Northeast Fisheries Science Center Reference Document 17-04

Program and Abstracts from the 2016 Atlantic Salmon Ecosystems Forum

edited by Mark D Renkawitz and Tara R Trinko Lake

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edited by Mark D. Renkawitz[1] and Tara R. Trinko Lake[2]

[1]NOAA, National Marine Fisheries Service, Northeast Fisheries Science Center,
166 Water Street, Woods Hole, MA 02543
[2]NOAA, National Marine Fisheries Service, Greater Atlantic Regional Fisheries Office,
55 Great Republic Drive, Gloucester, MA 01930

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INTRODUCTION

The biennial Atlantic Salmon Ecosystems Forum (ASEF) was held January 6-7, 2016 at the University of Maine in Orono, ME, marking the 8th meeting since 1990. Over 180 individuals from 43 different organizations attended the meeting. A diverse combination of students, scientists, managers, conservationists, restoration professionals and stakeholders, from Tribal (4%), State (15%), and Federal governments (36%), non-governmental organizations (15%), universities (23%), consulting firms or industry (6%), and the general public (1%) participated.

The goal of this two-day meeting was to facilitate information exchange and discussion of emerging issues pertaining to the science, management, conservation, and restoration of native diadromous species and the freshwater, estuarine, and ocean systems they utilize in New England, Quebec, Atlantic Canada, and distant waters. The unifying theme of the Forum emphasized re-establishing lost biological, physical, and social connections between and among humans, habitats, and fish.

U.S. Senator Angus S. King, Jr. addressed the audience via video, highlighting the successes of recent efforts to restore river connectivity and fish passage through the removal dams on the Penobscot River. He noted that the initial response of the river and components of the diadromous species complex have been positive. Regional Representative Chris Rector attended the Forum on the Senators' behalf and was available for questions from the audience.

Daniel Morris, NOAA Fisheries Deputy Regional Director of the Greater Atlantic Fisheries Office (GARFO), opened the meeting, commenting on different aspects of diadromous species science and management. Catherine Schmidt (Maine Sea Grant) then presented a cultural, socio-ecological chronicle of the decline of Atlantic salmon populations and fisheries in Maine as reflected by the historical presentation of the "Presidential Salmon" and the ultimate cessation of this tradition. Donna Wieting, Director of the Office of Protected Resources at NOAA Fisheries, followed with the keynote address, ushering in Atlantic salmon as one of NOAA's eight "Species in the Spotlight," a plan which calls for a redoubling of NOAA's science and management efforts to address three key components necessary for salmon recovery: marine survival, passage barriers, and a robust diadromous species complex. Over the next 2 days, 32 presentations and 12 posters on diverse topics were delivered among four theme sessions.

The *Management, Conservation & Restoration Programs* session detailed nuances of larger scale approaches to management and monitoring programs. Presentations in the *Marine and Estuarine Ecology* session provided novel research findings on topics related to various biotic and abiotic parameters during the Atlantic salmon smolt emigration, and examined the trophic ecology and survival implications of altered Atlantic salmon foraging conditions off the coast of West Greenland. The *Diadromous Species Ecology* session relayed information on different life stages and various topics including migration, mortality assessment, tracking methods, impacts of marine derived nutrients, and the effects of passage barrier removals on spawning behavior. The seven different diadromous species covered in this session reflected the importance a healthy co-occurring diadromous species complex plays in effective Atlantic salmon restoration via habitat conditioning, nutrient input, and predation buffers among other ecological services. Presentations in the *Freshwater Ecology and Passage Barriers* session provided information on egg enhancement strategies, the importance of in-stream thermal refugia, acoustic tracking and tag retention, impacts of up- and down-stream passage efficiencies, and behavioral and size-related responses to barrier removals (and at passage facilities) for several diadromous species. *Poster and Video* session topics (with 12 and 8

submissions respectively) were diverse and included information on predation and bioenergetics, survey methodology, dam passage survival, population enhancement, fisheries, and sociological elements of management among other topics related to diadromous species science, management, and restoration.

At the close of the meeting, the first annual ASEF Ecosystems Awards, in remembrance of Barbara Arter, a champion of diadromous species restoration in Maine, were awarded to two student presenters in recognition of their contributions to diadromous species ecology. Catherine Johnston (UMO - School of Marine Science) received the 2016 Ecosystems Award for her presentation entitled "*Shortnose sturgeon spawning potential in the Penobscot River after dam removals*" and Danielle Frechette (INRS - Quebec) received the 2016 Ecosystems Award for her poster entitled "*Hit the road: assisted migration as population enhancement?*"

The broad spectrum of presentations and discussions at the 2016 ASEF reflected the evolving movement toward an integrated ecosystem based approach to research and management, conservation, and restoration at multiple spatial and temporal scales among diverse habitats for maximum impact on target species. Atlantic salmon are an indicator of ecosystem conditions, and the call for a redoubling of research and management effort focusing on passage barriers, marine survival, and the diadromous species complex over the next 5 years under NOAA's "Species in the Spotlight" initiative should produce direct and indirect dividends for many diadromous species in the Gulf of Maine, without which Atlantic salmon are unlikely to recover.

NOAA Fisheries (Northeast Fisheries Science Center and Greater Atlantic Regional Fisheries Office) partnered with Project SHARE and the University of Southern Maine to organize, coordinate, and host the 2016 ASEF. Support was provided by NOAA Fisheries, Project SHARE, the U.S. Fish and Wildlife Service, The Nature Conservancy, the Atlantic Salmon Federation, and Big R Bridge. This publication contains the 2016 ASEF agenda and presentation abstracts, and supplements the compilation and documentation of the preceding 7 Fora from 1990-2014 (MacLean 2012; Renkawitz and Trinko 2015). Titles and presenting author are in bold type. Author contact information at the time of publication is provided on the individual abstracts. The material presented in this document does not necessarily reflect official NOAA policy or an endorsement of technology, products, or companies mentioned or referred to herein.

REFERENCES CITED

Renkawitz MD, Trinko Lake, TR. 2015. Program and abstracts of the 2014 Atlantic Salmon Ecosystems Forum. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 15-11; 57 p. doi: 10.7289/V5RV0KPJ, or online at:
http://www.nefsc.noaa.gov/publications/crd/crd1511/index.html

MacLean S. 2012. Programs and Abstracts of the Maine Atlantic Salmon Forums 2002-2012. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 12-12; 232 p. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 12-10; 171 p. Available from: National Marine Fisheries Service, 166 Water Street, Woods Hole, MA 02543-1026, or online at: http://www.nefsc.noaa.gov/publications/crd/crd1212/

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The 2016 Atlantic Salmon Ecosystems Forum

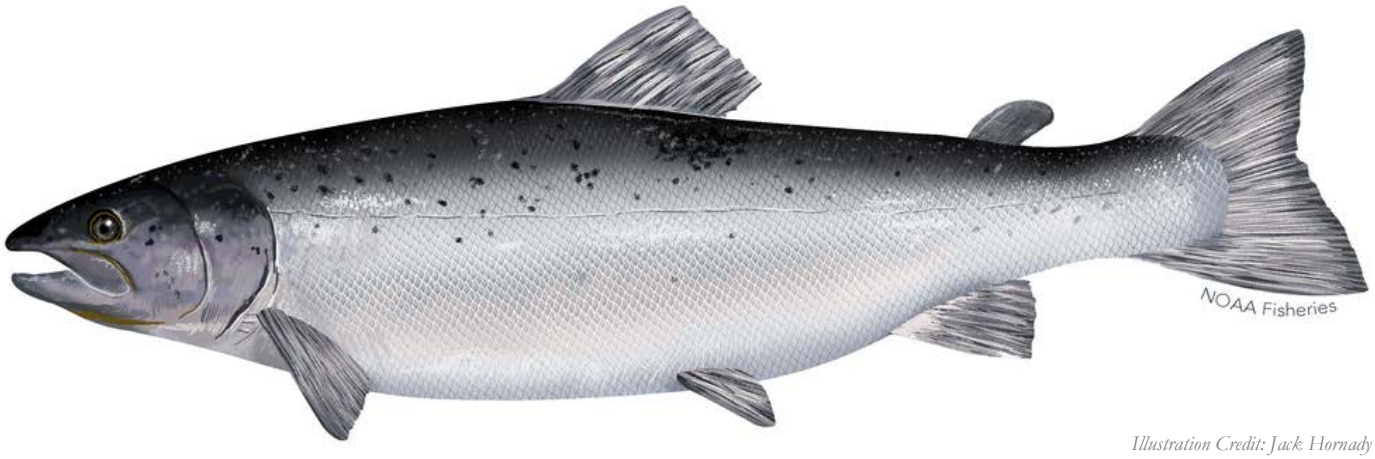

Illustration Credit: Jack Hornady

January 6-7, 2016
Orono, Maine, USA
University of Maine, Wells Conference Center

Sponsors:

The Atlantic Salmon Ecosystems Forum
January 6-7, 2016
University of Maine, Orono, Wells Conference Center

January 6, 2016

07:00-08:00 **Registration and Continental Breakfast**

08:00-08:05 Opening Remarks

08:05-08:10 A message from U.S. Senator Angus King, Maine

08:10-08:30 The President's Salmon ~*Catherine Schmitt*

08:30-09:10 **Keynote Address** ~*Donna Wieting, Director for Protected Resources, National Marine Fisheries Service*

Session I: Management, Conservation & Restoration Programs

09:10-09:30 Atlantic salmon – A Species in the Spotlight ~*Kimberly Damon-Randall*

09:30-09:50 Wild Atlantic salmon recovery planning: What Works? ~*Jonathan Carr*

09:50-10:30 **Morning Break (r*efreshments are provided)***

10:30-10:50 Running with renewal: reflections on the Penobscot River Restoration Project's accomplishments and efforts to restore sea-run fisheries while maintaining energy production ~*Molly Payne Wynne*

10:50-11:10 The NOAA Habitat Blueprint and what's next for Penobscot River habitat restoration ~*Matt Bernier, P.E.*

11:10-11:30 Developing priorities to repair stream connectivity: lessons from collaborations in the Maine ~*Joshua Royte*

11:30-11:50 Culvert replacement cost benefits in the long term ~*Ben Naumann*

11:50-12:10 The Maine Stream Temperature Monitoring Network ~*Serena Doose*

12:10-01:30 **Lunch Break in the Bear's Den *(the meal is not provided)***

Session II: Marine and Estuarine Ecology

01:30-01:50 Diadromous fish and their predators in the nearshore Gulf of Maine ~*Keri Stepanek & Christine Lipsky*

01:50-02:10 Changing trophic structure and energy dynamics in the Northwest Atlantic influences Atlantic salmon abundance ~*Timothy Sheehan*

02:10-02:30 Short-term temporal variation in West Greenland Atlantic salmon (*Salmo salar* L.) inshore/offshore feeding and trophic niche ~*Heather Dixon*

02:30-02:50 Fish behavior, presence, and distribution in relation to the Cobscook Bay Tidal Energy Project ~*Gayle Zydlewski*

02:50-03:30 **Afternoon Break *(refreshments are provided)***

03:30-03:50 From River to Ocean: implications of the shift in run-timing for Atlantic salmon post-smolts through the Gulf of Maine ~*James P. Hawkes*

03:50-04:10 Using mobile hydroacoustics to describe pelagic fish distribution in the Penobscot River Estuary ~*Justin Stevens*

04:10-04:30 Characterizing chemical and biological parameters in Penobscot Bay before, during and after the release of Atlantic salmon (*Salmo salar*) *~Shannon Meseck*

04:30-04:50 Characterizing the Penobscot River estuarine transition zone during Atlantic salmon smolt migration *~Rachel Lasley-Rasher*

04:50-06:30 **Reception, Poster Session, and Video Session *(refreshments provided, cash bar available)***

Posters:
Are the Restigouche River smolts on the menu for Double-Crested Cormorants? *~Joanie Carrier*

Hit the road: assisted migration as population enhancement? *~Danielle Frechette*

The interplay of dams, marine and freshwater survival, and hatchery supplementation on the recovery potential of Atlantic salmon in Maine *~Julie L. Nieland*

Improving hydroacoustic data collection and processing methods to estimate fish abundance in the Penobscot River before and after dam removal *~Constantin Scherelis*

Collect, Analyze, Make Informed Decisions - DATA collection: A critical component in supporting a successfully operating fishway now and into the future. *~Bryan Sojkowski, P.E.*

Atlantic tomcod in the Penobscot Estuary *~Justin Stevens*

American eel survival through Milford Dam on the Penobscot River, Maine *~Emily J. Thornton*

Do we hit to the target? Evaluation of thermal exposure of river- and hatchery-reared juvenile Atlantic salmon prior to migration on the Narraguagus River, Maine U.S.A. *~Dylan S. Whitaker*

Engaging indigenous peoples to facilitate river restoration on the St. Croix, Maine/New Brunswick *~Theodore Willis*

On river hatchery rearing of 0+ fall parr to increase adult Atlantic salmon returns to the East Machias River, a collaborative model for salmon recovery *~Kyle Winslow*

The Use of Natural Markers to Investigate Habitat Use and Growth of Juvenile Alewife (*Alosa pseudoharengus*) *~Greg LaBonte*

Videos:
A Culvert Story: Restoration of a Stream – Trout Unlimited, Mid-Coast Maine Chapter

