Northeast Fisheries Science Center Reference Document 12-12

Programs and Abstracts of the Maine Atlantic Salmon Forums 2002-2012

edited by Sharon A. MacLean

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NOAA National Marine Fisheries Service
Northeast Fisheries Science Center
28 Tarzwell Drive
Narragansett, RI 02882

US DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
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INTRODUCTION

NOAA Fisheries' Northeast Fisheries Science Center (NEFSC) has sponsored an Atlantic salmon research forum biennially since 2002. NEFSC Atlantic Salmon Conservation and Research Task staff coordinate and host this scientific and management forum. The forum brings together state, federal, and university researchers and managers; the Maine aquaculture industry; conservation groups; and other private entities. The common tie between presenters and attendees is a mutual interest in the restoration of Atlantic salmon and their habitat in Maine. Although most of the presentations are technical, the meeting is popular and well attended by people from conservation groups, forestry, transportation, energy organizations, and the general public. In addition, the meeting has consistently drawn participation from Canadian scientists and managers as well as visiting scientists from Europe. The goal of this meeting is to share knowledge, provide status updates on research and management activities, and identify future research needs. The discussions during question periods and interchanges between participants in structured breaks have become a core part of dialogue between scientists, managers, and other consumers of this information.

Initially the forums were named the "Maine Atlantic Salmon Technical Advisory Committee Research Forum," and over the years the name evolved along with the advancements in studies of Atlantic salmon and their habitats into the "Research Forum: Maine Atlantic Salmon and their Ecosystems." As will become apparent as you read, an ecosystem focus on Atlantic salmon in Maine enhances our understanding of multispecies interactions and of riverine, estuarine, and coastal habitats. This broader approach offers new insight into the multiplicity of factors affecting salmon populations at various life stages and the role of several diadromous species in the structure and function of salmon ecosystems from headwaters to the ocean.

This publication is a compilation of abstracts from six forums that occurred biennially during 2002-2012. An agenda is provided for each forum, followed by the abstracts in the order as scheduled in the agenda. Titles are bold-typed, as is the name of the presenting author. Poster session abstracts are presented after the abstracts for oral presentations. A list of the current contact information of the authors and co-authors, as well as could be determined, is provided as an appendix. Addresses are in the USA unless otherwise noted.

The quality of the science presented at these forums reflects the many advances in research and progress made toward understanding the complexities of restoring this highly valued endangered species. Attendees have been from federal and state governmental agencies, universities, non-governmental organizations, aquaculture industry, and interested community members. We extend our greatest appreciation to all the contributors for the excellent abstracts and presentations and to all the audience participants who provided provocative discussion and made these forums even more informative and exciting meetings.

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Research Forum
16 January 2002
Murray Hall
University of Maine, Orono, Maine

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Terry Haines
U.S. Geological Survey, Maine Field Station, University of Maine, Orono

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John F. Kocik and Kenneth F. Beland

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Terry Haines
U.S. Geological Survey, University of Maine, Orono, ME
John Kocik
NOAA, Northeast Fisheries Science Center, Orono, ME
Joan Trial
Maine Atlantic Salmon Commission, Bangor, ME

ABSTRACTS
ORAL PRESENTATIONS

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

Population dynamics of Atlantic salmon in the Narraguagus River

John F. Kocik[1] and Kenneth F. Beland[2]
[1]NOAA, Northeast Fisheries Science Center, Orono, ME; [2]Maine Atlantic Salmon Commission, Bangor, ME

Atlantic salmon populations in Maine have been at low levels of abundance for the last 75 years and have declined further in the past decade. As a result, the Gulf of Maine Distinct Population Segment of Atlantic salmon was listed as endangered in 2000. NOAA Fisheries (NMFS) and the Maine Atlantic Salmon Commission (ASC) have been quantitatively assessing populations in the Narraguagus River since 1991 to determine population trends and the causes of variable abundance. Trap catch of adults and red counts have confirmed that abundance has declined and remains low. To identify causes for this decline, we initiated a program to assess abundance at several life history stages to develop a stage-structured model of the dynamics of this population. We have generated a time series of pre-smolt abundance, smolt abundance, and adult returns. In addition, we age scale samples from each of these stages to facilitate assessment of cohort success. Pre-smolt production has ranged from 9,500 to over 27,000 from 1991-2000 and corresponding emigrating smolt estimates from 1996-2001 ranged from 1,800 to 3,600. Adult returns during this period have ranged from 23-87, indicating that adult Atlantic salmon are not replacing themselves despite supplemental fry stocking. Even in years with relatively large increases in large parr production (126%), smolt production has increased only modestly (3%). Total smolt production in these watersheds has averaged 44/ha (30-60/ha), well below the estimated production capacity of 300/ha. Additionally, marine survival continues to be below 1% and contributes to the declining abundance. We will extend this time series of data to facilitate further analysis to determine the ecological mechanisms responsible for production variability at each stage.

Session 1 ***9:00 a.m.***

Origin and distribution of Atlantic salmon postsmolts in Penobscot Bay, Maine

Russell W. Brown and Craig Tinus
NOAA, Northeast Fisheries Science Center, Woods Hole, MA

The fate of out migrating Atlantic salmon postsmolts is poorly understood because monitoring is extremely difficult once smolts have left the rivers and entered the marine environment. Over a two year period, NOAA Fisheries has developed a coordinated research program focused on hatchery and naturally reared Atlantic salmon smolts in the Penobscot River watershed. This coordinated program involves the marking and release of 170,000 – 180,000 hatchery smolts marked with site and release date specific visual elastomer marks, a rotary screw trap monitoring program at the head of tide, and an estuary and nearshore marine trawling program. In May 2001, NOAA Fisheries initiated a pair trawl sampling program utilizing a modified midwater trawl with an aluminum catch box at the cod end throughout Penobscot Bay and nearshore waters of the Gulf of Maine. A total of 1,458 Atlantic salmon postsmolts were sampled with a short term handling mortality of 7.9%. Of those fish, 608 scale samples were taken and preliminary analysis suggests that a very low proportion of postsmolts were naturally reared. Ninety-nine stomachs were removed and analyzed, and these data suggest that postsmolts shift from feeding on riverine drift to being opportunistic piscivores soon after entering the marine system. Recovery of 355 elastomer marked fish will allow for evaluation of the relative contribution of different hatchery release groups to the post-smolt population. A rough understanding of migration routes was gained from catch data. A follow-up cruise in spring 2002 will expand the spatial and temporal scale of sampling to further explore trends in nearshore marine distribution at this critical life history stage.

Session 1 ***9:20 a.m.***

Phenotypic differences expressed during the marine phase for three remnant populations of Atlantic salmon

Timothy F. Sheehan[1], John F. Kocik[2] and Ernie Atkinson[3]
[1]NOAA, Northeast Fisheries Science Center, Woods Hole, MA; [2]NOAA, Northeast Fisheries Science Center, Orono, Maine; [3]Maine Atlantic Salmon Commission, Jonesboro, ME

During 1998-2000, stock-specific marine growth rates were monitored for three endangered Atlantic salmon (*Salmo salar)* populations from eastern Maine. Atlantic salmon from the Dennys, East Machias, and Machias Rivers were spawned at a federal hatchery and their offspring were reared to the smolt stage at commercial facilities. Approximately 2,000 smolts from each stock were tagged with an elastomer injection, and then transferred to two marine sites (approximately 1,000 per site) for grow-out to the adult stage. At each site, smolts from each stock were placed together into a single sea cage for 29 months and reared under similar environmental and growing conditions. Biological sampling (length and weight measurements) was conducted bimonthly. Standardized photographs were taken from a random sample of individuals from one site at the conclusion of the study, and Truss Analysis (multivariate morphometrics) was conducted on these photographs. Significant differences in growth rates were detected at each site. Significant differences in body morphometrics were also detected among the three stocks, indicating a genetic basis for these phenotypic differences. Several hypotheses are offered as to the ecological meaning of these differences.

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

Population structure of Maine Atlantic salmon and other Atlantic salmon in Maine

Tim L. King[1] and Adrian P. Spidle[2]
[1]U.S. Geological Survey, Leetown Science Center, Kearneysville, WV; [2]Johnson Controls, Cape Canaveral, FL

Salmon in the drainages of Maine's Kennebec and Penobscot rivers were found to be genetically similar to those sampled from the eight rivers recently listed as an endangered Distinct Population Segment (DPS) under the United States Endangered Species Act. Genetic distance estimates confirm that Maine's Atlantic salmon, both landlocked and anadromous, represent a discrete population unit, with a gene pool as discrete from any Canadian population as each Canadian population is from any other Canadian population, or any North American population from any European population. Within Maine, the anadromous and landlocked populations of Atlantic salmon were statistically distinct from each other. Extensive analysis of neutral genetic variation in Atlantic salmon also provides clear discrimination between Atlantic salmon of European vs. North American origin. An 11-locus suite of microsatellite markers is being used to determine the continent of origin of fish caught in the mixed-stock fishery off the coast of Greenland, and to detect aquaculture escapees in broodstock of Maine origin. Aquaculture escapees can thus be culled from river-specific broodstocks maintained for federally endangered Maine Atlantic salmon. An additional 18 polymorphic loci have been developed, for application to broodstock management both in Maine and in the Connecticut River, and for fine scale resolution of individual reproductive success within and between redds in Maine's rivers.

Session 2 ***10:30 a.m.***

Acid rain: Still a problem for Maine's Atlantic salmon?

John A. Magee
Gomez and Sullivan Engineers, P.C., Weare, NH

Acidic precipitation has been responsible for the decline and extirpation of many Atlantic salmon populations, with well-documented cases in Nova Scotia and Norway. Although emissions of nitrogen oxides and especially sulphur oxides have been reduced in recent years, decades of acid rain have led to lower buffering capacity of soils and associated rivers. This may make surface water more susceptible to short pulses of low pH. The biological effects of acid rain are well documented, and recent data suggest that short pulses of acidity can cause delayed mortality and slow growth in Atlantic salmon smolts. The extent to which acid rain may have impacted Atlantic salmon in Maine is not known, but a wealth of biological and chemical data has been generated on the Atlantic salmon populations and rivers in Downeast Maine. I will discuss the effects of acid rain on surface waters and Atlantic salmon, and synthesize these into the framework of Atlantic salmon restoration in Maine.

Session 2 ***10:50 a.m.***

Field evaluation of calcein marks on Atlantic salmon fry stocked into the West Branch Sheepscot River, Maine

Jerre Mohler[1], Michael Millard[1] and David Perkins[2]
[1]U.S. Fish and Wildlife Service, Northeast Fishery Center, Lamar, PA; [2]U.S. Fish and Wildlife Service, Region 5 Office, Hadley, MA

The first field test of a new technique for mass-marking early life stage fish was initiated in April 2001 at Craig Brook National Fish Hatchery, Maine, where seven incubation trays containing a total of about 30,000 Atlantic salmon fry of Sheepscot River lineage were immersed into a solution of the fluorochrome dye known as calcein. In early May, equal numbers of marked and unmarked fry were stocked into the West Branch Sheepscot River at nine locations. Subsequent field recovery of marked and unmarked young-of-year salmon was undertaken using electrofishing techniques at fry release sites. Captured young-of-year were anesthetized, measured, and classified as marked or unmarked using battery-powered field detection wands. Additionally, an anal fin tissue sample was taken from all unmarked fish for subsequent genetic analysis to determine if unmarked fish were of hatchery origin. A total of 111 calcein-marked and 155 unmarked fry (42% marked vs. 58% unmarked) were recovered with a total of 558 minutes of electrofishing effort. Of the 13 stations sampled, seven had sufficient data for analysis with five of those seven stations showing marked and unmarked fish captured at the expected 1:1 ration. Replicated goodness-of-fit tests (G-statistic) applied to overall capture data showed that unmarked fry were recovered at a higher proportion than marked fry ($P<0.05$) (pending genetic analysis). Some calcein marks were weak and several marked fish could have been misclassified in the field. Field detection equipment performed well and resulted in instantaneous mark classification most of the time. The calcein mark technique has potential as a relatively inexpensive and practical way to perform hatchery product evaluations where a batch mark is adequate. Refinement of the batch-marking technique is needed to produce consistently visible calcein marks in nonfeeding Atlantic salmon fry.

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

Physiological changes in wild and hatchery Atlantic salmon smolts in Maine: Implications for marine survival

Stephen D. McCormick[1], Russell W. Brown[2], John F. Kocik[3], John A. Magee[4] and Craig Tinus[2]
[1]U.S. Geological Survey, Silvio O. Conte Anadromous Fish Research Center, Turners Falls, MA; [2]NOAA, Northeast Fisheries Science Center, Woods Hole, MA; [3]NOAA, Northeast Fisheries Science Center, Orono, ME; [4]Gomez and Sullivan Engineers, P.C., Weare, NH

Downstream migration and early seawater entry of smolts has been identified as a critical period for determining adult return rates in Atlantic salmon. Normal smolt development includes large increases in salinity tolerance and gill Na^+, K^+-ATPase activity. The capacity to develop salinity tolerance and other aspects of smolt physiology has been shown to be very sensitive to several classes of contaminants, including acid deposition, heavy metals and endocrine disrupting compounds. From 1998 to 2001, nonlethal gill biopsies have been taken from wild migrating smolts on the Narraguagus River, with additional sampling of other Downeast rivers in 1999 and 2001. Peak levels of gill Na^+, K^+-ATPase activity did not increase above 7 µmoles adenosine diphosphate (ADP) mg protein $^{-1}$ h^{-1}, substantially lower than values seen in southern New England, and moderately lower than the limited numbers of rivers sampled in New Brunswick and Newfoundland. Fish of Penobscot and Dennys rivers origin reared at Green Lake National Fish Hatchery were sampled from February until release in May. Gill Na^+, K^+-ATPase activity increased two-fold during hatchery rearing, and reached peak values of five to seven µmoles ADP mg protein^{-1}h^{-1} at the time of late release (May 9-13). Additional data on changes in circulating levels of hormones involved in smolt development, and gill Na^+,K^+-ATPase activity of fish captured in ocean trawls will also be presented. The results indicate that either Maine fish have inherently low gill Na^+,K^+-ATPase activity compared to other river systems, or that the development of fish in both the hatchery and the wild has been compromised by one or more environmental factors. Further work is needed to determine whether the observed low levels of gill Na^+,K^+-ATPase are related to short term performance (early survival and growth in seawater) and long term performance (adult returns) of hatchery and wild Atlantic salmon smolts.

Session 2 ***11:30 a.m.***

Salar MAP: Opportunities for Canada – USA Cooperation

Gilles L. Lacroix
Department of Fisheries and Oceans, St. Andrews, NB, Canada

Salmon stocks from inner Bay of Fundy rivers have crashed in the past decade and they were declared “endangered” under the new Canadian Species at Risk Act in 2001. Abnormally low survival of salmon during the oceanic phase has been targeted for the decline. In response, Salar MAP, the Atlantic salmon acoustic-tracking project, launched a major marine research effort in the Bay of Fundy in 2001. This project demonstrated the feasibility to track salmon postsmolts through coastal areas and developed the capability to capture live postsmolts during their marine migration. A large-scale acoustic telemetry project was conducted to track and compare the migration and distribution of tagged postsmolts from inner and outer Bay of Fundy rivers as they moved through the Bay of Fundy and into the Gulf of Maine. The aim was to find where they go after leaving the rivers and determine areas of potential loss. Simultaneously, a research cruise aboard the Canada Coast Guard fishing trawler, Alfred Needler, used new methods to capture live postsmolts on their way through and out of the Bay of Fundy. These were examined to determine origin and assess health and condition before release. Salar MAP is spearheaded by the Department of Fisheries and Oceans and the Atlantic Salmon Federation, and it involves the participation of many supporting partners. The goal is to ultimately determine the location and timing of salmon disappearance at sea for the endangered stocks and to try and uncover the causes. The focus of Salar MAP activities in the Bay of Fundy, and the expansion of the proposed project to the Gulf of Maine, present opportunities for Canada – USA cooperation.

Session 3 ***1:00 p.m.***

Baseflow and stormwater chemistry of the Maine salmon rivers during the 2001 field season

Mark Whiting
Maine Department of Environmental Protection, Bangor, ME

Overall, the baseflow water chemistry of the Maine salmon rivers is fairly good, having moderate pH (pH 6-7) and positive alkalinity (ANC 37-1300 μeq/L). During the 2001 field season, water quality monitoring was extended to storm runoff events. Even though 2001 was a historic drought year, strong runoff events were observed in the spring and fall. In the Sheepscot River, many summer baseflow sample sites are very warm (above the 22.5 C^o thermal stress threshold at which Atlantic salmon begin to lose weight and body condition). Many of these very warm sites also have high bacterial counts. The *E coli* counts throughout much of the central part of the river exceed the EPA recommended threshold for swimming and other water contact sports (126 colonies/100 ml). The bacteria evidently are primarily from dairy farms. Stormwater samples from this spring show that the Sheepscot has moderate turbidity (2.4-4.9 NTU) and suspended solids (10-47 mg/L). Cove Brook has the highest pH and alkalinity of the official salmon rivers (pH range 7.2-8.2 and ANC range 712-2350 μeq/L). These high values are unusual for Maine and suggest that there is a significant source of carbonates in this watershed. Only about 0.05% of Maine's surface waters have a pH greater than eight [Maine Volunteer Lake Monitoring Program website, Water Resources Institute (now the George J. Mitchell Center)]. During strong storms or snowmelt events, Cove Brook experiences high turbidity (range 1-40 NTU) and high suspended solids (2.9-100 mg/L). The high turbidity is apparently caused by some river bank failures. The Downeast rivers have the best overall water quality. Although these rivers have the lowest pH and ANC, the main stems of the rivers have not been observed to experience low pH (pH less than 5.5) and high exchangeable aluminum events. High *E coli* counts appear to be limited to the lower, mostly in-town, sections of the rivers. The herbicide Velpar (hexazinone), used extensively on blueberry farms in these watersheds, occurs in trace amounts (1-3 ppb) in the Narraguagus River, Pleasant River, and Mopang Stream. We plan to continue to monitor both baseflow and stormwater events in the salmon rivers, and to focus more effort on the water quality of tributaries and expand our bacterial monitoring.

Session 3 ***1:20 p.m.***

Screening for salmonid pathogens in wild marine fishes

Sharon A. MacLean
NOAA, Northeast Fisheries Science Center, Narragansett, RI

In an effort to identify potential carriers of salmonid pathogens, various species of wild marine fishes were collected and assayed for several salmonid viruses and *Renibacterium salmoninarum,* the agent of bacterial kidney disease (BKD). Fish tested were taken from the vicinity of salmon culture net pen sites, as well as from locations hundreds of miles away from salmon culture activities. Over 1,400 fish, including alewife, American eel, herring, mackerel, pollock, and winter flounder, have been assayed by cell culture for viruses, direct fluorescent antibody test for BKD, and/or RT-PCR and indirect fluorescent antibody test for infectious salmon anemia virus. BKD was not detected in any of the fish sampled. Viruses were not isolated in cell culture nor detected by IFAT from any fish sampled. RT-PCR positive results were obtained from two pollock taken from an ISA-diseased salmon net pen, whereas pollock collected outside a diseased pen were not positive by RT-PCR. Because the corresponding cell cultures were negative, the significance of the RT-PCR positive results is unclear. The most immediate use of this information is in industry attention to biosecurity practices concerning nonsalmonids retained in and harvested from salmon net pens.

Session 3 ***1:40 p.m.***

Occurrence of smallmouth bass (*Micropterus dolomieu*) in the Pleasant River watershed

Matthew Scott
Project SHARE (Salmon Habitat and River Enhancement), Belgrade, ME

Smallmouth bass is an exotic species to Maine and was introduced shortly after the Civil War. Since that time, the species has become one of the most popular and valuable warmwater sport fisheries in Maine. However, the intentional introduction of exotics is biological pollution of the worst kind. Understanding the implications of such illegal introductions is never fully understood by the perpetrators. Smallmouth bass were not found in the Pleasant River watershed based on fishery and angler surveys dating back to the 1950s, although drainage basins to the east and west have had smallmouth bass for many decades. During the mid-1970s, an illegal introduction of smallmouth bass was made into Pleasant River Lake, the largest headwater lake in the drainage. Based on Atlantic Salmon Commission data for 1995, this species has spread down the Pleasant River to Columbia Falls. This predator now directly feeds upon and competes with young Atlantic salmon life stages. The first fishery survey of Pleasant River Lake, Southwest Pond and other waters did not report collecting smallmouth bass. The water quality of the lake is marginal for coldwater species, but a large and healthy smelt population exists there. Extensive water quality data from the early 1970s conclude that the lake has very low productivity and there is a very small basin of cold water for salmonids. These studies collected chlorophyll *a,* total phosphorus, secci disk, total alkalinity and dissolved oxygen data. With this recent introduction, the recovery of wild Atlantic salmon for the Pleasant River is even more questionable and puts the recovery program into greater jeopardy with this predator expanding its range into the critical habitat of Atlantic salmon.

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

An investigation of drift of Atlantic salmon fry, *Salmo salar*, immediately after stocking

Ernie Atkinson[1], **Greg Mackey**[1], Gregg Horton[2] and Wayne Simmons[3]
[1]Maine Atlantic Salmon Commission, Jonesboro, ME; [2]U.S. Geological Survey, Silvio O. Conte Anadromous Fish Research Center, Turners Falls, MA; [3]Lunaform, Franklin, ME

Atlantic salmon restoration efforts in Maine employ fry stocking as one of the primary population enhancement strategies. However, the initial fate of stocked fry is unknown. Fry quickly disappear upon release, but the distance they drift is unknown. The behavior of fry after stocking could affect their survival and the quality of habitat they ultimately inhabit. We released 10,000 unfed fry in late morning into the Dennys River, Maine, May 1999. We trapped these fry using fry drift traps at three downstream transects spaced at 50-meter intervals from May 19 to June 14. Eighty-one percent of fry remained in the first 50 meters of release, with the remainder distributed throughout the next 100 meters and beyond. No fry were captured during daylight, with 75% caught after nightfall. Fry movement stopped after seven days. Taken together these data suggest that fry are not swept along with the current when stocked, but find refuge and then move volitionally during low light periods. Management implications of this study are to stock fry at rates that prevent over-saturation, but take advantage of fry drift to distribute fry effectively. Further study should focus on effects of current velocity on drift, and difference between fry emerging from gravel and stocked fry.

Session 4 **3:00 p.m.**

A measure of substrate embeddedness and its relationship to juvenile Atlantic salmon (*Salmo salar*) densities in the Narraguagus River

Ernie Atkinson[1], Joan Trial[2], Melissa Evers[3], Greg Mackey[1] and Kenneth Beland[2]
[1]Maine Atlantic Salmon Commission, Jonesboro, ME; [2]Maine Atlantic Salmon Commission, Bangor ME; [3]Maine Department of Environmental Protection, Augusta, ME

We estimated cobble embeddedness to evaluate the habitat quality for juvenile salmonids. Atlantic salmon (*Salmo salar)* parr use interstitial spaces for shelter from fast moving currents and to find thermal refuge, particularly during winter months. During the summer of 1993, we estimated cobble embeddedness and the interstitial space index (ISI) at 28 sites along the Narraguagus River and its tributaries. We found no significant difference between cobble embeddedness and ISI between riffles (means 22% and $3.10 m/m^2$) and runs (means 27% and $1.97 m/m^2$). Both ISI and embeddedness were correlated to substrate size.

Session 4 ***3:20 p.m.***

The use of hormone implants to synchronize, advance, and improve the maturation of sea-run and kelt salmon broodstock

Joseph Ravita[1] and **Stephen Gephard**[2]
[1]Connecticut Department of Environmental Protection, Riverton, CT; [2]Connecticut Department of Environmental Protection, Old Lyme, CT

Captive Atlantic salmon broodstock often "ripen" at different rates, resulting in a prolonged spawning season. Nonrandom, genetically based mating schemes can be thwarted by nonsynchronous ripening of spawners. The aquaculture industry has used commercially available hormones to synchronize ripening of Atlantic salmon broodstock, but government-based restoration programs in the US have not. In October 2001, the Connecticut River Atlantic Salmon Restoration Program implanted 150 μg of salmon gonadotropin-releasing hormone (SGnRH) into 20 female and nine male sea-run salmon at the Whittemore Salmon Station (Barkhamsted, CT) and the Richard Cronin National Salmon Station (Sunderland, MA) in order to synchronize their ripening. Also implanted were 36 female and 7 male reconditioned kelt salmon broodstock at the Whittemore Salmon Station and the North Attleboro National Fish Hatchery (North Attleboro, MA). This was done to accelerate their spawning and to study the impacts on the quality and production of milt by male kelts. This paper reports the costs and methodology of implantation, the impact on the timing of ripening of spawners, and the impact on the quality of the gametes.

Session 4 ***3:40 p.m.***

Geomorphology and trends in hydrologic conditions of coastal Maine rivers

Robert W. Dudley[1]**,** Joan Trial[2] and Jed Wright[3]
[1]U.S. Geological Survey, Augusta, ME; [2]Maine Atlantic Salmon Commission, Bangor ME;
[3]U.S. Fish and Wildlife Service, Falmouth, ME

The Maine Atlantic Salmon Commission (ASC), U.S. Geological Survey (USGS), and U.S. Fish and Wildlife Service are collaborating on a study of geomorphology of unregulated salmon streams in Maine in an effort to assemble a knowledge base with which to assess degraded river reaches and design restoration projects. The average characteristics describing the geometry of a river channel within a hydrologically homogenous region are sufficiently consistent that the degree of deviation from normal stream geometry can be interpreted as the magnitude of the effect of disturbance. For this reason, regional models or curves that relate normal stream channel geometry to drainage area size and reference discharge can be valuable tools used in quantifying disturbance at river reaches and designing projects to restore them. Preliminary curves for Maine based on the 1.5-year recurrence interval flow compare similarly to regional curves based on bankfull flows for Vermont. The Maine ASC is also working with the USGS in examining trends in hydrologic conditions for coastal Maine's rivers to aid in evaluation of climatological impacts on salmon. The trend analyses include looking at changes in monthly and annual flows, the timing of seasonal flows, and changes in snowpack and duration of river ice in the coastal river basins over time. Preliminary findings indicate a statistically significant trend in the timing of spring runoff for earlier dates over the past 86 years. Both the geomorphology and hydrologic trend studies are currently ongoing.

