Annual Report to Cooperators

Idaho Cooperative Fish and Wildlife Research Unit

1 July 2009 to 30 September 2010

Photo details
Top: Left to right Jessica Buelow, Kala Hamilton, Bryan Jones and Will Schrader sampling at Lower Granite Dam, photo by Zach Penney.

Middle: Kelly Stockton and REU intern Brittany Winston installing instruments at Dworshak National Fish Hatchery, photo by Tim Allan

Bottom: Sonoran pronghorn. Photo courtesy of the National Park Service

Cover Photos: (Left: Bryan Jones with steelhead at Fish Creek weir; photo by Jeff Grote. Right: Jeremy Baumgardt and assistant radio marking a male sage grouse, photo by Lisa Cross.

REPORT TO COOPERATORS
1 July 2009 — 30 September 2010

IDAHO COOPERATIVE FISH AND WILDLIFE RESEARCH UNIT

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IDAHO DEPARTMENT OF FISH AND GAME
UNIVERSITY OF IDAHO
U.S. GEOLOGICAL SURVEY
U.S. FISH AND WILDLIFE SERVICE
WILDLIFE MANAGEMENT INSTITUTE

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Introduction

Idaho Cooperative Fish and Wildlife Research Unit
A cooperative research and educational program of
U.S. GEOLOGICAL SURVEY
IDAHO DEPARTMENT OF FISH AND GAME
UNIVERSITY OF IDAHO
WILDLIFE MANAGEMENT INSTITUTE
U.S. FISH AND WILDLIFE SERVICE

HISTORY OF COOPERATIVE RESEARCH UNITS

The Cooperative Fish and Wildlife Research Unit Program was established in 1935 in the U.S. Fish and Wildlife Service in response to a recognized need for trained biologists and increased scientific analysis and skills in fish and wildlife management. In 1960, the Unit Program was formally sanctioned with the enactment of the Cooperative Units Act (PL 86-686). The resulting partnership that developed among federal and state resource agencies, the Land Grant Universities of the nation, and private entities evolved into a well-respected nationwide program. Beginning in 1984, wildlife and fishery units were combined into cooperative fish and wildlife research units. The Unit Program operated as part of the U.S. Fish and Wildlife Service until November 1993, when the program was moved into the National Biological Survey, established by a Secretarial Order under the FY 1994 Interior Appropriations Act. In October 1996, the Units Program was moved into the U.S. Geological Survey. Today, there are 44 Cooperative Research Units in 40 States. These units contain more than 160 Ph.D. scientists who oversee as many as 600 graduate students per year. Staff in the Cooperative Research Units conduct research on renewable natural resource questions; participate in the education of graduate students destined to become natural resource scientists; provide technical assistance and consultation to parties who have legitimate interests in natural resource issues; and provide various forms of continuing education for natural resource professionals.

The Idaho Cooperative Wildlife Research Unit was established at the University of Idaho September 20, 1947, and the Idaho Cooperative Fishery Research Unit was established in 1963. The two units were combined into the Idaho Cooperative Fish and Wildlife Research Unit in 1985. The Unit is housed in the Department of Fish and Wildlife Resources in the College of Natural Resources at the University of Idaho. The Unit is staffed, supported, and coordinated by the United States Geological Survey, the Idaho Department of Fish and Game, the University of Idaho, the Wildlife Management Institute, and the U.S. Fish and Wildlife Service.

The Unit works toward conducting research on fish and wildlife problems of state, regional, and international interest; training graduate students for careers in the fish and wildlife professions; and providing technical assistance to state and federal managers and researchers.

The Unit emphasizes research to help find solutions to problems affecting the fish and wildlife resources of Idaho, the Pacific Northwest, and elsewhere. Special areas of focus include: studies of anadromous fish passage in the Snake River basin; evaluation of methods to enhance fish health of hatchery reared fish; developing methods of establishing new animal populations

or augment existing populations; improving estimators of animal abundance, determining the effectiveness of existing reserve and management areas; developing methods to assess and control the effects of invasive aquatic species; evaluating the effectiveness of efforts to recover or prevent listing of endangered species; and evaluating factors that regulate the carrying capacity of freshwater and terrestrial ecosystems.

Idaho Unit Federal Scientists, Research, Expertise, and Interests

Unit personnel maintain close working and professional relationships with the University of Idaho faculty, Idaho Department of Fish and Game, and U.S. Fish and Wildlife Service personnel. Research studies are conducted with a focus on Idaho in the Pacific and Intermountain West, but include various locations and geographic scales.

Unit research is directly supported through Idaho Department of Fish and Game, and by contracts to the University from the U.S. Geological Survey, U.S. Fish and Wildlife Service, U.S. Army Corps of Engineers, U.S. Forest Service, Bonneville Power Administration, Northwest Power Planning Council, other federal, state, tribal and private agencies. In addition to mentoring graduate students engaged in this research, Unit personnel teach graduate-level courses, serve actively in the university community, and participate in a variety of professional activities.

J. Michael Scott, Ph.D. – Unit Leader and Professor of Wildlife Resources. Recent research activities include studies on: reserve identification, selection, and design in North America; the use of translocation as a tool for establishing or augmenting animal populations; predicting species occurrences; recovery of endangered species; and development of tools to facilitate the transfer of information at the science policy interface. Areas of interest include animal ecology and conservation biology. Specialty course: WLF 515 – Advanced Topics in Conservation Biology.

Christine M. Moffitt, Ph.D. – Assistant Unit Leader and Professor of Fishery Resources. Recent research activities include studies of steelhead physiology; temperature effects on fish physiology and health; assessing risks of aquatic invasive species; interactions between cultured and wild fish; evaluating the sustainability and risks of aquaculture systems; and fisheries history. Specialty courses: FISH 510, Advanced Fisheries Management; FISH 511 Fish Physiology; FISH/WLF 501, Graduate Seminar.

Michael C. Quist, Ph.D.

In July 2010, we added Dr. Michael C. Quist as an assistant Unit leader in fisheries, filling a position left open since the retirement of Jim Congleton. Quist was hired from Iowa State University, where he was assistant professor in the Department of Natural Resource Ecology & Management. Quist is not new to Idaho and the Pacific Northwest. He graduated from University of Idaho with a B.S. in Fisheries in 1996, and was raised in western Washington.

Quist's research interests focus on answering questions directly applicable to fisheries management and he is interested in all aspects of applied fisheries research and management. His focus includes understanding the relative importance of abiotic characteristics and biotic interactions in regulating fish population dynamics; identifying factors regulating the structure and function of fish assemblages across multiple spatial and temporal scales; and developing and evaluating techniques (i.e., field, age and growth analysis, data summarization and analysis) that allow managers to more effectively and efficiently evaluate fish populations.

Mike has already started projects in collaboration with Idaho Department of Fish and Game (pp 23 in this report).

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Kath Strickler, Ph.D.
Kala Hamilton
Andrew Pape
Boling Sun
Gina Wilson

Fish and Wildlife Departmental Administrative Staff

Carrie Barron
Linda Kisha

Department of Fish and Wildlife Faculty, Emeriti, and other Faculty Cooperators with Unit Projects in 2009-2010

* indicates Unit Project in 2009-2010

Cort Anderson, Research Assistant Professor
David H. Bennett, Emeritus Professor
*Kenneth Cain, Assistant Professor
James L. Congleton, Emeritus Professor
*Christopher Caudill, Research Assistant Professor
Brian Dennis, Professor
Michael Falter, Emeritus Professor
Alex Fremier, Assistant Professor
*E. O. (Oz) Garton, Professor
*Dale Goble, Professor of Law
*Kathleen (Katy) Kavanagh
*Brian Kennedy, Assistant Professor
James Peek, Emeritus Professor
*Madison "Matt" Powell, Adjunct Assistant Professor
*Janet Rachlow, Assistant Professor
*Kerry Paul Reese, Professor and Department Head
*Dennis Scarnecchia, Professor
Kerri Vierling, Assistant Professor
Lee Vierling, Assistant Professor
*Lisette P.Waits, Associate Professor
*Frank Wilhelm, Assistant Professor

Graduate Students Advised by Fish and Wildlife Resources Faculty, 2009-2010

* indicates Unit Affiliated Project in 2009-2010

Student	Discipline	Adviser
Stephen Abele	M.S. Wildlife Resources	E.O. Garton
Patrick Adam	Ph.D. Wildlife Resources	K. Vierling/L. Vierling
Neil Ashton	M.S. Fishery Resources	K. Cain
*Jocelyn Aycrigg	Ph.D. Natural Resources	E.O. Garton
*James Barron	M.S. Fishery Resources	K. Cain
*Jeremy Baumgardt	Ph.D. Natural Resources	K. P. Reese
*Peter Bloom	Ph.D. Natural Resources	J.M. Scott
*Justin Bohling	Ph.D. Natural Resources	L. Waits
*Samuel Bourret	M.S. Fishery Resources	B. Kennedy, C. Caudill
*Jessica Buelow	M.S. Fishery Resources	C. M. Moffitt

David Burbank	M.S. Fishery Resources	K. Cain
*Lubia Cajas Cano	Ph. D. Environmental Science	C.M. Moffitt
*Timothy Caldwell	M.S. Fisheries Resources	F. Wilhelm
Marcie Carter	M.S. Wildlife Resources	K. Vierling
Katherine Cleary	Ph.D. Natural Resources	L. Waits
Dawn Davis	Ph.D. Wildlife Resources	K. P. Reese
Rita Dixon	Ph.D. Wildlife Resources	E. O. Garton
Ethan Ellsworth	Ph.D. Wildlife Resources	Dennis Murray
John Erhardt	M.S. Fishery Resources	D. Scarnecchia
Natalia Estrada	Ph.D. Natural Resources	A. Fremier
*Trevor Fox	M.S. Wildlife Resources	J. Ratti
*Gifford Gillette	Ph.D. Wildlife Resources	K. P. Reese
*Caren Goldberg	Ph.D. Natural Resources	Lisette Waits
Shaun Grassel	Ph.D. Wildlife Resources	J. Rachlow
Ellen Hamann	M.S. Environmental Science	B. Kennedy
Theodore Harris	M.S. Fishery Resources	F. Wilhelm
*Richard Hartman	M.S. Fishery Resources	B. Kennedy
*Benjamin Ho	M.S. Fishery Resources	C. Caudill
*Dean Holecek	M.S. Fishery Resources	D. Scarnecchia
Harry Jageman	Ph.D. Wildlife Resources	E. O. Garton
Tarah Johnson	M.S. Fishery Resources	K. Cain
*Bryan Jones	M.S. Fishery Resources	C. M. Moffitt
*Tim Kiser	M.S. Fishery Resources	B. Kennedy
Karoline Lambert	M.S. Wildlife Resources	Anderson
Bill Leacock	Ph.D. Wildlife Resources	L. Waits
Meghan Leiper	M.S. Wildlife Resources	J. L. Rachlow
*Jesse Lewis	M.S. Wildlife Resources	J.L. Rachlow
*Jeff Lonneker	MS Forest Resources	P. Gessler
Teresa Lorenz	Ph.D. Wildlife Resources	K. Vierling
Jeffrey Manning	Ph.D. Wildlife Resources	E. O. Garton
Brian McIlraith	M.S. Fishery Resources	B. Kennedy, C. Caudill
Matthew Mumma	M.S. Wildlife Resources	L. Waits
Jessica Murray Pollock	M.S. Environmental Science	K. Vierling
*Marius Myrvold	PhD. Water Resources	B. Kennedy, C. Caudill
Daniel Nelson	M.S. Fishery Resources	F. Wilhelm
*Christopher Noyes	M.S. Fishery Resources	C. Caudill
*Zachary Penney	PhD. Natural Resources	C. M. Moffitt
*John Plumb	PhD Natural Resources	C. M. Moffitt
Mark Polinski	M.S. Fishery Resources	K. Cain
Amanda Price	M.S. Wildlife Resources	J. L. Rachlow
Scott Putnam	M.S. Fishery Resources	D. Scarnecchia
Jeffrey Reader	Ph.D. Water Resources	B. Kennedy
*Paul Reyes	M.S. Geography	C. M. Moffitt
Thomas Roadhouse	Ph.D. Wildlife Resources	K. Vierling/ Wright
*Adrienne Roumasset	M.S. Fishery Resources	C. Caudill
*David Rupp	M.S. Environmental Science	J.M. Scott