The fish that feeds all – *Maine Sea Grant*

River restoration in Downeast Maine – *Maine Sea Grant*

Maintaining alewife and blueback populations – *Maine Sea Grant*

Elver economics – Maine Sea Grant – *Maine Sea Grant*

What if there were no river fisheries in Downeast Maine? – *Maine Sea Grant*

The St. Croix River – *Maine Sea Grant*

Harvesting alewives at Grist Mill Stream – *Maine Sea Grant*

Harvesting alewives at the Orland River – *Maine Sea Grant*

January 7, 2016

07:00-08:00 **Registration and Continental Breakfast**

08:00-08:05 Opening Remarks

Session III: Diadromous Species Ecology

08:05-08:25 Methodologies of acoustic telemetry tagging in American Shad (*Alosa sapidissima*) ~*Michael Bailey*

08:25-08:45 Modeling migration of silver eels to forecast critical intervals of risk ~*Douglas B. Sigourney*

08:45-09:05 Shortnose sturgeon spawning potential in the Penobscot River after dam removals ~*Catherine Johnston*

09:05-09:25 Sea lamprey carcasses influence food webs in an Atlantic coastal stream ~*Daniel Weaver*

09:25-09:45 Size, age, and longevity of seven populations of landlocked and anadromous rainbow smelt (*Osmerus mordax*) ~*Andrew O'Malley*

09:45-10:25 **Morning Break (*refreshments are provided)***

10:25-10:45 Assessing alewife (*Alosa pseudoharengus)* movements in the St. Croix River watershed ~*Graham Chafe*

10:45-11:05 Tracking Siqonomeq (alewife) migration in the Passamaquoddy Bay ~*Asha Ajmani*

11:05-11:25 Feeding habits of juvenile alewife (*Alosa pseudoharengus*) in the Penobscot Estuary ~*Amy Webb*

11:25-11:45 Alewife (*Alosa pseudoharengus*) as marine-derived nutrient subsidies in two northeast Maine rivers ~*Betsy Barber*

11:45-01:15 **Lunch Break in the Bear's Den *(the meal is not provided)***

Session IV: Freshwater Ecology and Passage Barriers

01:15-01:35 The Relative Effects of Factors on Tag Retention of Atlantic Salmon (*Salmo salar*) ~*Jason Daniels*

01:35-01:55 Post-restoration assessment of Atlantic salmon (*Salmo salar*) survival during their downstream migration in the Penobscot River, Maine ~*Alejandro Molina-Moctezuma*

01:55-02:15 Methods and results of identifying potential groundwater upwelling within Atlantic salmon juvenile rearing habitat in three Downeast Maine Salmon Rivers ~*Scott Craig*

02:15-02:35 Atlantic salmon ova planting; dispersal, density dependent growth and implications for management ~*Paul Christman*

02:35-03:15 **Afternoon Break (r*efreshments are provided)***

03:15-03:35 Dam removal and fish passage improvement influence fish assemblages in the Penobscot River, Maine ~*Jonathan M. Watson*

03:35-03:55 Behavior and upstream passage of Atlantic salmon at the New Milford Fish Lift on the Penobscot River, ME ~*Lisa Izzo*

03:55-04:15 Size Matters: Fishways can exert size selective pressure on Atlantic salmon migrating in the Penobscot River ~*George Maynard*

04:15-04:35 Projected tradeoffs in population abundance of American shad (*Alosa Sapidissima*) in relation to upstream and downstream passage at dams ~*Dan Stich*

04:35-04:45 **Student Awards, Closing Remarks, and Adjourn**

2016 Atlantic Salmon Ecosystems Forum

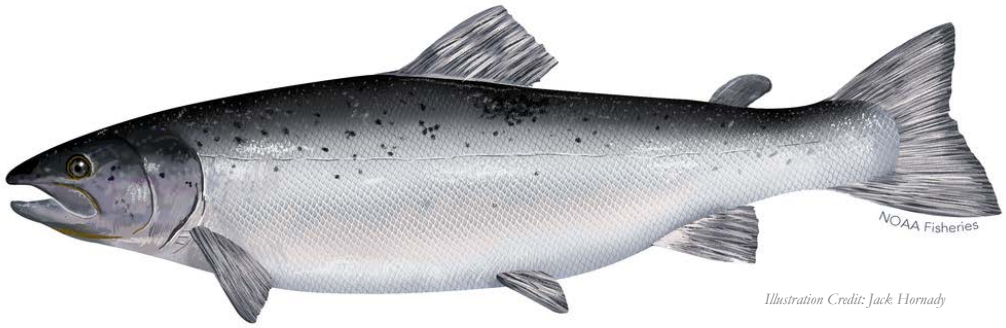

Illustration Credit: Jack Hornady

The Arter Ecosystems Award

This award has been established to acknowledge the substantive contributions of Barbara Arter to the restoration of Maine's waterways and species that use them. Through her work as a facilitator and ecologist, Barbara was instrumental in re-establishing lost biological, physical, and social connections between and among humans, habitats, and fish. Consistent with Barbara's vision as an educator, this award recognizes outstanding student papers presented at this Forum that further the conservation, protection, restoration, and enhancement of native diadromous species and their ecosystems in the Northwest Atlantic.

2016 Award Recipients:

Catherine Johnston *(presentation)*
Shortnose sturgeon spawning potential in the Penobscot River after dam removals
University of Maine, Orono, School of Marine Sciences

Danielle Frechette *(poster)*
Hit the road: assisted migration as population enhancement?
Institut National de la Recherche Scientifique, Centre Eau Terre Environnement

Session I: Management, Conservation & Restoration Programs

Moderators:

Daniel Morris, *Deputy Regional Director, NOAA Fisheries Service*

Jed Wright, *Project Leader, US Fish and Wildlife Service*

Atlantic Salmon in the Twentieth Century: The POTUS Perspective

Catherine Schmitt[1]

[1]*Maine Sea Grant, 5784 York Complex, University of Maine, Orono, ME*

Between 1912 and 1992, recreational anglers on the Penobscot River in Maine held an annual tradition of giving the first Atlantic salmon caught each spring to the President of the United States. The ritual provides a framework for analyzing how salmon were affected by national policies regarding energy, industrial water use, and pollution throughout the twentieth century. Each president's receipt and consumption of the "first fish" also retained a national memory of Atlantic salmon as food, a memory that otherwise may have faded due to the decline of Atlantic salmon populations. An exploration of the intertwined cultural, culinary, and political histories of Atlantic salmon in the United States has relevance for present efforts to conserve and restore populations of salmon and other fish to the nation's rivers.

Corresponding Author: Catherine Schmitt, 207-581-1434, catherine.schmitt@maine.edu

Atlantic salmon – A Species in the Spotlight

Kimberly Damon-Randall[1], Julie Crocker[1], Dan Kircheis[2], Tara Trinko Lake[2], John Kocik[3], and Rory Saunders[2]

[1]*NOAA, National Marine Fisheries Service, Greater Atlantic Regional Fisheries Office, 55 Great Republic Drive, Gloucester, MA*
[2]*NOAA, National Marine Fisheries Service, Greater Atlantic Regional Fisheries Office, Maine Field Station, 17 Godfrey Drive, Orono, ME*
[3]*NOAA, National Marine Fisheries Service, Northeast Fisheries Science Center, 17 Godfrey Drive, Orono, ME*

In 2015, NOAA announced a new program to focus and redouble its efforts to protect some of the species that are currently among the most at risk of extinction in the near future. The effort is called the "Species in the Spotlight: Survive to Thrive" initiative, a concerted agency-wide effort to spotlight and save these highly at-risk species. Recently, NOAA leadership selected the Gulf of Maine Distinct Population Segment of Atlantic Salmon as one of eight "Species in the Spotlight" nationally. At the regional level, we are currently developing a 5-year action plan (that builds upon the draft recovery plan) that details the focused efforts needed to reduce threats and stabilize population declines of the Gulf of Maine Distinct Population Segment of Atlantic Salmon. The plan highlights four key areas: reconnecting the Gulf of Maine with headwater habitats; increasing the number of fish successfully entering the marine environment; reducing international fishery mortality in West Greenland; and increasing our understanding and ability to improve survival in the marine environment. We now seek to engage our partners in the public and private sectors in actions they can take to support this important effort.

Corresponding Author: Kimberly Damon-Randall, 978-282-8485, kimberly.damon-randall@noaa.gov

Wild Atlantic Salmon Recovery Planning: What Works?

Jonathan Carr[1], Tim Sheehan[2], Joan Trial[3], Jamie Gibson[4], Geoff Giffin[1], and David Meerburg[1]

[1]*Atlantic Salmon Federation, PO Box 5200, St. Andrews, NB, Canada*
[2]*NOAA, National Marine Fisheries Service, Northeast Fisheries Science Center, 166 Water Street, Woods Hole, MA*
[3]*Department of Marine Resources Maine/Retired*
[4]*Fisheries and Oceans Canada, Bedford Institute of Oceanography, 1 Challenge Dr., PO Box 1006, Dartmouth, NS, Canada*

Developing a restoration plan for Atlantic salmon is a complicated undertaking with no single template available for all possible situations. To have an effective restoration program we need to focus on projects that maximize the chance of recovery success subject to effective use of limited resources, and involve broad partnerships across several disciplines. Several factors must be considered when developing a restoration plan, including assessments of stage-specific indices of salmon abundance, water quantity, water quality, habitat quality, connectivity, and the complexity of the biological community. A clear understanding of the problem, a statement of desired outcomes, an evaluation of available options, and a long-term commitment are required. An understanding of the goals and timelines for hatchery intervention is required if stocking is to be considered as part of the overall recovery effort. Genetic and population dynamic experts must be consulted, hatchery practices that mimic natal rearing conditions should be employed to the greatest extent practical, and stocking should be acknowledged as a temporary tool while root problems such as fish passage, habitat quality and quantity, and potentially, overharvest are addressed. We recommend five guiding principles that should form the foundation of any recovery plan: (1) committed team, (2) holistic approach, (3) long term commitment (funding and leadership), (4) monitoring and evaluation, and (5) outreach and communication. Finally, there are no guarantees that a holistic recovery program that addresses multiple threats within a watershed in support of either a wild population, or a live gene banking (stocking) program, will be successful. However, ensuring that freshwater habitat is as productive as possible increases the likelihood of salmon recovery irrespective of the factors necessitating the recovery program in the first place.

Corresponding Author: Jonathan Carr, 506-529-1385, jcarr@asf.ca

Running with renewal: reflections on the Penobscot River Restoration Project's accomplishments and efforts to restore sea-run fisheries while maintaining energy production

Molly Payne Wynne[1] and George Aponte Clarke[1]

[1]*Penobscot River Restoration Trust, P.O. Box 569, Augusta, ME*

Dams have impacted ecosystems for centuries, blocking connections between inland waters and the sea; people and the river. Populations of sea-run fish once measured in millions, has plummeted to fractions of their historic counts. Among the ecosystems threatened by the impact of dams is the Penobscot River, Maine's largest watershed; an extensive system of forests and wetlands, largest freshwater input to the Gulf of Maine, and home to the largest remaining population of endangered Atlantic salmon in the US. Importantly, the Penobscot has the greatest potential for diadromous fish restoration and their concomitant ecological processes. In 2004, an innovative agreement between the Penobscot Indian Nation, a hydropower company, seven conservation groups, and resource agencies resolved decades of conflict over fisheries and hydropower development. The Penobscot River Restoration Project, a collaborative initiative to restore self-sustaining populations of sea-run fish, charted a whole-system approach endeavoring strategic removal of multiple barriers while also rebalancing hydropower. The Project, implemented by the non-profit organization, the Penobscot River Restoration Trust, has reached major milestones endeavoring strategic removal of multiple barriers while rebalancing hydropower. Acquisition and decommissioning of three large mainstem dams is complete; the two lower-most mainstem dams were removed in 2012 and 2013 and construction of a nature-like bypass channel around another dam upriver will be operational for the spring 2016 migration. Widely recognized as a model for cooperative conservation, the completed Project provides 11 species of native fishes with significantly improved access to vital habitat within nearly 1,000 miles (1609 km) of watershed while maintaining hydropower, currently above pre-project levels. Targeted species include endangered Atlantic salmon, endangered short-nose and Atlantic sturgeon, shad, river herring and eel. Terrestrial and avian wildlife will also benefit from this "refueled" system. By re-establishing connections between inland waters and the sea, the Project promises renewed ecological function, cultural interactions, and economic activities throughout the watershed and entire Gulf of Maine. This presentation will inform watershed managers, resource specialist, and restoration interests by sharing creative steps taken to balance energy production with ecological and community values. Knowledge will be transferred through a summary of Project implementation, accomplishments, and initial monitoring.

Corresponding Author: Molly Payne Wynne, 315-749-6182, molly@penobscotriver.org

The NOAA Habitat Blueprint and what's next for Penobscot River habitat restoration

Matt Bernier, P.E.[1]

[1]*NOAA Habitat Restoration Center, Maine Field Station, 17 Godfrey Drive, Orono, ME*

Historically, diadromous fish populations in the Penobscot River were bountiful, with an estimated 14 to 20 million alewives (*Alosa pseudoharengus*), 75,000 to 100,000 Atlantic salmon (*Salmo salar*), and 3 to 5 million American shad (*Alosa sapidissima*) returning annually. While still home to all eleven native diadromous species, including three listed under the Endangered Species Act, fish populations historically dwindled in the river due to factors including dams and culverts that blocked access to major proportions of historic habitat.

