacity and the likelihood of sustained collaborative success in the ASRF and other collaborative governance structures.

Corresponding Author: Melissa E Flye, melissa.flye@maine.edu, (207) 922-8260

Fish passage decision-making during hydropower relicensing in the Kennebec and Penobscot Rivers, Maine

Sarah K Vogel, University of Maine, Dept of Wildlife, Fisheries, and Conservation
Jessica S Jansujwicz, University of Maine, Dept of Wildlife, Fisheries, and Conservation & Senator George J. Mitchell Center for Sustainability Solutions
Joseph D Zydlewski, U.S. Geological Survey, Maine Cooperative Fish and Wildlife Research Unit & University of Maine, Dept of Wildlife, Fisheries, and Conservation Biology

Hydropower dams represent a significant challenge for the successful migration of sea-run fish, many species of which are in decline. The Federal Energy Regulatory Commission (FERC) regulates most hydropower dams and grants 30-50 year licenses to projects and typically include conditions for the conservation of sea-run fish (e.g., fish passage construction, operation changes, monitoring, and other mitigative conditions). While FERC remains the primary authority in licensing, the current regulatory framework recognizes input from resource agencies (federal and state) and tribal entities. When negotiating hydropower operations, these stakeholders must make timely decisions and examine tradeoffs based on their competing authorities, values, and objectives. Using the Kennebec and Penobscot Rivers as a model system, we sought to identify the main factors that influence fish passage decision-making and describe patterns of stakeholder engagement in licensing from the 1980s to present day. Our results indicate an increase in concern for fish passage over time with mitigation measures focused almost exclusively on Atlantic salmon and American eel. Stakeholder engagement and the application of environmentally focused regulatory controls increased in the 21st century, especially with regards to the use of Water Quality Certification as a tool for addressing fish passage concerns. Overall, hydropower projects were found to differ along a spatial gradient. Projects located close to the coast included strong fish passage language in their licenses and received high input from the Maine Department of Marine Resources, US Fish and Wildlife Service, and National Marine Fisheries Service. Inland projects received conspicuously greater input from the Maine Department of Inland Fisheries and Wildlife while the Maine Department of Environmental Protection remained central to all projects. The Penobscot Indian Nation and Passamaquoddy Tribe were active stakeholders at projects in the Penobscot River. Despite widely stated interest and cultivation of basin-scale planning, our results suggest there remain significant opportunities to spatially integrate the FERC process.

Corresponding Author: Sarah K Vogel, sarah.vogel@maine.edu, (931) 216-0478

MaineDOTs Part in Atlantic Salmon Recovery

Eric Ham, Maine DOT

On January 23, 2017, the Federal Highway Administration (FHWA) and the Army Corps of Engineers (ACOE) received a biological opinion from the United States Fish and Wildlife Service (USFWS) for common scopes included on annual transportation infrastructure programs and their potential effects to endangered Atlantic salmon (ATS) and Atlantic salmon critical habitat (CH). ~80 projects have been found consistent with the programmatic consultation and have been efficiently following the signing of the biological opinion. To date, 14 projects have been completed that provide restoration of aquatic connectivity in designated Atlantic salmon critical habitat. Similar projects are slated to be completed on an annual basis. MaineDOT staff and contractors continue to design and construct projects that meet goals set forth to recover Atlantic salmon.

Corresponding Author: Eric D Ham, eric.ham@maine.gov, (207) 215-7356

Ecosystem implications of restoration evaluated through modeling

Adrian Jordaan, University of Massachusetts Amherst
Beatriz Dias, University of Massachusetts Amherst
Steven Mattock, University of Massachusetts Amherst

Anadromous fish have been shown to play important ecosystem roles as predators and prey across freshwater and marine systems. Modeling of food web dynamics can help further elucidate ecosystem-wide impacts, and help guide policy. A sequence of efforts from simple GIS and linear models and concluding with ecosystem models will be used to (1) describe how restoration of habitat connectivity will impact freshwater and marine ecosystems, and (2) evaluate the relative impacts of different management actions.

Corresponding Author: Adrian Jordaan, ajordaan@umass.edu, (413) 545-2758

Contributed Session VI (Day 2, Afternoon):

Watershed Restoration and Emerging Recovery Tools

Moderator:
Carl Wilson, Maine Department of Marine Resources

The Anatomy of Watershed Scale Restoration

Molly L Payne Wynne, The Nature Conservancy
Benjamin Matthews, The Nature Conservancy

Along our collective path of recovery of Atlantic Salmon in Maine, there have been many successes in how we are able to support habitat restoration through river connectivity projects. Here we present the “Anatomy of watershed restoration”, from data collection and prioritization, to funding, to finished product. We examine what makes our collective, large scale restoration efforts work, and investigate where we can work to advance technology, improve partnerships, and connect with community leaders to ensure success. Given the large range of the species and the spectrum of the challenges to recovery, we need to invest a great deal more of our resources in prioritizing, planning, and project managing in order to extend our impacts to the watershed scale over many more geographies around the state in areas that will have the most impact for salmon and the species they coevolved with. While it is important to celebrate and learn from our efforts to restore connectivity and thus critical habitat, such as the many successes in the Penobscot river watershed, it is equally important to understand the reasons that projects don’t reach the finish line, as this can reveal critical paths to success.

Corresponding Author: Molly L Payne Wynne, molly.paynewynne@tnc.org, (315) 749-6182

Narraguagus River Conservation Plan: Ecosystem based co-management for the next 20 years?

Jacob van de Sande, Maine Coast Heritage Trust, East Machias, Maine
Jeremy Gabrielson, Maine Coast Heritage Trust, Topsham, Maine

The Narraguagus is the most famous Atlantic salmon river in Washington County and most studied of the Downeast SHRU Rivers. In the almost 20 years since Atlantic salmon populations have been listed, there has been extensive research and collaboration on Narraguagus; we have begun to understand in more detail the many factors contributing to the decline of Atlantic salmon. It is increasingly clear that a single species management model is not meeting recovery objectives on the Narraguagus or elsewhere. At the same time, we increasingly see collaboration among agencies, NGOs and communities to take action on multiple fronts to improve salmon habitat, address aquatic connectivity, protect habitat and continue activity species management emergent issues. However much of the collaborative work to date has been ad hoc and spread across the geographic range of Atlantic salmon in Maine.

Maine Coast Heritage Trust chose the Narraguagus River as one of three rivers as a focus of our Rivers Initiative, based in part of the level of work already happening in the watershed and the potential for collaboration to yield results. After choosing the Narraguagus we began a yearlong planning process, engaging community members, town government, NGOs, and state and federal agencies and developed a Narraguagus River Conservation Plan. Although envisioned primarily as an internal planning document, the plan has also filled several important rolls in advancing Atlantic Salmon Conservation in the watershed: established and communicated broad priorities, identified roles, responsibilities and timelines, established a shared vision to communicate with funders, and convened stakeholders through the planning process and annually or bi-annually into the future. While our process has not been perfect, it highlights the value of the watershed-based planning process, convening diverse stakeholders on a regular basis, and the roll of collaboration in bringing more resources to the table…and could inform the management of Atlantic salmon into the future.

Corresponding Author: Jacob van de Sande, jvandesande@mcht.org, (207) 259-5040

Upper Narraguagus Watershed: Restoring habitat and managing expectations.

Joan G. Trial, Project SHARE, Eastport ME

Coastal Maine Atlantic salmon rivers are the result of a century of human activities that widened channels, armored streambeds, removed wood and boulders, and altered watershed hydrology and hydrologic connections. Since 2014 a team of fisheries, habitat, and forest managers; geomorphologists, and environmental regulators assembled by Project SHARE has been working collaboratively to restore salmon habitat in the Upper Narraguagus River. The team identified five habitat factors limiting smolt production. Atlantic salmon did not have access to all potential spawning and rearing habitat. Juvenile salmon carrying capacity was compromised by the quality of physical and thermal habitat; and competition from non-native fish species. The riparian forest did not have enough larger trees that could fall into the river and maintain streambed habitat diversity. The Team is integrating concepts and data from many disciplines to direct actions to improve stream function with the goal of increasing Atlantic smolt production.
Talks in this session will address: 1) streambed conditions and approaches to reverse historic changes; 2) how historically altered conditions limit the quality of physical and thermal juvenile Atlantic salmon habitat; 3) how SHARE is adaptively managing projects to allow salmon access to potential habitat and to increase the quality of physical and thermal habitat; 4) realistic expectations for the response of Atlantic salmon populations to habitat changes.