Joel Sauder	Ph.D. Wildlife Resources	J. L. Rachlow
*Jan Schipper	Ph.D. Natural Resources	J. M. Scott
*Timothy Smyser	M.S. Wildlife Resources	E.O. Garton
Mathew Sorum	M.S. Wildlife Resources	J.L. Rachlow
*Carisa Stansbury	M. S. Environmental Science	L. Waits
Jennifer Stenglien	M.S. Environmental Science	L. Waits
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*John Stephenson	M.S. Wildlife Resources	K.P. Reese
*Bryan Stevens	MS. Wildlife Resources	K. P. Reese
*Kelly Stockton	M.S. Fishery Resources	C. M. Moffitt
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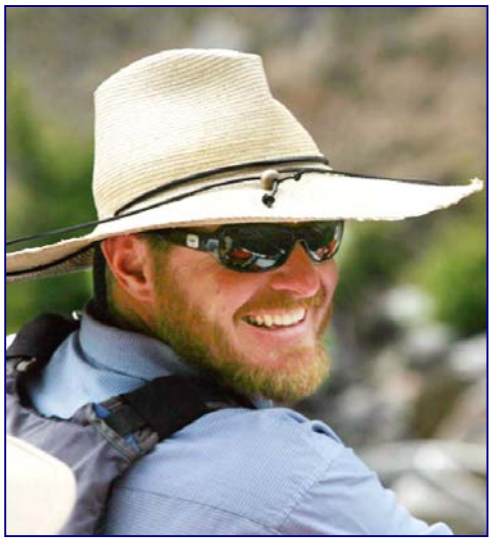
Chau Tran	M.S. Water Resources	B. Kennedy
Paulina Viteri	Ph.D. Wildlife Resources	L. Waits
Jody Vogeler	M.S. Wildlife Resources	K. Vierling
*Trevor Watson	M.S. Environmental Science	D. Scarnecchia
*Dana Weigel	Ph.D. Natural Resources	M. Powell
Adam Wells	Ph.D. Wildlife Resources	J. Rachlow/ E.O. Garton
Lief Wiechman	M.S. Wildlife Resources	K.P. Reese
Ann Winters	M.S. Wildlife Resources	E.O. Garton
Bonnie Woods	M.S. Wildlife Resources	J. L. Rachlow
*Don Zaroban	Ph.D. Natural Resources	J. M. Scott

IN MEMORIAM

Danielle Schiff
BS 1995; MS 2004

Larry Barrett
B.S. 1995

Larry Barrett and Danielle (Dani) Schiff, Biologists with Idaho Department of Fish and Game, were graduates of the University of Idaho Fisheries Resources Program. Both Larry and Dani were actively engaged with faculty, staff, and students. They gave of their time and enthusiasm to mentor countless young professionals over decades. They will be missed, and their legacy lives on.



Telly Evans
BS 2009

As a guide with his river family at Rocky Mountain River Tours on the Middle Fork of the Salmon, Telly provided interpretive presentations about Idaho's anadromous fish and nature, sharing his passion, stories and knowledge. Telly also worked in various capacities for the Idaho Fish and Game Department and with University of Idaho on chinook and lamprey migration studies.

Current Projects – Fisheries and Aquatic Resources

Development and Evaluation of Extensive Larval and Juvenile Rearing Techniques and Systems for Burbot (*Lota lota maculosa*) to Meet Conservation Aquaculture Needs

Principal Investigator:	Kenneth D. Cain, Ph.D.
Student Investigator:	James Barron
Research Technician:	Nathan Jensen
Funding Agency:	USGS – RWO 135
Collaborator:	U.S. Fish and Wildlife Service
Completion Date:	30 December 2010

Objectives

- Determine growth, condition, and survival of Kootenai River burbot reared from larval to juvenile life stages in replicated extensive (outdoor pond/tank) rearing systems.
- Evaluate existing natural ponds and potential pond sites at the Kootenai National Wildlife Refuge and other sites in Boundary County, Idaho (or elsewhere) for further developing and testing extensive rearing requirements for burbot.
- Determine optimum hatchery rearing temperature and density for maximum growth of burbot fed commercial diets.
- Test various commercial diet formulations for use in burbot culture.
- Integrate data from this project with previous research to develop a draft "Burbot Hatchery Manual"

Progress

This project was initiated in June of 2008. The overall project goal is to improve survival of burbot from larval to juvenile life stages and investigate "natural" rearing options that may better meet conservation aquaculture needs for this species. Demographic analysis in 2004 of the Lower Kootenai River burbot *Lota lota maculosa* population indicated that approximately 50 fish currently remain. A series of factors appear responsible for the collapse of riverine burbot populations in the Kootenai/y Basin, including: habitat alteration and loss (increased winter discharge and winter water temperatures, reduced primary and secondary productivity, hydro impoundment and operations, and Kootenay Lake flood control), harvest, reduction in mysid availability, and resulting ecological community composition shifts. Rather than listing burbot as threatened or endangered under the Endangered Species Act (ESA), the Kootenai Valley Resource Initiative Burbot Committee, along with the US Fish and Wildlife Service and additional committed stakeholders, contributed to a Conservation Strategy. The committee proposed the Kootenai River drainage as a "pilot project" to develop, implement, and evaluate this Conservation Strategy for Lower Kootenai River Burbot, in lieu of formal ESA listing. It is this multi-faceted international focus and commitment, and consistency with the proposed federal "Policy for Evaluating Conservation Efforts" (PECE Policy; U.S. Vol. 65 No. 114, June 13, 2000) that empowers this Conservation Strategy. The goal of this Conservation Strategy is to restore and maintain a viable and ultimately harvestable burbot population in the Kootenai River and in the south arm of Kootenay Lake through habitat restoration and conservation aquaculture efforts. The need to investigate the potential of rearing burbot larvae under

"natural" conditions has been identified as essential. This rearing method may simplify or improve our ability to rear this species for conservation aquaculture efforts. This study is being conducted as a graduate student (M.S.) project and contributes to ongoing burbot culture research at the University of Idaho's Aquaculture Research Institute (UI-ARI). Research on intensive burbot culture has been conducted at the UI-ARI since 2004. This project addresses important questions for future development of a conservation aquaculture facility. If extensive pond rearing of burbot is feasible and cost-effective, then facility design plans must incorporate pond construction. Temperature, growth, and feed requirements will also be important when considering water and tank needs.

In 2008, a preliminary investigation to address when burbot should be stocked into semi-intensive culture systems was conducted. The semi-intensive culture strategy shares many similarities to extensive culture with the addition of aeration. Juveniles were observed 109 days after release in the last stocking treatment, which consisted of larvae stocked after a 45 day period post first feeding under intensive conditions. Treatments where larvae were stocked earlier showed no survival. In 2009, semi-intensive culture systems at the UI-ARI were treated with varying stocking densities. Burbot were stocked based on the previous year's findings after 45 days on live feeds under intensive culture. Juvenile burbot survived in all treatments 65 days post stocking. Survival showed a decline as stocking densities increased. In 2010, the density study from 2009 was repeated using the same methods. After 65 days of semi-intensive culture, survival was observed in all tanks, and once again survival decreased with increased stocking density.

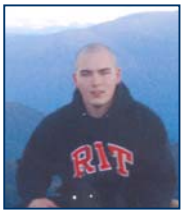
An additional experiment was conducted starting in June of 2009 to optimize culture temperature for larval burbot under intensive conditions. Trial one used larval burbot reared at three temperature treatments:10, 15 and 20°C for 30 days. Burbot larvae grew faster in warmer water; however, survival was diminished in higher temperatures. Cannibalism rates were elevated in higher temperatures, which lead to reduced survival. Trial two was conducted in July with slightly larger burbot than those used in trial one. Treatments were once again 10, 15, and 20°C for 30 days. Growth accelerated and survival declined with increased temperature. Cannibalism was high in all temperature treatments claiming over 50% of the population in all treatments by the end of the trial. Trial three was conducted in the fall of 2009 with dry feed transitioned juvenile burbot. Treatments were 10, 15 and 20°C for 60 days. Growth was fastest in the 15 and 20°C treatments. Survival was high in all treatments, over 90% over 60 days. Cannibalism was found to be low to non-existent at this stage.

Due to high cannibalism rates seen in the first two temperature optimization experiments in 2009, a follow-up study was conducted to find a method for reducing cannibalism. In the summer of 2010, a grading strategy was developed and tested. The grading strategy used a mesh box with square holes measuring 2.0 X 2.0 mm to passively separate a population into two groups based on fish body width. This strategy was tested when burbot larvae averaging 12 mm in total length and 2.3 mm in width began to exhibit cannibalism. The two groups separated by the grader were monitored for 15 days along with an ungraded control population. The grader effectively separated burbot larvae by width, resulting in differences in mean width between treatment groups. Over 15-day trial, the graded populations showed improved survival due to reduced cannibalism. Mean survival was increased from 59% on average in the control

to 74% and 93% in the low and high grade treatments, respectively. This gain in survival was supported by a decrease in the proportion of fish cannibalized from 29% on average in the control to 14% and 1% in the low and high grade treatments, respectively. The grading strategy was tested again with burbot averaging 21 mm in total length and 3.8 mm in width. This population was about to undergo a transition to dry feed, which typically results in high mortality. A larger mesh size (3.0 by 3.5 mm) was used on the grader box. Again, a 15-day study was conducted to monitor the low and high grade populations along with an ungraded control. The feeding regime during the 15-day trial included co-feeding live *artemia* and dry feed for 8 days followed by 7 days of solely dry feed. At this stage the grading strategy did not create a significant change in mean body width. Grading in this instance did not significantly reduce cannibalism or increase survival over 15 days.

This project provides new insight into several aspects of burbot conservation aquaculture. Basic methods for conducting semi-intensive/extensive culture of burbot have been successfully developed and will be critical in the development and operation of a future conservation aquaculture facility. Temperature optimization trials provide the burbot culturist guidance to make informed decisions when selecting culture temperatures, along with baseline data for predicting and comparing growth performance. The grading technique developed in this project provides an effective and applicable method for reducing cannibalism. Reporting of this work in manuscript form is underway.

IMPROVING ADULT PACIFIC LAMPREY PASSAGE AND SURVIVAL AT LOWER COLUMBIA RIVER DAMS



Principal Investigator:	Christopher Caudill, Ph.D.
Student Investigators:	Benjamin Ho
	Christopher Noyes
Collaborator:	Mary Moser, NOAA-Fisheries
	US Army Corps of Engineers
	Portland District
Funding Agency:	USGS – RWO 140 & RWO 146
Completion Date:	30 June 2011

Objective

- Develop and evaluate aids to passage and survival of adult Pacific lamprey (*Lampetra tridentata*) at lower Columbia River dams.

Progress

We are evaluating a major new modification to a fishway entrance at Bonneville Dam designed to improve passage of adult Pacific lamprey, simultaneously evaluate the effects of improved fishway operations, and monitor general passage behavior and success over the large lower Columbia River dams. We tagged lamprey with radio transmitters and half duplex (HDX) passive integrated transponder (PIT) tags and monitored their passage at Bonneville, The Dalles, John Day, McNary, Ice Harbor, and Priest Rapids dams, including use of Lamprey Passage Structures (LPS). Our aims were to calculate lamprey passage times, estimate escapement past the monitored sites, and evaluate potential correlates with lamprey escapement and behaviors through the study reaches. In 2009, we radio-tagged 596 lampreys and HDX-

PIT tagged 368 lampreys. Declining population size precluded responsible collection of the target HDX-PIT sample size (1,000). Escapement estimates from release below Bonneville Dam to top-of-ladder antennas were 33-47% depending on location and telemetry method, and were generally consistent with past monitoring results. Higher escapement estimates by HDX-PIT tagged fish, compared to radio-tagged fish, were consistent with results from a similar study in 2007-2008 and suggest that radio tagging and associated handling may negatively affect adult performance. This suggests a trade-off between tagging effects and the collection of high resolution, fine-scale data provided by the active radio tag telemetry system. Data from experimental, large HDX-PIT antennas in the modified entrance indicated that lamprey used the new entrance structure and telemetry results as a whole indicated slight improvements in passage conditions. We used the telemetry data to evaluate modified operation at Bonneville Dam in 2009. Lamprey primarily pass at night while salmonids pass primarily during daylight hours. A modified fishway operation providing lowered fishway entrance velocities was implemented using a modified block design during 2007and improved adult lamprey passage. The experiment was repeated in 2009 at Bonneville Dam, and the results indicated improved passage rates during the lowered velocity treatment. The operation was fully implemented in 2010.

We conclude that the combined radio telemetry and PIT-tag results provide complimentary data that can be used to inform adult lamprey management actions across a variety of scales. Data are being in collaboration with USACE to guide design, construction, and evaluation of additional, extensive lamprey-specific modifications at another highly used Bonneville Dam fishway entrance. Entrance modifications will occur during winter 2010-2011 before the onset of the 2011 run season.