In 2014, as part of the National Oceanic and Atmospheric Administration's Habitat Blueprint initiative, the Penobscot River was selected as one of only ten Habitat Focus Areas (HFA) in the United States. The Habitat Blueprint represents an opportunity for large scale restoration, building off the successful removal of the two lowermost dams on the Penobscot River as part of the Penobscot River Restoration Project. However, with over 30 hydroelectric dams, 100 non-hydroelectric dams and 2,000 culverts in the watershed, a lot of restoration work remains to be done. Working with partners such as The Nature Conservancy, NOAA hopes to break down holistic goals for watershed restoration into manageable pieces using multi-year planning. Tools for restoration include habitat protection, dam removals, fishway construction and culvert replacements, coupled with science and monitoring programs to evaluate outcomes against expectations. In contrast to a history of opportunistic restoration, the collaborative Penobscot HFA effort will attempt to prioritize barrier removals and develop strategies for restoring multiple diadromous species in three broad habitat types: lower river/tidal habitat, alewife lakes and headwater streams. The HFA effort will also devote resources to outreach and communications to inspire a culture of habitat restoration amongst municipalities in the watershed.

Corresponding Author: Matt Bernier, 207-487-4361, Matthew.Bernier@noaa.gov

Developing Priorities to Repair Stream Connectivity: Lessons from collaborations in the Maine

Joshua Royte[1], Alex Abbott[2], Jed Wright[2], Barbara Charry[3], Sally Stockwell[3], Ben Naumann[4], Charles Hebson[5], Merry Gallagher[6], Pat Sirois[7], Slade Moore[8], and Tara Trinko Lake[9]

[1]*The Nature Conservancy in Maine*
[2]*US Fish and Wildlife Service, Gulf of Maine Coastal Program*
[3]*Maine Audubon*
[4]*USDA Natural Resources Conservation Service*
[5]*Maine Department of Transportation*
[6]*Maine Department of Inland Fisheries and Wildlife*
[7]*Maine SFI Implementation Committee*
[8]*formerly Maine Coastal Program*
[9]*NOAA, National Marine Fisheries Service, Greater Atlantic Regional Fisheries Office, Gloucester, MA*

Road crossings worldwide fragment aquatic habitat and suppress fish and other wildlife populations. To address this problem, a collaboration has been working since 2007 in Maine including partners from over 50 state, federal, tribal, local and non-governmental organizations. The goal is to increase the quantity, speed, and quality of aquatic restoration. The Collaborative represents a series of working groups addressing six core strategies to correct stream connectivity problems at our roughly 25,000 road stream-crossings; 1) barrier assessment and prioritization, 2) outreach and training, 3) policy and rules, 4) technical assistance, 5) funding, and 6) restoration implementation and monitoring. Each strategy has one or more teams making progress. Different approaches are needed to address locally owned roads (greatest need), state roads, and road crossings on private timber lands covering half of our state with some of the best aquatic habitat.

These strategies have led to the assessment of 65% of the state's road-stream crossings; a database now includes information on over 19,000 sites, with another year of assessment funded. Over 30% of assessed crossings are barriers to aquatic passage and another 40% are likely problems for some or all species, some or all of the time. Data for public crossings are attributed with up and downstream habitat are shared widely including an online data viewer. The Collaboration using these data have already helped focus several dozen restoration projects. An interactive prioritization tool is being developed with barrier and species data for the Penobscot River Watershed, over ¼ of the state of Maine to guide funding and projects as part of the NOAA Penobscot Habitat Focus Area. Workshops have educated over 800 contractors and road managers with basic stream crossing design principles, and funding for aquatic organism passage has increased from private, federal and a new state bond for funding $5 million of municipal road upgrades and ensuring this work expands in the coming decades.

Corresponding Author: Joshua Royte, 207-607-4817, jroyte@tnc.org

Culvert replacement cost benefits

Ben Naumann[1] and Lynn Knight[2]

[1]*USDA, Natural Resources Conservation Service, 967 Illinois Ave Bangor ME*
[2]*USDA, Natural Resources Conservation Service, 2901 E. Gate City Blvd., Greensboro, NC*

Improperly installed or defective road-stream crossing culverts present impediments to stream function, and barriers to aquatic organism passage, including fish. The solution to these resource concerns is to replace problematic structures with environmentally sound structures. The initial cost of such structures is high and can be a disincentive. We analyzed costs of three road stream crossing case studies common on the landscape: one forestland culvert and two municipal culverts. For each case study, the estimated cumulative costs for road stream crossing structures (which included round culverts, arch culverts and bridges) were analyzed for a duration of 50 years. When road-stream crossing structure costs are amortized over a period of 50 years and compared, undersized round culverts are less economical than environmentally sound structures due to greater maintenance needs. Results also show that new technologies, forestry ingenuity, and regulations affect the economics of structures over time. Environmentally sound structures are more resilient and can better survive large storm events (e.g. Hurricane Irene) than undersized structures. These results can be used as an outreach tool to show that environmentally sound stream crossing structures are a good long-term investment.

Corresponding Author: Ben Naumann, 207-990-9504, bnaumann@me.usda.gov

The Maine Stream Temperature Monitoring Network

Serena Doose[1] and Jed Wright[1]

[1]*U.S. Fish and Wildlife Service, Gulf of Maine Coastal Program, Falmouth, ME*

The Maine Stream Temperature Monitoring Network was developed in 2014 to facilitate a coordinated stream temperature monitoring effort in Maine that will be integrated with regional and national efforts. The Network is being implemented by the Stream Temperature Working Group (STWG), composed of multiple state agencies, academic institutions, NGOs, tribes and federal agencies. The STWG is conducting a comprehensive inventory of existing data for current and past water temperature monitoring efforts, developing a web-based centralized database, training others in protocol methods, and deploying loggers state-wide. Within the first year, the STWG has collected historical temperature data from more than 800 locations and deployed over 200 stream temperature sensors in every watershed, with many more to come in the following seasons. Researchers and fisheries managers plan to use this robust data repository for fish occupancy modeling, habitat restoration prioritization, and regional climate studies.

Corresponding Author: Serena Doose, 207-781-8364, serena_doose@fws.gov

Session II: Marine & Estuarine Ecology

Moderators:

Andrew Goode, *Vice President of US Programs, Atlantic Salmon Federation*

Rory Saunders, *Fisheries Biologist, NOAA Fisheries Service*

Diadromous fish and their predators in the nearshore Gulf of Maine

Keri Stepanek[1], Christine Lipsky[2], Brian Smith[3], Stacy Rowe[3], Tim Sheehan[3], and Sean McDermott[4]

[1]*Maine Department of Marine Resources, West Boothbay Harbor, ME*
[2]*NOAA, National Marine Fisheries Service, Northeast Fisheries Science Center, Orono, ME*
[3]*NOAA, National Marine Fisheries Service, Northeast Fisheries Science Center, Woods Hole, MA*
[4]*NOAA, National Marine Fisheries Service, Greater Atlantic Fisheries Office, Gloucester, MA*

Several diadromous fish species, including river herring (*Alosa pseudoharengus; A. aestivalis*) and American shad (*A. sapidissima*), are known to have been historically important prey items for Atlantic cod (*Gadus morhua*) and other groundfish species in the Gulf of Maine (GoM). It has been hypothesized that the abundance declines of groundfish stocks over the past 200 years has been exacerbated by the loss of forage fish due to anthropogenic factors in freshwater and estuarine habitats (i.e., construction of passage barriers, water quality degradation, etc.). Recent large-scale restoration efforts in the Penobscot River system are anticipated to enhance the abundance of diadromous fish species in nearshore waters, and in turn aid restoration of ailing groundfish stocks regionally. Since 2000, The Maine-New Hampshire Inshore Trawl Survey has been conducted in the GoM waters from New Hampshire to the Canadian border out to the 12 mile limit. This resource assessment survey samples diverse substrates and strata, including important spawning and nursery habitat for several commercial groundfish species. Large numbers of diadromous fish species and several of their known predators, such as Atlantic cod, monkfish (*Lophius americanus*) and silver hake (*Merluccius bilinearis*), are regularly caught throughout the survey area. The nature of the trawl survey has made it an ideal platform for investigating diets of these nearshore groundfish species, and specifically to evaluate the importance of diadromous fish as prey.

This presentation examines the changes in size, relative abundance and distribution of diadromous fish species and their predators over the fifteen year span of the trawl survey. Additionally, we describe our analysis of stomachs from groundfish captured offshore of the Penobscot and Kennebec Rivers from 2010 to 2015. The Kennebec River, which supports a relatively robust diadromous species assemblage, was sampled for comparison with the Penobscot River that currently has a smaller diadromous run. Our results indicate that groundfish predation on diadromous fish offshore of both rivers was low, and river herring were the only diadromous species in the stomach samples. Concurrent assessment surveys and stomach sampling efforts in the GoM will assist in evaluating diadromous species responses to large-scale river restoration projects, and in evaluating the effect that changing prey resource availability may have on groundfish species distribution and abundance. Restoring a healthy diadromous prey species assemblage in the GoM may assist in rebuilding depleted groundfish populations regionally, given the close historical predator-prey relationship between the two groups of fish.

Corresponding Authors: Keri Stepanek, 207-633-9530, Keri.Stepanek@maine.gov, & Christine Lipsky, 207-866-4667, Christine.Lipsky@noaa.gov

Changing trophic structure and energy dynamics in the Northwest Atlantic influences Atlantic salmon abundance

Mark Renkawitz[1], **Timothy Sheehan[1]**, Heather Dixon[2], and Rasmus Nygaard[3]

[1]*NOAA, National Marine Fisheries Service, Northeast Fisheries Science Center, Woods Hole, MA*
[2]*University of Waterloo, Waterloo, Ontario, Canada*
[3]*Greenland Institute of Natural Resources, Nuuk, Greenland*

In the Northwest Atlantic, changes in large-scale climate conditions resulted in a phase shift in productivity, thereby altering trophic pathways that influence the growth, survival, and abundance of many species. Coherent abundance declines of disparate North America and European Atlantic salmon populations during this time, despite diverse population structures and management regimes, suggests that conditions experienced at common marine areas are causative. To understand the trophic mechanisms behind these declines, 1451 stomachs were examined from Atlantic salmon caught at the West Greenland feeding grounds between 2006 and 2011 and compared to stomach data from 1965-1970. Standardized stomach content weights and stomach composition varied among years but not between stock complexes. Atlantic salmon consumed a variety of prey taxa (primarily capelin and Themisto sp.) over a broad size spectrum. Standardized stomach content weight and proportions of taxa consumed were similar between historic and contemporary samples, although lower-quality boreoatlantic armhook squid, nearly absent from historic data, was of moderate importance in contemporary samples while higher-quality capelin decreased in importance. Congruent with the regional phase shift in productivity, mean energy density estimates of the keystone forage species, capelin, decreased by approximately 33.7 %, resulting in lower estimates of total energy consumption by Atlantic salmon over time. These results indicate altered trophic dynamics caused by 40 years of changing ocean conditions negatively influenced Atlantic salmon, and likely many other commercially, culturally, and ecologically important species in the Northwest Atlantic. Determining causal mechanisms that influence marine food webs is necessary to fully understand and evaluate survival and productivity trends, and establish realistic management targets for commercial, recreational, and protected species.

Corresponding Author: Mark Renkawitz, 508-495-2122, Mark.Renkawitz@noaa.gov

Short-term temporal variation in West Greenland Atlantic salmon (*Salmo salar* L.) inshore/offshore feeding and trophic niche

Heather J. Dixon[1], J. Brian Dempson[2], and Michael Power[1]

[1]*Biology Department, University of Waterloo, 200 University Avenue West, Waterloo, ON, Canada*
[2]*Fisheries and Oceans Canada, Science Branch, 80 East White Hills Road, P.O. Box 5667, St. John's, NL, Canada*

The marine feeding ecology of Atlantic salmon (*Salmo salar* L.) in the Northwest Atlantic is poorly understood, with little known about current diet and trophic status. Many non-maturing North American Atlantic salmon undertake a feeding migration along the west coast of Greenland. Coastal diet in other anadromous salmonid species has been shown to vary depending on whether fish were feeding in the inshore or offshore environment. As such, a study examining inshore/offshore feeding preferences and their impact on the Atlantic salmon trophic niche using stable isotope analysis methods was undertaken as part of the Salmon at Sea (SALSEA) Greenland initiative. Atlantic salmon were caught off the West Greenland coast during August to October over a three year period (2009-2011). Dorsal muscle tissue from sampled fish was used for a stable isotope based test of the hypothesis that Atlantic salmon increasingly relied on inshore feeding as a function of the months spent at West Greenland. Further, we examined relationships between inshore feeding, fish condition and size, and produced standard stable isotope derived metrics for niche width, diversity, omnivory, and basal resource use for each month of the sampling period. The proportion of reliance on inshore prey resources varied widely (0.00 – 0.84), and the mean proportion increased significantly over the sampling period ($p < 0.001$). Variance of inshore feeding differed significantly between months across all years combined and in 2011. Condition factor, size, $\delta^{13}C$ and $\delta^{15}N$ all varied positively and significantly with reliance on inshore feeding ($p < 0.001$), with all four variables also increasing over the sampling period ($p \leq 0.007$). Variations in trophic niche was also apparent across the sampling period, with trophic diversity, trophic width, omnivory, and basal resource use varying the most in September. The large variation in inshore resource use and trophic metrics is suggestive of widely different foraging strategies between individuals, i.e. Atlantic salmon as opportunists. An increasing reliance on inshore feeding could be due to exploitation of capelin, largely found inshore during the sampling period, as prey. By focusing foraging efforts inshore Atlantic salmon may be maximising growth, as demonstrated by increasing condition factor and size with increasing inshore feeding. Given the potential for climate change to alter the ecology of West Greenland inshore areas, understanding how Atlantic salmon resource use is partitioned allows for greater understanding of the potential consequences of these changes.

