Maine Cooperative Fish and Wildlife Research Unit and Department of Wildlife, Fisheries, and Conservation Biology; University of Maine

2015 Report to Cooperators

UNIT COOPERATORS

University of Maine

Maine Department of Inland Fisheries and Wildlife

United States Geological Survey

United States Fish and Wildlife Service

Wildlife Management Institute

Compiled and Edited by
Cynthia S. Loftin and Rena A. Carey

Special thanks to Mark McCullough for allowing us to use his original pen and ink drawings throughout the report.

To download a digital copy of this report, please visit:
http://www.coopunits.org/Maine/Documents/ *or*
http://umaine.edu/wle/maine-cooperative-fish-and-wildlife-research-unit/

Cover Photo: Lisa Izzo, Milford Dam, Maine

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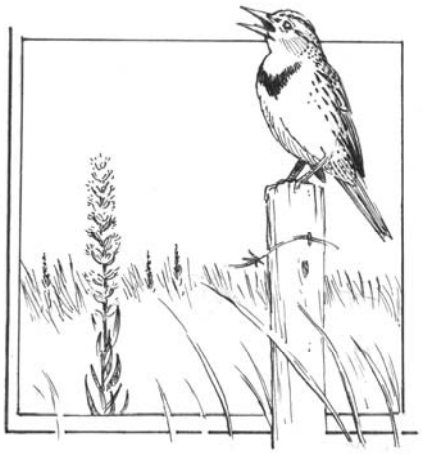
UNIT Mission

The Maine Cooperative Fish and Wildlife Research Unit (CFWRU) is uniquely suited to pursue research relevant to fish and wildlife conservation in northern ecosystems. Maine is the most heavily forested state in the Nation and is covered by numerous ponds, lakes, wetlands, streams, and rivers. Maine has an extensive coast line with a rich variety of habitats adjacent to one of the most productive marine areas of the world, the Gulf of Maine. Tourism and forest product industries are extremely important to Maine's economy and culture. These industries generate management challenges for fish and wildlife that require solutions based on sound science. The Maine CFWRU applies expertise in both terrestrial and aquatic ecology to State and Federal natural resource management priorities.

The primary objectives of the CFWRU are to: (1) facilitate and strengthen professional education and training of fisheries and wildlife scientists; (2) carry out research programs of aquatic, mammalian, and avian organisms and their habitats; and (3) disseminate research results through the appropriate media, especially peer-reviewed scientific articles. The educational and training objective is through advisement of graduate students and their research projects, formal classroom instruction, and supervision of technicians and research associates conducting collaborative research with University staff. In addition, Unit personnel are involved with extension and technical assistance to cooperating agencies and to the general public.

The research program of the Maine CFWRU broadly reflects the needs of the cooperators. Funding in recent years reflects a diversity of studies. Priority research areas are: (1) ecological studies on species of State and Federal interest (e.g., amphibians, Atlantic salmon, brook trout, native pollinators, black bears); (2) management and habitat-related studies with special reference to the effects of land and water-use practices (e.g., forest harvest, dams) on fish and wildlife; and (3) issues related to the effects of land management and forestry on aquatic and wetland systems, and fisheries management in Maine and northern New England.



STATE of the Unit and Department

The Maine Cooperative Fish and Wildlife Research Unit and the University of Maine Department of Wildlife, Fisheries, and Conservation Biology are pleased to summarize the past year's research accomplishments and activities in this annual report. Together, we have collaborated with scientists from State and Federal agencies, universities, and non-governmental organizations on 38 research projects presented in the pages that follow. These collaborative relationships enable us to pose a variety of research questions in interdisciplinary studies to address the resource management information needs of our research sponsors and to advance science in wildlife and fisheries ecology, management, and conservation. We value these opportunities to work together and look forward to continuing these relationships as well as developing new collaborations in the year ahead.

Our research occurs primarily in Maine and New England, however, our science is applicable beyond this geographical area. We broadly group our diverse array of projects into three categories: Fisheries and Aquatic; Wildlife and Habitats; Integrated Ecology. This report includes summaries of research ranging from defining species-habitat relationships, to modeling species responses to habitat change, and to developing tools to integrate public input into natural resource management decisions. Many of these projects have been recent, some are long-term, and some have been completed during the past year. The majority of our research is conducted as part of graduate degree programs; during the past year, Unit and Department faculty mentored 36 graduate students and postdocs and 5 graduate students completed requirements for M.S. or Ph.D. degrees. Our recent graduates are working for universities, state and federal agencies, and non-governmental organizations.

The year brought several changes to the Unit and its cooperators. Dr. Shawn McKinney, Assistant Unit Leader-Wildlife, resigned from the Unit program, to relocate with his family to Missoula, Montana. We wish him well! Long-time faculty members Dr. Malcolm Hunter and Aram Calhoun transitioned from full-time to a new shared appointment. Two new Assistant Professors, Dr. Alessio Mortelliti and Dr. Amber Roth, were hired and joined us during fall 2015. Dr. Roth's position is shared with the School of Forest Resources (SFR). Dr. Mortelliti's research addresses interactions of wildlife populations, particularly mammals, with their habitats; whereas, Dr. Roth's interests focus on forest-wildlife interactions in managed systems. We look forward to cooperating with them to address our department's growing needs in instruction, advising, and graduate mentoring. The Maine Department of Inland Fisheries and Wildlife (MDIFW) also welcomed new staff to their programs during the past year. We look forward to continuing to work with them to address their resource management information needs.

The past year has been a productive research year for the Department and Unit, with external research funding continuing to support our growing program. Our graduate program continues to be active and attract great students who ably represent our academic and research programs locally and at professional meetings across the country. Undergraduate student enrollment in WFCB continues to grow (149 to 183 students during 2014-2015) creating new challenges, expanded course and advising responsibilities, and exciting new opportunities. Dr. Aram Calhoun passed the reins of Director of the Ecology and Environmental Sciences (EES) degree programs to Dr. Sarah Nelson (SFR). Lindsay Seward, Instructor of Wildlife Ecology, assumed a new role as Undergraduate Coordinator for the major in Wildlife Ecology and passed her role as Undergraduate Coordinator for the EES major along to Julie Eubanks. Other changes are on the horizon for the department, as we address growing enrollments, while also meeting expanding research opportunities, and faculty transitions.

The Unit and Department look forward to another of continuing and new relationships with our colleagues. You can reach the investigators of the projects summarized in this report via contact information listed on the Unit (www.coopunits.org/Maine/) or Department (www.umaine.edu/wle/) websites. We welcome your comments.

COOPERATING PERSONNEL

UNIVERSITY OF MAINE

Dr. Carol H. Kim, Vice President for Research
Dr. Daniel J. Harrison, Chair: Department of Wildlife, Fisheries, and Conservation Biology

MAINE DEPARTMENT OF INLAND FISHERIES AND WILDLIFE

Mr. James Connolly, Director, Bureau of Resource Management

U.S. FISH AND WILDLIFE SERVICE

Ms. Laury Zicari, Supervisor, Maine Field Office

U.S. GEOLOGICAL SURVEY

Dr. John Organ, Chief, Cooperative Research Units Program

WILDLIFE MANAGEMENT INSTITUTE

Mr. Steve Williams, President

UNIT PERSONNEL

SCIENTISTS

Cynthia S. Loftin, Unit Leader, and Associate Professor of Wildlife Ecology
Shawn T. McKinney, Assistant Unit Leader for Wildlife and Assistant Professor of Wildlife Ecology
Joseph D. Zydlewski, Assistant Unit Leader for Fisheries, and Associate Professor of Wildlife Ecology

SUPPORT STAFF

Rena Carey, Administrative Support Supervisor
Katherine Goodine, Administrative Specialist

COLLABORATING AGENCIES AND ORGANIZATIONS

American Forest Management
American Recovery and Reinvestment Act (ARRA)
Army Corps of Engineers
Atlantic Salmon Federation
Baxter State Park
Biodiversity Research Institute
Canadian-American Centre; Downeast Salmon Federation
Central Maine Power
Eastern Maine Conservation Initiative
Fulbright Student Scholar Program
Gerald Pelletier, Inc
Institute of Marine Biology and Oceanography, University of Sierra Leone
Katahdin Forest Management
Maine Association of Wetland Scientists
Maine Audubon Society
Maine Department of Environmental Protection
Maine Department of Inland Fisheries and Wildlife
Maine Department of Marine Resources
Maine Outdoor Heritage Fund
Maine River Bird Volunteer Network
Maine Sea Grant
Maine State Planning Office
Muckleshoot Indian Tribe
National Fish and Wildlife Foundation
National Oceanic and Atmospheric Administration
National Park Service
National Science Foundation – Dynamics of Coupled Natural and Human Systems (CNH)
National Science Foundation – Experimental Program to Stimulate Competitive Research
NSF Adaptation to Abrupt Climate Change IGERT
Orono Land Trust
Orono, Town of
Passamaquoddy Tribe
Penobscot Indian Nation
Penobscot River Restoration Trust
Penobscot Valley Audubon Chapter
School of Agricultural, Forest, and Environmental Sciences at Clemson University
St. Croix International Waterway Commission
The Nature Conservancy
The World Bank
Topsham, Town of
U.S. Department of Agriculture
U.S. Fish and Wildlife Service
U.S. Fish and Wildlife Service – Craig Brook National Fish Hatchery
U.S. Fish and Wildlife Service – Division of Migratory Birds
U.S. Geological Survey – Biological Resources Discipline
U.S. Geological Survey – Eastern Regional Cooperative Fish and Wildlife Research
U.S. Geological Survey – Maine Cooperative Fish and Wildlife Research Unit
U.S. Geological Survey – Patuxent Wildlife Research Center
U.S. Geological Survey – Science Support Program
University of Guelph
University of Maine
University of Maine – Department of Wildlife, Fisheries, and Conservation Biology
University of Maine – Maine Agricultural and Forest Experiment Station
University of Maine – Maine Cooperative Forestry Research Unit
University of Maine – School of Biology and Ecology
University of Maine – School of Marine Sciences
University of Maine – Sustainable Solutions Initiative
USDA SARE Grants
West Enfield Fund
Wildlife Management Institute

UNIVERSITY OF MAINE COLLABORATORS

Department of Wildlife, Fisheries, and Conservation Biology

Daniel J. Harrison, *Chair, Professor*
Erik J. Blomberg, *Assistant Professor*
Aram J.K. Calhoun, *Professor*
Stephen M. Coghlan, Jr., *Associate Professor*
Cory Gardner, *Scientific Research Assistant*
Malcolm L. Hunter, Jr., *Professor*
William B. Krohn, *Professor Emeritus*
Sabrina Morano, *Research Associate*

Department of Anthropology

Samuel P. Hanes, *Assistant Professor*

School of Biology and Ecology

Allison Dibble, *Assistant Research Professor*
Francis A. Drummond, *Professor*
Jacquelyn L. Gill, *Assistant Professor*
Hamish S. Greig, *Assistant Professor*
Rebecca L. Holberton, *Professor*
Michael T. Kinnison, *Professor*
Brian J. McGill, *Professor*
Brian J. Olsen, *Associate Professor*
Mary S. Tyler, *Professor*

Department of Civil and Environmental Engineering

Aria Amirbahman, *Professor*

School of Earth and Climate Science

Sean M.C. Smith, *Assistant Professor*

School of Economics

Kathleen P. Bell, *Professor*
Mario Teisl, *Director*, *Professor*
Timothy M. Waring, *Assistant Professor*

School of Forest Resources

Daniel J. Hayes, *Assistant Professor*
Robert J. Lilieholm, *Professor*
Robert S. Seymour, *Professor*

School of Marine Sciences

Teresa R. Johnson, *Associate Professor*
Jeffrey A. Runge, *Research Professor*
Gayle B. Zydlewski, *Associate Research Professor*

EXTERNAL COLLABORATORS

Brad Allen, *Wildlife Biologist, Maine Department of Inland Fisheries and Wildlife*
Michael Bailey, *Fish Biologist, U.S. Fish and Wildlife Service*
Kyle Barrett, *Assistant Professor, Clemson University*
Dana M. Bauer, *Assistant Professor, Boston University*
James P. Bogart, *Professor Emeritus, University of Guelph*
Erynn M. Call, *State Raptor Specialist, Maine Department of Inland Fisheries and Wildlife*
Phillip deMaynadier, *Wildlife Biologist, Maine Department of Inland Fisheries and Wildlife*
Susan Gallo, *Wildlife Biologist, Maine Audubon*
Joseph E. Hightower, *Assistant Unit Leader, NC Cooperative Fish and Wildlife Research Unit*
David Irons, *Alaska Seabird Coordinator, U.S. Fish and Wildlife Service*
Walter Jakubas, *Mammal Group Leader, Maine Department of Inland Fisheries and Wildlife*
Ian Kiraly, *Fisheries Biologist, Gomez and Sullivan Engineers*
John Kocik, *Maine Task Chief, NOAA - NMFS Maine Field Station*
Daniel G. McAuley, *Station Leader, USGS Patuxent Wildlife Research Center*
Mark McCollough, *Endangered Species Specialist, U.S. Fish and Wildlife Service*
Jerry Mead, *Assistant Research Professor, Drexel University*
Cory Mosby, *Small Mammal Biologist, Maine Department of Inland Fisheries and Wildlife*
Dave Owen, *Professor and Associate Dean for Research, University of Maine School of Law*
Donna L. Parrish, *Research Professor and Unit Leader, VT Cooperative Fish and Wildlife Research Unit*
David Secor, *Professor, University of Maryland Center for Environmental Science*
Douglas Sigourney, *Modeller, National Oceanic and Atmospheric Association*
Kelsey Sullivan, *Wildlife Biologist, Maine Department of Inland Fisheries and Wildlife*
William Sutton, *Adjunct Assistant Professor, Tennessee State University*
Joan Trial, *Retired, Maine Department of Marine Resources*
Jennifer H. Vashon, *Wildlife Biologist, Maine Department of Inland Fisheries and Wildlife*
Andrew R. Whiteley, *Assistant Professor, University of Massachusetts Amherst*
Karen Wilson, *Assistant Research Professor, University of Southern Maine*
Petra B. Wood, *Assistant Unit Leader-Wildlife, WV Cooperative Fish and Wildlife Research Unit*

GRADUATE COMMITTEE LEADERSHIP

Unit scientists served as major advisors or co-advisors for these students during the reporting period.

Loftin	Abdulai Barrie, MS (September 2013 – Present) Brianne Du Clos, PhD (September 2012 – Present) Luke Groff, PhD (January 2011 – Present) Jared Homola, PhD (September 2013 – Present) Alyson McKnight, PhD (September 2013 – Present) Brian Rolek, PhD (September 2012 – Present) Nikko Shaidani, MS (September 2012 – Present) Connor Wood, MS (September 2013 – Present)
McKinney	John Clare, PhD (September 2013 – August 2015) Alyson McKnight, PhD (September 2013 – Present) Alyssa Vitale, MS (September 2013 – August 2015) Connor Wood, MS (September 2013 – Present)
Zydlewski	Betsy Barber, PhD (May 2013 – Present) Abdulai Barrie, MS (September 2013 – Present) Megan Begley, MS (May 2014 – Present) Lisa Izzo, MS (September 2013 – Present) George Maynard, PhD (May 2013 – Present) Alejandro Molina-Moctezuma, PhD (May 2015 – Present) Andrew O'Malley, MS (May 2012 – Present) Daniel Stich, PhD (March 2011 – January 2015) Emily Thornton, PhD (September 2015 – Present) Daniel Weaver, PhD (May 2013 – Present)

RECENT GRADUATES AND CURRENT PURSUITS

Student, Degree, Curriculum *Current Pursuits*	*Graduate Date* *Advisor(s)*
 **Erynn Call**, PhD, Wildlife Ecology State Raptor Specialist, Maine Department of Inland Fisheries and Wildlife	May 2015 Malcolm L. Hunter, Jr.
 **Vanessa Levesque**, PhD, Ecology and Environmental Sciences Project Coordinator, Presumpscot River Watershed Coalition	January 2015 Aram J.K. Calhoun, Kathleen P. Bell
 **Sheryn Olson**, MS, Wildlife Ecology Terrestrial Ecologist, U.S. Forest Service	May 2015 Daniel J. Harrison
 **Daniel Stich**, PhD, Wildlife Ecology Assistant Professor, State University of New York	January 2015 Joseph D. Zydlewski
 **Alyssa Vitale**, MS, Wildlife Ecology Contract Biologist, Maine Department of Inland Fisheries and Wildlife	August 2015 Shawn T. McKinney

CURRENT STUDENTS & POSTDOCS

Student, Degree, Curriculum	Advisor(s)
Brian Allen, MS, Wildlife Ecology	Erik J. Blomberg
Betsy Barber, PhD, Wildlife Ecology	Joseph D. Zydlewski
Abdulai Barrie, MS, Wildlife Ecology	Cynthia S. Loftin, Joseph D. Zydlewski
Megan Begley, MS, Wildlife Ecology	Stephen M. Coghlan, Jr., Joseph D. Zydlewski
Dana Berendt, Master of Wildlife Conservation	Malcolm L. Hunter, Jr.
Samantha Davis, MS, Wildlife Ecology	Erik J. Blomberg
Brianne Du Clos, PhD, Ecology and Environmental Sciences	Cynthia S. Loftin, Francis A. Drummond
Stephen Dunham, MS, Wildlife Ecology	Daniel J. Harrison
Carly Eakin, PhD, Wildlife Ecology	Aram J.K. Calhoun, Malcolm L. Hunter, Jr.
Luke Groff, PhD, Ecology and Environmental Sciences	Aram J.K. Calhoun, Cynthia S. Loftin
Kristine Hoffmann, PhD, Wildlife Ecology	Aram J.K. Calhoun, Malcolm L. Hunter, Jr.
Jared Homola, PhD, Ecology and Environmental Sciences	Cynthia S. Loftin, Michael T. Kinnison
Lisa Izzo, MS, Wildlife Ecology	Joseph D. Zydlewski
Mitchell Jones, PhD, Wildlife Ecology	Aram J.K. Calhoun, Malcolm L. Hunter, Jr.
Lydia Kifner, MS, Ecology and Environmental Sciences	Aram J.K. Calhoun, Aria Amirbahman
Zachary Loman, Postdoctoral Associate	Cynthia S. Loftin, Daniel J. Harrison
Ellie Mangelinckx, MS, Wildlife Ecology	Erik J. Blomberg
George Maynard, PhD, Wildlife Ecology	Joseph D. Zydlewski
Alyson McKnight, PhD, Ecology and Environmental Sciences	Cynthia S. Loftin, Shawn T. McKinney
Alejandro Molina-Moctezuma, PhD, Wildlife Ecology	Joseph D. Zydlewski
Ryo Ogawa, Master of Wildlife Conservation	Malcolm L. Hunter, Jr.
Andrew O'Malley, MS, Wildlife Ecology	Joseph D. Zydlewski
Brian Rolek, PhD, Wildlife Ecology	Cynthia S. Loftin, Daniel J. Harrison
Nikko-Ideen Shaidani, MS, Zoology	Cynthia S. Loftin, Michael T. Kinnison
Joel Tebbenkamp, PhD, Wildlife Ecology	Erik J. Blomberg, Daniel J. Harrison
Emily Thornton, PhD, Wildlife Ecology	Erik J. Blomberg, Joseph D. Zydlewski
Jonathan Watson, MS, Wildlife Ecology	Stephen M. Coghlan, Jr.
Daniel Weaver, PhD, Wildlife Ecology	Stephen M. Coghlan, Jr., Joseph D. Zydlewski
Connor Wood, MS, Wildlife Ecology	Cynthia S. Loftin, Shawn T. McKinney

UNIT SUPPORTED RESEARCH

Name, Affiliation	*Unit Advisor(s)*
Matthew Altenritter, PhD, Biological Sciences	Joseph D. Zydlewski
Catherine Johnston, MS, Marine Biology	Joseph D. Zydlewski


—Mark McCollough

FISHERIES and aquatic

Shortnose sturgeon demographics in the Penobscot River, Maine

1. Characterize the movements and demographics of shortnose sturgeon in the Penobscot River and broader Gulf of Maine.
2. Use microchemical analysis to infer life history and movement patterns in shortnose sturgeon.
3. Develop a life history model to examine the effects of connectivity on population abundance and highlight which parameters abundance is most sensitive to.