EVALUATION OF ADULT SALMON AND STEELHEAD DELAY AND FALLBACK AT SNAKE AND COLUMBIA RIVER DAMS

Principal Investigator:	Christopher Caudill, Ph.D.
Student Investigator:	Christopher Noyes
Funding Agency:	USGS - RWO 141 & RWO 145
Collaborator:	Brian Burke, NOAA-Fisheries
	U.S. Army Corps of Engineers
	Portland District
Completion Date:	30 June 2011

Objectives:

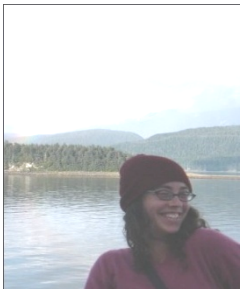
- Evaluate effects of modified Bonneville Dam Cascade Island entrance on the passage (e.g. passage times, entrance use and efficiency, etc.) of radio-tagged spring Chinook salmon.

Progress:

In an effort to improve passage of Pacific lamprey, the U.S. Army Corps of Engineers (USACE) installed a prototype fishway entrance at one ladder at Bonneville Dam (the first dam anadromous fishes encounter during upstream migration) on the Columbia River during winter 2008-2009. Since the changes may affect behavior and passage success of ESA-listed adult

salmonids, a radio telemetry study of spring Chinook salmon is underway. In spring and early summer 2009, 598 Chinook salmon were radio tagged and released below Bonneville Dam and their behavior was monitored. We detected evidence of slowed passage during early spring compared to years prior to the modification. A second year of the study was conducted in 2010 with the release of 599 radio-tagged adult Chinook salmon. Additional objectives in 2010 were to evaluate adult upstream migration at The Dalles Dam after construction of a large wall in the tailrace designed to improve juvenile salmon downstream migration, and to evaluate behavior of adult Chinook salmon through a reconstructed section of a fish ladder at John Day Dam. Final results will guide USACE and regional fish managers as further improvements for lamprey passage are designed and implemented in the lower Columbia River.

CONDITION AND SPAWNING SUCCESS OF ADULT SPRING CHINOOK IN THE WILLAMETTE RIVER



Principal Investigator:	Christopher Caudill
Student Investigator	Adrienne Roumasset
Collaborators:	Carl Schreck (USGS/OSU)
	& Michael Kent (OSU)
	U.S. Army Corps of Engineers
Funding Agency:	USGS - RWO 142 & RWO 147
Closing Date:	30 June 2011

Objectives

- Determine the factors affecting fate and spawning success in UWR spring Chinook salmon specifically focusing on prespawning mortality.
- Determine initial energetic condition and general fish traits (size, sex, etc.).
- Determine pathogen/parasite loads and development of disease during migration and spawning.
- Determine temperature history, collection and holding regime, and interactions among factors, e.g., disease development at high temperatures.

Progress:

In recent years, high percentages (80-90%) of adult Chinook salmon transported above dams in some Willamette River tributaries have died prior to spawning. In 2008 and 2009 we surveyed the energetic status and survival rates of two populations of Willamette River spring Chinook salmon, monitored river environmental conditions, and investigated the relationships among prespawning mortality and a suite of potential causative factors including assessment of disease.

We sampled a total of 395 Chinook salmon at Fall Creek, including 195 in 2008 and 200 in 2009. Fish were collected, assessed for energetic condition, PIT-tagged and/or radio-tagged, and then transported above the dam and allowed to spawn naturally. In 2008, a total of 32 PIT-tagged Chinook salmon were recovered from spawning ground surveys on Fall Creek, a recapture rate of 16.4%. Three (9.4%) of the recovered fish were prespawn mortalities and there were no clear relationships between mortality, initial energetic state, or fish morphometry

in this small prespawn mortality sample. Notably, water temperatures in Fall Creek were uncharacteristically low and discharge rates were high in 2008, which may explain the relatively high survival rates. In 2009, prespawn mortality estimates were 84.8% for PIT-tagged fish and 89.5% for radio-tagged fish. River temperatures in 2009 were high (>25° C) at the outplant release site in late July. Prespawn mortality in 2009 was associated with rising temperatures and was significantly related to overall physical condition of adult Chinook salmon at the time of tagging.

Tagged fish were outplanted into the North Fork Middle Fork (NFMF) Willamette River, Oregon (N = 239). To assess the effects of holding fish on prespawn mortality, the 2009 sample was separated into two groups: fish immediately outplanted and fish held at Willamette Hatchery prior to outplanting in late summer. Overall prespawn mortality of NFMF outplants was estimated to be 27% for radio-tagged fish and 40% for PIT-tagged fish in 2009. Carcass recovery rates from the NFMF were low in 2009, precluding statistical analysis of holding effects. However, observational data suggested that holding fish in the hatchery may reduce prespawn mortality and we recommend further evaluation of this potential management strategy. Differences in prespawn mortality between Fall Creek and the NFMF release groups in 2009 were attributed to differences in thermal regimes and outplant release dates.

Results from disease screening of adults collected during spawning surveys revealed that all of the fish examined had one or more of the following conditions that were, at least in part, responsible for death: swelling or hemorrhaging of internal organs, external evidence of trauma, and histological evidence of severe pathogenic infection. Severe infections of five pathogens (*Ceratomyxa shasta, Nanophyetus salminocola, Apophallus* sp., *Echinochasmus milvi,* and *Parvicapsula minbicornis*) were more frequent in adults that died prior to spawning compared to adults that successfully spawned. Nearly two-thirds of the fish that died prior to spawning were severely infected with one or more of these parasites. All adults were infected.

Results of this study, in combination with previous Chinook salmon studies on the Willamette River suggest prespawn mortality is caused by an interaction of environmental factors particularly, water temperatures, fish condition and disease load, and energetic status. Multi-year sampling of adult energetic status and other condition metrics will: 1) provide insight as to the factors causing prespawn morality; 2) determine how fish condition varies from year to year in response to environmental factors; and 3)assist in developing effective management strategies to reduce prespawn mortality.

We have also completed a literature review and synthesis report on critical information gaps for adult anadromous salmonids in the Willamette basin. We are also compiling and analyzing historical screw trap data for the U.S. Army Corps of Engineers in an effort to document life history variation and run timing in outmigrating juvenile Chinook salmon past project dams.

COMPARATIVE SURVIVAL OF RESERVOIR REARED AND RESERVOIR BYPASSED SPRING CHINOOK SALMON IN THE WILLAMETTE RIVER BASIN

Principal Investigators:	Christopher Caudill, Ph.D. and Brian Kennedy, Ph.D.
Student Investigator:	Sam Bourret
Collaborators:	Lisa Borgerson (ODFW) U.S. Army Corps of Engineers Portland District
Funding Agency:	USGS – RWO 144
Closing Date:	31 May 2011

Objectives:

- Determine the degree of life history variability in three Willamette River sub basins (McKenzie, Santiam, and Middle Fork Willamette basins) by surveying juvenile growth patterns and otolith isotopic ratios from individuals collected from stream and reservoir rearing habitats. These data will also provide a baseline for interpreting scale and otolith samples collected from juveniles in downstream locations and from returning adults.
- Evaluate the variation in growth patterns and potential life histories in unmarked juvenile salmon passing Willamette Falls, including preliminary estimates of the proportion of reservoir-reared vs. river-reared types.
- Evaluate the ability of scale and otolith analyses to resolve the natal stream, juvenile rearing habitat, and ocean entry timing for adult salmon of unknown source.

Progress:

Life history variation within and among populations contributes to the production of spring Chinook salmon, and there is evidence of both stream- and reservoir-rearing by juvenile Willamette River basin spring Chinook salmon. Understanding the distribution, abundance, and relative performance of individuals rearing in the different habitats and whether distinct life history types are present in the system is important to planning recovery efforts for Willamette basin spring Chinook salmon. These efforts may include collection from tributaries and transportation of juveniles around reservoirs and dams, as well as improvements to downstream passage. Identification of the relative use of rearing locations, life history variation present in the system, and potential geochemical markers is a first step to estimating relative performance of tributary- and reservoir-reared subpopulations. Results of this work will determine if scale analyses reliably identify life history types and whether otolith microchemisty variation can be used to identify life history types and/or inter-basin straying.

The methods for all objectives will include the collection of scales and otoliths from Chinook salmon (by UI personnel) followed by visual scale reading using standard protocols by Oregon Department of Fish and Wildlife personnel, and analysis of the otoliths by UI. Otolith analyses will include quantification of growth increments and microchemical determination of isotopic ratios for elements known to record biological information (e.g., stable isotope ratios of strontium and calcium. To date, we have collected preliminary juvenile and adult fish samples from three drainages and the first of seasonal water samples for a survey of water chemistry that will help validate otolith interpretations. We anticipate the first otolith analyses will be conducted in early fall 2010, along with the collection of addition juvenile samples.

LEWISTON ORCHARDS PROJECT: SWEETWATER BASIN FISH & FLOW STUDY

Principal Investigator:	Brian Kennedy, Ph.D.
Student Investigators:	Richard Hartson and Marius Myrvold
Collaborating Agency	U.S. Bureau of Reclamation
Funding Agency:	USGS – RWO 134
Completion Date:	30 September 2012

Objectives:

- Quantify temperature and primary stream and riparian habitat features relative to flow levels in Lapwai, Webb, and Sweetwater creeks.
- Quantify spatial variation in stream productivity (macroinvertebrate abundance, community composition and diversity) relative to stream flow and temperature in Lapwai, Webb, and Sweetwater creeks.
- Quantify demographics and bioenergetics of juvenile steelhead (*Oncorhynchus mykiss*) populations and the relative impacts of hydrologic alteration.
- Quantify the effects of interspecific interactions on juvenile steelhead demographics of growth, survival and emigration.
- Evaluate juvenile and adult movement and migration behavior in Sweetwater, Lapwai and Webb creeks relative to flow operations.

Progress:

The Bureau of Reclamation owns a series of water storage reservoirs, diversion dams and canals that provide irrigation water to the Lewiston Orchards area of Lewiston, Idaho. The Lewiston Orchards Project (LOP) is operated by the Lewiston Orchards Irrigation District (LOID), which distributes the water to agricultural, urban and suburban users. Lapwai watershed provides spawning and rearing habitat for a distinct population segment of federally threatened steelhead trout *Oncorhynchus mykiss* of the Snake River basin. The LOP withdraws water from these creeks that are designated as critical habitat for this species. Importantly, the major temporal impact that water withdrawals have occur during the summer months when juvenile fish are growing before smolting and migrating to the ocean. Diversion operations can potentially leave the streams dry. Decreased flows during spring may also impact spawning of adult A-run steelhead in the basin.

Understanding the effects of hydrologic changes on fish populations requires an integrative approach that addresses: 1) how the growth potential of individual fish is affected; 2) how changes in growth and growth potential influence survival of individuals and, ultimately, how processes for the individual scale up to population level dynamics; and 3) how population dynamics are influenced by altered connections among subpopulations. These changes can be a direct result of hydrologic change or an indirect effect through altered temperatures, productivity or trophic relationships. Our study is addressing how flow alterations in the Lapwai system influence growth and survival of juvenile *O. mykiss*. We are developing integrated models for flow-foraging relationships, bioenergetics (i.e., energy gains and losses), productivity relationships, and fish movements, which collectively are designed to identify mechanistic relationships between fish performance and habitat. Harston began course work in

the fall of 2007 and has led a team of field researches over the past two summers to establish long term study sites and install PIT-tag antennas. In February 2009, Rick presented a portion of his work at the Idaho Chapter of the American Fisheries Society, entitled "Effects of an altered hydrologic regime on juvenile *Oncorhynchus mykiss* growth, survival, and emigration" and in May 2009 he traveled to Michigan to attend a special workshop on MARK survival estimation models. In the summer of 2009, Marius Myrvold began as a Ph.D. student in the Water Resources graduate program. Marius is a Norwegian student with expertise on juvenile salmon and habitat relationships. He spent his first year completing his coursework and developing a Ph.D. proposal. Richard Hartson finished his M.S. in the summer of 2010 and is preparing two manuscripts for publication. He remained on the project to ensure a successful field season in 2010 during which we expanded the temporal and spatial sampling within the basin.