Corresponding Author: Heather Dixon, 519 888 4567 (x30166), hjdixon@uwaterloo.ca

Fish Behavior, Presence, and Distribution in relation to the Cobscook Bay Tidal Energy Project

Gayle Zydlewski[1], Garrett Staines[1], Haley Viehman[1], Haixue Shen[2], James McCleave[1], Jeffrey Vieser[3], and Alexander Jensen[4]

[1]*University of Maine, School of Marine Sciences, Orono, ME*
[2]*Louisiana State University, Department of Oceanography and Coastal Sciences, Baton Rouge, LA*
[3]*National Marine Fisheries Service, Silver Springs, MD*
[4]*Michigan State University, Department of Fisheries and Wildlife, East Lansing, MI*

We studied fishes associated with tidal-stream energy projects in Cobscook Bay. Tidal energy devices under consideration were Ocean Renewable Power Company's TidGen® Beta, TidGen® and OCGen® systems. The project began in 2009 to determine (1) the vertical distribution of fishes before and after device deployment; (2) how fish behave when encountering a tidal device in their natural environment; (3) what fish species are present and whether or not they were infected with sea lice; and (4) the probability of fish encountering a device. (1) From 2010 to 2013, 15 24-hr down-looking hydroacoustic surveys were carried out at a project site and control site. Relative densities of fish were generally greatest near the sea floor. Fish were more evenly distributed in the water column at night than during the day, but changes in vertical distribution between ebb and flood tides were inconsistent. There were significant differences between two of three before/after comparisons of vertical fish distributions, indicating an effect of the device. (2) Using DIDSON acoustic cameras, fish responses within 3 m of a test turbine were documented. Most fish observed were $\leq$10 cm long and moved in the same direction as the water current. Approximately 50% of individuals and 67% of schools did not interact with the turbine. Less than 1% of individuals and 15% of schools showed avoidance behavior, and 35% of individuals and 14% of schools entered or exited the turbine. Turbine rotation reduced the probability of entering the turbine by 35% and increased the probability of avoiding and passing by 120% and 97%, respectively. Schools avoided the turbine from farther away than individuals. (3) During the summer months of 2011-13, a variety of fish capture gears were used to sample fish in the sub- and inter-tidal zones. Three-spine stickleback, Atlantic herring and winter flounder dominated catches in all years. In 2012-13 fish were visually checked for sea lice. Three-spine sticklebacks had the highest infestation prevalence and intensity of *Caligus elongatus* but no *Lepeophtheirus* spp. were documented on wild fish. (4) Combining down-looking hydroacoustic surveys with mobile transects we determined that the probability of fish being at the depth of the moving foils (~6-9 m) ranged from 0.083 to 0.093. The four approaches combined provide a picture of fish interactions with a tidal-stream energy device.

Corresponding Author: Gayle Zydlewski, 207-581-4372, gayle.zydlewski@maine.edu

From River to Ocean: Implications of the Shift in Run-Timing for Atlantic Salmon Post-Smolts Through the Gulf of Maine

James P. Hawkes[1], John F. Kocik[1], Graham S. Goulette[1], Justin R. Stevens[2] and Carrie Byron[3]

[1]*NOAA, National Marine Fisheries Service, Northeast Fisheries Science Center, Maine Field Station, Orono, ME*
[2]*Integrated Statistics, Maine Field Station, Orono, ME*
[3]*University of New England, Biddeford, ME*

Migration of Atlantic salmon smolts from Maine rivers to the sea now occurs two weeks earlier than it did in the 1960s. This shift is consistent throughout the Atlantic salmon's range, and has been attributed to changing environments in the ocean and in coastal rivers (reduced snowpack, earlier ice out, and fluctuating water inputs). Multiple hypotheses exist on how this shift could challenge post-smolt survival: mismatch in environments, shifting forage bases, and predator fields. Recent telemetry assessments of Atlantic salmon smolt migrations from Maine rivers to the Scotian Shelf have provided novel information on fish entry and exit from the Gulf of Maine. To better understand the potential impacts of these shifts, we combined migration-timing data with telemetry speeds to simulate spatial-temporal distributions. Our goal was to illustrate theoretical changes in spring distribution of post-smolts in the Gulf of Maine. Highlighting these differences in timing through the Gulf of Maine is a first step in identifying the Atlantic salmon's response to a changing environment. The implications of this shift are unknown, but we believe visualizing them will inform modelers and managers to further explore spatial-temporal approaches.

Corresponding Author: James Hawkes, 207-866-7109, james.hawkes@noaa.gov

Using mobile hydroacoustics to describe pelagic fish distribution in the Penobscot River Estuary

Justin R. Stevens[1], Rory Saunders[2], Michael O'Malley[3], Timothy F. Sheehan[4], and J. Michael Jech[4]

[1]*NOAA, National Marine Fisheries Service, Greater Atlantic Regional Fisheries Office, Integrated Statistics, Maine Field Station 17, Godfrey Drive, Suite, 1 Orono, ME*
[2]*NOAA, National Marine Fisheries Service, Greater Atlantic Regional Fisheries Office, ME Field Station, 17 Godfrey Drive, Suite 1, Orono, ME*
[3]*Marine Scotland Science, 375 Victoria Road, Aberdeen, Scotland, UK*
[4]*NOAA, National Marine Fisheries Service, Northeast Fisheries Science Center, 166 Water St. Woods Hole, MA*

Temperate estuaries are inherently variable but productive ecosystems that provide nursery habitat, migration pathways, and forage areas for estuarine, diadromous, and marine fish. The Penobscot River is the focus of large scale habitat restoration efforts aimed at increasing diadromous fish abundance throughout the watershed. We used multi-frequency echosounders (SIMRAD EK60 split-beam 38 and 120 kHz) combined with catch data from pelagic trawl surveys to describe the spatial, temporal, and size distribution of pelagic fish in the Penobscot River Estuary (Maine, USA) from 2012 through 2015. Spatial and temporal distributions were heterogeneous, though several distinct patterns were apparent. First, we observed increases in fish density over the period of survey, coincident with increasing runs of river herring at upriver monitoring facilities. Second, we consistently observed relatively high densities of small fish, particularly near the estuary (salinity) transition zone. Based on trawl catch data, these fish appear to be predominantly age 1 and 2 juvenile river herring. Third, during May fish densities were consistently greatest near the estuarine transition zone and were lower both upstream and downstream of this zone. Finally, dense schools of fish were detected in higher salinity areas of the lower estuary during the summer in some years; catch data suggest that these fish were predominantly juvenile Atlantic herring. Overall, the - majority of individual fish were small (< 30cm estimated with acoustic data), while larger fish (>30 cm) were in low abundance. Our results demonstrate that measuring broad patterns of the spatial, temporal, and size distribution of the pelagic fish populations within the Penobscot River Estuary is a feasible objective for long-term monitoring and hypothesis testing in this dynamic ecosystem. We discuss the implications of these findings within the context of potential effects of a "prey buffer" for migrating Atlantic salmon smolts, as a monitoring tool for fishes entering and exiting the Penobscot River, and as a tool for exploring the fine-scale seasonal and spatial dynamics of fish as restoration efforts proceed.

Corresponding Author: Justin Stevens, 207-866-4166, Justin.Stevens@noaa.gov

Characterizing chemical and biological parameters in Penobscot Bay before, during and after the release of Atlantic salmon (*Salmo salar*)

Shannon Meseck[1], Judy Yaqin Li May[1], Mark Dixon[1], Paul Clark[1], Inke Sunila[2], Paul Music[3], Christine Lipsky[3], Justin Stevens[3], and Gary Wikfors[1]

[1]*National Ocean and Atmospheric Administration, Northeast Fisheries Science Center, Milford, CT*
[2]*State of Connecticut, Department of Agriculture, Bureau of Aquaculture, Milford, CT*
[3]*NOAA, National Ocean and Atmospheric Administration, Northeast Fisheries Science Center, Orono, ME*

Historical data from the Penobscot Estuary suggest that the environmental chemical and biological conditions in the estuary might be affecting the behavior of Atlantic salmon smolt (*Salmo salar*) as they migrate to the ocean during the spring. With the removal of the dam at Veazie it is important to re-examine the chemical and biological properties in the estuary. Estuarine transects were conducted before, during and after the Atlantic salmon smolt migrated through the Penobscot Estuary. Samples were taken for total suspended solids (TSS), chlorophyll-a, particle size, humic acid concentrations, particulate carbon and nitrogen concentrations, and phytoplankton identification. Furthermore, a few discrete pathology samples (n=20) of blueback herring, rainbow smelt, and alewife smolt in the estuary were taken to look for gill damage. The estuarine profiles suggest that TSS were behaving non-conservatively in the estuary, with an increase of TSS around the area of Frankfort Flats. Chlorophyll-a and humic acid concentrations were relatively low and followed a more conservative behavior. During the sampling time period *Heterosigma akashiwo* which is a toxic phytoplankton species was detected in the estuary. Gill analysis found that almost all 20 samples had some form of gill damage ranging from hyperplasia, inflammation to hemorrhaging. These results suggest that environmental chemical and biological conditions in the environment during Atlantic smolt runs could be important in the overall health of Atlantic salmon.

Corresponding Author: Shannon Meseck, 203-882-6531, shannon.meseck@noaa.gov

Characterizing the Penobscot River estuarine transition zone during Atlantic salmon smolt migration

Rachel Lasley-Rasher[1], Justin Stevens[2], Leah Derlath[1], John Kocik[3], and Damian Brady[1]

[1]*University of Maine, Department of Marine Science, Darling Marine Center, Walpole, ME*
[2]*Integrated Statistics, Woods Hole, MA*
[3]*NOAA, National Marine Fisheries Service, Northeast Fisheries Science Center, Orono, ME*

One factor impeding the recovery of Atlantic salmon is high mortality and smolt loss during their seaward migration through estuaries. High mortality rates may be due to a combination of physiological stressors, variable prey concentrations, and elevated predation pressure. Salmon migration success is likely influenced by physical conditions in the estuarine transition zone such as salinity, temperature and turbidity. The nature of the saltwater intrusion dictates how gradually smolts are exposed to seawater and thermal shifts. Another important factor is the strength of the turbidity maximum which could affect both smolt foraging success and predation risk. Despite the potential importance of such variables to smolt migration, a thorough characterization of the estuarine transition zone is lacking in the Penobscot estuary. The location and intensity of the salt intrusion and turbidity maximum is dually affected by riverine and tidal forcing. We conducted vertical profiles of temperature, salinity, turbidity, dissolved oxygen, and chlorophyll throughout the estuarine transition zone during smolt migration under various river flow conditions and tidal phases. We couple these data with surveys of zooplankton and fish to gain a holistic view of both biotic and abiotic conditions in the estuary during smolt migration. These data can be combined with ongoing acoustic telemetry efforts to determine what combination of physical variables contributes to smolt migration success in the Penobscot estuary.

Corresponding Author: Rachel Lasley-Rasher, 207-563-8115, rachel.lasleyrasher@maine.edu

Session III: Diadromous Species Ecology

Moderators:

Dan McCaw, *Fisheries Biologist, Penobscot Indian Nation*

Karen Wilson, *Associate Research Professor, University of Southern Maine*

Methodologies of acoustic telemetry tagging in American Shad (*Alosa sapidissima*)

Michael Bailey[1], Ben Gahagan[2], and Kevin Cheung[3]

[1]*United States Fish and Wildlife Service, Central New England Fishery Resources Office, Nashua NH, USA*
[2]*Massachusetts Division of Marine Fisheries, Annisquam River Marine Fisheries Station Gloucester, MA, USA*
[3]*United States Fish and Wildlife Service, North Attleboro National Fish Hatchery, North Attleboro MA, USA*

Telemetry is a quickly advancing tool for fisheries biologists. Advances in technology have improved efficacy in coastal marine waters and increased tag life now enables multi-season studies. American shad are often the focus of upstream and downstream fish passage studies on the East coast of North America. Shad are easily stressed from handling and gastric insertion of a transmitter is considered the standard method for tagging for both radio and acoustic telemetry studies. However, gastric tagging is not considered a viable long term methodology as fish will regurgitate or pass transmitters. In 2015, we implemented a study of tag retention and survival on tagged shad in a limited husbandry (minimal temperature control, unfiltered water) aquaculture setting. We were able to compare gastric tagging (standard methodology) to three methods of surgical tagging (single suture closure of incision, no closure of incision, and chemical adhesive closure of incision). We also conducted a field study of adult shad migrating in the Charles River, MA and investigated out migration through a lock and dam system. Fish were observed through the freshwater environment and out to Jeffreys Ledge in the Gulf of Maine. This represents one of the only studies to use telemetry to investigate near shore coastal movement of American shad.