The overall measure of success is a long term increase in annual Atlantic salmon smolt population estimates produced by NOAA Fisheries and the State of Maine. However, the variance of annual estimates suggests that to detect a change (10 years before and after) with high confidence a 39% increase is required. Habitat restoration actions cannot immediately increase Atlantic salmon populations. Current juvenile Atlantic salmon populations in the Upper Narraguagus River depend on annual fry stocking and variable and limited natural spawning. Population increases from restored habitat access will depend recruitment in the newly accessible habitat, either natural spawning or additional fry stocking. If there is not increased recruitment (stocked, or spawning) in the newly accessible habitat a population response is unlikely. Reallocating fry to newly accessible cooler stream habitat could increase parr and smolt populations only if the habitat is more productive and juvenile salmon density and survival are higher than in the habitat that was previously stocked. Salmon populations cannot respond to instream work until the substrate becomes less imbedded, is more sorted, channels are narrowed, reaches have more diverse depth cross sections and long profiles and more groundwater connections. These changes in streambed processes can take years. The team is monitoring river geomorphology, thermal conditions, and Atlantic salmon growth and survival. Changes in physical and thermal habitat and populations in the focus area direct adaptive habitat and fisheries management and provide interim measures of project success.

Corresponding Author: Joan Trial, trial@midmaine.com, (207) 949-2656

Evaluation of bed mobility using PIT-tagged tracer particles on the Narraguagus River, Maine

Douglas M. Thompson - Environmental Studies Program, Connecticut College
Anna E. Marshall - Environmental Studies Program, Connecticut College
Moriah McKenna - Environmental Studies Program, Connecticut College
Christopher M. Federico, Project SHARE
Stephen Koenig, Project SHARE

Critical spawning habitat for Atlantic salmon (Salmo salar) along the Narraguagus River in Maine was impacted by historic log drives with resultant over widening and immobile, embedded sediments. In 2016, ten cross-sections, spaced 5-m apart, were established and surveyed with a laser total station in each of three different study reaches. A grid of approximately 200 glass spheres embedded with passive integrated transponder (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. Control and treatment study reaches were used to evaluate the ability of large wood (LW) additions to enhance sediment mobilization, decrease embeddedness and promote greater variation in depth to improve aquatic habitat. In 2017 and 2018, the site was surveyed before the LW additions to document baseline tracer particle mobilization rates. Survey work was repeated in 2019 after Post-Assisted Log Structures (PALS), a type of Engineered Log Jam (ELJ), were installed in one of the two reaches. In annual surveys from 2017 to 2019, 86% to 99% of particles were rediscovered. The winter and spring peak flows included discharges of 88.9 m3/s, 175.6 m3/s, and 114.7 m3/s prior to 2017, 2018 and 2019 recovery efforts, respectively. Entrainment rates varied from 8.2% to 48.4% with higher mobilization ratios in the control reach relative to the treatment reach. On average, particles moved further distances in the control reach. Results indicate PALS did not significantly impact channel-bed elevations or entrainment rates in the treatment reach, but did increase step lengths of mobilized particles after LW additions in 2018.

Corresponding Author: Douglas M Thompson, dmtho@conncoll.edu, (860) 439-5016

Strategic Habitat Conservation in the Upper Narraguagus River: Using best available science to identify high priority restoration areas-actions intended to improve juvenile Atlantic salmon production in a catchment with ideal channel gradients and overall adequate summer time thermal conditions.

Scott Craig - U.S. Fish and Wildlife Service

The Upper Narraguagus River Working Group was charged with identifying the best location to implement an active stream restoration project utilizing heavy construction equipment/machinery below Hemlock Dam in the Upper Narraguagus River. The primary rationale was the current passive Post Assisted Log Structures would not fare well with higher flows, increased ice scour potential and higher channel gradients located below Hemlock Dam (Rkm 49.7, ~170 km2). This presentation will enumerate thermal refugia potential and other limiting factors for identifying a specific reach for a large scale restoration project that will significantly add habitat complexity (large wood/boulders) and increase low flow summer water depths by decreasing the active channel's width:depth ratio.

Two potential restoration areas (Hemlock Dam to Rt 9 (Rkm 47.6-49.7), and Rt 9 to Beddington Lake (45.9-47.6)) have similar ideal juvenile (parr) Atlantic salmon rearing habitat characterized of summer maximum water temperatures that rarely exceed 25 ºC (for multiple days), water velocities typically between 10-40 cm/sec (gradients ~0.5%) and substrates consisting of pebble-gravel to cobble. However, substrate embeddedness and overall lack of instream cover is problematic in both reaches.

In 2014, a low water summertime water temperature-depth profile survey was collected at a spatial scale of 1-2 meters. Results suggest that overall thermal refugia within mapped rearing habitat is higher in the reach below Rt 9 with 85 habitat units (1 unit=100m2) containing "Cooling" values as compared to 51 units above Rt. 9. Cooling locations were ranked by overall thermal contribution (Instantaneous Groundwater Contribution Index (IGwCI)) and mapped to identify, protect and prioritize cold water refugia restoration actions. Although cumulative IGwCI was similar for both reaches (3.7-3.4%), the overall intensity of cold water inputs suggests higher quality thermal refugia is located below Rt. 9.

Water depths collected suggest both reaches (Below Rt 9 versus Above Rt. 9) are less than ideal for optimal juvenile rearing because mean summer low flow depths are less than 20 cm; with values 12 and 17 cm, respectively.

Presentation Summary: Based on the higher amount of mainstem rearing habitat and analysis of thermal-depth profiles; the Rt 9 to Beddington Lake reach (403 rearing units) appears to have better thermal refugia conditions but, summer water depths are somewhat lower than the upstream sub reach. Thus, this subreach (below Rt 9) was selected for a large-scale pilot stream restoration project to improve juvenile rearing habitat suitability as well as to provide better adult holding habitat.

Corresponding Author: Scott Craig, scott_craig@fws.gov, (207) 240-3172

Managing for More Productive and Resilient Atlantic Salmon Habitat in the Narraguagus

River, Maine

Christopher M Federico, Project SHARE
Steven D Koenig, Project SHARE
Joan G Trial, Project SHARE
Colby WB Bruchs, Maine Dept. of Marine Resources

Since being founded in 1994, Project SHARE has worked collaboratively with state and federal resource agencies, academia, other NGO conservation groups, and private land owners to create a habitat restoration program targeting the recovery of Atlantic salmon, Eastern brook trout, and other cold-water native fishes. The SHARE restoration program is process-based and adaptive. We believe to truly restore the natural processes of a stream; the habitat must be connected first. Once habitat is connected, stream channel complexity (i.e. large wood and boulders) must be reintroduced. From 2005 to 2019 SHARE replaced and removed multiple culverts each year. In 2007, Project SHARE began implementing projects to directly restore and improve the riverine habitat in Downeast Maine. Beginning in 2020 culvert projects will be secondary to in-stream habitat projects. The early in-stream projects involved a series of large wood additions, each providing lessons to adaptively manage methods. As of 2016, large wood additions have increased in scale, treating more habitat in one year than in the 9 years before. As we continue to add more wood in more varied locations, limitations to our methodologies have become evident. As a result, existing methods have been adapted and new methods are being tried.