Shortnose sturgeon inhabiting the Gulf of Maine move extensively and appear to constitute a metapopulation, which contrasts with previous assertions that individuals remain in their natal river. The effects of among-river movements on local and regional population dynamics were uncertain. Local reproduction underpins the metapopulation concept, but has not been documented in all rivers where shortnose sturgeon have been reported in the Gulf of Maine. I developed a novel microchemical technique using dorsal scutes to infer life histories of shortnose sturgeon. Chronological and microchemical attributes of scutes were used to define putative freshwater to marine transitions. Based on these results, superficial sampling of dorsal scutes may allow microchemical reconstruction of past habitat including rivers of natal origin.

Because movements among local populations in a metapopulation are anticipated to influence local population dynamics, I characterized the demographic attributes of shortnose sturgeon in the two major rivers in the Gulf of Maine, the Kennebec River and Penobscot River. Individuals caught in the Penobscot River were larger and in better condition than those caught in the Kennebec River. The absence of relatively large individuals from the Kennebec River also suggests that individuals of greater size and condition may leave the Kennebec River for the Penobscot River. This may exemplify a conditional strategy representing a probable adaptive life history option providing a crucial demographic link between these two river systems.

Regional metapopulation dynamics of shortnose sturgeon were examined using a life history modeling framework. Using the model, mark-recapture abundance estimates of shortnose sturgeon inhabiting three rivers in the Gulf of Maine were successfully replicated. This model will be useful for identification of important knowledge gaps (e.g., model sensitivities) and for testing future scenarios of conservation interest (e.g., demographic disturbance).

I relate my findings to the recovery tasks of the National Marine Fisheries Service. For example, an evaluation of distinct population segment (DPS) stability (recovery task 1.1.3) should consider effects of connectivity with other DPS in the Gulf of Maine. My research illustrates that to implement recovery task 2 (protect shortnose sturgeon population and habitats) fully, consideration of overall regional dynamics is essential.

Investigator: Matthew Altenritter (PhD)

Advisors: Gayle B. Zydlewski (Co-Advisor)
Michael T. Kinnison (Co-Advisor)
Joseph D. Zydlewski
David Secor
Douglas Sigourney

Duration: August 2010—August 2015

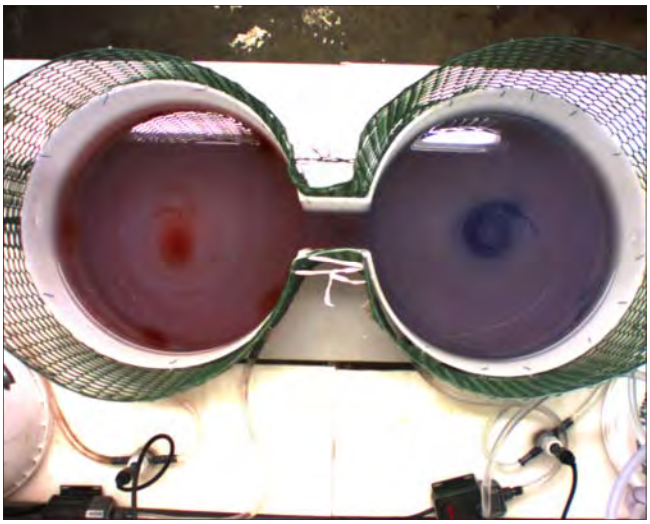
Cooperators:

Maine Department of Marine Resources
National Oceanic and Atmospheric Administration
U.S. Geological Survey – Maine Cooperative Fish and Wildlife Research Unit
University of Maine – School of Marine Sciences
University of Maine – School of Biology and Ecology

Passage of anadromous fish at mainstem dams on the Penobscot River, Maine

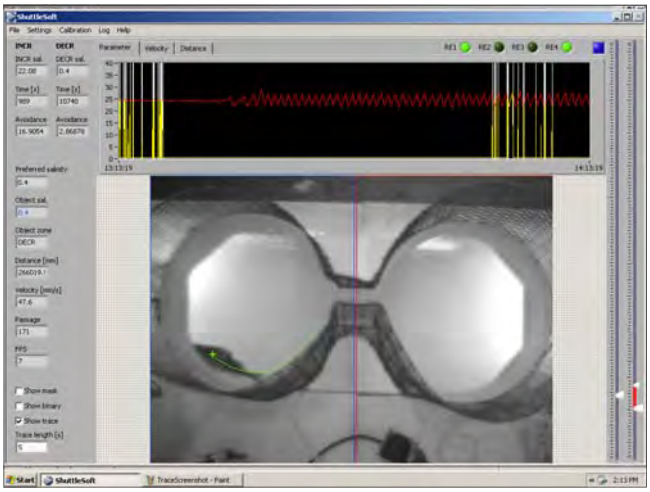
1. Model the survival of wild- and hatchery-origin Atlantic salmon smolts through the Penobscot River and Estuary.
2. Assess movement patterns and rates of migration for Atlantic salmon smolts through the Penobscot River.
3. Characterize patch choice and survival of Atlantic salmon smolts at Milford Dam on the Penobscot River.
4. Characterize the development of seawater tolerance and behavioral preference for seawater of Atlantic salmon smolts.

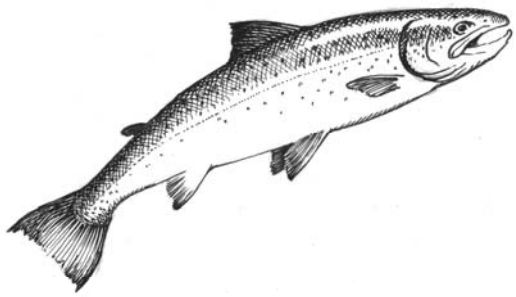
Atlantic salmon *Salmo salar* populations are diminished throughout their range and high marine mortality is among the drivers of the failure of many stocks to recover. A goal of salmon recovery is to maximize the number of juvenile 'smolts' entering the ocean to offset loss therein. Dam removals and changes to hydropower allocation in Maine's largest river, the Penobscot River, have occurred as part of the Penobscot River Restoration Project (PRRP). These activities, in addition to stocking have the potential to influence the number of smolts reaching the ocean. Telemetry was used to investigate factors influencing initiation of migratory behavior, movement rates, migratory route, and survival through freshwater (FW) before and after changes to the system resulting from the PRRP, and behavior and survival of smolts during estuary migration. Initiation of migration was influenced by smolt development, stocking location and environmental conditions. Smolts with the greatest gill Na +, K + -ATPase activity (physiological development) initiated migration 24 hours sooner than fish with the lowest gill NKA activity. Fish with the greatest cumulative temperature experience (accumulated thermal units: ATU) initiated migration 5 days earlier than those with lowest ATU. Smolts released furthest upstream initiated migration earlier than those released downstream, and movement rate increased 5-fold from upstream to the estuary. Movement rate increased from 2.8 kmh -1 to 5.4 kmh -1 in reaches where dams were removed, and decreased from 2.1 kmh -1 to 0.1 kmh -1 after powerhouse construction. Proportional use of the Stillwater Branch was low (0.12, 95% CI = 0.06 – 0.25), and survival through the dams therein was relatively high (0.99) prior to installation of new powerhouses, decreasing slightly thereafter. Survival at Milford Dam, now the lowermost dam in the main-stem, was low (0.91) prior to increased power generation, whereas survival at Great Works and Veazie Dams was high (0.99 and 0.98) prior to removal. Survival was higher through free-flowing reaches (> 0.99·km -1) than reaches containing dams (c. 0.95·km -1). Survival was reduced at high (> 2000 m 3 s -1) or low (< 300 m 3 s -1) flow, and was optimal between 12 C and 17 C. Survival increased following dam removal, but survival through those dams was high before removal. The greatest increase in survival (8%) followed turbine shutdown at Howland Dam. Smolts experiencing greatest ATU

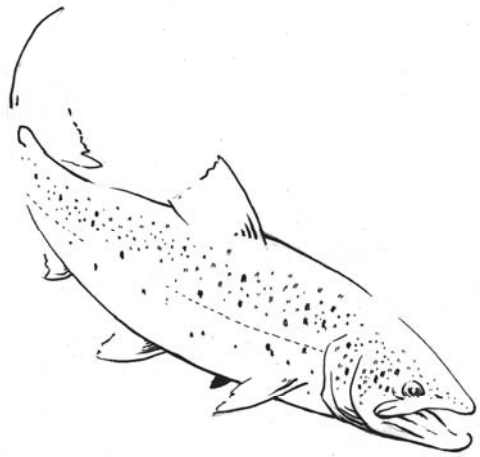


arrived in the estuary 8 days earlier than those experiencing lowest ATU. Estuary arrival date was 10 days later for fish experiencing high flow than for fish experiencing low flow. Fish released furthest upstream arrived in the estuary 3 days later than those stocked further downstream, but moved 0.5 kmh -1 faster through the estuary. Estuary survival decreased by 40% with increasing number of dams passed (from 2 to 9). Estuary movement rate and survival both peaked in mid-May, and slowed from FW to ocean, likely resulting from tidal influences. Smolts became increasingly surface-oriented during passage from FW to ocean as salt water (SW) became more prevalent. In laboratory experiments, preference for SW by never

exceeded 50% during smolt development. Thus, smolts likely select low salinity (i.e. surface) waters during migration through coastal areas. Smolts with low gill NKA activity spent greater time in FW reaches of the estuary than those with high gill NKA activity. However, there was no difference in travel time through SW reaches of the estuary based on gill NKA activity. Fish with the highest gill NKA activity incurred 25% lower mortality through the estuary than fish with lowest gill NKA activity, and survival was lowest where SW was prevalent. These results underscore the importance of physiological preparedness on performance and the delayed effects of dams on survival of smolts during estuary migration, ultimately affecting marine survival estimates.







Investigator: Daniel Stich (PhD)

Advisors: Joseph D. Zydlewski (Advisor)
Michael M. Bailey
Michael T. Kinnison
John Kocik
Gayle B. Zydlewski

Duration: January 2006—January 2016

Cooperators:

American Recovery and Reinvestment Act (ARRA)
Maine Department of Marine Resources
U.S. Geological Survey – Maine Cooperative Fish and Wildlife Research Unit
National Oceanic and Atmospheric Administration
University of Maine – Department of Wildlife, Fisheries, and Conservation Biology
National Fish and Wildlife Foundation
Penobscot River Restoration Trust
West Enfield Fund
Penobscot Indian Nation

Marine-derived nutrient cycling in the St. Croix River, Maine

1. Characterize the food web in the St. Croix prior to alewife return.
2. Characterize the temporal influx of marine nutrients due to alewife migration.
3. Explore how changes in passage efficiency at three main stem dams might change the flow and distribution of nutrients in a complex river system.

The purpose of this study is to determine how the presence of alewife affects the St. Croix watershed, both in terms of nutrient input and food web interactions. This will be done by developing a model of the existing food web using stable isotope data procured through sampling river and lake sites. Isotopes will include carbon and nitrogen, which typically show distinct signatures when moving from marine to freshwater environments. Samples will be collected three times annually at seven sites in the St. Croix concurrent with the alewife run. Nutrient limitation will also be determined at each site. Two sites on the East Machias River will be sampled as a reference.

The data from this study will be incorporated into a model to determine how alewives affect the input and output of nutrients within streams and lakes in the St. Croix watershed. The presence of alewives has the potential to directly affect other species in the system, including species of interest such as small mouth bass. As alewives are reintroduced into the St. Croix watershed in large numbers this study will be able to track their effect on nutrient cycling, as well as determine their role in the food web. Initial sampling was carried out in the spring and summers of 2013 and 2014 over a wide spatial scale. These samples are currently being prepared for analysis and run for stable isotope ratios. Preliminary data revealed expected trophic associations between fish and invertebrate taxa in the region. A marine "signal" was also clear from migrating alewife in the St. Croix system. In 2014 sampling in a reference system with an intact alewife run was also conducted so that the influence of alewife introduction might be better assessed.

Sampling has been carried out for 2013-2015 at seven sites in the St. Croix and 2014-2015 at two sites in the East Machias. Fish muscle, aquatic invertebrate, and planktkon samples were collected at each site in May, June, and July. The majority of these samples have been prepared and sent to a lab for stable isotope analysis, but food web modeling still needs to be performed on the data. All data analyzed so far has revealed expected trophic associations between fish and invertebrate taxa in the region. A marine "signal" was also clear from migrating alewife in the St. Croix system. All sites on the St. Croix are oligotrophic based on nutrient limitation data. Next steps include analyzing stable isotope data and incorporating this information into an alewife population model to explore nutrient dynamics in the St. Croix.

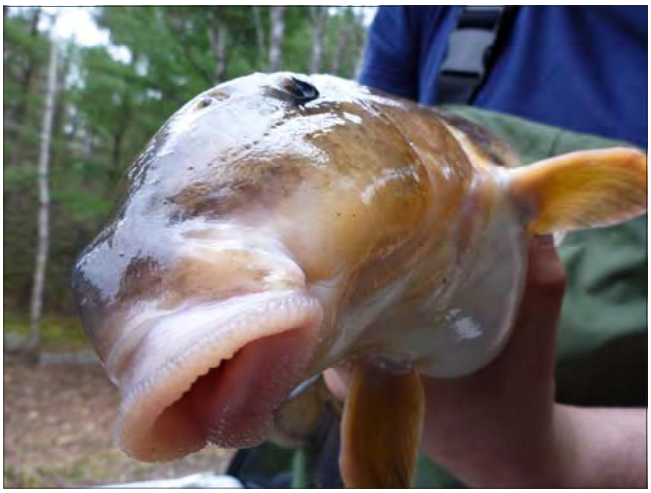
Investigator: Betsy Barber (PhD)

Advisors: Joseph D. Zydlewski (Advisor)
Joan Trial
Erik J. Blomberg
Stephen M. Coghlan, Jr.
Hamish S. Greig

Duration: May 2012—October 2017

Cooperators:

Atlantic Salmon Federation
International Joint Commission on the St. Croix Waterway
U.S. Fish and Wildlife Service
University of Maine – Department of Wildlife, Fisheries, and Conservation Biology
Maine Department of Inland Fisheries and Wildlife
Maine Department of Marine Resources
U.S. Geological Survey – Maine Cooperative Fish and Wildlife Research Unit
Passamaquoddy Tribe
Canadian-American Centre; Downeast Salmon Federation
St. Croix International Waterway Commission



Understanding the impact of commercial harvest on white sucker (*Catostomus commersonii*) in Maine

1. Compare the demographics of spawning suckers from fished and unfished lakes.
2. Use demographic data to assess sensitivity of suckers to fishing pressure.

The State of Maine issues an unlimited number of commercial permits to harvest white sucker in Maine's inland waters. The fishery provides a necessary source of lobster bait to coastal communities at a time when other bait sources are scarce. The impact of the increasing number of permits and subsequent numbers of fishermen on the white sucker population is unknown. The Maine Department on Inland Fisheries and Wildlife (MDIFW) has closed a number of waters due to concerns that overfishing and/or incidental catch of other fish species may occur. The goal of this project is to determine the impacts of commercial fishing on white sucker populations and review the existing management structure to optimize the population size and commercial white sucker harvest in waters that are open. This information will allow the MDIFW to determine which waters that are currently closed can be reopened to harvest.

Before additional waters can reopen, the department needs to determine the effect of the current commercial fishery on existing populations of white sucker. Specific biological data (age, length, sex, fecundity), catch/harvest information, assessment of existing data, needs to occur to determine which areas are overfished from those area that are not overfished. Currently, harvesters are not required to report the number or weight of the fish they harvest. This information is critical to manage a growing fishery that an increasing number of commercial fishermen are relying on to supply lobster bait and household income.

White suckers were harvested during the spring of 2014 from six lakes: 3 fished lakes and 3 unfished lakes. Each fished lake was paired with an unfished lake (based on lake size and depth) to provide a reference. Biological data was recorded for each individual fish: total length, fork length, total weight, and sex. Ovaries were used to estimate fecundity, and otoliths were sectioned for age esitmates. Analysis of demographic data is still ongoing.

Historical MDIFW sucker permits are being compiled to create a geographical representation of harvesting pressure in Maine. Estimates from the literature and this study will then be used to build population models to assess sensitivity of white suckers to varying levels of fishing pressure.

Investigator: Megan Begley (MS)

Advisors: Stephen M. Coghlan, Jr. (Co-Advisor)
Joseph D. Zydlewski (Co-Advisor)
Michael T. Kinnison

Duration: January 2012—December 2016

Cooperators:

Maine Department of Inland Fisheries and Wildlife
U.S. Geological Survey – Maine Cooperative Fish and Wildlife Research Unit
University of Maine

Effects of hook type on time to rehabilitation of *Lepidochelys kempii*

My objective is to characterize effects of hook type, width, and location on the rehabilitation of kemp's ridley sea turtles caught as incidental bycatch by recreational anglers from 2013 to 2015.

According to NMFS et al. (2011) the primary threat to sea turtle recovery is bycatch. Sea turtles are particularly vulnerable to bycatch in trawls, gillnets, longlines, dredge fisheries, and recreational hook-and-line (NMFS et al. 2011). Although effects of commercial longline fisheries gear on sea turtle bycatch are generally well-understood (Cooke & Suski 2004; Gilman et al. 2006; Read 2007; Stokes et al 2012) effects of recreational fishing gear is less well characterized. Furthermore, how these gears effect recovery time in rehabilitation centers is also poorly understood. The primary objective of this study is to characterize effects of hook type, width, and location on the rehabilitation of kemp's ridley sea turtles caught as incidental bycatch by recreational anglers from 2013 to 2015. In order to achieve this objective, I will examine the effects of incidental hook-and-line bycatch by recreational fishermen on survival and individual length of stay by kemp's ridley sea turtles as a rehabilitation center in Gulfport, Mississippi, USA.

My project is complete; I am currently analyzing my data.

Investigator: Dana Berendt (MWC)

Advisors: Malcolm L. Hunter, Jr. (Advisor)

Duration: May 2014—May 2016

Cooperators:

University of Maine – Department of Wildlife, Fisheries, and Conservation Biology

Upstream passage of adult Atlantic salmon in the Penobscot River; assessing critical thresholds for restoration

1. Assess delays that might be incurred through the Great Works and Veazie Dam remnants, the Stillwater Branch, and the new Milford fish lift using radio telemetry and PIT telemetry of Atlantic salmon.
2. Use historic adult Atlantic Salmon scales to investigate changes in ocean growth over six decades in Maine's Downeast rivers.

1. Returning adult Atlantic salmon will be captured at the Milford trap on the Penobscot River, maintained by the Maine Department of Marine Resources. As part of ongoing work, PIT tags will be implanted and adult Atlantic salmon released into the river following capture. Data will be generated for time of entry at the Milford fishway and time of exit for successful passage. This effort afford significant information as to success rate and speed of transport from the lower river to Milford Dam through the remnants of Veazie and Great Works Dams. In addition, gastric inserted radio tags will be used to track the movements of adult salmon. Up to 50 fish annually will be tagged.

2. A set of scale samples from over 6,000 individual adult Atlantic salmon was obtained from the Maine Department of Marine Resources. Samples were collected either by anglers or at traps and weirs on the Dennys, Machias, East Machias, Narraguagus, and Pleasant rivers from the 1940s to the 1990s. Scales will be aged, and suitable scales will be measured to estimate size at smolting and growth during first year at sea.

1. Access to fish was limited in 2014 due to the low run return, but telemetry data on tagged fish provided clear information that the two remnant dams provided no impediment to upstream migration of Atlantic salmon. Under some conditions, the Stillwater Branch was associated with delays in mainstem progress. Significant delays in passage occurred at Milford Dam. In 2015 a better run allowed for all 50 tags to be used. As in 2014, tagged fish were not delayed at the dam remnants but were significantly delayed at Milford Dam. Additional radio telemetry coverage at Milford in 2015 indicated that salmon are quickly locating the fish lift entrance. No delays were seen at the Stillwater Branch in 2015. A manuscript of the telemetry results is currently in progress.

2. Aging and measuring of scales is currently in progress, with results expected in spring of 2016.

Investigator: Lisa Izzo (MS)

Advisors: Joseph D. Zydlewski (Advisor)
Joseph E. Hightower
Gayle B. Zydlewski

Duration: May 2012—May 2016

Cooperators:

Maine Department of Marine Resources
U.S. Fish and Wildlife Service
U.S. Geological Survey – Maine Cooperative Fish and Wildlife Research Unit
National Oceanic and Atmospheric Administration
The Nature Conservancy

Shortnose sturgeon movements and habitat use in the Penobscot River, Maine

1. Assess the movements and habitat use of shortnose sturgeon after dam removal in the Penobscot River.
2. Monitor for sturgeon spawning activity in the Penobscot River.