LIFE CYCLE ASSESSMENT AND ECOSYSTEM SERVICES FRAMEWORK FOR SUSTAINABLE AQUACULTURE PRODUCTION

Major Professor:	Christine M. Moffitt, Ph.D.
Student Investigator	Lubia Cajas Cano
Undergraduate Interns	Joshua Peterson
	Kristy Marks
Funding Agency:	U of Idaho Multicultural Scholarship and International Programs
Completion Date:	30 August 2011

Objectives:

- Create a model to evaluate relevant environmental and socioeconomic factors involved in a life cycle of marine mussel production, and assign and obtain data using the model in an existing marine mussel production farm.
- Create a Life Cycle Assessment model to evaluate the main socioeconomic and environmental factors involved in the life cycle of marine fish production, and assign and obtain data using the model in an existing marine fish farm.
- Evaluate suitable native mussel candidates for rearing within a selected finfish aquaculture settings, and simulate the potential of integrating a marine mussel in existing marine environment settings.
- Evaluate the feasibility of raising native mussels in salmonid aquaculture settings in Idaho, simulate the benefits and estimate costs of development.

Progress:

This project focuses on creating models and tools to facilitate the evaluation of the use of human and natural resources in the life cycle of food production through aquaculture systems. These models will be easily adapted to any type of aquaculture. Research in this project includes analysis of socioeconomic and environmental costs and benefits of monocultures systems, and simulating the results in an Integrated Multi-Trophic Aquaculture systems (IMTA). The use of an IMTA may increase environmental sustainability as secondary species can use wastes and nutrients released from the target product production. Marine and

freshwater mussels are capable of filtering phosphorus, nitrogen, and other nutrients from content source water. Proper placement of mussel aquaculture systems close or within aquaculture systems can result in reduced nutrient loading, and increase community diversity through recycled nutrients. The project will using a Life Cycle Assessment (LCA) model framework to evaluate water, energy, and socioeconomic inputs and outputs associated with the production system. These tools can illustrate to regulators and policymakers the benefits of including LCA models and basic factors from socioeconomic and environmental factors to better understand and evaluate production systems for sustainability. Current work involves evaluation of the amount of water and energy used in the processing plant for marine mussel production system and the analysis of the socioeconomic factors. Included in the evaluation, are social factors of job security and safety for workers in the aquaculture farms and how the industry can provide better services to them and how this benefits sustainability.

Guidance Document To Prevent, Reduce, Eliminate or Contain New Zealand Mudsnail Infestations at Fish Propagation Facilities

Principal Investigator:	Christine M. Moffitt, Ph.D.
Collaborating Investigators:	Barnaby J. Watten, Ph.D. USGS Paul Heimowitz, Ph.D. USFWS Bryan Kenworthy, USFWS Larry Peltz, USFWS
Graduate Student:	Kelly Stockton
Undergraduate Interns	Tim Allan Brittany Winston Amber Barenberg
Funding Agency:	U.S. Fish and Wildlife Service
Completion Date:	30 May 2011

Objectives:

- Summarize and synthesize the state of knowledge on control measures.
- Evaluate completeness of data on control measures and determine areas of needed additional data.
- Provide a clear and accessible manual for hatchery biologists and managers that summarizes the state of the science, provides details on prevention and control measures and an outline of decision tools for a rapid response to new or potential infestations.

Progress:

Aquaculture facilities are at a risk of harboring invasive mollusk species, such as New Zealand mudsnails (NZMS) and zebra and quagga mussels. Federal and state regulations have required aquaculture facilities to ensure clean transport of their products by being invasive mollusk free. Managers of aquaculture facilities are interested in a biosecurity or certification program to help them assess and decontaminate their facilities. In January 2009, we presented a workshop for state, federal and private parties in collaboration with Idaho with Idaho Fish and Game to

begin communications with key managers and staff. The workshop included a summary of methods for risk analysis, monitoring and disinfection. Tools that lower the risk were described. More than 40 participants were able to learn to address hypothetical risks, and apply the tools. Demonstrations included microscopic displays of the different life stages of the NZMS and quagga mussels. A similar workshop is planned in collaboration with the US Fish and Wildlife Service and key members of the Western Regional Panel on Aquatic Invasive Species to inform personnel from other state and federal agencies about tools to assess and decontaminate facilities at risk from invasive mollusk infestations.

Laboratory studies conducted during 2009 and 2010 were conducted to determine the efficacy and safety of Virkon Aquatic, a chemical disinfectant that has the potential to be used to decontaminate aquaculture gear from invasive mollusk species. Tests with NZMS were conducted to determine the concentration and contact time needed to achieve 100% mortality at three temperatures: 8°, 15°, and 22°C. Using a 20-minute exposure in 2% Virkon Aquatic concentration results in 100% mortality of all life stages. We also tested quagga mussel adults and veligers at Willow Creek Hatchery (USFWS) to determine the effectiveness of Virkon Aquatic. We found an exposure of 10 minutes in a 0.5% concentration of Virkon Aquatic killed veligers and a 10-minute exposure in 2% Virkon Aquatic killed adult mussels. We exposed steelhead fry and fingerling to low doses of Virkon Aquatic to determine the safety limits. The lethal limits of this disinfectant depended on the amount of organic loading in the system, but application methods for gear can be derived to limit mortality of non-target fish.

We found that a bath application of Virkon was preferable to a spray application because of the variability in methods of using spray applications, and the opportunities that no contact with the chemical would be achieved. In addition, affected adult snails could release live neonates. Tests were conducted to compare efficacy of a bath disinfection of three different types of wading boots: felt, neoprene, and rubber soled. These three types of boots were infested with NZMS and then exposed to 2% Virkon Aquatic for 15, 20, and 30 minutes. We found that a bath exposure of 20 minutes effective in achieving 100% mortality on all wading boot types. Using a 3x3 factorial design, we tested the infestation rate of NZM on each of the three types of boots, and determined that the felt and neoprene wading boots attracted more snails than the rubber soled boots. We further investigated the deactivation of Virkon Aquatic by organic material and found that exposure to organic material will deactivate the disinfectant.

As part of our evaluation of tools to reduce or eliminate infestations in hatchery reared fish, we conducted several studies at Dworshak National Fish Hatchery to compare two pond designed used to rear steelhead trout. We compared a Burrow's pond system to a mixed cell raceway system. Studies included modeling hydraulic residence time of water particles with and without fish, and also modeling the removal of plastic beads that simulated particles of feed, or NZMS infested feces. The mixed-cell raceway rearing system was highly effective in removing water and simulated feces than the Burrow's pond. We suggest that use of a mixed-cell raceway system could adequately remove infested feces from the water column to make depuration of infested fish feasible.

RESEARCH, MONITORING AND EVALUATION OF EMERGING ISSUES AND MEASURES TO RECOVER THE SNAKE RIVER FALL CHINOOK SALMON ESU

Principal Investigator:	Christine M. Moffitt, Ph.D.
Student Investigators:	John Plumb
Collaborating Investigators:	William P. Connor, Ph.D. USFWS Ken Tiffan, USGS
Funding Agency:	Bonneville Power Administration
Completion Date:	31 May 2011

Objectives:

- Determine if the progression of wild fall Chinook salmon life history events is changing over time due to biological or physical alterations in the environment.
- Analyze the fork length, weight and morphology of PIT tagged wild fall Chinook salmon subyearings, and determine densities in fish rearing areas.
- Determine if the joint probability of active migration and survival to the tailrace of Lower Granite Dam is affected by biological or physical alterations in the free following river environment during the latter period of rearing.
- Determine if acclimating hatchery fall Chinook salmon subyearlings leads to different behavioral and life history patterns when compared with hatchery subyearlings released directly to the river or with wild reared fall Chinook salmon.
- Determine if summer spill operations decrease travel time and increase the probability of migration and survival for fall Chinook salmon migrating from Lower Granite Dam to the tailrace of McNary Dam.

Progress:

We have conducted several analyses to document and characterize historical changes in the juvenile life-history of the wild-reared population of fall Chinook salmon within Hells Canyon on the lower Snake River. The population was listed as threatened under the Endangered Species Act in 1992, when redd surveys indicated fewer than 200 fish were spawning in 173 river kilometers of remaining habitat. Multiple regression and stock-recruitment analyses strongly suggest that recent hatchery supplementation efforts applied since 1998 have been successful in increasing the number of wild-spawning adults, and in turn, the abundance of wild-reared juveniles in the rearing areas of the river.

Density-dependent mechanisms may also be responsible for earlier emigration of juveniles from the rearing habitats. Analysis of emigration past downstream federal hydroelectric dams required special consideration because differences in spill volume at the dams resulted in differences in sampling effort at the dams, necessitating that juvenile fish counts at the dams be adjusted based on the spill volume and sampling effort. Quantifying sampling effort of PIT-tagged juvenile fall Chinook salmon at the dam required fitting a multi-state, mark-recapture model to 1-2 day changes in passage counts of radio-tagged juvenile fall Chinook salmon passing the dam. Currently, the model has been successfully applied to juvenile fish passing Lower Granite Dam, the first dam downstream from the rearing areas in the Snake River. Current evidence supports the conclusion that the wild-reared population has been emigrating

from the rearing areas earlier in accordance with greater abundances of wild and hatchery-reared juveniles in the river.

Our modeling focus was been directed recently towards adjusting a general bioenergetics model for Chinook salmon to this locally adapted fall Chinook salmon population. We have used the model to account for the effects of temperature, fish size, and food consumption on growth, and plan to further refine these relationships with empirical laboratory data and field observations. We have added factors to the model to adjust for geographic location, and abundance of fish in the rearing areas. We found juvenile growth rates were highest in the reservoir during periods of low fish abundance, but growth rates are now lowest in the reservoir under higher fish abundance. Future efforts will be directed toward incorporating counts of hatchery and wild fish into the analysis to better understand the potential contribution hatchery fish abundance on the growth of naturally reared juvenile fall Chinook salmon.

DEVELOPING STRATEGIES TO IMPROVE SURVIVAL AND RETURN RECRUITMENT OF STEELHEAD KELTS FROM SNAKE RIVER STOCKS

Principal Investigator:	Christine M. Moffitt, Ph.D.
Student Investigators:	Jessica Buelow
	Zach Penney
	Bryan Jones
Scientific Staff:	Boling Sun
	Andy Pape
	Kala Hamilton
Collaborators:	Doug Hatch, CRITFC
	Brett Bowersox, IDFG
	Tim Copeland, IDFG
Funding Agency:	Columbia River Intertribal Fisheries Commission
Completion Date:	31 December 2011

Objectives:

- Obtain and synthesize physiological metrics into models that describe changes observed in hatchery-and natural-origin steelhead trout stocks from fall upriver migration through spawning and early kelt migration.
- Obtain a complete profile of the condition and physiology of downstream migrating natural origin stocks captured at Lower Granite Dam bypass facility, and compare and contrast these profiles with fish examined at upriver sites.
- Evaluate the survival and migration behavior of natural origin steelhead kelts collected from the bypass facility at Lower Granite Dam, tagged with acoustic tags and transported via barge or truck to locations below Bonneville Dam.
- Evaluate the emigration of natural origin steelhead kelts PIT tagged and released below Lower Granite Dam to migrate through the Snake and Columbia River hydro system.

Progress:
Within their native distribution, steelhead trout are iteroparous and the proportion of fish observed repeat spawning varies from ~ 50% to < 1%. In the Snake and Columbia river systems, fish passage facilities at hydroelectric dams were not designed or constructed to accommodate downstream-migrating, post spawning steelhead adults (kelts). Our research focus is to understand and pose a model of the physiology and sequence of changes in pre-and post-reproductive steelhead trout in the Snake River system that tests factors affecting stock iteroparity. In the 2009 – 2010 research year, we worked to complete analyses of all tissue and blood samples collected in the winter and spring of 2009. We provide selected data summaries from analyses of lethal and non-lethal samples, and migration data. During the past year we increased the number of samples from natural-and hatchery-origin steelhead at different times in their reproductive cycle to understand changes that occur from upstream migration through overwintering and sexual maturity. In the fall of 2009 and early spring of 2010, we sampled migrating pre-spawning natural origin steelhead trout at Lower Granite Dam adult trap in collaboration with the Nez Perce Tribe, Idaho Department of Fish and Game, and Washington Department of Fish and Wildlife. We established increased collaborative efforts with Idaho Department of Fish and Game to sample natural origin A and B run steelhead emigrating from tributaries of the Clearwater River, and sampled over 200 kelts at weirs in the Clearwater River. We worked in collaboration with the staff at Dworshak National Fish Hatchery to sample hatchery origin steelhead at selected time intervals from October, January, February, March, and April. We worked with the US Army Corps of Engineers and the U of Idaho Facilities skilled craft staff to design, fabricate and install a new collection system for capturing and holding migrating kelts to improve our ability to sample the kelt migration of hatchery and natural origin steelhead at Lower Granite Dam. As a result of these improvements we successfully diverted all natural origin fish entering the juvenile fish bypass for a total of 2,488 kelts. The natural origin kelts were sampled, PIT tagged, and selected groups were released to migrate downstream. At selected intervals we transported groups of kelts via barge and truck to release locations downstream of Bonneville Dam. Distributed within these transported groups of kelts were 120 fish surgically-implanted with acoustic tags to follow kelt migration and survival in fixed arrays located in the Lower Columbia River and offshore. We began analysis of all data and are preparing samples of plasma, and tissues for analysis. Preliminary results of our research were presented at regional and international professional society meetings, and we have begun plans for additional research and collaborations to fill data gaps in our models during 2010-2011.