Second Maine Atlantic Salmon Technical Advisory Committee
Research Forum
7 January 2004
D.P. Corbett Business Building
University of Maine, Orono

Program

8:00 a.m. *Registration, coffee*

8:30 a.m. **Welcome, announcements**
Michael Kinnison
University of Maine, Department of Biological Sciences, Orono, ME
Sharon A. MacLean
NOAA, Northeast Fisheries Science Center, Narragansett, RI

Session 1

Sharon MacLean, Moderator
NOAA, Northeast Fisheries Science Center
Narragansett, RI

8:40 a.m. **Update on coastal Maine river Atlantic salmon smolt studies: 2003**
James Hawkes, John Kocik and Gregory Mackey

9:00 a.m. **Changes in the proportion of naturally reared Atlantic salmon smolts to hatchery smolts emigrating from the Penobscot River, ME, during 2000-2003**
Christine Lipsky, James Loftin, Ed Hastings and Russell Brown

9:20 a.m. **Penobscot River adult Atlantic salmon migration study**
Kenneth Beland and Dimitry Gorsky

9:40 a.m. **Estimation of gamete viability, timing of sexual maturity, and fecundity of river-specific marine net pen reared Atlantic salmon in Maine**
Gregory Mackey, Michael Loughlin, Nick Brown and Ernie Atkinson

10:00 a.m. **Streamside incubation: a low tech, low cost approach to Atlantic salmon restoration**
Paul Christman, Kevin Dunham and Daniel McCaw

10:20 a.m. *Break*

Session 2
Michael Kinnison, Moderator
University of Maine
Department of Biological Sciences
Orono, ME

10:40 a.m.	**Consequences of movement on Atlantic salmon (*Salmo salar*) survival estimates** **Gregg E. Horton** and Benjamin H. Letcher
11:00 a.m.	**Evolution of population structure in Maine's Atlantic salmon** **Adrian P. Spidle** and Timothy L. King
11:20 a.m.	**Scale pattern analysis discriminates Atlantic salmon by river-reach rearing origin** **Ruth Haas-Castro**, Timothy Sheehan, Steve Cadrin and Joan Trial
11:40 a.m.	**Evaluation of adult Atlantic salmon scales to determine the origin of Atlantic salmon recovered in Maine** **Michael Pietrak**, Christopher Legault and Kenneth Beland
12:00 p.m.	*Lunch*

Session 3
Michael Kinnison, Moderator
University of Maine
Department of Biological Sciences
Orono, ME

12:50 p.m.	**Reduced genetic diversity and effective population size in an endangered Atlantic salmon population: Connecting past to present** **Christopher Lage** and Ira Kornfield
1:10 p.m.	**Loss of molecular and trait variation in six populations of endangered Maine salmon** **Nathan Wilke**, Michael Kinnison and Timothy King
1:30 p.m.	**Genetic parentage analysis of Sheepscot River Atlantic salmon: survival and distribution of stocked individuals** **Meredith Bartron**, Jerre Mohler and Timothy King
1:50 p.m.	**Nonlethal measurement of recent growth in Atlantic salmon smolts using RNA-DNA ratios** **Sharon A. MacLean** and Jeanne St. Onge-Burns

2:10 p.m. **Comparison of lethal versus nonlethal sample sources for the detection of infectious salmon anemia virus (ISAV)**
Cem Giray, H. Michael Opitz, Sharon A. MacLean and Deborah Bouchard

2:30 p.m. *Break*

Session 4
Sharon MacLean, Moderator
NOAA, Northeast Fisheries Science Center
Narragansett, RI

2:45 p.m. **Latent infectious salmon anemia virus infection in experimentally infected Atlantic salmon in saltwater and freshwater**
H. Michael Opitz, Sharon A. MacLean, Cem Giray, Deborah Bouchard, Sharon Clouthier, Wei Young-Lai, Dawna Beane and Sharon Blake

3:05 p.m. **Environmental persistence of infectious salmon anemia virus**
Cem Giray, Deborah A. Bouchard, Keith A. Brockway and Peter L. Merrill

3:25 p.m. **Evidence of episodic acidification in the Downeast Maine salmon rivers during the spring and fall of 2003**
Mark C. Whiting, Tracey Gamache and William Otto

3:45 p.m. **Evaluation of water alkalinity enhancement at the Craig Brook National Fish Hatchery on Atlantic salmon growth and survival**
Terry Haines, Benjamin Spaulding, Kenneth Beland and Barnaby Watten

4:05 p.m. **Ecology of the Atlantic salmon during the transition from maternal dependence to independent feeding: Research and management implications**
Keith H. Nislow, Benjamin H. Letcher, Sigurd Einum and John D. Armstrong

4:25 p.m. **Endocrine disruption in Atlantic salmon (*Salmo salar*) exposed to pesticides**
Benjamin Spaulding, Terry Haines, Rebecca Holberton and Rebecca Van Beneden

4:45 p.m. **Closing**
John Kocik
NOAA, Northeast Fisheries Science Center, Orono, ME

ABSTRACTS
ORAL PRESENTATIONS

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

Update on coastal Maine river Atlantic salmon smolt studies: 2003

James P. Hawkes[1], John F. Kocik[1] and Gregory Mackey[2]
[1]NOAA, Northeast Fisheries Science Center, Orono, ME, [2]Maine Atlantic Salmon Commission, Jonesboro, ME

The goal of our research is to quantify and compare Atlantic salmon smolt production across several of Maine's rivers. These comparisons are undertaken to (1) develop a better understanding of overwinter parr to smolt survival, population dynamics, and outmigration timing; and (2) strengthen stock assessments and population viability analyses. Atlantic salmon populations in Maine's rivers are critically low and recent survival estimates from juvenile to adult stages are well below replacement levels. Beginning with the deployment of a single rotary screw trap on the Narraguagus River in 1996, NOAA Fisheries and the Atlantic Salmon Commission have been investigating production, survival and migration of Atlantic salmon smolts in rivers of coastal Maine. Today, the salmon smolt research program operates 11 rotary screw traps on five rivers: four traps deployed in the Narraguagus, three traps in the Penobscot, one trap each on the Sheepscot, Pleasant and Dennys Rivers. These platforms support the field operations for the smolt production research, as well for mass marking and ultrasonic telemetry studies aimed at elucidating hatchery smolt movement patterns and survival rates. Findings of each of these field programs are summarized and briefly discussed.

Session 1 ***9:00 a.m.***

Changes in the proportion of naturally reared Atlantic salmon smolts to hatchery smolts emigrating from the Penobscot River, ME, during 2000-2003

Christine Lipsky[1], James Loftin[1], Edward Hastings[1] and Russell Brown[2]
[1]NOAA, Northeast Fisheries Science Center, Orono, ME, [2]NOAA, Northeast Fisheries Science Center, Woods Hole, MA

Beginning in 2000, NOAA Fisheries has operated rotary screw traps in the lower Penobscot River to capture/recapture emigrating Atlantic salmon (*Salmo salar*) smolts. One objective of this program is to determine the relative proportion of stocked smolts to naturally reared smolts, and to assess the annual variability in this ratio. During 2000-2003, smolts were captured in the rotary traps between April and June. Fin scores were assigned to each fish based on the degree of erosion, with a fin score of 0 indicating no erosion, and a score of 3 indicating almost complete erosion of the fins, commonly seen in hatchery reared fish. Fish with a fin score of 0 or 1 that had no tags or marks were sampled for scales, which were subsequently analyzed to determine age and life history. The proportion of stocked smolts to naturally reared smolts has remained relatively stable over the past four years. The 2003 smolt season produced a slightly higher percentage of naturally reared smolts than in previous years.

Session 1 ***9:20 a.m.***

Penobscot River adult Atlantic salmon migration study

Kenneth Beland[1] and Dimitry Gorsky[2]
[1]Maine Atlantic Salmon Commission, Bangor ME, [2]University of Maine, Orono, ME

The year 2002 marked the beginning of a cooperative research project between the Maine Atlantic Salmon Commission, U.S. Geological Survey (at Conte Anadromous Fish Research Center), University of Maine, U.S. Fish and Wildlife Service, National Marine Fisheries Service, and the Penobscot Indian Nation. This project investigates the temporal and spatial movements of Atlantic salmon during their upstream migration in the Penobscot River basin using PIT (Passive Integrated Transponder) tags. Antenna arrays and data loggers were installed at the entrance and exit of fishways at five Penobscot main stem dams (Veazie, Great Works, Milford, West Enfield, and Mattaceunk) and three Piscataquis drainage dams (Howland, Dover-Foxcroft, and Browns Mills). PIT tags were inserted into the dorsal musculature of approximately 400 salmon each year upon release to the river following capture at the Veazie Dam fishway trap. Remote fishway PIT tag antenna data loggers were downloaded weekly and data imported into a Microsoft Access relational database. These data allow assessment of salmon movements relative to date of capture, photoperiod, river flows, and temperature and of the final detection locations of salmon released as tagged smolts in the Penobscot basin.

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

Estimation of gamete viability, timing of sexual maturity, and fecundity of river-specific marine net pen reared Atlantic salmon in Maine

Gregory Mackey[1], Michael Loughlin[1], Nicholas Brown[2] and Ernie Atkinson[1]
[1]Maine Atlantic Salmon Commission, Jonesboro, ME, [2]University of Maine, Franklin, ME

As a means to supplement populations in several Downeast salmon rivers, NOAA's National Marine Fisheries Service, Maine Atlantic Salmon Commission, and U.S. Fish and Wildlife Service stocked river-specific Atlantic salmon adults in 2000 and 2001 that were reared in marine net pens by the aquaculture industry. Attempts to evaluate the reproductive success of these adults suggest that these fish achieved relatively low reproductive success. However, the methods used to evaluate this were either indirect or provided results with relatively low interpretive power. To test the hypothesis that poor gamete quality may be limiting reproduction by these fish, 26 pen reared adults were moved to the Center for Cooperative Aquaculture Research, Franklin, Maine, in October 2001, spawned as they matured, and the eggs were incubated in standard Heath tray stacks. These fish were of the same cohort that was stocked into the rivers and were moved to freshwater at the same time as river stocking. The fish matured slowly and many had not matured by December 12 when spawning efforts ceased. Of those that did mature, eight females and two males were spawned. Fertilization was greater than 95% in all spawnings, with the exception of one female that achieved 85% fertilization with both males. Survival to the eyed-egg stage was 83.8%. These results suggest that gametes are not the limiting factor in reproduction by these fish. However, the low rate of sexual maturation could explain poor reproductive performance if this occurred in the rivers.

Session 1 **10:00 a.m.**

Streamside incubation: A low tech, low cost approach to Atlantic salmon restoration

Paul Christman, Kevin Dunham and Daniel McCaw
Maine Atlantic Salmon Commission, Sidney, ME

During the winter of 2002 – 2003, staff from the Sidney office of the Maine Atlantic Salmon Commission tested the feasibility of streamside incubation as a method for volunteer groups to participate in Atlantic salmon restoration. Two types of flow-through incubators were constructed from discarded refrigerators. Three incubators were designed to hold egg filled Whitlock-Vibert boxes placed within an artificial channel and three were designed to hold eggs between layers of poultry nesting material. Prior to receiving eggs, incubators were deployed at three sites on two tributaries to the Sandy River. In February of 2003, a total of 43,496 eyed Atlantic salmon eggs at approximately 38% development were divided equally into each of the six incubators. At approximately 95% development, fry were removed from the incubators and enumerated to obtain hatching success. Success ranged from 85% to 98% with an average of 90% for all six incubators. Total operational cost for the project was $2,351. Operational costs for a second year are estimated at approximately 30% of the initial investment. Total time spent on this project, not including traveling time, amounted to 1,355 hours. Total time for a second project year is also estimated at approximately 30% of the time spent during the initial year. High hatching success, time expended, and low cost makes this streamside incubator system a feasible approach for volunteers. Additional studies to test capacity and improve incubator efficiency are recommended.

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

Consequences of movement on Atlantic salmon (*Salmo salar*) survival estimates

Gregg E. Horton and Benjamin H. Letcher
U.S. Geological Survey, Silvio O. Conte Anadromous Fish Research Center, Turners Falls, MA

An implicit assumption common in estimating abundance and survival of juvenile Atlantic salmon populations is that of no (or restricted) movement during sampling events (geographical closure). Although valid for sampling individual sites when a section of stream can be blocked off with nets during the course of a day's sampling, this assumption may be invalid for sampling that takes place over extended time and space. The ability of individuals to move between stream reaches can bias estimates of survival through unequal capture probabilities, which is one of the most severe forms of bias in capture-mark-recapture models. When the study aim is to compare survival among segments of the population (e.g., ages, sexes) or across seasons or years, movement is confounded with survival. Comparison of these "apparent survival" rates may be valid unless a) emigration rates are different for different segments of the population, or b) there are annual or seasonal differences in movement. Further, a valid study objective may be to uncover the degree to which differences in emigration rates and real survival (both alone and in combination) are operating to explain production patterns from a certain system, the outcomes of competition, responses to changes in habitat capacity, etc. These problems are best addressed by estimating real survival and emigration separately. In Shorey Brook, a tributary to the Narraguagus River, Maine, a multiyear study is underway to evaluate the interaction of movement with survival of pre-smolt Atlantic salmon. PIT (Passive Integrated Transponder) tag technology, multiple samples per year, and passive PIT tag detection gear has allowed new insights by accounting for emigration. Survival estimates that failed to incorporate emigration information were negatively biased, potentially leading to incorrect conclusions regarding size-dependent processes. This problem could be affecting parameter estimates at many different scales of study.

Session 2 ***11:00 a.m.***

Evolution of population structure in Maine's Atlantic salmon

Adrian P. Spidle and Timothy L. King
U.S. Geological Survey, Leetown Science Center, Kearneysville WV

Following the closure of commercial fisheries for Atlantic salmon in Maine in 1947, populations of Atlantic salmon in Maine were supplemented with broodstock of Maine origin through the 1950s. Broodstock of Canadian origin was used through the 1960s, before reverting to broodstock of Maine only origin from the 1970s onward. Present day Atlantic salmon population structure appears to reflect the relatedness of most Maine salmon back to the rivers used for supplementation in the 1950s, the Machias and Narraguagus, rather than the Miramichi, the Canadian river primarily used in the 1960s. We present a comparison of Atlantic salmon scales collected from the Machias and Narraguagus rivers in the 1950s and 1970s to present day Atlantic salmon populations, and infer the history of population structure in Maine's Atlantic salmon over the period examined (1952 through the present).

Session 2 ***11:20 a.m.***

Scale pattern analysis discriminates Atlantic salmon by river-reach rearing origin

Ruth Haas-Castro[1], Tim Sheehan[1], Steven Cadrin[1] and Joan Trial[2]
[1]NOAA, Northeast Fisheries Science Center, Woods Hole, MA, [2]Maine Atlantic Salmon Commission, Bangor, ME

Anadromous populations of Atlantic salmon (*Salmo salar*) spawning in Maine's rivers are at historic low numbers. Knowing the relative contribution of each individual river reach to overall production could provide insight into the dynamics of a particular watershed. We evaluated the use of scale pattern analysis to discriminate among Atlantic salmon parr reared in different reaches of the Narraguagus River basin. Measurements of parr scales collected during 1990-1999 were used in a principal component analysis and to create linear discriminant functions for seven geographic strata and three river basin strata groups reflecting natural habitat breaks and Atlantic salmon management considerations. Discriminant functions were calculated using both annual and pooled data. Our results indicate there is enough differentiation among rearing habitats of different reaches (or between geographically grouped reaches) in the Narraguagus River basin to allow discrimination to a degree useful for management. Applying our models to scales from emigrating smolts and returning adult salmon could further improve our understanding of the contributions of specific rearing habitats to Atlantic salmon populations.

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

Evaluation of adult scales to determine the origin of Atlantic salmon recovered in Maine

Michael Pietrak[1], Christopher Legault[2] and Kenneth Beland[3]
[1]Maine Aquaculture Association, Hallowell, ME, [2]NOAA, Northeast Fisheries Science Center, Woods Hole, MA, [3]Maine Atlantic Salmon Commission, Bangor, ME

Recently issued discharge permits for the salmon aquaculture industry in Maine require a phased in marking of all Maine farmed salmon. The Maine Aquaculture Association in cooperation with federal and state agencies, industry, and nongovernmental organizations has been examining potential marking technologies that could be used to mark Maine's farmed salmon. Through this process, it has become clear that for most marking technologies a two-step marking system will be required that includes 1) an external mark for easy, reliable streamside identification of aquaculture origin at a minimum and 2) an internal tag that provides additional information on the origin of the fish. Scales have potential as an external marker due to the ease of detection in the field, low cost to apply and detect mark, and 100% mark retention rate. Preliminary studies using smolt scales to differentiate river and hatchery origin showed over a 95% accuracy of correctly identifying fish. The current study examined adult scales of known origin to determine their value in streamside identification of fish origin. Scales were collected from aquaculture fish at the processing plant, marked restoration fish, and historical wild scale collections predating 1982. The scales were digitally imaged and distributed around the country to 30 scale readers of varying experience levels. Readers were asked to classify the freshwater origin as hatchery, river reared or unknown and the marine origin as net pen, ocean or unknown. Based on the responses, fish were classified as industry, restoration, or river reared. Readers were asked to classify the origins of two test sets containing 100 fish each. The first test set was completed with no training or reference scales. The readers were given a primer on scale reading and a labeled reference set of scales for use with the second test set. Analysis focused on the accuracy of readers to distinguish the origin and classification of the test scales. The effects of reader experience and the use of the labeled reference set on accuracy also were examined.

Session 3 ***12:50 p.m.***

Reduced genetic diversity and effective population size in an endangered Atlantic salmon (*Salmo salar*) population: Connecting past to present

Christopher Lage[1] and Ira Kornfield[2]
[1]*University of Maine, Department of Biological Sciences, Orono, ME;* [2]*University of Maine, School of Marine Sciences, Orono, ME*

Optimal conservation strategies should incorporate both present and historical knowledge of genetic variation, gene flow, ecological stability, and local adaptation. This study examined genetic diversity at seven microsatellite loci in wild and in aquaculture-origin Atlantic salmon from the Dennys River, Maine, from 1963 to 2001 using DNA extracted from archival scale and tissue samples. Composite haplotypes of the mitochondrial ND1 gene were generated using polymerase chain reaction primers designed for degraded mitochondrial DNA (mtDNA). An ND1 mtDNA haplotype previously thought diagnostic for European and Newfoundland stocks was discovered within this population. Additional cryptic genetic diversity, yet unrecognized, may be present in endangered Maine salmon populations and should be evaluated and maintained through conservation efforts. Overall temporal trends of diversity and effective population size (*Ne*) in wild fish show strong reductions from 1963 to 200l. Significant within-population differentiation was observed between 1995 and 2001 that, if generated through introgression, did not increase *Ne* estimations. Significant differentiation was observed between the aquaculture sample and all wild samples. Genetic diversity of aquaculture-origin fish from 1992-1998 was greater than that of contemporary wild samples and more representative of historic wild diversities. Observed temporal reductions in genetic diversity and *Ne* of the Dennys River salmon population raises the possibility that current restoration efforts may be impacted by historical loss of diversity critical to adaptation.

Session 3 ***1:10 p.m.***

Loss of molecular and trait variation in six populations of endangered Maine salmon

Nathan Wilke[1], Michael Kinnison[1] and Tim King[2]
[1]University of Maine, Department of Biological Sciences, Orono, ME; [2]U.S. Geological Survey, Leetown Science Center, Kearneysville, WV

One of the primary concerns surrounding population declines in species at risk is the loss of potentially adaptive trait variation and its implications for fitness and population persistence. Variation at molecular markers has at times been used as an indicator for potential loss of adaptive trait variation. However, theoretical predictions for the fate of quantitative trait variation under population decline are variable, and empirical associations between molecular and adaptive trait variation have often proved elusive. Until now microsatellite variation has been the primary data assessed for genetic variation in populations of Maine Atlantic salmon (*Salmo salar*). This study compares patterns of microsatellite variation, phenotypic trait variation, and demographic history in six endangered populations of Maine Atlantic salmon. All of these populations are closely related and most were reared to maturity under similar captive conditions, allowing for better control of potential confounding effects. The study suggests that the loss of microsatellite variation in Maine endangered Atlantic salmon populations indicates a loss in phenotypic trait variation and, in turn, adaptive potential.

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

Genetic parentage analysis of Sheepscot River Atlantic salmon: Survival and distribution of stocked individuals

Meredith L. Bartron[1], Jerre Mohler[1] and Tim King [2]
[1]U.S. Fish and Wildlife Service, Northeast Fishery Center, Lamar, PA, [2]U.S. Geological Survey, Leetown Science Center, Kearneysville, WV

Survival and dispersal of stocked juvenile Atlantic salmon (*Salmo salar*) are vital components to the restoration and recovery efforts for the Distinct Population Segment (DPS) rivers in Maine. Recovery and restoration efforts focus on the stocking of fry and smolts into the DPS rivers. Stocked fry are recaptured as parr and a portion are sent to Craig Brook National Fish Hatchery to serve as broodstock upon maturation. Smolts are rarely recaptured due to the subsequent emigration to the ocean. Therefore, in-river assessment of survival, habitat usage, and stocking practices are best conducted using the stocked fry. In 2001, calcein marked Atlantic salmon fry of known parentage were stocked into the Sheepscot River, Maine. Offspring of 21 families, grouped into 6 stocking batches, were stocked into three locations in the Sheepscot River: Trout Brook, Choate Brook, and four locations in the West Branch of the Sheepscot. Approximately half of the stocked juveniles were marked with calcein to compare the effects of the mark on survival. A disproportionate number of unmarked individuals were recovered compared to the number of marked individuals (potentially due to a number of factors). To determine if the unmarked individuals were actually the stocked individuals, we used genetic parentage analysis based on genotypes from 11microsatellite loci to identify origin. For individuals unable to be assigned parentage, the relatedness among the offspring was examined to determine the number of potential family groups represented and the potential of contribution of natural reproduction was evaluated. Due to the ability to determine parentage, the effects of stocking location and family group on survival were able to be evaluated to provide a better understanding of factors that contribute to restoration and recovery efforts.

Session 3 ***1:50 p.m.***

Nonlethal measurement of recent growth in Atlantic salmon smolts using RNA-DNA ratios

Sharon A. MacLean[1] and Jeanne St. Onge-Burns[2]
[1]NOAA, Northeast Fisheries Science Center, Narragansett, RI, [2]ETI Professionals, Inc., Amesbury, MA

RNA-DNA ratios, reflecting protein synthesis, have been used as an index of growth in fishes at various life stages from larvae to adults. This technique was evaluated for its potential use in field assessments of feeding/growth of hatchery released Atlantic salmon (*Salmo salar*) smolts. Various tissue samples taken from smolts for RNA-DNA analysis were evaluated in a study conducted at the University of Maine Center for Cooperative Aquaculture Research in 2003. Tissue samples were collected nonlethally from the dorsal muscle, caudal fin, scales, and gills of 110 Passive Integrated Transponder (PIT) tagged smolts that were individually weighed and measured. After a one-month feeding period, the fish were re-measured and re-weighed, and tissue samples again were taken for nucleic acid analysis. Of the 110 fish in the experiment, 88 fish gained weight. Dorsal muscle RNA-DNA ratios were strongly correlated with growth in weight (R^2 =0.76), whereas RNA-DNA ratios from scale, fin, and gill tissue samples were not. One month after sampling, all fish appeared healthy and showed no overt signs of distress or infection. Although the nonlethal sampling was highly successful, field experiments are needed to assess the utility of this technique for assessing the growth of smolts in the wild.

Session 3 ***2:10 p.m.***

Comparison of lethal versus nonlethal sample sources for the detection of infectious salmon anemia virus (ISAV)

Cem Giray[1], H. Michael Opitz[2], Sharon A. MacLean[3] and Deborah Bouchard[1]
[1]Micro Technologies, Inc., Richmond, ME, [2]University of Maine, Department of Animal and Veterinary Sciences and Cooperative Extension, Orono, ME, [3]NOAA, Northeast Fisheries Science Center, Narragansett, RI

The emergence of infectious salmon anemia virus (ISAV) in Canada and the USA has led to establishment of ISAV surveillance programs for cultured Atlantic salmon (*Salmo salar* L.) and wild fish species including Atlantic salmon. Current testing procedures for ISAV consist of viral culture, reverse transcription polymerase chain reaction (RT-PCR) and indirect fluorescent antibody test (IFAT) and have thus far employed the use of lethal sampling. In this study, blood samples were evaluated as a nonlethal way to test for ISAV using viral culture and RT-PCR. Kidney, spleen, blood, and mucus samples were tested from Atlantic salmon survivors of ISAV infection trials, representing potential ISAV-carriers, and from moribund individuals from ISA clinical sites. Blood compared well to tissue samples for viral culture and produced a greater number of positives than did kidney samples for the detection of ISAV by RT-PCR. Direct tissue RT-PCR using both kidney and blood samples was determined to be a more sensitive assay than viral culture which utilized kidney and spleen tissues. Mucus did not perform well in either assay compared to the other sample sources. Blood appears to be a reliable nonlethal sample source for the detection of ISAV by both viral culture and RT-PCR in both moribund and asymptomatic fish.

Session 4 ***2:45 p.m.***

Latent infectious salmon anemia virus (ISAV) infection in experimentally infected Atlantic salmon in saltwater and freshwater

H. Michael Opitz[1], Sharon A. MacLean[2], Cem Giray[3], Deborah Bouchard[3], Sharon Clouthier[4], Wei Young-Lai[5], Dawna Beane[1] and Sharon Blake[6]
[1]University of Maine, Department of Animal and Veterinary Sciences and Cooperative Extension, Orono, ME, [2]NOAA, Northeast Fisheries Science Center, Narragansett, RI, [3]Micro Technologies, Inc., Richmond, ME, [4]Maine BioTek, Inc., Winterport, ME, [5]Huntsman Marine Science Center, St. Andrews, NB, Canada, [6]University of Maine, Department of. Biochemistry, Microbiology and Molecular Biology, Orono, ME

A 63-day experimental study was conducted to determine if clinically normal ISAV-infected Atlantic salmon (*Salmo salar*) remain infectious with ISAV, and whether subclinical infection is re-activated during transition from marine to freshwater. Seventy Atlantic salmon smolts which had survived 39 days after intraperitoneal injection with 10^7 $TCID_{50}$ ISAV were divided into two equal groups. The first group (Group A, SW/SW) was kept in seawater throughout the study, while the second group (Group C, SW/FW) was gradually re-adapted to freshwater over a 3-week period. Fifteen naïve fish were added to both Groups A and C, and designated as Groups B (SW/SW) and D (SW/FW), respectively. Five naïve fish (designated as Group E, FW/FW) were kept in freshwater as isolated negative controls. Individually Passive Integrated Transponder-tagged fish were bled on days 1, 28 and 63 and the blood samples tested using reverse transcription-polymerase chain reaction (RT-PCR), virus isolation on SHK-1 cells, and antibody enzyme-linked immunosorbent assay (ELISA). Kidney tissues from all fish that died during the study and all fish that survived to the end of the experiment were also tested by RT-PCR and virus isolation. Re-activation of the ISAV infection did not occur in the 70 original ISAV-infected subclinical fish in Groups A or C, and there were no ISAV-related mortalities. In both groups, the number of RT-PCR positive fish declined until all fish were negative at day 63. However, subclinical infection of ISAV was detected in two fish in Group C and in one fish in Group A. Antibodies against ISAV were present in all but one fish in Groups A and C detected by ELISA on days 1 and 28, and 92% were still ELISA positive on day 63. ISAV was isolated from the naïve fish that died in Groups B (100%) and D (70%). RT-PCR, virus isolation, and ELISA remained negative in all fish in Group E (negative control). The results demonstrate that subclinical ISAV-infected fish can remain carriers of infection that can spread to susceptible fish. The stress associated with transition from saltwater to freshwater did not re-activate ISAV infection. While RT-PCR declined to zero 102 days after initial infection, ELISA antibodies were still detectable at a high rate.

Session 4 ***3:05 p.m.***

Environmental persistence of infectious salmon anemia virus

Cem Giray, Deborah A. Bouchard, Keith A. Brockway and Peter L. Merrill
MicroTechnologies, Inc., Richmond, ME

The causes and mechanisms of infectious salmon anemia virus (ISAV) transmission among populations at aquaculture sites are not fully understood. It is presently unknown how long ISAV can survive outside its host in the environment, i.e., in seawater and on suspended particles, once it is shed. This study examined the ability to detect the presence of ISAV in the environment and the ability of ISAV to survive in seawater. Viral culture and reverse transcription-polymerase chain reaction (RT-PCR) were used to test seawater, surfaces, sediments and invertebrates collected from the field. ISAV was detected by RT-PCR in recently collected seawater samples from affected sites following concentration using an inexpensive seawater filtration system. The system was sensitive enough to detect ISAV by RT-PCR at levels of less than 30 virus particles per liter of seawater. Testing by cell culture required approximately a 1,000-fold increase in ISAV concentration in seawater for viable virus to be detected. ISAV was also detected from pontoon and boat surfaces, and from invertebrates such as sea lice (*Lepeophtheirus salmonis*) and blue mussels (*Mytilus edulis*). Seawater samples were inoculated in the laboratory with ISAV at 10^4 $TCID_{50}$/ml final concentration, and virus loss over time under varying conditions of temperature and microbial activity was examined. ISAV was detectable by RT-PCR after incubation in nonsterile seawater for up to two weeks at 16°C and up to 5 weeks at 4°C. No cytopathic effect (CPE) was observed by viral culture after 24 hours incubation at 16°C and after incubation for 1 week at 4°C. Although reduced by two orders of magnitude, ISAV CPE was still observed after incubation for six weeks in sterile seawater at 16°C and 4°C. ISAV was also detected by RT-PCR in both sets of samples. Observations will continue until ISAV can no longer be detected by either method.

Session 4 ***3:25 p.m.***

Evidence of episodic acidification in the Downeast Maine salmon rivers during the 2003 field season

Mark C. Whiting[1], Tracey Gamache[2] and William Otto[3]
[1]Maine Department of Environmental Protection, Bangor ME, [2]Narraguagus River and Pleasant River Watershed Councils, Columbia Falls, ME, [3]University of Maine, Machias, ME

Maine Department of Environmental Protection and the watershed councils collaborate in water quality monitoring of the Maine salmon rivers. Electronic pH meters were used by watershed council volunteers within 24 hrs of rain events in spring and fall 2003 to measure potential episodic acidification events during high water flows. Weather data for 2003 show that spring precipitation was normal, summer was relatively dry, and fall was relatively wet. In the spring, pH values of Tunk Stream and the Pleasant, Narraguagus, Machias, and East Machias rivers were 4.7 to 5.8. In the fall, the pH of Tunk Stream and Pleasant and Narraguagus rivers measured 4.5 to 5.8. For Tunk Stream and Pleasant River, pH values in the low fives lasted for a month in the spring (late March to late April) and again in the fall (late October to late November). A pH of 5.6 was observed for two consecutive weeks in the lower Narraguagus River in the fall. Some tributaries were more or less acidic than their respective river main stem. East Little River was less acidic and West Little River more acidic than the main stem of the Pleasant. Cranberry Brook and Great Falls Branch were less acidic than the Narraguagus, while the West Branch of the Narraguagus and Lawrence Brook were more acidic. Schoodic Brook was similar to the Narraguagus in acidity and sensitivity to stormwater events. Published data indicate low pH, low calcium and high aluminum work synergistically to create conditions that can be harmful for salmon and other sensitive species. The lasting low pH values observed in 2003 could contribute to harmful conditions. Similar conditions were observed in 2002 but not in 2001, Maine's worst drought year.