The habitat use of shortnose sturgeon in the Penobscot River is poorly characterized, but telemetry efforts and habitat assessments are being used to understand the seasonal use of this river. The recent removal of the two lower most dams on the river has opened up access to this species' entire historic range. This access is important as previous research has been unable to document spawning in the Penobscot River prior to dam removal, rather fish are thought to travel to the Kennebec River to spawn. It is possible that the increase in habitat access will allow these fish to spawn in the Penobscot River if river habitat accessibility was a biological constraint.

Sturgeon are captured via gill netting and implanted with acoustic "pingers" are tracked through the entire Penobscot River system using an extensive deployment of stationary receivers. These acoustic receivers are deployed as part of ongoing cooperative work between NOAA-Fisheries, Maine Cooperative Fish and Wildlife Research Unit and the University of Maine. Extensive habitat surveys are being conducted in the lower river by foot and by boat. Monitoring for sturgeon spawning activity in the river will continue using egg mats and D-nets to capture eggs or young.

Habitat assessment was initiated in July 2014 to determine the quality of potential spawning habitat for sturgeon in areas upstream of the recently removed dams. Pebble counts were conducted along the east and west shores of the river between the Veazie Dam removal site and Ayer's Rips. These assessments will be used to generate information on grain size distribution along the shore to illuminate spawning habitat suitability. Pebble counts were performed in uniform intervals (approximately every 450 m) along the shore with additional counts performed at intermediate distances within the intervals when possible. Qualitative descriptions of the substrate features of each area were described and underwater video was collected to further explore the substrate type.

Investigator: Catherine Johnston (PhD)

Advisors: Gayle B. Zydlewski (Advisor)
Michael T. Kinnison
Joseph D. Zydlewski
Sean M.C. Smith

Duration: January 2012—September 2016

Cooperators:

Maine Department of Marine Resources
U.S. Geological Survey – Maine Cooperative Fish and Wildlife Research Unit
National Oceanic and Atmospheric Administration
Penobscot River Restoration Trust
University of Maine – School of Marine Sciences
University of Maine – School of Biology and Ecology

PIT tag monitoring of migrating anadromous fish in the Penobscot River, Maine

1. Determine the rate, timing and efficiency of upstream passage of Atlantic salmon, American shad and alewife through major dams in Penobscot River.
2. Provide near real time information to cooperating agencies as to the effects of fishway operation on migratory success.
3. Provide a quantitative assessment of the effect of dam removal on the migratory success of migratory fish in the Penobscot River.

The Penobscot River watershed is Maine's largest and hosts a number of anadromous species including the largest remaining run of Atlantic salmon in the USA. For many species, however, the majority of high quality spawning and rearing habitats are located upstream of lower river dams. By the fall of 2013, the two most downstream dams were removed as part of the Penobscot River Restoration Project (PRRP). Ultimately, benefits of dam removal for Atlantic salmon and other species will depend on the degree and fashion by which remaining dams facilitate fish passage success. In order to assess migratory success, we are using passive integrated transponders (PIT tags) to remotely track fish through nine major dams in the lower Penobscot River. Beginning in 2013, PIT tagging of fish occurred at the lower most dam (Milford) requiring an antenna installation at the new fishway in coordination with Maine Department of Marine Resources. This work will incorporate and build on recent research that demonstrated migratory behavior and passage efficiency of Atlantic salmon in the Penobscot River. The long term scope of this project is to monitor the effects of the PRRP with respect to Atlantic salmon in accordance with the State Operational Plan for the Restoration of Andromous Fishes to the Penobscot River. This study requires coordination with USGS, NOAA, DMR, the Penobscot River Restoration Trust (PRRT), the Penobscot Indian Nation, USFWS, and the various dam operators.

The project was initiated September 2009 and has included an M.S. student, a Ph.D. student and a post-doctoral associate over the years. By spring of 2010, PIT arrays were installed at all targeted lower mainstem dams and preliminary passage data were collected from more than 1,000 tagged fish. By spring of 2011 eight sites were fully functional and were maintained through the 2011 adult salmon season. Coordination with Department of Marine Resources allowed the successful tagging and tracking of 2,429 adult Atlantic salmon in 2011. Efforts were continued in 2012 and priorities will shift to data analysis and "near real time" coordination with management agencies for the optimization of fish passage. A Ph.D. student began this work in spring of 2013 and low Atlantic salmon returns have necessitated a shift in focus to other species. In addition to a limited number of Atlantic salmon in 2014, hundreds of alewife, sea lamprey and American shad have been tagged and tracked.

Additionally, focused efforts to radio tag and track adult American shad in 2014 have provided an improved picture of habitat use post-dam removal. The installation of new PIT antennas and a real time temperature monitor at the Milford Dam in 2015, provided information regarding fishway conditions and fish usage of the facility. The presence of iteroparous river herring in the Penobscot River was documented for the first time in recent history as individuals that were PIT tagged in 2014 were tracked upstream.

Investigator: George Maynard (PhD)

Advisors: Joseph D. Zydlewski (Advisor)
Erik J. Blomberg
Michael T. Kinnison
Joan Trial
Gayle B. Zydlewski

Duration: September 2009—October 2017

Cooperators:

American Recovery and Reinvestment Act (ARRA)
Maine Department of Marine Resources
U.S. Geological Survey – Maine Cooperative Fish and Wildlife Research Unit
National Oceanic and Atmospheric Administration
Penobscot River Restoration Trust
U.S. Fish and Wildlife Service – Craig Brook National Fish Hatchery

Passage of anadromous fish at mainstem dams on the Penobscot River, Maine

1. Model the survival of hatchery-origin Atlantic salmon smolts through the Penobscot River and Estuary.
2. Assess movement and behavioral patterns of migrating Atlantic salmon smolts through the Penobscot River.
3. Characterize passage and survival of Atlantic salmon smolts at Howland Dam in the Piscataquis River.

This project will draw upon a growing body of telemetry data reaching back to work begun in 2005 and continued through to present. Targeted releases of Atlantic salmon smolts implanted with acoustic "pingers" are tracked through the entire Penobscot River system using an extensive deployment of stationary receivers. These acoustic receivers are deployed as part of ongoing cooperative work between NOAA-Fisheries, Maine Cooperative Fish and Wildlife Research Unit and the University of Maine. The observed series of detections of an individual fish are used to construct a model of survival through the River system. Such a model allows the assessment of areas of high mortality, such as dams. We continued tagging hatchery-origin Atlantic salmon smolts from the Penobscot River through 2015. For the upcoming years, this project will focus on survival and passage through Howland Dam in the Piscataquis River. Beginning with the 2016 downstream migration, new downstream fish passage will be present in Howland Dam that has the potential to increase smolt survival. Therefore, it is important to characterize survival in this dam and compare it to survival in previous years.

Acoustic telemetry data have been collected since 2005 for downstream migrating Atlantic salmon smolts to assess movement and survival through the Penobscot River and Estuary. These data have been used to estimate survival of Atlantic salmon smolts throughout the system and are routinely used by agencies associated with the management of this federally endangered species. In 2015, 75 hatchery-reared Atlantic salmon smolts were released and data about their movement and survival was obtained using acoustic telemetry. This data is currently being analyzed to perform a post-restoration assessment of Atlantic salmon survival in The Penobscot River.

Investigator: Alejandro Molina-Moctezuma (PhD)

Advisors: Joseph D. Zydlewski (Advisor)

Duration: January 2006—January 2020

Cooperators:

American Recovery and Reinvestment Act (ARRA)
Maine Department of Marine Resources
U.S. Geological Survey – Maine Cooperative Fish and Wildlife Research Unit
National Oceanic and Atmospheric Administration
University of Maine – Department of Wildlife, Fisheries, and Conservation Biology
National Fish and Wildlife Foundation
Penobscot River Restoration Trust

Rainbow smelt enhancement as a fisheries management tool

1. Estimate the survival and growth of stocked rainbow smelt fry into Maine lakes.
2. Compare growth between andaromous and landlocked populations of adult smelt.

Landlocked rainbow smelt are a common fish in lakes in Maine. They are a coldwater fish that generally grow to 10-20 cm in length. They are important both for consumption by people, and as a food source for other game fish. They are currently known to inhabit 558 lakes, across all regions of the state, from York to Aroostook counties. Most of these populations were not naturally occurring, but a result of both private and state stockings. The landlocked salmon, is one of Maine's most popular sport fish, and draws many anglers from out of state. Smelt are the primary forage for landlocked salmon and fluctuations in population levels influence the size and health of landlocked salmon.

There is substantial benefit to anglers and local businesses to maintain a strong smelt population, and thus a strong landlocked salmon fishery. In attempts to boost salmon fisheries that have declined due to low smelt populations, many thousands of smelt fry have been stocked in Moosehead and East Grand Lakes. Thousands of dollars were spend in these efforts but there has been no clear answer to the efficacy of these efforts. There has been some indication that smelt numbers have increased, but there was no way to distinguish stocked fish from wild ones to validate that stocking worked. We are hoping to estimate what contribution these stocked smelt will make to population in a lake, as well as what impacts they might have on the lake community. To this end we are stocking smelt larvae in several lakes to estimate growth and survival over their first summer of life.

We also have collected scales and otoliths from adult smetlt from both landlocked and anadromous populations to compare annual growth and longevity of fish from different populations. Size and age have important impacts on the spawning potential and thus recruitment in the next generation for fish populations.

This project is nearing completion and has transitioned from collecting and anaylizing data, to synthesizing results for publication.

Trawl sampling was carried out in the spring and summer of 2013 and 2014 in lakes stocked with smelt fry. Smelt were captured in abundance at one lake in 2014, and were not captured in any lake in 2013. Age and growth data from these captured fish is being used to estimate the proportion of fish that are wild vs. stocked.

Otoliths and scales were examined from 850 adult smelt from seven different populations. These data reflect a highly variable mixture of ages and sizes between different populations of smelt. There was a wide difference in reader precision and bias between populations of smelt indicating that not all growth is equal.

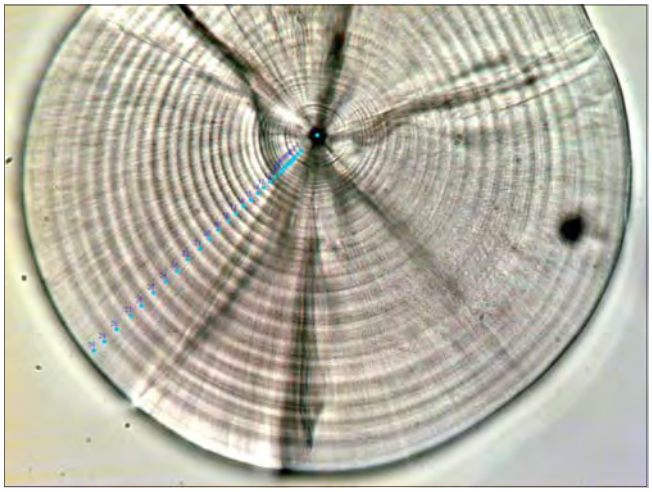
Investigator: Andrew O'Malley (MS)

Advisors: Joseph D. Zydlewski (Advisor)
Stephen M. Coghlan, Jr.
Donna L. Parrish

Duration: May 2012—December 2015

Cooperators:

Maine Department of Inland Fisheries and Wildlife
Maine Outdoor Heritage Fund



Life history and migration of American eels in the Penobscot River, Maine

1. Develop a model to forecast the downstream migration timing of American eels based on environmental factors (e.g., weather, lunar phase).
2. Use acoustic tags to track silver eels during emigration from the Penobscot River, and quantify mortality incurred at Milford Dam.
3. Analyze otolith Sr:Ca ratios to characterize the marine, estuarine, and freshwater habitat use of American eels, with particular emphasis on establishing a baseline for estuarine habitat use in the Penobscot River system prior to dam removal.

There is at present a rich body of literature on the timing of "silver" American eel migration. The movement of eels occurs during a relatively short period in the fall, usually associated with episodes of high precipitation and high flow events. In addition, eels tend to migrate at night and lunar phase is an important correlate of downstream migration. Despite numerous studies, there have been relatively few attempts to synthesize the existing information into a comprehensive model to predict eel migration. Efforts that would allow sensitivity analysis of turbine shut down to conservation and financial objectives appear absent.

The proposed work will use field data to inform a predictive Bayesian forecasting modeling framework as to both timing of migration and behavior and survival at dams. Bayesian forecasting has proven to be an effective way to use available information and summarize the probability of future scenarios. As such, they have become an important tool in ecological management. Such a model could serve as a useful tool to managers to inform management and conservation decisions as to hydropower facility operation. Results from telemetry and microchemical analyses will be used to inform our developing model.

Pilot work in the fall of 2015 included the designed and installation of a weir on a tributary of the Penobscot River. Silver eels were captured and surgically tagged and released above Milford Dam. The passive tracking of these fish is currently underway. Incidental mortalities at dams have been collected in 2014 and 2015. Microchemical analysis of otoliths (ear "bones") will be used to infer movement of these fish through the Penobscot River and estuary. Otolith extraction and sample preparation is in progress.

Investigator: Emily J. Thornton (PhD)

Advisors: Erik J. Blomberg (Co-Advisor)
Joseph D. Zydlewski (Co-Advisor)

Duration: September 2015—June 2020

Cooperators:

Maine Department of Marine Resources
U.S. Geological Survey – Maine Cooperative Fish and Wildlife Research Unit
National Oceanic and Atmospheric Administration
The Nature Conservancy
U.S. Fish and Wildlife Service
National Science Foundation – Experimental Program to Stimulate Competitive Research
Muckleshoot Indian Tribe

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

1. Describe changes to fish assemblages associated with the removal of two main-stem dams on the Penobscot River.
2. Develop a model to analyze pre and post dam monitoring data for all species.
3. Describe smallmouth bass (*Micropterus dolomieu*) growth and diet in sections of the Penobscot River watershed with varying abundances of river herrings.

Dams fundamentally alter the morphology and ecological characteristics of rivers. Notably, populations of diadromous fishes have been drastically impacted by the construction of dams because they severely limit access to habitat that is essential for the completion of those fishes complex life histories. Dam removal has been proposed as a method to restore the integrity of riverine systems and it is becoming an increasingly popular management solution. Thus, it is important to monitor the ecological changes that follow dam removal because it allows for appraisal of this management option.

The Penobscot River Restoration Project (PRRP) is one of the largest river restoration efforts currently underway in the United States. It aims to increase the ecological integrity of the watershed through both dam removal and enhanced fish passage at remaining barriers. Prior to restoration efforts, we conducted a baseline fish assemblage survey to allow for appraisal of this restoration. We found distinct assemblages associated with the lentic habitat in former impoundments and evidence of low habitat connectivity. Ultimately, we will examine short term changes to Penobscot River fish assemblages by comparing pre and post-dam removal data from these surveys.

In addition, we are completing a study to describe smallmouth bass predation on river herrings. We will examine diet and compare average growth of smallmouth bass in areas of the Penobscot River watershed to determine whether predation of river herrings enhances growth rates.

We monitored fish assemblages in the Penobscot River using shoreline electrofishing and a stratified random design. We conducted sampling twice a year in both early summer (May-June) and fall (September-October) from the spring of 2010 until the summer of 2012. Sampling was resumed in the spring of 2014 and is currently in progress. The dams of interest were removed during the interim (2012-2013) of these sampling periods. Sampling is scheduled to continue into 2016 in order to obtain a complete picture of the immediate effects of dam removal on the fish communities.

Initial results suggest that anadromous fishes are now able to access all areas of the mainstem river and that lacustrine fishes have largely disappeared from former impoundments.

In 2015 we collected approximately 750 smallmouth bass at monthly intervals and removed their stomachs and otoliths for diet and growth analyses, which are currently underway.

Investigator: Jonathan Watson (MS)

Advisors: Stephen M. Coghlan, Jr. (Advisor)
Joseph D. Zydlewski
Daniel J. Hayes
Ian Kiraly

Duration: May 2014—December 2016

Cooperators:

American Recovery and Reinvestment Act (ARRA)
Maine Department of Inland Fisheries and Wildlife
Maine Department of Marine Resources
National Oceanic and Atmospheric Administration
Penobscot River Restoration Trust
University of Maine – Department of Wildlife, Fisheries, and Conservation Biology
University of Maine
U.S. Geological Survey – Maine Cooperative Fish and Wildlife Research Unit
National Oceanic and Atmospheric Administration
The Nature Conservancy

Anadromous sea lamprey (*Petromyzon marinus*) as vectors of marine-derived nutrients in Atlantic coastal streams

1. Quantify the spatial and temporal effects of marine-derived nutrient subsidies from adult sea lamprey.
2. Compare autotrophic and heterotrophic nutrient response pathways from nutrient subsidies.
3. Characterize the spatial heterogeneity of juveniles (ammocoets) within the Penobscot Watershed.
4. Develop a model that predict nutrient responses in freshwater systems.

Historically, many freshwater systems in Maine were linked to the marine environment by spawning migrations of adult anadromous fishes and subsequent seaward migration of juveniles. These fish were important vectors of marine-derived nutrients that fertilized otherwise oligotrophic freshwater systems until populations declined. Sedgeunkedunk Stream, a 3rd order tributary to the Penobscot River, historically supported several anadromous fish species including sea lamprey and endangered Atlantic salmon. Several small dams constructed in the late 1800s reduced or eliminated spawning runs entirely. As of late 2009, a small population of sea lamprey used the accessible portion of Sedgeunkedunk regularly for spawning. Efforts to restore marine–freshwater connectivity in this system have included the construction of a rock-ramp fishway at 6 in 2008 and the removal of a dam in 2009. The latter has opened up 5 km of lotic habitat and facilitated recolonization and range expansion of sea lamprey, resulting in quadrupling of abundance of spawning adults after 4 years. We hypothesize that sea lamprey will contribute an influx of marine-derived nutrients thereby increasing primary and secondary production in the system.

We examined the influence of sea lamprey nutrient subsidies on stream food webs over spatial and temporal scales. We found that carcass decomposition and nitrogen and phosphorus liberation occur within a three week period. We found sea lamprey nutrient subsidies increased algal biomass 57 - 71% over a three week period, alleviating stream nutrient limitations, however we observed no changes in fungal biomass from added nutrients. Using stable isotopes analysis, we found nutrient subsidies were assimilated among stream macroinvertebrates, but found no discernible patterns in assimilation among juvenile sea lamprey (ammocoetes). Furthermore, our results suggest nutrient subsidies exhibit relatively localized effects, influencing components of food webs adjacent to decomposing carcasses. Additionally, the response pathways by which subsidies are assimilated may depend upon stream and terrestrial covariates (flow and canopy cover). Juvenile sea lamprey are ubiquitous throughout the Penobscot Watershed. Juvenile distributions appear to be functions of historically accessible streams and suitable habitat characterized by slow moving waters with fine substrates. Our work underscores the importance of connectivity in small streams to allow sea lamprey migration and spawning.