LOWER METHOW FISHERIES POPULATION GENETIC ANALYSIS

Principal Investigator:	Madison Powell, PhD
Student Investigator:	Dana Weigel
Technical Staff:	Joyce Faler
Collaborating Agency	U. S. Bureau of Reclamation Pacific Northwest Region
Funding Agency:	USGS – RWO 123
Completion Date:	31 December 2010

Objectives:

- Assess the effects of parentage and hatchery fish on steelhead trout colonization of newly-opened stream habitat.
- Compare population genetics and life history information across steelhead populations in several natal tributaries (Beaver, Libby, and Gold creeks).

Progress:

Tissue samples were collected by project cooperators from juvenile steelhead rearing in Beaver, Libby and Gold creeks during 2004, 2005, 2006, 2007, 2008 and 2009. In addition, tissue samples from migrating adult and juvenile steelhead were collected in upstream-downstream weir during 2005, 2006, 2007 and 2008. These samples were delivered to the University of Idaho, Aquaculture Research Institute. DNA was extracted from samples and they are currently being analyzed with 16 standardized microsatellite markers for steelhead. Microsatellite data for 2004, 2005, 2006 and 2009 samples have been completed. Remaining laboratory analyses will be completed this year. These data will be analyzed to identify source populations for individuals colonizing upper Beaver Creek after barrier removal, life history interactions in steelhead, and the effects of hatchery fish spawning naturally in local tributaries.

USE OF SEISMIC AIR GUNS TO REDUCE SURVIVAL OF SALMONID EGGS AND EMBRYOS: A PILOT STUDY

Principal Investigator:	Michael C. Quist, Ph.D.
Research Technician:	Benjamin Cox
Collaborating Scientist:	Andy Dux, IDFG
Funding Agency:	Idaho Department of Fish and Game
Completion Date:	28 February 2011

Objective:

- Evaluate the efficacy of using seismic air guns to reduce survival of salmonid eggs and embryos

Progress:

Introduced lake trout *Salvelinus namaycush* have had a number of detrimental effects on native fishes across the western U.S. In addition to disrupting aquatic food webs (i.e., energy flow and nutrient dynamics), lake trout compete with and directly consume native species such as kokanee *Oncorhynchus nerka* and cutthroat trout *O. clarkii*. The detrimental impacts of introduced lake trout to aquatic ecosystems in the western U.S. have prompted natural resource

management agencies to implement lake trout suppression programs. Currently, these programs focus on using gill nets or trap nets to remove subadult and adult lake trout. Population models suggest that lake trout population growth is highly sensitive to changes in survival from age 0 to age 1. Thus, developing methods to reduce survival of age-0 fish will most likely provide the greatest benefit toward obtaining suppression effort goals. This project will evaluate a novel technique, seismic air guns, for reducing mortality of age-0 lake trout.

Seismic air guns are used in both reflection and refraction seismic surveys. The guns use compressed air to produce a steep-fronted percussion wave that is reflected by subsurface geological features. The reflected waves are monitored much like traditional sonar techniques. Common uses of air gun technology oil and gas exploration, engineering site evaluations, or other geologic surveys. Seismic air guns can cause mortality in eggs and larvae of fish; however, mortality caused by seismic air guns varies by species, life stage, and distance from the air gun. Seismic air guns are an attractive alternative to netting efforts because of the comparatively low cost of using air guns. Seismic air guns are also preferred over toxicants for controlling lake trout because of the relatively low mortality induced when fish are > 5 m from the air gun. This study will determine the feasibility of using a small air gun (655.5 cm^3; 40 in^3) to induce mortality in rainbow trout *O. mykiss* and lake trout eggs and embryos. A 655.5 cm^3 air gun was selected because it is the size of gun most likely to be used by state and federal fisheries scientists due to the simple infrastructure required to deploy and use the gun. If the air gun proves to be a useful tool for increasing lake trout mortality, additional research will likely focus on factors influencing efficacy (e.g., life history stage, substrate composition, depth) and on its ability to help managers reach suppression goals.

OCCURRENCE, HABITAT ASSOCIATIONS AND CONSERVATION ACTIONS FOR THE WOOD RIVER SCULPIN (*COTTUS LEIOPOMUS*)

Principal Investigator: J. Michael Scott, Ph.D.
Student Investigator: Donald W. Zaroban
Funding Agencies: U.S. Bureau of Land Management, U.S. Environmental Protection Agency, Idaho Department of Environmental Quality, The Nature Conservancy, Lava Lake Foundation for Science and Conservation
Completion Date: 31 December 2010

Objectives:

- Inventory Wood River sculpin occurrence across its distribution.
- Develop a multivariate habitat association model to predict species occurrence.
- Assess feasibility of using PIT tags to track individual Wood River sculpins. Use shorthead sculpins (*C. confusus*) as a surrogate to avoid possibility of inter-basin

transfer of *Myxobolus* sp. Observe survival, tag retention, net-avoidance behavior and subsequent detectability.

Progress:

Electrofishing was conducted in 166 stream reaches in 2004 and 2006. Historical occurrence was evaluated by compiling 700 existing records. To evaluate potential distributional changes, all records were aggregated by subwatershed and detections were assessed over time. Sampling efficiency was assessed through mark-recapture monitoring. A manuscript of these findings has been submitted to *Western North American Naturalist*.

The occurrence modeling is ongoing. The model is being developed with decision tree analyses. Basin-scale variables will be used as predictors. The model will be evaluated using independent data from the Idaho Department of Fish and Game, Idaho Department of Environmental Quality, and the U.S. Forest Service. Stream reach and habitat unit scale variables will be used to recommend in-stream management targets. The PIT tag assessment is completed and this work has been published in the *Western North American Naturalist.*

THE ROLE OF *MYSIS DILUVIANA* IN THE NUTRIENT AND FOOD WEB DYNAMICS OF LAKE PEND OREILLE, IDAHO

Principal Investigator:	Frank M. Wilhelm, Ph.D.
Student Investigator:	Timothy Caldwell
Funding Agency:	Idaho Department of Fish and Game
Completion Date:	December 2010

Objectives

- Examine the role of *Mysis diluviana* in the nutrient dynamics of Lake Pend Oreille.
- Quantify the nutrients (phosphorus - P) imported, cycled, and exported to and from surface waters by *Mysis* during their nocturnal vertical migration.
- Quantify the seasonal dynamics of nutrients.
- Determine the density of *Mysis* at each of two sampling sites.
- Develop a life history model for mysids.
- Determine if *Mysis* removal to “free-up” nutrients could be an alternative to adding nutrients to surface waters to stimulate production of zooplankton for kokanee fry.
- Determine the effects of mysid predation on cladoceran populations.

Progress:

The goal of the project is to examine and understand the role of the non-native opossum shrimp *Mysis diluviana* in the nutrient and food web dynamics in the surface water of Lake Pend Oreille (LPO). The opossum shrimp were introduced into lakes in many locations in the Pacific Northwest as a forage supplement for fish based on the production of large kokanee salmon in Kootenay Lake, British Columbia (B.C.), Canada in the mid 1960 after the introduction of *Mysis*. However, the lack of spatial overlap between *Mysis* and kokanee salmon in most systems resulted in opossum shrimp populations expanding rapidly because of the lack of predation. Since *Mysis* prefer zooplankton, they directly compete with early life history stages of fish and may cause recruitment failure of fish populations. Whole-lake fertilization (e.g., Kootenay and Arrow Lakes in B.C.) has been used to successfully increase the amount of food

available to fish fry by stimulating a bottom-up trophic cascade. Success in these lakes has prompted the idea of such a strategy for LPO, however, these lakes differ from LPO because each experienced significant reductions in nutrient inputs (oligotrophication) due to dam construction. Thus, fertilizer replaces nutrients lost to oligotrophication. In LPO, no large reduction in nutrient influx has occurred as a result of dam construction and offshore pelagic chemical conditions have remained largely unchanged since studies in 1911. However, much effort and money has and continues to be expended to limit and reduce the input of nutrients to nearshore areas which were deemed to suffer from excess nutrients. The efforts have included several interstate agreements with significant monetary implications in the watershed upstream of LPO. In light of these agreements, a fertilization program on LPO may be counterproductive and socially unacceptable. This situation is similar to that at Okanagan Lake, B.C. where long-term efforts to abate nutrients from the watershed precluded the addition of fertilizer to the lake for the production of kokanee. Instead, managers opted for a *Mysis* fishery to reduce the impact on kokanee salmon.

The great depth of LPO [max depth of 357 m (1,171 ft)] represents a significant migration distance for *Mysis* and we hypothesize that mysids arriving in surface waters will have empty guts. After feeding on zooplankton in surface waters and returning to depth during the day, *Mysis* represent a one way transport or net sink of material and nutrients from surface waters. Other researchers have speculated that the loss of P to lake sediments through diel vertical migration by *Mysis* may be significant. Thus in LPO it may be possible to "free-up" nutrients exported from surface waters by harvesting *Mysis* rather than undertaking nutrient additions. However, this requires that we understand their role in the nutrient dynamics of the lake.

Monthly sampling to quantify the nutrient dynamics associated with the vertical migration of *Mysis* has been completed (April 2009 - July 2010). Results show that mysids excrete P at the same rate during all phases (ascending, pelagic, and descending) periods of migration. This could mean that they feed during the upward migration, they have food remaining in their gut or it is a result of the catabolism of energy reserves associated with vertical migration. Combining these data with mysid densities, and lake thermal regimes, we find that mysids represent a net loss of nutrients from surface waters during summer stratification period. Our density estimates are highly variable and indicate potential large-scale seasonal movements of the mysid population. This is currently a limiting factor in our calculations.

The examination of gut contents showed that mysids consume cladocerans, copepods, diatoms, pollen, and rotifers. Interestingly, we found the remains of Cladocerans in mysid guts before any were sampled from the lake indicating high selective pressure on Cladocerans by mysids. Historical data show that after the introduction of mysids in LPO, the onset of blooms of Cladocerans was delayed from late March to early April, to the month of July. This delay in the availability of Cladocerans coincides with the appearance of kokanee fry and likely contributes to their poor recruitment.

The research has been presented at various state and international meetings (International Association for Great Lakes Research, Toronto, May 2010 and American Society of Limnology and Oceanography joint meeting with North American Benthological Society, Sante Fe, June 2010, and Washington Area Lakes Protection Association, Tacoma, September 2010) where it

was well-received. Manuscripts are in preparation and the student is writing his thesis for completion and graduation in December 2010.

Back row, left to right: EPSCoR funded REU intern, Will Schrader; graduate students Jessica Buelow, Kelly Stockton, and Zach Penney; NSF REU intern Kausei Martin Perales. Front row, NSF REU intern Brittany Winston. Interns provided assistance with research projects in the summer of 2010, and were mentored by graduate students. Photo by Christine Moffitt.

Completed Projects – Fisheries and Aquatic Resources

IMPROVEMENT IN ESTIMATES OF COLUMBIA RIVER FALL CHINOOK SALMON (*ONCORHYNCHUS TSHAWYTSCHA*) ESCAPEMENT

Principal Investigator:	Christopher Caudill, Ph.D.
Collaborating Agencies:	Pacific Salmon Commission
	Columbia River Inter-tribal Fish Commission
Funding Agency:	USGS – RWO 139
Closing Date:	30 June 2010

Objectives:

- Refine and apply a previously developed mark-recapture likelihood model for calculation of escapements, their variances, and associated parameters to several target up-river bright fall Chinook salmon from the Hanford Reach /Priest Rapid Hatchery, the Deschutes River, the Snake River, and the Yakima River.
- Compare estimates from the likelihood model with those used by the U.S. v. Oregon Technical Advisory Committee and standard mark recapture techniques.
- Address the relationship between precision of escapements and sample size.