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

Evaluation of water alkalinity enhancement at the Craig Brook National Fish Hatchery on Atlantic salmon growth and survival

Terry Haines[1], Benjamin Spaulding[1], Kenneth Beland[2] and Barnaby Watten[3]
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The Craig Brook National Fish Hatchery, East Orland, Maine, is a key component of the Atlantic salmon conservation and recovery program. However, the hatchery is located in an area that receives acidic precipitation and where the geologic material is low in acid-neutralizing (buffering) capability. The prime water source, Craig Pond, is very low in dissolved minerals and is below the optimum alkalinity level (20 mg/L as $CaCO_3$) for rearing Atlantic salmon. This project evaluated the efficacy of a system to add limestone (calcium carbonate) to the hatchery water source to increase alkalinity, and the effects of rearing in higher-alkalinity water on fitness of the fish produced. The system was designed to increase water alkalinity from the average of 7 mg/L normally to approximately 30 mg/L ("medium alkalinity water") and 50 mg/L ("high alkalinity water"). The limestone dissolution system was able to maintain reasonably consistent water chemistry with minimal attention and few apparent adverse effects to the fish, and was effective in raising the alkalinity and pH of the hatchery water to levels believed to be optimal for Atlantic salmon culture. There was a nonsignificant trend to higher mortality of embryos in the treated water that may have been caused by washout of fine limestone particles from the system to the hatching and rearing containers. Sand filters greatly alleviated this problem. The limestone treatment significantly improved survival of the fish in the riverine environment. Two years of stocking fry in the Narraguagus River demonstrated improved survival of fish from the treated water after five months as fry, after a year and five months as parr, and after two years as parr. Fish from the medium and high alkalinity treatments were recovered at significantly greater rates than expected if there had been no effect of the treatment on survival.

Session 4 ***4:05 p.m.***

Ecology of Atlantic salmon during the transition from maternal dependence to independent feeding: research and management implications

Keith H. Nislow[1], Benjamin H. Letcher[2], Sigurd Einum[3] and John D. Armstrong[4]
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As salmon fry transition from dependence on maternally derived yolk reserves to independent feeding, they experience a highly dynamic biotic and abiotic environment, which often results in high mortality rates. Field experiments were conducted in North America and Europe to investigate the importance of fine scale spatial (scale of meters) and temporal (scale of weeks) variation in environmental (stream discharge, temperature) and biotic (population density, prior residence) factors for survival, growth, and life history. Results of these studies indicate that survival and growth during this period result from a complex interaction between abiotic and biotic factors in combination with maternal effects (egg size) and may have longer term and larger scale population and life history consequences. The implications of these results for management, specifically in the context of restoration efforts involving stocking programs will be discussed.

Session 4 ***4:25 p.m.***

Endocrine disruption in Atlantic salmon (*Salmo salar*) exposed to pesticides

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Previous research has shown that smolts from the Narraguagus River, a Distinct Population Segment (DPS) river, have low gill Na^+/K^+-ATPase activity and did not tolerate saltwater challenge tests (Magee et al., 2001). Commercial cultivation of lowbush blueberries is a common activity in the watersheds of many of the rivers in the DPS, and chemicals registered for use on blueberries have been detected in the Narraguagus and Pleasant rivers (Dill et al., 1998). Some of these pesticides are endocrine disruptors that may affect osmoregulatory ability (Fairchild et al., 1999). To determine if pesticides may contribute to osmoregulatory failure of Atlantic salmon smolts in Maine, chemicals registered for use on blueberries were tested for estrogenic activity in a cell culture assay (E-SCREEN). Mixtures of the highest-scoring E-SCREEN chemicals then were experimentally exposed to Penobscot strain smolts obtained from the Green Lake National Fish Hatchery. Fish in the first trial were exposed to Velpar (hexazinone), Orbit (propiconazole) and SuperBK (2,4-dichlorophenoxyacetic acid; 2,4-D) and in the second trial to Orbit, Sinbar (terbacil) and Imidan (phosmet). Pre-smolts were subjected to a total of five weekly, 24-hour pesticide mixture exposures and were then subjected to a 24 hour saltwater challenge (SWC). Gill tissue Na^+/K^+-ATPase (McCormick, 1993) and blood plasma chloride, 17 beta-estradiol and vitellogenin concentration analyses were done. There was no significant difference in Na^+/K^+-ATPase values between control and exposed fish in trial 1, but significant differences in trial 2 were found. Plasma chloride values did not show significant differences in either trial. The 17 beta-estradiol and vitellogenin assays are nearing completion with the data and results to follow.

References:
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Fairchild WL, Swansburg EO, Arsenault JT, Brown SB. 1999. Does an association between pesticide use and subsequent declines in catch of Atlantic salmon (*Salmon salar*) represent a case of endocrine disruption. Env. Health Persp. 107(5):349-358.
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Third Maine Atlantic Salmon Technical Advisory Committee
Research Forum
10 January 2006
D.P. Corbett Business Building
University of Maine, Orono

Program

8:00 a.m. *Registration, coffee*

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

Session 1
Christine Lipsky, Moderator
NOAA's National Marine Fisheries Service

8:40 a.m. **Seasonal patterns in the relative importance of organic acids and sulfates in episodic acidification of the Downeast salmon rivers**
Mark C. Whiting

9:00 a.m. **Assessment of water chemistry in Downeast Maine rivers and effects on Atlantic salmon smolts**
Daniel Kircheis, Stephen McCormick, Richard Dill, Trent Liebich, and Kenneth Johnson

9:20 a.m. **Comparison of responses of Atlantic salmon parr and smolts to acid/aluminum exposure and detection of gill aluminum accumulation using nonlethal gill biopsy**
Michelle Y. Monette and Stephen D. McCormick

9:40 a.m. **Thresholds of acid and aluminum impacts on survival and physiology of Atlantic salmon smolts**
Stephen D. McCormick, Michelle Y. Monette, and Amanda Keyes

10:00 a.m. **Smolt rearing origins from scales: Scale readers vs. computers**
Ruth Haas-Castro, Christine Lipsky, and Edward Hastings

10:20 a.m *Break and Poster session*

Session 2
Sharon MacLean, Moderator
NOAA's National Marine Fisheries Service

10:40 a.m. **Waterborne transmission of ISAV in marine waters: Studies from the Quoddy region of Maine and New Brunswick**
Stephen K. Ellis and Lori Gustafson

11:00 a.m. ***Mytilus edulis* investigated as a bioaccumulater of infectious salmon anemia virus**
Victoria A. Bowie, Keith A. Brockway and Cem Giray

11:20 a.m. **Descaling impairs osmoregulation in seawater challenged Atlantic salmon smolts**
Gayle Zydlewski, Joseph Zydlewski and G. Russell Danner

11:40 a.m. **Heritable adaptive trait variation in Maine's endangered Atlantic salmon (*Salmo salar*) – what's the next step?**
Nathan Wilke, Michael Kinnison and Timothy King

12:00 p.m. **Postsmolt survival and growth of five Atlantic salmon stocks in seawater**
William R. Wolters

12:20 p.m. *Lunch*

Session 3
Richard Dill, Moderator
Maine Atlantic Salmon Commission

1:20 p.m. **Penobscot River salmon smolts: Movements, survival, and path choice during a flood year**
Christopher M. Holbrook, Joseph Zydlewski and Michael T. Kinnison

1:40 p.m. **Movements of pre-spawn Atlantic salmon in Penobscot Bay and River: A pilot study using acoustic telemetry**
Christopher M. Holbrook, Joseph Zydlewski and Michael T. Kinnison

2:00 p.m. **Movements and fate of sonically tagged, experimentally "escaped" farmed Atlantic salmon from the border area between Maine and New Brunswick of east coast North America**
Fred Whoriskey, Paul Brooking, Gino Doucette, Steve Tinker and Jonathan Carr

2:20 p.m. **The development and use of fish assemblage assessment tools for determining the ecological benefits of dam removal and diadromous fish restoration in Maine rivers**
Christopher O. Yoder and Brandon H. Kulik

2:40 p.m. **Incubation capacity of streamside incubators**
Paul Christman, Kevin Dunham and Daniel McCaw

3:00 p.m. *Break and* **Poster Session**

Session 4
Joan Trial, Moderator
Maine Atlantic Salmon Commission

3:20 pm. **Inferring selective mortality in hatchery raised Atlantic salmon (*Salmo salar*) fry**
Michael Bailey and Michael Kinnison

3:40 p.m. **Review of captive adult salmon as a restoration approach in Maine**
Gregory Mackey, Timothy Sheehan and Randy Spencer

4:00 p.m. **Research prioritization lists: Quit meeting and start reading**
John Kocik and Joan Trial

4:20 p.m. **Maine Atlantic salmon recovery and restoration priorities**
Melissa Laser, Willa Nehlsen and Mark Minton

4:40 p.m. **Closing**
Rory Saunders
NOAA's National Marine Fisheries Service

Posters/Exhibits Session
D.P. Corbett Atrium

Designing road-stream crossings to accommodate aquatic organism passage
Jason Czapiga

The Student Conservation Association
Abraham R. Gates and Douglas Smithwood

In situ feeding behavior of Atlantic salmon juveniles at warm water temperatures: Are salmon in Maine adapted to warm water temperatures?
Alexandra Rohrer and Gregory Mackey

Atlantic salmon, smallmouth bass, and restored habitat in Kenduskeag Stream, Maine
Peter Ruksznis and Joan Trial

ABSTRACTS
ORAL PRESENTATIONS

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

Seasonal patterns in the relative importance of organic acids and sulfate in episodic acidification of the Downeast salmon rivers

Mark C. Whiting
Maine Dept of Environmental Protection, Bangor, ME

From 1999 to 2002, volunteers collected water samples from the Downeast salmon rivers for analysis at the George J. Mitchell Center for Environmental and Watershed Research, University of Maine. Assays included pH, alkalinity, major cations, anions, conductivity, and dissolved organic carbon (DOC). In 1999, all samples were taken during baseflow conditions. From 2000 through 2002, both baseflow and stormwater samples were collected. The timing of low pH events coincides with high riverflows that occur from October through May. The causes of low pH include dilution of alkalinity by storms, natural organic acidity (DOC), and anthropogenic sources of sulfate and nitrate. These observed patterns in pH were compared with patterns in the major acidic anions (DOC, sulfate and nitrate) in different rivers, flow conditions, and months. This report discusses the relative importance of different acidity sources. Under normal flow conditions, DOC plays a dominant role in determining pH. However, during low pH events, sulfate plays an important role in all the rivers and a dominant role in Tunk Stream and the Narraguagus and Pleasant rivers. DOC plays the most obvious and dominant role in the Dennys River, with a strong fall maximum in November. Often both sulfate and DOC were important (Machias, East Machias, and Dennys rivers). Nitrate and sulfate peak at the same times, but the relative contribution of nitrate is small. In conclusion, the relative importance of sulfate and DOC will vary by river basin or subbasin, time of year, and storm event. Low pH events in Downeast rivers are driven by complicated interactions between weather, hydraulic pathways through or over soils, wetland inputs, and by precipitation chemistry.

Session 1 ***9:00 a.m.***

Assessment of water chemistry in Downeast Maine rivers and effects on Atlantic salmon smolts

Daniel Kircheis[1], Stephen McCormick[2], Richard Dill[3], Trent Liebich[4] and Kenneth Johnson[5]
[1]NOAA, Northeast Regional Office, Orono, ME; [2]U.S. Geological Survey, Silvio O. Conte Anadromous Fish Research Center, Turners Fall, MA; [3]Maine Atlantic Salmon Commission, Bangor, ME; [4]University of Minnesota, Duluth, MN; [5]University of Maine, George J. Mitchell Center for Environmental and Watershed Research, Orono, ME

Episodic low pH and high aluminum associated with anthropogenic acidification has been identified by the Maine Atlantic Salmon Technical Advisory Committee as a possible threat to Atlantic salmon (*Salmo salar*) recovery in the Gulf of Maine distinct population segment (DPS). Low pH and high aluminum can impair a smolt's ability to successfully migrate and sometimes results in direct mortality (Lacroix and Townsend 1987; Staurnes et al. 1996; Magee et al. 2003). The level to which pH and aluminum impact smolts depends on other water chemistry conditions, particularly acid neutralizing capacity (ANC) and dissolved organic carbon (DOC). In 2003, we began investigating water chemistry effects on Atlantic salmon smolts by 1) documenting spatial and temporal patterns of episodic low pH and high aluminum across DPS watersheds, and 2) monitoring the physiological response of Atlantic salmon to these conditions using streamside exposure studies. Preliminary findings indicate that smolts in Downeast rivers exhibit signs of stress, indicated by elevated plasma glucose and depressed plasma chloride levels, when river pH falls below 5.6. Among the Dennys, Machias, East Machias, Pleasant and Narraguagus rivers, the Pleasant River is the only main stem documented to experience pH episodes below 5.6 during the spring smolt migration. Nine tributaries are documented to have had at least one occurrence of pH less than 5.6. Many more rivers and tributaries experience pH episodes below 5.6 in the autumn, though less is known about the effects (immediate or cumulative) on eggs or parr. Even though gill aluminum concentrations were low in the 2004 and 2005 streamside studies, more work is needed to determine to what extent aluminum in the Downeast rivers may be impacting smolt survival.

References:

Lacroix GL and Townsend DR. 1987. Responses of juvenile Atlantic salmon (*Salmo salar*) to episodic increases in acidity of Nova Scotia rivers. Can. J. Fish. Aquat. Sci. 44:1475–1484.

Staurnes M, Hansen LP, Fugelli K, Haraldstad O. 1996. Short-term exposure to acid water impairs osmoregulation, seawater tolerance, and subsequent marine survival of smolts of Atlantic salmon (*Salmo salar*). Can. J. Fish. Aquat. Sci. 53:1695–1704.

Magee JA, Obedzinski M, McCormick SD, Kocik JF. 2003. Effects of episodic acidification on Atlantic salmon (*Salmo salar*) smolts. Can. J. Fish. Aquat. Sci. 60:214–221.

Session 1 ***9:20 a.m.***

A comparison of responses of Atlantic salmon parr and smolts to acid/aluminum exposure and detection of gill aluminum accumulation using nonlethal gill biopsy

Michelle Y. Monette[1] and Stephen D. McCormick[2]
[1]*University of Massachusetts, Organismic and Evolutionary Biology Program, Amherst, MA;* [2]*U.S. Geological Survey, Silvio O. Conte Anadromous Fish Research Center, Turners Falls, MA*

Acid rain coupled with increased aluminum (Al) is a potential cause of Atlantic salmon decline in many North American rivers including those of eastern Maine. Smolts appear to be the most sensitive of the salmon life stages to acid/Al (AA); however, the mechanisms underlying increased sensitivity are unknown. Our objectives were to 1) validate nonlethal, gill biopsy for measuring gill Al, 2) confirm that smolts are more sensitive to AA than parr, and 3) identify mechanisms underlying increased sensitivity. Parr and smolts were exposed to control and AA conditions in both the lab and the field, and were sampled after two and six days. In both test environments, AA caused a dose-dependent elevation of gill Al. Gill Al measured by the gill arch method did not differ from gill Al measured by nonlethal gill biopsy. In the lab and field, gill Al in both life stages increased > 7-fold after two days. After 6 days, parr gill Al was 2-fold greater than smolts. In lab exposures, plasma chloride of AA smolts decreased 11%, and glucose increased 3-fold after six days; however, chloride and glucose in parr were unaffected. Gill Na^+, K^+-ATPase activity (NKA) of both lifestages was unaffected. In the field, plasma chloride decreased 8.3% in AA parr and 27% in smolts after two days. Chloride in parr continued to decline but partially recovered in smolts. Plasma glucose increased > 2-fold in AA parr and smolts after two days. Gill NKA decreased 45% in AA parr and smolts after six days. We demonstrate that measurement of gill Al using nonlethal gill biopsy provides a valid indicator of AA exposure. We confirm that smolt ionoregulatory ability is more sensitive to AA than that of parr, however, neither decreased gill NKA nor elevated gill Al appear to be mechanisms of increased sensitivity.

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

Thresholds of acid and aluminum impacts on survival and physiology of Atlantic salmon smolts

Stephen D. McCormick[1,2], MichelleY. Monette[2], Amanda Keyes[1] and Keith Nislow[2,3]
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Previous work has established that smolts are more sensitive to acid and aluminum than most other life stages of Atlantic salmon. Recent work also indicates that relatively short-term exposure (several days) to acid and aluminum can cause mortality and reduce salinity tolerance. We conducted laboratory and field studies to determine the levels of acid and aluminum that affect survival, salinity tolerance, and stress in Atlantic salmon smolts. In the laboratory, fish were exposed to three levels of pH (6.0, 5.6, 5.2) and four levels of aluminum (0, 40, 80, 175 µg/l) for two days. All smolts died at low pH and high aluminum, and intermediate levels of acid and aluminum resulted in moderate mortality, loss of salinity tolerance, loss of plasma ions in fresh water and increased stress. Cage studies in southern Vermont streams indicated that similar thresholds of impact occur in natural stream waters over a three to six day period. The results indicate that an interaction of aluminum and low pH causes mortality and loss of salinity tolerance in Atlantic salmon smolts.

Session 1 ***10:00 a.m.***

Smolt rearing origins from scales: Scale readers vs. computers

Ruth Haas-Castro[1], Christine Lipsky[2] and Edward Hastings[2]
[1]NOAA, Northeast Fisheries Science Center, Woods Hole, MA; [2]NOAA, Northeast Fisheries Science Center, Orono, ME

Identification of the source of Atlantic salmon that survive to advanced life stages (smolts and adults) must be accomplished to evaluate the effectiveness of stocking strategies. In Maine's Penobscot and Dennys rivers, smolt production occurs as a result of natural spawning and also by fry, parr, and smolt stocking. Using scales sampled from smolts collected by a rotary screw trap in the Pleasant River tributary of the Penobscot River, we conducted a scale reading study to determine the degree to which biologists can visually distinguish (with the aid of only a microscope) between scales from naturally and hatchery reared smolts. Hatchery reared smolts had been clipped on the ventral fin and stocked as parr 20 months or eight months prior to capture. No smolts had been stocked in the Pleasant River. Three experienced scale readers assigned age and origin (Parr20, Parr8, or naturally reared) to 177 scale samples. Readers accurately classified the stocking group of Parr8 in 75-94% of the cases. Accuracy for Parr20 was much lower, 10-53%, but the misclassification was mostly into the Parr8 category rather than into the naturally-reared category. A second study objective was to investigate the utility of computer-assisted scale pattern analyses in reliably determining smolt rearing origins. We derived a linear discriminant function (LDF) from measurements of scale growth variables (radius, circuli numbers and spacings, etc.). The LDF correct classification rate was 85% for Parr8 and 86% for Parr20. Scale feature measurements from Dennys River smolts were also analyzed using linear discriminant functions to distinguish among the above groups as well as smolt stocked fish. LDF correct classification rates were all above 90%. Quantifiable differences exist in the growth characteristics of parr-stocked and smolt-stocked individuals that can be reliably inferred not only through scale pattern analysis, but also visually by experienced scale readers.

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

Waterborne transmission of ISAV in marine waters: Studies from the Quoddy region of Maine and New Brunswick

Stephen K. Ellis and Lori Gustafson
U.S. Department of Agriculture, Animal Plant Health Inspection Service-Veterinary Services, Eastport, ME

Passive dispersal of virus by water is considered a probable means of distribution of Infectious Salmon Anemia in marine waters. The relevance of this means of transmission in the field has been presumed, but not clearly demonstrated; however, the implications to disease management and zonation strategies in the bi-national Quoddy region of Maine and New Brunswick are significant. Historical context and laboratory evidence is presented that led the authors to develop and implement an epidemiologic field study to try to identify the impacts of tidal flow on the distribution of ISA virus in the Passamaquoddy Bay and adjacent waters. The relationship between circulation patterns and the spatial and temporal incidence of ISA in the 2002 production year class of Atlantic salmon is evaluated. Findings, management implications, and ongoing concerns are discussed.

Session 2 ***11:00 a.m.***

Mytilus edulis investigated as a bioaccumulator of infectious salmon anemia virus

Victoria A. Bowie, Keith A. Brockway and Cem Giray
Micro Technologies, Inc., Richmond, ME

Infectious salmon anemia virus (ISAV) has seriously affected the Atlantic salmon aquaculture industry in North America. Pathogen surveillance and disease management programs have been established in Canada and the USA to curb its effects. A key need for these programs has been the early detection of the pathogen before it can cause infections in aquaculture salmon. Research is currently being conducted to determine whether seawater, oceanographic parameters or other components can be used for the early detection of the virus or impending infections, but with limited results. Shellfish have been employed in environmental testing for human viral agents such as rotavirus and hepatitis A, and have also been implicated as potential reservoirs of aquatic pathogens. Blue mussels (*Mytilus edulis*) make up a substantial portion of the fouling organisms found on equipment such as nets and pontoons at marine Atlantic salmon (*Salmo salar*) grow-out sites. These filter feeders pump large volumes of seawater through them as they grow on net pen structures and may potentially retain ISAV. In this study we examined the ability of *M. edulis* to concentrate ISAV and its potential use as an indicator organism for the early detection of ISAV. Methods were developed and optimized for the extraction and detection by RT-PCR of viral RNA from *M. edulis* tissues, and laboratory bioaccumulation trials were conducted to determine if *M. edulis* could concentrate ISAV from seawater and at a level that could be useful as indicator organisms in the field. Results indicated that ISAV was not concentrated to any significant level by *M. edulis* and that, instead, the filtration activity of *M. edulis* reduced the viability of ISAV beyond that expected from degradation in seawater.

Session 2 ***11:20 a.m.***

Descaling impairs osmoregulation in seawater challenged Atlantic salmon smolts

Gayle Zydlewski[1], Joseph Zydlewski[2] and G. Russell Danner[3]
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Descaling is a commonly observed injury in Atlantic salmon smolts migrating in watersheds that have dams with poor downstream passage. These injuries are particularly observed towards the end of the migratory season. The effect of this type of injury on the ability to osmoregulate upon seawater entry was investigated using hatchery smolts. A series of seawater transfers was conducted three times to reflect "early", "middle" and "late" periods of migration (April 25, May 11 and May 31). Before each transfer, 120 fish were anesthetized and measured (length and weight). Half served as controls and received no injury. The other half received a descaling injury of 20 % of the body surface. Immediately after recovery, 15 control and 15 treatment fish were subjected to a 35 ppt seawater challenge. After 24 h blood was collected (for plasma osmolality, hematocrit, and on day 7 septic bacterial load) and gill biopsies taken to measure gill Na^+,K^+-ATPase activity. Three additional seawater challenges were carried out at 1, 3, and 7 days after the initial sampling. Gill Na^+,K^+-ATPase activity levels indicate that the time series spanned the period from early smolting (increasing activity) to desmolting (decreasing activity). In each group, descaled fish showed greater osmotic perturbation than control fish. Control fish stabilized within 7 days for early and middle series; however, descaled fish failed to recover in this time frame. For the "late" fish, plasma osmolality was elevated in both groups; descaled fish did not differ from controls at days 3 and 7. No clear pattern of septic bacterial load and treatment was apparent. The evidence suggests that descaling impairs osmoregulatory performance during smolting and full recovery does not occur within 7 days. Therefore, descaled smolts entering seawater within 7 days of the injury may have compromised long-term survival.

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

Heritable adaptive trait variation in Maine's endangered Atlantic salmon (*Salmo salar*) – what's the next step?

Nathan Wilke[1], Michael Kinnison[1] and Tim King[2]
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One of the primary concerns surrounding population declines in species at risk is the loss of potentially adaptive trait variation and its implications for fitness and population persistence. Variation at molecular markers has at times been used as an indicator for potential loss of adaptive trait variation. However, theoretical predictions for the fate of quantitative trait variation under population decline are variable and empirical associations between molecular and adaptive trait variation have often proved elusive. Until now, microsatellite variation has been the primary data assessed for genetic variation in populations of Maine Atlantic salmon (*Salmo salar*). In this study we compare patterns of heritable, adaptive trait variation in six populations of Maine Atlantic salmon that have experienced recent population declines. The populations have been listed under the U.S. Endangered Species Act, and are currently managed at the Craig Brook National Fish Hatchery. All of these populations are closely related and most were reared to maturity under similar captive conditions, allowing us to better control for some of the confounding effects that may have limited other studies.

Session 2 ***12:00 p.m.***

Postsmolt survival and growth of five Atlantic salmon stocks in seawater

William R. Wolters
U.S. Department of Agriculture, National Cold Water Marine Aquaculture Center, University of Maine, Orono, ME

Atlantic salmon aquaculture is one of the most successful global aquaculture enterprises, and farmed salmon has wide acceptance as a main food item by American consumers. Maine has the ideal location and unique opportunity to further increase salmon production and be the leader in coldwater marine finfish aquaculture. However, environmental issues, mandatory stocking of 100 percent native North American salmon, and disease have impacted economic viability of the U.S. salmon industry. In response, the Agricultural Research Service (ARS) established the National Cold Water Marine Aquaculture Center (NCWMAC) in Orono and Franklin, Maine. Initial research is aimed at developing a comprehensive Atlantic salmon breeding program from native North American fish stocks and release of genetically improved salmon lines to commercial producers. In the first two years of the breeding program, individual families were obtained from two St. John River sources, the Penobscot River, the Gaspé Peninsula, and landlocked salmon stocks in Maine. Eyed eggs were disinfected upon arrival and incubated in separate hatching jars. Yolk-sac fry were transferred into individual 0.1-m^3 tanks receiving 8 L/min of oxygen-saturated, biofiltered, recirculated freshwater. Approximately 30 days after initiation of feeding, fish densities were equalized to 250 fish per tank. Fish were fed 5% of the tank's total biomass daily and evaluated for growth over a 30-day period. Thirty fish from each family were tagged with Passive Integrated Transponder tags and stocked communally into replicated 10-m^3 tanks receiving 400 L/min of recirculating freshwater. One month prior to stocking into sea cages for performance evaluations, serum chloride levels and gill Na^+, K^+-ATPase activity were measured on subsamples from all stocks in freshwater and the subsequent seawater challenge. Analysis of variance was used to determine differences between stocks. Fish were weighed prior to stocking into sea cages for growth evaluations. Smolts were stocked into sea cages in June 2005 and are being evaluated for growth, survival, and sexual maturity under commercial culture situations. Fish will be sampled prior to the first winter in the cage for intermediate (6-month) growth measurements. Analysis of data on survival and growth will be presented.

Session 3 ***1:20 p.m.***

Penobscot River salmon smolts: Movements, survival, and path choice during a flood year

Christopher M. Holbrook[1], Joseph Zydlewski[2] and Michael T. Kinnison[1]
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The Penobscot River supports the largest run of Atlantic salmon in the United States; however, populations in this and neighboring systems have recently experienced precipitous declines. Restoration efforts have included extensive hatchery supplementation, and the majority of returning adults are believed to be the product of hatchery smolt stocking. In this study, we use acoustic telemetry to describe movements of both hatchery and naturally reared smolts in order to quantify path choice, transit times and loss to the system (mortality). These factors are related to smolt condition, supplementation practices, and the impacts of hydroelectric facilities. A total of 335 smolts were surgically implanted with acoustic transmitters and released at four locations in the Penobscot River and tributaries in the spring of 2005. Hatchery smolts were released in the Mattawamkeag River (n=40), the Penobscot River, Howland (n=150), and the Pleasant River, Milo (n=85) in mid-late April. Wild smolts (n=60) were captured during emigration, tagged, and released in the Penobscot River below Weldon Dam in late May. Tagged smolts were detected by an array of acoustic receivers spanning more than 150 km of the Penobscot River and its estuary. Peak discharge (107,000 cfs) during the study period was above the 90^{th} percentile for the last 102 years of data, resulting in variable reach detection efficiencies. Nonetheless, preliminary results suggest that the majority of losses occurred in upper reaches, with small losses in the vicinity of dams. On average, hatchery smolts took 21 (SE ±.0.49) days to reach the estuary, whereas later migrating wild smolts took 3.5 (SE ±.0.22) days. These results indicate that survival to the estuary varied by rearing, stocking location and release date.