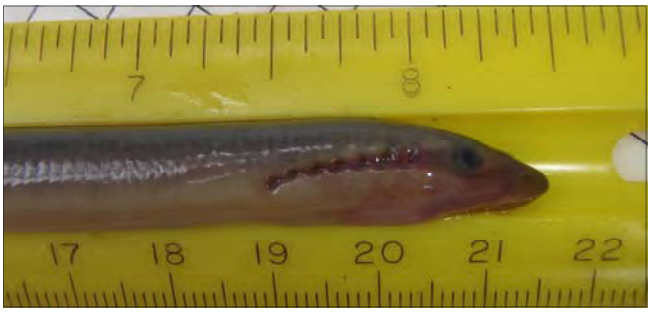
Investigator: Daniel Weaver (PhD)

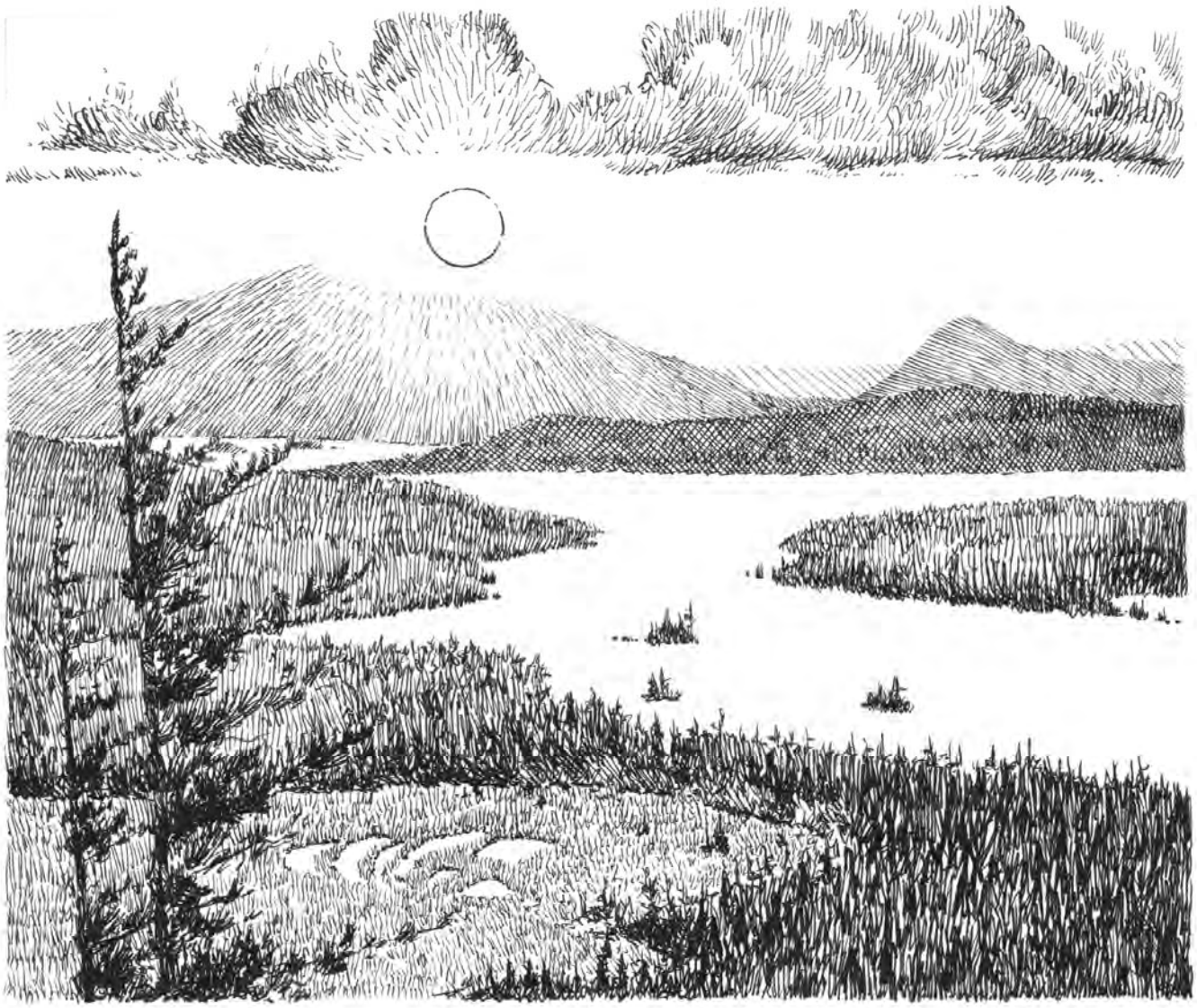
Advisors: Stephen M. Coghlan, Jr. (Co-Advisor)
Joseph D. Zydlewski (Co-Advisor)
Hamish S. Grieg
Michael T. Kinnison
Jerry V. Mead

Duration: May 2013—May 2017

Cooperators:

Maine Sea Grant
Atlantic Salmon Federation
Maine Audubon Society
Maine Department of Inland Fisheries and Wildlife
Maine Department of Marine Resources
University of Maine – Department of Wildlife, Fisheries, and Conservation Biology
U.S. Geological Survey – Maine Cooperative Fish and Wildlife Research Unit
Penobscot Valley Audubon Chapter
National Oceanic and Atmospheric Administration
The Nature Conservancy





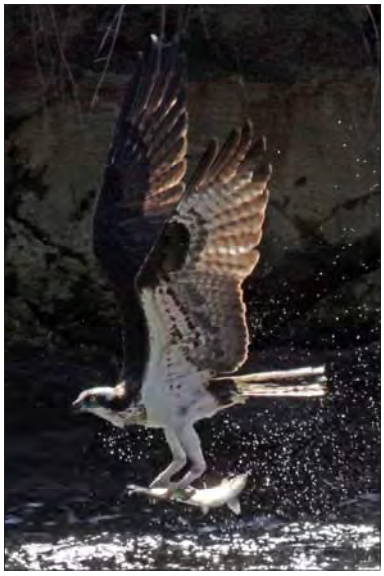
WILDLIFE and habitats

WILDLIFE and habitats continued

River restoration in the northeast: Implications for avian assemblages

1. Develop a citizen science monitoring framework that will assess the response of River Bird Assemblage RBA to dam removal.
2. Characterize RBA prior to dam removal.
3. Examine pre-dam removal Osprey nest distribution and nest success as a baseline for measuring response to fish restoration.
4. Investigate the relationship between habitat and RBA.
5. Evaluate the relative importance of marine and freshwater prey to bald eagle, osprey, belted kingfisher, and tree swallow using analysis of marine derived nutrients.

River-associated birds may be valuable indicators of environmental change in riverine ecosystems because they are predators of fishes and therefore often top predators in the aquatic food web. o evaluate the likely scope of one form of change - river restoration through dam removal and the expected return of abundant diadromous fish prey- we: 1) developed an appropriate river bird survey protocol; 2) documented the relative importance of sea-run fish in the diet of four river bird species, bald eagle (*Haliaeetus leucocephalus*), osprey (*Pandion haliaetus*), belted kingfisher (*Megaceryle alcyon*), and tree swallow (*Tachycineta bicolor*); 3) documented nest distribution and brood size of osprey; and 4) investigated the relationships between river bird abundance and various habitat parameters. We expect these measures will reflect changes to the river system post-dam removal as diadromous fish populations recover, proliferate, and integrate into the food web. Based on species accumulation curves and first-order Jacknifes, we concluded that biweekly or triweekly 15 minute surveys are sufficient to meet our objectives. Within the Penobscot River, stable isotope analysis of river bird diets indicated that marine nutrients are consumed by bald eagle, osprey, and belted kingfishers that reside below the lowermost dam, but not tree swallows. Despite greater connectivity for and abundance of spawning diadromous fishes (particularly river herring), in the Kennebec and Sebasticook Rivers as compare to the Penobscot River, osprey brood size was not significantly larger. We suspect other factors such as competition with bald eagles may be limiting the benefit of large river herring runs to nesting osprey. Finally, an ordination of 26 river bird species and 5 single-species (invertivore - spotted sandpiper, piscivore – osprey; piscivore - bald eagle; insectivore - tree Swallow; and omnivore - American black duck) generalized linear models, I revealed associations between estimated species abundance and water flow, water level, distance from the river mouth (river kilometer), site position in relation to a dam (e.g. above, below, or not at a dam), and adjacent land cover composition.



Investigator: Erynn M. Call (PhD)

Advisors: Malcolm L. Hunter, Jr. (Advisor)
Cynthia S. Loftin
Brian J. Olsen
Karen Wilson
Joseph D. Zydlewski

Duration: April 2009—May 2015

Cooperators:

Eastern Maine Conservation Initiative
Maine Department of Inland Fisheries and Wildlife
Biodiversity Research Institute
Maine Audubon Society
Maine River Bird Volunteer Network
Maine Outdoor Heritage Fund
The Nature Conservancy
Penobscot River Restoration Trust
University of Maine – Sustainable Solutions Initiative
University of Maine – Department of Wildlife, Fisheries, and Conservation Biology
National Oceanic and Atmospheric Administration

Seasonal influences on habitat use by snowshoe hares: implications for Canada lynx in northern Maine

1. To document the influence of different forest stand types and seasonality on stand-level snowshoe hares densities.
2. To determine the relationship between seasonal changes in vegetation structure among different forest stand types and seasonal snowshoe hare densities.
3. To document seasonal food habits of Canada Lynx in northern Maine.

Snowshoe hares (*Lepus americanus*) respond to seasonal changes in vegetation and use dense conifer stands during winter that provide thermal and predatory refugia, shifting their habitat use in summer to adjacent areas with more herbaceous food and cover. These movements influence hare demographics, with greater survival rates corresponding to seasonal use of stands with dense, primarily coniferous vegetation. Different harvesting practices in commercial forests produce vegetative communities that may support differing hare densities among forest stand-types between seasons, but in the Acadian Forest region, seasonal use of habitat has not been documented. In response to spatio-temporal availability of hares, the U.S. federally threatened Canada lynx (*Lynx canadensis*) shift their resource selection. Though lynx may depend less upon snowshoe hares in mid- and southwestern regions of their range, their degree of dietary specialization has not been quantified in Maine.

In Chapter One, I investigated whether snowshoe hare pellet densities were different between two seasons across three forest stand-types: regenerating (RG) coniferous-dominated (19-39 years post-harvest), selection harvested (SEL) mixed coniferous-deciduous (8-18 years), and mature (42-80 years post-harvest). I then determined what vegetation characteristics most influence hare densities between seasons in a sample of 26 forest stands. I evaluated 17 candidate models using generalized linear mixed models and standard model selection techniques. Hare densities, indexed by pellet densities, repeatedly measured in 41 stands during 2005–2012, differed significantly from leaf-on to leaf-off periods in RG stands, but not in mature or in SEL stands. Further, during leaf-on seasons pellet densities were greater in RG than other stand-types. These results suggest higher winter survival or immigration to RG stands, and relatively higher summer survival and juvenile recruitment in RG stands. Seasonal differences in pellet densities across 26 stands were primarily related to two vegetation characteristics; conifer sapling density had 68% relative importance weight (RIW) and total sapling density had 11% RIW. During leaf-off season when snow interacts with vegetation, percent understory conifer (all conifer foliage, live, dead, tree and sapling boles) most strongly influenced pellet densities (RIW 88.9%).

In Chapter Two I examined whether lynx shift prey from predominantly hares in winter during a higher hare period, to more generalized diets during snow-free periods, and when hares were at a relatively lower density. I documented food habits using scats that were genetically confirmed as lynx, from a summer-low hare (2007-2012, n=199) and a winter-high hare density period (2001-2006, n=125). Dietary breadth increased from the winter-high hare density to the summer-low hare density period ($F_{4,322}$=0.0068, 1000 randomizations). Frequency of occurrence of hares in food item categories declined during summer-low (75.2%, n=230) compared to the winter-high hare density period (92.1%, n=127). I suggest increased availability and accessibility of rodents and birds in summer as a major reason for the diversification of lynx diets. The dominance of snowshoe hare in lynx diets during both seasons and across periods of changing hare density indicated lynx specialize on snowshoe hares at the southeastern limit of their geographic range, although lynx broadened their diet during a summer-low hare density period.

Investigator: Sheryn J. Olson (MS)

Advisors: Daniel J. Harrison (Advisor)
William B. Krohn
Robert S. Seymour
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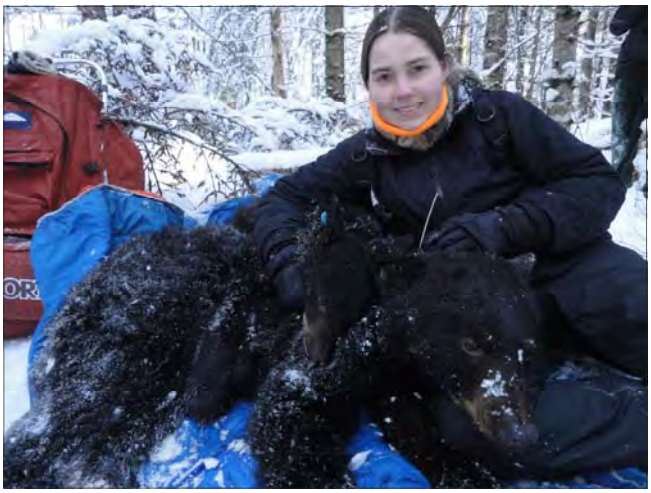
Mark McCollough (ex-officio)

Duration: January 2010—May 2014

Cooperators:

University of Maine – Department of Wildlife, Fisheries, and Conservation Biology
University of Maine – Maine Agricultural and Forest Experiment Station
U.S. Geological Survey – Maine Cooperative Fish and Wildlife Research Unit
U.S. Fish and Wildlife Service
Maine Department of Inland Fisheries and Wildlife
University of Maine – Maine Cooperative Forestry Research Unit



Reproductive ecology of black bears in Maine: maternal effect, philopatry, and primiparity

1. Examine the influence of maternal effect and philopatry on den type selection in female subadult black bears.
2. Determine if there is regional variation in the age of primiparity of Maine black bears.
3. Evaluate the effects of den type and age of primiparity on lifetime productivity and offspring recruitment.

The American black bear (*Ursus americanus*) relies upon dens in order to successfully reproduce and protect their offspring. Black bears utilize a variety of den types, each providing a different degree of protection. Black bears also exhibit an extended maternal care period in which offspring stay with their mother for 18 months. Maine's black bear population is one of the largest in the U.S. (>30,000 bears) and since 1975, the Maine Department of Inland Fisheries and Wildlife has conducted research and monitoring to manage the population. This unique dataset allowed for examination of several generations of multiple maternal lineages which was ideal for assessing both den type selection and primiparity (age of first reproduction).

My objectives for this study were to determine: 1) whether subadult females chose the same den type as their mother (maternal effect) or if they selected a den near their yearling den, regardless of den type (philopatric effect); 2) whether differences among study areas explained observed differences in den site selection; 3) if there was regional variation in the age of primiparity of Maine black bears; 4) the relationship between the age of primiparity and the probability of recruitment from the primiparous litter; 5) the relationship between the age of primiparity and lifetime productivity; and 6) the relationship between the age of primiparity and body condition.

I analyzed den selection data of 168 subadult females and primiparity data of 85 females from 1981-2013 at four study sites in Maine using GIS, generalized linear modeling, model selection, and analysis of variance (ANOVA). The top den selection model, which included maternal effect and study area, accounted for 85% of the den type selection model likelihood. Maternal effect models were more strongly supported than philopatric effect models and regional variation in den type use was observed. These results suggest that not only is a behavioral maternal effect present in black bears and that this maternal effect combined with regional variation in den type availability influences den type selection, but also that the protection afforded by den type may be an important factor in selection decisions.

I found regional variation in age of primiparity among the study areas ($p = < 0.001$). Multiple comparison testing indicated age of primiparity differences between Spectacle Pond – Bradford ($p = < 0.001$) and Stacyville – Bradford ($p = 0.009$). Logistic regression indicated there was a difference in the successful recruitment of at least one offspring from the primiparous den among the primiparous ages ($p = 0.002$). Probability of successful recruitment increased with increasing age of primiparity. I found no difference in lifetime productivity among the primiparous ages ($p = 0.532$). I also found no difference in primiparous body condition among the primiparous ages ($p = 0.591$). These results suggest that regional differences in food quality and abundance may influence regional variation in age of primiparity. Understanding factors that influence den type selection as well as the influence of age of primiparity on other reproductive life history traits can help guide wildlife and habitat management decisions.

Investigator: Alyssa Vitale (MS)

Advisors: Shawn T. McKinney (Co-Advisor)
Daniel W. Linden (Co-Advisor)
Mary S. Tyler

Duration: September 2013—August 2015

Cooperators:

University of Maine
Maine Department of Inland Fisheries and Wildlife

American woodcock migration ecology on the Mid-Atlantic coast

1. To investigate en route second order habitat selection of migratory woodcock during stopover.
2. To evaluate drivers affecting migratory decision making of woodcock during stopover.
3. To determine age- and sex-specific departure rates.
4. To determine if habitat use influences minimum stopover duration: a proxy for habitat quality.

Understanding migration ecology is essential for the conservation of migratory species, and particularly important for effective management of migratory game birds. American woodcock are a migratory game bird undergoing population decline since the 1960's stemming from land-use/land-cover change, specifically forest maturation. Research to date has largely focused on habitat use and demographics on northern breeding areas, and wintering grounds in the southern United States. This has left a large knowledge gap in woodcock migration ecology. To begin filling this void, an interagency effort between USGS and USFWS was initiated to evaluate habitat selection, timing of migration, and survival during the migration period. The study area was Cape May county, NJ, a well-known concentration point along the Atlantic coast during fall migration. Woodcock were caught on fields used for roosting at night by way of a spotlight and a long-handled net. Approximately 10 birds were banded and fitted with a uniquely tuned very-high frequency (VHF) radio-transmitter per week. Each bird was monitored daily for presence in the study area and homed in on at least twice a week to record a precise location, collect habitat data, and determine live/dead status.

Field work took place from 2010 to 2014 during late October through January. Over the course of this period 497 birds were captured and banded. Of those, 271 were fitted with radio-transmitters. We will be using the known locations from telemetry and habitat characteristics derived from GIS to investigate the factors that influence the habitat selection process. We are acquiring weather and astrological data evaluate the effects of these variables on stopover duration. Preliminary analyses are currently in process.

Investigator: Brian B. Allen (MS)

Advisors: Erik J. Blomberg (Advisor)
Daniel G. McAuley
Joseph D. Zydlewski
Brian J. Olsen

Duration: October 2010—May 2017

Cooperators:

U.S. Fish and Wildlife Service – Division of Migratory Birds
U.S. Geological Survey – Patuxent Wildlife Research Center
University of Maine – Department of Wildlife, Fisheries, and Conservation Biology

BatME: Monitoring bat distributions in Maine using outreach-based citizen science

1. Evaluate the utility of handheld bat detectors for monitoring bat distributions in Maine by enlisting the help of citizen scientists.
2. Develop appropriate sampling designs that can couple citizen science data with robust methods for data analysis and modelling.
3. Through use of a focus group, develop a plan to expand BatME into a statewide program and to integrate education and outreach components into BatME.

Bats are critically important species in many ecosystems because of the role they play in ecological food webs. White-nose bat syndrome (hereafter WNS), a fungal pathogen first identified in New York in 2006, has spread rapidly throughout the Northeast, reaching Oxford County Maine in 2011. It has resulted in unprecedented range-wide declines in populations of cave-hibernating bats in the Northeast, with some species experiencing a 90% population decline over the last five years. In 2015 we initiated a citizen-science project, BatME, to enlist the help of volunteers for monitoring Maine's bat populations. This project uses acoustic monitoring of the high-frequency echolocation calls made by bats, which can be used to both record bat presence and identify bat species. We use mobile bat detectors comprised of an Apple iPad and a Wildlife Acoustics Echo Meter Touch ultrasonic microphone, which allows volunteers to detect and record bat calls while simultaneously displaying the call and identifying the bat in real-time. This provides volunteers an opportunity to interact with bats (via the Echo Meter App) in a way that is typically not possible, while simultaneously providing us with geo-referenced recordings that provide information on data on bat occurrence.

During summer 2015 BatME volunteers collected more then 4,000 recordings of bats in 15 Maine counties, including numerous recordings of little brown bats (*Myotis lucifugus*) which are of particular concern due to declines related to WNS. Volunteers reported that detector units were easy and fun to use. We will continue and expand the project in 2016 to cover a greater geographic area and will also include repeated sampling so that data collected can be applied in an occupancy-modelling approach. We will also incorporate vehicle-based mobile detection surveys and surveys of known bat maternity roosts to further expand the potential of citizen scientists to collect important data on Maine's bat populations.

Investigators: Erik J. Blomberg, Sabrina Morano, Cory Mosby, Susan Gallo

Duration: June 2015—May 2016

Cooperators:

Maine Outdoor Heritage Fund
Maine Department of Inland Fisheries and Wildlife
Maine Audubon Society

American marten in Maine: Understanding spatial population dynamics and evaluating monitoring methods

1. Compare remote cameras and hair-snares as sampling methods for estimating marten occurrence and density.
2. Evaluate the power and precision of different combinations of sampling methods and analyses to detect population trend.
3. Develop optimal sampling design for future monitoring with consideration for cost and effort constraints.
4. Construct spatially-explicit predictive models of marten population parameters in relation to exploitation and habitat composition.
5. Determine the relative sensitivity of marten population size to changes in the underlying mechanistic components (recruitment, adult survival, immigration and emigration).

American marten are valued in Maine for commercial and conservation purposes. Changes in forest management over previous decades have led to reductions in suitable habitat for the species, and climate change poses a major risk to the its long-term viability within the state. Accordingly, Maine's Department of Inland Fisheries and Wildlife (IFW) seeks to enhance current monitoring efforts in order to more accurately gauge population trends. We will weigh different combinations of sampling scheme, methodology, and subsequent metrics in order to indentify monitoring designs that are both robust and cost-effective. Focusing our survey efforts in northcentral Maine, we will also investigate how marten vital rates respond to different environmental and anthropocentric influence, and in turn, how influential specific vital rates are upon population size and stability. This information may be critical for evaluating the potential of varied management actions for manipulating population trend, and understanding how forest condition and configuration influences martens at a population-level scale more aligned with the scale of forest management.

