Sixth Research Forum
Maine Atlantic Salmon and their Ecosystems
10-11 January 2012
Hilton Garden Inn, Bangor, ME

Program

Tuesday, January 10

7:30 a.m. *Registration, coffee*

8:30 a.m. **Welcome, announcements**
Sharon MacLean
NOAA's National Marine Fisheries Service
Northeast Fisheries Science Center

Session 1
Colby Bruchs, Moderator
Maine Department of Marine Resources
Bureau of Sea Run Fisheries and Habitat

8:40 a.m. **Penobscot River shad: Establishing baseline prior to restoration**
Ann B. Grote, Joseph D. Zydlewski and Michael M. Bailey

8:55 a.m. **The winter population of shortnose sturgeon (*Acipenser brevirostrum*) in the Penobscot River, Maine**
Kevin Lachapelle, Gayle Zydlewski, Michael Bailey, Kate Beard-Tisdale and Michael Kinnison

9:10 a.m. **Coastal river connectivity and shortnose sturgeon: A metapopulation perspective**
Matthew Altenritter, Gayle Zydlewski, Michael Kinnison and Joseph Zydlewski

9:25 a.m. **Barrier removal in Sedgeunkedunk Stream: Sea lamprey re-colonization and implications for Atlantic salmon habitat restoration**
Robert S. Hogg, Stephen M. Coghlan Jr., Joseph Zydlewski and Cory Gardner

9:40 a.m. **Impacts of spawning sea lamprey on foraging behaviors and growth potential of stream fishes: A bioenergetics modeling approach to quantify benefits from dam removal**
Stephen M. Coghlan Jr.

9:55 a.m. **Dam impact analysis on Atlantic salmon recovery in the Penobscot River, Maine**
Julie L. Nieland, Timothy F. Sheehan, Rory Saunders, Jeffrey S. Murphy and Tara Trinko Lake

10:10 a.m. *Break*

Session 2
Joan Trial, Moderator
Maine Department of Marine Resources
Bureau of Sea Run Fisheries and Habitat

10:25 a.m. **Atlantic salmon (*Salmo salar*) eyed ova planting: Sandy River Project update 2010-2011**
Paul M. Christman, Jason Overlock and Joan Trial

10:40 a.m. **The fate of lower mode Atlantic salmon, *Salmo salar,* stocked into the Penobscot River watershed, Maine**
Andrew O'Malley, Joseph Zydlewski, Oliver Cox, Peter Ruksznis and Joan G. Trial

10:55 a.m. **Growth and survival of stocked juvenile Atlantic salmon (*Salmo salar*) in 1st and 2nd order streams of the Machias River watershed**
Wesley Ashe, Stephen Coghlan Jr., Joan Trial and Joseph Zydlewski

11:10 a.m. **Movement, spawning, and overwinter habitat of captive reared Atlantic salmon (*Salmo salar*) out-planted in a spawning stream**
Colby Bruchs, Ernest Atkinson and Joseph Zydlewski

11:25 a.m. **Atlantic salmon smolt movements and survival in the Penobscot River**
Daniel Stich, Michael Bailey, Christopher Holbrook, Michael Kinnison, Gayle Zydlewski and Joseph Zydlewski

11:40 a.m. **Assessing the direct stocking of imprinted smolts into the Penobscot River Estuary**
Joseph Zydlewski, Anitra Firmenich, Paul Santavy, Christine Lipsky, James Hawkes and John Kocik

11:55 a.m. **Genetic analysis of Atlantic salmon natural reproduction in Hobart Stream, Maine**
Meredith L. Bartron, Denise Buckley and Ernie Atkinson

12:10 p.m. *Lunch*

Session 3
Dan McCaw, Moderator
The Penobscot Indian Nation
Department of Natural Resources

1:15 p.m. **Intrafish variability in scales of Atlantic salmon (*Salmo salar*) smolt from the Sheepscot River, Maine**
Molly McCarthy, **Ruth Haas-Castro** and Mark Renkawitz

1:30 p.m. **Effects of marine derived nutrients on juvenile Atlantic salmon (*Salmo salar*) growth and body condition**
Margaret Guyette, Cynthia Loftin and Joseph Zydlewski

1:45 p.m. **Implications of marine derived nutrients delivered to Atlantic rivers by three species of anadromous fishes**
Kurt Samways, Brittany Graham and Richard Cunjak

2:00 p.m. **Examining environmental triggers for aggregation-type behavior in juvenile Atlantic salmon (*Salmo salar*) subjected to thermal stress**
Emily Corey, Cindy Breau, Tommi Linnansaari and Richard Cunjak

2:15 p.m. **Assessing estuarine and coastal migration performance of age-1 hatchery reared Atlantic salmon smolts released into the Dennys River**
James Hawkes, Timothy Sheehan, Paul Music, Dan Stich and Ernie Atkinson

2:30 p.m. **Estimating Penobscot River fish passage using fixed location SONAR**
Patrick J. Erbland, Gayle B. Zydlewski and Joseph D. Zydlewski and Joseph E. Hightower

2:45 p.m. *Break and* **Poster Session**

Poster Session
Hilton Ballroom

Investigating variability of North Atlantic alewife (*Alosa pseudoharengus*) populations by integrating historic run data with climate and geophysical data
Barbara S. Arter, Derek Olson and Karen Wilson

Status of baseline science monitoring for the Penobscot River Restoration Project
Charles Baeder

Effects of temperature on growth and stress in brook trout
Joseph G. Chadwick Jr. and **Stephen D. McCormick**

Altering vertical placement of hydroacoustic receivers for improved efficiencies
Graham S. Goulette and James P. Hawkes

Environmental contaminants in fillets of sea-run Atlantic salmon (*Salmo salar*) from the Gulf of Maine DPS
Steven E. Mierzykowski

Revisiting the marine migration of U.S. Atlantic salmon using historic Carlin tag data
Alicia S. Miller, Timothy F. Sheehan, Mark D. Renkawitz, Alfred L. Meister and Timothy J. Miller

Genetic variability of MHC class II in rainbow smelt, *Osmerus mordax*
Janyne Pringle, Catherine Chipman and Gerard P. Zegers

Juvenile salmon abundances: Comparing catch per unit effort and depletion sampling among years
Joan Trial, Ernie Atkinson and Paul Christman

Genetic variation in MHC class II alpha and beta genes in Maine populations of Atlantic salmon, *Salmo salar*
Mallory L. Ward and Ellen E. Hostert

The use of clam shells for water quality enhancement and fishery restoration
Mark Whiting and Jacob van de Sande

Session 4
Peter Lamothe, Moderator
U.S. Fish and Wildlife Service
Maine Fisheries Program Complex

3:45 p.m. **Monitoring adult Atlantic salmon in the Penobscot River using PIT telemetry**
Edward Hughes, Joseph D. Zydlewski, Oliver Cox and **Doug Sigourney**

4:00 p.m. **Telemetry-based estimates of Atlantic salmon survival in estuaries and bays of Maine**
John F. Kocik, Graham S. Goulette, James P. Hawkes and Timothy F. Sheehan

4:15 p.m. **Surface trawl survey for U.S. origin Atlantic salmon (*Salmo salar)* in Penobscot Bay, Maine**
Timothy Sheehan, Mark Renkawitz and Russell Brown

4:30 p.m. **The Penobscot Estuarine Fish Community and Ecosystem Survey**

Christine Lipsky, Michael O'Malley, Justin Stevens, Rory Saunders and John Kocik

4:45 p.m. **Avian and Marine Mammal Census of the Penobscot River estuary**
Paul Music and John Kocik

Wednesday, 11 January

7:45 a.m. *Registration, coffee*

Session 5
Timothy Sheehan, Moderator
NOAA's National Marine Fisheries Service
Northeast Fisheries Science Center

8:15 a.m. **Migration and survival in the Atlantic: Are postsmolts running on empty?**
Carrie Byron, Andy Pershing and Huijie Xue

8:30 a.m. **Trophic ecology of Atlantic salmon in the northwest Atlantic**
Mark Renkawitz, Timothy Sheehan, David Reddin, Gerald Chaput and Rory Saunders

8:45 a.m. **The influence of environmental, oceanographic, and low trophic level conditions on marine survival of Atlantic salmon**
Katherine Mills, Andrew Pershing, David Mountain and Timothy Sheehan

9:00 a.m. **Retrospective analysis of Atlantic salmon marine growth parameters in the northwest Atlantic based on tag-recovery data**
Alicia S. Miller, Timothy J. Miller, Timothy F. Sheehan and Mark D. Renkawitz

9:15 a.m. **Fishes and tidal power development in Cobscook Bay**
Haley Viehman, Gayle Zydlewski, James McCleave and Garrett Staines

9:30 a.m. **Fish diversity and spatial distribution in Cobscook Bay: Anticipating broad scale changes**
Jeffrey Vieser, Gayle Zydlewski, James McCleave and Garrett Staines

9:45 a.m. *Break*

Session 6

Tara Trinko Lake, Moderator
NOAA's National Marine Fisheries Service
Northeast Regional Office

10:00 a.m. *Guest Speaker*
Historical alewife predation by four gadids, Atlantic cod (*Gadus morhua*), haddock (*Melanogrammus aeglefinus*), white hake (*Urophycis tenuis*), and pollock (*Pollachius virens*) in Muscongus Bay and Penobscot Bay
Edward P. Ames, Karen Wilson and Theo Willis

10:30 a.m. **Can mussels reduce the risk of fish farms spreading pathogens?**
Michael R. Pietrak, Sally D. Molloy, Deborah A. Bouchard and Ian R. Bricknell

10:45 a.m. **Freshwater and seawater isoforms of gill Na,K-ATPase and their use in assessing Atlantic salmon smolt quality, acidification impacts, and strain differences**
Stephen D. McCormick, Amy Regish, Michael O'Dea and Arne Christensen

11:00 a.m. **Differential life stage response to common endocrine disruptors in two endangered species, Atlantic salmon and shortnose sturgeon**
Tara Duffy and Stephen McCormick

11:15 a.m. **Fish scales as nonlethal biosensors of surface water contaminants: Studies with Atlantic salmon**
Daniel G. Skall and Adria A. Elskus

11:30 a.m. **Migratory behavior of alewife in the Penobscot River and Penobscot Bay after spawning**
Theo Willis

11:45 a.m. **Closing**
John Kocik
NOAA's National Marine Fisheries Service
Northeast Fisheries Science Center

ABSTRACTS
ORAL PRESENTATIONS

Session 1 ***8:40 a.m.***

Penobscot River American shad: Establishing baselines prior to restoration

Ann B. Grote[1], Joseph D. Zydlewski[1,2] and Michael M. Bailey[3]
[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; [3] U.S. Fish and Wildlife Service, Central New England Fishery Resource Office, Nashua NH

Although American shad were historically abundant in the Penobscot River, the current population is poorly characterized. Implementation of the Penobscot River Restoration Project is expected to improve marine-freshwater connectivity and to restore access to habitat for American shad throughout much of the Penobscot River system. We captured and monitored adult shad during three spawning seasons (2009-2011) to describe pre-restoration behavioral and demographic baselines. American shad were collected via boat electrofishing, and were gastrically implanted with radio (n=76) or acoustic (n=15) tags. Shad movements were monitored by seven stationary radio data loggers, a network of >50 acoustic receivers, and mobile tracking surveys. Electrofishing and telemetry results indicate shad concentrated in two locations, Eddington Bend (rkm 45) and Hogan Pool (rkm 41.5), and that residence times ranged from 0.31 – 25.44 days post-tagging. Most study fish displayed distinct movement patterns, however, few tagged shad (7.1%) were detected at Veazie Dam which is the current terminus of shad migration in this system. Hydroacoustic (Dual-frequency Identification Sonar DIDSON) imaging surveys were used to monitor fish approaching the Veazie Dam fish ladder. The length distribution of DIDSON-imaged fish describes 3 peaks (30, 48, and 74 cm), which correspond well with Penobscot-specific length distributions for river herring (20-30 cm), American shad (34-54 cm), and Atlantic salmon (48-90 cm). Comparisons of the hydroacoustic measurements with the species length distributions were used to estimate the proportion of species encounters in the DIDSON footage, and to validate the timing of the shad run.