Corresponding Author: Michael Bailey, 603-595-0957, michael_bailey@fws.gov

Modeling Migration of Silver Eels to Forecast Critical Intervals of Risk

Douglas B. Sigourney[1] and Joseph D. Zydlewski[2,3]

[1]*Integrated Statistics, Falmouth, MA*
[2]*University of Maine, Dept. of Wildlife Ecology, 5755 Nutting Hall Orono, ME*
[3]*U.S. Geological Survey, Maine Cooperative Fish and Wildlife Research Unit, 5755 Nutting Hall Orono, ME*

Populations of eels are in decline worldwide. One potentially significant source of mortality may occur at hydroelectric facilities during the downstream migration of adult silver eels. To help mitigate this mortality, a tool that can forecast migratory events could be of great use to managers that aim to reduce dam mortality while minimizing disruption of power generation at hydroelectric facilities. A number of studies have demonstrated relationships between downstream movements of silver eels and environmental events; however, there have been few attempts to summarize this available information into a predictive framework. Herein, we assess the utility of Bayesian hierarchical modeling methods to forecast the probability of migratory events of silver eels. We combine information on daily counts of migrating eels with information on environmental conditions to predict migration. We apply our modeling approach to multiple datasets of migrating eels and assess the ability to forecast migration in systems that are both data rich and data poor. The hierarchical framework we adopt combines information from a number of sources to provide robust estimates of the probability of eel migration and provides a flexible forecasting tool to aid managers in making decisions in regards to reducing turbine mortality.

Corresponding Author: Douglas Sigourney, 508-495-2120, douglas.sigourney@noaa.gov

Shortnose sturgeon spawning potential in the Penobscot River after dam removals

Catherine Johnston[1], Gayle Zydlewski[1], Joe Zydlewski[2], Michael Kinnison[3], and Sean Smith[4]

[1]*School of Marine Sciences, University of Maine, Orono, ME*
[2]*USGS Cooperative Fish and Wildlife Research Unit, University of Maine, Orono, ME*
[3]*School of Biology and Ecology, University of Maine, Orono, ME*
[4]*School of Earth and Climate Sciences, University of Maine, Orono, ME*

Recently the two lowermost dams were removed from the Penobscot River, Maine, restoring 14 km of diadromous fish habitat. Endangered shortnose sturgeon have been documented foraging and wintering in the Penobscot River but there has been no indication of spawning since monitoring began in 2007. During the first two springs after the dam removals, early life stage sampling and tracking using acoustic telemetry were performed. Fish were not observed moving upstream of the lowermost removal site during the spawning season and no early life stage sturgeon were captured during 168 h of netting in 2014 and 286 h in 2015. Field assessment and hydrodynamic modeling studies in the Penobscot River suggest that spawning habitat is available upstream of the Veazie Dam remnants (Wegener 2012). Suitable spawning habitat has been characterized as areas with water depths of 1.2-10.4 m, velocities from 0.4-1.8 m/s, and bottom substrate with large interstitial spaces (Kieffer and Kynard 1996; Kynard 1997). After the dam removal we documented gravel (40%) and cobble (31%) as dominating the shoreline. In the spring, high discharge levels create suitable water depths for spawning in these areas. Initial results from hydrodynamic simulations for the 5 km river reach between the previous Veazie Dam site and Basin Mills indicate that at a river discharge of 1308 cm/s, 69% of the area is suitable for spawning. Weighted usable area estimates can be used to compare suitable habitat availability under various river discharge levels. In October 2015, three tagged female shortnose sturgeon were detected on receivers upstream of the previous Veazie Dam site, in the dam head pond at rkm 48, and at rkm 53. This demonstrates that under certain flow conditions, shortnose sturgeon are capable of swimming over the Veazie Dam remnants to habitat that had been inaccessible since 1913. Their presence in this habitat during the fall is promising since shortnose sturgeon often stage for spawning just downstream of the spring spawning location (Billard and Lecointre 2000). Continued monitoring in the spring of 2016 will focus on whether sturgeon move above the dam site again and if early life stage sturgeon are present.

Contact: Catherine Johnston, 207-557-0944, catherine.johnston@maine.edu

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Sea Lamprey Carcasses Influence Food Webs in an Atlantic Coastal Stream

Daniel Weaver[1], Stephen Coghlan Jr.[1], and Joseph Zydlewski[2, 1]

[1]*University of Maine, Department of Wildlife, Fisheries, and Conservation Biology, Orono, ME,* [2]*U.S. Geological Survey, Maine Cooperative Fish and Wildlife Research Unit, University of Maine, Orono, ME*

Anadromous sea lamprey *Petromyzon marinus* deliver a predictable pulsed nutrient subsidy to Atlantic coastal waters during the spring. However, the mechanisms by which recipient food webs respond to those nutrient subsidies not yet clear. We conducted sea lamprey carcass addition experiments to quantify the autotrophic and heterotrophic responses of small stream food webs. We found increases in primary productivity immediately adjacent to carcasses but we did not detect broader spatial changes in productivity downstream of a gradient of increasing subsidies. Among heterotrophs we detected the assimilation of nutrients (via $\delta^{13}C$ and $\delta^{15}N$) among several macroinvertebrate families and juvenile sea lamprey. In contrast we detected no increase in aquatic hyphomycete (fungi) biomass from carcass subsidies. Canopy cover and flow disturbances were likely factors contributing to observed patterns. Juvenile sea lamprey are widely distributed through contiguous reaches of the Penobscot River watershed, however existing barriers (dams and culverts) likely serve as a hindrance to recolonization. Our work underscores the importance of connectivity in small streams to allow sea lamprey migration and spawning. These carcass subsidies elicit varying food web responses that may be significant for the small stream community.

Corresponding Author: Daniel Weaver, 703-595-3644, daniel.weaver@maine.edu

Size, age, and longevity of seven populations of landlocked and anadromous rainbow smelt (*Osmerus mordax*)

Andrew O'Malley[1], Claire Enterline[2], and Joseph Zydlewski[3,1]

[1]*Department of Wildlife, Fisheries and Conservation Biology, University of Maine, Orono, ME*
[2]*Maine Department of Marine Resources, Augusta, ME*
[3]*U.S. Geological Survey, Maine Cooperative Fish and Wildlife Research Unit, and Department of Wildlife, Fisheries and Conservation Biology, University of Maine, Orono, ME*

Rainbow smelt are an important part of fish communities in both fresh and saltwater over much of the range of Atlantic salmon. Looking at the health of populations of sympatric species may help to understand ecosystem influences on salmon habitat. We compared ages of smelt using scales and otoliths from four anadromous populations of smelt from coastal Maine. Landlocked smelt were collected via dip net during spawning, anadromous fish were collected with fyke nets set in the tidal area of spawning tributaries. Approximately 170 fish were sampled from each of the freshwater populations, and 75 from each of the anadromous populations, stratified by sex and length. Additionally, we back calculated size at age for the four coastal populations and three landlocked populations from western Maine. Using growth modeling, we looked at the differences in size at age and von Bertalanffy growth parameters to infer growth potential of different populations. Anadromous populations show a gradient of rate of growth along coastal Maine. Freshwater populations approach maximum size relatively quickly then plateau. Mixture modeling was used to estimate the proportion of observed spawning runs by age class. The southernmost anadromous run sampled was dominated by age 1 fish, whereas all other runs were dominated by fish aged 2 and 3 with small but variable proportion of older, larger individuals.

Corresponding Author: Andrew O'Malley, 413-231-4906, Andrew.omalley@maine.edu

Assessing alewife (*Alosa pseudoharengus)* movements in the St. Croix River watershed

Graham Chafe[1] and Jonathan Carr[1]

[1]*Atlantic Salmon Federation, Chamcook, NB, Canada*

Migratory movement of alewife (*Alosa pseudoharengus*) in the St. Croix River watershed was investigated using acoustic telemetry. Parts of the St. Croix River were closed to upstream fish passage in 1988, with the fishways at Woodland and Grand Falls Dams blocked in 1995. The last barrier to fish passage, at Grand Falls Dam, was removed in 2013. This project investigated the re-colonizing of the watershed by alewife. Fifty-nine alewife were tagged during the 2014 and 2015 migration seasons with Vemco V9-6L tags, measuring 9mm in diameter by 21mm in length. Fish were tagged entering the river at the top of the passage facility of the first dam, Milltown. The river section between the Milltown and Woodland dams contained the most upstream migration point for 78% of the fish over the two years. Eleven fish ascended past the Woodland Dam but remained below the Grand Falls Dam, an area that comprises 4.7% of the available spawning habitat of the watershed (Dill et al., 2010). One fish in each year passed the Grand Falls Dam and entered the Grand Falls flowage, neither returned below the dam post-spawn. No fish were detected in either year ascending the river section towards Spednic Lake. Twenty-four fish each year were detected in the estuary below Milltown Dam leaving the river post-spawn and in 2015 acoustic receivers at the exits from Passamaquoddy Bay detected 23 fish entering the Bay of Fundy. A receiver placed at the base of the Woodland Dam indicates that upstream passage there may be in issue with only eight of 21 fish near the entrance of the fishway successfully passing above. Future studies should include higher resolution work on movements near and at the fishways of the Milltown, Woodland and Grand Falls dams. Passive Integrated Transponders (PIT) or radio telemetry could provide further insight into usage and management of the fish passage facilities.

Corresponding Author: Graham Chafe, 506-529-1023, gchafe@asf.ca

Tracking Siqonomeq (alewife) migration in the Passamaquoddy Bay

Asha Ajmani[1], Theodore Willis[1], Edward Basset[1], William Longfellow[1], and Marvin Cling[1]

[1]*Sipayik Environmental Department, Passamaquoddy Tribe - Pleasant Point, Perry, ME*

The St. Croix River is the largest river in Passamaquoddy Traditional Homeland. Connecting to the Passamaquoddy Bay near Pleasant Point, Maine, the Passamaquoddy Tribe relied on its plentiful resources for survival. Siqonomeq (alewife) return annually to enter their traditional spawning grounds in the St. Croix River. Alewives are culturally significant to the Passamaquoddy as the "fish that feeds all", playing an important role in nutrient flux between the freshwater spawning habitat and marine rearing habitat. Since the 1820's, there have been noticeable declines in alewife returns to the St. Croix River. In 2014, the Sipayik Environmental Department (SED) partnered with governmental agencies and non-profits to study and facilitate recovery of the St. Croix River alewife population. In Spring 2015, the SED and Atlantic Salmon Federation (ASF) committed to tracking alewife movements through the St. Croix River and Passamaquoddy Bay to determine their annual migration route. The SED, in collaboration with the Ocean Tracking Network and the United States and Canadian Coast Guards, placed an array of twenty VEMCO hydrophone receivers along suspected migration routes throughout Passamaquoddy Bay. ASF deployed twenty hydrophones in the St. Croix River, between Milltown Dam, New Brunswick, and Vanceboro Dam, Maine. NOAA deployed three receivers in the St. Croix River estuary. The array tracked the upstream and downstream migration routes of sixty VEMCO tagged alewives intercepted at Milltown Dam. None of the thirty alewives tagged below the Milltown Dam fish ladder were detected upstream. A total of fifty of the sixty acoustic tags were detected on receivers placed in Western Passage and Letete Passage, connecting Passamaquoddy Bay to the Bay of Fundy. Between June and September 2015, forty-eight fish were detected near Frost Ledge in Western Passage, just off Pleasant Point, Maine. Detections through Letete Passage suggest alewives migrate through Western Passage and north into the Bay of Fundy. Two alewives were detected further south, on NOAA receivers placed near Mt. Desert Rock. These results have implications for determining the stock composition and phenology of St. Croix River alewife. Future studies should assess habitat usage during alewife migration, including length of time spent in each environment. In addition, studies should focus on multi-year alewife tracking in and beyond the Passamaquoddy Bay.

Corresponding Author: Asha Ajmani: 207-904-9688, aajmani@wabanaki.com

Feeding Habits of Juvenile Alewife (*Alosa pseudoharengus*) in the Penobscot Estuary

Amy Webb[1], Karen Wilson[2], Rachel Lasley-Rasher[3], and Greg LaBonte[1]

[1]*University of Southern Maine, Department of Biological Science, Portland, ME*
[2]*University of Southern Maine, Department of Environmental Science, Gorham, ME*
[3]*University of Maine, Department of Marine Science, Darling Marine Center, Walpole, ME*

Alewife have experienced dramatic declines throughout their range. They are a Species of Concern, listed by the National Oceanic and Atmospheric Administration (NOAA) in 2006, yet little is known about critical early life histories of these fish. This study examines the feeding habits and prey selectivity of juvenile alewife in the Penobscot Estuary over time (May, July and September), space (high and low salinity) and fish size (small and large) using diet content analysis.

Fish were collected by NOAA Fisheries, Maine Field Station. Zooplankton samples collected during the trawl survey were analyzed by Dr. Rachel Lasley-Rasher from the Darling Marine Center. This data was used to calculate electivity indices for each prey item.

132 alewife ranging in size from 47 mm to 208 mm fork length collected from May to September, 2013 in both sections of the estuary (upper salinity: 5-15 ppt; lower salinity 10-20 ppt) were used in the diet analysis. 128 of the 132 alewife examined (97%) had identifiable prey in their stomachs. The Index of Relative Importance (IRI) was calculated for each prey category and Ivlev's Electivity Index was used to determine the alewife's preference for prey items.
Results show that estuarine copepods, mysid shrimp and barnacle larvae were the most abundant prey items. Diet composition was relatively homogenous among both small (47-90 mm fork length) and large (91-208 mm fork length) size groups throughout the estuary during July and September with *Eurytemora* copepods being the most important prey item. Across all groupings, barnacle larvae decreased in importance from July to September while *Eurytemora* copepods, mysid shrimp and *Temora* copepods increased in importance.