A brief pilot season was conducted in late winter 2014 to both evaluate the ability to identify individual martens based upon photographs, and assess joint camera/hair-snare detection stations. Work in the summer and fall of 2014 focused on optimizing detection station design, and we continued sampling in January 2015 in our north Maine woods study area. Given relocation of the project graduate student and PI, we discontinued the field study at the end of March 2015. Currently we are analyzing the collected data and preparing manuscripts summarizing the data collection efforts.

Investigator: John Clare (PhD)

Advisors: Shawn T. McKinney (Advisor)
Walter Jakubas
Cynthia S. Loftin

Duration: September 2013—March 2016

Cooperators:

Maine Department of Inland Fisheries and Wildlife
U.S. Geological Survey – Maine Cooperative Fish and Wildlife Research Unit
University of Maine – Department of Wildlife, Fisheries, and Conservation Biology

Harvest, seasonal survival, and drumming ecology of ruffed grouse in Maine

1. Evaluate seasonal survival and harvest rates in relation to environmental variables to build and improve future management and harvest practices.
2. Understand relationships among individuals, and groups of individuals such as, age and sex, that contribute to mortality risk throughout the year.
3. Evaluate male drumming rates in relation to habitat features and explore relationships with male survival.

Ruffed grouse are a native Maine bird, and are arguably the most popular small game animal in the state. We are using a combination of banding and radio-telemetry to monitor demographics (survival and reproductive success) and harvest of ruffed grouse at two studies areas in Maine. Ruffed grouse are captured during late summer using cloverleaf interception traps, and are fitted with very high frequency (VHF) radio collars that include mortality sensors so that marked birds may be monitored for survival and causes of mortality can be identify as they occur. Additionally, birds are fitted with aluminum leg bands stamped with contact information to allow for hunters to report any harvested grouse. During the mating season we will quantify male drumming (display) rates and relate drumming rates to habitat characteristics such as stem density, understory coverage, and species composition.

During August and September in 2014 and 2015 we captured and radio-collared ruffed grouse at the two study areas. We monitored survival of 105 radio-collared grouse following the 2014 capture season. Ruffed grouse hunters reported harvesting 17 grouse during the 2014 hunting season (October 1st through December 31st), and an additional 28 non-harvested mortalities were recorded, the majority of which were attributed to avian predation. Winter mortality was higher than expected with a total of 16 mortalities recovered during January and February 2014. During the Spring of 2015 we located 40 drumming logs between the two study sites and recorded individual male drumming rates and habitat characteristics at each log location. Habitat sampling was performed at the log and at 2 paired random points located less then 200m from the log. Our field work is ongoing and survival monitoring, drumming analyses and habitat sampling will continue in 2016.

The project is integrated with project Population densities and summer habitat use of ruffed grouse in Maine on Page46.

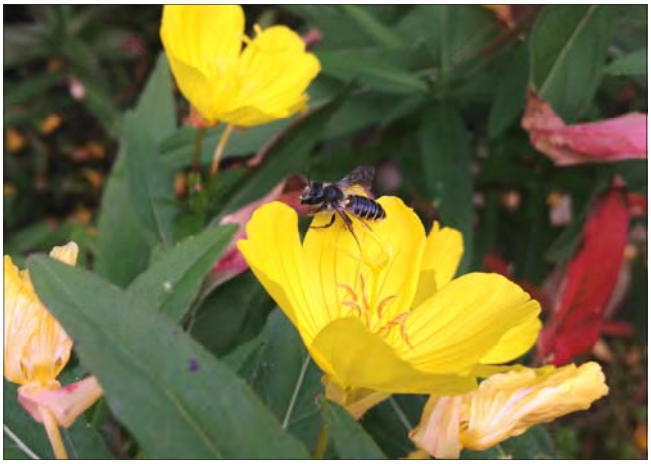
Investigators: Samantha Davis (MS)

Advisors: Erik J. Blomberg (Advisor)
Kelsey Sullivan
Brad Allen
Brian J. Olsen

Duration: July 2014—May 2017

Cooperators:

Maine Department of Inland Fisheries and Wildlife
American Forest Management
University of Maine – Maine Agricultural and Forest Experiment Station
University of Maine – Department of Wildlife, Fisheries, and Conservation Biology



Landscape pattern and native bee communities in the northeastern United States

1. Determine if a relationship exists between pesticide residues in pollen loads and landscape configuration.
2. Examine power line rights-of-way as semi-natural habitat for native bees.
3. Compare the performance of a spatially explicit ecosystem service simulation model in landscapes with different complexities.
4. Develop a tool for blueberry growers to assess native bee habitat in the landscape surrounding their crop fields.

Native bees provide a critical ecosystem service to human and wildlife populations by pollinating fruit-bearing cultivated crops and wildlife forage. Historically, commercially managed bees have been an important pollinator of agricultural crops, however, Colony Collapse Disorder has decreased hive availability, increasing reliance on native bees to provide this service. Enhancing habitat around crop fields to promote native bee populations will benefit fruit production for both agricultural interests and wildlife populations. In Maine, wild blueberry growers invest heavily in honey bees for pollination; concern about pollination deficit due to fewer honey bees and growing costs has lead to increased interest in management to promote native bee pollination. This study is examining factors that potentially affect native bee abundance in wild and cultivated fruits from a spatial ecology perspective. Our spatial assessment includes evaluation of relationships between landscape pattern and composition and exposure of native bees to pesticides applied to crop fields; evaluates habitat quality of power line rights-of-way as semi-natural habitat for native bees; compares performance of a spatially explicit ecosystem service simulation model (InVEST) in landscape with different pattern complexities; and, develops a tool for blueberry growers to use to assess native bee habitat in the landscape surrounding their crop fields.

Native bees have been surveyed in power line rights-of-ways in Downeast Maine during 3 summers, and in mid-coast Maine during 2014 and 2015. Pesticide burden samples collected in 2012-2014 have been analyzed and data are being prepared for spatial analyses. Additional pesticide data provided by project collaborators in MA, CT, and ME will be added to the database during 2015. Development of a web-based spatial tool for wild blueberry growers and land managers will be completed during 2015. Modification of the spatial model will begin during late 2015, incorporating data from bee surveys conducted in non-crop land cover types to improve model accuracy.

Investigators: Brianne Du Clos (PhD)

Advisors: Cynthia S. Loftin (Co-Advisor)
Francis A. Drummond (Co-Advisor)
Dana M. Bauer
Samuel P. Hanes
Allison Dibble

Duration: January 2012—December 2016

Cooperators:

U.S. Geological Survey – Maine Cooperative Fish and Wildlife Research Unit
University of Maine
University of Maine – Sustainable Solutions Initiative
U.S. Department of Agriculture
USDA SARE Grants

Relative densities, patch occupancy, and population performance of spruce grouse in managed and unmanaged forests in northern Maine

1. Quantify patch occupancy of breeding spruce grouse across a variety of harvested and unharvested stands to determine the link between measurements of forest structure and breeding habitat occupancy.
2. Document home range and within-stand habitat selection and composition of brood rearing female spruce grouse with regard to forest vegetation, structure, and harvest history to evaluate effects of forest management on brood rearing habitat.

Spruce grouse (*Falcipennis canadensis*) are a species of forest grouse dependent on conifer dominated forests. The southeastern extent of the geographic range of spruce grouse coincides with southeastern distribution of red and black spruce within the Acadian forests of Maine, northern New Hampshire, northernmost Vermont, the Adirondacks region of New York State, as well as the eastern maritime provinces of Canada. Spruce grouse are a state-listed species in NY and VT and a species of conservation concern in NH. Although there is no hunting season on the species in Maine, little else is known about their current status in the state.

Although industrial forest management has been shown to reduce the survival and reproductive success of spruce grouse, populations in unharvested portions of the Adirondack Forest Preserve also have exhibited substantial declines. Additionally, spruce grouse have been documented to occur in plantations and PCT stands. The effects of extensive forest management in commercially managed landscapes on habitat viability for spruce grouse is unknown. Thus, this study will evaluate of the effects of commercial forest management in northern Maine on patterns of habitat occupancy, habitat use, and reproductive success of spruce grouse using breeding season occupancy surveys and radio telemetry of females during the brood rearing season.

Analyses of occupancy and abundance patterns of displaying male spruce grouse (Chapter 1) were completed during the spring of 2015. The occupancy and abundance data was collected from sets of 3 callback surveys during May conducted across 3 years in 30 stands. S urveyed stands represented mature conifer, regenerating clearcuts, pre-commercially thinned stands, and selection harvests. We constructed single season occupancy models and single season abundance models in program MARK. We model averaged across all models with AICc scores greater than those of the null model and with significant beta values for the variables of interest. For the occupancy models the overall probability of detection was 0.58 and the overall probability of occupancy was 0.84. For the abundance models a male grouse had a probability of detection around 0.18 and the abundance of male grouse in the average stand was 5. Based upon the covariates included in the models, breeding male spruce grouse in a managed landscape appear to prefer mid-successional, moderately dense, conifer dominated stands that have experienced intensive forestry practices such as clearcutting, herbicide application, and pre-commercial thinning.

The analyses for the habitat use of female spruce grouse during the brood rearing season (Chapter 2) are ongoing and the vegetation measurements for the final 5 females tracked in 2014 were collected during August of 2015. Expected date of project completion is December 2015.

Investigator: Stephen Dunham (MS)

Advisors: Daniel J. Harrison (Advisor)
Brian J. Olsen
Erik J. Blomberg
Daniel G. McAuley (ex-officio)

Duration: July 2011—May 2016

Cooperators:

University of Maine – Maine Cooperative Forestry Research Unit

Effects of urbanization on pool-breeding amphibians: Implications of condition for persistence of wood frog (*Lithobates sylvaticus*) and spotted salamander (*Ambystoma maculatum*)

1. Characterize wood frog and/or spotted salamander breeding pools along a gradient of human disturbance via documentation of biotic factors (faunal assemblages, vegetation characteristics), abiotic factors (temperature, water quality, hydroperiod), and land cover types and configuration at various scales in the surrounding landscape.
2. Examine the effects of breeding pool characteristics on amphibian health (i.e., development, morphology, disease susceptibility, and physiology).
3. Examine population dynamics (e.g., occupancy, breeding effort and success, and connectivity) relevant to population persistence.

Pool-breeding amphibians in Maine, similar to most groups of amphibians worldwide, are threatened by human land use disturbance and the resultant habitat loss, fragmentation, and degradation. Changes in conditions associated with development can exacerbate effects of climate change (e.g., heat island effect, acid rain, UVB light) and introduce environmental pollutants and disease. These amphibians require both aquatic and terrestrial habitats to complete their life cycles and are, thus, sensitive to disturbances in both environments. Animal response to changes in landscape conditions may not immediately affect population demographics; i.e., there may be a time lag between impaired condition and reductions in fecundity and survival. Amphibian populations that are chronically exposed to adverse factors may have reduced likelihood of survival. It is currently unknown how amphibian health and survival are affected by various intensities of development. Understanding how pool-breeding amphibians respond to development will provide crucial information for land managers and policy makers to make decisions about development that best conserves pool-breeding amphibian species. Our project addresses how land use disturbance affects the likelihood of pool-breeding amphibian population persistence via examination of amphibian health and survival and habitat parameters. I will continue to collect data from amphibians in various life stages.

We have completed two field seasons focusing on characterizing vernal pools and the health and survival of larval wood frog (*Lithobates sylvaticus*) and mole salamander (Ambystoma spp.) populations along a development gradient. We conducted egg mass and larvae counts to estimate reproductive effort and the percent of eggs that survived to leave pools. We also conducted weekly health surveys, which consisted of measuring body length and mass and noting developmental stage, injuries, malformations, and indications of disease. In the lab, we piloted tadpole blood collection techniques using African clawed frog tadpoles (*Xenopus laevis*), and later in the field we collected blood from wood frog tadpoles to count white blood cells (used as a proxy to measure baseline physiological conditions). Throughout the season we quantified changes in within-pool vegetation and water characteristics which likely affect larval amphibian health and survival. We conducted trail camera and visual detection surveys to describe vertebrate predator pressures on pool-breeding amphibians.

Investigator: Carly Eakin (PhD)

Advisors: Malcolm L. Hunter, Jr. (Co-Advisor)
Aram J.K. Calhoun (Co-Advisor)
Hamish S. Greig
Rebecca L. Holberton
Michael T. Kinnison

Duration: August 2013—May 2017

Cooperators:

National Science Foundation – Experimental Program to Stimulate Competitive Research
University of Maine – Department of Wildlife, Fisheries, and Conservation Biology
University of Maine – Maine Agricultural and Forest Experiment Station

Habitat use by pool breeding amphibians In Maine's montane region

1. Determine micro- and macrohabitat features selected for by wood frogs (*Lithobates sylvaticus*) during the post-breeding period.
2. Evaluate hibernaculum microclimate and determine micro- and macrohabitat features selected for by wood frogs prior to hibernation.
3. Assess the influence of local and landscape scale variables on wood frog and spotted salamander (*Ambystoma maculatum*) breeding site occupancy in Maine's Upper Montane/Alpine Zone ecoregion.

Maine is ecologically diverse with varied landscapes. Although pool-breeding amphibians generally are distributed across the state, the vernal pools they typically use for breeding are more limited geographically. Current legislation to protect vernal pools is based on research conducted in southern, central, and downeast Maine where vernal pools are relatively abundant; it is not clear how these species use alternative breeding habitats where vernal pools are scarce. For example, Maine's montane region is rugged and relatively wetland-limited, with one of the coldest climates in New England. Very little is known about pool-breeding amphibian dispersal, migration, hibernation, and habitat selection in this wetland-limited region of Maine. Hibernaculum selection may be critical to individual fitness, as six-months of hibernation is immediately followed by a short, explosive breeding period. Our research examines habitats used by pool-breeding amphibians throughout the species' annual life history cycle in Maine's western and interior mountains.

We have completed four field seasons; two investigated wood frog post-breeding and overwintering habitat selection, and two investigated wood frog and spotted salamander breeding site occupancy in Maine's Upper Montane/Alpine Zone ecoregion. We used radio telemetry to track the post-breeding movements of 71 wood frogs at Turtle Ridge in Maine's Nahmakanta Public Reserved Land during 2011-2013. We continued to track a reduced number of frogs throughout fall and early winter in 2011 and 2012 until they were poised for hibernation. We then erected enclosures around each hibernating frog, which served to contain them until we arrived on-site to attach new radio transmitters; do so allowed us to track individuals across all annual life history periods (i.e., breeding, post-breeding, and hibernal periods). We conducted amphibian egg mass and larvae surveys at 135 wetlands in six study areas during late spring and summer in 2013 and 2014. We have published two manuscripts, submitted one, and are currently writing three others.

Investigator: Luke Groff (PhD)

Advisors: Cynthia S. Loftin (Co-Advisor)
Aram J.K. Calhoun (Co-Advisor)
Daniel J. Harrison
Brian J. McGill
Francis A. Drummond

Duration: January 2010—May 2016

Cooperators:

Maine Department of Inland Fisheries and Wildlife
U.S. Geological Survey – Eastern Regional Cooperative Fish and Wildlife Research
U.S. Geological Survey – Maine Cooperative Fish and Wildlife Research Unit
University of Maine – Department of Wildlife, Fisheries, and Conservation Biology
University of Maine – Sustainable Solutions Initiative
School of Agricultural, Forest, and Environmental Sciences at Clemson University

Breeding ecology and habitat selection of the blue-spotted salamander (*Ambystoma laterale*) and its unisexual kleptogen

1. Compare the breeding site selection of blue-spotted salamanders to that of unisexual salamanders.
2. Explore terrestrial habitat use by unisexual salamanders.
3. Examine the breeding success of each lineage at 4 vernal pools.
4. Examine orientation of vernal pool species migrating to and from the wetland.

The blue-spotted salamander complex in Maine consists of the blue-spotted salamander (*Ambystoma laterale*) and a unisexual lineage containing both the DNA of the blue-spotted and Jefferson salamander (*A. jeffersonianum*). The unisexuals are almost entirely polyploid females, and parasitize sperm from the blue-spotted salamanders to reproduce (kelptogens). We are examining the breeding site selection, reproductive variation, and upland habitat use of this complex.

Breeding site selection: We will trap salamanders, collect tissue samples, and record environmental data at wetlands in several landscapes. We will model which factors influence the breeding site selection of each lineage.

Habitat use: We implanted breeding salamanders with radio transmitters and followed them as they emigrate from the pool.

Breeding success: Using drift fences at four vernal pools, we captured adult and juvenile salamanders and collected tissue samples for genotyping.

Orientation: We will use circular statistcs to examine data collected over 2 years of pitfall trapping.

We have completed a two seasons of radio telemetry, during which we followed 35 salamanders dispersing from breeding pools. We have collected data and tissue samples for both breeding adults and dispersing juveniles from 4 vernal pools across three years. We conducted 2 seasons of trapping salamander at pools to examine breeding site selection. We have begun statistical analysis.

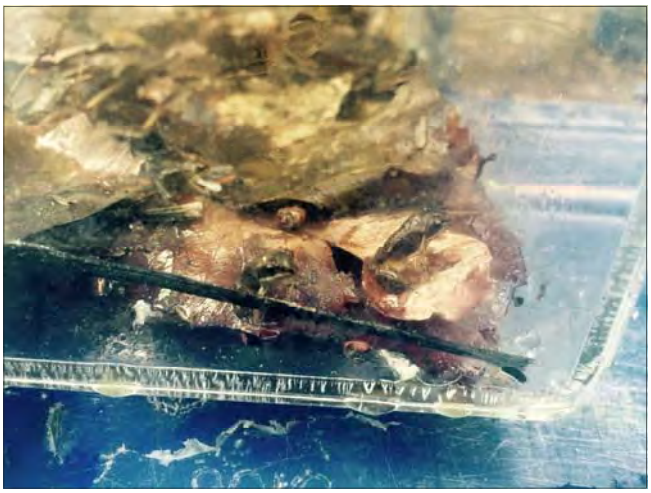
Investigator: Kristine Hoffmann (PhD)

Advisors: Aram J.K. Calhoun (Co-Advisor)
Malcolm L. Hunter, Jr. (Co-Advisor)
Daniel J. Harrison
Michael T. Kinnison
James P. Bogart

Duration: January 2012—May 2016

Cooperators:

National Science Foundation – Experimental Program to Stimulate Competitive Research
University of Guelph
Orono Land Trust
University of Maine – Department of Wildlife, Fisheries, and Conservation Biology
University of Maine – Sustainable Solutions Initiative



Land-use effects on movement between and around breeding sites by wood frogs

1. Create a human disturbance index (HDI) map using NLCD data in ArcMAP.
2. Adult wood frogs will be captured leaving several breeding pools urban settings, fitted with radio tags, and tracked to determine distance of migration range size, summer activity area size and different land use cover types encountered and crossed.
3. Compare adult wood frog survival and condition in heavily modified landscapes to those in relatively unmodified landscapes.
4. Model wood frog dispersal and metapopulation dynamics across a gradient of human modification.
5. Examine conspecific olfactory cues influencing juvenile orientation following emergence.

As human landscape modification (HLM) increases, large tracts of contiguous forest are reduced and fragmented by roads, houses, lawns, agricultural fields, and shopping centers. These landscape changes alter community structure and reduce an ecosystem's resilience. Given limited resources conservation efforts must focus on landscape features that provide high ecological return on investment. In the North eastern United States vernal pools provide numerous ecosystem services despite being relatively small wetlands. HLM physically impacts vernal pools, through outright destruction, pollution and altered hydrology. The ecological consequences of vernal pool degradation and destruction compromise the ultimate survival of the populations that have historically utilized them. A better understanding of the impact of HLM on pool breeding amphibians is needed to avoid local extirpations in urbanizing landscapes by developing best practices that work for the creatures and the people.

Our first step was to define a gradient of anthropogenic impact using simple, repeatable and accessible methods. Once the landscape was well understood we began working to better understand how pool-breeding amphibians move through urban landscapes and the impact of those landscapes on their populations.

The Human Development Index (HDI) was created using ArcMAP and used in site selection for this and other studies. We have completed one field season focusing on movement of wood frogs (*Lithobates sylvaticus*). Adults were tracked over several weeks after leaving breeding pools using fluorescent powder. Wood frog tadpoles from seven breeding pools along an urban to rural gradient were reared in mesocosms and measured weekly to determine if inherent differences in growth or survival existed between urban and rural pools. Metamorphosed tadpoles were used in two movement experiments. The first was a willingness to cross study comparing pavement to lawn. The second was a y-maze experiment to determine if newly metamorphosed wood frogs follow scent trails left by conspecifics.