Session 1 ***8:55 a.m.***

The winter population of shortnose sturgeon *(Acipenser brevirostrum)* in the Penobscot River, Maine

Kevin Lachapelle[1], Gayle Zydlewski[2], Michael Bailey[3], Kate Beard-Tisdale[4] and Michael Kinnison[5]
[1]University of Maine, Department of Ecology and Environmental Science, Orono, ME; [2]University of Maine, School of Marine Sciences, Orono, ME; [3]U.S. Fish and Wildlife Service, Central New England Fishery Resource Office, Nashua, NH; [4]University of Maine, Department of Spatial Information, Science and Engineering, Orono, ME; [5] University of Maine, School of Biology and Ecology, Orono, ME

Shortnose sturgeon *(Acipenser brevirostrum)* exhibit a specific wintering behavior in northern rivers of their range. This behavior is characterized by the formation of a dense aggregation and cessation of most movement in a wintering habitat that is used annually. This presents an opportunity to estimate the population size without the complications of immigration and emigration. In 2008, a shortnose sturgeon wintering site was identified on the Penobscot River. To estimate population size, a DIDSON (Dual-frequency Identification Sonar) imaging system has been used to spatially survey the wintering site. These spot densities that are calculated from DIDSON footage are then used in a spatial data analysis (kriging) to estimate the total number of individuals in the wintering area on multiple sampling dates. These estimates can be used to infer the demographics of shortnose sturgeon in the Penobscot River and can be used to validate other independently developed population estimates. For example, mark-recapture, robust design modeling, and acoustic telemetry methods have been used to estimate summer and fall population sizes of the shortnose sturgeon population in the Penobscot. Sampling has occurred annually since 2008, and has encompassed a range of water temperatures (7.7°C to 0.5°C). There are two conditions that must be met for sampling to occur: sturgeon must be exhibiting winter aggregation behavior, and river conditions must allow for access to sample. This typically results in a short sampling window of only a few days in November when water temperatures drop enough to trigger wintering behavior (~ 7.0°C), but before a layer of ice forms on the river surface. In March 2010, a short second sampling window occurred when the ice cover cleared early, but sturgeon were still wintering. Our current dataset consists of samples from November of 2008, 2009, and 2010, (three days of data each year) with an additional two days in March 2010. Sampling will also occur in November 2011. Data analyzed for 29 November 2010 produced a preliminary estimate of 681 individuals (446-1506 95% CI). This estimate is comparable to previous fall mark-recapture estimates of 641 individuals (399 – 1074 95% CI) for 2008 and 602 individuals (410 – 911 95% CI) for 2009 (using robust design modeling). This novel approach allows for an annual estimate that can track trends in the shortnose sturgeon population, while only requiring a few days of fieldwork each year. This method also does not require any direct capturing and handling of individuals which is desirable when working with an endangered species such as shortnose sturgeon, where limiting risk to all individuals is a priority.

Session 1 ***9:10 a.m.***

Coastal river connectivity and shortnose sturgeon: A metapopulation perspective

Matthew Altenritter[1], Gayle Zydlewski[2], Michael Kinnison[1] and Joseph Zydlewski[3]
[1]University of Maine, School of Biology and Ecology, Orono, ME; [2]University of Maine, School of Marine Sciences, Orono, ME; [3]U.S. Geological Survey, Maine Cooperative Fish and Wildlife Research Unit, University of Maine, Orono, ME

Recent telemetry work on shortnose sturgeon in the Penobscot River detected novel movement patterns in the Gulf of Maine (Dionne 2010, Fernandes 2010). Previously, shortnose sturgeon were believed to remain within rivers. However, the above studies demonstrated frequent directed movements among large coastal rivers (such as the Penobscot and Kennebec Rivers) and numerous incursions into neighboring smaller coastal rivers (e.g., Damariscotta and Sheepscot rivers). Based on these observations, assumptions of closed single river populations for estimates are not supported; a metapopulation structure may be most appropriate. This work focuses on determining local and regional scale factors that influence the shortnose sturgeon Gulf of Maine metapopulation. To do so, immigration and emigration rates are being quantified using acoustic telemetry in the Penobscot and other Gulf of Maine rivers. Robustly designed mark-recapture methods are being used within the Penobscot River to estimate population size. Elemental analyses of hard structures (scutes) may prove useful in determining river of origin, thereby increasing our understanding of connectivity and source/sink dynamics in the region. Diet analyses and concurrent habitat surveys will be used to assess habitat use and habitat quality. Such demographic information will contribute to understanding the drivers of intracoastal movements. We hypothesize that coastal movements are important in maintaining population viability and propose expanding the metapopulation framework in the Gulf of Maine.

References:

Dionne PE. 2010. Shortnose sturgeon of the Gulf of Maine: The importance of coastal migrations and social networks. M. Sc. Thesis. University of Maine, Orono, ME.

Fernandes SJ, Zydlewski GB, Zydlewski JD, Wippelhauser GS, Kinnison MT. 2010. Seasonal distribution and movements of shortnose sturgeon and Atlantic sturgeon in the Penobscot River estuary, Maine. Tran. Amer. Fish. Soc.139:1436-1449.

Session 1 ***9:25 a.m.***

Barrier removal in Sedgeunkedunk Stream: Sea lamprey re-colonization and implications for Atlantic salmon habitat restoration

Robert S. Hogg[1,2], Stephen M. Coghlan Jr.[1], Joseph Zydlewski[1,2] and Cory Gardner[1,2]
[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

Sedgeunkedunk Stream, a 3rd-order tributary to the Penobscot River, historically supported several anadromous fish species, including sea lamprey and Atlantic salmon. However, two small dams constructed in the 1800s at rkm 0.7 and rkm 6.0 reduced or eliminated spawning runs entirely. In 2009, efforts to restore marine–freshwater connectivity in the system culminated with removal of the lowermost dam returning over 5-km of lotic habitat accessible to anadromous fish. Sea lamprey utilized accessible habitat prior to dam removal and were chosen as a sentinel species to quantify re-colonization following restoration. During lamprey spawning runs of 2008 through 2011 (pre- and post-dam removal), individuals were marked with Passive Integrated Transponder (PIT) tags upon entering the stream and their activity was tracked with daily recapture surveys. Mark-recapture encounter histories were entered into the POPAN extension of Program MARK, and results indicated a four-fold increase in the abundance of spawning sea lamprey with population estimates, increasing from 59 ± 6 (95% CI) pre-dam removal (2008) to 223 ± 35 and 248 ± 25 post-dam removal (2010 and 2011, respectively). Microhabitat metrics including fine sediment accumulation (particles < 2 mm), proportion of embedded particles (> 40 mm), and stream-bed depth and velocity profiles were measured in the mounds, pits and adjacent reference locations at randomly selected nesting sites. Reduced fine sediments and proportions of embedded particles are primary drivers of Atlantic salmon spawning habitat quality (Stanley and Trial 1995), and streambed depths and velocities dictate the positioning of optimal foraging stations for drift-feeding fishes (Nislow et al. 2000). Analysis of these metrics revealed that lamprey spawning activities conditioned streambed morphology favorably for Atlantic salmon and other resident drift feeding fishes. Fine sediment accumulation and proportion of embedded particles were significantly reduced in mound microhabitats relative to pit and reference microhabitats. Lamprey nest construction increased substrate complexity by producing shallower mounds with increased velocities adjacent to deeper pits with lower velocities relative to reference microhabitats. Barrier removal has facilitated sea lamprey re-colonization and their spawning activities may have improved physical conditions at the microhabitat level for Atlantic salmon.

References:

Nislow KH, Folt CL, Parrish DL. 2000. Spatially explicit bioenergetic analysis of habitat quality for age-0 Atlantic salmon. Trans. Am. Fish Soc. 129:1067-1081.

Stanley JG, Trial JG. 1995. Habitat suitability index models: nonmigratory freshwater life stages of Atlantic salmon. U.S. Dept. Interior, Nat. Biol. Serv., Biol. Sci. Rep. 3. 19 pp.

Session 1 ***9:40 a.m.***

Impacts of spawning sea lamprey on foraging behaviors and growth potential of stream fishes: A bioenergetics modeling approach to quantify benefits from dam removal

Stephen M. Coghlan Jr.
University of Maine, Department of Wildlife Ecology, Orono, ME

Historically, many Maine streams supported spawning runs of sea-run fishes including Atlantic salmon, sea lamprey, and alewife. These fishes once served as important vectors of marine derived nutrients and energy that fertilized otherwise nutrient poor systems, but have declined or disappeared during three centuries of dam construction. Currently, dam removal is a popular tool in recovery of native fishes and stream restoration. Sedgeunkedunk Stream, a small tributary to the Penobscot River, has been the focus of such a restoration effort. During 2008-2009, one dam was removed and another bypassed with a fishway, and by 2010 spawning sea lamprey had re-colonized formerly inaccessible habitat for the first time in more than a century. Sea lamprey construct nests in shallow riffles and the tails of pools by rearranging cobbles and pebbles to form pit-and-mound structures similar to salmon nests. In the process, they dislodge aquatic insects from the substrate, and these drifting insects and newly released eggs may provide an important food source for stream fishes. In summer 2011, I combined snorkeling observations, videography, drift sampling, and diet analysis to quantify the foraging behavior and consumption rate of drift feeding stream fishes during the sea lamprey spawning run in Sedgeunkedunk Stream. By coupling empirical estimates of fish consumption and food availability with bioenergetics models that predict growth as a function of energy gains and losses associated with occupying a specific habitat – in this case, an active sea lamprey nest – I can quantify the magnitude of energetic subsidies that sea lamprey provide directly to stream fishes via bioturbation. Preliminary results are forthcoming, and should clarify the interactive ecology of anadromous and resident fishes and also help predict the effects of sea lamprey recovery on these fishes in newly accessible habitat gained by dam removal.