Summary:
Naturally spawning Columbia River fall Chinook salmon (*Oncorhynchus tshawytscha*) are indicator stocks identified by Pacific Salmon Commission (PSC) Chinook Technical Committee (CTC). A key issue in management of these stocks is the accuracy of escapement estimates. We have been collaborating with the Columbia River Inter-Tribal Fish Commission (CRITFC) to improve escapement models for this important group of populations. PSC CTC calculates ocean abundance of a fish stock from the estimate of its escapement using a stock-recruit model such as a Ricker model. If the adult escapement estimate has a large error, the resultant estimate of ocean abundance will also have a large error. To improve the current management agency methods, we conducted two years of mark-recapture studies using PIT-tags on fall Chinook salmon collected at Bonneville dam. The tagged fish were later detected at upstream dams, in hatchery returns, and during spawning ground surveys conducted by multiple natural resource agencies. We also used the extensive adult fall Chinook salmon radiotelemetry database developed by UI and the National Marine Fisheries Service (NMFS) in 1998 - 2005 to simulate PIT-tag detection histories for multiple years and to compare radiotelemetry versus PIT-tag approaches.

Results from the two-year study were informative. We successfully modeled point estimates and confidence intervals for population-specific salmon escapement for the primary Columbia River spawning sites. Results from multinomial likelihood models and more traditional Petersen models converged for most populations in most years, and more complex stratified models that accounted for population-specific migration timing patterns provided more realistic uncertainty estimates. Overall, mark-recapture techniques had several advantages over agency fish count and survey-based methods, importantly including the ability to rigorously estimate confidence intervals around escapement estimates and reduced sensitivity to survey biases. There were also clear tradeoffs between active (radiotelemetry) versus passive PIT-tag mark-

recapture approaches. Radiotelemetry provided better spatial resolution among populations, especially for tributary spawners, while PIT-tags provided low-cost, easily-replicated estimates using the permanent and expanding PIT-tag detection system at dams. As part of the final report, we made recommendations regarding optimum sample sizes for continuing mark-recapture escapement studies and offered suggestions on how to improve PIT-tag-based evaluations.

ASSESSING THE RISKS AND BENEFITS OF BARRIER REMOVAL TO NATIVE FISH POPULATIONS IN IDAHO

Principal Investigator:	Christine M. Moffitt, Ph.D.
Student Investigator:	Paul Reyes
Agency Collaborator	Jody Brostrom, USFWS
Funding Agency:	U.S. Fish and Wildlife Service
Completion Date:	31 September 2010

Objectives:

- Provide GIS derived maps and summaries of the range, migration barriers, and habitat characteristics of native fish species of concern in Idaho.
- Prepare and summarize GIS derived maps of known information on aquatic invasive species and fish pathogens in proximity to the range of fish species of concern, as well as corridors or vectors or pathways of human activity that could increase the likelihood of introduction of invasive species or pathogens within the range.
- Using these spatially referenced data sets, and GIS tools, provide models that can be used to prioritize and select barriers to fish migrations that if removed will result in the greatest benefit to native fish populations.
- Using GIS tools, identify and prioritize areas of risk and needs for further evaluation and monitoring.

Summary:

Decisions regarding the removal or retention of road culverts that are barriers to fish passage involve complex trade-offs. Some of the benefits of removing barriers for native salmonids populations include extending access to upstream spawning areas, improving the access of salmonids to different types of habitat necessary for meeting life history requirements and enhancing the viability of metapopulations. However, barriers can also serve to prevent upstream spread on invasive species. A systematic approach is necessary to consider the risk and benefits of culvert removal for native salmonids. We used Geographic Information System (GIS) tools and methods to develop an integrative framework to assess the potential gains in connectivity associated with the removal of fish passage barriers and the risks of invasions. The framework combined landscape and local information and had two main phases: (1) delineation of habitat characteristics of selected species of concern and (2) spatial analysis of stream network connectivity. The first phase of the framework focused on using geospatial and statistical analyses to model habitat suitability of three invasive species: brook trout *Salvelinus fontinalis*, New Zealand mudsnail *Potamopyrgus antipodarum* and the annelid *Tubifex tubifex*, which is host of *Myxobolus cerebralis*, the causative agent of whirling disease in salmonids.

Criteria used to develop these models included geomorphologic characteristics (stream channel slope, watershed contributing area, and percentage agriculture), climate data, and dispersal vectors. With habitat characteristics delineated, the second phase centered on the assessment of potential gains in stream network connectivity based on a measurement of hydrologic distance upstream of each culvert. The locations of culverts relative to native and invasive species and the potential gains in connectivity were considered to develop a removal priority score for each culvert. The framework was applied to the upper Boise River basin (UBRB) in southwestern Idaho as a case study. A Spatial Decision Support System (SDSS) was developed to facilitate replicating the framework to other watersheds and basins. The results and approach used in this study will help managers to efficiently prioritize the removal of culverts while minimizing the associated risks for native salmonids.

LIFE HISTORY AND FISHERY CHARACTERISTICS OF REDBAND TROUT IN MANN CREEK RESERVOIR

Principal Investigator:	Dennis L. Scarnecchia, Ph.D.
Student Investigator:	Dean Holecek
Funding Agency:	Idaho Department of Fish and Game
Completion Date:	1 June 2010

Objectives:

- Identify key life history characteristics of an adfluvial redband trout *Oncorhynchus mykiss gairdneri* population in Mann Creek Reservoir.
- Quantify harvest and fishing effort for redband trout in Mann Creek Reservoir.
- Predict impacts of potential fishing regulation changes on the fishery and population of redband trout in Mann Creek Reservoir, Idaho.

Summary:
Redband trout of the interior Columbia River basin display both resident and anadromous (i.e., steelhead) life histories, often in the same waters. The redband trout of Mann Creek, a tributary of the Weiser River drainage, Idaho, historically had anadromous steelhead trout populations. Since the impoundment of Mann Creek Reservoir in 1967, the migrating population was limited to an adfluvial life history. This trout population is also situated close to Idaho's largest urban center and has the potential to provide an important and accessible quality fishery. There are few quality trout fisheries in the southwest region of Idaho; however, the Idaho Department of Fish and Game has identified Mann Creek Reservoir as a potential quality trout fishery site.

The goals of this research were to compare key life history attributes between putative resident and adfluvial forms and to determine if Mann Creek Reservoir would support a quality fishery. A portion (26.4%) of juvenile emigrants from Mann Creek showed elevated ATPase activity and a prevalence of silver body coloration while migration timing of emigrants was synchronous with other juvenile steelhead populations of the Snake River basin. Juvenile redband trout emigrants appear to be undergoing smoltification more than 50 years after the loss of an anadromous component to the population. Migratory adult life history characteristics were similar to anadromous forms as well. The skewed sex ratios (2.78 females per male), spawn timing (peak of hydrograph), fecundity, and growth patterns of the adfluvial population

all match closely to what one would expect of an anadromous population. Harvest management strategies that restrict harvest (catch and release; 2 fish daily and 406 mm minimum TL) from the current regulations (6 fish daily and no size restriction) were predicted to increase population size, and length structure, and decrease harvest. The life history attributes of this population are similar to anadromous populations and suggest that this population could be important to recovery of steelhead trout populations of the Snake River. The harvest management information provides critical information for both conserving this unique population and for evaluating management options to develop a quality trout fishery in southwest Idaho.

Graduate student Lubia Cajas Cano and Marco Pinchot discuss aspects of the Taylor Shellfish Farm operations. Photo courtesy of Taylor Shellfish Farm.

Current Projects – Wildlife and Terrestrial Resources

ANALYSIS OF POLAR BEAR MOVEMENTS IN THE CHUKCHI, BERING AND EAST SIBERIAN SEAS

Principal Investigators:	Jon S. Horne, Ph.D. J. Michael Scott, Ph.D.
Collaborator:	U.S. FWS
Funding Agency:	USGS – RWO 150
Completion Date:	28 May 2011

Objectives:

- Conduct preliminary analyses on polar bear location data to identify analytical methods for determining the spatio-temporal distribution of polar bear movements.
- Conduct preliminary analyses of polar bear habitat selection to identify potentially important environmental and biological factors affecting space use and determine appropriate analytical methods for investigating ecological aspects of habitat use.
- Identify geographic sampling locations that are most likely to provide a representative sample of the population.
- Identify approaches to investigate future changes in habitat use due to changes in climate, management, and population status and assist in defining objectives for future research.

Progress:

This project recently began in September 2010. The goal is to initiate a collaborative research effort between U.S. Fish and Wildlife Service (USFWS) biologists and researchers with United States Geological Survey Cooperative Research Units Program and the University of Idaho. We will assist USFWS staff with preliminary analysis of current data to evaluate potential research questions, identify analytical methods for answering research questions, and determine if current methods of data collection need modification. Specifically, this project will focus on evaluating approaches for determining space use of individual polar bears; identifying environmental and biological characteristics associated with current habitat selection and use; and developing approaches to evaluate responses of Chukchi Sea polar bears to changes in environmental conditions and management practices. The results of this project will provide the basis for future collaboration to meet long-term research and management objectives of USFWS.

IMPACTS OF FENCES ON GREATER SAGE-GROUSE: COLLISION, MITIGATION, AND SPATIAL ECOLOGY

Principal Investigator: Kerry Reese, Ph.D.
Student Investigator: Bryan Stevens
Funding Agencies: Idaho Department of Fish and Game and U.S. Bureau of Land Management
Completion Date: 30 June 2011

Objectives:

- Estimate collision rates of sage-grouse with fences on study areas in breeding habitats.
- Estimate carcass and collision sign detectability and longevity in sagebrush-steppe habitats.
- Evaluate the effectiveness of fence marking as a mitigation method to reduce collision rates in high risk areas.

Progress:

Collision mortality is a widespread and relatively common phenomenon among European grouse species. Research concerning the relative extent and impacts of collision mortality on North American grouse are limited. Recent concerns involving the impacts of elevated infrastructure on sage-grouse have brought to our attention the lack of empirical data concerning collision frequency and grouse in North America. The spatial extent of fences and other elevated structures has increased dramatically in sagebrush habitats during the last 50 years, and the impact of structures on sage-grouse has not gone unnoticed. Few studies have evaluated collision rates over large geographic areas and no studies have evaluated factors influencing collision rates across multiple spatial scales, further limiting our knowledge of what influences collision risk across the landscape.

We estimated sage-grouse fence collision rates in breeding habitats in the spring of 2009 and 2010. The influence of topographic, biological, and technical features on collision rates will be modeled. To estimate carcass and collision sign detectability and longevity, we conducted a field experiment using pen-raised hen ring-necked pheasant carcasses as the experimental unit, and evaluated factors influencing scavenging and detectability of these carcasses in sagebrush-steppe habitats. This was done using a completely randomized design with 50 carcasses placed on each of two study areas. Carcass detectability was a function of microsite vegetation characteristics at the carcass location. Carcass daily survival rates were not strongly influenced by local or microsite habitat characteristics, but did vary between study sites. The carcass analysis is complete, and a manuscript has been accepted by the *Journal of Wildlife Management*. In 2010, to evaluate the effectiveness of fence marking at reducing sage-grouse collision rates we used a repeated measures complete block design replicated on eight study sites determined to be potentially high risk areas based on 2009 field data. At each site a 3 km fence segment was divided into six, 500-m segments, which served as the experimental units in the study. At each site three fence segments were randomly selected for fence marking treatment and the remaining three were used as unmarked control segments. All fence segments were surveyed for the presence of avian collision sites five times, at approximate 2-week intervals from March - May 2010. Analysis is currently underway for the fence-marking study, and collision risk modeling will begin shortly. In 2010, two oral presentations and one

poster presentation were presented with preliminary results from these studies at the annual meeting of the Idaho Chapter of The Wildlife Society and the Western Association of State Fish and Wildlife Agencies 27th Sage and Columbian Sharp-tailed Grouse workshop. All analysis and thesis work for this project will be completed by May 2011.

DISPERSAL PATTERNS AND PHILOPATRY IN RED-TAILED AND RED-SHOULDERED HAWKS

Principal Investigator: J. Michael Scott, Ph.D.
Student Investigator: Peter Bloom
Completion Date: June 2011

Objectives

- Determine dispersal and philopatry in red shouldered hawks and red tailed hawks using historical records from banding and recovery.

Progress:

This is a 40-year study of Red-shouldered Hawks *Buteo lineatus elegans* and Red-tailed Hawks *Buteo jamaicensis calurus,* fledged from southwestern California, involving the banding of 2,867 nestling Red-shoulders hawks in southern California between 1970-2009, 127 nestlings in other California studies (1956-2008), and the analyses of 145 subsequent recovery records from the Bird Banding Laboratory (1957-2009). The total number banded was 5,844 nestling red-tailed hawks from 1970 – 2009, of these, 246 (4%) were recovered. We also examined 2,117 North American band recovery records of Red-tailed Hawks banded as nestlings from 1940 through 2008, and all North American long-distance band recoveries of nestling Red-tailed Hawks that traveled greater than 100 km were included.