Investigator: Mitchell Jones (PhD)

Advisors: Malcolm L. Hunter, Jr. (Co-Advisor)
Aram J.K. Calhoun (Co-Advisor)
Joseph D. Zydlewski
Michael T. Kinnison
Alessio Mortelliti

Duration: September 2015—May 2020

Cooperators:

National Science Foundation – Dynamics of Coupled Natural and Human Systems (CNH)

Evaluation of representative bird species' Landscape Capability models developed by the Designing Sustainable Landscapes project in the 13-state, northeastern region of the United States

1. Evaluate relationships between abundance of selected representative species and DSL Landscape Capability products with breeding bird points count survey data collected within the northern region of the Connecticut River watershed and then across the NA-LCC region.
2. Evaluate Landscape Capability models under development for additional species (e.g., Cerulean Warbler) for which we have point count data and after upon completion of the models by the DSL project (scheduled for completion by 2015).
3. Evaluate relationships between predictions of representative species Landscape Capability models evaluated in Objectives 1-3 and the species they represent within ME, NH, PA, VA, and WV to evaluate the models from watershed to regional extents.
4. Provide information to managers regarding relationships of priority, forest-associated avian species populations and forest structure and landscape conditions to inform conservation and land management planning.

The University of Massachusetts Designing Sustainable Landscapes (DSL) project has developed Landscape Capability models (LC) for representative species, integrating climate niche, habitat capability, and prevalence models to assess sustainability of the representative species in the 13 northeastern states under future landscape conditions. Several representative species for which Landscape Capability models have been completed are USFWS priority species of high conservation concern in coniferous, hardwood-dominated or mixed coniferous-deciduous forest in the northeastern region, and models for some representative species are expected to serve as surrogate models for other species with USFWS Northeast Region conservation priority designation. Although the LC models for most bird species have been evaluated with recent eBird data, they have not been evaluated with data collected in independent, systematic, repeated surveys, nor has the transferability of the representative species models been evaluated for the species they are assumed to represent. Additionally, the application of DSL models to meet regional population objectives remains uncertain, because these models have not been tested for associations between abundance while accounting for detectability. Our analysis will incorporate detectability in evaluating the utility and predictive ability of DSL LC models and will facilitate transferability of these models into concrete conservation objectives and actions.

Activity on the project began in early September 2015 with appointment of the Post-Doctoral Research Associate, Dr. Zachary Loman, to the project. We are compiling available point count data collected by colleagues across the project area and are beginning preliminary assessment of these data. We have begun analyses of the point count data as density estimates to validate the abundance or occupancy predictions of the DSL LC models. We also are evaluating DSL LC models for Ruffed Grouse and American Woodcock with point- and management unit-scale monitoring data to verify and validate these models for predictions of relative abundance and occupancy at these scales.

Investigator: Zachary Loman (Postdoc)

Advisors: Cynthia S. Loftin (Co-Advisor)
Daniel J. Harrison (Co-Advisor)
Petra B. Wood (Co-Advisor)

Duration: September 2015—December 2018

Cooperators:

U.S. Geological Survey – Biological Resources Discipline
U.S. Geological Survey – Maine Cooperative Fish and Wildlife Research Unit
U.S. Fish and Wildlife Service
U.S. Geological Survey – Science Support Program

Population densities and summer habitat use of ruffed grouse in Maine

1. Quantify fine-scale habitat characteristics (e.g. stem density, basal area by tree species, and understory coverage and species richness) at random locations and summer locations used by ruffed grouse to assess habitat selection, and compare with results of similar studies conducted in other portions of the species' range.
2. Estimate densities of ruffed grouse at two study areas using spatially-explicit capture-recapture models to investigate the relationship of ruffed grouse population densities to forest type and forest management practices.
3. Contribute to the broader understanding of forest management effects on wildlife populations by examining variation in ruffed grouse demographic rates as a function of forest structure, composition, landscape characteristics, and forest management practices.

Ruffed grouse are a native Maine bird, and are arguably the most popular small game animal in the state. We are using a combination of banding and radio-telemetry to monitor demographics (survival and reproductive success) of ruffed grouse at two studies areas in Maine. Ruffed grouse are captured during the late summer using cloverleaf interception traps, and birds are fitted with very high frequency (VHF) radio collars that include mortality sensors so that marked birds may be monitored remotely for survival. Using individual ruffed grouse capture histories from our trapping efforts, we will estimate densities of grouse at the two study areas and relate them to landscape characteristics. During the breeding season we quantify characteristics of reproduction, such as clutch size, nest success, and brood productivity, and will evaluate the effects of habitat characteristics (e.g. stem density, understory coverage, species composition) on reproductive output. In addition, we monitor males throughout the breeding season to study how habitat characteristics affect selection by ruffed grouse. This work seeks to inform ruffed grouse management and improve our ability to conserve the species in Maine.

During August and September of 2014 and 2015, we captured and radio-collared ruffed grouse at two study areas in Maine. We will continue to monitor the survival of our radio-collared grouse year-round, while attempting to identify the causes of their mortality. In the summer of 2015, we monitored 16 ruffed grouse nests between the two study areas until each nest either succeeded or failed. Brood productivity was monitored via weekly flush counts until chicks reached 6 weeks of age. We obtained 2 locations per radio-collared bird per week from May through July, and measured habitat characteristics at half of these locations to compare to 1) random points less then 200m from birds' locations and 2) randomly generated points within the study areas.

Investigators: Joelle "Ellie" Mangelinckx (MS)

Advisors: Erik J. Blomberg (Advisor)
Kelsey Sullivan
Brad Allen

Duration: August 2014—May 2017

Cooperators:

Maine Department of Inland Fisheries and Wildlife
University of Maine – Maine Agricultural and Forest Experiment Station
University of Maine – Department of Wildlife, Fisheries, and Conservation Biology

Individual, colony, and metapopulation-level drivers of seabird colony dynamics

1. Investigate long-term costs of reproduction in a long-lived seabird;
2. Investigate differences in life-history strategy between two allopatric seabird populations with differing survival rates.
3. Investigate factors driving seabird productivity.
4. Investigate seabirds' ability to buffer productivity against fluctuations in food availability.
5. Investigate factors driving seabird colony initiation and extinction
6. Investigate factors affecting seabird nesting patch selection.
7. Use results from 1-6 to develop an agent-based model of seabird dynamics to allow population-level prediction in novel situations.

The purpose of this research is to investigate seabird dynamics on multiple scales and to use the resulting information to assess the resilience of seabirds to ecosystem perturbation. First, I will use a long-term mark-recapture dataset to revisit a reproductive cost experiment on Black-legged Kittiwakes (*Rissa tridactyla*) in Alaska to examine how cumulative reproductive costs may play out over an individual's lifespan. I then will use the same dataset to explore differences in life history strategy between this Pacific population vs. published accounts of an Atlantic population with differing survival rates. Next, I will use a 30-year monitoring dataset from the same region to examine how multiple stressors interact to affect kittiwake productivity on a colony scale and to identify which productivity components are used to buffer productivity. I then will investigate factors driving colony initiation and extinction. A s a part of this last component, I will test several hypotheses regarding recruit attraction to nesting patches. Finally, I will synthesize this work in developing a general agent-based model to predict seabird responses to changes in the marine ecosystem.

All data are collected, most cleaning and proofing is complete, and some analysis has begun. The bulk of the analysis will occur after I have completed my comprehensive examinations in Fall 2015.

Investigator: Alyson McKnight (PhD)

Advisors: Shawn T. McKinney (Co-Advisor)
Cynthia S. Loftin (Co-Advisor)
Erik J. Blomberg
Brian J. Olsen
Jeffrey A. Runge
David Irons

Duration: September 2013—May 2017

Cooperators:

U.S. Fish and Wildlife Service
University of Maine
U.S. Geological Survey – Maine Cooperative Fish and Wildlife Research Unit
Maine Department of Inland Fisheries and Wildlife

Summarizing Maine Department of Inland Fisheries and Wildlife bald eagle mortality data in Maine during 1962-2015

1. Summarize the cause of death of bald eagles by season, age, and location.
2. Evaluate mortality time trends from 1962-2015, such as changing proportions of gunshots, vehicle collisions, or lead poisonings.
3. Investigate relationships between lead concentration and deceased or released bald eagles.

I will calculate the number of eagles by season, month, and age, and then use circular analysis to show significant frequency of the carcass data from Maine Department of Inland Fisheries and Wildlife bald eagle mortality data in 1962-2015 and Avian Haven data in 2010-2015. I will also evaluate the probability of their survival by lead concentration using Program R. Finally, I will use ArcGIS to map out the carcass location in Maine depending on season, age, and location, and analyze the trends.

I have almost finished objectives, now I am reporting on paper and going to move onto spatial analysis.

Investigator: Ryo Ogawa (MWC)

Advisors: Malcolm L. Hunter (Advisor)
Erynn M. Call

Duration:

Cooperators:

Maine Department of Inland Fisheries and Wildlife
University of Maine – Department of Wildlife, Fisheries, and Conservation Biology

Effects of forest management practices in the Acadian Northern Hardwood/ Conifer Forests of Maine on forest bird communities

1. Quantify and define the composition and forest associations of coniferous bird communities in several silvicultural treatments including: regenerating, mature, overstory removal, precommercially thinned, selection, and shelterwood harvest.
2. Model the influences of silvicultural practices and vegetative attributes on coniferous forest bird communities.
3. Model factors influencing the abundance, occupancy, and distribution of focal species. This analysis will take a multi-scale approach and use both USGS Breeding Bird Surveys along with surveys that will be conducted 2013-2015.

To test for effects from forestry on bird densities, we conducted multi-species point count surveys in 2013 through 2015 during the breeding season of most passerine species (June through August) in the silvicultural treatments listed above. Our surveys recorded the number of birds present for each species along with variables that may influence their probabilities of detection. We measured vegetation at each survey location in 2014. Stand attributes will be used to assess habitat seleciton on focal species and communities. Additionally, we surveyed Bay-breasted Warbler reproductive success and spruce budworm adult moths (prey) in 2015. These data will be supplemented with USGS Breeding Bird Survey data to address large-scale questions, temporal trends, and the influence of budworm outbreaks. We will model habitat selection by birds to make inference about their responses to silvicultural management. We thank the U.S.F.W.S. Migratory Bird Division, U.S.F.W.S. National Wildlife Refuge System, UMaine Cooperative Forestry Research Unit, and UMaine Department of Wildlife Ecology, Maine Cooperative Fish and Wildlife Research Unit, and Baxter State Park for access to sites, project support, and funding.

We established sampling protocols for birds and vegetation and collected multi-species bird data at five areas throughout the Acadian forest region: Nulhegan NWR (VT), Umbagog NWR (NH), North Maine Woods (ME), Baxter State Park (ME), Aroostook NWR (ME), and Moosehorn NWR (ME) using standardized point count surveys. A total of 6,163 bird surveys were conducted during the summer of 2013, 2014, and 2015, and 65,760 detections of birds were collected during surveys at 657 point count locations within 117 forest stands. Vegetation surveys were completed at all sites during 2014. Reproductive success and eastern spruce budworm data were collected in 2015. All field data collection was completed in 2015. Statistical analysis and reporting of results will occur in 2015 and 2016.

Investigator: Brian Rolek (PhD)

Advisors: Daniel J. Harrison (Co-Advisor)
Cynthia S. Loftin (Co-Advisor)
Petra B. Wood
Brian J. McGill
Brian J. Olsen

Duration: August 2012—December 2016

Cooperators:

University of Maine – Department of Wildlife, Fisheries, and Conservation Biology
U.S. Geological Survey – Maine Cooperative Fish and Wildlife Research Unit
U.S. Fish and Wildlife Service
University of Maine – Maine Cooperative Forestry Research Unit
U.S. Geological Survey – Science Support Program
Baxter State Park

Biogeography and conservation of Maine's island amphibians, with focus on redback salamanders (*Plethodon cinereus*)

1. Survey Maine islands and near coastal areas for redback salamanders (*Plethodon cinereus*).
2. Conduct microsatellite DNA and trait-based assessments of genetic diversity, local adaptations, and colonization history of island redback salamanders and relate these data to spatial analyses of island features and historic sea levels.
3. Share information on islands likely to support genetically unique populations with stakeholders, and collaborate on outreach concerning the importance of islands for the natural history and conservation of Maine's amphibians.

Amphibians face some of the greatest rates of local and global extinctions among vertebrates. A significant challenge for conservation of amphibians is simply a lack of sufficient data on their historic and current distribution and where important genetic resources exist to target for conservation. Much of what we know about amphibian distributions is from accessible mainland habitats, and information about amphibian distributions on coastal islands is largely lacking. Amphibians are physiologically intolerant of seawater, and thus, island populations may have been isolated for thousands of years. Such populations can serve as important reserves of unique genetic diversity. Indeed, island populations of other taxa often possess unique morphological, behavioral and physiological adaptations relative to mainland populations. The proposed project seeks to conduct surveys of amphibians on coastal islands along the entire Maine seaboard to enhance current knowledge of their distributions. It also seeks to characterize genetic diversity and the ancient history of island colonization in one species, the redback salamander (*Plethodon cinereus*), that we anticipate is widely distributed on Maine's islands. By combining our surveys and genetic data with spatial analyses (GIS) we will identify islands most likely to support amphibian populations and communities that warrant conservation priority. We also will collaborate with project partners on outreach surrounding the role of islands in the natural history and conservation of Maine's amphibians.

We conducted surveys for redbacked salamanders on 16 coastal islands and 9 mainland locations, and have collected over 600 genetic samples. We are examining genetic variation at nine published microsatellite loci. Data analysis is complete. The thesis will be completed in 2016.

Investigator: Nikko-Ideen Shaidani (MS)

Advisors: Cynthia S. Loftin (Co-Advisor)
Michael T. Kinnison (Co-Advisor)
Rebecca L. Holberton

Duration: September 2012—June 2016

Cooperators:

Maine Outdoor Heritage Fund
U.S. Geological Survey – Maine Cooperative Fish and Wildlife Research Unit
U.S. Fish and Wildlife Service—Maine Coastal Isla
University of Maine
National Park Service

Population dynamics of spruce grouse in the managed forest landscapes of northern Maine

1. Estimate demographic rates of spruce grouse, such as adult survival for males and females, nest success, and chick survival, using a combination of radio-telemetry and capture-mark-recapture methods.
2. Evaluate micro-habitat characteristics such as understory composition, canopy cover, or tree basal area, at locations used by spruce grouse during important life phases (e.g. brood rearing or nesting) and determine the influence of these habitat characteristics on demographic rates.
3. Relate objectives 1 and 2 to population performance using predictive stage-structured population models. Use these models to evaluate the overall trajectory of spruce grouse populations, and classify populations as stable, increasing, or experiencing decline.
4. Provide guidance in the form of a status evaluation and recommendations for future conservation of spruce grouse populations, to include evaluation of forest management activities that promote habitat composition that is consistent with healthy spruce grouse populations.

Spruce grouse are native forest birds that inhabit conifer forests found throughout the northern U.S. and Canada. In other northeastern states spruce grouse are state-listed as an endangered species, but currently very little information exists to evaluate whether similar status is warranted in Maine. We will use a combination of radio telemetry and mark-recapture methods to collect data on survival and reproductive success of marked individuals. Survival will be evaluated year-round, as well as during distinct biological season's (e.g. breeding vs. overwinter). Reproductive success will be monitored during the spring and summer breeding season (May - August). We will monitor birds in areas of varying forest composition and silvicultural activities, and will also sample vegetation characteristics, such as tree basal area and canopy cover as well as forest understory composition and structure, at spruce grouse locations. We will also evaluate the current status of spruce grouse populations based on whether their demographic rates are consistent with stable or declining population trajectories. Ultimately, we will link population characteristics to components of spruce grouse habitat for the purpose of informing forest management and state-level regulatory decisions.

During the 2015 field season we monitored 43 spruce grouse, including 10 previously radio-marked birds that survived the 2014 - 2015 winter and 33 that were captured between May and October 2015. We located and monitored 8 nests and conducted vegetation sampling at all nest sites and 3 dependent random points per nest. We monitored 11 broods, including 5 from the monitored nests that were successful and 6 from hens captured with broods. Approximately once per week we located all radio-marked hens to assess survival and reproductive status and also conducted vegetation sampling at the use and 1 dependent random location. Male spruce grouse, and females captured after 1 August were monitored monthly for survival. All radio-marked grouse will continue to be monitored once a month for survival over the winter. Starting May 2016 we will resume monitoring spruce grouse on a weekly basis and also continue our capture efforts.

Investigator: Joel Tebbenkamp (PhD)

Advisors: Erik J. Blomberg (Co-Advisor)
Daniel J. Harrison (Co-Advisor)

Duration: September 2014—May 2018

Cooperators:

Maine Department of Inland Fisheries and Wildlife
Maine Outdoor Heritage Fund
University of Maine – Maine Cooperative Forestry Research Unit
Katahdin Forest Management
Gerald Pelletier, Inc

Small mammal community ecology

1. Determine if elevational gradients in northern New England harbor distinctive small mammal communities.
2. Understand patterns of community assembly and predict response to climate change.
3. Identify foundational species in each community and model their abundance.
4. Model intraspecific functional diversity of common species (Deer Mouse, Red/backed Vole).
4. Survey for high-elevation specialist species (Northern Bog Lemming, Yellow-nosed Vole).

Upon completion of two field season, we hope to address the stated projected objectives. Community-level analyses will rely primarily on multivariate statistics; species-level analyses will be primarily univariate. We plan examine patterns of intraspecific variation using basic field data and stable isotope analyses. These results will inform management of Maine's forests and address broad ecological questions.

Both field seasons have been completed, and we are currently working on data analysis and writing. A note documenting a record long-distance movement by a Deer Mouse has been published.

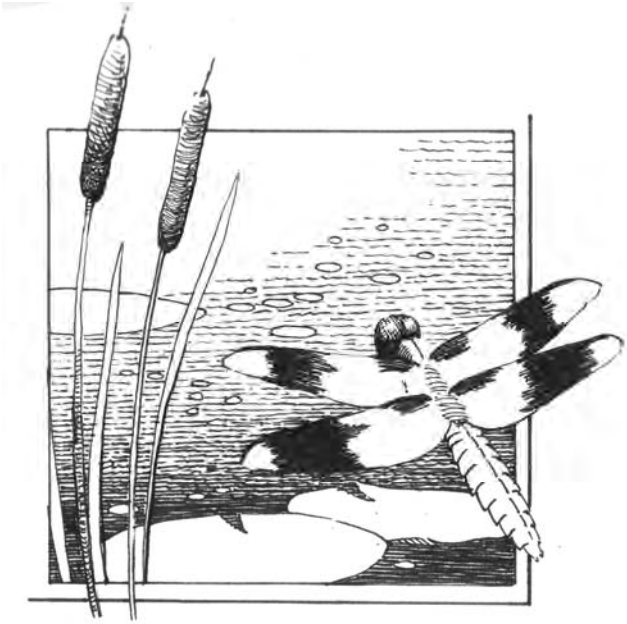
Investigator: Connor Wood (MS)

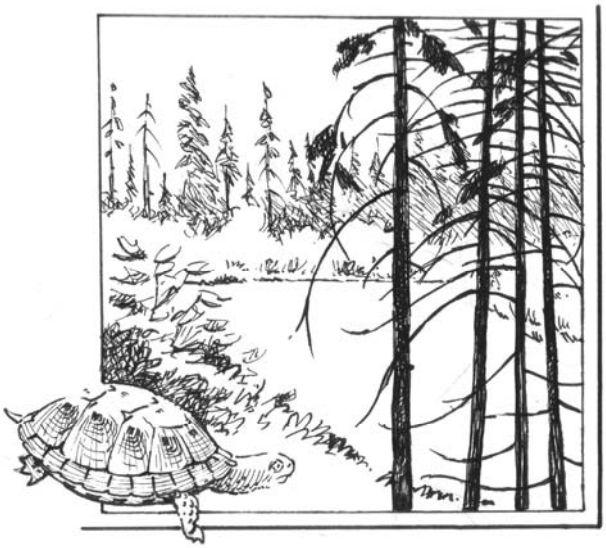
Advisors: Cynthia S. Loftin (Co-Advisor)
Shawn T. McKinney (Co-Advisor)
Jacquelyn L. Gill
Malcolm L. Hunter, Jr.