Corresponding Author: Christopher M Federico, cfederico@salmonhabitat.org, (207) 731-7488

The Maine-eDNA EPSCoR program and its ties to Maine's salmon ecosystems

Michael Kinnison, University of Maine, School of Biology and Ecology, Orono, ME, USA
David Emerson, Bigelow Laboratory for Ocean Sciences, East Boothbay, ME, USA
Heather Leslie, University of Maine, School of Marine Sciences and Darling Marine Center, Walpole, ME, USA
Kate Beard-Tisdale, University of Maine, School of Computing and Information Sciences, Orono, ME, USA
Shane Moeykens, University of Maine, Maine EPSCoR Office, Orono, ME, USA
Kody Varahramyan, University of Maine, Office of the Vice President for Research and Dean of the Graduate School, Orono, ME, USA

Environmental DNA (eDNA) is rapidly becoming a widespread tool in environmental monitoring and research because of its ability to detect organisms with higher sensitivity, species breadth, ease of sampling, and less harm than many current sampling methods. It has the potential to revolutionize both how we study populations, communities and ecosystems, and who participates in that monitoring and research. The vision of the NSF EPSCoR RII Track-1 program Molecule to Ecosystem: Environmental DNA as a Nexus of Coastal Ecosystem Sustainability for Maine (Maine-eDNA) is to make Maine 'the DNA Coast' - a world leader in eDNA-based partnerships, understanding, and sustainability of coastal marine and freshwater ecosystems. To do so, we will harness the power of eDNA science to 1) advance ecological understanding crucial to the current needs of Maine's marine and freshwater resources, while 2) building the Big Data and IP innovations, technical workforce, and partnership capacities to address the increasingly large-scale and complex sustainability challenges of changing coastal ecosystems. In this talk, we will introduce the Maine-eDNA program's focal eDNA research around diadromous fish restoration, the larval black box of shellfish and macroalgae recruitment, the emergence and effects of harmful algal blooms, range shifts of diverse coastal species, microbial responses to coastal disturbance events, Big Data integration to understand coastal stability, and the communication processes that underpin effective eDNA team science. We will also outline Maine-eDNA's broader impacts through investments in education, training, commercialization, and outreach to diverse communities, as well as the new technical capacities it brings to Maine and Maine's salmon ecosystems.

Corresponding Author: Michael T Kinnison, mkinnison@maine.edu, (207) 581-2575

Comparative assessment of environmental DNA and backpack electrofishing methods for estimating Atlantic salmon occupancy and abundance

Bradley F. Erdman, University of Maine, School of Biology and Ecology, Orono, ME, USA
Zachary T. Wood, University of Maine, School of Biology and Ecology, Orono, ME, USA
Geneva, York, University of Maine, Environmental DNA Service Center, Orono, ME, USA
Joan, G. Trial, Project SHARE, Argyle TWP, ME, USA
Michael T. Kinnison, University of Maine, School of Biology and Ecology, Orono, ME, USA

Managing freshwater ecosystems often requires that we understand the distribution and abundance of species on the landscape. However, this core monitoring need is often highly constrained and costly for endangered species like anadromous Atlantic salmon (Salmo salar). Traditional population monitoring relies on labor intensive capture, requires special permits, and thus can only be conducted by relatively few specially-trained personnel. Environmental DNA (eDNA) testing of stream water provides a promising alternative to survey aquatic species in a more cost-effective, less invasive, and potentially more sensitive way. Here we provide results of a pilot study which compares the detection rates of backpack electrofishing and eDNA methods, correlates parr relative abundance to downstream eDNA concentration estimates, and investigates eDNA dynamics in a low order stream. Backpack electrofishing and eDNA methods detected Atlantic salmon at 85% of survey sites. Site-specific detections were largely consistent across methods with positive detections using both methods at 21 sites, electrofishing-only detections at two sites, and eDNA-only detections at two sites. Interestingly, we found a strong relationship between eDNA concentrations and site-specific salmon abundance in the upper part of the drainage which contained the highest densities of parr. However, this relationship deteriorated in the lower part of the stream which is likely due to eDNA transport. We go on to test several eDNA decay functions to better understand eDNA dynamics within the system, predict areas of locally high parr abundance, and compare these predictions to empirical backpack electrofishing data.

Corresponding Author: Bradley F Erdman, bradley.erdman@maine.edu, (920) 479-0245

Experimental assessment of optimal lotic eDNA sampling and assay multiplexing for Atlantic salmon

Zachary T. Wood, University of Maine
Bradley F. Erdman, University of Maine
Geneva York, University of Maine
Joan G. Trial, Maine Department of Marine Resources
Michael T. Kinnison, University of Maine

Designing eDNA tools to detect and quantify rare species includes inherent assumptions about the spatial distribution of the organism, spatial nature of eDNA dynamics, and the real-world performance of alternate assays under field conditions. Here, we use cage experiments with small numbers of Atlantic salmon (Salmo salar), to reveal that eDNA detection rates and eDNA quantities follow a predictable, but non-linear relationship with distance from a point source. In contrast to the common assumption of consistent eDNA degradation moving away from a source, eDNA detections and concentrations increased up to roughly 70 m downstream before declining steadily. We apply our eDNA distance functions to selection of stream sampling intervals for detecting fish without known locations, and find that even a single juvenile salmon can be reliably detected with intervals up to 400m spacing. Finally, we show that two different qPCR eDNA assays provide very different detection probabilities in nature despite similar efficiency in lab testing, demonstrating the importance of experimentally assessing assay efficiencies in the wild as well as the capacity for multiplexing as a strategy to ensure high detection efficiency when monitoring rare species.

Corresponding Author: Zachary T Wood, zachary.t.wood@maine.edu

Untying a Gordian knot: Collective salmon recovery on the East Machias

Dwayne P. Shaw, Downeast Salmon Federation

This is a presentation drawing from a synthesis collective efforts and partnerships involving dozens of participants over two plus decades.

This presentation will describe and explore the collective investments made in salmon recovery in the East Machias watershed since the ESA listing 20 years ago. Investments in habitat protection, habitat restoration, community engagement education and stewardship, live gene banking of river specific brood stock, stream side conservation hatchery rearing of parr, fry and other life stages, aggressive stocking levels, complimented by ecosystem based watershed management and reductions in the Greenland fishery are each, to a degree, producing remarkable results for salmon recovery on the East Machias River. In 2019, redd counts and estimated adult salmon returns surpassed all years within the 20+ year time series for this river and at this time appears to have produced a smolt to adult return rate unparalleled anywhere in the Gulf of Maine.

This presentation will explore the following questions: What were the driving factors? Was it the synergy of the collective investments or singular critical investments that have produced these results?

Corresponding Author: Dwayne P. Shaw, dwayne@mainesalmonrivers.org, (207) 598-8474

Fort Folly First Nation's ambitious plan to restore endangered inner Bay of Fundy Atlantic salmon to the Petitcodiac River

Tim Robinson, Manager Fort Folly Habitat Recovery program Fort Folly First Nation, NB CAN

Wendy Epworth, Manager Fort Folly Habitat Recovery program Fort Folly First Nation, NB Can
For 20 years Fort Folly First Nation, through it's Habitat Recovery (FFHR) program has been a fully engaged, boots on the ground member of the National Recovery Team and Planning Group for the critically endangered inner Bay of Fundy Atlantic salmon population. Initially trained and working primarily as river technicians the FFHR team carried out monitoring and recovery actions on 3 southeastern New Brunswick index salmon rivers in partnership with Department of Fisheries and Oceans and Parks Canada Agency staff. These index rivers; namely the Big Salmon, Upper Salmon and Point Wolfe Rivers were supported through Live Gene Bank (LGB) restocking from remnant iBoF Atlantic salmon families being maintained at the Mactaquac Biodiversity Facility. A recent 15 years peer review of the LGB found that it has been instrumental in keeping the population from extinction but does not display the capacity to restore the population upwards towards self-sustaining levesl. In 2010 Fort Folly shifted it focus onto a 4th River within it's traditional territory, the Petitcodiac River. This river, which once produced 20% of the entire iBoF Atlantic salmon was opening up again because a causeway structure barrier to fish passage, in place for over 40 years, was to be removed. Now the small rural community of Fort Folly First Nation is making a big splash when it comes to restoring the iconic Atlantic salmon through LGB support and a new unique collaborative recovery approach called Fundy Salmon Recovery (FSR). Wild exposed juvenile salmon collected from Petitcodiac River tributaries are transported to the world's first dedicated wild Atlantic salmon conservation farm located at Dark Harbour, Grand Manan. Here they are grown by industry partners until mature then returned annually to the Petitcodiac River to spawn naturally producing larger and larger never captive reared next generations of iBoF Atlantic salmon.