Session 3 ***1:40 p.m.***

Movements of pre-spawn Atlantic salmon in Penobscot Bay and River: A pilot study using acoustic telemetry

Christopher M. Holbrook[1], Joseph Zydlewski[2] and Michael T. Kinnison[1]
[1]University of Maine, Department of Biological Sciences, Orono, ME; [2]U.S. Geological Survey, Cooperative Fish and Wildlife Research Unit, University of Maine, Orono, ME

Previous research has revealed extensive information on the freshwater stages of Atlantic salmon life history in the Gulf of Maine Distinct Population Segment, but the behavior of pre-spawn adults, particularly in the marine and estuarine environments, remains unclear. Migrating adults may incur significant mortality or delay at dams or through other sections of the river, representing critical impediments to restoration. In this study, we assessed the feasibility of acoustic telemetry as a method to describe patterns of upstream movement and migratory success over more than 200 km of the Penobscot Bay and River. Ten two-sea-winter (2SW) adult male salmon of hatchery origin were surgically implanted with acoustic transmitters; five of these were released in Penobscot Bay (near Rockland) and five were released above Veazie Dam (in Orono). An array of acoustic telemetry receivers provided detailed information on movement rates and path choice, including depth at detection. Detection efficiencies were robust, with minimal missed detections. Although all salmon were released in late June, only three had passed the Milford Dam (approx. 14 km upstream of Veazie Dam) by late October. These data suggest that dams are a severe impediment to migrating salmon. We recommend the use of acoustic telemetry in future assessments of migrating Atlantic salmon in the Penobscot River.

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

Movements and fate of sonically tagged, experimentally "escaped" farmed Atlantic salmon from the border area between Maine and New Brunswick of east coast North America

Fred Whoriskey[1,2], Paul Brooking[1], Gino Doucette[1], Steve Tinker[1] and Jonathan Carr[1]
[1]Atlantic Salmon Federation, St. Andrews, NB, Canada; [2]Huntsman Marine Science Centre, St. Andrews, NB, Canada

Farmed Atlantic salmon were sonically tagged then experimentally "escaped" from a cage site in Cobscook Bay, Maine, USA, to document movement patterns and fates of the fish. Fish were liberated in either the winter or spring. Cobscook Bay and the surrounding Bay of Fundy region are dominated by intense tidal currents, and tagged salmon dispersed away from the cage sites within a few hours post-release. There were high mortalities of the fish within Cobscook Bay and the surrounding coastal region (56% of winter release fish; 84% of the spring group) probably due to seal predation. Surviving fish exited the coastal zone to the Bay of Fundy primarily by following the dominant tidal currents in the region through Canadian waters. No sonically tagged fishes were detected during the autumn spawning season in any of 40 monitored Atlantic salmon rivers draining to the Bay of Fundy.

Session 3 ***2:20 p.m.***

The development and use of fish assemblage assessment tools for determining the ecological benefits of dam removal and diadromous fish restoration in Maine rivers

Christopher O. Yoder[1] and Brian H. Kulik[2]
[1]Midwest Biodiversity Institute, Columbus, OH; [2]Kleinschmidt Associates, Pittsfield, ME

We are developing indices of fish assemblage condition based on the concepts of the Index of Biotic Integrity (IBI) as proposed by Karr et al. (1986) and modified by others for large rivers. The approach is flexible as the baseline data required for an IBI can be used for other resource assessment and management purposes including assessing the restoration of diadromous fishes and the ecological effects of altering habitat and habitat connectivity. The principal field sampling goal is to produce estimates of relative abundance for species amenable to efficient capture and for large numbers of sites located along extended reaches of large rivers on an annual basis. During 2001 and 2002, we began exploratory work in Maine on a fish assemblage assessment tool by constructing and testing a sampling device, and sampling 100 miles of the Kennebec River to ascertain changes in the fish assemblage of the main stem following removal of the Edwards Dam. Conventional analysis of the data showed marked differences in assemblage composition, density, and biomass between the newly re-created free flowing river and upstream impoundments. We sampled the Penobscot River main stem and selected tributaries in 2004, and in 2005, included the St. John, Allagash, Aroostook, and St. Croix rivers. Strong differences were found in various assemblage parameters and species relative abundance between major habitat types (riverine, impounded, tidal) and along the lengths of each river (cold to warm water). Important tasks that remain to be completed include delineation of reference conditions, determining the correspondence of the assemblage assessment to un-sampled species, and refining the definition of biological metrics that are applicable to Maine's large rivers. We will detail progress to date and describe a long term strategy for IBI development and its application to other New England rivers.

Reference:
Karr JR, Fausch KD, Angermier PL, Yant PR, Schlosser IJ. 1986. Assessing biological integrity in running waters: A method and its rationale. Illinois Nat. Hist. Surv., Spec. Pub. 5. 28pp.

Session 3 ***2:40 p.m.***

Incubation capacity of streamside incubators

Paul Christman, Kevin Dunham, and Daniel McCaw
Maine Atlantic Salmon Commission, Sidney, ME

The egg incubation capacity of decommissioned refrigerators as streamside incubators was tested in 2004. Two incubators were designed to allow incoming water to flow under a false floor and up through eight layers of poultry nesting material 127cm long and 74cm wide. Incubators were deployed in February and connected to a gravity fed waterpipe laid in a small tributary of the Sandy River. Each incubator received 42 L/minute of stream water. Eggs were loaded at a different density in each incubator. One incubator received 40,000 eyed eggs yielding a density of 0.55 eggs/cm^2 and one received 90,000 eyed eggs yielding a density of 1.25 eggs/cm^2. Incubators and temperature were monitored until egg development reached approximately 95%. All fry were removed, counted, and weighed. Observations and counts indicate the high-density incubator had over 60% mortality and the low-density incubator had less than 10% mortality. The results indicate safe egg densities may be 0.55 eggs/cm^2 for a refrigerator-sized incubator. It was also noted that temperature fluctuated due to a warm spring season which could have exacerbated mortality. Newly designed re-circulation systems and filter chambers will be discussed.

Session 4 ***3:20 p.m.***

Inferring selective mortality in hatchery raised Atlantic salmon (*Salmo salar*) fry

Michael Bailey and Michael Kinnison
University of Maine, Department of Biological Sciences, Orono, ME

Atlantic salmon (*Salmo salar*) restoration efforts in Maine employ fry stocking as one of the primary population enhancement strategies. The earliest periods of fry development are thought to represent the greatest phases of mortality in most fishes, including salmonids. In the wild, larger size, faster growth, or more advanced developmental state during these periods are often hypothesized to convey better survival; however, there is little data on the actual survival of newly emerged Atlantic salmon fry based on these characters. Hatchery rearing may reduce mortality up to stocking in hatched fry; however, it may also disrupt the natural match between fry characteristics and the features of their natal habitats, causing natural selection to act strongly on stocked fry in the wild. This, in turn, may have important implications for later aspects of the life history and productivity of fry-stocked fish. We have designed, and are now implementing, a series of experiments to assess patterns of size, growth and development related survival patterns for fry spending between 30 and 60 days in the wild. Our approaches all rely on reconstruction of attributes of fry at stocking using characters of growth rings in otoliths. Developing relationships between fry biology and otolith characters has been challenging. Nonetheless, we believe these experiments will provide important insights into the features of fry best suited for restoration efforts.

Session 4 ***3:40 p.m.***

Review of captive adult salmon as a restoration approach in Maine

Gregory Mackey[1], Timothy Sheehan[2] and Randy Spencer[3]
[1]Maine Atlantic Salmon Commission, Jonesboro, ME; [2]NOAA, Northeast Fisheries Science Center, Woods Hole, MA; [3]Maine Atlantic Salmon Commission, Bangor, ME

Maine Atlantic salmon stocks remain at extremely low levels. Although captive broodstock programs for six populations have been in place and extensive stocking of fry, parr and smolts has occurred, the populations remain at critically low levels. In addition to stocking juvenile life history stages, sexually mature adult salmon have been stocked on several occasions over the last ten years. The fish stocked have differed markedly in rearing history, with juveniles derived from the wild or domestic sources and adult fish reared to maturity in marine net pens or freshwater hatcheries. Monitoring of the reproductive effort and success of these fish indicates that they generally achieved relatively little reproductive output, with some exceptions (additional genetic analyses pending). Nevertheless, use of stocked adult salmon as natural spawners remains a tenable restoration method. Although this approach affords managers less control over the number of eggs successfully reared to fry (or older life history stages) and the spatial distribution of the offspring in the rivers, the fry that do emerge are derived from natural spawning (mate choice, competition for mates or spawning locations, choice of spawning location, etc.) and natural incubation and emergence conditions. These factors are lacking in our current hatchery fry production method. Whether these factors are important to the success of individual fish, and by extension, to the restoration of these populations, must be evaluated. Finally, we present some considerations for adult stocking that may improve the likelihood of success.

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

Research prioritization lists: Quit meeting….and start reading

John Kocik[1] and Joan Trial[2]
[1]NOAA, Northeast Fisheries Science Center, Orono, ME; [2]Maine Atlantic Salmon Commission, Bangor, ME

Are "personalized prioritization lists" of the factors affecting Atlantic salmon survival and recovery necessary to direct research in Maine? We believe not - because several excellent syntheses (Parrish et al. 1998; O'Neil et al. 2000; Cairns 2001; National Research Council 2004) already exist that can readily be used in crafting and guiding strategic Atlantic salmon research plans. The common message from ALL of these syntheses is clear - Atlantic salmon populations are declining throughout their range and these declines are related to four principal concerns: (1) habitat connectivity (*e.g.,* dams); (2) marine survival; (3) hatchery influences; and 4) climate change. No single factor is responsible for the declines, and hence it is fruitless to look for a single-cure panacea (*i.e.,* a Holy Grail) that will miraculously recover Atlantic salmon in Maine. Overriding issues in the U.S. mirror those identified in larger-scale reports - some as old as the 1800's! An adaptive management approach is necessary to integrate research findings, recovery projects, and monitoring needs within a 'big picture' (ecosystem) context. Atlantic salmon life history and population dynamics are complex and naturally reproducing populations require balancing survival and production in both freshwater and marine systems. When new information is developed, these results need to be rapidly assimilated into recovery efforts. Two case studies are highlighted: (a) fry rearing alkalinity research and (b) smolt return data from in the Dennys River. Rigorous application of the scientific method and rapid adaptability and response to information are critical to understanding (1) what works, (2) what does not, and most importantly, (3) why.

References:

Parrish DL, Behnke RJ, Gephard SR, McCormick SD, Reeves GH. 1998. Why aren't there more Atlantic salmon (*Salmo salar*)? Can. J. Fish. Aquat. Sci. 55(S1):281-287.

O'Neil S, Ritter J, Robichaud-LeBlanc K, editors. 2000. Proceedings of a workshop on research strategies into the causes of declining Atlantic salmon returns to North American rivers, 12-14 June 2000, Dalhousie University, Halifax, Nova Scotia. Canadian Stock Assessment Secretariat Proceedings Series, 2000/18. Science Branch, Fisheries and Oceans Canada.

Cairns DK. 2001. An evaluation of possible causes of the decline in pre-fishery abundance of North American Atlantic salmon. Can. Tech. Rep., Fish. Aquat. Sci., No. 2358.

Committee on Atlantic salmon in Maine National Research Council. 2004. Atlantic Salmon in Maine. Washington, DC: National Academies Press.

National Marine Fisheries Service and U.S. Fish and Wildlife Service. 2005. Recovery Plan for Gulf of Maine Distinct Population Segment of Atlantic salmon (*Salmo salar*). Silver Spring. MD: National Marine Fisheries Service. Available from: http://www.nero.noaa.gov/nero/hotnews/salmon/FinalATSRPlan.pdf

Session 4 ***4:20 p.m.***

Maine Atlantic salmon recovery and restoration priorities

Melissa Laser[1], Willa Nehlsen[2] and Mark Minton[3]
[1]Maine Atlantic Salmon Commission, Augusta, ME; [2]U.S. Fish and Wildlife Service, Hadley, MA; [3]NOAA, Northeast Regional Office, Gloucester, MA

NOAA Fisheries, the Atlantic Salmon Commission and the U.S. Fish and Wildlife Service are committed to working together to meet common objectives while fulfilling their respective responsibilities for Atlantic salmon management and recovery. While the three agencies may share common objectives, their priorities for actions to achieve these objectives are not always in the same order of preference, nor are they known to their partners. To improve collaboration and effectiveness among the agencies and partners, during the summer of 2005, the Services and ASC began a priority setting exercise to identify actions that the agencies believe should be accomplished in the near to medium term for Atlantic salmon survival and recovery, focusing on freshwater survival. The results of the priority setting exercise will be presented as well as a description of how these priorities fit in with the many other "lists" of priorities.

ABSTRACTS
POSTER PRESENTATIONS

Designing road-stream crossings to accommodate aquatic organism passage

Jason Czapiga
Maine Atlantic Salmon Commission, Bangor, ME

Forestry and recreational roads constitute a large part of the road system in Maine. Scattered throughout this road system are a significant number of road-stream crossings that disrupt the form and function of stream channels. Culverts were installed exclusively to pass water and create a crossing; however, they have fragmented the aquatic habitat and impeded passage for aquatic organisms. Habitat connectivity in a watershed is as important on the main stem of the river as it is on the smallest of tributaries. Re-establishing habitat connectivity through installation of natural crossings would provide access to spawning and rearing grounds and restore thermal refuges for coldwater fish. Recently there has been an effort in Downeast Maine to inventory and prioritize passage improvement projects at road-stream crossings. This process will determine, at individual sites, the potential for culvert replacement with a natural stream bottom crossing or culvert removal and road discontinuation. The replacement culverts will create a road crossing that is invisible to the stream and passable to all aquatic organisms and most terrestrial animals. An interdisciplinary team of professionals including watershed groups, landowners, contractors, engineers, and state and federal agencies are collaborating to make assessments on what is best for the aquatic resource while maintaining the road infrastructure. Presented is a case study on a small tributary in the Machias River drainage.

The Student Conservation Association

Abraham R. Gates[1] **and Douglas Smithwood**[2]
[1]Student Conservation Association, Charlestown, NH; [2]U.S. Fish and Wildlife Service, Central New England Fishery Resource Complex, Nashua, NH

The Student Conservation Association (SCA) is a nonprofit organization that has been in existence for 48 years and is the oldest and largest conservation service organization in the USA. SCA works closely with Department of Interior (DOI) agencies and other public and private sector groups to provide low cost internship opportunities, outdoor education and leadership training to young people with an interest in conserving the natural environment. Around the nation, SCA has a well established fisheries program that provides many U.S. Fish and Wildlife Service (USFWS) facilities with interns who are college students or recent graduates looking to gain more experience in the fisheries field. SCA has a strong partnership with the Central New England Fishery Resource Complex which has helped expand SCA's involvement with several other USFWS sites within New England. We will be available for discussion and provide literature about the program, presenting an overview of what SCA can offer a facility and details on the logistics of the Internship Program.

In situ feeding behavior of Atlantic salmon juveniles at warm water temperatures: Are salmon in Maine adapted to warm water temperatures?

Alexandra Rohrer and Gregory Mackey
Maine Atlantic Salmon Commission, Jonesboro, Maine

Atlantic salmon (*Salmo salar*) in Maine occupy the southern extent of their range in North America. Therefore, salmon in Maine routinely experience warmer water temperatures than are reported in the literature for the upper limits of feeding and growth. We conducted a pilot investigation of the *in situ* feeding behavior of juvenile salmon across various water temperatures. Snorkeling observations of feeding strikes in relation to water temperature were made on unmarked Atlantic salmon young-of-the-year and parr in Northern Stream and Old Stream, Maine. Observations were made from 25 June to 6 August, 2005. During this time the water temperatures ranged between 17 and 23°C. Feeding strikes were recorded during timed observation events, and later converted into strikes per minute. No cessation or slowdown in foraging activity was observed across the range of temperatures in this study, and in fact, juvenile salmon were actively feeding beyond the maximum reported feeding temperature of 22.5°C. This suggests that these fish may be adapted to warmer water temperatures. Identifying the temperature ranges for feeding and growth is essential to understanding the role water temperature plays in limiting Atlantic salmon populations in Maine.

Atlantic salmon, smallmouth bass, and restored habitat in Kenduskeag Stream, Maine

Peter Ruksznis and Joan Trial
Maine Atlantic Salmon Commission, Bangor, ME

Two separate projects on Kenduskeag Stream are presented. The first addresses temporal effectiveness of electrofishing removal of smallmouth bass from juvenile Atlantic salmon habitat. In 2002 smallmouth bass were removed from seven sites distributed throughout the drainage. Electrofishing removal was found to be moderately effective in reducing smallmouth bass numbers in juvenile habitat. The second project was to stock fall parr from Green Lake National Fish Hatchery following minimal habitat restoration of an area where dairy cows had eroded the riverbanks and destroyed the riparian buffer. The first steps in stream habitat restoration were fencing out the cows (accomplished in 2000) and replacing a reduced hydraulic opening bridge with one that spanned greater than bankfull width (completed in 2004). The study area is the highest quality salmon habitat in the upper portion of the Kenduskeag Stream drainage, with cool water temperatures, good physical natural habitat, and suitable water chemistry. Two 50-unit reaches, a control area upstream of the bridge, and the cow loafing area downstream of the bridge were stocked in fall 2003, 2004, and 2005. A varying portion of the parr either died or left the area, presumably emigrating as smolts (size dependent). While habitat changed as a result of the fencing and bridge replacement, the outcome of the removal of the cows has had the greatest impact on riparian habitat recovery. The degraded area has not supported the same densities of stocked parr as the control site. The degraded area has more run habitat, slower velocity and shallower water depth than the control site, limiting carrying capacity. Further restoration is needed to increase the carrying capacity of the degraded area. However, parr grew at nearly the same rate throughout the study area.

2008 Research Forum
Maine Atlantic Salmon and their Ecosystems
8-9 January 2008
D.P. Corbett Business Building
University of Maine, Orono

Program

Tuesday, January 8

8:00 a.m. *Registration, coffee*

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

Session 1
Gail Wippelhauser, Moderator
Maine Department of Marine Resources
Bureau of Sea Run Fisheries and Habitat

8:40 a.m. **Coordinating local habitat restoration initiatives with Atlantic salmon habitat databases: How to make sure we're fixing the right stuff**
Kenneth Beland and Steven Koenig

9:00 a.m. **Driving tips from the Hatchery Review**
Joan G. Trial

9:20 a.m. **Managing Atlantic salmon in Ireland – a case study on the River Shannon**
Lorraine O'Donnell and Eamon Cusack

9:40 a.m. **Penobscot River Multi-Species Management Plan: Does multispecies mean ecosystem-based?**
Melissa Laser, Rory Saunders, Timothy Sheehan and Tara Trinko

10:00 a.m. **Effect of slimy sculpin on juvenile salmon survival and density dependence**
Darren M. Ward, Keith H. Nislow and Carol L. Folt

10:20 a.m. *Break*

Session 2
Tim Sheehan, Moderator
NOAA's National Marine Fisheries Service
Northeast Fisheries Science Center

10:40 a.m.	**Large wood in Maine rivers and juvenile Atlantic salmon population densities and habitat use** **Gregory Mackey**, Francis Magilligan, Keith Nislow, Burch Fisher, Jed Wright, Melissa Laser and Ernie Atkinson
11:00 a.m.	**Effects of hydroelectric dams on survival and behavior of migrating Atlantic salmon smolts in the Penobscot River, Maine** **Christopher Holbrook**, Joseph Zydlewski and Michael Kinnison
11:20 a.m	**Habitat effects on resident brook trout persistence** **Benjamin Letcher**, Keith Nislow, Jason Coombs, Matthew O'Donnell and Todd Dubreuil
11:40 a.m.	**Managing the impacts of double-crested cormorant predation on endangered Atlantic salmon smolts** **James P. Hawkes**, Rory Saunders and Adam Vashon
12:00 p.m.	**Monitoring the infective pressure of *Lepeophtheirus salmonis* (Krøyer 1837) on wild salmonid populations in Scotland** Cambell C. Pert, Katy Urquhart, Paul Cook, Una McCarthy, Alastair McBeath, Judy Simons, Sonia McBeath, Rachel Kilburn and **Ian R. Bricknell**
12:20 p.m.	*Lunch*

Session 3
Christine Lipsky, Moderator
NOAA's National Marine Fisheries Service
Northeast Fisheries Science Center

1:20 p.m.	**Planting Atlantic salmon eggs with a new hydraulic planter** **Paul M. Christman**, Daniel McCaw and Jason Overlock
1:40 p.m.	**Nutrient restoration using Atlantic salmon carcasses in Scottish Highland streams** **Keith H. Nislow**, Brian P. Kennedy, John D. Armstrong and Keith H. Williams

2:00 p.m. **Observations of bedload sediment transport in Maine rivers: Implications for Atlantic salmon habitat restoration**
Noah P. Snyder, Michael R. Castele and Jed R. Wright

2:20 p.m. **Assessment of rotary screw trap environmental conditions and sampling effects on emigrating Atlantic salmon smolts**
Paul A. Music and James P. Hawkes

2:40 p.m. **Stable isotopic composition of otoliths in identification of hatchery origin of Atlantic salmon (*Salmo salar*) in Maine**
David Bean and Yongwen Gao

3:00 p.m. **Blue mussel (*Mytilus edulis*): a natural ISA vaccine factory?**
Cem Giray, Victoria Bowie, Wei Young-Lai and Brian Glebe

3:20 p.m. *Break and* **Poster Session**
Soderberg Lobby in Jenness Hall

Wednesday, January 9

8:00 a.m. *Coffee*

Session 4
Dan McCaw, Moderator
Maine Department of Marine Resources
Bureau of Sea Run Fisheries and Habitat

8:30 a.m. **Evidence for acidification as a causative factor in the decline of Atlantic salmon in eastern Maine**
Stephen D. McCormick, John T. Kelly, Michelle Monette and Trent Liebich

8:50 a.m. **Initial findings on multiple stressor effects in early life stage Atlantic salmon (*Salmo salar*): blueberry pesticides, acid, aluminum**
Adria A. Elskus and Crista Straub

9:10 a.m. **Evidence of water quality enhancement of Crooked River due to roadbed applications of crushed limestone adjacent to the stream**
Mark C. Whiting and Stephen Koenig

9:30 a.m. **Result of selective pressures measured by otolith characteristics of newly released, hatcheryraised Atlantic salmon fry**
Michael Bailey and Michael Kinnison

9:50 a.m. **Long-term seawater performance and scale circuli deposition of Atlantic salmon smolts**
Gayle Zydlewski, Joseph Zydlewski and Sheena Lashua

10:10 a.m. **Annual movement and migration patterns of Atlantic and shortnose sturgeons in the Penobscot River, ME**
Steven Fernandes, Gayle B. Zydlewski and Michael T. Kinnison

10:30 a.m. *Break*

Session 2
Michael Kinnison, Moderator
University of Maine
School of Biology and Ecology

10:50 a.m. **Upstream migration by *Salmo salar* hatchery fry in four Downeast streams**
Michael Loughlin

11:10 a.m. **Comparison of migratory urge and gill N^+, K^+-ATPase activity of Atlantic salmon (*Salmo salar*) smolts from Dennys River and Penobscot River stocks**
Randy Spencer, Joseph Zydlewski and Gayle Zydlewski

11:30 a.m. **Survival and life history variation of Atlantic salmon in Shorey Brook, Maine**
Michael Bailey and Michael Kinnison

11:50 a.m. **Feeding ecology of Atlantic salmon postsmolts in Penobscot Bay, Maine: Rearing origin matters**
Mark D. Renkawitz and Timothy F. Sheehan

12:10 p.m. **Sonic tracking of smolts from Canadian rivers across the Gulf of St. Lawrence to the Strait of Belle Isle**
Fred Whoriskey

12:30 p.m. **Closing**
John Kocik
NOAA's National Marine Fisheries Service
Northeast Fisheries Science Center

Poster Session
Jenness Hall, Soderberg Lobby

Diadromous Species Restoration Research Network (DSRRN): a new five-year collaborative effort
David Hart, Karen Wilson, Peter Vaux and **Adria Elskus**

Measuring sedimentation rates and land-use change in a dam-influenced lake delta: Narraguagus River, Maine
Alan Kasprak, Noah P. Snyder, Ilya V. Buynevich and Elizabeth A. Johnson

Water temperature changes in canopy-lined riparian habitat at four Distinct Population Segment utility crossings
Michael Loughlin

Survey of northwestern Atlantic fishes for salmonid viral pathogens
Sharon A. MacLean, Cem Giray and Stephen K. Ellis

Contaminant assessment of white suckers from eight rivers in the Gulf of Maine Distinct Population Segment for Atlantic salmon
Steven E. Mierzykowski

Depth, behavior and survival of emigrating Atlantic salmon (*Salmo salar*) postsmolts in Penobscot Bay, Maine
Mark D. Renkawitz, Timothy F. Sheehan and Graham S. Goulette

Comparison of channel morphology in two Atlantic coastal streams: Implications for Atlantic salmon habitat – preliminary results and analysis
Benjamin C. Wilkins and Noah P. Snyder

ABSTRACTS
ORAL PRESENTATIONS

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

Coordinating local habitat restoration initiatives with Atlantic salmon habitat databases: *How to make sure we're fixing the right stuff*

Kenneth Beland and Stephen Koenig
Project SHARE, Eastport, ME

Project SHARE (Salmon Habitat and River Enhancement) has been conducting an active program to assess and correct habitat degradation on private lands occurring in the five so-called 'Downeast Salmon Rivers" (Dennys, East Machias, Machias, Pleasant, and Narraguagus rivers). These five watersheds are included within the Gulf of Maine Distinct Population Segment designated by federal resource agencies. SHARE maintains a database containing more than 800 locations where potential habitat degradation has been documented, and documents measures to address issues identified during field surveys. Among many ongoing activities, SHARE is implementing a program to assess and correct habitat connectivity and fish passage deficiencies at stream crossings associated with the extensive logging road networks that occur in these watersheds. Improving the capacity to use these location data in conjunction with resource agency habitat and resource assessment datasets has become a priority for SHARE, in order to direct limited habitat restoration funds to areas most likely to improve habitat conditions for Atlantic salmon. Despite increasingly widespread use of an electronic database and GIS for information management, much progress remains to be made to realize seamless coordination of datasets originating from various sources. Frequently encountered barriers to data communication include: data confidentiality issues, incompatible data formats, inconsistent stream and town naming conventions, lack of unique record identifiers, and others. Ultimately, SHARE wishes to participate in coordinated habitat enhancement efforts that transcend single issue projects and address aquatic habitat quality and connectivity within focused areas having the greatest potential to benefit Atlantic salmon in Maine.

Session 1 ***9:00 a.m.***

Driving tips from the Hatchery Review

Joan G. Trial
Maine Department of Marine Resources, Bureau of Sea Run Fisheries and Habitat, Bangor, ME

The Hatchery Review team made a point about changing the drivers of recovery for the Maine program. Specific quotes include "*Hatchery supplementation should follow, not drive, recovery*" and "*Hatchery evaluation should not be viewed as research but as a core element of the Recovery Program. Accordingly, it is important to integrate scientific assessment advice into decisions regarding hatchery production and release schedules*." Past stocking requests have been for a number of fish of a given life stage. Except that fish meet New England Fish Health standards, managers were not explicit about fish quality, developmental maturity, or about matching development to stocking timing. Hatchery practices, history, and economics drove the product and delivery date. It is necessary to refine requests for hatchery products so that recovery goals drive hatchery production. The Bureau of Sea Run Fisheries and Habitat has started a process to facilitate a change. Teams for each life stage (fry to smolt) have been established to: 1) review the literature on survival of hatchery products related to measurable characteristics of "fish quality" and evaluate past stocking performance of current hatchery products in Maine; 2) determine which requests to the Craig Brook National Fish Hatchery or Green Lake National Fish Hatchery may be appropriate for quality of fish; 3) prepare a request and justification in a written "White Paper" that highlights changes from the current product and develop an evaluation of the product. The measurable quality traits likely will vary by life stage and be linked to rearing regime and hatchery practices. Effective management of hatchery products also involves understanding environmental variability, so target dates are year-specific not calendar-specific. Answers to questions that will help refine stocking timing will also be in the literature and in data from past program practices.