Session 1 ***9:55 a.m.***

Dam impact analysis on Atlantic salmon recovery in the Penobscot River, Maine

Julie L. Nieland[1], Timothy F. Sheehan[1], Rory Saunders[2], Jeffrey S. Murphy[2] and Tara Trinko Lake[2]
[1]NOAA's National Marine Fisheries Service, Woods Hole, MA; [2]NOAA's National Marine Fisheries Service, Orono, ME

Atlantic salmon populations in Maine are listed as endangered under the Endangered Species Act (ESA), and dams have been identified as a major contributor to their historic decline and current low abundance. Under the ESA, federal agencies must ensure that their actions, such as the licensing of hydroelectric dams by the Federal Energy Regulatory Commission, do not preclude population recovery. To help meet this requirement, we developed a model to quantitatively evaluate the impact of federally licensed dams on Atlantic salmon dynamics. We examined the Penobscot River, a large river system in Maine that produced approximately 75% of all U.S. adult Atlantic salmon returns in recent years. This highly modified river has multiple hydroelectric facilities that reduce passage rates for downstream migrating smolts and upstream migrating adults on both main stem and major tributary reaches. We developed a life-stage specific model to compare the population dynamics of the current state of passage success to a hypothetical scenario of 100% passage success (i.e., no dams). Downstream passage survival distributions were generated for each dam using site- and facility-specific attributes, as well as biological and river flow data, accounting for both direct mortality and indirect secondary effects, such as increased passage time. Empirical field data were used to verify these distributions and also to develop upstream passage survival distributions. This general approach allowed for the development of more accurate passage distributions for dams with and without prior data. Model outputs include probability density functions for smolt and adult abundance, dam induced losses at each hydroelectric facility, and natural mortality losses at key life stages. This model will allow the National Marine Fisheries Service to develop dam passage survival standards for downstream and upstream migrating salmon that will not significantly reduce the recovery of the species. The model will also help prioritize future passage improvement efforts to maximize the benefits to the Penobscot River Atlantic salmon population.

Session 2 ***10:25 a.m.***

Atlantic salmon *(Salmo salar)* eyed ova planting: Sandy River project update 2010-2011

Paul M Christman[1], Jason Overlock[1] and Joan Trial[2]
[1]*Maine Department of Marine Resources, Bureau of Sea Run Fisheries and Habitat, Hallowell, ME;* [2]*Maine Department of Marine Resources, Bureau of Sea Run Fisheries and Habitat, Bangor, ME*

In 2010, the Maine Department of Marine Resources began a novel Atlantic salmon restoration project in the Sandy River, a tributary to the Kennebec River. The project goal was to utilize the wealth of juvenile rearing habitat found in the Sandy River in order to evaluate the potential of Atlantic salmon eyed ova planting as a supplementation strategy. The criteria used to evaluate the project were juvenile distribution and abundance. In 2010, an estimated 599,849 eyed ova were planted in the Sandy River drainage and in 2011, the estimated number of eyed ova was 859,893. Eyed ova were planted at 12 sites in 2010 and expanded to 15 sites in the 2011. The juvenile assessment included fry emergence traps, CPUE sampling methodology focused around planting sites, and a small number of population estimates. A regression predicting densities from CPUE was used to generate basin estimates for reaches stocked in 2010. All plantings produced juveniles in both years. In addition, the estimated abundance of 0+ parr in 2010 was 193,014 with the young of year occupying more than 35.5 kilometers of juvenile habitat. Given the size of the Sandy River drainage and shortages in staff, efforts shifted in 2011 to a basinwide random sample. The area covered by the random sample is estimated to exceed 15,000 units (1unit = $100m^2$) of juvenile rearing habitat. A sampling of 30 sites resulted in 73.3% of the sites containing either 0+ parr, 1+ parr or both. While several of the samples contained wild juveniles, the majority were expected to have been from plantings.

Session 2 ***10:40 a.m.***

The fate of lower mode Atlantic salmon, *Salmo salar*, stocked into the Penobscot River watershed, Maine

Andrew O'Malley[1], Joseph Zydlewski[1,2], Oliver Cox[3], Peter Ruksznis[3] and Joan G. Trial[3]
[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; [3]Maine Department of Marine Resources, Bureau of Sea Run Fisheries and Habitat, Bangor, ME

Hatchery supplementation has been a critical component of Atlantic salmon restoration in Maine, and is thought to have played a key role in preventing extinction. Stocking 18 month smolts usually provides the most cost effective returns. The lower mode, those fish not growing fast enough to assure smolting by the time of stocking, are generally looked at as a byproduct of the smolt program. During 2002 and 2009, between 70,000 and 170,000 marked lower mode Atlantic salmon were stocked into the Pleasant River (Piscataquis County) in late September to early October. Rotary screw traps were fished in the Pleasant River between mid-April and early June from 2004 to 2009. This effort spanned the smolt run and included a minimum of 36 days fished annually. From 2004 to 2006, all marked migrating smolts were sampled while from 2007 to 2010 a daily maximum of five fish were sampled from each year class. Fork length was measured and a scale sample was taken to retrospectively estimate length at age 1 using the intercept-corrected direct proportion model. Lower mode fish were observed to migrate as smolts 8, 20 and rarely 32 months after stocking. Those migrating the next spring were distinctly larger (>12 cm) than those that remained in the river for at least one year. Such data will allow managers to better assess the smolting probability of their product, or match growth rates to a targeted lower mode product.

Session 2 ***10:55 a.m.***

Growth and survival of stocked juvenile Atlantic salmon (*Salmo salar*) in 1st and 2nd order streams of the Machias River watershed

Wesley Ashe[1], Stephen Coghlan[1], Joan Trial[2] and Joseph Zydlewski[1,3]
[1]University of Maine, Department of Wildlife Ecology, Orono, ME; [2]Maine Department of Marine Resources, Bureau of Sea Run Fisheries and Habitat, Bangor, ME; [3]U.S. Geological Survey, Maine Cooperative Fish and Wildlife Research Unit, University of Maine, Orono, ME

The Machias River, located in Downeast Maine, harbors one of the few remaining wild populations of Atlantic salmon (*Salmo salar*) in the US and provides a model system for investigating the productive capacity of headwater streams currently inaccessible to wild juvenile salmon due to impassable culverts. In spring 2010 and 2011, we scatter stocked salmon fry in 20 study reaches and quantified growth and survival across multiple environmental gradients. In late summer, fry abundance per 100 m reach averaged 40 and 62 individuals (2010 and 2011, respectively) and ranged from 0 to 225 fry. Mean mass of fry at time of capture was 1.5 g and 1.6 g, and ranged from 0.6 to 2.7 g, whereas mean length at time of capture was 54.0 mm and 55.5 mm and ranged from 40.5 to 70.4 mm. Apparent survival among sites ranged between 0 and 50.5%, with yearly means of 12.1 and 12.7%. Mean density was 0.29 and 0.30 fry/m^2 and ranged from 0.00 to 1.21 fry/m^2. Mean biomass was 0.42 g and 0.52 g of salmon tissue/m^2 and ranged from 0.00 to 2.15 per reach. Brook trout (*Salvelinus fontinalis*), the dominant fish throughout the study area, were collected in 95% of study reaches. Of the 20 habitat variables measured, temperature, brook trout biomass, interstitial space availability, and percent cobble were correlated most strongly with growth and survival. We anticipate results that will validate the importance of headwater streams as critical nursery and rearing habitat for juvenile salmon, thus providing the impetus toward culvert removal and the reestablishment of watershed connectivity.

Session 2 ***11:10 a.m.***

Movement, spawning, and overwinter habitat of captive reared Atlantic salmon (*Salmo salar*) out-planted in a spawning stream

Colby Bruchs[1], Ernest Atkinson[1] and Joseph Zydlewski[2]
[1]Maine Department of Marine Resources, Bureau of Sea Run Fisheries and Habitat, Jonesboro, ME; [2]U.S. Geological Survey, Maine Cooperative Fish and Wildlife Research Unit, University of Maine, Orono, ME

Out-planting gravid adult Atlantic salmon (*Salmo salar*) to populate habitat with juveniles produced from natural spawning is increasingly used as a management strategy in Maine. However, movement of adults away from release streams potentially confounds wild salmon return estimates based on redd counts, may lead to behavioral and biological interaction with wild conspecifics, and limits agency ability to fully assess juvenile production potential of captive reared broodstock. This study assessed movement, behavior, and spawning of 30 out-planted captive reared broodstock (20♀; 10♂) before, during, and after spawning. Adults were tagged with hydroacoustic transmitters (Bridger and Booth 2003; Smith et al. 1998) and passively tracked throughout the East Machias River drainage with an array of receivers from early October 2010 through the spawning period and post-spawn overwinter until June 2011. From release, telemetry data indicated 45% of female salmon (9) and 60% of male salmon (6) migrated out of the release stream pre-spawn. Of those salmon, five females and five males returned to the release stream during the spawning period. Active and passive tracking during the spawning period indicated presence of 16 females (80%) in the release stream. Redd surveys documented 32 redds. The apparent redds/♀ ratio (total females released) was 1.6. However, the redds/♀ ratio (females present) was 2.0, supporting the hypothesis that the apparent redds/♀ ratios calculated from previous releases underestimated the redd construction rates of captive reared females. Female survival through the spawning period was estimated at 0.55; for males, 0.50. Kelts primarily overwintered in lakes. Post-spawn survival and location of mortality are discussed. Overall, seven females and three males successfully emigrated to the estuary. Additional data is collected annually to develop a method of probabilistic assignment of redds in a drainage to captive reared or sea-run spawners. Findings to date are guiding management of captive reared Atlantic salmon outplants within the Maine program.

References:

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Session 2 ***11:25 a.m.***

Atlantic salmon smolt movements and survival in the Penobscot River

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The effects of dams on Atlantic salmon smolt migration and survival were studied in the Penobscot River, Maine, to develop baseline knowledge prior to dam removal. Wild (n=417) and hatchery (n=1,228) Atlantic salmon smolts were acoustically tagged and released at multiple locations in the river during 2005-2011. Smolts were detected throughout the river and estuary during migration using an array of acoustic receivers moored to the river bottom. Movement rates and passage path of fish were characterized in impounded and free flowing sections of the Penobscot River. Survival was estimated in each reach of the river using multistate, Cormack-Jolly-Seber mark-recapture models that included path choice through a secondary migratory route in freshwater (Stillwater Branch). Average cumulative survival of all Atlantic salmon smolts through freshwater was about 0.57 (±0.08) to the estuary, and average cumulative survival was about 0.48(±0.16) from the upper Penobscot River to Penobscot Bay. Reach-specific movement rates and survival probabilities of Atlantic salmon smolts were higher in free flowing reaches of the river than in impounded reaches. Most acoustically tagged smolts migrated through the main stem of the Penobscot River in all years, and did not use the Stillwater Branch.