Corresponding Author: Tim A Robinson, timrobinson@ffhr.ca, (506) 379-3401

Salmon for Maine's Rivers: A New Partnership for Recovery

Danielle Frechette, MDMR
Casey Clark, MDMR
Sean Ledwin, MDMR

Twenty years after being listed under the Endangered Species Act, the Gulf of Maine Distinct Population Segment of Atlantic Salmon remains critically endangered, earning it a place on NOAA's Species in the Spotlight list in 2016. Hatchery supplementation and management has succeeded in preserving genetic diversity present at the time of listing, and numerous restoration projects have improved connectivity and habitat within several of the DPSs drainages. However, with federal hatchery resources at capacity and significant areas of habitat for wild spawning and rearing underutilized or vacant, these actions have thus far been insufficient to overcome extant factors limiting recovery. While poor marine survival and poor connectivity continue to impede recovery, increasing freshwater production and fitness are key controllable actions that can support demographic recovery and invigorate broodlines.

Following successes with the Fundy Salmon Recovery Project, the Salmon for Maine's Rivers Program represents a bold endeavor to jumpstart recovery by using smolt-to-adult supplementation to release thousands of pre-spawn adults into the wild. Smolts reared to maturity in near-shore net pens and released into underutilized habitat are expected to support salmon recovery by significantly increasing adult spawning escapement, a priority 1 action identified in the Recovery Plan for Atlantic salmon released in 2019. Just as no one factor led to the decline of Atlantic salmon in Maine, no one action or agency alone will bring about recovery. In addition to relying on longstanding partnerships between DMR, USFWS, NOAA, the Penobscot Indian Nation and USGS, Salmon for Maine's Rivers has developed a new partnership with Cooke Aquaculture USA to bring their expertise to the conservation of Atlantic salmon.

This program will leverage gains in connectivity and protections of habitat through the actions of the Penobscot River Restoration Program, stream-connectivity projects on Tribal Trust lands within the Penobscot River, and conserved areas within the Machias River Habitat Protection Project, with the first releases expected in 2021 and 2022. Assessment of post-release spawning behavior and production of offspring will permit this program to move forward in an adaptive management framework based on measurable objectives and milestones.

Corresponding Author: Danielle M Frechette, danielle.frechette@maine.gov, (207) 941-4486

Using a Keystone Management Species to support Ecosystem Based Management?

Sean Hayes, NOAA Fisheries

Hare et al. argued Atlantic Salmon management is a form of Ecosystem Based Fisheries Management (EBFM), but semantically one might argue that it is really management of a single species across all of the ecosystems they cross… but maybe it's both? In the efforts to ensure functionally of all needed salmon habitat- because their life cycle bridges all habitats from the mountains to the sea, perhaps we are really doing not just EBFM, but EBM when we work to restore salmon habitats. Indeed there have been many examples of salmon habitat recovery having cascading impacts across ecosystems in both the Pacific and the Atlantic. But EBM and EBFM are concepts that many scientists and managers, much less the public and Congress, struggle to wrap their heads around as a priority. Perhaps it is necessary to link particular ecosystems to species with a cause- a Keystone Management Species. Is it possible that there are key species- often charismatic- that can be used to bridge single species management to this EBM paradigm? If so, are there certain characteristics that should be considered or needed in developing a management paradigm around such key animals? Should they be an apex predator, or a true ecological keystone species? Would these species often be an endangered species? If it's a species that has historically been a part of the ecosystem, would we not be always trying to recover the historical ecosystem around these species regardless? A range of examples and exploratory ideas for the Gulf of Maine and beyond will be discussed.

Corresponding Author: Sean A Hayes, sean.hayes@noaa.gov, (508) 495-2347

Poster Presentations

Distribution and abundance of zooplankton in the Penobscot River estuary

Cody T. Dillingham, School of Biology and Ecology, University of Maine, Orono, ME
Joseph D. Zydlewski, U.S. Geological Survey, Maine Cooperative Fish and Wildlife Research Unit, University of Maine, Orono, ME; Department of Wildlife, Fisheries, and Conservation Biology, University of Maine, Orono, ME
Rachel Lasley-Rasher, Department of Biological Sciences, University of Southern Maine, Portland, ME

In the Penobscot River estuary, zooplankton are a crucial food source for many organisms such as juvenile shad (*Alosa sapidissima*) and river herring (Alewife, *A. pseudoharengus* and Blueback herring, *A. aestivalis*). As these species recover, it becomes more important to understand the availability of prey in the river system. However, the abundance, diversity and density of zooplankton in this system are poorly characterized. To evaluate zooplankton abundance, diversity and density, samples were collected at four river transects spanning the salinity gradient in the Penobscot River estuary. To evaluate seasonal variations, sampling was conducted monthly (May to October) during the day and night at (or about) low tide within the same week. These samples will be identified and enumerated to characterize seasonal and spatial patterns.

Corresponding Author: Cody T Dillingham, cody.dillingham@maine.edu, (207) 399-1194

Working Together For Healthy Streams: the US FWS National Fish Passage Program

Cathy Bozek, US Fish and Wildlife Service

Would you like assistance in restoring river habitat or to learn more about how the US Fish and Wildlife Service (US FWS) restores fish passage? Through the National Fish Passage Program (NFPP), the US FWS works with partners to remove fish passage barriers to promote healthy streams and river systems. We collaborate with federal, state, and local agencies, non-profit organizations, local communities, and landowners, and we support projects with funding and technical assistance. Our projects improve habitat and build sustainable populations of target fish and mussel species, while also providing benefits to the community such as improved public safety and recreational opportunities. Come talk with the NFPP Coordinator for the Northeast, and learn how to get involved. We can discuss the types of projects supported through NFPP, who you should contact if you have a project idea, and how to partner with the US FWS to improve river habitat and fish passage throughout the Northeast.

Corresponding Author: Cathy Bozek, catherinebozek@fws.gov, (413) 253-8661

Cost Effective Fish Passage Improvement Tools and Techniques for Community Groups

Amy Weston, Nova Scotia Salmon Association's Adopt a Stream Program
Bob Rutherford, Thaumas Environmental Consultants

In Nova Scotia, there are estimated to be over 30,000 road-stream crossings; most of these crossings are culverts. Based on field surveys, >70% of these culverts are barriers to some species and/or life stages of fish during fish passage flows (Q60). Vertical (perched culverts) and velocity/depth barriers are commonly the culprit isolating residential populations of fish upstream and limiting the range of diadromous species for spawning and rearing habitat. To address this problem in Nova Scotia, the Adopt a Stream Program began developing tools and techniques to assess and improve fish passage through culverts that are attainable by community groups with limited resources. Over 1500 water crossing sites have been assessed using the Adopt a Stream Water Crossing Assessment Protocols in Nova Scotia. These assessments guide prioritization/cost-benefit assessments and design for fish passage improvement projects. Several relatively inexpensive tools have been developed to address common barrier types: "Outflow Chutes", "Box Fish Ladders", "Low Flow Barriers", and "Steep Passes" have all since been developed and installed at road-stream crossings across Nova Scotia. In total, there have been over 80 fish passage improvements using these techniques completed in Nova Scotia since 2013 largely led by community groups. Training and consultation with watershed stewardship organizations in Prince Edward Island, New Brunswick, Quebec, and Newfoundland on these techniques have begun as well.

Corresponding Author: William J Daniels, willdaniels@adoptastream.ca, (902) 219-0224

Movements of radio-tagged Atlantic salmon (*Salmo salar*) in the Penobscot River, Maine

Erin Peterson, University of Maine
Sarah Rubenstein, University of Maine
Joseph D. Zydlewski, USGS, University of Maine

Atlantic salmon (*Salmo salar*) runs have experienced significant declines due to extensive damming in the Penobscot River, Maine. Restoration efforts have resulted in two main-stem dam removals and other fish passage improvement efforts. Most of the high-quality spawning habitat for this species is upstream of at least three dams. We tagged and tracked 99 adult Atlantic salmon in 2018-2019 using gastrically implanted radio tags. All fish were tagged at Milford Dam, the first dam encountered on their spawning migration. They were then transported downstream and released into the river so that movement rates and passage delays could be assessed. Twenty-nine fish were sent to the hatchery to be used as broodstock after they had re-ascended the dam. Ten fish were never recaptured and the remaining 60 were allowed to continue their migration upstream of Milford Dam. Delays at Milford Dam ranged from 0-154 days with an average of 20 days (in excess of the 48-hour passage criteria in place at this dam). Thirty-seven fish were observed performing downstream reversals, presumably searching behavior, below Milford Dam. Of the fish that continued upstream of Milford, 33 (33.3%) successfully navigated the nature-like bypass at the old Howland Dam (rkm 99) at the confluence with the Piscataquis River. Twenty-one (21.2%) passed West Enfield Dam on the main-stem (rkm 100), and one radio-tagged fish has been confirmed to have passed Weldon Dam (rkm 150) to access spawning habitat in the East Branch Penobscot River. Four and one radio-tagged salmon approached Brownsmill and Pumpkin Hill Dams, respectively, but we do not have any evidence that they passed either dam. One of these salmon experienced a multi-month delay below Brownsmill before returning downstream (presumably without spawning). Movement rates were 25 times higher in free-flowing reaches than in impounded reaches. Overall, these data show that there are persistent passage inefficiencies at Milford Dam that can delay these fish. Other dams in the system that may impose similar barriers to migration, but quantification of passage rates is hampered by low sample sizes.