Duration: September 2013—May 2016

Cooperators:

Maine Outdoor Heritage Fund
U.S. Geological Survey – Maine Cooperative Fish and Wildlife Research Unit
University of Maine – Department of Wildlife, Fisheries, and Conservation Biology





INTEGRATED ecology

An examination of the drivers, institutions and economics of sustainability planning in Maine

1. Characterize sustainability policies in Maine municipalities and identify the drivers that lead to the adoption of such policies.
2. Study efforts of two Maine towns that are developing vernal pool regulatory policy, as an example of a sustainable policy.
3. Conduct economic policy analysis to inform local vernal pool policy development.

In this dissertation, I examined two aspects of natural resource governance: collaborative policy making and the contribution of municipalities. In my first study, I explored how power, trust, and learning function within a collaborative network of multiple scales of government and private interests that formed to improve protection of vernal pools. Using a qualitative case study and quantitative network analysis, I identified approaches that enable power to become more horizontally distributed, institutional features that may reduce tendencies to trust only those who share similar beliefs, and network structures that encourage both new information sources and deep deliberation.

In my second study, I conducted an ex-ante policy assessment to compare local-level outcomes of an existing standard to protect vernal pools with a market -based policy that was developed by a collaborative group. I employed economic models to predict economic costs and ecological outcomes associated with each policy option. I found that while a local market-based instrument has the potential to result in better ecological outcomes, hurdles exist related to market size and fiscal feasibility. Conducting this policy analysis within a collaborative process has allowed the group to discuss the challenges and to develop solutions.

In my third study, I examined if and why municipalities adopt policies that contribute to broader sustainability efforts by analyzing ordinances for the presence of policies and estimating regression models to identify the drivers of policy adoption. I found a range of communities adopt policies that promote sustainability. My results confirmed that interest group, public choice, and political market theories are successful in explaining the variation between municipal policy adoption rates, and that application to smaller municipalities allows refinement of policy adoption theories.

In summary, the institutional structure of collaborative organizations can greatly influence important mechanisms such as power, trust and learning that effect how a group functions. A well-functioning group can grapple with difficult issues and develop creative policies. In addition, some local level governments are capable of developing policies that have positive environmental, economic and social outcomes, and considering smaller municipalities can lead to a more complete understanding governance options.

Investigator: Vanessa Levesque (PhD)

Advisors: Aram J.K. Calhoun (Co-Advisor)
Kathleen P. Bell (Co-Advisor)
Mario Teisl
Teresa R. Johnson
Dave Owen

Duration: January 2010—December 2014

Cooperators:

Maine Department of Environmental Protection
Maine Department of Inland Fisheries and Wildlife
University of Maine – Sustainable Solutions Initiative
Maine State Planning Office
Army Corps of Engineers
Topsham, Town of
Orono, Town of

Changes in fish communities and chimpanzee distributions in the Bumbuna hydroelectric project area following impoundment by the dam

1. Characterize patterns in fish assemblages from estuary to the upper reaches of the Seli River prior to impoundment and compare the changes in fish assemblages in the upper reaches of the Seli River pre and post impoundment
2. Describe the distribution of chimpanzees in the pre- and post-impoundment area.

The Bumbuna Hydroelectric Project in Sierra Leone offers an opportunity to study complex effects of impoundment creation on aquatic, terrestrial and human communities. The Seli River is the third largest river system in Sierra Leone with a drainage area of 10,620 km2. The newly completed Bumbuna Dam is in the Sula Mountains valley 200 km northeast of the capital, Freetown, and is a run-of-river facility. The patterns in fish assemblages in the Seli River prior to impoundment will be assessed using data collected in surveys conducted by Marine Resources Group (UK) and the Institute of Marine Biology and Oceanography (IMBO), University of Sierra Leone and Bumbuna staff. The Seli River was sampled in 2006 (pre-impoundment) at seven sites located in the upper, middle/dam area and lower regions of the basin and post-impoundment in 2012. Measures of species richness and diversity will be applied.

Preliminary assessments in 2005 identified the presence of chimpanzees in the vicinity of the Bumbuna Dam project, although distributions and abundance of this species were too poorly characterized to prompt any meaningful mitigation measures. This information gap resulted in a detailed year-long study to assess both the pre- (2006) and post -impoundment (2013) status of chimpanzees in the project area with direct (observation of a chimpanzee) and indirect (observation of chimpanzee sign) methods. Nest counts, the traditional method for estimating chimpanzee densities, are being used to describe distribution and vegetation use.

Preliminary analyses for both the fish assemblage and chimpanzees work have been completed and writing is underway.

Investigators: Abdulai Barrie (MS)

Advisors: Cynthia S. Loftin (Co-Advisor)
Joseph D. Zydlewski (Co-Advisor)
Erik J. Blomberg
Robert J. Lilieholm

Duration: September 2013—May 2016

Cooperators:

Fulbright Student Scholar Program
The World Bank
Institute of Marine Biology and Oceanography, University of Sierra Leone
U.S. Geological Survey – Maine Cooperative Fish and Wildlife Research Unit

Eco-evolutionary implications of environmental change across developing landscape

1. Empirically evaluate the eco-evolutionary consequences of ongoing urbanization on the structure and connectivity of Maine's wood frogs and spotted salamanders.
2. Develop eco-evolutionary agent-based models to examine consequences of varying rates and forms of environmental perturbation across a complex landscape.
3. Quantify the gene expression profiles of ESD infected and uninfected lobsters to evaluate correlations between environmental stress and disease presence.

The influence of natural and anthropogenic barriers to gene flow among wood frog and spotted salamander populations will be assessed using a landscape genetics approach, whereby observable inter-population genetic structure is evaluated for correlations with various landscape features. The patterns documented using landscape genetic analyses will be incorporated into agent-based simulation models (ABMs), which will be used to assess the ecological and evolutionary responses of species to environmental perturbation. Because ABMs allow simulated individuals with unique characteristics to interact with each other in a simulated environment, they provide an excellent tool for capturing emergent phenomena in naturally complex eco-evolutionary systems. Model parameterization and validation will be informed using empirical data on vernal pool amphibians originating from landscape genetic analyses and the literature. Finally, as part of an interdisciplinary research effort designed to improve understanding of the causes of epizootic shell disease (ESD), I will be quantifying differences in gene expression profiles of infected and uninfected lobster from presumably high stress and low stress environments. These analyses will be competed using the RNA-Seq technique, which has recently been developed to utilize advances in next generation sequencing technologies to quantify gene expression profiles in non-model organisms.

Sampling for wood frog and spotted salamander larvae for use in landscape genetic analyses was conducted throughout Maine in the springs of 2014 and 2015. During this time, 2628 wood frogs and 2436 spotted salamanders were collected from 100 sites from throughout Maine. Collection of microsatellite data is underway with 10 loci being genotyped for each species. The agent-based model simulation framework is currently under development with hypotheses being established and the details of the models being finalized. During the last several months, I have worked with experts in epizootic shell disease, lobster biology and ecology, and disease ecology to finalize methods for sampling and analyzing lobster from the Gulf of Maine. Lobster tissue samples were obtained from coastal Maine in May and June 2015 and will be sequenced and analyzed in the coming months.

Investigators: Jared J. Homola (PhD)

Advisors: Cynthia S. Loftin (Co-Advisor)
Michael T. Kinnison(Co-Advisor)
Malcolm L. Hunter, Jr.
Timothy M. Waring
Andrew R. Whiteley

Duration: September 2013—May 2018

Cooperators:

Maine Department of Marine Resources
U.S. Geological Survey – Maine Cooperative Fish and Wildlife Research Unit
Maine Association of Wetland Scientists
NSF Adaptation to Abrupt Climate Change IGERT
Central Maine Power

Assessing Priority Amphibian and Reptile Conservation Areas (PARCAs) and vulnerability to climate change in the North Atlantic Landscape Conservation Cooperative

1. Compile reptile and amphibian species record data from states in the NE-LCC region into a data base.
2. Develop species distribution models of priority amphibians and reptiles in the NA-LCC region. Combine these models with richness data to identify conservation areas for priority reptile and amphibian species (PARCAs).
3. Combine modeled PARCAs with climate vulnerability models to identify areas within the NA-LCC where losses of vulnerable species are anticipated, where potential climatic refugia for priority species occur, and identify species for which gaps in current known distributional data prohibit these projections.
4. Identify conservation lands that fall within the priority amphibian and reptile areas identified in Objective 2, and identify areas with highest priority for supporting reptiles and amphibians in the Northeast that are not currently protected.
5. Incorporate climate vulnerability projections into final PARCA analysis, including a ranking of high priority current and future conservation areas.
6. Communicate results to key state, federal, and NGO partners via publications and regional workshops.

Amphibians and reptiles are experiencing severe habitat loss throughout North America; however, this threat to biodiversity may be mitigated by identifying and conserving areas that serve a disproportionate role in sustaining herpetofauna. Identification of such areas must take into consideration the dynamic nature of habitat suitability. Areas currently deemed climate-suitable may no longer be so in the future. We are collaborating with scientists from Clemson University, Tennessee State University, Maine Department of Inland Fisheries and Wildlife, and the Association of Fish and Wildlife Agencies to generate spatially-explicit models to (1) identify Priority Amphibian and Reptile Conservation Areas (PARCAs) – those discrete areas most vital to maintaining reptile and amphibian diversity, (2) project regions of current and future climatic suitability for a number of priority reptiles and amphibians in the North Atlantic Landscape Conservation Cooperative, and (3) identify gaps in distributional data for these species that may prevent or inhibit the identification of species-level climatic suitability.

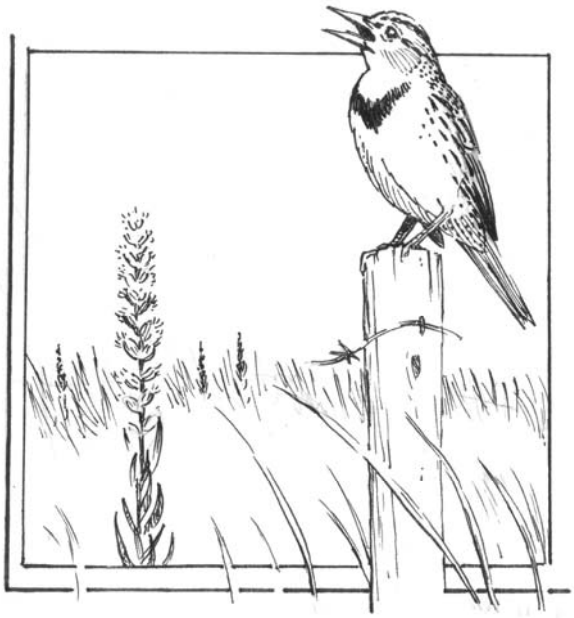
We received species occurrence data from 13 NA-LCC states and Washington, DC and converted datasets into a spatial format. We combined occurrence data with expert-selected environmental variables to develop species distribution models with the Maximum Entropy modeling approach, combined these models with species richness information, and spatially applied guidelines (Sutherland and deMaynadier 2012) for identifying priority reptile and amphibian habitat to model draft PARCAs. We evaluated draft models developed with richness data from state and web-available sources, scaled to state and ecoregions within state, and with alternative estimates of landscape viability, incorporating feedback from state reptile and amphibian experts into the revised PARCA maps. The final phase of the project will combine the proposed PARCAs with species climate niche models to evaluate predicted distributions of climate suitable habitat with climate change. Final project products will include a modeled PARCA map database with species distribution models, PARCAs resulting from modeling approaches and state-provided feedback, and guidelines for spatially implementing the criteria (Sutherland an deMaynadier 2012) in other regions.

Investigators: Cynthia S. Loftin, Phillip deMaynadier, Kyle Barrett, William Sutton, Allison Moody

Duration: August 2012—June 2016

Cooperators:

U.S. Fish and Wildlife Service
U.S. Geological Survey – Maine Cooperative Fish and Wildlife Research Unit
University of Maine
Maine Department of Inland Fisheries and Wildlife
Wildlife Management Institute



PUBLICATIONS and presentations

SCIENTIFIC PUBLICATIONS

Beier, P., M.L. Hunter, and M. Anderson. 2015. Conserving nature's stage. *Conservation Biology* 29:613-617.

Blomberg, E.J., J.S. Sedinger, D. Gibson, P.S. Coates, and M.L. Casazza. 2014. Carry-over effects and climatic conditions influence the postfledging survival of greater sage-grouse. *Ecology and Evolution* doi:10.1002/ece3.1139.

Calhoun A.J.K., J.S. Jansujwicz, K.P. Bell, and M.L. Hunter, Jr. 2014. Improving management of small natural features on private lands by negotiating the science-policy boundary. *Proceedings of the National Academy of Science* 111:11002-11006.

Calhoun, A.J.K., J. Arrigoni, R.P. Brooks, M.L. Hunter, and S.C. Richter. 2014. Creating successful vernal pools: a literature review and advice for practitioners. *Wetlands* 34:1027-1038.

Capps, K.A., R. Rancatti, N. Tomczyk, T. Parr, A. Calhoun, and M.L. Hunter, Jr.. 2014. Biogeochemical hotspots in forested landscapes: The role of vernal pools in denitrification and organic matter processing. *Ecosystems* 17:1455-1468.

Cline, B.B. and M.L. Hunter, Jr. 2014. Juvenile amphibians discriminate among open-canopy habitats: An experimental investigation of habitat permeability. *Journal of Applied Ecology* 51:319-329.

Colgan, C., M.L. Hunter, B. McGill, and A. Weiskittel. 2014. Managing the middle ground: Forests in the transition zone between cities and remote areas. *Landscape Ecology* 29:1133-1143.

Drahovzal, S.A., C.S. Loftin, and J. Rhymer. 2015. Environmental predictors of shrubby cinquefoil (*Dasiphora fruticosa*) habitat and quality as host for Maine's endangered Clayton's copper butterfly (*Lycaena dorcas claytoni*). *Wetlands Ecology and Management* DOI:10.1007/s11273-015-9427-1.

Gibson, D., E.J. Blomberg, M.T. Atamian, and J.S. Sedinger. 2015. Observer effects strongly influence estimates of daily nest survival probability but do not substantially increase rates of nest failure in greater sage-grouse. *The Auk: Ornithological Advances* 132:397-407.

Gill, J.L., J. Blois, B. Benito, S. Dobrowski, M.L. Hunter, Jr., and J. McGuire. 2015. A 2.5-million-year perspective on coarse-filter strategies for conserving nature's stage. *Conservation Biology* 29:640-648.

Groff, L.A., A.L. Pitt, R.F. Baldwin, A.J.K. Calhoun, and C.S. Loftin. 2015. Evaluation of a waistband for attaching external transmitters to anurans. *Wildlife Society Bulletin* DOI:10.1002/wsb.554.

Groff, L.A., C.S. Loftin, and A.J.K Calhoun. 2015. *Lithobates sylvaticus* (Wood Frog) hibernation. *Herpetological Review* 46(2):2015.

Hjort, J., J.E. Gordon, M. Gray, and M.L. Hunter Jr. 2015. Valuing the stage: why geodiversity matters. *Conservation Biology* 29:630-639.

Hogg, R., S.M. Coghlan Jr., J. Zydlewski, and C. Gardner. 2015. Fish community response to dam removal in a Maine coastal river tributary. *Transactions of the American Fisheries Society* 144(3):467-479.

Houlahan, J.E., S.T. McKinney, and R. Rochette. 2015. On theory in ecology: another perspective. *BioScience* 65:341-342.

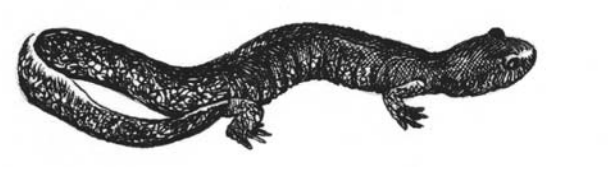
Hunter, M.L. D. Lindenmayer, and A. J.K. Calhoun. 2015. Saving the earth as a career: Advice on

becoming a conservation professional. 2nd edition. Wiley-Blackwell, Oxford, United Kingdom.

Hunter, M.L. Jr., K.H. Redford, and D.B. Lindenmayer. 2014. The complementary niches of anthropocentric and biocentric conservationists. *Conservation Biology* 28:641-645.

Hunter, M.L., Jr. 2015. A rich forest. Essay *in* A.W. Hopkins and E. Kaufman, eds. Reflections - Thirty Years, A Million Acres. Forest Society of Maine, Bangor, Maine.

Politi, N., L. Rivera, L. Lizárraga, M. Hunter, Jr., and G.E. DeFosse. 2014. The dichotomy between protection and logging of an endangered and valuable timber species: conservation of *Amburana cearensis* in northwestern Argentina. *Oryx* 49:111-117.



Ryan, K. and A.J.K. Calhoun. 2015. Post-breeding habitat use of the rare pure-diploid blue-spotted salamander (*Ambystoma laterale*). *Journal of Herpetology* 48(3).

Saura, S, E. Martin, and M.L. Hunter, Jr. 2014. Forest landscape change and biodiversity conservation. Pages 167-198 *in* J.C. Azevedo, A.H. Perera, and M.A. Pinto (eds). Forest Landscape Change and Global Change. Springer-Verlag New York.

Stich, D.S., G.B. Zydlewski, J. Kocik, and J. Zydlewski. 2015. Linking behavior, physiology, and survival of Atlantic Salmon smolts during estuary migration. *Marine and Coastal Fisheries* 7(1) 68-86.

Stich, D.S., M. Bailey, C. Holbrook, M. Kinnison, and J. Zydlewski. (Online). Catchment-wide survival of wild- and hatchery-reared Atlantic salmon smolts in a changing system. *Journal of Applied Ecology* 10.1139/cjfas-2014-0573.

Stich, D.S., M. Kinnison, J. Kocik, and J. Zydlewski. (Online) Initiation of migration and movement rates of Atlantic Salmon smolt migration in fresh water. *Canadian Journal of Fisheries and Aquatic Sciences* 10.1139/cjfas-2014-0570.

Stich, D.S., M. Kinnison, J. Kocik, and J. Zydlewski. 2015. Initiation of migration and movement rates of Atlantic Salmon smolt migration in fresh water. *Canadian Journal of Fisheries and Aquatic Sciences 72:1339-1351*.

Stich, D.S., Bailey, M., Holbrook, C., Kinnison, and Zydlewski J. 2015. Catchment-wide survival of wild- and hatchery-reared Atlantic Salmon smolts in a changing system. *Canadian Journal of Fisheries and Aquatic Sciences 72:1352- 1365*.

Sutton, W.B., R. Barrett, A.T. Moody, C.S. Loftin, P. deMaynadier, and P. Nanjappa. 2015. Changes in climate niche and climate refugia of conservation priority salamander species: a case study from the northeastern United States. *Forests* 6:1-26.

Weaver, D.M., S.M. Coghlan Jr., J. Zydlewski, R.S. Hogg, and M. Canton. 2015. Decomposition of sea lamprey *Petromyzon marinus* carcasses: Temperature effects, nutrient dynamics, and implications for stream food webs. *Hydrobiologia* DOI 10.1007/s10750-015-2302-5.

TECHNICAL AND SEMI-TECHNICAL PUBLICATIONS

Dunham, S. and D. Harrison. 2015. Patch occupancy, habitat use, and population performance of spruce Grouse in commercially managed conifer stands. Pages 75-79 *in* B.E. Roth, editor, Cooperative Forestry Research Unit: 2014 Annual Report, University of Maine, Orono.

Harrison, D. and S. Olson. 2015. Relationships among forest harvesting, snowshoe hares, and Canada lynx in Maine. Pages 68-74 *in* B.E. Roth, editor, Cooperative Forestry Research Unit: 2014 Annual Report, University of Maine, Orono.

Rolek, B., D. Harrison, C. Loftin, and P. Wood. 2015. Bird communities of coniferous forests in the Acadian Region: Habitat associations and response of birds to forest management. Pages 80 -88 *in* B.E. Roth, editor, Cooperative Forestry Research Unit: 2014 Annual Report, University of Maine, Orono.

THESES AND DISSERTATIONS

Call, E.M. 2015. River birds as indicators of change in riverine ecosystems. Ph.D. Dissertation, Wildlife Ecology, University of Maine, Orono: 155 pp.

Levesque, V.R. 2014. Advancing conservation efforts through collaborative development of locally tailored policies. Ph.D. dissertation, Ecology and Environmental Sciences, University of Maine, Orono.

Olson, S.J. 2015. Seasonal influences on habitat use by snowshoe hares: Implications for Canada lynx in northern Maine. M.S. thesis, Wildlife Ecology, University of Maine, Orono: 153 pp.

Stich, D.S. 2014. Phenology and effects of dams on the success of Atlantic salmon migrations in the Penobscot River, Maine. Ph.D. dissertation, Wildlife Ecology, University of Maine, Orono, 257 pp.