Session 2 ***11:40 a.m.***

Assessing the direct stocking of imprinted smolts into the Penobscot River Estuary

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During migration, smolts can incur significant direct or indirect mortality from dams and predation. Successful transition into the marine environment is thought to occur during a "window of opportunity," when physiological condition is optimal for survival. In addition to the obvious advantage of surviving emigration, ability of anadromous salmon to return to a natal stream based on in river experience is pivotal to their reproductive success. From 2009 to 2011, an experimental stocking strategy was initiated on the Penobscot River to balance risks of mortality during migration with straying risks and the timing of seawater entry. Approximately 30,000 smolts marked with Visual Implant Elastomer were transferred from the U.S. Fish and Wildlife Service Green Lake National Fish Hatchery and acclimated in "imprinting pools" located at West Enfield (rkm 101) on the Penobscot River. These fish were held for 10 days before they were trucked to Verona Island (rkm 0) and released at night on an outgoing tide. For each year, 45-50 fish receiving this treatment were implanted with acoustic tags and tracked as they migrated out to sea using stationary acoustic receivers. We measured migration speed and estimated survival into the ocean for these fish. Ongoing telemetry efforts tracking tagged smolts released with upstream stocking efforts serve as a reference. Similarly, up river releases with VIE batch marks provide a benchmark for adult returns. Over the three years, telemetry indicates that reach survival in the lower river is comparable with run-of-the-river fish, though overall survival to the ocean may be increased (higher in 2 of the 3 years). The first 2-seawinter adult returns from this experiment are arriving in 2011 and these data will be presented and compared with upriver stocking efforts.

Session 2 ***11:55 a.m.***

Genetic analysis of Atlantic salmon natural reproduction in Hobart Stream, Maine

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To increase natural reproduction of Atlantic salmon in Maine's rivers and to evaluate the potential of hatchery adults to successfully spawn in the natural environment, gravid adult Atlantic salmon from Craig Brook National Fish Hatchery have been stocked prior to spawning. In general, these adult hatchery salmon are returned to their population of origin; however, Hobart Stream has been experimentally stocked with adults from multiple hatchery broodstocks. Prior to this study, no Atlantic salmon or natural reproduction by Atlantic salmon had been detected in Hobart Stream. We used microsatellite loci to genotype all stocked hatchery adults and sampled juveniles, and did genetic parentage analysis to assess the reproductive ability of the hatchery adults and determine mate choice patterns for hatchery adults in the wild. We assessed natural reproduction for two release years (2006 and 2007), through captures of parr and smolts in 2008, 2009, and 2010. In 2006, adults from three different broodstock populations were stocked into Hobart Stream, and in 2007, adults from two different broodstock populations were stocked. Of the 90 juvenile Atlantic salmon sampled and genotyped, 84 were assigned to parental spawning pairs, indicating that hatchery raised Atlantic salmon can successfully reproduce in streams and produce offspring that survive through the juvenile life stages. Based on assignment of sampled juveniles to parental broodstock, observed spawning pair combinations significantly deviated from expected proportions based on numbers stocked, indicating either nonrandom selection of mates or differential survival of offspring occurred, both for the 2006 release year (X^2=40.36, $p<0.001$) and 2007 release year (X^2=9.17 $p=0.03$). Determination of reproductive capabilities of hatchery reared Atlantic salmon, and their mating strategies following stocking in the wild, will provide important information to guide restoration activities and stocking practices of hatchery Atlantic salmon.

Session 3 ***1:15 p.m.***

Intrafish variability in scales of Atlantic salmon (*Salmo salar*) smolt from the Sheepscot River, Maine

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Scale measurements are routinely used for fish growth rate and length-at-age back-calculations. Variability in features among scales from the same fish may be sufficient to influence scale measurements and subsequently the results of such investigations. We measured five scales from 10 Atlantic salmon smolts sampled from the Sheepscot River, Maine, to examine scale variability within each fish. Distances to scale features along a line transect from the scale focus to the scale edge were measured using a computer image analysis system. Distances from the scale focus to the scale edge and from the focus to the first freshwater annulus, mean spacing between the first 10 circuli, and the total number of circuli per scale did not vary significantly among scales from the same fish. Our study indicates that smolt scales collected from the same region of the fish exhibit little variation in scale morphology. Within-fish variability for scales from adult salmon should be analyzed before assuming that scale variability will not influence growth or other analyses.

Session 3 ***1:30 p.m.***

Effects of marine derived nutrients on juvenile Atlantic salmon (*Salmo salar*) growth and body condition

Margaret Guyette[1], Cynthia Loftin[1,2] and Joseph Zydlewski[1,2]
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Prior to construction of dams beginning in the early 1800s, Atlantic salmon and other anadromous species migrated from the ocean to spawn in Maine's extensive rivers and streams. Spawning fish transported marine derived nutrients to these systems in the form of metabolic expenditure and through decomposition of mortalities. These contributions may have strongly influenced productivity in otherwise nutrient limited systems, bolstering the growth and survival of young Atlantic salmon and other anadromous species and influencing other components of the stream communities. We are investigating the effects of marine derived nutrients on Atlantic salmon nursery streams in the Penobscot River watershed, Maine. We stocked four headwater streams with young-of-the-year Atlantic salmon in May 2009 and 2010. We manipulated nutrient input by placing carcass analog at a density of 0.10 kg/m^2 in 300 meter treatment reaches in July and late October each year. This was timed to match sea lamprey and Atlantic salmon spawning. We collected Atlantic salmon, macroinvertebrate, periphyton, and water samples from June through December each year. We assessed Atlantic salmon growth and lipid content. Young-of-the-year Atlantic salmon were 22 – 56% larger and had 1.3 – 2.3 times greater fat reserves in treatment reaches relative to control reaches for three months following nutrient additions. We also analyzed Atlantic salmon and macroinvertebrate samples for $\delta^{15}N$ and $\delta^{13}C$ to trace marine derived nutrient uptake within these stream communities. Salmon carcass analog uptake was evident in fish muscle tissue within one month and in some macroinvertebrate taxa within two weeks following nutrient addition. These data indicate that nutrient addition, through natural spawning or supplementation, may be critical to growth in young Atlantic salmon.

Session 3 ***1:45 p.m.***

Implications of marine derived nutrients delivered to Atlantic rivers by three species of anadromous fishes

Kurt Samways, Brittany Graham and Richard Cunjak
Canadian Rivers Institute, University of New Brunswick, Department of Biology, Fredericton, NB, Canada

Returns of anadromous fish have declined dramatically in the past century throughout Atlantic Canada, reducing the delivery of marine derived nutrients (MDN) to rivers. The role of MDN transport in coastal rivers is a function of net nutrients transferred by all anadromous fish and collectively may result in MDN subsidies equivalent to those delivered by salmon on the Pacific coast. The current scarcity of these fishes may have profound effects on aquatic production, particularly in nutrient poor systems. We examined *i*) the primary pathways of incorporation of MDN delivered by three species of anadromous fishes to freshwater food webs, and *ii*) how different timing and spawning strategies affect freshwater productivity. Stable isotopes of carbon and nitrogen were used to track the flow of MDN from primary producers to consumers in rivers containing different species of anadromous fish. In rivers with rainbow smelt (broadcast spawners), MDN incorporation was in the form of direct consumption of eggs by freshwater invertebrates, and indirectly through nutrient uptake by the biofilm and subsequent grazing by invertebrates. In salmon rivers, incorporation was also through both direct and indirect pathways; however, incorporation was delayed, likely due to eggs being buried in redds. In contrast, MDN incorporation was only through an indirect pathway in rivers with alewives, which are pelagic spawners. The connectivity between freshwater and marine inputs may be larger in scope than previously understood. The reduction of MDN may act to constrain freshwater productivity, and therefore, the sustainability of anadromous and resident fish populations.

Session 3 ***2:00 p.m.***

Examining the environmental triggers for aggregation-type behavior in juvenile Atlantic salmon (*Salmo salar*) subjected to thermal stress

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It is well documented that wild juvenile Atlantic salmon exhibit a physiological stress response when temperatures exceed 23ºC. Once the physiological threshold is surpassed and water temperature verges on the upper lethal limit (27ºC), juveniles exhibit thermoregulation in the form of behavioral adaptations. Regularly observed territoriality is abandoned in favor of an aggregated response in areas of cooler water (refugia). The objective of this study was to determine environmental threshold conditions required for initiating behavioral thermoregulation of salmon parr *in situ*. Temperature data and Passive Integrated Transponder (PIT) tags were used over two field seasons (2009 and 2010) to monitor temperature related movements of 635 individually tagged 1+ and 2+ Atlantic salmon parr within the Little Southwest Miramichi River (>60m wide) located in northeastern New Brunswick, Canada. Parr were found to have traveled >10km in an effort to locate refugia when water temperatures exceeded 30ºC. In 2010, 36.5% of current year juveniles were re-sighted prior to thermal stressors, of which 53.0% were subsequently located within aggregations, with a total seasonal return rate for current year fish of 66.8%. Preliminary data analysis suggests nighttime temperature or cumulative degree-days may be vital stimuli for the initiation of aggregate behavior in parr. An earlier response to similar thermal stressors is recorded with regards to adult Atlantic salmon. If a predictive model for presence of aggregations in juveniles can be conceived, it is possible that such a model can be extrapolated to include the more temperature sensitive adults. With various climate change models for eastern Canada predicting these temperature thresholds to be transcended on a more frequent basis, it is of utmost importance regulatory agencies have an understanding of the behavioral coping strategies of salmonids. A better understanding of behavior will aid in the proper management of recreational fishing practices while maintaining conservation as a top priority.

Session 3 ***2:15 p.m***

Assessing estuarine and coastal migration performance of age-1 hatchery reared Atlantic salmon smolts released into the Dennys River

James Hawkes[1], Timothy Sheehan[2], Paul Music[1], Dan Stich[3] and Ernie Atkinson[4]
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The Dennys River Atlantic salmon stock is at the northern extent of the endangered Gulf of Maine Distinct Population Segment range. Although the stock once supported a prominent US salmon rod fishery, the population has since collapsed, thought to be the result of several factors including dams, pollution, overfishing, and poor marine survival. A broodstock hatchery restoration program (fry and smolt stocking) has been in effect since the early 1990s, but this has produced only low numbers of returning adults; since 2001, annual adult returns have averaged seven fish. To better understand the reason for the poor returns, we used acoustic telemetry from 2001-2005 to assess estuarine and coastal migration and survival of age -1 hatchery smolts (n=70-150). The fish we tracked averaged 183.2 mm (±12.9) fork length and 68.8 g (±15.1) wet weight. Most smolts (70%) made multiple reversals within the estuary and bay during outmigration; at least 30% of smolts made 10 or more reversals. This behavior prolongs estuarine and bay residency times and may be conditioning to the marine environment, but it may also result in migration delays and increased exposure to predators. During each of the five years, we observed significant mortality almost immediately after smolts entered the marine environment. Our estimate of loss from the estuary to early bay ranged from 36 to 83%. These early marine losses are higher than documented in many other systems and not surprisingly those rivers have higher return rates. With few postsmolts making it to the Gulf of Maine and Bay of Fundy, recovery of this stock will be challenging.