Corresponding Author: Erin Peterson, erin.peterson1@maine.edu, (425) 736-7928

Science communication: methods, importance, and impact of community engagement during the International Year of the Salmon

Nicole J. Beauchamp, Ocean Tracking Network, Dalhousie University
Frederick G. Whoriskey, Ocean Tracking Network, Dalhousie University

Mass media have made the presentation of complex scientific research almost indistinguishable from content-marketing tactics. Traditionally, researchers have not targeted sharing their findings with the general public. Now, the field of science communication is evolving as fast as the online platforms where much of this activity takes place. These factors challenge our ability to communicate science, and have contributed to low science literacy rates in Canada, which translates to poor understanding of ecological processes and their wider relevance to society. The Atlantic salmon's (Salmo salar) population declines, intricate life cycle, long migrations, and the lack of information about the impacts of many potential factors on survival have created a difficult communication task of mustering public support for conservation and restoration.

Science communication is the practice of informing, educating, sharing wonderment, and raising awareness of science-related topics. A growing number of science communication forums are making research accessible and transparent to a general audience. The International Year of the Salmon (IYS) provided a focused opportunity to "bring people together to share and develop knowledge more effectively, raise awareness, and take action."

The Ocean Tracking Network (OTN), in collaboration with private and federal partners, hosted a suite of engagement events towards informing latent and aware audiences on status, risk and conservation measures of Atlantic salmon. Communications methods involved a series of interrelated projects.

Events were well attended, but brought out knowledgeable and dedicated salmon supporters. Despite the novelty of the events and their locations, we did not draw in a lot of new interest from the general public. Collectively, the science community needs to find ways of engaging supporters who are not only salmon fishermen. People arrived with well-formed opinions of what they considered to be the source of the salmon's problems. If the science messages do not match these expectations, they meet considerable resistance in being uptaken. Messages of hope were far more effective in engaging people than senses of despair, especially to the knowledgeable people attending the events.

Corresponding Author: Nicole Jeanette Beauchamp, n.beauchamp@dal.ca, (902) 494-4440

Growth and habitat use of juvenile alewife in Highland Lake, Windham, Maine

Emma Dennison, University of Southern Maine
Alayna McNally, University of Southern Maine
Haylee Parsons, University of Southern Maine

Highland Lake (Windham, Maine) experienced unusual picocyanobacteria blooms from 2014-2017, and partial blooms in 2018 and 2019, corresponding to the first few years of increases in a searun alewife spawning run. As part of a multi-investigator project researching the potential causes of the picocyanobacteria bloom, our research group investigated juvenile alewife growth and habitat use (via stable isotopes) in Highland Lake in 2018 and 2019. In both years, low water levels prevented downstream migration by juvenile alewife from mid-summer until mid to late October. Juvenile alewife were sampled after dark when schools broke up. They were consistently captured in waters 5 - 20 m deep in both years, and at least two distinct size classes were present on most sampling dates. In 2018, juvenile alewife showed distinct shifts in habitat use correlated with fish total length (TL), from fully pelagic as larvae, to fully littoral by >30 mm TL, followed by a gradual shift to a mix of pelagic and littoral food sources. We were still capturing juvenile alewife in September and October in both years, although numbers dropped off dramatically as juveniles emigrated from the lake after fall rains. Despite abundant juvenile alewife in the lake in 2018 and 2019, picocyanobacteria blooms were minimal, suggesting that the lake ecosystem may be adjusting to the presence of alewife.

Corresponding Author: Emma Dennison, emma.dennison@maine.edu

Can Clam Shells Reduce the Impacts of Stream Acidification in Eastern Maine?

Emily Zimmermann, Maine DOT

Despite restored access, Atlantic salmon (Salmo salar) populations in eastern Maine remain low. Loss of fish populations due to surface water acidification in the North Atlantic region has been well documented. Most waters in eastern Maine periodically experience acidic conditions (pH <6.5), resulting in detrimental impacts to salmon, especially during snow melt and spring/fall runoff. Liming acidic waters using agricultural lime has increased salmon abundance in Scandinavia and Nova Scotia and has been recommended as a restoration action for Maine. A 2009 Project SHARE pilot study investigating the efficacy of using clam shells to lime streams suggested a positive impact. In collaboration with the Downeast Salmon Federation, a multi-year effort has begun in the East Machias River watershed to further investigate the efficacy of this mitigation method, with the goal to increase macroinvertebrate abundance and diversity, and to increase juvenile salmon abundance. The first two years of the project characterized baseline conditions by monitoring water quality May-November using continuous monitoring devices and grab samples. Shells were added to the treatment stream July through October 2019. Preliminary data analysis does not indicate significant changes in water quality parameters following the first shell application. Periodic stressful conditions are still occurring as observed during baseline monitoring, including low pH (minimum of 4.19), high temperature (maximum of 27.7 °C), low calcium (minimum of 0.70 mg/L), and high exchangeable aluminum (maximum of 53 ug/L). Monitoring will continue for at least five years from the first shell placement to determine the efficacy of using clam shells to mitigate acidity.

Corresponding Author: Emily Zimmermann, emily.zimmermann@maine.gov, (207) 446-1003

The Maine Water Temperature Working Group: *Working collaboratively to identify thermal refugia for cold water species*

Graham Goulette, NOAA Fisheries
Merry Gallagher, Maine Department of Inland Fisheries & Wildlife
Kirstin L. Underwood, U.S. Fish and Wildlife Service

Climate change is a worldwide phenomenon with the northern hemisphere experiencing greater temperature increases than its counterpart. In the contiguous United States, the region realizing the fastest warming rate is the Northeast. As the climate continues to change and future temperatures in the Northeast are expected to continue to rise, suitable habitat for cold water species will be reduced. In 2014 the Maine Water Temperature Working Group was formed from multiple state and federal agencies, academia, Tribes, and NGO's to create The Maine Interagency Stream Temperature Monitoring and Modeling Network to facilitate a coordinated stream temperature monitoring effort in Maine that was integrated with regional and national efforts. Since 2015, 26 organizations have been involved in the effort. Historical temperature data have been collected and uploaded from more than 1900 locations providing over 4000 temperature time series comprised of more than 17 million records. A total of 287 active long-term monitoring stations have been deployed across the state and continue to collect data. These data are uploaded into a web-based database, SHEDS, for storage in one centralized repository. SHEDS also hosts a module for predictive catchment modeling and other stream temperature modeling tools. Researchers and fisheries managers have used this robust data repository for brook trout occupancy modeling and regional climate studies. Resource managers can use the Interactive Catchment Explorer tool derived from SHEDS to prioritize sites for habitat restoration.

Restoring Stream, Wetland, and Riparian Processes in Third Lake Stream

Steven D Koenig, Project SHARE
Christopher M Federico, Project SHARE

During the log drive era the Machias River was highly engineered to speed water transport of logs to mills along the coast. Nowhere is this more evident than between Third Machias and Second Machias Lakes, also known as Third Lake Stream. A preliminary survey identified 14 rock walls, some of which are several hundred feet long, blocking 11 side channels/meander bends and evidence of at least 2 dams spanning the river; all in less than a mile of river. The rock walls are built from large boulders removed from the river channel; which are too large for the river to mobilize and redistribute. Straightening the channel and reducing in-stream complexity has "locked" the channel in an altered state with increased gradient and current velocities. Lateral connectivity between the river and its floodplain has been severely altered, affecting current velocities, hyporheic flow, and sediment transport. The side channels are part of that lateral connectivity. Reconnecting floodplains and side channels has the potential to reestablish vernal pools, recover fringing/lateral wetlands, and redistribute sediments. Project SHARE will be breaching portions of the rock walls. The breeches will be approximately as wide as the bank-full width of the blocked channels, restoring more natural flows to the channels. Material from the rock walls will be returned to the mainstem channel increasing its habitat complexity. Pre- and post-assessment will include: longitudinal profiles, cross-sections, habitat surveys, and water temperature monitoring.