Session 1 ***9:20 a.m.***

Managing Atlantic salmon in Ireland – a case study on the River Shannon

Lorraine O'Donnell and Eamon Cusack
Shannon Regional Fisheries Board, Limerick, Ireland

The river Shannon is the largest river in Ireland measuring over 380 km long with a 70-km estuary and yet it doesn't have a sustainable stock of wild Atlantic salmon. Only two sub-catchments are currently reported as capable of sustaining an exploitable salmon population – the rivers Mulkear and Feale. In 2007, the Irish government decided to ban mixed stock fishing for Atlantic salmon. For Ireland as a whole, this meant no drift net fishing was permitted at sea, and cessation of any drift net fishing where mixed stocks were intercepted. In addition to the closure of commercial fisheries, rivers were either closed for salmon fishing or severe restrictions were placed on angling. The Shannon system is a mixed fishery holding large stocks of pike, perch, rudd, roach and bream. Ireland's largest hydroelectric power scheme operates a dam with a boran fish lift on a bypass channel at the upper tidal limit of the fishery. Various low head hydro schemes are also present in the catchment and are now being upgraded due to a switch to "greener" energy supplies. Water quality and habitat degradation continue to be major issues facing the protection of salmon in the juvenile stages. Fish counters have become an invaluable tool to fishery managers in accessing the status of the adult populations, and 2007 has seen dramatic increases in the numbers of salmon returning to our rivers. So what lies ahead now for the fishery manager with a limited capital budget? The Shannon Regional Fisheries Board are involved in many projects, such as: Development of a partnership model with the state agency, fishery owner and angling clubs; Creation of a committee and technical group, that includes the country's top scientists, to advise on strategies to restore salmon populations to the upper catchment; Participation in the steering group which is implementing the European Union Water Framework Directive (*2000/60/EC*); Rehabilitation of spawning and nursery streams through provision of technical assistance to various bodies including NGO's. One year on, we have made considerable progress, but a lot more is required. This won't happen overnight. Fishery managers need to plan for the long term, i.e., 5-10 years.

Reference:

Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy.

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

Penobscot River Multi-Species Management Plan: Does multispecies mean ecosystem based?

Melissa Laser[1], Rory Saunders[2], Timothy Sheehan[3] and Tara Trinko[2]
[1]Maine Department of Marine Resources, Bureau of Sea Run Fisheries and Habitat, Hallowell, ME; [2]NOAA's National Marine Fisheries Service, Protected Resources Division, Orono, ME; [3]NOAA's National Marine Fisheries Service, Northeast Fisheries Science Center, Woods Hole, MA

The Penobscot River Restoration Project (PRRP) offers some unique opportunities to reconnect the native diadromous species with historic habitats and restore the concomitant ecological functions of the native diadromous suite. In particular, alewives are presently absent from the drainage with the exception of two tributaries of the Penobscot Estuary (Souadabscook Stream and the Orland River). While the PRRP will substantially improve passage conditions in the Penobscot Basin, it is in no way a "silver bullet." There are roughly 100 small dams and other fish passage barriers in the Penobscot Basin that will prevent some species from accessing historic habitats after the implementation of the PRRP. Thus, many other passage impediments will need to be addressed in order to realize the full potential of the PRRP. In order to begin to prioritize restoration efforts following implementation of the PRRP, the Maine Department of Marine Resources, Maine Department of Inland Fisheries and Wildlife, and NOAA's National Marine Fisheries Service have begun evaluating ways to prioritize restoration efforts. This effort, the Penobscot River Multi-Species Management Plan, includes four strategic goals: (1) coordinating management activities, (2) providing safe and effective upstream and downstream passage for diadromous and native freshwater fishes, (3) maintaining or improving abiotic (physical) and biotic habitat for diadromous and selected resident fishes, and (4) using adaptive ecosystem based management. An interagency Penobscot Fisheries Committee will develop an operational plan that details how these goals will be achieved as passage to habitat becomes available.

Session 1 ***10:00 a.m.***

The effect of slimy sculpin on juvenile salmon survival and density dependence

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The effects of slimy sculpin (*Cottus cognatus*) on survival of stocked Atlantic salmon (*Salmo salar*) in the Connecticut River basin were evaluated. In field sampling across salmon stocking sites, survival of salmon during the first summer declined with increased sculpin density, but salmon survival was not affected by any other fish species. Stomach sampling showed that sculpin preyed on newly stocked salmon fry. In 2005 and 2006, we conducted manipulative field experiments to determine how sculpin affect salmon density-dependent survival. Salmon fry were stocked at three population density treatments in three streams with sculpin and in three streams without sculpin (density treatments blocked within streams, 18 sites total). Mean salmon survival was three-fold higher in streams without sculpin (18±3%) than in streams with sculpin (6±2%). Furthermore, sculpin reversed the direction of density dependence for juvenile salmon survival. Salmon survival was highest at low stocking density in streams without sculpin, while salmon survival was highest at the highest stocking density in streams with sculpin. The results show that spatial variation in fish community characteristics influences salmon population dynamics and has important implications for management strategies such as determining optimal stocking densities.

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

Large wood in Maine rivers and juvenile Atlantic salmon population densities and habitat use

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Maine streams have large wood loads far below predicted levels, and notably low compared to other parts of the United States. Although extensive research has been done on the relationship between Pacific salmonids and wood, relatively little is known about the role wood plays in influencing juvenile Atlantic salmon populations. Two hypotheses were tested in Old Stream, Maine, via snorkel survey in sites with naturally occurring high and low wood densities: 1) the density of juvenile Atlantic salmon was higher in sites that contained high as opposed to low loading of wood, and 2) where wood was available, juvenile salmon tended to be associated with it within a site. Results showed that age 1+ or older juveniles were at significantly higher densities in sites with high wood loading, but substrate coarseness was a more important factor. In addition, a significant proportion of both age 0+ and older juveniles were associated with wood in sites where it was available. However, this association also interacted with substrate coarseness and weed cover. These findings suggest that wood is an important habitat feature for juvenile Atlantic salmon, but cannot be viewed in isolation of other habitat factors. This work supports the need for greater understanding of the relationship between Atlantic salmon and wood in rivers.

Session 2 ***11:00 a.m.***

Effects of hydroelectric dams on survival and behavior of migrating Atlantic salmon smolts in the Penobscot River, Maine

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Survival and behavior of migrating hatchery (n=493) and naturally reared (n=133) Atlantic salmon (*Salmo salar*) smolts were evaluated in 2005 and 2006 through the Penobscot River and estuary in Maine using acoustic telemetry. Mortality, movement rates, and use of a secondary migration path (the Stillwater Branch) were quantified. River sections containing three main stem dams (Howland, Milford and West Enfield dams) accounted for 43% and 60% of total losses for 2005 and 2006, respectively, though these sections accounted for only 16% and 6% of monitored reaches. Survivorship through sections with dams ranged from 95-100% and 71-100% in 2005 and 2006, respectively. Movement rates were significantly slower at dams compared to free-flowing reaches, and smolts arriving at dams during the day experienced longer delays than smolts arriving at night. Use of the Stillwater Branch by individual release groups 1) ranged from 0-26% and 0-19% in 2005 and 2006, respectively, 2) was significantly lower for groups released in a tributary compared to the main stem, and 3) was positively associated with river discharge. As part of the Penobscot River Restoration Project, the planned removal of two dams is expected to enhance passage through the main stem corridor for salmon and other migratory fish. However, this study demonstrates that the two dams scheduled for removal (Great Works and Veazie dams) had little effect on smolt survival and highlights the need to improve passage at the Milford, Howland and West Enfield dams, as well as at facilities in the Stillwater Branch, where more smolts are likely to pass after hydrosystem changes are implemented.

Session 2 ***11:20 a.m.***

Habitat effects on resident brook trout persistence

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To determine habitat effects on persistence of brook trout populations, the effects of habitat fragmentation among stream reaches and of habitat structure within a stream reach were estimated. Direct estimations were made of size-specific dispersal, growth, and survival of stream-dwelling brook trout in a stream network with connected, as well as naturally isolated, tributaries. Growth and survival differences were estimated between fish living in pools as compared to fish living in riffles. Multigeneration, individual-based data were used to develop and set parameters for a size class and location (or habitat)-based population projection model, allowing for testing effects of habitat structure on population dynamics at local (i.e., subpopulation) and of habitat fragmentation on local and system wide (i.e., meta-population) scales. Demographic rates which influence the persistence of isolated and fragmented populations were identified. In the naturally isolated tributary, persistence was associated with higher early juvenile survival (~45% greater), shorter generation time (one-half) and strong selection against large body size as compared to the open system, resulting in a stage distribution skewed towards younger, smaller fish. Simulating barriers to upstream migration into two currently connected tributary populations caused rapid (2- 6 generations) local extinction. These local extinctions in turn increased the likelihood of system wide extinction, as tributaries could no longer function as population sources. Within stream reaches, average yearly survival was 5% higher for fish in pools as compared to riffles, but was up to two-fold higher for large fish (>135 mm). In contrast, there was no difference in body growth for fish in pools compared to fish in riffles. Thus, variation in habitat structure will influence population persistence by influencing survival, but not body growth. For both analyses, large fish had disproportionately large effects on population persistence, suggesting that it will be particularly important to protect large fish from harvest in stressed systems (fragmented or low pool density).

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

Managing the impacts of double-crested cormorant predation on endangered Atlantic salmon smolts

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Atlantic salmon (*Salmo salar*) smolts are exposed to intense predation pressure as they migrate from freshwater into estuarine and nearshore marine environments. During this period, double-crested cormorants (*Phalacrocorax auritus)* are a significant predator of Atlantic salmon smolts. To assess whether cormorant predation rates could be reduced, cormorant harassment activities were undertaken in 2004 and 2005 using various pyrotechnic, laser, and human/boat activities. These endeavors effectively displaced cormorants from feeding locations and effectively lowered predation on emigrating smolts in the Narraguagus River, Maine.

Session 2 ***12:00 p.m.***

Monitoring the infective pressure of *Lepeophtheirus salmonis* (Krøyer 1837) on wild salmonid populations in Scotland

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There is controversy concerning the distribution of salmon lice (*Lepeophtheirus salmonis*) within sea lochs. Some authors suggest there are low numbers of sea lice in the marine regions of a sea loch and that *L. salmonis* infection occurs under conditions of full salinity. Low numbers of lice then infect their host and gradually reach peak infection levels with time. A second model proposes that salmon lice gather at river mouths during the spring and early summer, and infect during a large single settlement event in low salinity waters. The aim of this research is to establish (i) where within the Loch Torridon system infestation with *L. salmonis* occurs, (ii) seasonal variation in infectious pressure, and (iii) whether copepodid, pre-adult or adult stages are responsible for infesting the host. Sentinel cages were located in Loch Shieldaig in a tidal exchange zone between Loch Torridon and the open sea, positioned to correspond to migration patterns of salmonids, tidal currents and to allow easy access. Fifty Atlantic salmon were introduced at each station for 7 days at monthly intervals, and environmental parameters, including plankton, temperature, salinity, and current speed and direction were recorded. After exposure to lice infectious pressure in the loch, the species and number of lice at each developmental stage were recorded. Data from Mar 2006 through Sep 2007 showed the majority of lice were at the copepodid stage. The mean number of lice per fish showed a continual increase throughout the study period even when the numbers of lice on adjacent salmon farms had been very low. There were low numbers of mobile *L. salmonis* stages within the loch from spring to early summer, which increased throughout the winter and following spring, with no winter decline in lice numbers as previously reported. Infection was initiated by copepodid and pre-adult stages. Adult salmon lice play a minor role in establishing infection. In addition, a survey of the *L. salmonis* burdens of returning sea trout (*S. trutta*) was conducted over three years (2005-2007), comparing the Scottish east and west coast populations. Over 350 returning sea trout were caught and sea lice burdens established. This is a direct comparison between the lice burdens of wild salmonids in an area with high farming activity (west coast) and low farming activity (east coast). In this part of the study, the highest lice burden was found on east coast fish (7.8 lice/fish) compared with only 3.3 lice/fish on the west coast of Scotland. This complex result suggests that the decline in sea trout on the west coast of Scotland may not be due to increased sea lice burdens. Instead, sea lice form part of a complex, multifactoral problem and the reasons behind the decline in Scottish west coast sea trout remains poorly understood.

Session 3 ***1:20 p.m.***

Planting Atlantic salmon eggs with a new hydraulic planter

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In the past several years, Maine Department of Marine Resources has made several advances in utilizing green and eyed eggs for population enhancement of Atlantic salmon (*Salmo salar*). Green eggs have been found to be difficult to move due to handling shock. However, both green and eyed eggs have been successfully transported and buried in artificial redds in the Sandy and Sheepscot rivers. In the most recent study, efforts have been made to overcome the logistics of burying eggs in the gravel while minimizing mortality. In the 2006/2007 project eggs were buried using a newly developed hydraulic egg planter that utilizes a water stream to drill into the substrate and deposit eggs. Green and eyed eggs were buried using the new planter on the Sandy River and eyed eggs on the Sheepscot River. Fry trapping results indicate that the new planter successfully deposited eyed eggs and produced juveniles. Emergence rates were 43.6%, 33.8% and 10% for three artificial redds on the Sandy River and 10.4%, 1.3% and 0.53% for three artificial redds on the Sheepscot River. Green eggs did not develop on the Sandy River, most likely due to handling. Also, fry were trapped from three natural redds produced by released pre-spawn adults; emergence rates estimated from a range of fecundity were 8.9% -10.1%, 8.4% - 9.9% and 0%. Overall, the new planter worked very well given that juveniles were produced. Observations indicate that large enough numbers of eggs can be planted in a reasonable time frame to make it possible to use for watershed scale supplementation.

Session 3 ***1:40 p.m.***

Nutrient restoration using Atlantic salmon carcasses in Scottish Highland streams

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It has long been known that an excess of nutrients can degrade freshwater ecosystems and fish habitat. However, in some situations human activities can reduce nutrients below expected levels and negatively affect fish production. In this study, nutrients (in the form of adult Atlantic salmon carcasses) were restored to salmon rearing streams in the Conon River basin, northeastern Scotland, in order to determine impacts on aquatic food webs and juvenile salmon production. Carcasses were extensively colonized by aquatic macroinvertebrates, and salmon-derived nutrients were readily incorporated into periphyton, macroinvertebrates, and juvenile salmon, in some cases at considerable distance from carcass addition locations. Juvenile salmon and macroinvertebrate biomass was significantly greater in carcass-addition site as compared to reference sites. These results suggest that nutrient limitation of production should be considered in habitat management plans, and that migratory salmon may play an important role in the nutrient dynamics of small oligotrophic streams.

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

Observations of bedload sediment transport in Maine rivers: Implications for Atlantic salmon habitat restoration

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Atlantic salmon spawning and rearing success partially depends on substrate habitat quality, which is influenced by grain size (median, D_{50} = 16-256 mm) and mobility. The ability of a given stream reach to transport coarse bedload controls whether it is embedded or armored. Historical land use changes in Maine may have altered channel geometry, resulting in changed frequency of substrate mobilizing events. Future adjustments in channel geometry and habitat quality (via natural stream processes or restoration projects) depend on erosion, transport and deposition of sediment. We present results from monitoring of coarse bedload transport using marked particles at one site on the Narraguagus River (December 2005-June 2007) and at three sites in the Sheepscot River watershed (July 2006-June 2007). All four sites are mapped as salmon spawning and/or rearing habitat, and we monitor two cross sections at each. The greatest observed bed reorganization occurred in winter/spring of 2006/2007, which included a significant flood event in April [recurrence interval (RI) ~9 yr on the Sheepscot River and ~5 yr on the Narraguagus River]. During this period, two of the three sites in the Sheepscot watershed exhibited significant particle mobility (40-75% of all marked particles), and the third had modest mobility (~15%). This contrast in mobility is likely due to differences in local channel morphology (slope, flow depth, width), and upstream sediment mobility and supply from eroding glacial deposits. The Narraguagus River reach had significant mobility during the winter-spring 2005-2006 period (~40%; including a RI ~2 yr flood) and the winter-spring 2006-2007 period (50-67%). We cannot separate the effects of ice rafting processes from those of floods, but the similarity in mobility during the two winters suggests that ice is likely an important influence on bedload transport processes. These results suggest that the frequency of bedload transport is reach specific, depending on factors including local channel geometry, upstream sediment supply and transport, and formation of frazil ice. This underscores the importance of conducting reach-scale studies of present channel conditions as a prerequisite for habitat restoration projects. This analysis holds the potential for refining watershed- and reach-based Atlantic salmon productivity models.

Session 3 ***2:20 p.m.***

Assessment of rotary screw trap environmental conditions and sampling effects on emigrating Atlantic salmon smolts

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Rotary Screw Traps (RSTs) are used to collect data on Atlantic salmon smolt production, migration timing, and run composition in several rivers in Maine. To better understand the possible environmental effects of using RSTs to sample smolts, water velocity and temperature conditions in RST live cars and rivers were monitored during the 2004 field season. Water temperature in the live cars ranged from 4.5°C to 20.8°C and was within 0.33°C of river water temperature 95% of the time. Water velocity in the live cars varied from 0 to 2.06 meters per second, and no stagnant water or excessive flows were recorded. Smolt mortalities in the RST live cars were extremely low (only 0.2% of the total catch) and were generally due to debris loading. The data indicated that environmental conditions inherent to RST live cars are unlikely to harm smolts. RSTs provide a low stress and safe environment for capturing Atlantic salmon smolts and other fishes, and most hazards are foreseeable and preventable. As such, RSTs should be considered a safe tool for sampling juvenile Atlantic salmon.

Session 3 ***2:40 p.m.***

Stable isotopic composition of otoliths in identification of hatchery origin of Atlantic salmon (*Salmo salar*) in Maine

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Stable isotope analyses of otoliths of Atlantic salmon (*Salmo salar*) were conducted in an attempt to develop a reference database on isotopic variability among various production hatcheries that support the Maine aquaculture industry and recovery of endangered Atlantic salmon populations. If successful, a diagnostic tool that can provide definitive information on identification of the hatchery origin could serve as a novel marking technique, and the chemical method may provide a low cost and more effective alternative to DNA analysis for mixed stocks. During the first phase of the study, 40-50 sagittal otoliths of juvenile Atlantic salmon were collected from each of the five Atlantic salmon production hatcheries in Maine and analyzed for stable isotope ratios ($^{18}O/^{16}O$ or $\delta^{18}O$, and $^{13}C/^{12}C$ or $\delta^{13}C$). By identifying stable isotopic variations of otoliths of Atlantic salmon from different hatchery settings, we were able to establish some isotopic criteria or standards to assign a likelihood that the origin of the cultured salmon was from a specific study hatchery. Combination of $\delta^{18}O$ and $\delta^{13}C$ values in otoliths showed that the five hatcheries can be clearly separated and chemically identified. The statistical results indicate that otolith samples can be correctly identified to a hatchery with higher than 88% correct classification for four hatcheries; one hatchery was slightly lower at 73% correctly classified. The data support the hypothesis that detectable differences between hatchery water sources can be detected within the otoliths of Atlantic salmon, and that isotopic separations among the five hatcheries appear to be well correlated with the different river systems or watersheds in which the hatcheries are located.

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

Blue mussels (*Mytilus edulis*): A natural ISA vaccine factory?

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Bivalve shellfish are routinely used as indicator species for human viral and bacterial pathogens due to their ability to concentrate these agents from the surrounding waters. While they have also been implicated as potential reservoirs of aquatic animal pathogens, previous work investigating infectious salmon anemia virus (ISAV) bioaccumulation by blue mussels (*Mytilus edulis*), a common fouling organism at marine Atlantic salmon (*Salmo salar*) grow-out sites, indicated some unexpected outcomes; not only was ISAV not concentrated by *M. edulis*, but its viability was reduced below that expected from mere degradation in seawater. Since the ability of ISAV to cause cytopathic effect in cell culture was significantly reduced following filtration by *M. edulis*, we examined whether its ability to cause disease in *S. salar* was also negatively affected. Naïve salmon were exposed by immersion to a virulent strain of ISAV processed through *M. edulis* and the survivors were subsequently challenged by injection with ISAV. Results showed that positive control treatments exposed to virus not filtered by *M. edulis* suffered heavy mortalities. Conversely, fish initially exposed to ISAV filtered through *M. edulis* showed significantly lower mortalities during both the immersion exposure and the injection challenge with virulent virus. ISAV processed through *M. edulis* appears to lose virulence, but retain sufficient structural properties to produce immune protection in *S. salar* from subsequent exposure to the virus.

Session 4 ***8:30 a.m.***

Evidence for acidification as a causative factor in the decline of Atlantic salmon in eastern Maine

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Acid precipitation has caused chronic acidification and extirpations of Atlantic salmon in Norway and Nova Scotia. The moderate buffering capacity of rivers in eastern Maine prevents chronic acidification, but these rivers do experience episodic low pH events. It was previously thought that Atlantic salmon were sensitive only to long term (several weeks) exposure to low pH. However, our recent laboratory studies demonstrate that even short term (2-6 days) exposure of smolts to pH 5.3 results in loss of seawater tolerance, impaired ion regulatory ability in fresh water and mortality at inorganic Al levels of 11, 42 and 55 µg/L, respectively. Preliminary data on pH and inorganic aluminum levels in an ongoing survey in eastern Maine indicate that these levels occur in many sites in eastern Maine. Compromised ion regulation of smolts reared in streamside tanks occurred in the main stem of the Narraguagus and Pleasant rivers when pH dropped below 5.5. Further, data from Norway provide direct evidence that compromised ion regulatory ability of smolts results in reduced adult return rates. Together these results provide strong circumstantial evidence that episodic acidification has been a contributing factor to the decline of Atlantic salmon and that this effect continues today.

Session 4 ***8:50 a.m.***

Initial findings on multiple stressor effects in early life stage Atlantic salmon *(Salmo salar*): Blueberry pesticides, acid, aluminum

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Rivers in Maine experience a broad range of stressors, including acidity, aluminum (Al), endocrine disrupting chemicals, organochlorines and pesticides, some of which may be present simultaneously. Exposure to multiple stressors can have effects on organisms that cannot be predicted from exposure to individual stressors alone (Relyea and Mills 2001). Blueberry pesticides, acidic water and Al combinations are present in some Downeast rivers, but their potential effects on resident Atlantic salmon (*Salmo salar*) are unknown. Additionally, alternative pesticides are being proposed to replace those currently used in Maine, and their effects on salmonids also are unknown. We hypothesized that combinations of acid/Al (AA) + pesticides would have stronger sublethal effects on early life stage salmon than either stressor alone. The study objectives were to determine whether pesticide-contaminated, AA rivers pose a greater threat to salmon than pesticide contaminated rivers alone, and to provide data on the potential effects of candidate pesticides on sensitive early life stages before these pesticides come into use. We exposed F2 Penobscot River Atlantic salmon swim up fry to the current use herbicide formulation, Velpar™ (active ingredient hexazinone), or its proposed alternative, Callisto™ (active ingredient mesotrione), at environmentally realistic concentrations (0.75 ppb a.i.) and at concentrations ten fold higher (7.5 ppb a.i.), in the presence and absence of high acidity (pH = 3.9 - 5.2) and elevated inorganic (toxic) aluminum (254-724 ppb). To better mimic real world conditions in which dissolved organic carbon significantly affects the availability of toxic aluminum, dosing solutions were made up in Machias River water (DOC = 7.2 mg/L). Fish were exposed for 5 days in a flow-through system at 14°C. Survival, prey capture and immune function were evaluated. Pesticide treatment alone had no effect on survival relative to untreated controls, but AA treatments significantly reduced survival. Of the four multistressor (pesticide +AA) groups, three sustained mortalities significantly higher than those of the AA control. However, it is likely that the dramatic drop in pH on day 2 (pH 3.8-4.3 across all acid/Al treatments), rather than a multistressor effect, drove this difference in mortality. High variability masked potential treatment effects on prey capture. Immune function assays were inconclusive. The results indicate that blueberry pesticide effects on prey capture and survival may increase in the presence of acid/Al, but high variability among replicates, and the dramatic drop in pH on day 2, confounds interpretation of the data. Studies with additional endpoints and replicates are planned.

Reference:
Relyea RA, Mills N. 2001. Predator-induced stress makes the pesticide carbaryl more deadly to gray treefrog tadpoles (*Hyla versicolor*). Proc. Nat. Acad. Sci. USA 98: 2491-2496.

Session 4 ***9:10 a.m.***

Evidence of water quality enhancement of Crooked River due to roadbed applications of crushed limestone adjacent to the stream

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Episodic acidification of the Downeast salmon rivers during high stormwater flows has been an on going concern relative to the restoration of Atlantic salmon. Experimental limestone applications to add stream buffering capacity was identified as a high priority project by the Project SHARE (Salmon Habitat and River Enhancement) Research Committee. To date, we have not added limestone directly to rivers. However, Maine Dept. of Environmental Protection has determined that limestone can be added to terrestrial infrastructure (road surfaces, roadside ditches, bridge abutments, etc.) without water pollution discharge permits. In May of 2007, crushed limestone gravel was added to the 52 00 0 logging road on a 300 foot long slope on the north side of the bridge over the Crooked River, a second order stream and tributary to the Machias River. The stone was added to improve roadbed traction and to reduce erosion. During rainstorms, runoff has been observed to flow down the sloped roadway into the Crooked River, and the potential addition of carbonate buffering to the river was an anticipated benefit of using limestone. A comparison of before and after treatments above and below the bridge show that stream pH has been less extreme below the bridge after the treatment. During Hurricane Noel (beginning on November 3, 2007), the pH above the bridge went as low as 5.0; below the bridge the pH remained above 5.5. The data indicate that terrestrial limestone applications can affect the chemistry of stormwater runoff and can enhance buffering capacity of a second order stream.

Session 4 ***9:30 a.m.***

Result of selective pressures measured by otolith characteristics of newly released, hatchery raised Atlantic salmon fry

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Atlantic salmon (*Salmo salar*) restoration efforts in Maine employ fry stocking as one of the primary population enhancement strategies. Some characters, such as large size or fast growth, are often thought to correlate with high survival in the wild. However, there are few data on the survival of newly stocked Atlantic salmon fry based on these characters. Hatchery rearing may reduce mortality in newly hatched fry, but natural selection may act strongly on stocked fry after they are released into the wild. These resulting survival patterns can be examined by reconstructing attributes of fry biology at stocking using characteristics of growth rings in otoliths. For this study, otoliths (sagittae) were compared from newly released fry with otoliths from stocked fry residing in the wild for 30 to 60 days. Developing a relationship between fry biology and otolith characteristics for newly hatched Atlantic salmon may well be an important tool for describing selective mortality at early life stages.

Session 4 ***9:50 a.m.***

Long term seawater performance and scale circuli deposition of Atlantic salmon smolts

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Penobscot strain Atlantic salmon were held in saltwater for up to four months to examine the relationship between growth and survival to gill Na^+, K^+-ATPase activity levels and determine scale circuli deposition rates. In May 2006, 940 salmon smolts from Green Lake National Fish Hatchery were analyzed for their freshwater gill Na^+, K^+-ATPase activity levels. Individuals were classified as having “low”, “medium”, or “high” levels based on the normal distribution of activities observed on the day of gill collection (10 May). All individuals were transferred isothermally to full strength seawater and maintained on photoperiod and temperature regimes similar to what they would normally experience during their migration from the Penobscot River to the Labrador Sea. Fish scales were taken and size (fork length and weight) was recorded on days 1, 3, 14, 44 and monthly for four months. Fish grew throughout the experiment, but fish size, growth rate, and gill Na^+, K^+-ATPase activity in saltwater did not differ among freshwater ATPase groups. Scale circuli spacing was greater when the salmon were in saltwater (than when in freshwater in the hatchery). It took approximately two weeks to deposit a single circulus in saltwater, compared to 11 days while in freshwater. Scale circuli deposition rates from this study can be used to approximate ages of adult Atlantic salmon returning to freshwater rivers. Based on this laboratory experiment, it is unlikely that small scale variation in gill Na^+, K^+-ATPase activity is predictive of long-term performance (measured as survival and growth) in seawater.

Session 4 ***10:10 a.m.***

Annual movement and migration patterns of Atlantic and shortnose sturgeons in the Penobscot River, ME

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

The status of Atlantic and shortnose sturgeon populations in the Penobscot River of Maine are currently unknown yet vital to protection of these at risk species. In this study we have begun to assess abundance, distribution, and movements of adult and subadult Atlantic and shortnose sturgeons in this river system. In 2006 and 2007, we sampled for sturgeon using multifilament nylon gillnets set on the bottom of the river and estuary in likely habitat. We recorded the length, weight and morphometric measurements from all individuals and assessed their sex and reproductive status. All individuals were implanted with an external numeric tag and internal 124 kHz Passive Integrated Transponder tag, and a subset of individuals were tagged with ultrasonic transmitters to allow us to track the movement via active tracking and a large acoustic receiver array in the river and bay. In this presentation, we consider Atlantic and shortnose sturgeon movement patterns through the summer, fall, and winter of 2006 and the spring and summer of 2007. In particular, we discuss patterns of seasonal movements associated with foraging, overwintering, and spawning habitat use. Our results not only provide management agencies with a better idea of the status and ecology of Atlantic and shortnose sturgeon in a portion of their range that is understudied, but also highlight critical habitat and associated risks to sturgeon in this system.