Ten (6.9%) of the Red-shouldered Hawks recovered moved more than 100 km and were considered long-distance dispersers. Three (2.1%) were vagrants found between 374 and 843 km northeast of and south of their banding locations across portions of the Mojave, Great Basin, and Viscaino deserts. The distribution of long-distance dispersal directions was bipolar, closely corresponding with the northwest-southeast orientation of the species' distribution in southern California. One of the ten long-distance dispersers survived and traveled to its breeding range (10.25 months), whereas eight of the other nine perished before 15.3 months. The implications of long-distance dispersal for conservation of this resident subspecies are that a relatively small source area can contribute genetic material over a vastly larger receiving area, but contributions are rare because of high mortality rates.

Northbound, spring-summer initiated, long-distance migrations of terrestrial bird species are rare. The majority of Red-tailed hawk fledglings banded in southern California that traveled greater than 100 km did so in a significant northerly direction, generally into the Great Basin Desert and surrounding habitat. Fifteen of 17 hawks equipped with Platform Transmitter Terminal transmitters (PTTs) initiated their first northbound migration from southern California in summer, from late June to early August (about 4 – 6 weeks post-fledging) and exhibited the same northward movement. Individuals summered as far as northern Idaho and southwest Montana, a maximum distance of 1,462 km from their natal nest. Two siblings with PTTs did not migrate and remained in their natal region. Some individuals returned and wintered in their

natal region from August to early October. The oldest survivor wearing a PTT was a 4-year-old 2004 fledgling that made four round-trip migrations, generally departing progressively earlier each spring-summer between its natal region in southern California to Idaho or Oregon. Most PTT-tagged hawks, including two pairs of siblings, took remarkably similar pathways and summered and wintered in the same regions. In contrast, all nestlings banded in northern California migrated south. Examination of banding records for nestling red-tailed hawks for the rest of North America revealed a similar northern movement directly after fledging in other longitudes and at similar latitudes.

Preliminary analysis of recapture and recovery data from hawks banded in this study suggests that the red-tailed hawk is highly philopatric and the red-shouldered hawk is less so. The fact that the red-tailed hawk appears to be strongly philopatric is of particular interest because many fledglings undertake a 1,000 km north-northeast migration and could nest anywhere between the natal area and summering range, but often return to within 10 km of their natal nest. A primary question is why philopatry is such a dominant form of dispersal in so many species of plants and animals. This research will provide insight on this important subject. All data have been collected and the analysis is ongoing. A manuscript on origins and dispersal patterns has been accepted for publication in *The Condor*, and final reporting will occur in 2011.

HOW IS RECOVERY DEFINED BY THE NUMBERS?

Principal Investigator:	J. Michael Scott, Ph.D.
Cooperators:	Dale Goble, Ph.D. U I School of Law
	Maile Neel, Ph.D.,University of Maryland
	Aaron Haines, Ph.D.
Completion Date:	January 2011

Objectives:

- Evaluate the percentage of recovery units considered to have potential to be delisted.
- Determine the percentage of recovery units have quantitative criteria for delisting.
- Compare how abundances required for delisting compare to those reported historically at the time of listing and writing of recovery plans with abundance thresholds suggested in the literature.
- Determine how abundance values for delisted species compare to these values.
- Evaluate how abundances required for recovery differ between threatened and endangered species.

Progress:

Our analysis allowed us to evaluate whether recovery definitions have changed since they were last reviewed comprehensively. A database of all listed species with completed recovery plans has been developed. The database includes information on species population size and number of populations at time of listing, at time recovery plan was written, and what has been stipulated for recovery goals. In addition, a database has been developed that outlines the listing and recovery record for species that have been delisted from the Endangered Species Act (ESA).

The purpose of the ESA is to conserve at-risk species and the ecosystems on which they depend (16 U.S.C sec. 1531(b)). This purpose is achieved when the measures provided by the Act are no longer necessary to ensure long-term survival of the species in the wild, i.e., when species are recovered (16 U.S.C sec. 1532(3)). In this project we quantified the *de facto* operational definitions of these categories as they are specified in recovery plans and *Federal Register* documents.

Delisting was considered possible for 74% of the 1,173 recovery units, 69% of the 942 recovery units listed as endangered, and 92% of 231 recovery units listed as threatened. Of the 863 recovery units for which delisting was deemed possible, more than 90% had at least one quantitative recovery objective related to abundance. Number of populations was specified for 86% and number of individuals was specified for 55% of the recovery units with quantitative objectives; 50% (391) of these recovery units had both values. Amount of habitat was a recovery objective for only 7% of recovery units with objectives and amount of range for only 1%. Twenty-seven recovery units stated recovery objectives in terms of probability of persistence for a specified amount of time (17 vertebrates, 2 invertebrates, and 8 plants). Persistence probabilities varied from 90% to 99% with a median of 95%. The time horizon for persistence ranged from 20 to 300 years with a median of 100 years.

When points in the endangerment-recovery process were compared within recovery units to control for sample size differences, 64% of 399 recovery units with data at both time points required no more populations for delisting than were known to exist historically, 37% of 423 units required no more than existed at listing, and 30% of 614 units required no more than existed when the recovery plan was written. A median of 2,400 individuals was required to delist endangered recovery units (n = 359) while a median of 5,000 individuals was required to delist threatened recovery units (n = 63). Thus, endangered recovery units could be delisted at lower individual abundances than threatened recovery units.

Results of our findings were shared with the Chief of the Endangered Species program and staff in Washington DC and Arlington, Virginia. The data base was transferred to US Fish and Wildlife Service and two manuscripts have been prepared for publication: “What is a recovered species?” and “Defining recovery under the Endangered Species Act: By the Numbers.”

ASSESSING THE VULNERABILITY OF SPECIES AND ECOSYSTEMS TO PROJECTED FUTURE CLIMATE CHANGE IN THE PACIFIC NORTHWEST

Principal Investigator:	J. Michael Scott, Ph.D.
Collaborators:	Leona K. Svancara, Ph.D. IDFG
	Sarah Shafer, USGS, Oregon
	Joshua J. Lawler, University of Washington
Funding Agency:	USGS – RWO 148
Completion Date:	December 2012

Objectives:

- Develop moderate spatial resolution (e.g., ~1 km) data of projected future climate changes for the Pacific Northwest.
- Simulate how vegetation and habitat types are likely to change in response to climate change.
- Model potential shifts in the distributions of 12 focal animal species, chosen in discussions with land managers from the region.
- Assess the vulnerability of particular species, ecosystems, and managed lands to future climate change based on projected changes in climate, vegetation, and species distributions, as well as on inherent species and ecosystem sensitivities to climate change.
- Summarize uncertainties in the simulated climate, vegetation, and species distribution changes.
- Work in collaboration with conservation and natural resource managers to incorporate the research results into management planning and implementation efforts

Progress:

Future climate changes projected for the Pacific Northwest will affect the region's species and ecosystems in a multitude of ways. The frequency and magnitude of wildfires, droughts, and other disturbance regimes could be significantly altered. There may be changes in the timing and variability of seasonal precipitation. Species' distributions may expand or contract and the timing of important phenological events, such as reproduction and migration, may change. These and other projected impacts of climate change present significant challenges for the conservation and management of species and ecosystems across the region.

Many conservation and natural resource organizations are interested in assessing the potential impacts of climate change to develop adaptive management responses for the species and ecosystems they manage. In support of these efforts, this study aims to evaluate the potential vulnerabilities of species and ecosystems to future climate change in the Pacific Northwest. The project involves the collaboration of researchers and managers from the Idaho Department of Fish and Game, The Nature Conservancy, University of Idaho, University of Washington, U.S. Geological Survey, and Washington Department of Fish and Wildlife.

A key goal of this research is to develop analyses and products describing species and ecosystem vulnerabilities (sensitivity and exposure) to climate change that can be used by conservation and natural resource managers to inform conservation and management activities. We are evaluating projected changes in climate, vegetation, and species distributions through

the year 2099 and assessing the potential impacts of these changes on key species and managed lands. Initial climate and vegetation data sets and analyses from this research are expected to be available at the end of 2010, with additional research results available in 2011.

The species and systems vulnerability assessment is designed to evaluate the inherent susceptibility to of species and ecological systems in the region and to model the potential effects of climate change for selected focal species. The estimated sensitivity of individual species is based on the ability of the species to disperse and whether dispersal barriers exist, dependence on the nature of particular disturbance regimes such as fire or flood regimes, physiology (e.g., sensitivity to temperature, precipitation, and salinity), dependence on climatically-sensitive habitats (e.g. alpine areas, shallow wetlands, and perennial streams), sensitivity of ecological relationships (e.g., are prey or forage species sensitive to climate change), whether the species is a generalist or specialist and whether the species' existence is dependent on other specific species. An online database to record the sensitivity of species and habitats has been developed and preliminary results are available for approximately 100 species of the roughly 500 species and systems that will eventually be ranked with respect to their sensitivity to climatic change. This information will provide resource managers and decision makers with the basic and most important information about how species and systems will likely respond to climate change. Such information will facilitate development of key adaptation strategies.

Projected current and potential future ranges will be modeled for 12 focal species using a hierarchical approach and the downscaled climate and habitat models created earlier in the project. We are currently working with resource managers in the region to identify an appropriate group of species that are of interest to project partners, occur across a diversity of environments and are likely to show a wide range of responses to climate change.

LINKING CONSERVATION ACTIONS WITH POPULATION VIABILITY MODELS: REDUCING UNCERTAINTY TO BETTER PREDICT MANAGEMENT EFFECTS ON VIABILITY

Principal Investigators:	J. Michael Scott, PhD. E. O. (Oz) Garton, PhD. Scott Mills, University of Montana
Post Doctoral Researchers:	Jon Horne, Ph.D. Katherine Strickler, Ph.D.
Collaborators:	U. S. Department of Defense
Funding Agency:	USGS – RWO 143
Completion Date:	31 December 2010

Objectives:

- Develop and test tools that can be used to better manage listed species on Department of Defense installations by estimating management effects and extinction risk under a range of life history attributes, available data, and training, testing, and management actions.

Progress:
When fitting population growth models to time series of abundance estimates, residual error in the models is due to a combination of demographic and environmental variation. We are currently working to partition out these two important sources of variation in population growth models of Sonoran pronghorn and greater sage-grouse .

We have finished development of a viability model that incorporates sources of uncertainty due to model selection, parameter estimation, environmental stochasticity, and management effects. Each source of uncertainty is propagated through the viability model via simulation. We used average monthly precipitation from 3 weather stations to characterize regional precipitation influencing the Sonoran pronghorn population. The sum of these averages for each month was used to estimate annual precipitation that was subsequently related to pronghorn growth rates. We fit nine models using previously recorded estimates (biannual) of pronghorn abundance from 1992 through 2008. We used information theoretic criteria to identify the best model and used this model and its estimated parameters to project viability of the wild pronghorn population. We also fit an exponential growth model to abundance data for the captive population of Sonoran pronghorn. This model and estimated parameters were used to project future changes in the captive population. Residual variation from all of the models mentioned above is a combination of demographic variation and environmental variation. In the near future, additional models will be developed that will allow us to separate different sources of variation. This modeling effort is being coordinated with staff from Arizona Department of Game and Fish and the U.S. Fish and Wildlife Service.

We have extended the density dependent Gompertz state space (GSS) model to cover situations with missing data or unequal time intervals. The modified GSS model is appropriate for estimating baseline properties of populations that have been stationary or fluctuating around carrying capacity for extended periods. We have compiled a database that includes spatial and environmental variability at Yakima Training Center, Washington, in relation to sage grouse population abundance for 1977-2007. Environmental conditions included the area of different habitat types, nesting season temperatures (extreme, normal, and departure from normal), nesting season precipitation (extreme, normal, and departure from normal), and Palmer Drought Indices for each year. To derive annual estimates of habitat types (e.g., sagebrush, grassland, mixed sage-grass, riparian areas, development, and agricultural land), we obtained LANDSAT images from 1977, 1987, 1997, and 2007 and used eCognition, an object-based classification software program, to calculate the amount of each land cover type within 1, 5, and 18 km of each sage-grouse lek. We merged these data with fire history within Yakima Training Center and interpolated the amount of each habitat type available around leks for each year during the 10-year intervals between pairs of LANDSAT images. We are now developing population growth models that incorporate these and other environmental covariates to estimate sage grouse population viability.