Corresponding Author: Steven D Koenig, stevenkoenig0@gmail.com, (207) 214-6096

Distribution and abundance of zooplankton in the Penobscot River estuary

Cody T. Dillingham, School of Biology and Ecology, University of Maine, Orono, ME
Joseph D. Zydlewski, U.S. Geological Survey, Maine Cooperative Fish and Wildlife Research Unit, University of Maine, Orono, ME; Department of Wildlife, Fisheries, and Conservation Biology, University of Maine, Orono, ME
Rachel Lasley-Rasher, Department of Biological Sciences, University of Southern Maine, Portland, ME

In the Penobscot River estuary, zooplankton are a crucial food source for many organisms such as juvenile shad (Alosa sapidissima) and river herring (Alewife, A. pseudoharengus and Blueback herring, A. aestivalis). As these species recover, it becomes more important to understand the availability of prey in the river system. However, the abundance, diversity and density of zooplankton in this system are poorly characterized. To evaluate zooplankton abundance, diversity and density, samples were collected at four river transects spanning the salinity gradient in the Penobscot River estuary. To evaluate seasonal variations, sampling was conducted monthly (May to October) during the day and night at (or about) low tide within the same week. These samples will be identified and enumerated to characterize seasonal and spatial patterns.

Corresponding Author: Cody T Dillingham, cody.dillingham@maine.edu, (207) 399-1194

Acid rain and salmon recovery: success and expansion of the West River Acid Rain Mitigation Project

Jillian A. Leonard, Nova Scotia Salmon Association
Edmund A. Halfyard, Nova Scotia Salmon Association
Acid rain and salmon recovery: success and expansion of the West River Acid Rain Mitigation Project

Acid rain, while greatly reduced in some areas since the 1980's, has continued to negatively impact aquatic and terrestrial habitat in Nova Scotia. The survivability of freshwater fish is greatly decreased, as is the abundance of prey items and native plant species that contribute to healthy aquatic ecosystems.

In 2005 the Nova Scotia Salmon Association began an acid rain mitigation project northeast of Halifax on the West River, Sheet Harbour. An automated lime doser continuously administers powdered limestone directly into the acidic river water to raise pH. This reduces the concentration of toxic aluminum and ultimately increases the survival and abundance of Atlantic Salmon and other acid-sensitive aquatic species. Since then, the freshwater production of juvenile Atlantic Salmon has increased by >300% in treated areas of the watershed, and water chemistry is above target levels. Untreated areas continue to show low fish abundance and large areas of vital habitat remain impacted, thus limiting the full recovery of the population.

In 2016 the project expanded to include a second automated doser, aerial terrestrial liming and physical habitat restoration. Early results of these combined efforts have shown positive impacts on soil quality, vegetation and fish abundance. Through partnerships and collaboration, this work will continue to inform Atlantic Salmon recovery strategies and the development of a data-driven model for habitat restoration in the province.

Corresponding Author: Jillian A Leonard, jilliananita@gmail.com, (709) 769-0184

Evaluating the Efficiency of a Hydropower Bypass for Atlantic Salmon (Salmo salar) in the Tobique River, New Brunswick

Hilary OJ MacLean, Canadian Rivers Institute, University of New Brunswick
Dr. Kurt Samways, Canadian Rivers Institute, University of New Brunswick
Dr. Tommi Linnansaari, Canadian Rivers Institute, University of New Brunswick

This research focuses on assessing the efficiency of a hydropower bypass for Atlantic salmon (Salmo salar) pre-smolts and smolts in the Tobique River, New Brunswick. There are three large hydropower stations which act as dams on the Saint John River, including the Tobique Narrows Generating Station which was built near the confluence of the Tobique River with the Saint John River. No dam on the SJR provided downstream passage using fish-friendly structures until the construction of a bypass system for juvenile salmon at Tobique Narrows Generating Station in 2017. However, building a bypass does not ensure successful fish passage, and its efficiency remains to be determined. Atlantic Salmon are an endangered species in the SJR, and the Tobique River catchment is a primary focus for salmon restoration by Fisheries and Oceans Canada. The objectives of this project are to (1) evaluate downstream passage efficiency at TNGS by determining if juvenile Atlantic Salmon are using the newly-built bypass, and (2) examine a trap-and-haul downstream passage management strategy as a potential alternative to the current free-swim approach. For the purpose of this study, we will use radio telemetry to monitor the fine-scale movements of juvenile Atlantic salmon as they approach TNGS to determine how they navigate the dam and whether they use the bypass system. We will also use acoustic telemetry to track the movements of juveniles within the SJR following downstream passage of TNGS. Specifically, we will assess the migration success of juveniles released into the TNGS bypass system (representing a free-swim strategy) and track them as they move downstream past the remaining two dams. We will then compare the migration success of this free-swim group with the migration success of a group transported and released downstream of the final dam on the river (representing a trap-and-haul strategy). Effective downstream passage at TNGS could potentially aid in the restoration of Atlantic salmon to the upper Saint John River. The knowledge gained from this project will help to inform Atlantic salmon pre-smolt and smolt management strategies as well as engineering decisions for salmon downstream passage.

Corresponding Author: Hilary OJ MacLean, hilary.maclean@unb.ca, (1506) 476-5528

Assessment of flow dynamics and fish habitat conditions in Togus Stream in relation to the ongoing restoration of anadromous fish passage into Togus Pond, Chelsea/Augusta, ME.

Carl Merrill, Suffolk University
Fred Seavey, US Fish and Wildlife Service
Nate Gray, Maine Department of Marine resources
Carl Merrill, Suffolk University, Boston, MA

Togus Stream is a tributary to the Kennebec River passing from Togus Pond in Augusta and Chelsea through Randolph, and eventually flowing into the Kennebec along the Pittston-Randolph border. Togus stream once supported a fairly robust atlantic salmon run and currently supports small runs of alewife and blueback herring (re-established and sustained over the past several years by transferring adult river herring via dip nets over the dam at Lower Togus Pond) as well as a natural run of sea lamprey. Maine Department of Marine Resources is engaged in an effort to re-establish more substantial river herring runs and hopefully the return of Atlantic salmon runs. DMR has recognized the good salmon habitat quality of Togus. River herring runs will be benefitted by the newly completed (in September of this year) fish passage that was made possible by funds provided by NOAA Fisheries (species recoveries grants to States) augmented by funds from other government agencies and environmental organizations with the support of the Worromontogus ("Togus") Lake Association (WLA, of which CLM is a board member). We have collected data across several seasons at the dam site (location of fish passage), along the length of the stream, and at specific locations about flow dynamics, DO2, water temperature, and pH. We will report on these data, the construction and completion of the fish passage, and the potential implications for improving and monitoring fish runs in Togus and beyond.

Corresponding Author: Carl L. Merrill, carlmerrill2014@gmail.com, (207) 5926528

Baseline Sampling of Penobscot River Sturgeon for Mercury

A. Dianne Kopec, Senator George J. Mitchell Center for Sustainability Solutions, University of Maine
Kevin A. Lachapelle, School of Marine Sciences, University of Maine
Catlin W. Ames, School of Marine Sciences, University of Maine
Gayle B. Zydlewski, School of Marine Sciences, University of Maine

Toxic contaminants, including mercury, have been identified as a detrimental factor in the recovery of both Shortnose (*Acipenser brevirostrum*) and Atlantic (*Acipenser oxyrinchus*) sturgeon. Expressions of methyl mercury toxicity in sturgeon and other fish species range from reduced reproduction and decreased plasma testosterone in males, to liver damage, lowered condition index, and negative behavioral changes. An ongoing concern in the Penobscot River, ME is the residual mercury contamination of river sediment near and downstream from the former HoltraChem site on the Penobscot River in Orrington, ME. Previous work linked elevated mercury concentrations in fish to contamination of the river's benthic food web. Preliminary analysis of sturgeon diet indicate they are actively foraging the benthos in the Penobscot estuary, and it is very likely these sturgeon are exposed to mercury. Further, foraging sturgeon disturb sediments to the depth of their rostrum, roughly 7 cm, increasing bioturbation of the sediment surface and so the availability of inorganic mercury to methylating bacteria. We have begun collecting non-lethal blood samples to document total mercury exposures in the two listed sturgeon species in the Penobscot River Estuary. Mercury concentrations in blood indicate dietary exposures during the preceding months, in contrast to muscle mercury concentrations which reflect exposure over multiple years. Blood samples were collected from 24 Atlantic sturgeon and 118 shortnose sturgeon captured in the Penobscot using gill nets from 7 June 2019 through 26 November 2019. Two shortnose sturgeon were sampled twice within this period (12 Jun and 10 Sept; 19 Jun and 29 Oct). Two other shortnose sturgeon that were sampled had previously been captured and implanted with acoustic transmitters, one of which is currently active. These fish have telemetry data available that can be used to determine habitat use prior to blood sampling, and compared to current mercury loads. These samples will be useful in determining if blood mercury concentrations increase over a period when estuarine foraging is known to occur. Analyses of blood mercury concentrations are ongoing.