Session 5 ***10:50 a.m.***

Upstream migration by *Salmo salar* hatchery fry in four Downeast streams

Michael Loughlin
Maine Department of Marine Resources, Bureau of Sea Run Fisheries and Habitat, Jonesboro, ME

Point stocking of Atlantic salmon fry is a routine fisheries practice. Numbers of fry stocked at points are calculated based on desired stocking densities. When point stocking fry on tributary streams from access roads and trails, frequently there are substantial lengths of inaccessible suitable habitat upriver of the access points. Information on upstream movement of fry is valuable to predict if habitat upriver of the crossing can be expected to be used by fry or parr. If upstream habitat is used by fry, then that habitat area should be used to calculate the estimated number of fry to be stocked. Upstream migration of fry is noted in Masu salmon fry (Nagata and Irvine 1997) and in Atlantic salmon parr (Erekinaro and Gibson 1997). Observations of Maine Bureau of Sea Run Fisheries and Habitat researchers suggest upstream migration of Atlantic salmon fry (Atkinson 2006, comm.) but are confounded by fry stockings 5.5 and 6.5 kilometers upriver, as well as by potential unobserved "wild" redds in the vicinity. Fry movement of *Salmo salar* downstream to 2,000 meters is documented (Atkinson 2006, comm.) and was used as an anticipated downstream movement distance. Two tributaries of the Machias and East Machias rivers were examined with a CPUE electrofishing technique. Transects equidistant above and below the stocking point were chosen and sampled up to a distance of 500 meters approximately 4 months post stocking. This preliminary study found evidence of upstream migration of fry to 100 meters at all locations and up to 500 meters above the stocking point at one location.

References:

Atkinson EA. (comm.) 2006. Maine Department of Marine Resources, Bureau of Sea Run Fisheries and Habitat, Jonesboro, ME. Observations on fry drift studies at Northern Stream. Atlantic Salmon Commission staff training, Little Lyford Pond Camps.

Erekinaro J, Gibson RJ. 1997. Interhabitat migration of juvenile Atlantic salmon in a Newfoundland river system, Canada. J. Fish Biol. 51(2):373-388.

Nagata M, Irvine JR. 1997. Differential dispersal patterns of male and female masu salmon fry. J. Fish Biol. 51(3): 601-606.

Session 5 ***11:10 a.m.***

Comparison of migratory urge and gill Na^+, K^+-ATPase activity of Atlantic salmon *(Salmo salar)* smolts from Dennys River and Penobscot River stocks

Randy Spencer[1], Joseph Zydlewski[2] and Gayle Zydlewski[3]
[1]*University of Maine, Department of Biological Sciences, Orono, ME;* [2]*U.S. Geological Survey, Cooperative Fish and Wildlife Research Unit, University of Maine, Orono, ME;* [3]*University of Maine, School of Marine Sciences, Orono, ME*

Migratory urge and gill Na^+, K^+-ATPase activity of Penobscot River and Dennys River smolts were investigated simultaneously in a controlled hatchery environment. Smolts were tagged with Passive Integrated Transponders (PIT) and placed in behavioral evaluation tanks for a series of seven two-week long trials (n=30 new smolts*stock^{-1}*trial^{-1}) spanning the smolt migratory window (April-June). Nonlethal gill biopsies were collected from each smolt at the start and end of each trial to measure gill enzyme activity. Dennys River smolts had the same or higher mean Na^+, K^+-ATPase activity than Penobscot smolts on all sample dates. The seasonal pattern of increase, peak, and decline in enzyme activity of Dennys smolts were temporally and quantitatively similar to Penobscot smolts. The dates of onset, peak, and reduction of downstream (with tank flow) movements were independent of stock, but overall, Penobscot River smolts moved 15.5% more frequently. Smolt activity became increasingly diurnal during peak migration but most downstream movement (>59%) still occurred at night. Dennys smolts were slightly but significantly more nocturnal than Penobscot smolts during peak migration. Correlations between the frequency of downstream movement and gill Na^+, K^+-ATPase activity were absent or weak for Penobscot and Dennys smolts.

Session 5 ***11:30 a.m.***

Survival and life history variation of Atlantic salmon in Shorey Brook, Maine

Michael Bailey and Michael Kinnison
University of Maine, School of Biology and Ecology, Orono, ME

From 2000 to 2006, individually marked juvenile Atlantic salmon (*Salmo salar*) were regularly monitored in Shorey Brook, a tributary of the Narraguagus River. Sampling included over 25 electrofishing samples from 37 sections (each 20m long) of Shorey Brook, and from smolt weirs and in-stream passive integrated transmitter (PIT) arrays. The use of these PIT arrays allowed us to account for fish leaving the system as smolts and non-smolt migrants, decreasing biases in mortality estimates. These arrays have also recorded three likely adult salmon returning to the stream (two confirmed adults, one unconfirmed). The software program MARK was used to estimate survival of four year classes during this study, relative to seasonality and life history attributes of the fish. Results indicate that parr in Shorey Brook have higher over winter survival, higher percentage precocious parr, and higher numbers of fall migrants than has been noted in other salmon streams in New England. These characteristics of parr life history can be missed by traditional survey approaches that occur only once per year, with substantial demographic consequences.

Session 5 ***11:50 a.m.***

Feeding ecology of Atlantic salmon postsmolts in Penobscot Bay, Maine: Rearing origin matters

Mark D. Renkawitz and Timothy F. Sheehan
NOAA's National Marine Fisheries Service, Northeast Fisheries Science Center, Woods Hole, MA

Maine's Penobscot River Atlantic salmon population remains at critically low abundance, despite intensive stocking of multiple life stages. High rates of mortality in the nearshore environment may be contributing to low adult return rates. NOAA Fisheries Service conducted post-smolt trawl surveys from 2001-2005 to investigate this hypothesis. Dietary analyses on post-smolt mortalities collected during this survey have yielded insights into the health and fitness of early marine phase postsmolts. Of the 253 stomach samples obtained, 4% were empty while 85% contained two prey types or less. A negative relationship was observed between stomach content weight and fish length. Fish that lived in the river longer (naturally-reared and parr-stocked fish) tended to be smaller and consumed more fish prey than fish that emigrated immediately post stocking (fish stocked as smolts). Fish reared naturally and those stocked as parr consumed 81% fish and 18% crustaceans (by weight), whereas stocked smolts consumed 48% fish and 42% crustaceans. Differences in the type and quantity of consumed prey may imply contrasting levels of fitness and be indicative of other behavioral differences that affect survival. These data improve our understanding of early marine phase dynamics among the different stocking groups and may aid in defining causal ecological mechanisms that influence marine survival.

Session 5 ***12:10 p.m.***

Sonic tracking of smolts from Canadian rivers across the Gulf of St. Lawrence to the Strait of Belle Isle

Fred Whoriskey
Atlantic Salmon Federation, St. Andrews, NB, Canada

Sonic telemetry was used to document concurrently the movements, and freshwater and estuary survival, of smolts from Canadian rivers over a 600 km north to south gradient. Some of the postsmolts were tracked subsequently across the Gulf of St. Lawrence to the Strait of Belle Isle, a distance of up to > 1,000 km from the initial release points. Survival patterns in freshwater and the estuary were consistent for individual rivers among years. Also, there were consistent differences in survival rates among rivers, but survival to the sea was not systematically higher in more northern sites. Movement rates across the Gulf of St. Lawrence were about 25 km/d. Fish from multiple rivers were detected in the Strait of Belle Isle on the same day, providing the first documented evidence in the ocean of shoals of salmon postsmolts originating from multiple rivers. The Strait appears to be an important migration pathway for smolts from southern Gulf of St. Lawrence rivers. However, no tagged smolts from the site on the Quebec North Shore were detected there. Water temperatures < 0°C were recorded in the Strait during the smolt migration period.

ABSTRACTS
POSTER PRESENTATIONS

Diadromous Species Restoration Research Network (DSRRN): A new five year collaborative effort

David Hart[1], Karen Wilson[2], Peter Vaux[1] and **Adria A. Elskus**[3]
[1]University of Maine, George J. Mitchell Center for Environmental and Watershed Research, Orono, ME; [2]University of Southern Maine, Aquatic Systems Group, Portland, ME; [3]U.S. Geological Survey, Maine Field Office, University of Maine, Orono, ME

Diadromous fish populations are undergoing steady declines in the US leading to threatened and endangered listings. The central goal of the Diadromous Species Restoration Research Network (DSRRN) is to leverage, expand, and integrate the diverse array of research and management activities focused on the restoration of diadromous fish species in ways that improve ecological understanding and enhance restoration outcomes. The strength of the DSRRN is its connection to and integration with the Penobscot River Restoration Project (Maine), the most ambitious restoration effort ever proposed for a watershed of this size. Within this context, unparalleled opportunities exist to study questions fundamental to diadromous fish ecology and restoration, including: the role of diadromous fish in marine-freshwater linkages, the interdependency of co-evolved diadromous species, multispecies interactions in a restoration context, and the effects of multiple stressors on restoration results. DSRRN will work to coordinate the overlapping and interconnected research efforts of academic, government, tribe and watershed stakeholders, and provide administrative structure and support data management. This grant will support two scientific meetings to identify critical research areas in multispecies restoration (Year 1) and synthesize outcomes (Year 5), and three interactive workshops targeting critical research topics (Years 2, 3 and 4). We anticipate at least one synthesis paper per workshop and several master's theses focused around workshop topics and diadromous species. Evaluations, member feedback, reports, quarterly meetings with core members, and other mechanisms will be used to assess progress and success. The issue of diadromous fish restoration is complex and it is only through a broad collaborative approach drawing on data and knowledge from other systems worldwide, that progress may be achieved and mis-steps minimized. Through research partnerships facilitated by the Research Coordination Network (RCN), that place mission-driven restoration efforts in an integrated science context, key basic and applied research needs can be identified that might otherwise be overlooked. By actively engaging stakeholders, the RCN will facilitate public understanding of the critical role that science plays in guiding ecological restoration. *Please help us begin this process by bringing your questions, your ideas and your vision to the network!*

Measuring sedimentation rates and land-use change in a dam-influenced lake delta: Narraguagus River, Maine

Alan Kasprak[1], Noah P. Snyder[1], Ilya V. Buynevich[2] and Elizabeth A. Johnson[1]
[1]Boston College, Department of Geology and Geophysics, Chestnut Hill, MA; [2]Woods Hole Oceanographic Institution, Coastal Systems Group, Woods Hole, MA

Deposits of the Narraguagus River in coastal Maine were investigated to determine river sediment transport rates during the past ~150 years, a period of extensive timber harvest in the watershed. Such transport rates will provide a baseline for process based studies of interactions between substrate mobility and habitat characteristics. The study area was the inlet of Beddington Lake, which has undergone changes in its surface level due to the construction (circa 1850) and subsequent failure in 1951 of a dam installed at the lake outlet to facilitate log drives on the Narraguagus River. Based on historic (1946-1996) aerial photograph analysis, exposed river deposits from the period of elevated lake level were identified. In August 2007, these subaerial deposits were sampled using soil pits, hand auger cores, bailer-borings, and ground penetrating radar (GPR). In-channel pebble counts were performed at several locations at and upstream of the study area. Overall, sediment samples collected from the subaerial deposit show a fining trend downstream from the Narraguagus River mouth into Beddington Lake. Upstream sediment pits and cores in the deposit show a gravel layer at ~1 m depth. We hypothesize that this layer corresponds to river deposition prior to dam construction. Above this gravel layer was found a coarsening upward trend in individual soil pits and cores, from mud to coarse sand, which is representative of a prograding lake delta. This sediment package is, on average, 0.98 m thick, and we believe that its deposition occurred during the ~100 years that the dam was present on Beddington Lake. The calculated average vertical sedimentation rate, therefore, was 1.0 cm/yr at this proximal position in the lake delta during the time the dam was operational. Above this coarsening upward sequence, soil pits and cores have a topmost layer of fine sand and mud, with 0.22 m average thickness. Given that Beddington Lake has not been dammed since 1951, a current average vertical floodplain sedimentation rate of 0.4 cm/yr was calculated. Organic materials, dominated by wood chips and fragments of cut logs, can be found in the subaerial deposit. The concentration of these organics increases with depth, suggesting that logging activities in the Narraguagus River were most vigorous in the time soon after dam construction. Our ongoing research includes interpretation of GPR transects, textural sediment analyses, Wolman pebble count analyses, and mapping and correlation of the sediment pits and cores.

Water temperature changes in canopy-limited riparian habitat at four Distinct Population Segment utility crossings

Michael Loughlin
Maine Department of Marine Resources, Bureau of Sea Run Fisheries and Habitat, Jonesboro, ME

During 1999, a natural gas pipeline was installed across eastern Maine roughly following logging road 01-00-0 (the Stud Mill Road), widening the open corridor created by the road. This increased the corridor width from approximately 18 meters, for the logging road alone, to approximately 45 meters. Three of the four streams crossed the original road corridor in culverts or at a bridge. The forth crossing was wooded prior to the installation of the pipeline corridor. The corridor was widened from 45 meters to approximately 95 meters for an electric transmission line during the winter of 2005/2006. During summer 2005, automated synchronized temperature loggers were installed above and below four stream crossings, and temperatures recorded hourly were analyzed by regression analysis and the Student's t-test., Water temperatures at three locations were significantly higher downstream of the clearings. One exception was noted on the West Branch Machias River, where downstream temperature was significantly cooler than upstream. During summer 2006, temperature loggers were installed above, within and below the same four crossings, and temperatures recorded hourly were analyzed by regression analysis and the Student's t-test. Water temperatures at three locations were again significantly higher downstream of the clearings. Again an exception was noted on the West Branch Machias River, where downstream temperatures were significantly cooler than upstream.

Survey of Northwestern Atlantic fishes for salmonid viral pathogens

Sharon A. MacLean[1], Cem Giray[2] and Stephen K. Ellis[3]
[1]NOAA's National Marine Fisheries Service, Northeast Fisheries Science Center, Narragansett, RI; [2]Micro Technologies, Inc., Richmond, ME; [3]U.S. Department of Agriculture, Animal and Plant Health Inspection Service-Veterinary Service, Eastport, ME

Tissues from more than 3,600 fish of 20 different species were assayed in efforts to identify potential reservoirs of salmonid viral pathogens, with special interest in the infectious salmon anemia virus (ISAV). Fish were taken from rivers, streams, and coastal areas of Maine, from within or near net pens containing ISAV-infected salmon, and from the West Greenland commercial salmon fishery. Assays included viral culture on 3 cell lines (epithelioma papillosum cyprini; chinook salmon embryo-214; salmon head kidney or Atlantic salmon kidney) and reverse transcription-polymerase chain reaction specific for ISAV (ISAV-RT-PCR) or for salmon swimbladder sarcoma virus (SSSV-RT-PCR). ISAV-RT-PCR positive results were obtained from one fish taken from the Narraguagus River, Maine, of 931 (0.1%) alewife (*Alosa pseudoharengus*) sampled in total, and from one of 549 (0.2%) Atlantic salmon (*Salmo salar*) collected from the West Greenland commercial fishery. Twelve of 137 (9%) Atlantic salmon smolts used in streamside experiments tested positive for SSSV types 1 or 2 by SSSV- RT-PCR. A North American strain (IVa) of viral hemorrhagic septicemia virus (VHSV), most closely related to Pacific coast strains, was isolated from one of 260 (0.4%) herring (*Clupea harengus harengus*) taken from Maine coastal waters. Viruses were not detected in samples from 12 Atlantic salmon escapees or from fishes taken from within or near salmon net pens. Aside from SSSV, the results indicate that the prevalence of salmonid viruses in wild marine fish populations in Maine is quite low, leaving the source(s) of ISAV in cultured salmon in Maine still to be determined.

Contaminant assessment of white suckers from eight rivers in the Gulf of Maine Distinct Population Segment for Atlantic salmon

Steven E. Mierzykowski
U.S. Fish and Wildlife Service, Maine Field Office, Old Town, ME

White suckers (*Catostomus commersoni*) are a common sentinel species used in state, regional, and national biomonitoring programs to illustrate contaminant conditions and trends. White suckers were collected for tissue residue analyses between 2003 and 2006 to assess contamination in eight Gulf of Maine rivers where the endangered Atlantic salmon (*Salmo salar*) is considered a Distinct Population Segment (DPS) under the Endangered Species Act. Ninety whole-body white suckers collected from 27 locations among the eight rivers having DPS salmon were analyzed individually (n=25) or in multi-fish composites (n=22) for organochlorine compounds and trace elements. Of 22 organochlorine compounds included in the analytical scan, two were detected with regularity - polychlorinated biphenyls (PCBs) and p,p'-DDE. Total PCB was detected in all sucker samples from the Dennys River (mean 0.041 µg/g), two fish from the Pleasant River (0.007 µg/g, 0.018 µg/g), and four composite samples from the East Machias River (mean 0.005 µg/g). Total PCB in suckers from the DPS rivers were similar to levels reported in regional and national biomonitoring programs. Although Total PCB was detected in 25 samples, and suckers from the Dennys River had six-fold higher Total PCB concentrations than fish from two other DPS rivers, Total PCB concentrations in DPS river white suckers did not exceed suggested biological effect levels. DDE, a metabolite of the insecticide DDT, was found in 12 of 28 samples (median 0.003 µg/g) from the DPS rivers at levels 3 to 15 times lower than levels reported in regional and national biomonitoring programs, and two orders of magnitude below a suggested DDT tissue threshold-effect level of 0.60 µg/g. The mean mercury concentration for all white sucker samples (0.22 µg/g) from the DPS rivers was at the suggested tissue effect threshold level (0.20 µg/g). Mercury is frequently found in biota at elevated levels in New England. Relative to higher trophic level fish species such as smallmouth bass (*Micropterus salmoides*), elevated levels of mercury (> 0.50 to 1.00 µg/g) are not commonly found in white suckers in New England. Among the DPS rivers, the highest mercury levels were found in white suckers from the Machias River (0.69 µg/g) and to a lesser extent in the West Branch of the Sheepscot River (mean 0.35 µg/g). In white suckers from DPS-designated rivers, concentrations of 18 other trace elements appeared lower or similar to median values reported in Maine, regional, or national biomonitoring programs.

Depth, behavior and survival of emigrating Atlantic salmon (*Salmo salar*) postsmolts in Penobscot Bay, Maine

Mark D. Renkawitz[1], Timothy F. Sheehan[1] and Graham S. Goulette[2]
[1]NOAA's National Marine Fisheries Service, Northeast Fisheries Science Center, Woods Hole, MA; [2]NOAA's National Marine Fisheries Service, Northeast Fisheries Science Center, Orono, ME

Maine's Penobscot River Atlantic salmon population remains at low abundance despite intensive stocking. High nearshore mortality is hypothesized to contribute to low adult returns. To gain information on emigrating post-smolt dynamics, NOAA Fisheries Service conducted a post-smolt trawl survey in Penobscot Bay from 2001 to2005. The assumption that emigrating postsmolts were available for capture by a surface trawl was evaluated by implanting 26 salmon smolts with acoustic depth tags. Detection arrays monitored fish passage through 40 km of estuary and 45 km offshore through Penobscot Bay. Greater than 90% of the detections occurred in water depths of 4m or less, but depths up to 18m were recorded, suggesting that postsmolts spend most of the time near the surface but occasionally dive deeper. Emigration rates for successful migrants were rapid (approximately 1 km/h), and only 39% of the postsmolts were successfully detected by the outermost arrays. These results suggest that postsmolts experience high rates of nearshore mortality despite their short residence time. These data improve our understanding of nearshore dynamics and may aid in defining the causal mechanisms influencing early marine survival.

Comparison of channel morphology in two Atlantic coastal streams: Implications for Atlantic salmon habitat - preliminary results and analysis

Benjamin C. Wilkins and Noah P. Snyder
Boston College, Department of Geology and Geophysics, Chestnut Hill, MA

Bedload sediment mobility is important to Atlantic salmon (*Salmo salar*) spawning and rearing success. Channel beds that are not mobilized on a frequent basis will become armored or embedded over time, impeding the creation of redds and negatively influencing the likelihood of egg survival. Channel shape is an important factor affecting bedload sediment mobility within streams. It is believed that river channel morphology in Maine has been altered by land use practices, ultimately creating wider and shallower channels and lowering the stream competence. If correct, these changes may be partially responsible for the limited number of returning Atlantic salmon currently observed in Maine's rivers. To evaluate the magnitude of these changes, we are preparing a statistical comparison of channel morphology between two Atlantic coastal streams: the Narraguagus River in Downeast Maine and the Jacquet River in northern New Brunswick, Canada. Compared to the Narraguagus, the Jacquet River has relatively healthy returns of adult salmon and a differing land-use history. Both watersheds have roughly equal drainage areas (Narraguagus 588 km^2, Jacquet 510 km^2) and similar mean annual precipitation (1,244 and 1,200 mm, respectively). During the summer of 2007, we surveyed a 13.6 km section of the Narraguagus River with drainage area ranging from 129 to 247 km^2, and a 10.4 km reach of the Jacquet River with drainage area ranging from 94 to 265 km^2. Measurements were made of active and bankfull width, depth, and channel gradient at 100 meter intervals, and grain size counts were performed at 200 meter intervals. Preliminary results indicate significantly greater bankfull width to depth ratios on the Narraguagus River (29 ± 11) than in the Jacquet River (23 ± 9). This is indicative of lower basal sheer stress and reduced bedload sediment mobility.

2010 Research Forum
Maine Atlantic Salmon and their Ecosystems
6-7 January 2010
Wells Conference Center
University of Maine, Orono

Program

Wednesday, January 6

8:00 a.m. *Registration, coffee*

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

Session 1
Joan Trial, Moderator
Maine Department of Marine Resources
Bureau of Sea Run Fisheries and Habitat

8:40 a.m. **New insights into marine life of Atlantic salmon**
Gilles L. Lacroix

9:00 a.m. **Sonic tracking of Atlantic salmon smolts to sea: Correlates of survival and lessons on the migration pathway**
Fred Whoriskey

9:20 a.m. **Environmental and biological factors affecting the survival of Atlantic salmon in Maine**
Kevin D. Friedland, James P. Manning and Jason S. Link

9:40 a.m. **Coastal migration and survival of Atlantic salmon smolts in the Narraguagus River**
John F. Kocik, James P. Hawkes, Timothy F. Sheehan, Paul A. Music and Kenneth F. Beland

10:00 a.m. **Evaluating the influence of environmental conditions on the survival of outmigrating Atlantic salmon smolts within the Narraguagus River system, Maine**
Michael S. Cooperman, John F. Kocik and James P. Hawkes

10:20 a.m. *Break*

Session 2

G. Russell Danner, Moderator
Maine Department of Inland Fisheries and Wildlife
Fish Health Laboratory

10:40 a.m. **Atlantic salmon diet in coastal waters: Spatial and temporal forage patterns with inferences from alternative sampling platforms**
Mark D. Renkawitz and Timothy F. Sheehan

11:00 a.m. **Detection of carrier state infectious pancreatic necrosis in post-spawned sea-run Atlantic salmon at the Richard Cronin National Salmon Station**
Gavin Glenney, Patricia A. Barbash, John Coll and William Quartz

11:20 a.m. **Nonlethal detection of infectious salmon anemia virus (ISAV) in Penobscot River sea-run Atlantic salmon using Real-time Reverse Transcription-Polymerase Chain Reaction**
Patricia A. Barbash, Gavin Glenney and John Coll

11:40 a.m. **Mercury accumulation in stream-dwelling juvenile Atlantic salmon and brook trout (*Salvelinus fontinalis*)**
Darren M. Ward, Keith H. Nislow and Carol L. Folt

12:00 p.m. **Developing nonlethal biomarkers for waterborne organic contaminants**
Adria A. Elskus and Jennifer C. Meyers

12:20 p.m. *Lunch*

Session 3

Christine Lipsky, Moderator
NOAA's National Marine Fisheries Service
Northeast Fisheries Science Center

1:20 p.m. **Passage of hatchery reared Atlantic salmon smolts at dams and movement through estuary and bay on the Penobscot River, Maine**
Michael Bailey and Joseph Zydlewski

1:40 p.m. **Monitoring changes in resident and anadromous fish communities in Sedgeunkedunk Stream (Penobscot Co., Maine) after barrier removal**
Cory Gardner, Stephen M. Coghlan Jr., Joseph Zydlewski and Rory Saunders

2:00 p.m. **Barrier removal in Sedgeunkedunk Stream: Sea lamprey colonization and implications for Atlantic salmon habitat restoration**
Robert Hogg, Stephen M. Coghlan Jr. and Joseph Zydlewski

2:20 p.m. **Evaluating changes in diadromous species distributions and habitat accessibility following the Penobscot River Restoration Project**
Tara Trinko, Kyle Ravana and Rory Saunders

2:40 p.m. **Growth and survival of stocked juvenile Atlantic salmon in first and second order streams of the Machias River watershed**
Wesley Ashe and Stephen M. Coghlan Jr.

3:00 p.m. **Restoring stream connectivity in the Machias River watershed: A watershed based, focus area approach to salmonid restoration**
Steven Koenig and Scott Craig

3:20 p.m. *Break and* **Poster Session**

Poster Session
Wells Conference Center Sunroom

Diadromous Species Restoration Research Network (DSRRN): a five-year collaborative research effort
Barbara S. Arter

Atlantic and shortnose sturgeon management and research needs
Kim Damon-Randall, Lynn Lankshear and Jessica Pruden

Major Histocompatibility Complex Class II alleles: Genetic and functional variation in the Antigen Binding Site of Atlantic salmon
Ellen E. Hostert, Gerard Zegers, Mallory Ward and Amanda Corey

Monitoring progress for the Penobscot River Restoration Project
Blaine S. Kopp

Apparent channel alterations associated with historic log drives in the Machias River drainage
Derik Lee, Thomas Cochran, Tora Johnson, Steven Koenig and Sherrie Sprangers

Focus area approach to salmonid restoration: Basinwide stream-road crossing and fisheries assessment
Joseph McKerley, Josh Noll, Iris Lowery, Steven Koenig and Scott Craig

Restoring fish passage and natural stream function in eastern Maine

Katrina Mueller and Steven Koenig

Thursday, January 7

8:00 a.m. *Coffe*e

Session 1
Dan McCaw
Maine Department of Marine Resources
Bureau of Sea Run Fisheries and Habitat

8:30 a.m. **Interactive ecology of Atlantic salmon and smallmouth bass: Competition for habitat**
Gus Wathen, Stephen M. Coghlan Jr., Joseph Zydlewski and Joan Trial

8:50 a.m. **Assessing juvenile Atlantic salmon habitat suitability within small catchments (<2km^2) in Downeast Maine**
Scott Craig, Joseph McKerley, Jacques Tardie and Steven Koenig

9:10 a.m. **Effects of ice on juvenile Atlantic salmon in New Brunswick**
Tommi Linnansaari and Richard Cunjak

9:30 a.m. **Spawning behavior, reproductive success and production of juvenile offspring by stocked adult Atlantic salmon in four Maine streams**
Gregory Mackey, **Ernie Atkinson**, Colby Bruchs, Paul Christman and Dan McCaw

9:50 a.m. **Ontogenetic selection on hatchery salmon in the wild: Natural selection on artificial phenotypes**
Michael Bailey, Kevin Lachapelle and Michael Kinnison

10:10 a.m. **Historical summer baseflow trends in New England rivers**
Robert W. Dudley and Glenn A. Hodgkins

10:30 a.m. *Break*

Session 2
Mary Colligan, Moderator
NOAA's National Marine Fisheries Service
Northeast Regional Office

10:50 a.m. **Evaluating management strategies by individual based simulation**
Krzysztof Sakrejda-Leavitt and Benjamin Letcher

11:10 a.m. **Basinwide Geographic and Ecological Stratification Technique (BGEST): Parr populations, habitat and management**
Joan G. Trial, Greg Mackey and Paul Christman

11:30 a.m. **American shad in the Penobscot River – choosing recovery tools**
Joseph Zydlewski and Michael Bailey

11:50 a.m. **American shad population genetics: Focus on Maine drainages**
Meredith L. Bartron, Shannon Julian and Jeff Kalie

12:10 p.m. **Outside the box: Coastal movements of shortnose sturgeon and implications for management**
Phillip Dionne, Michael Kinnison, Gail Wippelhauser, Joseph Zydlewski and Gayle Zydlewski

12:30 p.m. **Using acoustic telemetry to track movements of alewives (*Alosa pseudoharengus*) in freshwater and the coastal zone**
Jonathan Carr and Fred Whoriskey

12:50 p.m. **Tidal power development in Maine: Preliminary laboratory tests and field assessments in Western Passage and Cobscook Bay**
Gayle Zydlewski, James McCleave and Haley Viehman

1:10 p.m. **Closing**
John Kocik
NOAA's National Marine Fisheries Service
Northeast Fisheries Science Center

ABSTRACTS
ORAL PRESENTATIONS

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

New insights into the marine life of Atlantic salmon

Gilles L. Lacroix
Department of Fisheries and Oceans, St. Andrews Biological Station, St. Andrews, NB, Canada

Atlantic salmon kelts from three different regions of the Bay of Fundy were tagged with pop-up satellite archival tags (PSATs) with 4-month pop-off delay as they left the rivers in the fall and spring for reconditioning at sea. Kelts from one region migrated thousands of kilometers to the northern edge of the Labrador Sea and as far east as the Flemish Cap, whereas those from the other two regions remained in the Bay of Fundy and Gulf of Maine. Detailed migration tracks were obtained from the archived light data (geo-positioning using sunrise and sunset times and day length). Preliminary examination of the water temperature and depth data archived at 2-15 min intervals revealed some interesting and common behavior. Although kelts encountered a wide temperature range (-1˚C to 20˚C), they tended to exploit areas within a narrow range (5-10˚C). Kelts spent most of their time near the surface (depth <2 m) while migrating, but nevertheless, there were frequent periods of repeated diving to 25-50 m, possibly associated with feeding. There were also occurrences of deep diving in the 100-500 m range (maximum depth 700 m). Mortality during migration was high and the archived parameters revealed that predation was a frequent cause. Changes in diving behavior and temperature also allowed for identification of a common predator for several cases in the Gulf of Maine.