Session 3 ***2:30 p.m.***

Estimating Penobscot River fish passage using fixed location SONAR

Patrick J. Erbland [1], Gayle B. Zydlewski[1] and Joseph D. Zydlewski[2] and Joseph E. Hightower[3]
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Dam removals and passage improvements by the Penobscot River Restoration Project will improve connectivity and access for 12 diadromous fish species in New England's second largest river by 2013. As part of a larger assessment of changes in fish community dynamics, we are using fixed location, side-aspect acoustics to estimate the number of fish passing by a designated location near Bangor, Maine, on the Penobscot River. Counts will then be apportioned to the lowest taxonomic level possible. Our methods are derived from similar ongoing research of diadromous fishes in rivers of the northwestern US and Canada and southeastern US; however, strong (3m) tidal flux and tight restrictions on capture sampling pose unique challenges. Since May of 2010 (excluding months of ice cover), two Biosonics DTX, 200 kHz, split beam transducers have been mounted on opposite sides of the river at rkm 35 to sample perpendicular to flow. Complementary sampling with Dual-frequency Identification Sonar (DIDSON) and additional sources of information (e.g., upstream fish ladder counts, concurrent sampling projects) are used to validate split beam data. These data also provide physical and behavioral characteristics for taxonomic discrimination (to varying levels) of individual fish and subsequent apportionment of counts. Initial analyses indicate pulses of upstream moving fish following spring freshets and suggest these movements predominately occur between peak ebb and low tide. Methods will be discussed and fish passage estimates from the 2010 and 2011 field seasons will be presented in the context of documented environmental cues and clues to migration.

Session 4 ***3:45 p.m.***

Monitoring adult Atlantic salmon in the Penobscot River using PIT telemetry

Edward Hughes[1], Joseph D. Zydlewski[1,2], Oliver Cox[3] and **Doug Sigourney [1]**
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In 2010, Passive Integrated Transponder (PIT) telemetry arrays were established in the Penobscot River to monitor Atlantic salmon adult migration. This work continues similar efforts conducted from 2002 to 2004 to assess migratory route, passage success and the seasonal patterns of passage of Atlantic salmon at the Veazie Dam. Together these data will form the baseline for the pre-removal passage status of Atlantic salmon. In these two years, over 3,000 salmon were PIT tagged at Veazie Dam and released either directly into the Veazie Dam forebay or trucked above Milford Dam. Differences in transit times and overall disposition of trucked and run of the river fish were compared. Trucking resulted in an approximately two week faster arrival at upriver sites (Pumpkin Hill, Howland, or West Enfield dams). Overall "success" (defined as passing an upriver dam) was inversely related to fish length at tagging and may reflect differential performance in fishways. Fallback was observed at all main stem dams, with many fish dropping into the estuary. Speed and disposition of adults based on stocking treatments (site and life stage) will be presented.

Session 4 ***4:00 p.m.***

Telemetry based estimates of Atlantic salmon survival in estuaries and bays of Maine

John F. Kocik[1], Graham S. Goulette[1], James P. Hawkes[1] and Timothy F. Sheehan[2]
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We have monitored Atlantic salmon smolt emigration from select Maine rivers using acoustic telemetry and extensive fixed position arrays. Through these studies, we have 1) quantified survival; 2) identified zones of high mortality: and 3) documented individual fates, including confirmation of predator species. We examined the survival of Atlantic salmon in coastal Narraguagus and Dennys rivers populations (< 4,000 smolts) and in the larger Penobscot River population (> 500,000 smolts). We modeled survivorship and detection efficiency probabilities between monitoring sites using the Cormack-Jolly-Seber release-recapture model from detection histories at multiple sites using Program MARK. Although mortality estimates include relatively broad error bounds, the scope of these estimates is informative to investigate early marine survival. We discuss the evolution of our analyses and the utility of focused studies that partition emigration survival by habitat. We found that average survival was highest in the Narraguagus River and lowest in the Dennys River populations with the Penobscot River population intermediate. Our results suggest that losses during the short estuary transit are higher than the monthly average losses at sea. Next steps are to incorporate improved efficiency measurements and stage based models to inform management prioritization.

Session 4 ***4:15 p.m.***

Surface trawl survey for US origin Atlantic salmon (*Salmo salar)* in Penobscot Bay, Maine

Timothy Sheehan, Mark Renkawitz and Russell Brown
NOAA's National Marine Fisheries Service, Woods Hole, MA

Poor marine survival of Atlantic salmon (*Salmo salar)* populations across the North Atlantic is a key factor limiting returning spawning adults. Nearshore mortality is higher than previously assumed and imparts a large influence on overall marine survival. A surface trawl survey conducted during 2001-2005 in Penobscot Bay, Maine, USA, and the nearshore Gulf of Maine waters was conducted to investigate early marine dynamics of a hatchery dependent Atlantic salmon population from a severely modified river system. Data generated were used to evaluate the effect of stocking location and time on migration success, and to describe the early marine migratory pathways and environment that postsmolts traverse. Significant differences in early migration success were detected among different stocking groups, but subsequent marine survival was independent of stocking group. While the post-smolt population was primarily comprised of hatchery origin smolt stocked fish, other life stage stocking strategies (i.e., parr stocking) represented a higher proportion of the population than previously assumed. Catch distribution suggests evidence of an initial marine migratory pathway out of the dynamic Penobscot Bay environment. The hypothesized benefits of a predator refuge based on the co-occurring species complex is considered minimal for emigrating postsmolts given a mismatch in the size overlap among species and low abundance of other co-occurring diadromous populations. These data can be used to modify current management actions to optimize salmon recovery and inform future research agendas.

Session 4 ***4:30 p.m.***

The Penobscot Estuarine Fish Community and Ecosystem Survey

Christine Lipsky[1], Michael O'Malley[2], Justin Stevens[2], Rory Saunders[3] and John Kocik[1]
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It is becoming extremely important for biologists to develop less obtrusive, fishery-independent, and cost effective methods to quantify changes in estuarine fish distributions, particularly where endangered species occur. In Maine, the Penobscot Estuarine Fish Community and Ecosystem Survey is developing methods to describe the spatial and temporal distribution of fish and reduce sampling bias. Our work integrates fish capture techniques with hydroacoustics to develop an index of fish biomass, size distribution and species composition to monitor changes over time. The project began with an initial exploratory and descriptive phase and is evolving into a study where long-term monitoring, hypothesis testing, and impact assessments can be conducted in the future. The Penobscot system also allows us to monitor estuarine responses to a major upstream river restoration project. The feasibility studies that began in 2010 and continued in 2011 include surveys that used capture techniques including beach seining, fyke netting, and trawling, which are being integrated with hydroacoustic methods. Initial survey results found contemporary evidence of natural reproduction of American shad (*Alosa sapidissima*), previously undocumented in the Penobscot River. The temporal distribution of shad juveniles suggests spawning in the Penobscot River may occur over 3-4 months. The presence of juvenile bluefish (*Pomatomus saltatrix*) and rough scad (*Trachurus lathami*), species with a more southerly distribution, was unexpected and will be monitored over time to detect patterns consistent with range shifts. Knowledge gained from this study will improve our ability to manage estuaries in the future and conduct vital research on the habitats and ecosystem services they provide. The design specifics should be transferable to multiple systems to provide a regional perspective.

Session 4 ***4:45 p.m.***

Avian and Marine Mammal Census of the Penobscot River estuary

Paul Music and John Kocik
NOAA's National Marine Fisheries Service, Orono, ME

The Penobscot ecosystem allows a unique opportunity to monitor estuarine responses to major upstream river restoration projects. We developed the Avian and Marine Mammal Census as a part of the Penobscot Estuarine Fish Community and Ecosystem Survey to better describe the upper trophic levels of the estuarine ecosystem and the relationships between avian and mammalian predators and the fish community. We believe the behavior of avian predators can help describe the estuarine fish community as a whole. We enumerated avian and mammalian species utilizing the Penobscot estuary, mapped the location of avian and mammalian species in the estuary over time, and began to correlate avian, mammalian and piscine abundances. We used point counts, line transects and time lapse photography to quantify avian and mammalian use of estuarine habitat, and focused on identifying the species that utilize the estuarine habitats at various times of the year. Our data show that double crested cormorants (*Phalocrocorax auritus*) are present throughout most of the year, but their distribution within the estuary fluctuates as a response to prey availability and their breeding season. The cormorants' use of the estuary was further influenced by presence of suitable roosts and habitat that was advantageous to foraging. Other species, such as ducks are more abundant in the estuary before breeding season in the spring and after fledging in late summer. Generalist species such as American crows (*Corvus brachyrhynchos*) are present throughout the year, but use the estuary almost exclusively at low tide. Seals and porpoises have been sighted in the estuary, but there was little recorded data about marine mammal abundance. Data for our study includes each marine mammal observed during any and all field operations in the estuary. Marine mammals were regularly observed near haul out sites in the lower estuary, and were documented as far upstream as the Veazie dam. We will continue to collect data during the early phases of the Penobscot River Restoration Project (PRRP). Knowledge from this study will improve our ability to manage estuaries in the future, and conduct vital research on the habitats and ecosystem services they provide.

Session 5 ***8:15 a.m.***

Migration and survival in the Atlantic: Are postsmolts running on empty?

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Atlantic salmon spawning returns to rivers continue to decline despite intensive restoration programs. Anadromous species, such as salmon, are important transport vectors of nutrients between marine and freshwater ecosystems. Most management and research efforts have focused on freshwater life stages and conservation of freshwater habitat. Little is known about the marine phase of postsmolts, but recent work suggests a potential bottleneck at this life stage. Dynamic modeling was used to examine growth and survival of postsmolts as they migrate through the Gulf of Maine to the Scotian Shelf. A coupled ocean circulation model and a bioenergetics model were used to explore post-smolt energetic costs during this migration over observed ranges of hydrographic variability. Preliminary results suggest interannual variability in environmental conditions may contribute to survivability and migration success. There is little variation in migration success across natal river populations, despite extreme differences in the amount of time postsmolts spend swimming against strong coastal currents and potential predator and prey communities encountered. Currents and temperature gradients alone do not explain navigational behavior. High adult return rates in regions in the Atlantic in 2011 suggest that large scale oceanographic conditions contribute to survivability of salmon and that coastal predator-prey interactions alone do not account for the high marine mortality. The model serves as a template on which we can layer other hypothesized factors (e.g., shifting predator and prey fields, climate change scenarios) to evaluate their relative importance, singularly or interactively.

Session 5 ***8:30 a.m.***

Trophic ecology of Atlantic salmon in the Northwest Atlantic

Mark Renkawitz[1], Timothy Sheehan[1], David Reddin[2], Gerald Chaput[3] and Rory Saunders[4]
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Atlantic salmon, *Salmo salar* L., are considered opportunistic generalist predators that forage on locally abundant forage species. However, specific dietary requirements at various life stages may be necessary to promote growth and survival. Consequently, changes in ocean productivity that influence prey quality over time, or the spatial and temporal abundance of key forage items may have population level effects on salmon abundance. Stomachs from postsmolts and immature adults have been collected intermittently in coastal North American waters, at feeding grounds in the Labrador Sea, and along the West Greenland coast over the past five decades to gain insight into the feeding ecology of marine phase salmon. In coastal waters, postsmolts consumed Atlantic herring and euphausiids. In the Labrador Sea, postsmolts consumed fish early in the time series and amphipods in recent decades. Consistent with historical record, adults in the Labrador Sea consumed primarily fish. Diets at West Greenland consisted primarily of capelin and amphipods, and despite expected annual variability in prey composition, the findings are generally consistent with historical data. Evidence from the literature suggests the energy content of key prey species may have declined in recent decades. As a result, salmon may require increased consumption to promote the growth necessary to achieve marine survival levels experienced in previous decades. Further examination of prey quality and abundance may provide clues as to whether changes in the forage base have contributed to low marine survival of North American populations.