Corresponding Author: A. Dianne Kopec, dkopec@maine.edu, (207) 581-3254

Development of environmental DNA tools for sustainable monitoring of northeast sea-run fishes

Samantha J Silverbrand, University of Maine
John Kocik, NOAA- F Northeast Fisheries Science Center
Michael Kinnison, School of Biology and Ecology, University of Maine
Geneva York, eDNA CORE Facility, University of Maine

Many sea-run fishes support important commercial and recreational fisheries and are targets for extensive restoration efforts in the Northeastern United States. These resources require regular monitoring with emphasis on species distributions, phenology, and population dynamics if they are to be managed in a sustainable fashion. Historically, sampling techniques such as gill netting, electrofishing, and trap netting have been used to monitor diadromous species. These traditional methods are labor-intensive, require special training and permitting, are inefficient and may be inaccurate for rare species, and can harm captured individuals. Recent advances in molecular biology suggest that environmental DNA (eDNA), genetic material naturally shed by organisms into their environment, can be detected in water samples to provide a less laborious, non-stressful, and more sensitive alternative. Indeed, environmental DNA samples can be collected by non-specialists, providing an opportunity to increase monitoring participation. The first step in establishing eDNA monitoring is to develop and vet molecular assays. Here we provide results of an effort to complete a suite of species-specific environmental DNA markers for diadromous fish species in the Gulf of Maine. Our target species include: Atlantic salmon, Brook trout, Rainbow smelt, River herring, American shad, Sea lamprey, Shortnose sturgeon, Atlantic sturgeon, Striped bass, and American eel. Our goal is to make these assays interchangeable and combinable in the same sample reactions to permit co-detection. The markers developed here have already been used by academic and government groups to detect Atlantic salmon, Brook trout and Rainbow smelt runs. The development of these new eDNA assays will ultimately provide monitoring and restoration programs with a powerful tool to complement or supplant current sampling methodologies.

Corresponding Author: Samantha J Silverbrand, samantha.silverbrand@maine.edu, (774) 313-7533

Tracking Changes in Atlantic Salmon Habitat Availability using GIS

Christopher M Federico, Project SHARE
Steven D Koenig, Project SHARE
Joan G Trial, Project SHARE

Atlantic salmon can be very tricky to manage. They use three major habitats throughout their lifecycle; freshwater streams and rivers, estuaries, and open ocean. Of those, probably the easiest (relatively) habitat to alter is within freshwater. A variety of factors affect the quality of habitat that salmon use including; water temperature, shelter availability, food availability, depth, velocity, and substrate size and permeability. Further, different life stages have different needs; good spawning habitat is not generally good habitat for large parr and vice versa. The one thing that all salmon life stages need is connected habitat. If a fish can not access the habitat then that habitat is useless. SHARE recognized that there was not a convenient way to track how habitat became available when a stream/road crossing was either decommissioned or replaced with an aquatic organism passage-friendly structure. SHARE wanted to try and answer the following questions for a given watershed using a convenient GIS-based approach: 1) How many total units of habitat are there in the watershed; 2) How many of those units are connected to the ocean; 3) How many units have a suitable temperature; 4) How many units have suitable complexity; and 5) How many units of suitable habitat are not connected? SHARE can track the number of connected units and those with suitable temperatures (with enough data). We can also track the locations of habitat suitability projects. We are trying to develop data for tracking habitat complexity in the watersheds where we are currently working.

Corresponding Author: Christopher M Federico, cfederico@salmonhabitat.org, (207) 731-7488

Fish Community Assessment 6 years following dam removal in the Penobscot River, Maine

Kory A Whittum, University of Maine
Stephen M. Coghlan Jr.-Department of Wildlife, Fisheries, and Conservation Biology, University of Maine, 5755 Nutting Hall, Room 210, Orono, Maine, 04469 USA
Joseph Zydlewski – U.S. Geological Survey, Maine Cooperative Fish and Wildlife Research Unit and Department of Wildlife Fisheries and Conservation Biology, 5755 Nutting Hall, University of Maine, Orono, ME 04469, USA
Daniel B. Hayes- Department of Fisheries and Wildlife, Michigan State University, 480 Wilson Road, Room 13, East Lansing, Michigan, 48824 USA

Large scale dam removal has gained popularity as a means for rehabilitating coastal rivers and their diadromous fishes. Removing dams and their impoundments fundamentally changes flow regimes and increases connectivity, with profound effects on fish assemblages. Recent efforts on the Penobscot River in Maine represent one of the largest ever completed river rehabilitation projects, culminating in the removal of Veazie and Great Works Dams in 2012 and 2013 respectively. In addition to dam removals, significant improvements to fish passage systems were implemented at several remaining dams. To quantify spatial and temporal changes associated with river rehabilitation efforts, fish assemblage monitoring via boat electrofishing began 3 years prior to dam removal and continued for 3 years post-removal. Pre-removal results indicated distinct fish assemblages associated with dams and their impoundments. Post-removal results showed a significant reduction in lacustrine species in formerly impounded sections shifting towards more lotic and diadromous species.

Now 6 years post-removal, we have just begun a new round of sampling to assess longer-term fish responses. Over spring and fall 2019 we electrofished 75 stratified-random transects for a total coverage of 39 km, capturing 9,611 individual fish of 28 species. Smallmouth bass Micropterus dolomieu was found to be most abundant throughout sampling events. Diadromous fishes represented roughly one third of the total biomass and one fifth of the total number of fish encountered.

Corresponding Author: Kory A Whittum, kory.whittum@maine.edu, (585) 6454402

Characterization of in-river plus growth in Atlantic salmon smolt scales

Rachel, Y, Kim, NOAA
Ruth, Haas-Castro, NOAA Fisheries
Mark, Renkawitz, NOAA Fisheries
Brandon, Ellingson, NOAA Fisheries

Wild Atlantic salmon Salmo salar populations have been in decline since the 20th century and were listed as endangered in the US in 2000. Continued research efforts, including growth studies using scale analyses, contribute to a better understanding of Atlantic salmon's behavior and survival. Little information is available regarding the relationship between plus growth observed in smolt scales and emigration timing. Plus growth is a notable characteristic in salmon smolt scales and consists of circuli that have formed after the last freshwater annulus, before the smolts emigrate to a marine environment between April and June. The extent of plus growth may vary depending on the state of an individual fish and whether it lingers in freshwater longer, potentially to reach a threshold size before entering the ocean. To characterize the relationship between the plus-growth formation and time of migration, scale samples from 79 age 2 wild Atlantic salmon smolts from Narraguagus River and 55 from Sheepscot River in Maine were imaged. The best scale from each fish was selected and measured for distances from the scale focus to each circulus, annulus, and the scale margin. The percentage of age 2 smolts with plus growth, the amount of plus growth, and the number of plus-growth circuli were determined per week throughout the migratory season. The results from the two rivers were then compared using regression analyses. The next phase of this research is to characterize the relationship of plus growth in smolt scales and run-out in returning adult salmon scales.