Session 1 ***9:00 a.m.***

Sonic tracking of Atlantic salmon smolts to sea: Correlates of survival and lessons on the migration pathway

Fred Whoriskey (presented by Jonathan Carr)
Atlantic Salmon Federation, St. Andrews, NB, Canada

We have used sonic telemetry to document Atlantic salmon smolt migration patterns and survival from freshwater river release sites to 1) the head of tide, 2) through the estuary, and 3) across the Gulf of St. Lawrence to the Strait of Belle Isle. The rivers studied [Miramichi, Restigouche, Cascapedia, Margaree and St. Jean (North Shore)] fell on an approximately 600 km south to north gradient. Survival patterns of smolts in freshwater and through the estuary were generally similar among years for a given river. We also found consistent differences in survival to the head of tide and across the estuary among rivers. However, these differences did not clearly correlate with latitude. Heavy losses occurred in most river estuaries. Twenty to 30% of the smolts that survived to exit the estuaries of the Miramichi, Restigouche and Cascapedia Rivers passed through the Strait of Belle Isle enroute to ocean feeding grounds off Greenland. Travel rates in the Gulf were estimated as 17- 25 km/d, and survivals and travel speeds were not correlated with fish body lengths. The results show that Atlantic salmon from different rivers migrate together in the sea, and suggest that behavioral and social factors may be important in determining smolt survival.

Session 1 ***9:20 a.m.***

Environmental and biological factors affecting the survival of Atlantic salmon in Maine

Kevin D. Friedland[1], James P. Manning[2] and Jason S. Link[2]
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The general parameters of a recruitment mechanism for North American salmon have emerged that suggest sea mortality is a punctuated event that occurs within the first two months at sea. The post-smolt population is most likely decremented by predation, mediated by the changing nature of the predator field in the Gulf of Maine. We examined a suite of environmental and biological factors in order to test and extend the hypothesis formulated for the North American stock complex to the stocks that would utilize the Gulf of Maine as postsmolts. The marine survival of Atlantic salmon in the Gulf of Maine appears to be influenced by a complex set of physical and biological interactions. Marine survival has declined as sea surface temperature in the coastal ocean has increased, and there also appears to have been a deterioration of synchronization between smolt migration and ocean conditions for postsmolts. There has been a change in spring wind conditions in the Gulf of Maine area, which could be modifying the post-smolt migration across the Gulf of Maine and Georges Bank regions. The shift in environmental conditions have also affected the distribution in time and space of many predators that likely prey upon salmon postsmolts. Notably, hake species have increased in abundance in the areas that serve as migration corridors for postsmolts. The time series changes in environmental conditions and predator distribution is consistent with the hypothesis that Gulf of Maine salmon experience a growth-independent mortality during the first months at sea, thus forming the basis of recruitment control for these populations.

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

Coastal migration and survival of Atlantic salmon smolts in the Narraguagus River

John F. Kocik[1], James P. Hawkes[1], Timothy F. Sheehan[2], Paul A. Music[1] and Kenneth F. Beland[3]
[1]NOAA's National Marine Fisheries Service, Northeast Fisheries Science Center, Orono, ME; [2]NOAA's National Marine Fisheries Service, Northeast Fisheries Science Center, Woods Hole, MA; [3]Maine Department of Marine Resources, Bureau of Sea Run Fisheries and Habitat, Bangor, ME

We studied the estuarine and early marine ecology of Atlantic salmon smolts within the relatively large and spatially dynamic environments of eastern Maine using ultrasonic transmitters and a large network of fixed receivers. We monitored natural smolt migration in the Narraguagus River and Bay, and the coastal environment of the Gulf of Maine (GoM). Our 30 km long study area began in the lower river, extended 8 km downstream to head-of-tide, 7 km through the estuary, then fanned out seaward 15 km in the western GoM along the interface with the Maine Coastal Current. From 1997 to 2004, we increased sampling network density in the estuary and expanded marine arrays further into the GoM. We designed receiver networks to monitor all smolt exit routes and were able to: (a) estimate smolt survival to the GoM; (b) map primary migration paths; and (c) document emigration timing. Survival ranged from 36% to 47% to the GoM. Median migration rates were 0.7 km/h in the estuary to Middle Bay and 1.0 km/h in the Outer Bay. Smolts generally traveled with the tides and upon entering saltwater and most commonly used the western 6 km of a 23 km wide embayment. These are among the first quantitative data to estimate survival during early marine migration of wild Atlantic salmon smolts. A Cormack-Jolly-Seber model estimated site efficiency and smolt survival simultaneously, providing a useful methodology and information benchmarks for other studies to better understand emigration dynamics and to help identify mortality factors at sea.

Session 1 ***10:00 a.m.***

Evaluating the influence of environmental conditions on the survival of out migrating Atlantic salmon smolts within the Narraguagus River system, Maine

Michael S. Cooperman, John F. Kocik and James Hawkes
NOAA's National Marine Fisheries Service, Northeast Fisheries Science Center, Orono, ME

The out migration of anadromous salmon smolts from freshwater to saltwater is a time of elevated mortality, but factors contributing to mortality have not been well quantified. During 2002-2004, we used acoustic telemetry to explore how environmental conditions affect Atlantic salmon smolt survival during their migration through the Narraguagus River system of Downeast Maine. Each year approximately 85 wild smolt in the Narraguagus River were tagged and smolt survival monitored within the ecozones of the lower river (FW), estuary (EST) and bay (SW). Tagged smolts were partitioned into one of 16 four-day cohorts based on date of entry to each ecozone. There were large differences among cohorts in survival within each zone (all χ^2 test $p < 0.03$), with mean cohort survival (i.e., # exiting an ecozone / # which entered) in FW of 0.85 (range 0.60 – 1.0), 0.70 in EST (range 0.25 – 1.0), and 0.65 in the SW (range 0.38 – 1.0). Our results suggest 1) smolts survived best when delaying migration until after the cold temperatures of early season, 2) late season river water temperatures can be stressful to smolts but rain events could improve survival, and 3) that surface oriented predators (i.e., birds) may be a primary source of mortality. These findings are consistent with other studies, but the observed relationships were weak (all r^2_{adj}. of models with $\Delta AICc < 2$ were < 25.2). In contrast, wind speed and direction, tidal amplitude, lunar phase, and mean and variability of river discharge were not related to survival. When smolt cohorts were partitioned into groups of good (> 75%) and bad (< 60%) survival, MANOVA (all p > 0.37), MRPP (all p> 0.18), and NMS ordination each failed to identify environmental differences experienced by the groups. In total, our results suggest abiotic conditions were not a primary driver of differences in survival among cohorts in the Narraguagus system, and therefore provides evidence that predation is perhaps the principle mechanism of smolt mortality.

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

Atlantic salmon diet in coastal waters: Spatial and temporal forage patterns with inferences from alternative sampling platforms

Mark D. Renkawitz and Timothy F. Sheehan
NOAA's National Marine Fisheries Service, Northeast Fisheries Science Center, Woods Hole, MA

Atlantic salmon populations in the Northwest Atlantic have significantly declined in abundance. Conditions in the marine environment are at least partially responsible for these declines and are hampering recovery efforts. Populations in the southern extent of the species range are extinct, and the existing populations in the USA are currently classified as 'endangered'. These populations undertake extensive round trip migrations from natal rivers to feeding grounds off the coast of Greenland, utilizing different coastal environments over multiple life stages. To understand how Atlantic salmon forage in coastal environs, NOAA's National Marine Fisheries Service collected post-smolt stomachs from different rearing origins in Penobscot Bay, Maine, USA, and from immature adults off the west coast of Nuuk, Greenland. Significant dietary differences were found between years and between salmon life stages. Postsmolts in USA waters primarily fed on juvenile Atlantic herring (*Clupea harengus*) and euphausiids, while adults in Greenland primarily fed on capelin (*Mallotus villosus*) and amphipods (*Parathemisto* sp.). Significant differences were found in the quantity and quality of food items consumed by postsmolts from different rearing origins. Contemporary adult salmon diets at Greenland differed from those determined from studies conducted four decades earlier. Overall, considerable interannual variation was evident in the composition, availability, and abundance of prey species consumed by Atlantic salmon in coastal USA and Greenland waters. Similar interannual variations in the diets of co-occurring seabird species have been linked to patterns in fitness, and may influence Atlantic salmon survival and reproductive success, as well. It is unclear whether these dietary changes are related to cyclic interannual variations in the forage base or to permanent shifts caused by large scale climatic factors. No matter which, fluctuating foraging conditions at various life stages may be negatively impacting the marine survival of Atlantic salmon.

Session 2 ***11:00 a.m.***

Detection of carrier state infectious pancreatic necrosis in post-spawned sea-run Atlantic salmon at the Richard Cronin National Salmon Station

Gavin Glenney, Patricia Barbash, John Coll and William Quartz
U.S. Fish and Wildlife Service, Lamar Fish Health Center, Lamar PA

The infectious pancreatic necrosis virus (IPNV) pathogen was isolated and identified from two pools of Connecticut River sea-run Atlantic salmon ovarian fluid during the 2007 spawning season at the Richard Cronin National Salmon Station. A small 130 base-pair (bp) polymerase chain reactions (PCR) product was amplified (USFWS and AFS-FHS 2003) and sent to the USGS Western Fisheries Research Center for sequence analysis. The isolate closely resembled the Canada_3 strain, falling into genogroup V described by Romero-Brey et al. (2009), which is different from the more common genogroup I in the USA. This information allows us to speculate that the Cronin Atlantic salmon were not infected with IPNV during the freshwater life stage in the Connecticut River watershed. On November 20, 2007, the Connecticut River Atlantic Salmon Commission (CRASC) voted to depopulate the infected stock at Cronin and the entire suspect egg lots held at White River National Fish Hatchery. Approximately 4 weeks following confirmation of IPN at Cronin, 121 Connecticut River Atlantic salmon sea runs were euthanized and sampled for a follow up investigation to determine the location and prevalence of infection and to perform a comparison between the standard lethal tissue samples (kidney/spleen) with various blood fractions for development of a reliable nonlethal screening tool for future years. Although no IPNV positive blood samples were detected, one kidney/spleen homogenate (male-#55) exhibited cytopathic effect on the chinook salmon embryo (CHSE) cell line and tested positive for IPNV via PCR. A total of 2,943 bp of segment A was sequenced and determined to be a new strain of IPNV closely resembling Canada_2 and Canada_3 of genogroup V. Further work is being conducted to develop a qPCR assay to detect a variety of IPNV isolates and increase sensitivity for potential nonlethal testing.

References:

Romero-Brey I, Bandin I, Cutrin JM, Vakharia VN, Dopazo CN. Genetic analysis of aquabirnaviruses isolated from wild fish reveals occurrence of natural reassortment of infectious pancreatic necrosis virus. J. Fish Dis. 32:585-595.

USFWS and AFS-FHS (U.S. Fish and Wildlife Service and American Fisheries Society-Fish Health Section). 2003. Standard procedures for aquatic animal health inspections. In: AFS-FHS. FHS blue book: suggested procedures for the detection and identification of certain finfish and shellfish pathogens. 2003 ed. Bethesda, MD: American Fisheries Society-Fish Health Section.

Session 2 ***11:20 a.m.***

Nonlethal detection of infectious salmon anemia virus (ISAV) in Penobscot River sea-run Atlantic salmon using real-time Reverse Transcription – Polymerase Chain Reaction

Patricia A. Barbash, Gavin Glenney and John Coll
U.S. Fish and Wildlife Service, Fish Health Center, Lamar, PA

Since 2000, the U.S. Fish and Wildlife Service's Lamar Fish Health Center (LFHC) has been monitoring for infectious salmon anemia virus (ISAV) in Atlantic salmon (ATS) migrating to New England rivers, using tissue culture and polymerase chain reaction (PCR) techniques on whole blood. Standard PCR detected ISAV in one of 60 ATS sampled from the Penobscot River in 2001, but the virus did not cause cytopathic effect (CPE) on targeting cell lines. This was later determined to be the HPR0 genotype of ISAV, which had been reported in wild ATS in Europe, and thought to have low or no pathogenicity. In 2009, the LFHC implemented a real-time RT-PCR assay (Snow et al. 2006) in ATS sea-run broodstock health screening protocols. The more sensitive molecular tool produced positive detections of ISAV from 6 of 570 pre-spawn ATS sea-run blood samples screened from the Penobscot River. No CPE was observed in tissue culture assays. Sequence analysis of the PCR product targeting segment 8 of the ISAV genome confirmed the positive detection. Preliminary sequence analysis indicated the genotype to be similar to European ISAV types. In order to prevent possible viral transmission of the virus to progeny, and subsequently to facilities where progeny are cultured for stocking and domestic broodstock, the two females and 4 male fish suspected of carrying the virus were removed from the spawning population. Results from subsequent genotyping of the haemagglutinin (HA) gene in the highly polymorphic region (HPR) will be presented, as well as a discussion of fish health management implications for feral broodstock programs.

Reference:
Snow M, McKay P, McBeath AJ, Black J, Doig F, Kerr R, Cunningham CO, Nylund A, Devold M. 2006. Development, application and validation of a Taqman real-time RT-PCR assay for the detection of infectious salmon anaemia virus (ISAV) in Atlantic salmon (*Salmo salar*). IN: Vannier P, Espeseth D, editors. New Diagnostic Technology: Applications in Animal Health and Biologics Control. Basel, Karger. Dev. Biol. 126:133-145.

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

Mercury accumulation in stream dwelling juvenile Atlantic salmon and brook trout (*Salvelinus fontinalis*)

Darren M. Ward[1], Keith H. Nislow[2] and Carol L. Folt[1]
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We measured mercury concentrations in juvenile Atlantic salmon and brook trout at 20 sites in tributary streams of the Connecticut River in 2008. All study streams were in largely forested watersheds with no point source inputs of mercury pollution. Mercury concentrations of both species varied widely across sites, with a >10-fold range in site mean concentrations for salmon (60-800 ppb dry) and a >5-fold range for trout (60-330 ppb dry), and concentrations frequently exceeded critical values for protection of piscivorous wildlife (ca. 100 ppb for birds, 500 ppb for mammals). For both species, variation in mercury concentrations across sites increased with environmental factors that reflect increased mercury bioavailability and accumulation in the stream food web (e.g. low pH, low ANC, high mercury concentrations in prey invertebrates) and decreased with factors that reflect increased secondary productivity (high prey biomass, high fish growth rate). Mercury concentrations in salmon and trout were significantly correlated across sites ($r=0.77$, $P<0.0001$). However, while salmon and trout concentrations were similar at sites with low mercury levels, salmon mercury concentrations were up to 3 times higher than mean trout concentrations at the most contaminated sites. This species-specific pattern may reflect bioenergetic differences in mercury and biomass accumulation or a differential switch to relatively uncontaminated terrestrial prey by trout at unproductive sites with high mercury levels.

Session 2 ***12:00 p.m.***

Developing nonlethal biomarkers for waterborne organic contaminants

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Threatened and endangered (T&E) fish species are in decline due to many factors, including polluted habitats. A common approach to assessing contaminant exposure in fish is to measure chemical body burdens or to assess physiological, developmental, reproductive or biochemical changes; both approaches are typically lethal. Our objective is to develop nonlethal approaches for determining pollutant exposure and response for use with T&E species. The monooxygenase enzyme, cytochrome P4501A (CYP1A), is an established biomarker that is rapidly and strongly induced by many of the most toxic organic pollutants found in aquatic systems, including dioxin, polynuclear aromatic hydrocarbons, and polychlorinated biphenyls (PCBs). We hypothesized that CYP1A could be measured nonlethally using gill filaments and scales. We exposed Atlantic salmon parr to two aqueous concentrations of 3,4,3',4',5'-pentachlorobiphenyl (PCB-126, 0.01 μM & 0.001 μM, static exposure), vehicle (32.25 ppm acetone), or untreated water for 24 h before transferring the fish to clean, flow-through water. At 6 and 24 h during exposure, and at 2, 14 and 34 days post-exposure we sampled gill filaments and scales (nonlethally) and whole livers (lethally). PCB-126 treatment strongly and significantly induced CYP1A activity (measured as ethoxyresorufin-o-deethylase, EROD) in all tissues, with the strongest induction seen in the gills (up to 414 fold over controls), followed by the liver (up to 25 fold over controls), and the scales (up to 17 fold over controls). Significant elevation occurred within 6 hours of exposure and persisted for at least 34 days after fish were placed in clean water. Signs of disease and distress were not observed in fish sampled nonlethally and held for 34 days post sampling. We conclude that CYP1A activity in salmon gills and scales shows great promise as a nonlethal biomarker of organic pollutant exposure and response for use with threatened and endangered fish species.

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Session 3 ***1:20 p.m.***

Passage of hatchery reared Atlantic salmon smolts at dams and movement through estuary and bay on the Penobscot River, Maine

Michael Bailey[1] and Joseph Zydlewski[1,2]
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The Penobscot River hosts the largest return of adult Atlantic salmon in the US, but runs are very low compared to historic numbers. Stocking of hatchery reared smolts is a major restoration tool but has had only moderate success in recent years. Previous telemetry studies have shown that downstream passage success is variable among years and sites. We used acoustic telemetry to quantify downstream passage success and movement through the estuary in 2009. We also assessed the success of survival for three stocking areas: Milo, Passadumkeag and Verona Island. The heavily dammed sections of the river accounted for over 10% mortality in some study reaches. Our best fit model comparing reaches with and without dams demonstrates the lower survival of dam influenced sections. We found variable survival through the estuary for the different hatchery releases.

Session 3 ***1:40 p.m.***

Monitoring changes in resident and anadromous fish communities in Sedgeunkedunk Stream (Penobscot Co., Maine) after barrier removal

Cory Gardner[1], Stephen M. Coghlan Jr.[1], Joseph Zydlewski[1,2] and Rory Saunders[3]
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Sedgeunkedunk Stream is a third order tributary to the Penobscot River. The stream once supported anadromous fish runs that have declined or disappeared due to two barrier dams. A restoration project has been completed on the Sedgeunkedunk which removed the lowermost dam and replaced an upstream dam with a rock-ramp fishway. This project provides an opportunity to characterize the responses of resident fish communities and anadromous fish populations to dam removal. We anticipate dramatic impacts on the stream system associated with connectivity, hydrology, temperature and marine derived nutrient influx. In order to assess fish community response, we have collected data on abundance, length, and mass of all fish species present. The fish community in the stream sections above the dam shows reduced biomass, species richness, and species diversity, compared to the section below the dam. The immediate response to the removal of the lower dam was a drop in fish abundance and species richness downstream of the removal. Fish abundance above the site of the former dam increased, which could be caused by the more common species moving upstream in response to the disturbance caused by the dam removal. Sea lamprey, anadromous fish already present in the stream, are being monitored for both abundance and habitat use. This restoration will serve as a model for other small streams in the watershed, and elsewhere, targeted for dam removal.

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

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

Robert Hogg[1], Stephen M Coghlan Jr.[1] and Joseph Zydlewski[1,2]
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Sedgeunkedunk Stream is a tributary of the lower Penobscot River, debouching downstream of several impassible barriers on the Penobscot main stem. Historically, Sedgeunkedunk Stream provided spawning habitat for several native anadromous fish species including endangered Atlantic salmon, but several small dams reduced or eliminated spawning runs entirely. Currently, only a small population of sea lamprey (*Petromyzon marinus*) uses the accessible portion of Sedgeunkedunk Stream regularly for spawning and rearing. As part of the Sedgeunkedunk Stream Restoration Project (SSRP), the abandoned Mill Dam was removed in August 2009, and this latest restoration effort has opened up an additional 5 km of potential lotic habitat. Consequently, Sedgeunkedunk Stream provides a unique opportunity to examine ecological interactions within a suite of diadromous species in the context of long-term restoration efforts. We hypothesize that semelparous sea lamprey may provide an influx of marine derived nutrients and energy (MDNE) in Maine streams, similar to that documented for Pacific salmon in western streams. Furthermore, we hypothesize that sea lamprey spawning will condition habitat to better suit Atlantic salmon spawning. Sea lamprey spawning activities rearrange gravel and small cobble substrate in the process of nest construction. Lamprey nest building also releases fine sediments while reducing embeddedness. Atlantic salmon prefer loose gravel substrate free of fine sediments for redd construction and as lamprey colonize previously inaccessible habitat beyond the former Mill Dam, lamprey conditioning may attract salmon spawners. Comparing lamprey abundances, stream productivity, and fine-scale changes in habitat before and after dam removal, as well as comparisons with a nearby control stream, will test these hypotheses. Johnson Brook is a stream similar to Sedgeunkedunk Stream but with a natural barrier waterfall excluding diadromous fishes. Comparisons with Johnson Brook will elucidate whether changes in Sedgeunkedunk Stream were a function of colonization and expanded range for diadromous species.

Session 3 **2:20 p.m.**

Evaluating changes in diadromous species distributions and habitat accessibility following the Penobscot River Restoration Project

Tara Trinko[1], Kyle Ravana[2] and Rory Saunders[1]
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[2]*University of Maine, Department of Wildlife Ecology, Orono, ME*

The Penobscot River Restoration Project (PRRP) is a multimillion dollar endeavor that aims to restore native sea-run fish through the removal of two main stem dams and improved fish passage at a third dam on the Penobscot River. We used geographic information systems (GIS) to quantify changes in species distribution and habitat accessibility for 11 diadromous species in the Penobscot Basin following the PRRP. Using previously compiled accounts of historic range, barrier survey data, and simulated barrier passage data, we modeled species-specific distributions and river access for 11 species following the proposed dam removals and compared these against the current ranges and accessibility. For some species such as Atlantic sturgeon (*Acipenser oxyrhinchus oxyrhinchus*), the PRRP will provide access to 100% of their historic freshwater habitat. However, for alewives (*Alosa pseudoharengus*), approximately 46% of historic spawning and rearing habitat will remain inaccessible due to the presence of other passage barriers. These results demonstrate that the PRRP is an important step toward ecosystem recovery in the Penobscot Basin, but other restoration activities will be needed in order to realize the full potential of the PRRP.

Session 3 ***2:40 p.m.***

Growth and survival of stocked juvenile Atlantic salmon in first and second order streams of the Machias River watershed

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

The Machias River, located in Downeast Maine, harbors one of the few remaining wild populations of anadromous Atlantic salmon in the US. This study focuses on Atlantic salmon habitat in first and second order streams of the Machias River watershed. Over the past century, the Machias River watershed has experienced much alteration due to anthropogenic disturbances. These activities, mainly the construction of roads for timber harvest and log driving, have severely disrupted the structure and function of the river and its tributaries. The extensive network of logging roads required the construction of dozens of culverts on many of these headwater streams. Currently, these poorly designed and malfunctioning culverts impede the movement of juvenile Atlantic salmon into tributaries that historically provided nursery and rearing habitat. These productive habitats are essential to the growth and survival of juvenile Atlantic salmon, as they provide thermal refuge, protection from predators, and abundant food supply. However, current management of Atlantic salmon in the Machias River involves stocking fry in larger tributaries because many of these smaller tributaries are blocked by culverts and, thus, would be inaccessible to returning adults. The objectives of this study are to determine the growth and survival of stocked Atlantic salmon fry in these headwater streams, better understand those habitat characteristics most significant to juvenile salmon production, and assess the benefits of culvert removal in the context of Atlantic salmon restoration.

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

Restoring stream connectivity in the Machias River watershed: A watershed-based focus area approach to salmonid restoration

Steven Koenig[1] and Scott Craig[2]
[1]Project SHARE, Eastport, ME; [2]U.S. Fish and Wildlife Service, Maine Fishery Resources Office, East Orland, ME

Since 2001, Project SHARE (Salmon Habitat and River Enhancement) has organized aquatic habitat restoration work intended to improve Atlantic salmon populations in the Downeast Distinct Population Segment (DPS) rivers. The overreaching goal of the restoration strategy is to improve aquatic and riparian habitat conditions on a watershed scale. The restoration thought process is based on correction of stream process rather than technical modifications of a site-specific reach to achieve short-term habitat improvements. Recognition that stream process begins in small headwater streams that influence the entire downstream water course provides the basis for a top-down approach. Therefore, the restoration strategy intends to identify and address multiple habitat threats at many relatively small restoration sites on a watershed scale. Working within the context of SHARE's mission and authority, specific goals are to increase watershed connectivity (including fish passage), increase instream habitat complexity, decrease anthropogenic sedimentation inputs, and mitigate anthropogenic changes in water chemistry (pH, temperature). Identification of high priority subwatersheds and threats assessment within selected focus areas allows limited resources to be focused in a manner that improves the potential for long-term success and benefit to the resource. It is generally recognized that dams and culverts can present barriers to both upstream and downstream fish passage. Less obvious disruptions of the continuum of stream ecological processes have not reached a similar level of mainstream awareness among land-use planners, regulators, and conservation groups. Road-stream crossings have been identified as a principle impact to stream connectivity and subsequently to salmon recovery in the Machias River watershed. Working cooperatively with landowners, state and federal agency partners, SHARE has replaced 50+ undersized round culverts with open bottom arch culverts and has decommissioned 10+ road crossings in the Machias River watershed. Funding is in place to complete 30+ additional road crossings in 2010. Although dams are recognized as a similar threat to salmon restoration in other areas of the DPS, it is generally recognized that most of the dams on the Machias River were removed at the end of the log drive era. SHARE has documented the existence of 50+ historic dam sites in the Machias River drainage. In most cases, the sites do not present impairment to fish passage. However, remnant structures and the reservoirs associated with the sites do present an anthropogenic impact to channel morphology that continues to affect hydrology, sediment transport and water temperature. We will present an overview of the Machias Watershed restoration strategy including: identified threats, symptoms of altered stream connectivity, and habitat restoration efforts to date.

Session 4 ***8:30 a.m.***

The interactive ecology of Atlantic salmon and smallmouth bass: Competition for habitat

Gus Wathen[1], Stephen M. Coghlan Jr.[1], Joseph Zydlewski[1,2] and Joan Trial[3]
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We are investigating competition for habitat between native Atlantic salmon (ATS) and invasive smallmouth bass (SMB). Our major objectives are to determine if: (1) the two species overlap in habitat use, and at what time of year; (2) the overlap causes ATS to shift in their habitat use; and (3) the presence of SMB negatively impacts ATS growth rates. The first objective will be met through a series of snorkel observations of habitat use of both fish in sympatry and allopatry. A simulated stream and an *in situ* "controlled invasion" experiment are being used to meet objective two. Measurements incorporated into a Wisconsin Bioenergetic Model will allow us to calculate ATS growth rates in sympatry and allopatry. Initial results indicate that ATS and SMB age 0+ fish overlap significantly in habitat use during the late summer months, and the overlap does cause shifts in ATS habitat use. Results from this study will be used to better inform managers on the interactive ecology of two of Maine's most culturally and economically important fish.

Session 4 ***8:50 a.m.***

Assessing juvenile Atlantic salmon habitat suitability within small catchments (<2 km^2) in Downeast Maine

Scott Craig[1], Joseph McKerley[1], Jacques Tardie[2] and Steven Koenig[2]
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[2]*Project SHARE (Salmon Habitat and River Enhancement), Eastport, ME*

The U.S. Fish and Wildlife Service's Maine Fishery Resources Office has been collaborating with multiple partners to restore ecological stream processes within small catchments in Downeast Maine. In the past four years, over 80 projects have restored aquatic organism passage and ecological stream functions within fish bearing catchments varying in area from 0.2 to 61.7 km^2 (mean 3.8 km^2). In 2009, we collected pre-restoration stream data to quantify juvenile Atlantic salmon "Habitat Suitability" as defined by Stanley and Trial (1995). This habitat suitability index (HSI) model is useful for evaluating stream habitats for production and survival of juvenile Atlantic salmon. HSI results of fry and parr, and water quality components, will be summarized for tributaries ranging in size from 0.3 to 2.0 km^2.