Diet selectivity varied by month with large alewife selecting for larger prey items later in the season (e.g., in the lower estuary large alewife selected for barnacle larvae and *Temora* in May, while *Calanus* copepods, Mysid shrimp and *Temora* copepods were selected for by large alewife in September). These results demonstrate that the estuary is a significant feeding habitat for these fish and often overlooked as critical habitat.

Corresponding Author: Amy Webb, 207-373-8687, amy.webb@maine.edu

Alewife (*Alosa pseudoharengus*) as Marine-Derived Nutrient Subsidies in Two Northeast Maine Rivers

Betsy Barber[1] and Joseph Zydlewski[2,1]

[1]*University of Maine, Department of Wildlife Ecology, Orono, ME*
[2]*U.S. Geological Survey, Maine Cooperative Fish and Wildlife Research Unit, University of Maine, Orono, ME*

Anadromous fish exhibit rapid growth in the ocean and many adults die during the course of migration, leaving carcasses in streams to decay. Migrating fish also release nutrients through excretion and gametes. This spring pulse is part of the nutrient budget of intact coastal systems and is interrupted by dams. The effect of marine-derived nutrients has been traced through multiple trophic levels in Pacific salmon systems. Large alewife spawning runs may play a similar ecological role on the east coast. The large established alewife run in the East Machias River provides the opportunity to assess marine-derived nutrient input in a system with an intact alewife migration in comparison to the St. Croix River which has had a negligible run for decades. We used stable isotopes and nutrient diffusers to infer both trophic level and influence of marine derived nutrients. Fish, macroinvertebrate, and zooplankton samples were collected before, at the peak, and after the alewife run from 2013-2015 (7 sites in the St. Croix River and 2 sites in the East Machias River) for stable isotope analysis. Results indicate that alewife are enriched in both $\delta^{13}C$ and $\delta^{15}N$ compared to freshwater fish and invertebrates. Trophic level differences were distinct between fish and invertebrates. Comparisons of data from the two systems will be presented.

Corresponding Author: Betsy Barber, 207-974-7452, betsy.barber@maine.edu

Session IV: Freshwater Ecology & Passage Barriers

Moderators:

Oliver Cox, *Division Director, Marine Department of Marine Resources*

Joseph Zydlewski, *Associate Professor and Assistant Leader-Fisheries, Maine Cooperative Fish and Wildlife Research Unit (UMAINE/USGS)*

Tag retention of Atlantic salmon (*Salmo salar*) surgically implanted with acoustic transmitters

Jason Daniels[1], Jonathan Carr[1], Alex Hanke[2], James Hawkes[3], Ross Jones[2], and Fred Whoriskey[4]

[1]*Atlantic Salmon Federation, St. Andrews, NB, Canada*
[2]*Fisheries and Oceans Canada, NB, Canada*
[3]*NOAA, National Marine Fisheries Service, Northeast Fisheries Science Center, Orono, ME*
[4]*Ocean Tracking Network, Halifax, NS, Canada*

Acoustic telemetry is a valuable tool for estimating survival of free-ranging fish across a range of geographic scales. When estimating survival rates through acoustic telemetry data, however, it is generally assumed that the rate of tag expulsion is low. To determine the relative risk and rate of tag expulsion in Atlantic salmon, 240 hatchery-reared smolts were implanted with three different sized dummy acoustic tags (21 and 24×9mm and 21×8mm) and monitored in the hatchery for 1 year post implantation. Logistic regression and Cox Proportional Hazards models were fit to tag retention data to identify the probability and rate of tag loss with respect to covariates related to surgical procedure and fish size and condition. The 21 and 24×9mm tags were estimated to have 64% and 55% chance of tag loss, while the 21×8mm tags had an estimated 34% chance of tag loss. We found that, across all tag types, nearly 48% of tags were expelled between 12 and 120 days with the greatest rate of loss occurring between 35 and 48 days. Results suggest that, under hatchery conditions and within the range of this study's covariates, tag type is the major concern with respect to tag loss. It is not clear if free-ranging wild fish would show similar levels of tag loss.

Corresponding Author: Jason Daniels: 506-529-1039, jdaniels@asf.ca

Post-restoration assessment of Atlantic salmon (*Salmo salar*) survival during their downstream migration in the Penobscot River, Maine

Alejandro Molina-Moctezuma[1], Daniel Stich[2], and Joseph Zydlewski[3,1]

[1]*University of Maine, Department of Wildlife, Fisheries, and Conservation Biology, Orono, ME*
[2]*State University of New York at Oneonta, Biology Department, Oneonta, NY*
[3]*U.S. Geological Survey, Maine Cooperative Fish and Wildlife Research Unit, University of Maine, Orono, ME*

The Penobscot River (Maine, USA) has been the focus of a restoration project that has modified the conditions that Atlantic salmon *Salmo salar* smolts face during their downstream migration. The modifications include the removal of dams (Great Works and Veazie Dams), increased hydropower generation in different dams (including Milford Dam), and the construction of a nature-like fish bypass at Howland Dam (completed in fall 2015). We evaluated survival, path choice and movements of Atlantic salmon smolts during their downstream migration after dam removal. We also characterized the survival and passage of fish through Howland Dam, before the building of a modified fish passage. All survival and movement estimates were compared to results obtained prior to the Penobscot River restoration (2005 – 2014). Survival and proportional use of migration routes were estimated from multi-state models based on one year of acoustic-telemetry data from 75 smolts in 2015. Consistent with previous work, 6% of the fish used the Stillwater Branch of the Penobscot River while the majority of fish moved through the main stem. Survival at Howland and Milford Dams was relatively low (0.94 and 0.91), while survival through the sites where dams were removed remained high (0.98 and 1.00), comparable to pre dam removal conditions. The fish passage change at Howland Dam has the potential to increase survival in the next smolt migration, while improving the passage through Milford Dam offers the best opportunity to increase the overall smolt survival during downstream migration.

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

Methods and results of identifying potential groundwater upwelling within Atlantic salmon juvenile rearing habitat in three Downeast Maine Salmon Rivers

Scott Craig[1]

[1]*U.S. Fish and Wildlife Service, Maine Fish and Wildlife Conservation Office, Orland, ME*

A water temperature profile method developed by Vaccaro and Maloy (2006) to locate groundwater upwelling was used to help identify cooling and warming trends within mainstem habitats of the Narraguagus, Machias and East Machias Rivers above Rt. 9. This simple and low cost methodology uses 1-2 second interval sampling events that are linked with survey coordinate data (GPS). Cooling trends identified within mapped Atlantic salmon rearing habitats are likely associated with groundwater inputs that could aid salmon during known times of thermal stress (>22.5ºC).

Survey data collection and equipment is relatively inexpensive because only 1-2 people are needed and sampling equipment consists of a handheld GPS Unit (Garmin Etrex <$100) and a highly sensitive (records to thousandths of a °C) temperature logger (Solinst Inc. $600).

Surveys were completed between the hours of 10AM and 4 PM to coincide with optimal thermal conditions during peak water temperature periods (July-August). Overall spatial coverage per day is somewhat dependent on stream gradient and habitat complexity. In the Upper Narraguagus River study area (Catchment=53-192 km2 (21-74 mi2), 0.1% gradient and poor canoeing conditions due to low water) we surveyed at a speed of 2.4km/hr (1.5 mi/hr) covering between 7-11 km (4.2-6.8 mi) over 3-4.5 hours. This equated to 5,400 – 8,100 data records per day-trip.

When time-temperature data is output into a simple scatter plot, heating and cooling trends are readily apparent, and these outputs will be discussed in the presentation. Joining water temperature data with coordinate information and mapped rearing habitat allows spatial visualization through GIS. In the Downeast Coastal SHRU, thermal stress (>22ºC) has been shown to occur each summer, we have utilized this water temperature profile information to help identify large wood treatment project area within mapped salmon rearing habitat in the Upper Narraguagus.

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

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Vaccaro, J and Maloy, K. 2006. A Thermal Profile Method to Identify Potential Ground-Water Discharge Areas and Preferred Salmonid Habitats for Long River Reaches. U.S. Geological Survey Scientific Investigations Report 2006-5136

Atlantic Salmon Ova Planting; Dispersal, Density Dependent Growth and Implications for Management

Paul Christman[1], Jason Overlock[1], and Jennifer Noll[1]

[1]*Maine Department of Marine Resources, 32 Blossom Ln., Augusta, ME*

Planting Atlantic salmon eggs as a management strategy is gaining acceptance in many recovery programs in Maine. In recent years the number of eggs planted annually has grown into the millions. Introducing Atlantic salmon in the egg stage allows for synchronicity between juveniles and the environment, resulting in a more wild-like population. While there may be numerous advantages to having natural emergence, management can be more complex than the traditional methods of stocking such as scatter stocking fry. In an effort to develop a management strategy which relies solely on eggs, sixteen sites were evaluated from 2010 to 2015 for 0+parr population structure at approximately 150 days following the burial of eyed eggs. The 0+parr were sampled using the CPUE methodology at randomly chosen transects around each planting site in a centrifugal fashion. The resulting densities indicate a population that is structurally very similar to that observed from wild spawning. Dispersal was disproportionately downstream in almost all instances, as well as the characteristic high densities at or just below the planting site. In addition, fork lengths were inversely related to density in all sites. The relationship was significant in all but one site in the initial year of planting when intraspecific competition from other year classes was low. No relationship was found between distance traveled away from planting site and number of eggs planted, as well as tributary verses mainstem sites. The results of this study suggests emergence rates and intraspecific competition from other year classes are the two most important characteristics in determining intervals of planting sites along habitat corridors. Secondary characteristics that need to be considered are distances fry move away from planting site and carrying capacity.

Corresponding Author: Paul Christman, 207-624-6359, paul.christman@maine.gov

Behavior and Upstream Passage of Atlantic Salmon at the New Milford Fish Lift on the Penobscot River, ME

Lisa Izzo[1], George Maynard[1], and Joseph Zydlewski[2,1]

[1]*University of Maine, Department of Wildlife, Fisheries, and Conservation Biology, Orono, ME*
[2]*U.S. Geological Survey, Maine Cooperative Fish and Wildlife Research Unit, University of Maine, Orono, ME*

As part of the Penobscot River Restoration Project (PRRP), Great Works (rkm 59) and Veazie (rkm 46) dams were removed from the Penobscot River, ME, making Milford Dam (rkm 61) the first impediment to federally endangered Atlantic Salmon upstream migration. The PRRP is expected to increase upstream habitat access for Atlantic Salmon, however this increase is dependent upon successful passage at a newly constructed fish lift at Milford Dam, as nearly all suitable spawning habitat is located upstream of Milford. In 2014 and 2015, a total of seventy three adult salmon were captured at Milford, radio and PIT tagged, and displaced downstream in tidal reaches below the removed dams to track their upstream migration through the lower Penobscot River. Movement rates through the Veazie or Great Works dam remnants were comparable to open river reaches. Passage efficiency of the new fish lift was high, with 90 to 100% of tagged fish passing in the two study years. However, fish did experience significant delays at Milford Dam (0.03 to 78.3 days), with 30% and 36.8% of fish taking more than a week to pass in 2014 and 2015, respectively. In 2015, over 75% of fish were detected near the fishway entrance within 5 hours of arrival at Milford Dam, and detections at the entrance occurred at all hours of the day. The results of this study show that while adult Atlantic Salmon locate the new fish lift entrance, the passage of these fish is significantly delayed under current operations.

Corresponding Author: Lisa Izzo, 484-678-6729, lisa.izzo@maine.edu

Size Matters: Fishways can exert size selective pressure on Atlantic salmon migrating in the Penobscot River

George Maynard[1], Richard Dill[2], Michael Kinnison[3], William Halteman[4], and **Joseph Zydlewski[5,1]**

[1]*University of Maine, Department of Wildlife, Fisheries, and Conservation Biology, Orono, ME;*
[2]*Maine Department of Marine Resources, Bangor, ME*
[3]*University of Maine, School of Biology and Ecology, Orono, ME*
[4]*University of Maine, Department of Mathematics, Orono, ME*
[5]*United States Geological Survey, Maine Cooperative Fish and Wildlife Research Unit, Orono, ME*

The ability of humans to induce evolution in populations of wild fishes through size-selective harvest is increasingly well documented. However, recent research also suggests that sub-lethal selection forces (e.g. size selection at fish passage facilities) may be able to cause evolutionary shifts in morphology and life history characteristics. We investigated the influence of fish size on successful passage through six fishways at hydropower dams on the Penobscot River by tracking Atlantic salmon upstream migration through the system with PIT tags from 2002-2004 and 2010-2012. Then, we used a long-term (1978-2012) dataset of Atlantic salmon returns to the Penobscot River to investigate changes in size and population structure over time. Passage success at fishways was modeled as a Bayesian logistic regression that included fish size, environmental variables (temperature, flow, timing), and in-river delay as possible predictors of passage success. Large fish were less likely to successfully pass through fishways at Great Works Dam and Milford Dam (respectively the second and third dams on the river). Comparisons of coefficients of variation and standard deviations of fork lengths indicated that dispersion in fish size decreased over the past several decades in both multi-sea-winter (MSW) and one sea-winter (grilse) salmon, indicating that diversity in fish sizes in the breeding population is decreasing. This decrease was similar to the decrease observed in a population of brown trout that were subjected to selective pressure at a fishway in Norway for several generations. Evolutionary rates and response to selection did not indicate any strong, directional selection within the population. This lack of response may be an artifact of the extensive hatchery program in the Penobscot drainage, which currently accounts for ≈ 95% of adult returns. Although evolutionary impacts of fishways may not be apparent in the Penobscot River system, and the two fishways causing the selection have been removed or upgraded, the potential for fishways to exert size-selective pressure should not be ignored. Other fishways farther up in the system (not included in the models) share characteristics with those exerting selection against large individuals, and access to much of the spawning habitat in the system still necessitates passage at those facilities.