Session 5 ***8:45 a.m.***

The influence of environmental, oceanographic, and low trophic level conditions on marine survival of Atlantic salmon

Katherine Mills[1], Andrew Pershing[1], David Mountain[2] and Timothy Sheehan[3]
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North American Atlantic salmon populations experienced substantial declines in the early 1990s, and many populations have persisted at low abundances into recent years. The coherence of declines across multiple populations suggests a shift in marine survivorship, rather than the influence of river-specific factors. While the processes controlling marine survival of Atlantic salmon are poorly understood, concurrent shifts in the Northwest Atlantic ecosystem have been documented. We use time series analyses to identify and quantify the influence of oceanographic and environmental conditions on Atlantic salmon during their marine migration, overwintering, and feeding stages. Findings suggest that a series of changes in the Gulf of Maine and North Atlantic ecosystems contributed to reduced marine survival of Atlantic salmon populations across North America.

Session 5 ***9:00 a.m.***

Retrospective analysis of Atlantic salmon marine growth parameters in the northwest Atlantic based on tag-recovery data

Alicia S. Miller, Timothy J. Miller, Timothy F. Sheehan and Mark D. Renkawitz
NOAA's National Marine Fisheries Service, Woods Hole, MA

The life history of North American Atlantic salmon populations (*Salmo salar*) is characterized by extensive round trip migrations between freshwater rearing habitats and marine feeding grounds off the coasts of Canada and Greenland. Low marine survival of postsmolts and immature adults is one factor causing population declines and preventing recovery of the endangered salmon populations in Maine, USA. Growth is rapid during the marine migration and the rate of growth may be an indicator of salmon health during this period of intense growth. The growth data we evaluated were obtained from a tag-recovery program conducted between 1966 and 1991 using hatchery reared Atlantic salmon released as smolts in the Penobscot River. Information from recaptures of approximately 4,000 salmon at large for 1 month to 3 years was analyzed. Length-weight measurements coupled with time-at-large data were used to estimate von Bertalanffy growth parameters specific to the marine phase. We also examined variations in growth over time and in relation to oceanographic conditions in the North Atlantic. Determining the mechanisms that influence growth of individuals during the marine phase will elucidate the factors responsible for the significant declines and help guide future research and management efforts to facilitate recovery of the population.

Session 5 ***9:15 a.m.***

Fishes and tidal power development in Cobscook Bay

Haley Viehman, Gayle Zydlewski, James McCleave and Garrett Staines
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The Ocean Renewable Power Company (ORPC) has applied to install a pilot tidal energy device in Cobscook Bay, Maine in 2012. Little is known about fish presence and distribution in the region or of the effects such a device could have on the local fish community. Baseline studies prior to project deployment have been initiated to analyze the potential risks to fish. Two null hypotheses are being tested: (1) fish presence and distribution is the same before, during, and after device installation; and (2) fish behavior is not influenced by the presence of an instream tidal turbine. Hydroacoustic gears were chosen as the most appropriate tool for data collection as they are less invasive than more traditional fisheries sampling techniques and better suited to the extreme tidal environments targeted for device deployments. Baseline knowledge of fish presence and vertical distribution in the water column over time is necessary to document any changes associated with device deployment. Data have been collected at project and control sites since August of 2009 using a stationary, down-looking, single beam SIMRAD echosounder and a Dual-frequency Identification Sonar (DIDSON) acoustic imaging camera to document the relative density of fish from nearsurface to seafloor. Surveys of 24 hours duration were carried out at a control site and a project site in Cobscook Bay during each season except winter 2010, in order to assess variation in fish density and distribution associated with site, year, season, and diel and tidal cycles. Results from baseline data analyses will be used to predict the likelihood of fish-turbine interaction and create a basis for comparison of data collected after device deployment. In addition, direct observation of fish interacting with a full scale test device was carried out from ORPC's research platform, the Energy Tide 2, in September and October of 2010. A test turbine suspended below the platform was monitored for 24 hours during each month using two DIDSON acoustic cameras, mounted fore and aft of the device. Fish behavioral responses to the turbine were classified as entrance, exit, and active avoidance, and the influence of factors such as fish size, current speed, and time of day on the number and type of interactions was examined. Most of the fish observed were small (<10 cm), and fish numbers peaked at night. A higher proportion of small fish passed into the device than of larger fish, which were observed actively avoiding the turbine. More fish of all sizes entered the turbine at night. Combining the baseline knowledge of where fish are in the water column with knowledge of how they behave in close proximity to an operating tidal device will provide a more complete picture of the potential impacts these devices could have once installed.

Session 5 ***9:30 a.m.***

Fish diversity and spatial distribution in Cobscook Bay: Anticipating broad scale changes

Jeffrey Vieser, Gayle Zydlewski, James McCleave and Garrett Staines
University of Maine, School of Marine Sciences, Orono, ME

Cobscook Bay is located in eastern Maine at the mouth of the Bay of Fundy. The bay is inhabited by many economically valuable species, as well as by the endangered Atlantic salmon, *Salmo salar*. The presence and distribution of Atlantic salmon and other fish species in the bay is generally unknown. Our research, in cooperation with local fishermen, focuses on generating a baseline dataset of fish presence and general distribution throughout the bay. Such datasets are important for understanding broad scale changes in the bay fish community, which may result from anthropogenic changes, e.g., the introduction of marine hydrokinetic (MHK) devices. The impacts of these changes cannot be predicted, and as a result they pose challenging issues for scientists. What are potential impacts of these changes? At what temporal and spatial scale can they be detected? Can they be measured? How will fishermen adapt to them? To answer these questions we are documenting fish presence and spatial distribution through the bay for two years. Before sampling began, we brought this research problem to the local fishermen to gather information on how best to capture the diverse fish species of the bay. Their knowledge, combined with our initial ideas, resulted in an approach that targeted a variety of habitats to document annual and seasonal (spring and fall) presence and distribution of fishes. This includes sampling the five major sub-bays within Cobscook with pelagic and benthic trawls, and sampling the intertidal mudflats, seagrass beds, and rockweed patches in six different coves with seine and fyke nets. These areas are targeted to gather species-specific presence-absence data with respect to various habitats. From these data, we will be able to generate species richness and abundance estimates throughout the bay. Standard protocols will be used for two years to establish baseline data, and the same methods can be employed in future surveys to examine broad scale changes in species abundance and distribution following deployment of MHK devices. One year of data has been collected and to date, 31 different species of fish have been documented. We have observed general trends in habitat preferences among many species, with few species inhabiting both the intertidal zones and deeper regions of the bays. Incorporating a second year of data into this analysis will allow us to examine interannual variation and complete the baseline dataset. All data will be shared with local fishermen throughout the research process, allowing them to make better informed decisions about marine resources in Cobscook Bay in the future.

Session 6 ***10:00 a.m.***

Historical alewife predation by four gadids, Atlantic cod *(Gadus morhua)*, haddock *(Melanogrammus aeglefinus)*, white hake *(Urophycis tenuis)*, and pollock *(Pollachius virens)* in Muscongus Bay and Penobscot Bay

Edward P. Ames[1], Karen Wilson[2] and Theo Willis[2]
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In an effort to evaluate the significance of alewife *(Alosa pseudoharengus*) restoration on coastal fisheries, gadid predation of alewives near Muscongus Bay and Penobscot Bay were mapped and evaluated. Changes associated with the availability of alewives were linked to the distribution and population structure of Atlantic cod *(Gadus morhua),* haddock *(Melanogrammus aeglefinus),* white hake *(Urophycis tenuis)* and pollock *(Pollachius virens)*. Determination of gadid distribution and population structure was derived from empirical data and fishermen's anecdotal information gathered in the 1920s during a period of greater gadid abundance and when coastal habitats were relatively undamaged. During the 1920s, Muscongus Bay had two secondary rivers with documented landings of alewives and local resident gadid groups near the bay's entrance. Predation at the site was evaluated by tracking the seasonal movements of each gadid species toward the rivers hosting alewife populations. Movements toward arriving or departing alewives were assumed to indicate predation. Gadid groups had abandoned their coastal fishing grounds in Penobscot Bay north of Vinalhaven by 1935, but still remained south and out along the coastal shelf, often near Atlantic herring (*Clupea harengus)* spawning areas. However, gadid groups remained near Muscongus Bay and the spawning migrations of alewives. All fishing grounds in outer Penobscot Bay and Muscongus Bay collapsed in the 1980s, though some juvenile cod, pollock and white hake continue to be present. A proposed hypothesis links the formation of coastal resident gadid population units to the abundance of alosids and clupeids, but not to crustaceans, mollusks, or annelids.

Reference:
Ames EP. 2004. Atlantic cod stock structure in the Gulf of Maine. Fisheries 29:10–28.

Session 6 ***10:30 a.m.***

Can mussels reduce the risk of fish farms spreading pathogens?

Michael R. Pietrak[1], Sally D. Molloy[2], Deborah A. Bouchard[3] and Ian R. Bricknell[1]
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The role of fish farms in amplifying and spreading disease to passing wild fish has long been debated. Investigating the interactions between farmed fish, wild fish, and pathogens can be difficult to study. The idea of growing multiple aquatic species on a farm, known as integrated multi-trophic aquaculture (IMTA), has raised questions among farmers about unexpected consequences of growing different classes of organisms in close proximity: in particular, what role filter-feeding bivalves, such as the blue mussel *Mytilus edulis*, might play in limiting or increasing the infectious pressure of pathogens around fish farms. The University of Maine Aquaculture Research Institute has been examining the interactions between mussels and several pathogens. The pathogens include: *Vibrio anguillarum 02β*, a bacterial pathogen; infectious salmon anemia virus (ISAV), an enveloped virus; infectious pancreatic necrosis virus (IPNV), a non-enveloped virus; and *Lepeophtheirus salmonis*, a parasitic copepod. Mussels were exposed to individual pathogens in static systems, and water and mussel digestive gland were sampled over time. When viable pathogens were detected in mussel tissues, shedding trials were conducted to determine if and how the mussels shed viable pathogen back into the water. Further trials using the pathogen, mussels, and fish were conducted to determine if mussels reduce or increase the infectious pressure of the pathogen on fish. Results indicate that the interaction between mussels and pathogens varies with pathogen type. In some cases, such as ISAV and larval sea lice, the co-culture of mussels with fish may reduce the potential infectious pressure, while in other cases, such as IPNV and *Vibrio anguillarum 02β*, the potential for increased infectious pressure exists through transmission in mussel feces and pseudofeces. An examination of the addition of cultured mussels and their effect on the dynamics and ecology of pathogens on an IMTA farm should provide insight into this new farming method and the likelihood of increasing or decreasing the risk of pathogens. It also highlights some key areas where further study may be able to help better understand the interactions between fish farms and wild fish.