Reference:

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 4 ***9:10 a.m.***

Effects of ice on juvenile Atlantic salmon in New Brunswick, Canada

Tommi Linnansaari and Richard Cunjak
Canadian Rivers Institute, University of New Brunswick, Department of Biology, Fredericton, NB

Winter is often considered to be a bottleneck for survival of juvenile stream salmonids in temperate and arctic latitudes. Due to logistical difficulties in following fish behavior in ice-covered streams, the effects of different ice formations have not been thoroughly understood. The study used Passive Integrated Transponder (PIT) technology that allows fish monitoring throughout the winter and was carried out over three years to understand how different winter periods, distinguished by contrasting ice condition, affect the ecology of the species. The steepest decline in apparent survival of salmon parr was observed during the pre-ice period in late autumn/early winter, whereas relatively high apparent survivals was observed during the period dominated by ice. Apparent survival possibly decreased again in early spring. Large-sized pre-smolt individuals obtained positive growth during winter. Salmon parr showed plasticity in their winter behavior in relation to prevailing ice conditions. The activity pattern remained generally nocturnal throughout the winter regardless of ice conditions. The level of activity was adjusted, however, being reduced during subsurface ice events, while more daytime activity was observed when the amount of surface ice increased. Salmon parr were sedentary during winter, showing generally short and nonrandom movements. Movement tactics were adjusted relative to the prevailing ice conditions. Subsurface ice did not preclude tagged salmon parr from large areas. The presence of ice cover allowed salmon parr to disperse to areas where no other cover was available. Overall, negative effects of ice on Atlantic salmon parr were minimal and the presence of stable surface ice cover was considered beneficial for salmon parr when water temperatures remained close to 0^oC. In the future, anthropogenic impacts such as climate change and hydropower regulation can lead to changes in the natural ice regime of fluvial waters. Therefore, consideration of winter at a subperiod level will be crucial in order to assess how different salmon populations and their behaviors will be affected.

Session 4 ***9:30 a.m.***

Spawning behavior, reproductive success, and production of juvenile offspring by stocked adult Atlantic salmon in four Maine streams

Gregory Mackey[1], Ernie Atkinson[2], Colby Bruchs[2], Paul Christman[3] and Dan McCaw[3]
[1]Douglas County P.U.D. #1, East Wenatchee, WA; [2]Maine Department of Marine Resources, Bureau of Sea Run Fisheries and Habitat, Jonesboro, ME; [3]Maine Department of Marine Resources, Bureau of Sea Run Fisheries and Habitat, Hallowell, ME

Management strategies used to restore endangered populations of Atlantic salmon within the Gulf of Maine Distinct Population Segment (DPS) have included fry stocking, smolt stocking, egg planting, and stocking gravid adults. Management focusing on fry and smolt stocking has not resulted in significant adult returns and natural reproduction. Adult stocking circumvents much of the hatchery influence on mate selection and potentially results in progeny that are more likely to survive and reproduce in the wild. However, stocking adults sacrifices numerical production advantages achieved by traditional hatchery methods. In 2005, an adaptive management project began in Mopang Stream (Machias), Chase Mill Stream (East Machias) and the Sheepscot River in which river specific Atlantic salmon adults, reared to maturity from captive large parr, were stocked in the autumn. In 2006, a similar project began on Hobart Stream. Results varied across streams, stocked adults successfully spawned, and fry were captured during the following spring. However, the number of redds per female was less than the expected two redds per wild female spawner. Movements of stocked adults were highly variable. The captive reared pre-spawn salmon often left the study reach but did not move upstream of passable obstacles such as waterfalls. Juvenile assessments documented that 0+ and 1+ parr densities were similar to densities in fry stocked areas. However, stocked adults produced fewer 0+ and large parr per capita than adults spawned for fry stocking. Managers need to consider lifetime fitness in evaluating large scale gravid adult stocking projects.

Session 4 ***9:50 a.m.***

Ontogenetic selection on hatchery salmon in the wild: Natural selection on artificial phenotypes

Michael Bailey, Kevin Lachapelle and Michael Kinnison
University of Maine, School of Biology and Ecology, Orono, ME

Captive rearing often alters the phenotypes of organisms that are destined for release into the wild. Natural selection on these unnatural phenotypes could have important consequences for the utility of captive rearing as a restoration approach. We show that normal hatchery practices significantly advance the development of endangered Atlantic salmon fry by 30+ days. As a result, hatchery fry might be expected to face strong natural selection resulting from their developmental asynchrony. We investigated patterns of ontogenetic selection acting on hatchery produced salmon fry by experimentally manipulating fry development stage at stocking. Contrary to simple predictions, we found evidence for strong stabilizing selection on the ontogeny of unfed hatchery fry, with weaker evidence for positive directional selection on the ontogeny of fed fry. These selection patterns suggest a seasonally independent tradeoff between abiotic or biotic selection favoring advanced development and physiological selection linked to risk of starvation in unfed fry. We show through a heuristic exercise how such selection on ontogeny may exacerbate problems in restoration efforts by impairing fry productivity and reducing effective population sizes by 13 to 81%.

Session 4 ***10:10 a.m.***

Historical summer baseflow trends for New England rivers

Robert W. Dudley and Glenn A. Hodgkins
US Geological Survey, Maine Water Science Center, Augusta, ME

River baseflow is important to aquatic ecosystems, particularly because of its influence on water temperatures. Summer (June through September) daily mean streamflows were separated into baseflow and stormflow components by use of an automated method at 25 stations in the New England region of the United States that have long term records and predominantly drain natural basins. Summer monthly mean baseflows increased at most stations in western New England from 1950 to 2006 with many large increases (>20%) and some very large increases (>50%) in New Hampshire and Vermont. The same was true for increases in summer 7-day low baseflows in New Hampshire and Vermont during this same period; in contrast, there were small and large decreases in 7-day low baseflows in northern and coastal areas of Maine. Seven-day low baseflow trends at the 10 stations with records from 1930 to 2006 were similar to trends from 1950 to 2006. Summer stormflows increased from 1950 to 2006 by more than 50% at many stations in New England, particularly in New Hampshire and Vermont. Summer rainfall increased at most weather stations in New England from 1950 to 2006 with many increases of more than 20% in western New England.

Session 5 ***10:50 a.m.***

Evaluating management strategies by individual based simulation

Krzysztof Sakrejda-Leavitt[1] and Benjamin Letcher[2]
[1]*University of Massachusetts, Organismic and Evolutionary Biology, Amherst, MA*; [2]*U.S. Geological Survey, Silvio O. Conte Anadromous Fish Research Laboratory, Turners Falls, MA*

Allocating resources between different habitat improvements and stocking strategies is key to optimal use of resources in salmon conservation. Presently, it is difficult to evaluate the trade-offs inherent in management decisions because no single model incorporates all the relevant aspects of the salmon life cycle. We developed an individual based simulation model of freshwater growth, movement, and survival for the Atlantic salmon life cycle from stocking to smolting. All three parts of the simulation are driven by a common set of factors: local density, water temperature, discharge volume, seasonality, and habitat quality. The simulation model is parameterized based on statistical models developed directly from a mark-recapture study on a stocked population. These features allow us to evaluate the trade-offs between management strategies in terms of the effect on the number and size distribution of salmon smolts.

(Abstract only, no presentation)

Session 5 ***11:10 a.m.***

Basinwide Geographic and Ecological Stratification Technique (BGEST): Parr populations, habitat and management

Joan G. Trial[1], Greg Mackey[2] and Paul Christman[3]
[1]Maine Department of Marine Resources, Bureau of Sea Run Fisheries and Habitat, Bangor, ME; [2]Douglas County P.U.D. #1, East Wenatchee, WA, [3]Maine Department of Marine Resources, Bureau of Sea Run Fisheries and Habitat, Hallowell, ME

Basin large parr populations have been estimated on the Narraguagus River (1991 to 2006), the Dennys River (2001-2005), and the Sheepscot River (2003 - 2006). The estimates, based on stratifying the watersheds (geographic) and habitat (ecological), and expanding population parr estimates from sites based on the proportion of habitat sampled, have annual confidence intervals ($\pm$) that averaged 29 % of the estimate on the Narraguagus River, 34% of the Dennys River estimates, and 45 % of the Sheepscot River estimates. The estimates represent a large investment in planning, field work, and data management and computation. While the parr numbers track population trends, their strengths are in what can be learned about habitat and as the basis of adaptive management. On the Narraguagus River in 10 of 16 years, tributaries containing only 1.6 % of the surveyed juvenile rearing habitat reared approximately 19 % of the annual estimates (range 13 % to 33 %). In three of four years, the Upper West Branch of the Sheepscot River reared on average 49% of the large parr (range 37 % to 59 %), yet contained only 17 % of the surveyed habitat. In 2005 and 2006, the lower main stem Sheepscot strata population was over six times higher than the two previous years, corresponding to 0+ parr stocking in 2004 and 2005. Following an assessment year, 0+ parr stocking was continued in this portion of the Sheepscot River. The switch from scatter to clump stocking in the main stem Narraguagus strata immediately below Beddington Lake in 2005 did not result in lower parr populations, and clump stocking fry will be continued in this portion of the Narraguagus. The key to using ecologically stratified large parr estimates in adaptive management is to geographically and temporally segregate management strategies.

Session 5 ***11:30 a.m.***

American shad in the Penobscot River –choosing recovery tools

Joseph Zydlewski[1,2] and Michael Bailey[1]
[1]University of Maine, Department of Wildlife Ecology, Orono, ME; [2]U.S. Geological Survey, Cooperative Fish and Wildlife Research Unit, University of Maine, Orono, ME

The planned restoration efforts in Penobscot River include the removal of two main stem dams and the improvement of passage at the lowest remaining dam, Milford. This ambitious undertaking has generated optimism for the recovery of anadromous fish such as Atlantic salmon, but also for alosine fishes such as American shad. Shad are present in the Penobscot River, though presumed to be few in number, fueling concerns that unaided recovery could either fail or be unnecessarily protracted after access to upriver habitat is restored. While supplementation is a commonly used tool in fisheries management, the use of hatchery products is often a contentious issue. Concerns include impacts of hatchery reared fish on natural populations via behavioral, ecological and genetic effects. The cost effectiveness of supplementation strategies can also be questionable. In order to assess the possible benefits of artificial supplementation on the rate of recovery, we applied data from several sources to build a deterministic population model. In this model, the shad population was represented by age classes up to 11 years (representative of age structure of shad observed in the Gulf of Maine) and iteroparity was included. Age of first maturation, at sea mortality, and fecundity were derived from Atlantic States Marine Fisheries Commission reporting. Shad stocked as fed larvae were assumed to have ten-fold higher survival than wild spawned fish. As expected, the model was very sensitive to initial population. Presuming a current run of 1,000 shad to the river and a population that stabilizes at 600,000 upon restored connectivity, the population would increase to 15,000 within 15 years and stabilize in less than 40 years. A stocking scenario that adds 12 million fry annually would accelerate stabilization to less than 30 years. It is hoped that this heuristic exercise may inform decisions associated with an intensive shad stocking program.

Session 2 ***11:50 a.m.***

American shad population genetics: Focus on Maine drainages

Meredith L. Bartron, Shannon Julian and Jeff Kalie
U.S. Fish and Wildlife Service, Northeast Fishery Center, Lamar, PA

American shad (*Alosa sapidissima*) are an important component of the diadromous fish community and ecosystem for Atlantic salmon. Evaluation of the genetic structure of American shad stocks, with particular focus on northeastern and Maine drainages, can be used to understand the genetic relationships among drainages and provide information for management and conservation. Samples were obtained in 2008 from five drainages in Maine, and genetic results obtained from 15 variable microsatellite loci were compared to other primary American shad rivers in the northeast: Merrimack, Connecticut, Hudson, Susquehanna, and Delaware. Observed estimates of genetic diversity were slightly lower in Maine drainages relative to other populations examined. Mean observed heterozygosity (H_o) and mean allelic richness (A_r) were lower among Maine populations (H_o=0.795 and A_r=9.414) compared to estimates observed among other populations (H_o=0.809 and A_r=10.061). Comparisons of differences in allele frequencies among all rivers sampled indicated that samples obtained from the Narraguagus River were significantly different (P<0.01) from all rivers analyzed, including Maine rivers. Samples from the Merrimack River, which has been and is currently used as a source for American shad stocking throughout New England, did not differ significantly in allele frequencies from the Androscoggin, Kennebec, Saco, or Sheepscot drainages, but did significantly differ in allele frequencies from the Narraguagus River (P<0.01). Allele frequencies from American shad sampled from the Hudson, Susquehanna, and Delaware rivers generally were significantly different from the Connecticut, Merrimack, and Maine rivers (P<0.01). Resulting information about the genetic structure of American shad populations and knowledge of the history of stock transfer can be used to evaluate past and current reintroduction efforts, and to assist ongoing management and conservation efforts for American shad in New England.

Session 5 ***12:10 a.m.***

Outside the box: Coastal movements of shortnose sturgeon and implications for management

Phillip Dionne[1], Michael Kinnison[2], Gail Wippelhauser[3], Joseph Zydlewski[4] and Gayle Zydlewski[1]
[1]University of Maine, School of Marine Sciences, Orono, ME; [2]University of Maine, School of Biology and Ecology, Orono, ME; [3]Maine Department of Marine Resources, Bureau of Sea Run Fisheries and Habitat, Hallowell, ME; [4]U.S. Geological Survey, Cooperative Fish and Wildlife Research Unit, University of Maine, Orono, ME

The shortnose sturgeon (*Acipenser brevirostrum*) is managed as 19 river-specific distinct population segments under the US Endangered Species Act. River-specific information about population size, distribution, and habitat use are critical to the management of this species. Recently, answering such questions has become complicated by evidence of movement between distant river systems, e.g., the Penobscot and Kennebec rivers in Maine (>140km direct path). Closed population estimates for the Penobscot and Kennebec rivers are 1,531 (95% CI: 885 – 5,681), and 9,488 (95% CI: 6,942 to 13,358), respectively. In 2006 and 2007, 40 shortnose sturgeon captured in the Penobscot River were implanted with acoustic tags; 10 of these tags were subsequently detected in the Kennebec River. The high rate of exchange between these systems indicates that we are likely sampling individuals from multiple sources. We have been using mark-recapture methods and acoustic telemetry to estimate the proportion of sturgeon moving between these two rivers. In 2008, individuals were documented using three additional coastal Maine rivers. Sampling techniques since 2008 reflect the open nature of this population and abundance estimates based on discrete closed population periods bounded by periods of emigration and immigration. Our current population estimates are: for summer 2008: 1,739 (95% CI: 847-3653) and fall 2008: 1,007 (95% CI: 674 – 1531). These estimates will be applied to data collected in 2009. These, along with movement patterns, will provide more accurate information for the management of this endangered species.

Session 5 ***12:30 p.m.***

Using acoustic telemetry to track the movements of alewives (*Alosa pseudoharengus*) in freshwater and the coastal zone

Jonathan Carr and Fred Whoriskey
Atlantic Salmon Federation, St. Andrews, NB, Canada

We used acoustic telemetry to assess the pre- to post-spawning movement and survival of alewives in a Canadian river. A total of 40 alewives were tagged (20 each in 2007 and 2008) after they ascended a fish ladder at the Magaguadavic River's head of tide hydroelectric dam. Fish resided in the lower river reaches and a nearby lake during the spawning period. Six and two alewives are presumed to have died during the 2007 and 2008 spawning periods, respectively. During the return to sea, signals from five (2007) and two (2008) fish were lost near the top of the dam. Nine (2007) and four (2008) fish passed the dam via the turbines and suffered a mortality rate of 62%. No alewives used the downstream fish bypass facility in 2007. However, 12 fish used the bypass facility in 2008 when increased attraction flow was provided. Fish passing the dam alive were subsequently tracked through the river estuary and up to 28 km through the coastal zone. This study has demonstrated that sonic telemetry can be successfully employed for this species.

Session 5 ***12:50 p.m.***

Tidal power development in Maine: Preliminary laboratory tests and field assessments in Western Passage and Cobscook Bay

Gayle Zydlewski, James McCleave and Haley Viehman
University of Maine, School of Marine Sciences, Orono, ME

Waterfront communities are changing nationwide and Maine is no exception. One change that some communities will face is the development of alternative energy, including wind and tidal power. It is only when the value of the energy resource is balanced against the environmental and social impact that the potential for developing a site can be understood. While environmental impacts of tidal turbines will be complex, the most acute impacts are likely to be observed as direct contact of aquatic species with turbines. Because open turbine designs are new technology, studies examining the ability of fishes and other aquatic organisms to avoid a turbine are not standardized. Test procedures necessarily will be different from those used with conventional (enclosed) hydroelectric turbines. We have initiated laboratory studies to consider how Gorlov turbines may impact free swimming fish, examining turbine blade strikes and turbine avoidance. In addition, we have examined individuals for injury (bruising, descaling) and stress levels. We have also initiated field testing. Baseline fisheries data were collected in Western Passage and Cobscook Bay in summer/fall of 2009. Baseline data include stationary acoustic surveys (24 h) of proposed turbine deployment sites to determine vertical distribution of aquatic organisms. In fall of 2009 a barge-deployed turbine will be tested by Ocean Renewable Power Company in Cobscook Bay and a field deployment is scheduled for fall 2010. Barge deployment will be assessed using DIDSON (Dual-frequency Identification SONAR) in fall of 2009. Laboratory and field results will be used to inform engineers about turbine design and/or operation to minimize environmental impacts as well as informing resource agencies in permitting decisions.

ABSTRACTS
POSTER PRESENTATIONS

Diadromous Species Restoration Research Network: A five-year collaborative research effort

Barbara S. Arter
University of Maine, George J. Mitchell Center for Environmental and Watershed Research, Orono, ME

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 multispecies restoration at the ecosystem level. DSRRN integrates many diverse activities that improve the understanding of ecosystems and enhance restoration outcomes, facilitates the study of questions fundamental to diadromous fish ecology and restoration through scientific meetings, workshops and local networking, and enhances coordination of diadromous species restoration efforts of academic, government, and watershed stakeholders. The Network which is funded through the National Science Foundation, provides information and networking on research and restoration funding opportunities, research and restoration project partnerships, conferences and meetings, the Penobscot Science Exchange, fisheries and restoration links, and the Gulf of Maine Knowledge Base which provides access to spatially referenced bibliographic information so that users can locate information using text based and map based searches by state/province and by watershed.

Atlantic and shortnose sturgeon management and research needs

Kim Damon-Randall, Lynn Lankshear and Jessica Pruden
NOAA's National Marine Fisheries Service, Protected Resources Division, Gloucester, MA

NOAA's National Marine Fisheries Service (NMFS) has jurisdiction for both Atlantic and shortnose sturgeon. Atlantic sturgeon is currently designated as NMFS Species of Concern and Candidate species. In 2007, a status review team completed a status review for Atlantic sturgeon indicating that there are five distinct population segments of Atlantic sturgeon in the United States and recommending that three of the five Distinct Population Segments (DPS) be listed under the Endangered Species Act (ESA). The five DPS are: Gulf of Maine, New York Bight, Chesapeake Bay, Carolina, and South Atlantic. NMFS is currently in the process of considering the existing information to determine if listing is warranted for Atlantic sturgeon, and the Northeast Regional Office will be publishing a listing determination for the three DPSs in the Northeast early in 2010. Shortnose sturgeon is listed as endangered throughout its range. NMFS recently assembled a status review team to update the existing status of shortnose sturgeon. The status review report is expected in 2010, and it is possible that based on the information in this report, NMFS could propose to list DPSs of shortnose sturgeon. Consequently, the listing status of shortnose sturgeon in Maine could change in the near future. The Northeast Regional Office has been working with sturgeon researchers for several years to compile information on both species of sturgeon. Much of this research effort has been focused in Maine in recent years including projects on the Penobscot, Kennebec, and Saco Rivers. The various research efforts have provided crucial information that is being considered by NMFS in recovery efforts and in consultations under Section 7 of the ESA. While a significant amount of information has been collected in recent years, there are still many remaining questions that need to be answered including: information on the distribution, abundance, and movements of all life stages, particularly for young-of-the year and juveniles; identification of particular spawning locations; developing population estimates for both species where they occur in Maine; assessing impacts of water quality and contaminants on sensitive life stages; assessing interbasin movements and potential for colonization; and basic habitat characterizations.

Major histocompatibility complex class II alleles: Genetic and functional variation in the antigen-binding site of Atlantic salmon

Ellen E. Hostert, Gerard Zegers, Mallory Ward and Amanda Corey
University of Maine at Machias, Division of Environmental and Biological Sciences, Machias, ME

Our strategy is to use comparative genomic analysis to study the evolution of immune system genes in response to differences in life history strategies, specifically the differences in the suites of parasites experienced by landlocked versus anadromous fish. Here we report early results from a comparison between landlocked and anadromous populations of Atlantic salmon distributed throughout the Distinct Population Segment (DPS). Preliminary work in our laboratory indicated high levels of heterozygosity for the major histocompatibility complex (MHC) class-IIβ gene. Analysis of single-strand conformational polymorphisms (SSCP) from the Machias, East Machias, and Dennys rivers salmon indicates a general pattern of shared polymorphism within the DPS and with fish from Atlantic Canada. Extensive sharing of alleles among closely related species is well known for MHC alleles. We demonstrate that our SSCP patterns are repeatable, and that SSCP patterns derived from cloned DNA are identical to alleles observed in our source fish. DNA sequencing demonstrates that at least some DPS fish alleles are similar to those previously reported from Atlantic Canada. Future work includes identification of the corresponding amino acid changes in the antigen-binding site for each allele sampled, and broad correlation of functional allelic diversity with life history differences. This study will be expanded to other immune system genes, especially MHC class-IIα, as well as MHC class-I and a minor histocompatibility complex gene such as transporter associated with antigen processing (TAP). This will allow multilocus genotyping of fish, and determination of the existence of unique immune system genotypes within the DPS.

Monitoring progress for the Penobscot River Restoration Project

Blaine S. Kopp
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 will also initiate scientific baseline monitoring to allow tracking of 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. 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 most seaward 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; (7) wetland and riparian plant communities. This baseline monitoring will provide an objective basis for evaluating restoration outcomes, and a framework for researchers to address additional PRSSC and GOMC monitoring priorities.

Apparent channel alterations associated with historic log drives in the Machias River drainage

Derik Lee[1*], **Thomas Cochran**[1*], Tora Johnson[2], Steven Koenig[3] and Sherrie Sprangers[2]
[1]University of Maine at Machias, Machias, ME; [2]University of Maine at Machias, Division of Environmental and Biological Sciences, Machias, ME; [3]Project SHARE, Eastport, ME

Spring log drives were an annual event on the Machias River from the 1800's through 1977. Remnants of the infrastructure associated with the drives are scattered throughout the watershed. Landings used for transferring logs onto the river or lakes and water control dams are the most commonly identified structures. Rock footings and earthen and wood berms are common structural remnants of the water control dams both on the main stem of the river and its tributaries. These channel alterations potentially degrade Atlantic salmon spawning and rearing habitat by creating a hydraulic check in the stream. As a result, the channel is artificially widened upstream and sediment deposition occurs both upstream and downstream of the check. Another type of log drive relic has been identified along the main stem of the Machias River between Second and Third Machias Lakes: rock and log walls appear to have been constructed to essentially cut off side channels, resulting in the creation of artificial oxbows behind the walls. Project SHARE (Salmon Habitat and River Enhancement) in partnership with faculty and students at the University of Maine at Machias have removed dam remnants at some sites in the Machias and East Machias watersheds. During the fall of 2009, a project was initiated on the Machias to map the locations of the rock walls, the length of the blocked side channels behind each wall, the substrate characteristics of the blocked side channels, and cross-sectional profiles through the side channels and associated main channel. Future studies will combine the data from these projects with existing salmon habitat survey data for the same reaches of river, assess the potential effect of the channel alterations on Atlantic salmon habitat availability, and evaluate potential habitat unit gains (or losses) that might be realized by removal of some of these channel altering structures.

**Environmental Studies undergraduate*

Focus area approach to salmonid restoration: basinwide stream-road crossing and fisheries assessments

Joseph McKerley[1], Josh Noll[2], Iris Lowery[2], Steven Koenig[2] and Scott Craig[1]
[1]U.S. Fish and Wildlife Service, Maine Fishery Resources Office, East Orland, ME; [2]Project SHARE Eastport, ME

In 2007 and 2008, the USFWS Maine Fishery Resources Office and Project SHARE (Salmon Habitat and River Enhancement) completed culvert and fisheries assessments at all stream-road crossings in two high priority salmonid subbasins in Downeast Maine – West Branch Machias River and Old Stream (above Rt. 9). We identified fish bearing, stream-road crossings for a restoration strategy designed to restore ecological stream processes within watersheds that have exceedingly high conservation merit in terms of both existing high quality salmonid habitat *and* projected long term protection from threats such as urbanization and increased road development. Identification of high priority focus areas allows limited resources to be focused in a manner that improves the potential for long term success and benefit to the natural resource. It should be noted that private landowner support was established prior to conducting surveys. Working within the context of the 2009 Project SHARE Restoration Strategy, specific goals are to increase watershed connectivity and instream habitat complexity, decrease anthropogenic sedimentation inputs, and mitigate anthropogenic changes in water chemistry (pH, temperature). The principle target species are Atlantic salmon (federally endangered) and brook trout.

Restoring fish passage and natural stream function in eastern Maine

Katrina Mueller and Steven Koenig
Project SHARE, Eastport, ME

Undersized round culverts at road-stream crossings on first and second order perennial streams are the principle impediment to fish passage in the Downeast coastal region of Maine. Whereas rivers draining this region are relatively free of main stem dams, the impact of commercial road networks on connectivity and natural stream function is extensive. Road-stream crossings can create fish passage barriers through hanging outfalls and excessive or insufficient velocity and flow. En masse, they can alter temperature, hydrologic and sediment transport regimes, and subsequently decrease the quality and quantity of available habitat for native fishes. Recent habitat assessments suggest that legacies from the log driving era might also be wide ranging, significant, and wholly negative from a native species standpoint. Since 2005, SHARE (Salmon Habitat and River Enhancement) has focused its on-the-ground efforts on restoring natural function to all first and second order perennial streams within high priority subwatersheds draining the Machias River (a historically important and well protected Atlantic salmon migration corridor). These subwatersheds are considered the "best of the best" in terms of habitat quality (existing and potential) by regional salmon biologists and also rank very high in terms of habitat quality for native eastern brook trout and future security from urbanization. In 2009, SHARE received funding under the American Recovery and Reinvestment Act to decommission or replace 53 undersized round culverts with open bottom structures in its current geographical focus area. With half of these sites completed in 2009, we are actively working towards our goals of reconnecting headwaters to the main stem and lower watershed; re-establishing fish passage and natural temperature, sediment and nutrient transport regimes at all fish-bearing sites; and continuing to expand our capacity as an organization to coordinate with regional stocking efforts and engage a broader base of youth and professionals on-the-ground.

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]
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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:
Bridger CJ, Booth RK. 2003. The effects of biotelemetry transmitter presence and attachment procedures on fish physiology and behavior. Rev. Fish. Sci. 11:13-34.
Smith GW, Campbell RNB, MacLaine JS. 1998. Regurgitation rates of intragastric transmitters by adult Atlantic salmon (*Salmo salar* L.) during riverine migration. Hydrobiol. 371/372: 117-121.

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

Atlantic salmon smolt movements and survival in the Penobscot River

Daniel Stich[1], Michael Bailey[2], Christopher Holbrook[3], Michael Kinnison[4], Gayle Zydlewski[5] and Joseph Zydlewski[1,6]
[1]University of Maine, Department of Wildlife Ecology, Orono, ME; [2]U.S. Fish and Wildlife Service, Central New England Fishery Resource Center, Nashua, NH; [3]Michigan State University, Department of Fisheries and Wildlife, East Lansing, MI; [4]University of Maine, School of Biology and Ecology, Orono ME; [5]University of Maine, School of Marine Sciences, Orono, ME; [6]U. S. Geological Survey, Cooperative Fish and Wildlife Research Unit, University of Maine, Orono, ME

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

Joseph Zydlewski[1,2], Anitra Firmenich[3], Paul Santavy[3], Christine Lipsky[4], James Hawkes[4] and John Kocik[4]
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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

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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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Canadian Rivers Institute, University of New Brunswick, Department of Biology, Fredericton, NB, Canada

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

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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]
[1]NOAA's National Marine Fisheries Service, Orono, ME; [2]NOAA's National Marine Fisheries Service, Woods Hole, MA

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
University of Maine, School of Marine Sciences, Orono, ME

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

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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

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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?

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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

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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

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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

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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

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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

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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 $ng•ml^{-1}$) and increased with temperature to a peak of 23.4 $ng•ml^{-1}$ 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*

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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*

Mallory L. Ward and **Ellen E. Hostert**
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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.

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