Corresponding Author: George Maynard, 207-613-1554, george.maynard@maine.edu

Dam removal and fish passage improvement influence fish assemblages in the Penobscot River, Maine.

Jonathan M. Watson[1], Stephen M. Coghlan, Jr.[1], Joseph Zydlewski[2,1], Daniel B. Hayes[3], and Ian Kiraly[4]

[1]*Department of Wildlife, Fisheries, and Conservation Biology, University of Maine, Orono, ME*
[2]*U.S. Geological Survey, Maine Cooperative Fish and Wildlife Research Unit, Orono, ME*
[3]*Department of Fisheries and Wildlife Michigan State University, East Lansing, MI*
[4]*Gomez and Sullivan Engineers, DPC, Henniker, NH*

Dams disrupt river habitat connectivity to the detriment of migratory fishes. The two lower-most dams, Great Works and Veazie, were removed from the Penobscot River, Maine in 2012 and 2013, respectively. We assessed fish assemblages in the main-stem river and several major tributaries before (2010-2012) and after dam removal (2014-2015) using boat electrofishing surveys, employing a stratified-random sampling design. We observed a substantial reduction in lacustrine species (e.g. pumpkinseed sunfish *Lepomis gibbosus* and golden shiner *Notemigonus crysoleucas*) abundances in former impoundments associated with the restoration of lotic habitat. During both pre and post-dam removal surveys we found all anadromous species in greatest abundance below the lower-most dam. However, during the post-removal surveys we found evidence that river herrings *Alosa* spp. passed above Milford Dam, the current lower-most dam, either through the new fish elevator or stocking efforts and spawned in newly available habitat. We also observed greater abundance of American eel *Anguilla rostrata* in most main-stem strata above the former dams due either to changes in detection or distribution. Our initial results demonstrate that large dam removals impact lacustrine specialists negatively and enhance riverine connectivity for migratory fishes.

Corresponding Author: Jonathan Watson, 803-429-3751, Jonathan.Watson@maine.edu

Projected tradeoffs in population abundance of American shad (*Alosa Sapidissima*) in relation to upstream and downstream passage at dams

Dan Stich[1,2], Timothy Sheehan[2], and Joseph Zydlewski[3]

[1]*State University of New York College at Oneonta, Oneonta, NY*
[2]*NOAA, National Marine Fisheries Service, Northeast Fisheries Science Center, Woods Hole, MA*
[3]*U.S. Geological Survey Maine Cooperative Fish and Wildlife Research Unit, the University of Maine, Orono, ME.*

Diadromous fishes require uninterrupted passage during freshwater migration to successfully complete their life cycle. Passage failure and delay at dams can affect spatial and demographic structuring of spawning adults and downstream migrants, and has contributed to range-wide declines in Alosine (shad and river herring) stocks. Recovery actions commonly involve increasing dam passage performance and reducing delay at regulated hydropower dams during upstream and downstream migration; however a quantitative approach that incorporates uncertainty in life-history parameters and migration characteristics is often absent. We describe the development of a stochastic life history-based simulation model for Alosines that can be used to estimate effects of dam passage and migratory delay on vital rates of migrants, distribution of spawning adults, and demographic structuring through space and time. Using an individual-based approach to simulate migration dynamics, we relate fish passage and associated delay at hydropower dams to metrics that can be used to support quantitative-based regulatory decisions. We examine projected American Shad (Alosa sapidissima) population responses to changes in dam passage performance standards in the Penobscot River, Maine. Recovery was achieved under high rates (90%) of upstream and downstream passage. Demographic tradeoffs, including reduced spawner abundance, truncated age structures, and decreased rates of repeat spawning resulted when downstream passage was less than 100% even at high rates of upstream passage. The tradeoffs became more pronounced when we considered effects of delayed, dam-related mortality in fresh water and the estuary during downstream migration. These results underscore the importance of providing adequate downstream passage for adult and juvenile migrants in addition to upstream passage for adults if recovery targets for this population are to be met. Although these results are likely system-specific, they strongly suggest that tradeoffs in recovery metrics resulting from interactive effects of upstream and downstream passage for diadromous fishes warrant consideration during the decision-making process at regulated hydropower dams.

Corresponding Author: Dan Stich, 607-436-3734, daniel.stich@oneonta.edu

Posters:

On river hatchery rearing of 0+ fall parr to increase adult Atlantic salmon returns to the East Machias River, a collaborative model for salmon recovery

Kyle Winslow[1] and Zach Sheller[1]

[1]Downeast Salmon Federation, East Machias Aquatic Research Center, East Machias, ME

For the past 20 years, the focus of the stocking program in the Downeast rivers has been "unfed" fry and limited smolt stocking, but success has been limited. Research suggests that un-natural rearing conditions in hatcheries inhibit the ability of stocked fish to transition to the wild resulting in high mortality. To address the limited success of the stocking program, the Downeast Salmon Federation (DSF), in collaboration with federal, state, and NGO partners, is implementing a project to assess the effectiveness of "on river" hatchery reared 0+ "fall parr" to increase juvenile abundance and adult returns. The 0+parr are being reared in an "enhanced" rearing setting. Utilizing unfiltered river water, substrate incubators, dark colored tanks, natural feed, and water velocity manipulation, the DSF is producing a more natural, physically fit, and more cryptic 0+ parr. All parr will be stocked in the fall after river temperatures are below 10C. Stocking densities will also be increased to well above historic levels. The project will include rigorous assessment of all life stages. Along with changes in rearing techniques, age at stocking and stocking densities, there will be a collaborative focus on addressing connectivity, adding large woody debris, and low pH mitigation in the East Machias watershed. This project is a new model for salmon recovery in the Downeast region.

Corresponding Author: Kyle Winslow, 207-263-7072, kyle@mainesalmonrivers.org

Improving hydroacoustic data collection and processing methods to estimate fish abundance in the Penobscot River before and after dam removal

Constantin Scherelis[1], Gayle B. Zydlewski[1], and Garrett J. Staines[1]

[1]*University of Maine, School of Marine Sciences, Orono, ME*

In an effort to restore native fish populations, two dams were removed from the lower reach of the Penobscot River, Maine. Estimating changes in fish abundances from a pre- to a post- dam removal condition will provide valuable insight into how fish populations recover after a significant portion of their natural habitat becomes re-accessible. This project uses hydroacoustics to estimate and compare fish abundances both pre- and post- dam removal. Data collection began in 2010 and were gathered from May to November each year. One transducer installed on each side of the river below the river surface generates an acoustic beam that is directed across the river channel, covering part of the cross sectional river area. Information about fish size, location, and direction of travel can be obtained by analyzing fish movements through the acoustic beam of the transducer. As a result of a 5 meter tidal range in the Penobscot River at the survey site, the quality and range of the collected data varies significantly with tidal height. Due to the acoustic beam encountering the river surface after a certain distance, the range available for data processing changes in accordance to the tidal height, thus requiring different processing approaches from high to low tide. In order to compare fish abundances across seasons and years, a standardized approach for data processing was developed to enable automated processing of the continuous data. The approach groups data into periods of similar tidal height and applies different processing algorithms to each tidal group. This accounts for varying data quality and range throughout the collection period. The standardized approach is intended to reduce interferences associated with tidal periodicities, isolate fish targets, and identify fish tracks to estimate abundance. To date, three algorithms at low tide (0.25m – 1m) and two at slack tide (2.5m – 3.0m) have been developed, verified through manual observations, and applied to the 2015 data set from May through July for the two survey stations, one on each side of the river. The next steps will involve applying this automated processing approach to previous collection years and extract fish abundance estimates before dam removal. Abundance estimates pre- and post- dam removal will then be compared and analyzed for correlations with various environmental conditions and natural cycles.

Corresponding Author: Constantin Scherelis, 423-902-1016, constantin.scherelis@maine.edu

Atlantic tomcod in the Penobscot Estuary

Justin R. Stevens[1], Jamie Fisher[2], and Richard Langton[3]

[1]*NOAA, National Marine Fisheries Service, Greater Atlantic Regional Fisheries Office, Integrated Statistics, Maine Field Station 17, Godfrey Drive, Suite, 1 Orono, ME*
[2]*University of Maine, School of Marine Sciences, 5741 Libby Hall, Room 202A, Orono, ME*
[3]*NOAA, National Marine Fisheries Service, Northeast Fisheries Science Center, Maine Field Station, 17 Godfrey Drive, Suite 1, Orono, ME*

Atlantic tomcod is one of a number of diadromous fish species that are dependent on estuaries for growth, maturity, and reproduction. In general, diadromous fish are at historically low levels of abundance with species such as Atlantic salmon being designated as Federally Endangered in the USA. Atlantic salmon recovery plans highlight the necessity of understanding the entire estuarine fish community by having "*freshwater and estuary migration sites with abundant, diverse native fish communities to serve as a protective buffer against predation*". The niche overlap of Atlantic tomcod with Atlantic salmon in estuaries is largely unknown due to the paucity of basic data on tomcod's local life history, abundance, and distribution. We surveyed estuarine fish populations in the Penobscot River Estuary from 2010-2012, using beach seines, small and large fyke nets, and a pelagic trawl, and found Atlantic tomcod to be a frequent component of the Penobscot Estuary fish community. Our perception of relative abundance and size structure of the tomcod population is shaped by gear-type, season, and habitat type. Tomcod were more common in shallow intertidal habit than deeper or pelagic habitat. Smaller tomcod were most common in beach seines during spring whereas larger tomcod were more common in fyke nets during fall. Tomcod's temporal and spatial overlap with migratory suggests a need for further research to investigate the interactions of these two species particularly the potential influence an abundant tomcod population on the recovery potential of Atlantic salmon. Careful consideration of gear-type should accompany future directed research on estuarine fish populations given the obvious influence of gear-selectivity on the data collected for this Atlantic tomcod population.

Corresponding Author: Justin Stevens, 207-866-2527, Justin.Stevens@noaa.gov

American eel survival through Milford Dam on the Penobscot River, Maine

Emily J. Thornton[1], Erik Blomberg [1], and Joseph Zydlewski [1, 2]

[1]*Department of Wildlife, Fisheries, and Conservation Biology, University of Maine, 5755 Nutting Hall, Room 210, Orono, ME*
[2]*U.S. Geological Survey, Maine Cooperative Fish and Wildlife Research Unit, University of Maine, 5755 Nutting Hall, Room 210, Orono, ME*

American eel abundance has decreased range-wide since the 1970s and several anthropogenic influences have been implicated in the decline. Among them, hydroelectric dams are a known source of mortality for migrating silver eels because the eels can be injured or killed when they move downstream through dam turbines. Recent efforts have been undertaken to assess environmental influences on migration timing from sites throughout the Penobscot River. Conspicuously absent from these efforts is a quantification of mortality risks at dams during downstream migration.

We propose a project that will examine American eel survival during passage through the Milford Dam on the Penobscot River, Maine. Pilot work began in autumn 2015 with the construction of an eel weir on Souadabscook Stream, a tributary to the Penobscot River. Two silver eels were captured, surgically implanted with acoustic tags, and released upstream of Milford Dam. We will use acoustic telemetry to detect eel movement and survival around and through the dam. Weir construction and fish tagging and tracking will continue annually through autumn 2019 with a target sample size of 50 tagged eels each year. We will estimate the probability of survival for American eels passing through Milford Dam, and provide this information to local managers and dam operators who wish to balance economic and environmental priorities.

Contact: Emily J. Thornton, 908-304-5509, emily.j.thornton@maine.edu

Engaging indigenous peoples to facilitate river restoration on the St. Croix, Maine/ New Brunswick

Edward Basset[1], **Theodore Willis[1]**, Asha Ajmani[1], William Longfellow[1], and Marvin Cling[1]

[1]*Sipayik Environmental Department, Passamaquoddy Tribe - Pleasant Point, Perry, ME*

The Passamquoddy people occupied a homeland bordered by Bar Harbor, ME, Point Lepreau, NB, and Monument, NB for millenia. There are dozens of coastal rivers in this swath of the Maine/New Brunswick coast that supported sustenance fishing of diadromous fish species for tens of thousands of Native people. American eel would have been, and still are found in nearly every lake in the Traditional Homeland. American shad penetrated over one hundred miles inland via larger rivers, like the Narraguagus and Pleasant Rivers. Atlantic salmon were sought after in the Machias, East Machias, Dennys and throughout the Downeast coast. Alewife were found in any river with standing water not blocked by high falls. The St. Croix is the largest river in Passamaquoddy territory and hosted all the major diadromous species, including sturgeon and striped bass, until the mid-19th century. Today the St. Croix has no Atlantic salmon, striped bass or sturgeon, hosts less than half of 1% of the alewife at their carrying capacity and remnant populations of shad and smelt.