Corresponding Author: Rachel Y Kim, rachel.kim@noaa.gov, (805) 314-9619

Beyond Connectivity: Restoring the Upper Narraguagus River Smolt Output Using a Collaborative Process-Based Approach

Joan G. Trial, Project SHARE, Eastport ME
Steven Koenig, Project SHARE, Eastport ME
Christopher Federico, Project SHARE, Eastport ME
John Kocik, NOAA Fisheries, Orono ME
James Hawkes, NOAA Fisheries, Orono ME
Ernie Atkinson, ME Department of Marine Resources, Jonesboro ME
Colby W. B. Bruchs, ME Department of Marine Resources, Jonesboro ME
Scott Craig, US Fish &Wildlife Service, Orrington ME
Douglas M. Thompson, Connecticut College, New London, CT

The structure and function of coastal Maine Atlantic salmon rivers are the result of a century of human activities including road building, dam construction, and log drives. As a result these rivers have obstructions that limit fish movements and the channels are straight, wide, and lack instream wood and boulders. In the last 25 years restoring fish habitat focused initially on reconnecting river corridors by removing dams and replacing culverts, and more recently on restoring other stream processes. In 2014, Project SHARE assembled a team to develop a project in the top priority Atlantic salmon sub-watershed of the Narraguagus River. By focusing on the Upper Narraguagus River watershed, which produces approximately 75% of smolts in the watershed annually, we were more likely see to measure response in juvenile salmon production. This project is novel in both scope and methodology. Actions are collaborations among geomorphologists, fisheries scientists, and habitat managers. Since 2014, SHARE has focused on restoring altered riverine processes within Atlantic salmon freshwater habitat in Downeast Maine: including: culvert and bridge replacements or removals, remnant log dam removals, reopening and reconnecting remnant side channels, and wood additions. As of September 2019, over 99% of identified Atlantic salmon habitat is accessible to fishes. Wood additions are being managed adaptively to increase their influence on substrate mobility and channel form. There is likely a long lag between wood additions and restored physical processes that are required to increase Atlantic salmon growth and survival. The team believes that, given hatchery stocking, Atlantic salmon smolt production is limited by the amount and quality of physical habitat and higher than optimal stream temperatures. Working to understand the interplay between restored physical habitat and salmon production will require habitat restoration specialists and fisheries scientists and managers to interactively measure system responses. The ultimate measure of success for this novel collaborative sub-watershed scale habitat restoration project will be the long-term trend in annual Atlantic salmon smolt population estimates.

Corresponding Author: Joan Trial, trial@midmaine.com, (207) 949-2656

Effects of ocean currents on the migration of Atlantic salmon post-smolts in a semi-enclosed bay

Brady, K, Quinn, Fisheries and Oceans Canada
Marc, Trudel, Fisheries and Oceans Canada
Brent, Wilson, Fisheries and Oceans Canada
Susan, Haigh, Fisheries and Oceans Canada
Mitchell, O'Flaherty-Sproul, Fisheries and Oceans Canada
Fred, Page, Fisheries and Oceans Canada

Atlantic salmon populations along the east coast of North America have undergone considerable declines in recent decades, particularly in Maine, New Brunswick, and Nova Scotia. Hence, understanding the factors that affect the productivity of Atlantic salmon is necessary to develop effective mitigation strategies to ensure their recovery. The early marine life phase is considered to be a critical period that regulates the productivity of Atlantic salmon. To understand how Atlantic salmon are affected by the environmental conditions they encounter during their early marine life, it is necessary to determine their migration routes, as well as their residence times in different habitats. Acoustic telemetry has provided valuable information on the migration of Atlantic salmon post-smolts in estuaries and in the nearshore marine environment. However, these studies are generally limited in terms of the number of fish tagged. The window for tagging smolts is also generally narrower than the smolt outmigration window, which may limit the generalization of the results obtained from acoustic telemetry studies. Herein, we explored the merit of using an individual-based bio-physical model coupled to output from a preliminary run of the FVCOM physical oceanographic model to simulate the seaward dispersal of Atlantic salmon post-smolts. In contrast to previous modeling efforts, which focused on modeling the dispersal of post-smolts in open waters of the North Atlantic Ocean, we simulated the dispersal of Atlantic salmon post-smolts in a semi-enclosed bay (Passamaquoddy Bay, New Brunswick, Canada). The dispersal model was run with different post-smolt behaviors included, and calibrated against acoustic telemetry data. The purpose at this early stage was to explore the sensitivity of model outputs to various biological and physical assumptions.

Corresponding Author: Brady K Quinn, Brady.Quinn@dfo-mpo.gc.ca, (506) 529-5967

Integrated conservation planning for priority watersheds within the NS Southern Upland Priority Areas

Fielding A Montgomery, Nova Scotia Salmon Association
Amy Weston, Nova Scotia Salmon Association
Bob Rutherford, Nova Scotia Salmon Association
Eddie Halfyard, Nova Scotia Salmon Association

Nova Scotia's Southern Upland contains at least 72 watersheds that provide valuable habitat for several aquatic species. A regional restoration framework is needed to promote the ecological integrity of these aquatic ecosystems, with emphasis on the recovery of four aquatic at-risk species: Atlantic Salmon, Atlantic Whitefish, American Eel and Brook Floater. The goal of this project is to develop a multispecies Watershed Stewardship Plan for candidate priority watersheds to aid in conservation delivery. Eight priority watersheds were selected by experts based on conservation, societal, and science-led evaluation. For each watershed, previously collected biotic and abiotic data will be summarized to identify knowledge gaps and prioritize sites for additional sampling. Tools such as LiDAR-based mapping, remote sensing, water chemistry analysis, and eDNA will be used at select sites, to contribute to our overall understanding of key habitat areas with high recovery potential. We will then integrate species-habitat relationships, important habitat-conservation biology principles, and ecological integrity and threat assessment information in a spatially explicit framework. Ultimately, the assessment output will identify, detail, and rank pragmatic conservation actions across spatial planning units within the eight watersheds to guide conservation planning.

Corresponding Author: Fielding A Montgomery, fielding.montgomery@mail.utoronto.ca, (647) 981-9160

50 years of sampling Atlantic salmon at Greenland

Timothy F. Sheehan, NOAA Fisheries Service (USA)
Martha J. Robertson, Fisheries and Oceans Canada (Canada)
Mark D. Renkawitz, NOAA Fisheries Service (USA)
Nick Kelly, Fisheries and Oceans Canada (Canada)
Rasmus Nygaard, Greenland Institute of Natural Resources (Greenland)
Niall Ó Maoiléidigh, Marine Institute (Ireland)
Ian Russell, Centre for Environment, Fisheries and Aquaculture Science (United Kingdom)
Gérald Chaput, Fisheries and Oceans Canada (Canada)
Cathal Gallagher, Inland Fisheries Ireland (Ireland)
Nora Hanson, Marine Scotland (United Kingdom)

A mixed-stock Atlantic salmon (Salmo salar) fishery that harvests fish from North America and Europe has existed off the west coast of Greenland since the early 1960's. Reported harvest peaked at ~2700 t in 1971, but has been reduced to an average of 37 t over the past ten years due to a downturn in salmon abundance and the adoption of increasingly stringent management measures. Effective management of the resource requires data on annual landings and information on the biological characteristics of the harvest (i.e. length, weight, and scale/tissue samples) to assess the impact of the fishery on contributing stocks. Information on fish age and growth are interpreted from the scale samples and region of origin determined by further analysis of scale or tissue samples. Annual sampling of the Greenland Atlantic salmon harvest has occurred since 1969 (excluding 1993-1994) through international collaborative efforts, latterly coordinated through NASCO. However, the sampling methodology varied by time period as follows: (1) 1969-1981 random samples from research vessels using commercial gillnets, (2) 1982-1997 and 2001 non-random samples from commercial factory landings and (3) 1998-2000 and 2002-2018 random samples from local markets, vendors, and commercial factories when landings were permitted. The West Greenland database currently contains over 60,000 individual records of sampled salmon. The sampling program and resulting dataset are a rare and unique resource supporting science and management. The program offers a cost efficient platform to support a wide variety of marine salmon studies and the spatial and temporal coverage of these data and samples provide an opportunity to investigate the factors affecting marine survival of this highly migratory species in a variable and rapidly changing environment. To continually meet the challenges of Atlantic salmon conservation, restoration, and science-based management, long-term monitoring programs like this one must be maintained and supported into the future.

Corresponding Author: Tim Sheehan, Tim.Sheehan@noaa.gov, (647) 981-9160