Session 6 ***10:45 a.m.***

Freshwater and seawater isoforms of gill Na^+,K^+- ATPase and their use in assessing Atlantic salmon smolt quality, acidification impacts, and strain differences

Stephen D. McCormick, Amy Regish, Michael O'Dea and Arne Christensen
U.S. Geological Survey, Silvio O. Conte Anadromous Fish Research Center, Turners Falls, MA

The sodium pump, Na^+, K^+-ATPase (NKA), in the gills of teleost fish is involved in ion regulation in both freshwater and seawater. Freshwater and seawater isoforms of the catalytic α subunit of NKA have previously been identified in gill chloride cells of Atlantic salmon. We examined the abundance and cellular localization of these isoforms during the parr-smolt transformation, a developmental process which is preparatory for seawater entry. NKA activity increased 2.5-fold during smolt development, and salinity tolerance was higher in smolt than in parr. The abundance of the freshwater isoform (NKAα1a) was lower in smolts than in parr, but remained relatively constant during spring and decreased in summer. The abundance of the seawater isoform (NKAα1b) increased 10-fold in smolts during spring, peaking in early May at the time of downstream migration and increased salinity tolerance. NKAα1b increased a further two-fold after seawater exposure of smolts, whereas NKAα1a decreased by 98%. Laboratory experiments with Atlantic salmon smolts indicate that NKAα1b is more sensitive to acid and aluminum exposure than NKAα1a, which explains the decrease in salinity tolerance and marine survival caused by acidification. Gill NKAα1b was higher in Connecticut River (anadromous) than Sebago (landlocked) strains of Atlantic salmon during smolt development, whereas the NKAα1a did not differ. The strong correlation between NKAα1b and salinity tolerance under a variety of conditions indicates that NKAα1b will be a useful metric for predicting seawater performance of Atlantic salmon smolts.

Session 6 ***11:00 a.m.***

Differential life stage response to common endocrine disruptors in two endangered species, Atlantic salmon and shortnose sturgeon

Tara Duffy and Stephen D. McCormick
U.S. Geological Survey, Silvio O. Conte Anadromous Fish Research Center, Turners Falls, MA

Atlantic salmon and shortnose sturgeon (*Acipenser brevirostrum*) are endangered anadromous fish that spawn in rivers, and offspring develop in their natal stream before migrating out to sea or moving into estuaries. Therefore, these species may be exposed to wastewater effluent during early life history stages, potentially impacting survival and development. Little is known about differential life stage sensitivity to environmental endocrine disrupting compounds (EDCs) in these species, but this knowledge is crucial to conservation and protection under the Endangered Species Act. The purpose of this research was to determine differential life stage sensitivity to three common endocrine disrupting chemicals in Atlantic salmon and shortnose sturgeon. We carried out short-term (four day) exposures using three doses each of nonylphenol (NP), 17β-estradiol (E2) and 17α-ethinylestradiol (EE2) in four life stages; embryos, yolk-sac larvae, feeding fry, and 1+ year old juveniles of both species. Differential sensitivity was compared using a common biomarker of exposure to EDCs, vitellogenin (Vtg, a precursor egg protein). For each species we validated an enzyme immunoassay (EIA) measurement of plasma or whole body Vtg and quantitative real-time PCR measurement of Vtg gene transcription. No dose-dependent mortality occurred in our exposures, indicating that sublethal impacts are necessary endpoints to determine which life stages are most sensitive to common EDCs. The impact of exposure to estrogenic compounds on plasma Vtg and Vtg transcription at four developmental stages of Atlantic salmon and shortnose sturgeon will be presented.

Session 6 ***11:15 a.m.***

Fish scales as nonlethal biosensors of surface water contaminants: Studies with Atlantic salmon

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There is great need for nonlethal, biologically relevant screening tools to assess the effects of surface water contaminants on threatened or endangered fish species, as typical screening procedures, such as liver sampling and skin plugs, are lethal or highly invasive. We hypothesized that fish scales could serve as nonlethal, rapid biosensors of fish response to contaminants. Using immunohistochemistry and real time quantitative polymerase chain reaction (qPCR) we demonstrate that the pollutant biomarker, cytochrome P4501A (CYP1A), is significantly induced in the epithelial covering of the scale of Atlantic salmon parr aqueously exposed to model toxicants (polychlorinated biphenyls and polyhalogenated aromatic hydrocarbons), but is not affected by the pharmaceutical fluoxetine (active ingredient of Prozac™). For detection of estrogen-active compounds, we found that vitellogenin (Vtg), an exquisitely sensitive biomarker for estrogenic contaminants, was significantly induced in liver, but not scales, of fish exposed to the model estrogen ethynylestradiol, a finding which may reflect tissue-specific temporal differences in Vtg induction. Our goal is to establish fish scales as field- and fish-friendly screening tools, capable of detecting a variety of contaminants. Future work will focus on assessing metallothionein as a biomarker for toxic metals in scales, the effects of chemical mixtures commonly found in surface waters on scale biomarker expression levels, and biomarker verification in field trials. Nonlethal biosensors would allow researchers and managers to determine if endangered fish species are being exposed to contaminants and in what part of their geographic range, would allow repetitive analysis of the same individual, and, for diadromous fishes, would indicate when during migration exposure may occur.

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Session 6 ***11:30 a.m.***

Migratory behavior of alewife in the Penobscot River and Penobscot Bay after spawning

Theodore Willis
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Alewife have become a powerful symbol of restoration and fishery excess because they are visible to the casual observer, particularly in their northern range where they migrate up small streams to reach their spawning habitat. However, very little is known about their post-spawning behavior. In 2009, 14 adult alewife were intercepted on their way to spawning habitat in the Penobscot River drainage and implanted with Vemco acoustic tags. Using the UMaine-NOAA acoustic receiver array, movement of these fish was tracked between Great Works Dam and Isleboro over the course of three months. Two tags were lost within seven days of release. The remaining tags were active from 20 to 65 days. Alewife exhibited drop-back behavior after tagging, followed by resumption of spawning migration. Nine of 14 tagged fish demonstrated behavior with a pronounced loitering period north of Verona Island, presumably after spawning. No fish were detected beyond the Isleboro line of receivers.

ABSTRACTS
POSTER PRESENTATIONS

Investigating variability of North Atlantic alewife (*Alosa pseudoharengus*) populations by integrating historic run data with climatic, geographic, and landscape data

Barbara S. Arter[1], Derek Olson[1] and Karen Wilson[2]
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The goal of the Diadromous Species Restoration Research Network (DSRRN) is to advance the science of diadromous fish restoration and promote state-of-the-art scientific approaches to multiple-species restoration at the ecosystem level. This is achieved through local and regional networking, scientific meetings, and workshops designed to facilitate the study of questions fundamental to diadromous fish ecology and restoration. In May 2011 a DSRRN workshop, titled "Variability of North Atlantic Diadromous Fish Populations: Establishing Reference Points for Restoration Assessment," brought together 34 fisheries, habitat, and climate specialists to investigate variability in alewife populations over time and among watersheds. Participants from over 15 different agencies, institutions, and organizations were asked to share alewife data with other workshop participants and to collaborate on analyses and manuscript preparation as products of this workshop. Unlike classic approaches to species assessment which focus on population numbers, this study will focus on *variability* (e.g., relative standard error, CV, quintiles of variability, and/or other measures of variance) of population *characteristics* (e.g., number, size, run timing, age structure, survival) over time and space. We will use variability measures as response variables for blocks of data (e.g., group of years, group of rivers within a year). This will be achieved by integrating spatial climate, landscape, and geographic (GIS) data (e.g., drainage area, order, channel gradient, climate, flow, velocity, geology, elevation, slope, and landcover) with alewife run parameters (e.g., freshwater run size, run timing, harvest, length, age, juvenile index, and sex ratio). We anticipate reporting the results from this study at the final DSRRN Science Meeting in 2013.

Status of baseline science monitoring for the Penobscot River Restoration Project

Charles Baeder
Penobscot River Restoration Trust, Augusta, ME

In June 2009, the National Oceanic and Atmospheric Administration (NOAA) announced it would invest $6.1 million through the American Recovery and Reinvestment Act of 2009 (Recovery Act) to help rebuild the sea-run fisheries of Maine's Penobscot River. A grant to the Penobscot River Restoration Trust will fund removal of the Great Works Dam. It has also funded baseline scientific monitoring to track physical, chemical and biological changes in the river following the removal of Great Works and Veazie dams, and the decommissioning and bypass of the dam at Howland. Understanding the effectiveness of dam removal requires systematic project monitoring and data reporting. Toward that end, a diverse group of government agency staff, academic researchers, and non-profit representatives established the Penobscot River Science Steering Committee (PRSSC) and developed a conceptual framework for monitoring. Concurrently, the Gulf of Maine Council on the Marine Environment (GOMC) sponsored a similar effort to develop regional guidance for stream barrier removal monitoring (Collins et al. 2007). NOAA was represented in both of these efforts, and their priorities for Recovery Act funding were aligned with metrics identified as both "core" to the PRSSC monitoring framework, and "critical" within the GOMC guidance. This includes monitoring of (1) fish community structure and function, passage at barriers, assembly of diadromous species at the seaward-most dam, and import of marine derived nutrients and organic matter, (2) monumented river cross-sections to document vertical and horizontal channel adjustments, (3) sediment grain size distribution at the above cross-sections to document changes in bed material, (4) photos taken quarterly at permanent stations to provide a visual record of riparian vegetation and channel configuration, (5) basic water quality for assessing and understanding changes in fish habitat use, population numbers, and community structure, (6) benthic macroinvertebrate community structure as an indicator of aquatic ecosystem habitat quality, and (7) wetland and riparian plant communities. This baseline monitoring will provide an objective basis for evaluating restoration outcomes. Baseline monitoring field work has largely been completed and final reporting is expected to be completed summer 2012. The first dam removal – Great Works Dam – is scheduled to be completed in fall 2012.

Reference:
Collins M, Lucey K, Lambert B, Kachmar J, Turek J, Hutchins E, Purinton T, Neils D. 2007. Stream barrier removal monitoring guide. Gulf of Maine Council on the Marine Environment. Available from: http://www.gulfofmaine.org/streambarrierremoval

Effects of temperature on growth and stress in brook trout

Joseph G. Chadwick Jr.[1,2] and **Stephen D. McCormick**[1,2]
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Global warming presents many challenges for the conservation and management of wildlife. Yet, the mechanisms by which temperature affects populations are often unknown. Although somatic growth is a key aspect of population persistence, our understanding of the means by which temperature impacts growth and stress physiology is limited. In the present study, brook trout (*Salvelinus fontinalis*) exposed to constant temperatures (16, 18, 20, 22, or 24°C) were monitored for growth, and tissue samples were collected at 8 and 24 days for physiological analysis. Through 24 d, growth rate was highest at 16°C and decreased with temperature to a low at 24°C. Plasma cortisol levels were lowest at 16°C (1.3 $ng \bullet ml^{-1}$) and increased with temperature to a peak of 23.4 $ng \bullet ml^{-1}$ at 24°C. Abundance of the inducible isoform of heat shock protein (Hsp)-70 in gill tissue increased with temperature and was 10-fold and 56-fold higher at 22°C and 24°C than at 16°C. In brook trout exposed to constant 21°C or daily temperature fluctuations of 4 or 8°C (with mean of 21°C), growth rate was highest at constant temperature and decreased with increased magnitude of temperature fluctuation. We did not detect an effect of temperature fluctuation on plasma cortisol levels. Gill Hsp-70 was 40-fold and 700-fold higher at 4 and 8°C fluctuation than at constant temperature. A field study was conducted in summer 2010 and 2011 at 8 sites in western Massachusetts. Both plasma cortisol ($p < 0.001$, $r^2 = 0.23$) and gill Hsp-70 ($p < 0.001$, $r^2 = 0.51$) were found to increase with temperature. These data suggest that sublethal, yet stressfully elevated temperatures limit growth in brook trout and may provide a mechanism by which this species is ecologically limited. Furthermore, plasma cortisol and gill Hsp-70 may serve as valid biomarkers for exposure to stressful temperatures in brook trout and other fish populations in the wild.