In 2012 the Passamaquoddy Joint Tribal Council declared a state of emergency for the St. Croix River and Passamaquoddy Bay. Notwithstanding the reserved treaty rights of the Passamaquoddy, fish populations have dwindled through the hazards of industrialization and pollution that once dominated almost every river in the Passamaquoddy homeland, particularly the St. Croix. In 2014 the Sipayik Environmental Department (SED) at Pleasant Point commenced restoration and rebuilding plans with the objective of benefitting culturally important diadromous species in the St. Croix River through partnerships with USFWS, NOAA, BIA and EPA. Advances have been made but much work and many hurdles still remain. Since 2014 the SED has been working with BIA and USFWS to design and implement passage efficiency studies in the river. American shad were thought to be extinct in the St. Croix River until 2015, when eleven were caught in the Milltown Dam fish trap. Atlantic salmon restoration is stalled by political decisions that left the St Croix out of the DPS, presumed black bass predation, jurisdictional questions and identification of an appropriate stock. The status of rainbow smelt, tomcod, striped bass and sturgeon are unknown. The SED is committed to pursuing monitoring and restoration plans for alewife, sturgeon and shad, and developing plans for salmon and striped bass in years to come, with a commitment to help sustain these species as they sustained the Passamaquoddy.

Corresponding Author: Edward Basset, 207-214-7887, edb@wabanaki.com

The interplay of dams, marine and freshwater survival, and hatchery supplementation on the recovery potential of Atlantic salmon in Maine

Julie L. Nieland[1] and Timothy F. Sheehan[1]

[1]*NOAA, National Marine Fisheries Service, Northeast Fisheries Science Center, 166 Water Street, Woods Hole, MA*

Atlantic salmon populations in Maine are listed as endangered under the Endangered Species Act (ESA). Marine survival and dams are considered to be two of the biggest impediments to increasing these populations, but freshwater survival and hatchery supplementation will also affect their recovery potential. We used a population viability analysis of Atlantic salmon in the Penobscot River, Maine, to assess the effects of dams, marine and freshwater survival, and hatchery supplementation on the demographics of this population. We ran various scenarios to evaluate the influence of these four factors on the attainment of ESA recovery criteria in the foreseeable future for adult Atlantic salmon in the Penobscot Bay Salmon Habitat Recovery Unit (PN SHRU). Increased marine survival led to greater increases in abundance than increased freshwater survival, and, as expected, hatchery supplementation and fewer dams in the PN SHRU helped the population reach recovery when marine and freshwater survival rates were low. Although increases in marine and freshwater survival will both be necessary for this Atlantic salmon population to recover, new management options for increasing marine survival appear limited. Therefore, restoration efforts should focus on increasing the number of salmon coming from the freshwater environment, which means increasing survival during juvenile life stages, minimizing dam impacts, and continuing hatchery supplementation to increase the recovery potential of the PN SHRU. Quantifying the impacts of these factors on the recovery potential of Atlantic salmon in Maine can help inform management strategies and frame expected outcomes for potential management options across the species' U.S. range to facilitate recovery.

Corresponding Author: Julie Nieland, 508-495-2006, julie.nieland@noaa.gov

Are the Restigouche River Smolts on the Menu for Double-Crested Cormorants?

Joanie Carrier[1], Carole-Anne Gillis[1,2,3], Danielle Frechette[1], Jonathan Carr[3], and Normand Bergeron[1]

[1]*Institut National de la Recherche Scientifique, Centre Eau Terre Environnement, Quebec, QC, Canada*
[2]*Restigouche River Watershed Management Council (RRWMC), Matapedia, QC, Canada*
[3]*Atlantic Salmon Federation, St. Andrews, NB, Canada*

Substantial decreases of fish stocks have been attributed, or are suspected to be in part due, to the impact of seabird predation. In many parts of the world, cormorant populations have been increasing since the end of the 1970s and, in coastal regions of the Gulf of St. Lawrence, Double-crested cormorant (*Phalacrocorax auritus*) is now observed to be abundant. To reach the ocean, Atlantic salmon smolts (*Salmo salar*) originating from the Restigouche River watershed must migrate past the breeding cormorant colony of Bonamy Rocks, located at the mouth of the river. Results from a preliminary assessment of smolt migration through the estuary suggest that cormorant predation could be an important factor of smolt mortality. The project aims to address this question by providing the locally derived inputs required to adjust a bioenergetics model towards estimating the potential predation risk on Restigouche River smolts by the Bonamy Rocks cormorants. The size of the colony was estimated using aerial photos in 2014 (905 breeding pairs) and 2015 (1147 breeding pairs). To determine cormorant diet, pellets regurgitated by cormorants were collected and the contents were analyzed. Prey identification and enumeration was based on presence of paired fish otoliths. During the six-week smolt outmigration period, a minimum of 60 pellets were collected each week, in 2014 (n=441 pellets) and in 2015 (n=433 pellets). Based on a sub-sample analysis of 30 pellets per week collected in 2014 (n=180), the two most consumed species of fish, in terms of proportion, were Winter flounder (*Pseudopleuronectes americanus*) at 35% and Rainbow smelt (*Osmerus mordax*) at 22%. Following the analysis of pellets collected in 2015, cormorant diet composition and colony size will be used to estimate smolt predation via the bioenergetics model. Preliminary results, however, indicate that Restigouche smolts likely do not comprise an important prey species contributing to the diet of cormorants nesting at Bonamy Rocks.

Corresponding Author: Joanie Carrier, 418-334-4353, joanie.carrier@gmail.com

Hit the road: assisted migration as population enhancement?

Danielle Frechette[1], Normand Bergeronn[2], and Mélanie Dionne[2]

[1]*Institut National de la Recherche Scientifique, Centre Eau Terre Environnement, 490 rue de la Couronne, Québec, QC, Canada*
[2]*Ministère des Forêts, de la Faune et des Parcs, Direction de la faune aquatique, 880 Chemin Sainte-Foy, Québec, QC, Canada*

Assisted migration is routinely used to enable fish to bypass barriers to migration (e.g. hydroelectric dams, natural falls) through volitional passage (e.g. fishways) or "trap and haul" programs (e.g. translocation). In the Province of Québec (Canada), there is increasing interest in using assisted migration of adult Atlantic salmon as an alternative to hatchery propagation for population enhancement. Population enhancement via assisted migration is based on the hypothesis that colonization of previously inaccessible habitat by reproductive adults will increase habitat availability, thus reducing density-dependent negative effects on juvenile growth and survival, thereby increasing the number of out-migrating smolts while avoiding negative evolutionary impacts associated with hatcheries. The purpose of this study is to evaluate the impact of a "trap and haul" program on the population productivity of the Sainte-Marguerite River (Québec). For three years, a subsample of returning adults are being captured in a fish ladder at river kilometer (RKM) 7, transported by truck, and released upstream of a pair of impassable waterfalls located at RKM 25 and RKM 30. Specifically, the objectives are (1) to assess habitat use and migratory behavior of adult Atlantic salmon following transport and (2) to determine the implications of spawning habitat choice on juvenile growth and development. Here we summarize the first two years of the program. Twelve adults were transported in 2014 (2 females 10 males) and 25 were transported in 2015 (12 females and 13 males). Each translocated fish was surgically implanted with an acoustic transmitter (Vemco V13) and then tracked via a network of acoustic receivers (VR2W). The percentage of fish that strayed downstream over the falls was fairly high (42% in 2014; and 28% in 2015). In 2015, females had a higher propensity to stray than males, but this was not statistically significant ($\chi 2(1, n = 25)$, $p > 0.05$). Evidence of reproductive activity was obtained from fish telemetry, visual inspection, and electro-fishing the following year. The passive acoustic system has proven ideal for tracking fish movements in a remote, turbulent, gravel-bed river. Placement of receivers in pools (≥ 0.5 m deep) allowed us to obtain multiple positions per fish per day, at all but flood-stage discharge. The results of the study will be used to inform the future of "trap and haul" programs for this and other rivers in Québec.

Corresponding Author: Danielle Frechette, joanie.carrier@gmail.com

Do we hit the target? Evaluation of thermal exposure of naturally- and hatchery-reared juvenile Atlantic salmon prior to migration on the Narraguagus River, Maine U.S.A.

Dylan S. Whitaker[1,2], James P. Hawkes[1], Joe Zydlewski[4,2], and Timothy F. Sheehan[3]

[1]*National Oceanic and Atmospheric Administration -Fisheries - Maine Field Station, Orono, ME*
[2]*Department of Wildlife, Fisheries and Conservation Biology, University of Maine, Orono, ME*
[3]*National Oceanic and Atmospheric Administration Northeast Fisheries Science Center, Woods Hole, MA*
[4]*U.S. Geological Survey Maine Cooperative Fish and Wildlife Research Unit, University of Maine, Orono, ME*

U.S. Atlantic salmon are at critically low abundance, with remnant populations listed as endangered under the Endangered Species Act. Extensive hatchery supplementation has been used to meet recovery objectives. Conservation hatcheries strive to produce individuals similar to wild conspecifics, but fundamental differences in thermal and environmental regimes exist. Additionally, the timing of stocking is often based on average historic data, which fails to recognize the impacts of inter-annual variation. Development of Atlantic salmon from parr to smolts is influenced by environmental conditions, and the developmental and/or physiological state of hatchery-reared fish often differs from their river-reared counterparts. An indirect method of assessing smolt development is through the summation of daily thermal experience (Accumulated Thermal Units; ATUs). We have assessed smolt migration timing in the Narraguagus River since 1997 using rotary screw traps. Captured smolts are identified as either "naturally reared" (from wild spawning and fry stocking) or of hatchery origin. From 2008-2012 when smolt stocking occurred (annually 50,000 age-1+ smolts), we conducted a comparative assessment of captured fish, which included assignment of origin, size, ATU experience (starting January 1 of each migration year using instream and hatchery temperatures), and migration duration. Hatchery fish tended to be larger, experience 10-260 more ATUs, and had much shorter run duration. Unlike naturally–reared fish, the migratory timing of hatchery smolts is limited by stocking date. Our data suggest that some hatchery smolts may have missed their developmental "smolt window," which has been demonstrated to decrease survival during seawater entry. Further work is needed to evaluate the impacts of differences in ATUs on the survival of naturally- and hatchery-reared Atlantic salmon. Monitoring ATUs in the hatchery and in the wild may allow hatchery managers to optimize development of hatchery smolts and timing of stocking in an effort to mimic natural environments.

Corresponding Author: James Hawkes, 207-866-7109, james.hawkes@noaa.gov

Collect, Analyze, Make Informed Decisions - DATA collection: A critical component in supporting a successfully operating fishway now and into the future.

Bryan Sojkowski, P.E.[1]

[1]*United States Fish & Wildlife Service, 300 Westgate Center Drive, Hadley, MA*

All too often, fishways are constructed and assumed to require little to no post-construction monitoring of fishway effectiveness. This "build it and they will come" mentality has severe consequences on safe, timely, and effective fish passage which in turn reduces the pace at which important species can re-inhabit historical spawning grounds as well as support overall riverine connectivity. The purpose of this presentation is to express the intricacies of a properly operating fishway and the data needed on an annual basis (or finer temporal resolution) to validate a fishway is performing as designed. A specific site example will be provided, demonstrating how detailed data can assist in clarifying fish passage issues and analyzed to support future fish passage decisions in a meaningful way.

Corresponding Author: Bryan Sojkowski, 413-253-8645, bryan_sojkowski@fws.gov

The Use of Natural Markers to Investigate Habitat Use and Growth of Juvenile Alewife (*Alosa pseudoharengus)*

Greg LaBonte[1], Karen Wilson[2], and Amy Webb[3]

[1]*University of Southern Maine, Biology Department, Portland, ME*
[2]*University of Southern Maine, Department of Environmental Science, Aquatic Systems Research, Portland, ME*
[3]*University of Southern Maine, Biology Department, Portland, ME*

Change in growth corresponding to a change in habitat of Penobscot estuary and bay juvenile alewives were investigated using otolith microchemistry and growth increments. Alewives were collected via pelagic trawl in the Penobscot estuary and bay during May and October of '13 and '14. Otoliths were removed, polished, and photographed using a Tucsen 5.0 MP camera mounted on a compound microscope. Growth increments were measured using ImageJ 1.48v. From measured increments, average growth was calculated by taking the mean of all increments measured. To get an assessment of instantaneous growth, individual increments were divided by the average growth. All alewife captured were considered under 1 year of age, based on the number of growth increments (Campana 2005). Otoliths were then brought to SUNY college of Environmental Science and Forestry, Syracuse, New York to quantify otolith elemental ratios of Calcium, Barium (indicative of freshwater) and Strontium (indicative of saltwater) using laser ablation inductively coupled plasma mass spectrometry (LA ICP-MS, Limburg 1998). Using water chemistry from the Penobscot watershed, criterion were established to determine habitat changes using Ba and Sr. Not all groups statistically averaged the same amount of time in freshwater or bay habitats ($ANOVA_{FW}$: $F_{5,128} = 4.902$, $p < 0.001$; $ANOVA_{bay}$: $F_{5,128}=3.209$, $p<0.05$), but all groups statistically averaged the same amount of time in estuarine habitat. Group FallBay '14 was the only group that differed in mean time spent in freshwater (≈27% less than the next lowest group) and bay habitats (≈43% less than the next lowest group). The difference in time spent had no statistical effect on growth, as average growth did not differ between groups during freshwater, estuary, or bay phases. However, when groups were combined, average growth was found to differ in freshwater (1.10±0.22), bay (1.00 ± 0.35), and estuary habitats (0.89±0.19). There were also differences in weight: length ratios between groups. Fall Bay '13 had the highest W:L ratio and the largest mean days spent in the bay (40.5 days).

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Contact: Greg LaBonte, 207-212-4596, Gregory.Labonte@maine.edu

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