Vitale, A.A., 2015. Reproductive ecology of black bears in Maine: maternal effect, philopatry, and primiparity. M.S. thesis, Wildlife Ecology, University of Maine, Orono: 78 pp.

PROFESSIONAL TALKS PRESENTED

Altenritter, M., G. Zydlewski, M. Kinnison, J. Zydlewski, D. Secor, and D. Sigourney. 2015. "Shortnose sturgeon population dynamics in the Gulf of Maine." Annual meeting of the Maine Cooperative Fish and Wildlife Research Unit, University of Maine, Orono. March 25.

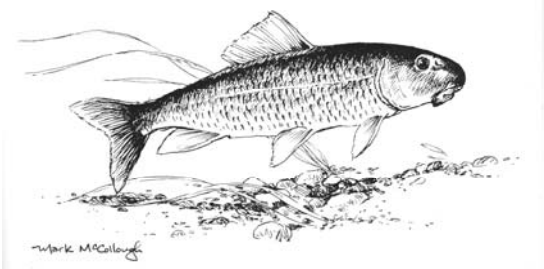
Balukas, J.A., K.P. Bell, A.J.K. Calhoun, M.L. Hunter, Jr., D. Bauer. 2015. Poster. "Advancing innovative conservation tools by improving knowledge of decision-making on private lands." Maine Sustainability and Water Conference, Augusta, ME. March 31.

Barrie, A., C. Loftin, and J. Zydlewski. 2015. "Changes in fish assemblages after completion of the Bumbuna hydroelectric dam, northern Sierra Leone, West Africa." Annual meeting of the Maine Cooperative Fish and Wildlife Research Unit, University of Maine, Orono. March 25.

Barrie, A., C. Loftin, and J. Zydlewski. 2015. "Influence of dam construction on chimpanzee distribution, abundance, and nest characteristics in the Bumbuna Hydroelectric Project, Northern Sierra Leone, West Africa." Annual meeting of the Maine Cooperative Fish and Wildlife Research Unit, University of Maine, Orono. March 25.

Begley, M., S. Coghlan, Jr., and J. Zydlewski. 2014. "Impacts of commercial harvest on white suckers." Maine Department of Inland Fisheries and Wildlife. Bangor, ME. November 15. INVITED.

Begley, M., S. Coghlan, Jr., and J. Zydlewski. 2015. "Understanding commercial harvest impacts on white suckers in Maine." Annual meeting of the Maine Cooperative Fish and Wildlife Research Unit, University of Maine, Orono. March 25.



Bell, K.P., A.J.K. Calhoun, D.M. Bauer, R. Freeman, and J. Balukus. 2015. "The cost-effectiveness of using a hybrid regulatory approach to conserve small natural features: Lessons from Maine, USA." Joint Annual Meetings of the Northeast Agricultural and Resource Economics Association and the Canadian Agricultural Economics Society, Newport, RI. June 28-30.

Blomber, E.J., D. Gibson, M. Atamian, S. Espinosa, and J. Sedinger. 2015. "Population ecology of greater sage- grouse following transmission line construction: Results of a 10-year study in Nevada, USA." International Grouse Symposium, Raejkiavik, Iceland. September 7.

Blomberg, E.J. 2015. "Landscapes, life histories, and populations: the challenge of (and opportunities for) conserving greater sage-grouse in a changing climate." University of New Hampshire Biology Seminar Series, Durham, NH. February 13. INVITED.

Calhoun, A.J.K. 2014. "Conservation of small natural features in complex landscapes." Australian National University. Canberra, AU. November 1.

Calhoun, A.J.K. 2014. "Stakeholder driven conservation solutions: A Maine, USA, case study." University of Melbourne. Melbourne, AU. December 1.

Calhoun, A.J.K. 2015. "Improving wetland restoration success." Webinar, Association of State Wetland Managers. http://www.aswm.org/aswm/6925-past-webinars-improving-wetland-restoration-success-project. April 21.

Coghlan Jr., S.M., R. Hogg, I.A. Kiraly, K.S. Simon, J. Watson, D.M. Weaver, and J. Zydlewski. 2015. "Effects of dam removals on fish populations and assemblages in the Penobscot River." Invited presentation at the Maine Science Festival, Bangor, ME. March 21.

Cory, G. and J. Zydlewski. 2015. "Assessing the influence of imprinting and stocking timing in the

Penobscot River on smolt to adult returns." First Annual University of Maine Freshwater Science Symposium, University of Maine, Orono. January 29.

Cory, G. and J. Zydlewski. 2015. "Assessing the influence of imprinting and stocking timing in the Penobscot River on smolt to adult returns." Annual meeting of the Maine Cooperative Fish and Wildlife Research Unit, University of Maine, Orono. March 25.

Du Clos, B., S. Hanes, C. Loftin, F. Drummond, and S. Groff. 2015. "Development of a pollinator habitat assessment tool in Maine's wild blueberry landscape." Presentation at the 2015 Maine Sustainability and Water Conference, Augusta, ME. March 31. INVITED.

Du Clos, B., S. Hanes, C. Loftin, F. Drummond, and S. Groff. 2015. "Development of a pollinator habitat assessment tool in Maine's wild blueberry landscape." Presentation at the 2015 Northeast Natural History Conference, Springfield, MA. April 18-20.

Du Clos, B., S.P. Hanes, C.S. Loftin, and F.A. Drummond. 2015. "A web-based tool for grower assessment of native bee abundance in the wild blueberry production landscape." Poster. Maine Cooperative Fish and Wildlife Research Unit Annual Coordinating Committee Meeting, Wells Conference Center, Orono, ME. March 25.

Du Clos, B., S.P. Hanes, C.S. Loftin, and F.A. Drummond. 2015. "A web-based tool for grower assessment of native bee abundance in the wild blueberry production landscape." Maine State Wild Blueberry Growers meeting, Bangor, ME. March 15. INVITED.

Du Clos, B.L., S. Hanes, C.S. Loftin, F. Drummond. 2014. "A web-based tool for grower assessment of native bee abundance in the wild blueberry production landscape." Presentation at the Maine EPSCoR State Conference, Wells Conference Center, Orono, ME. December 1. INVITED.

Du Clos, B.L., S.P. Hanes, C.S. Loftin, and F.A. Drummond. 2014. "A web-based tool for grower assessment of native bee abundance in the wild blueberry production landscape." Wild Blueberry Commission Advisory Board Meeting, Brunswick, ME, November 30. INVITED.

Eakin, C.E., A.J.K. Calhoun, M.L. Hunter. 2015. "Patterns in pool-breeding amphibian health across a gradient of human disturbance." Annual Northeast Partners in Amphibian and Reptile Conservation Conference, West Greenwich Rhode Island. August 20.

Feuka, A., K. Hoffmann, M. Hunter, and A. Calhoun. 2015. "Effects of light pollution on substrate selection in post-metamorphic wood frogs (*Lithobates sylvaticus*) and unisexual blue-spotted salamanders (*Ambystoma laterale x jeffersonianum*): A mesocosm study." Poster presented at the Annual Meeting of Northeast Partners in Amphibian and Reptile Conservation. West Greenwhich, RI. 18-19 August.

Groff, A.J.K. Calhoun, C.S. Loftin. 2015. "Habitat features mediate wood frog hibernaculum microclimate." Poster. Annual Coordinating Committee Meeting of the Maine Cooperative Fish and Wildlife Research Unit, University of Maine, Orono, ME. March 25.

Groff, L.A., A.J.K. Calhoun, and C.S. Loftin. 2015. "Habitat features mediate wood frog hibernaculum microclimate." North Carolina Congress of Herpetology Meeting, Asheboro, NC. May 1-3.

Groff, L.A., A.J.K. Calhoun, and C.S. Loftin. 2015. "Habitat features mediate wood frog hibernaculum microclimate." Poster. American Society of Ichthyologists and Herpetologists Annual Meeting, Reno, NV. July 15-19.

Groff, L.A., C.S. Loftin, and A.J.K Calhoun. 2015. "Habitat selection by pool-breeding amphibians in Maine's montane landscape." Annual Coordinating Committee Meeting of the US Geological Survey, Maine Cooperative Fish and Wildlife Research Unit; Orono, Maine, USA. 25 March.

Groff, L.A., C.S. Loftin, and A.J.K. Calhoun. 2015. "Local- and landscape-scale predictors of breeding site occupancy by pool-breeding amphibians in wetland-limited, montane landscapes." Presentation at the American Society of Ichthyologists and Herpetologists Annual Meeting, Reno, NV. July 15-19.

Harrison, D. 2014. "Origin, spatial and social ecology, and predator-prey relationships of eastern coyotes: a review." Invited lead presentation in Symposium on Ecology and Management of Coyotes in Eastern North America: Synthesizing Information

from Contemporary Studies, The Wildlife Society 21st Annual Conference, Pittsburg, Pennsylvania. October 14.

Hoffmann, K.E., A. Calhoun, and M. Hunter. 2015. "A salamander enigma; testing the unisexual salamander's reproduction in Maine." Poster presented at the Annual Meeting of Northeast Partners in Amphibian and Reptile Conservation. 18-19 August. West Greenwhich, RI.

Hogg, R., S. Coghlan Jr., J. Zydlewski, and K. Simon. 2015. "Fish community response to a small-stream dam removal in a Maine coastal river tributary." Guest Lecture: Principles of Fish and Wildlife Conservation (FW 251), Eastern Oregon University, La Grande, OR. February 23. INVITED.

Homola, J.J., M.T. Kinnison, and C.S. Loftin. 2015. "Adapting to transforming environments: consequences of climate change and urbanization on vernal pool amphibians." Maine Association of Wetland Scientists Annual Meeting, Brunswick, ME. March 21. INVITED.

Homola, J.J., M.T. Kinnison, and C.S. Loftin. 2015. "Comparative population structure of vernal pool amphibians in a developing landscape." Seventy first Annual Northeast Fish and Wildlife Conference, Newport, RI. April 19-21.

Homola, J.J., M.T. Kinnison, and C.S. Loftin. 2015. "Ecoevolutionary responses of spatially structured species experiencing climatic changes." Harold W. Borns Symposium, University of Maine, Orono, ME. April 9-10. INVITED.

Hunter, M.L. 2014. "Conserving small natural features with large ecological roles." Australia National University. November 18.

Hunter, M.L. 2014. "Conserving small natural features with large ecological roles." University of Melbourne. December 1.

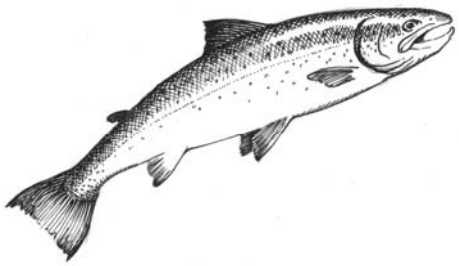
Hunter, M.L. 2015. "Conserving small natural features with large ecological roles." International Congress for Conservation Biology, Montpellier France. August 4

Irish B, and J. Zydlewski. 2015. "Marine-derived nutrient cycling in the St. Croix River, Maine." Annual Meeting of the Maine Cooperative Fish and Wildlife Research Unit, Orono, ME. March 25.

Irish, B., J. Zydlewski, and R. Cunjak. 2014. "Marine-derived nutrient cycling in the St. Croix River, Maine." Presented at: Sustaining the St. Croix Watershed: Research, Partnership and Action. St. Andrews, NB. November 20-21. INVITED.

Irish, B., J. Zydlewski, and R. Cunjak. 2015. "Marine-derived nutrient cycling in the St. Croix River, Maine." First Annual University of Maine Freshwater Science Symposium, University of Maine, Orono. January 29.

Izzo, L. and J. Zydlewski. 2015. "Post-restoration movements of upstream migrating adult Atlantic salmon in the lower Penobscot River." University of Maine Graduate Research Exposition, University of Maine, Orono. April 2.



Izzo, L., G. Maynard, and J. Zydlewski. 2015. "Movements of adult Atlantic salmon in the lower Penobscot River after dam removal and fish passage upgrades." First Annual University of Maine Freshwater Science Symposium, University of Maine, Orono. January 29.

Izzo, L., G. Maynard., and J. Zydlewski. 2015. "Adult Atlantic salmon telemetry study, 2014." Atlantic Salmon Recovery Working Group, NOAA Maine Field Station, Orono, ME. February 13. INVITED.

Loftin, C.S., W. Sutton, P. deMaynadier, K. Barrett, A.T. Moody, and P. Nanjappa. 2015. "Identifying Proposed Priority Amphibian and Reptile Conservation Areas (PARCAs) in the Northeastern United States." Presentation at the 2015 Annual Meeting of the Society for the Study of Amphibians and Reptiles, Lawrence, KS. July 28-August 3. INVITED.

Maynard, G. and J. Zydlewski. 2015. "Size selection of adult Atlantic salmon at fish passage facilities." First Annual University of Maine Freshwater Science Symposium, University of Maine, Orono. January 29.

Maynard, G., and J. Zydlewski. 2015. "Size selection of adult Atlantic salmon at fish passage facilities." Annual meeting of the Maine Cooperative Fish and Wildlife Research Unit, University of Maine, Orono. March 25.

McGreavy, B., A.J.K. Calhoun, V. Levesque, and J. Jansujwicz. 2015. "Citizen science and natural resource governance: applying a resilience framework to vernal pool policy innovation." Maine Water Conference, Augusta, ME. March 31.

O'Malley, A, and J. Zydlewski. 2014. "Assessment of a hatchery based rainbow smelt supplementation effort." Maine Department of Inland Fisheries and Wildlife Divisional Meeting, Bangor ME. INVITED. December 1.

O'Malley, A. and J. Zydlewski. 2015. "Assessment of a hatchery based rainbow smelt supplementation effort." Annual meeting of the Maine Cooperative Fish and Wildlife Research Unit, University of Maine, Orono. March 25.

O'Malley, A. and J. Zydlewski. 2015. "Assessment of a hatchery based rainbow smelt supplementation effort." Maine Department of Inland Fisheries and Wildlife Baitfish Working Group, Bangor ME. April 15. INVITED.

O'Malley, A. and J. Zydlewski. 2015. "Distribution and Abundance of zooplankton and larval fish in several small Maine lakes." First Annual University of Maine Freshwater Science Symposium, University of Maine, Orono ME. January 29.

O'Malley, A. and J. Zydlewski. 2015. "Distribution and abundance of zooplankton and larval fish in several small Maine lakes." Annual meeting of the Maine Cooperative Fish and Wildlife Research Unit, University of Maine, Orono. March 25.

Rolek, B., C. Loftin, D. Harrison, P. Wood. 2015. "Bay-breasted Warbler abundance and associations with forest management and vegetation in northern New England coniferous forests." Presentation at the Joint meeting of the Association of Field Ornithologists, Society of Canadian Ornithologists, and the Wilson Ornithological Society, Wolfville, Nova Scotia, Canada. July 15-19.

Rolek, B.W., C.S. Loftin, D. Harrison, and P.B. Wood. 2015. "Effects of forest management on avian abundance in spruce-fir forests of New England." Maine Cooperative Fish and Wildlife Research Unit's Annual Coordinating Committee Meeting, Wells Common, Orono, ME. March 25.

Rolek, B.W., C.S. Loftin, D. Harrison, and P.B. Wood. 2015. "Effects of forest management on avian abundance in spruce-fir forests of New England." Poster. Maine Cooperative Fish and Wildlife Research Unit's Annual Coordinating Committee Meeting, Wells Common, Orono, ME. March 25.

Schilling, E.G., R.G. Butler, P.G. deMaynadier, and C.S. Loftin. 2015. "Predation structured Odonata assemblages in fishless, Salmonid, and Centrarchid ponds in Maine." Presentation at the annual meeting of the Society of Freshwater Science, Milwaukee, WI. 17-22 May.

Shaidani, N., M. Kinnison, and C.S. Loftin. 2015. "The biogeographic origins and population structure of Maine's island red-backed salamanders (*Plethodon cinereus*)." Maine Cooperative Fish and Wildlife Research Unit, Annual Coordinating Committee Meeting, Wells Conference Center, Orono, ME. March 25.

Shaidani, N., M. Kinnison, and C.S. Loftin. 2015. "The biogeographic origins and population structure of Maine's island red-backed salamanders (*Plethodon cinereus*)." Poster. Maine Cooperative Fish and Wildlife Research Unit, Annual Coordinating Committee Meeting, Wells Conference Center, Orono, ME. March 25.

Shaidani, N., M.T. Kinnison, C.S. Loftin, L. Welch, B. Connery, and P. deMaynadier. 2015. "The biogeographic origins and population structure of Maine's island red-backed salamanders (*Plethodon cinereus*)." Seventy first Annual Northeast Fish and Wildlife Conference, Newport, RI. April 19-21.

Stich, D. and J. Zydlewski. 2015. "Modeling effects of dam passage performance standards on American shad populations." First Annual University of Maine Freshwater Science Symposium, University of Maine, Orono. January 29.

Stich, D. and J. Zydlewski. 2015. "Modeling effects of dam passage performance standards on American shad populations." Annual meeting of the Maine Cooperative Fish and Wildlife Research Unit, University of Maine, Orono. March 25.

Stich, D., M. Bailey, M. Kinnison, J. Kocik, G. Zydlewski, and J. Zydlewski. 2015. "Atlantic salmon smolt survival during freshwater and estuary migrations." Annual meeting of the Maine Cooperative Fish and Wildlife Research Unit, University of Maine, Orono. March 25.

Sutton, W.B., K. Barrett, A.T. Moody, C .Loftin, P. deMaynadier, P. Nanjappa. 2014. "Determining vulnerability of priority amphibian and reptile conservation areas to climate change in the northeastern United States." Presentation at The

Wildlife Society Annual Conference, Pittsburgh, PA. October 25-30.

Sutton, W.B., K. Barrett, A.T. Moody, C .Loftin, P. deMaynadier, P. Nanjappa. 2015. "Determining vulnerability of priority amphibian and reptile conservation areas to climate change in the northeastern United States." Presentation at the 2015 Annual Meeting of the Society for the Study of Amphibians and Reptiles, Lawrence, KS. July 28—August 3. INVITED.

Watson, J., S. Coghlan, Jr., J. Zydlewski, D. Hayes, and I. Kiraly. 2015. "Fish community changes associated with dam removal in the Penobscot River, Maine." First Annual University of Maine Freshwater Science Symposium, University of Maine, Orono. January 29.

Watson, J., S. Coghlan, Jr., J. Zydlewski., D. Hayes, and I. Kiraly. 2015. "Fish community changes associated with dam removal in the Penobscot River, Maine." The University of Maine Graduate Research Exposition. Orono, ME. April 2.

Watson, J., S. Coghlan, Jr., J. Zydlewski., D. Hayes, and I. Kiraly. 2015. "Fish community changes associated with dam removal in the Penobscot River, Maine." Annual meeting of the Maine Cooperative Fish and Wildlife Research Unit, University of Maine, Orono. March 25.

Weaver, D., S. Coghlan, Jr., and J. Zydlewski. 2015. "Anadromous sea lamprey influence stream nutrients and primary productivity." First Annual University of Maine Freshwater Science Symposium, University of Maine, Orono. January 29.

Weaver, D.M., S.M. Coghlan Jr., and J. Zydlewski. 2015. "Anadromous sea lamprey influence stream nutrients and primary productivity." Annual meeting of the Maine Cooperative Fish and Wildlife Research Unit, University of Maine, Orono. March 25.

PUBLIC TALKS PRESENTED

Calhoun, A.J.K. 2015. "Local initiatives for conserving small natural features on private lands: vernal pools in Maine." Cathance River Educations Association, Topsham, ME. 31 March.

Calhoun, A.J.K. and E. Hertz. 2015. "The vernal pool Special Area Management Plan." Brunswick Topsham Landtrust, Topsham, Maine. 20 May.

Harrison, D. 2015. "Eastern coyotes and wolves: their history, origin, and ecology in the northeastern U.S." Invited presentation at the Maine State Museum, Augusta, April 8.

Hoffmann, K.E. 2015. "Outsmarting salamanders: collaboration with Upward Bound Math Science from a researcher's perspective." Maine Education Opportunities Association, 32nd Annual Conference, Orono, ME. 6 January.

WORKSHOPS, NEWSPAPER, RADIO, TELEVISION INTERVIEWS/ARTICLES, AND OUTREACH

Calhoun, A.J.K. 2014. "Use of surrogates in aquatic ecosystems." Workshop on surrogacy and indicators, Brisbane, AU. October 1.

AWARDS

Calhoun, A.J.K. 2015. University of Rhode Island Distinguished Scholar for the Ledermann Lecture in Natural History and Conservation Biology. Kinston, RI. April 17.