This project was supported by the U.S. Geological Survey and a National Science Foundation graduate fellowship to Joseph Chadwick Jr.

Altering vertical placement of hydroacoustic receivers for improved efficiencies

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Marine survival of many stocks of Atlantic salmon (*Salmo salar*) is at historic lows. Acoustic telemetry is being used to study salmon migration ecology and identify problem zones in Maine and southeastern Canada. Improved detection efficiency will increase spatial and temporal resolution of these efforts. While emigrating smolts are considered pelagic, using the top few meters of the water column, literature suggests they briefly sound to 10 m or deeper. Given general surface orientation, we typically deploy receivers at 10m depth when total depth exceeds 25m. In an attempt to improve our monitoring efforts, we tested the location of receiver deployments in Penobscot Estuary and Bay to determine the optimal vertical placement for increased detection efficiency at three sites. We found significant improvements in total detections with experimental depths used during this study (Kruskal-Wallace $p < 0.05$). At two sites, with depths up to 25m, detection efficiency of smolts improved as much as 17% at experimental depths. At the third site, where the water column was greater than 25m, detection efficiencies improved by 9.2% at units placed 20 m deep versus 10m deep. We also discovered while median duration times were greater at experimental depths, the differences were not always significant. Smolt origin had no effect on number of detections per smolt or duration times. Other factors such as tide, diel period and wave action will be discussed. Our results can be used to improve detection probability in coldwater estuary zones between 10 and 100m deep.

Environmental contaminants in fillets of sea-run Atlantic salmon (*Salmo salar*) from the Gulf of Maine DPS

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Between 2008 and 2010, skin-on fillets from seven dead sea-run Atlantic salmon from the Gulf of Maine Distinct Population Segment (GOM DPS) were analyzed for organochlorine compounds, polybrominated diphenyl ether (PBDE), and trace metals. Five fish were collected from the Penobscot River and single fish were recovered from the Narraguagus and Dennys rivers. Dioxin toxic equivalents (TCDD-TEQ) concentrations in fillets ranged from 0.04 pg/g to 0.62 pg/g (mean 0.21 ± 0.23 pg/g; all concentrations expressed as wet weight). Seventeen dioxin and furan congeners were below detection limits in all fish, while several *non-ortho* and *mono-ortho* dioxin-like polychlorinated biphenyl (PCB) congeners were frequently detected. The dominant PCB congener contributor to the TCDD-TEQ varied. The PCB congener pattern in the Dennys and Narraguagus fish was similar and dominated by PCB#118. No consistent PCB congener pattern was evident among the five Penobscot fish. Mean ΣPCB in salmon fillets was 56.8 ± 13.2 ng/g with a range of 41.5 to 77.5 ng/g. ΣPBDE ranged from 0.4 to 4.7 ng/g (1.7 ± 1.4ng/g). BDE#47 was the dominant PBDE congener in all samples. Dichlorodiphenyl-dichloroethylene (DDE) ranged from 3.2 to 10.9 ng/g with a mean of 6.3 ± 2.6 ng/g. Mercury concentrations in GOM DPS salmon fillets were low (0.07 ± 0.04 µg/g, range: < 0.03 – 0.14 µg/g). Compared to other contaminant studies of wild and farmed salmon, PCB levels in GOM DPS salmon appeared higher, while levels of TCDD-TEQ, ΣPBDE, DDE and mercury appeared lower. Contaminant concentrations in returning GOM DPS Atlantic salmon were at levels that would trigger state and federal fish consumption advisories for several organochlorine compounds and trace metals.

Revisiting the marine migration of US Atlantic salmon using historic Carlin tag data

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The discovery of Atlantic salmon (*Salmo salar* L.) in the sea at West Greenland prompted the start of a US tagging program in 1962. Between 1962 and 1996, more than 1.5 million fish from New England rivers, primarily hatchery reared smolts, were tagged and released. Overall, the tag recovery rate was 0.55%: 23.2% from Canada, 26.0% from Greenland, and 50.8% from the US. A general additive model was used to analyze marine survival based on natal river returns of tagged salmon. The value of month and year of release, sea age, smolt age, environmental variables, such as the North Atlantic oscillation (NAO) and Atlantic multidecadal oscillation (AMO) indices, and local surface temperatures were assessed to explain variability in marine survival. The AMO and NAO indices, surface temperature, sea age, and time across years, all affected survival assessed in terms of river returns. These results provide insight into managing on spatial and temporal scales Atlantic salmon stocks in US rivers and the fishery at West Greenland.

Genetic variability of MHC class II in rainbow smelt, *Osmerus mordax*

Janyne Pringle, Catherine Chipman and Gerard P. Zegers
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Rainbow smelt, *Osmerus mordax,* is a species of interest in Maine because of its role as a forage fish, and because of recent population declines throughout its range. As in Atlantic salmon, *Salmo salar*, both landlocked and anadromous populations of *O. mordax* exist in Maine. These contrasting life histories expose rainbow smelt to different parasite and pathogen regimes, which could lead to differential selection of the genes that encode the major histocompatibility complex (MHC). MHC molecules are expressed on the surface of antigen presenting cells as a dimer of an alpha (α) and a beta (β) chain. The MHC of rainbow smelt has yet to be described, but mRNA sequences of two MHC class II α loci are available on Genbank (H2K and H2DP). We designed primers to amplify DNA from both of these loci. Our initial survey of smelt from the Pleasant River, Harrington River, and Narraguagus River indicate genetic monomorphism at H2K and considerable polymorphism at H2DP. We also designed degenerate primers for an H2 β chain locus by aligning Atlantic salmon and northern pike, *Esox lucius*, sequences from Genbank. Using the degenerate primers, we isolated an H2 β mRNA from a rainbow smelt spleen preparation. In contrast to Atlantic salmon, there appears to be little polymorphism at this locus.

Juvenile salmon abundances: Comparing catch per unit effort and depletion sampling among years

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In 2006, the Bureau of Sea Run Fisheries and Habitat (BSRFH) (then the Atlantic Salmon Commission) began using an electrofishing catch per unit effort (CPUE) method to assess juvenile Atlantic salmon relative abundance and spatial distribution. Briefly, a crew of three biologists sample juvenile rearing habitat (e.g., riffle or run) by electrofishing for 300 seconds of wand time in an open site. CPUE is calculated for parr and young-of-the-year (YOY) as the number of salmon captured per minute. Although the primary goal is to provide relative abundance across a wide spatial scale, it is also possible to estimate population densities at sites using CPUE. On the Miramichi, biologists from the Department of Fisheries and Oceans Canada switched all juvenile sampling from closed site, multiple pass population estimates to open site, timed sampling based on a consistent and predictable relationship between relative abundance and density estimates. However, a major concern with this approach is that changes in equipment or crews over the years that would not affect depletion estimates, might affect measures of relative abundance. In 2006, the BSRFH sampled 42 closed sites across six drainages using both multiple pass depletion and CPUE within the same site. In 2010, 27 sites and in 2011, 39 sites were sampled using both methods. Only those sites with CPUE greater than zero were used to develop regressions to predict parr and YOY density from CPUE relative abundance. The age group regressions were comparable among the three years confirming that methods for CPUE were consistent over time and CPUE and predicted densities can be used to document temporal trends. BSRFH intends to use randomly chosen “double method” sites annually to maintain a record of catchability for gear and methods and to calibrate CPUE data among years.

Genetic variation in MHC class II alpha and beta genes in Maine populations of Atlantic salmon, *Salmo salar*

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The major histocompatibility complex (MHC) class II alpha (α) and beta (β) genes present peptides from bacteria and other parasites to the T-cells as part of the adaptive immune response in vertebrates. We are investigating these genes in Maine populations of Atlantic salmon (ATS), *Salmo salar*. Seven alleles at the α gene and 10 alleles at the β gene have been detected in our populations. We are testing for deviations from the Hardy-Weinberg equilibrium in each population, as well as performing some analyses to detect positive or negative selection at sites within each gene. We are also testing for the presence of linkage disequilibrium between the two genes in Maine populations. Stet et al. (2002) demonstrated complete linkage of α and β genes in a population of European aquaculture fish. We want to know whether the same pattern of linkage between α and β genes exists in populations of ATS in the state of Maine. To date, we have found that α and β genes both have alleles that are shared between different populations of ATS in Maine. Selection analyses of the β chain alleles indicate some sites are under positive selection, while others are under negative selection. Interestingly, two of the sites under positive selection in ATS are involved in antigen binding in humans.

Reference:
Stet RJ, de Vries B, Mudde K, Hermsen T, van Heerwaarden J, Shum BP, Grimholt U. 2002. Unique haplotypes of co-segregating major histocompatibility class II A and class II B alleles in Atlantic salmon (*Salmo salar*) give rise to diverse class II genotypes. Immunogen. 54:320-331.

The use of clam shells for water quality enhancement and fishery restoration

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Many years of acid rain and intensive commercial forestry have depleted base cations from the soils of some of Maine's most sensitive watersheds (Miller, 2006). For some of eastern Maine's most sensitive streams, this translates to a major loss of buffering capacity for surface waters. Project SHARE (*Salmon Habitat and River Enhancement*) began using clam shells from Maine's seafood industry as a calcium carbonate source to mitigate stream acidity and restore brook trout and Atlantic salmon. During the 2010 field season, two metric tons of shells were added to Dead Stream – Bowles Lake Stream. In the summer of 2011, we put another two tons into Dead Stream, and for the first time put two tons in the Bowles Lake outlet and six tons in an unnamed tributary to Bowles Lake Stream. Brook trout (our most abundant fish) have increased from 13 in 2009 (baseline study) to 100 in 2011 within a 200 m study reach. The interpretation of this increase in fish abundance is tempered by the fact that culvert upgrades, salmon stocking, and coarse woody debris additions are also taking place in the watershed. Aquatic insect and algal diversity has also increased in the treatment areas and downstream.

Reference:
Miller E. 2006. Assessment of forest sensitivity to nitrogen and sulfur emissions in Maine. Conference of New England Governors and Eastern Canadian Premiers Forest Mapping Group. 20 pp.