EVALUATION OF ASSISTED MIGRATION AS A POTENTIAL CLIMATE CHANGE ADAPTATION TOOL FOR ENDANGERED SPECIES

Principal Investigator:	J. Michael Scott, Ph.D.
Post Doctoral Researcher:	Katherine Strickler, Ph.D.
Collaborating Agency	U.S. Fish and Wildlife Service
Funding Agency:	USGS – RWO 149
Completion Date:	31 July 2011

Objective:

- Evaluate species translocations that have been conducted to determine factors that best predict failure or success.
- Develop recommendations (and associated science-based rationale) regarding specific factors for decision makers to consider with regard to assessed colonization as a climate change adaptation tool.

Progress:

This project will evaluate and providing recommendations on the scientific basis for the potential use of assisted colonization as means of ensuring the survival of species, particularly threatened or endangered species. We will identify additional research that is important to informing policy or management decisions regarding the potential use of assisted colonization. The project has been intensively coordinated with Nancy Green, Climate Change Scientist with U.S. Fish and Wildlife Service Endangered Species Program. Additionally, we are collaborating with Dov Sax, Assistant Professor of Ecology and Evolutionary Biology at Brown University, and Ariana Spawn, undergraduate honors environmental fellow at Brown University. In August we held a team meeting at Brown University to focus research efforts to address the most immediate and relevant management questions.

AMPHIBIAN CHYTRID FUNGUS DISTRIBUTION

Principal Investigator:	Lisette Waits, Ph.D.
Student Investigator:	Caren Goldberg
Funding Agency:	Idaho Department of Fish and Game
Completion Date:	15 May 2011

Objectives:

- Provide IDFG with sampling supplies for the amphibian pathogen *Batrachochytrium dendrobatidis* (Bd).
- Quantify the amount of Bd in each sample.
- Map and archive results to be used with other data for a publication on the prevalence of Bd in different amphibian species.

Results:

We provided IDFG with supplies for sampling 100 amphibians during the spring and summer of 2008 and 2009. We received and analyzed 36 samples from three species [31 Columbia spotted frogs (*Rana luteiventris*), 1 Western toad (*Bufo boreas*), 1 Pacific treefrog (*Pseudacris regilla*), and 2 unknown] at 30 locations. Twenty-five of the samples tested positive for *Bd*: 24 Columbia spotted frogs and 1 unknown. These data have been mapped and archived.

BIGHORN SHEEP GENETIC DIVERSITY AND STRUCTURE

Principal Investigator:	Lisette P. Waits
Student Investigator:	Nathan Borg, University of Montana
Funding Agency:	Idaho Department of Fish and Game
Collaborators:	Nez Perce Tribe, University of Montana
Completion Date:	20 August 2011

Objectives:

- Evaluate the genetic diversity and structure of the Salmon River population of Bighorn Sheep.
- Assess the genetic uniqueness of the Salmon River population.
- Evaluate gene flow and population structure within the Salmon River and between the Salmon River sheep and sheep in other drainages.

Progress:

This is a collaborative project involving Idaho Fish and Game, University of Montana, Nez Perce Tribe and the USGS Montana Cooperative Research Unit. We are providing molecular genetics laboratory training for Nathan Borg, a Idaho Fish and Game employee and new MS student at the University of Montana. We have identified genetic samples for 100 sheep in the Salmon River drainage and over 300 sheep from adjacent populations. DNA has been extracted from 100 samples and we have selected the mitochondrial DNA and nuclear DNA microsatellite gene regions that will be analyzed. Two PCR multiplexes totaling 17 loci have been optimized and we have begun to collect data.

PYGMY RABBIT SURVEY

Principal Investigator:	Lisette Waits, Ph.D.
Student Investigator and current post doc:	Caren Goldberg
Funding Agency:	Idaho Department of Fish and Game
Completion Date:	30 December 2010

Objectives:

- Complete optimization of protocol to distinguish between pellets of all North American lagomorph species using a single PCR reaction.
- Work with IDFG to organize an effort to collect pygmy rabbit pellets from multiple locations in southern Idaho.
- Identify all collected pellets to species.

Progress:

We have completed optimization of the PCR protocol for the lagomorph species identification reaction, which has been tested on at least 15 of each of the following species: black-tailed jackrabbit (*Lepus californicus*), white-tailed jackrabbit (*Lepus townsendii*), mountain cottontail (*Sylvilagus nuttallii*), desert cottontail (*Sylvilagus audubonii*), eastern cottontail (*Sylvilagus floridanus*), and pygmy rabbit (*Brachylagus idahoensis*). All species have been accurately

identified with one exception. We found that mountain and desert cottontail gene sequences are so similar that this test will not be able to distinguish between them. However, all pygmy rabbit samples were identified as pygmy and no other species was misclassified as a pygmy rabbit.

We have evaluated the success rates for our species ID test for pellet samples collected in the field during spring, summer and fall (n = 128) compared to samples collected on snow in the winter (n = 30). Success rates (94%) were considerably higher for samples collected in the winter. We analyzed 143 pellets collected by IDFG in the fall and early winter of 2009 - 2010. Success rate for species identification of these pellets was 73%. Pygmy rabbits were detected at 40 out of 55 plots sampled. We are currently working on a manuscript that describes the genetic testing protocol and reports results from field surveys.

RED WOLF MICROSATELLITE GENETICS AND HABITAT USE PROGRAM

Principal Investigator:	Lisette P. Waits, Ph.D.
Student Investigator:	Justin Bohling
Collaborator:	USFWS
Funding Agency:	USGS – RWO - 129
Completion Date:	30 June 2011

Objectives:

- Determine the genetic identity and ancestry of all puppies, captured animals, and fecal samples collected in the Red Wolf Experimental Population Area.
- Complete a scat survey the area immediately adjacent to the Experimental Population Area to determine if any red wolves or red wolf hybrids are present.
- Evaluate the genetic consequences of red wolves dispersing from the Red Wolf Experimental Population Area.
- Use USFWS field data to evaluate proximate causes of red wolf/coyote hybridization events.
- Conduct genetic identification of scats used for red wolf and coyote diet study.

Progress:

In the winter of 2010 we conducted a scat survey in the region directly outside the Red Wolf Experimental Population Area to search for red wolves or red wolf coyote hybrids. We collected 500 scats along approximately 650 km of roads and are currently in the process of analyzing the results through genetic analysis. Thus far, 245 of these scats have been identified as belong to *Canis* species using an mtDNA species identification test. This study will provide insights into the patterns of red wolf-coyote hybridization where the two species population come into contact and exist at low densities.

In the spring of 2010, 47 puppies were captured, 39 of which were identified as red wolves and 8 as F1 red wolf-coyote hybrids. From 2009-2010, 36 additional unknown adult canids were captured by the USFWS, 26 of which were identified as coyotes, 4 as F1 hybrids, and 6 as red wolves. We have also tested several computational techniques for evaluating hybridization

using genetic data. Using 17 microsatellite loci, we compared the known ancestry to values estimated using BAPS and STRUCTURE. We found that both programs had high power to detect F1 hybrids, but both methods had difficulty distinguishing later generation backcrosses from pure individuals. Our results suggest that these programs are useful for distinguishing early generational hybrids, but may struggle to accurately detect backcrosses using a moderate number of loci.

We also conducted a review of field and genetic data from 2002-2009 to elucidate the factors that may have influenced hybridization events between red wolves and coyotes. We found that hybridization events were bidirectional, with both male and female wolves breeding with coyotes. We also found that hybrid litters compared to red wolf litters were produced by younger female wolves breeding that were more likely to be breeding for the first time. Of the 17 documented hybridization events, six occurred after a breeding red wolf pair was disrupted by gunshot mortality while an additional two pairs were disrupted by other human activities (trapping and poison).

MONITORING GRAY WOLVES IN IDAHO

Principal Investigator: Lisette Waits
Student Investigator: Carisa Stansbury
Funding Agency: Idaho Department of Fish and Game
Completion Date: December 2011

Objectives:

- Evaluate the accuracy and cost-effectiveness of monitoring grey wolves in Idaho using fecal DNA analysis
- Collect and analyze wolf hair and fecal samples collected from predicted rendezvous sites.
- Conduct species and individual ID on all hair and fecal samples to obtain information on the presence and minimum count of wolves across two study areas
- Investigate and evaluate population estimation techniques using fecal DNA samples.

Progress:

In the 2009 field season, we surveyed 538 predicted rendezvous sites in three study areas: the Panhandle region (Game Management Unit – GMU – 6), the Sawtooth region (GMUs 33, 34, 35), and the Salmon region (GMU 28). We obtained scat and/or hair samples at 129 of these sites and found 16 active rendezvous sites. We collected 1,155 scat samples and 62 hair samples at sites plus 86 incidental scats collected while traveling to predicted rendezvous sites. DNA was extracted from all samples and a mitochondrial DNA species ID test was used to distinguish grey wolves from other carnivores. Success rates for obtaining species ID on fecal samples ranged from 92 – 95% per study area and 80% of the samples were from wolves. Individual identification of wolf samples was accomplished by genotyping 9 nuclear DNA microsatellite loci multiple times (2 – 6) to obtain a consensus genotype of 6 – 9 loci. Success rates for individual ID ranged from 50% (Panhandle) to 80% (Sawtooth). The lower success rates in the Panhandle are likely due to the wetter summer climate likely degrades DNA more rapidly. In the Panhandle region, we obtained 99 consensus genotypes representing 35 wolves. In the Sawtooth region, we obtained 248 consensus genotypes representing 50 wolves. In the

Salmon region, we obtained 344 consensus genotypes representing 54 wolves. For mark-recapture population estimation, we set the following recapture rules: 1) individuals could be recaptured at a rendezvous site between scat and hair; 2) individuals could be recaptured between rendezvous sites; and 3) individuals could be recaptured between a rendezvous site and an incidental scat location. Individual were captured 1 – 2 times at the Panhandle site, 1 – 6 times at the Sawtooth site, and 1 – 4 times at the Salmon site. Population size and 95% confidence intervals (CI) were estimated using two single-session methods that applied maximum likelihood (ML) or Bayesian models. The population size of the Panhandle region was estimated as 86 (61 – 135 CI) by the ML model and 103 (65 – 186 CI) by the Bayesian model. The population size of the Sawtooth region was estimated my ML methods as 103 (64 – 118 CI) and 69 (58 – 87 CI) by the Bayesian model. The population size of the Salmon region was estimated as 80 (63 – 99 CI) by the ML model and 82 (67 – 107 CI) by the Bayesian model. These estimates are higher than determined by field observations.
We also completed rendezvous site sampling for 2010 focusing on the Panhandle and northern Panhandle (GMU 1) regions. Over 500 samples were collected and the DNA has been extracted from ~50% of the samples.

Above, Carisa Stansbury and Lisette Waits collecting grey wolf scat. Photo by Sarah B. Bassing

Completed Projects Wildlife and Terrestrial Resources

USING THE METAPOPULATION CONCEPT TO UNDERSTAND THE SPATIAL AND TEMPORAL POPULATION DYNAMICS OF ELK IN IDAHO

Principal Investigator:	E. O. (Oz) Garton, Ph.D.
Student Investigator:	Jocelyn Aycrigg
Funding Agency:	Idaho Department of Fish and Game
Completion Date:	18 December 2010

Objectives:

- Delineate elk populations and the associated metapopulation in Idaho using genetic methods.
- Delineate elk populations and the associate metapopulation using demographic data and to measure correlations in demographic rates, such as abundance, between populations.
- Investigate the influence of environmental factors, such as weather, predation, habitat, and harvest on the delineated elk populations and the associated metapopulation.

Summary:
We found the distribution of genetic variation was consistent among elk populations. A patchy metapopulation structure described the distribution of genetic variation among Idaho elk populations implying enough interchange of individuals occurred that only slight differences in genetic variation were detected.

We delineated populations within an elk metapopulation based on demographic characteristics and measured population synchrony. Elk populations were synchronized, but the degree and magnitude of synchrony varied widely. Overall, elk populations in Idaho suggested a moderate amount of synchrony, meaning populations were balanced between being independently or dependently influenced by similar population and environmental factors. For environmental factors, we modeled the response of elk population growth rates to density dependence, harvest, wolf population estimates, precipitation, snow depth, and estimates of vegetation productivity. Population growth rate decreased as total elk, cow, and calf densities increased indicating negative density dependence. Overall, density dependence, weather, and habitat covariates appeared in models that best fit the data more often than mortality covariates. Density dependence was contained in all the most supported models.

Our time-series analysis of elk population growth rates and environmental factors revealed that multiple factors with complex relationships were acting on elk populations. Our data and analysis can provide a baseline for genetic and demographic monitoring from which to measure future genetic variation and gauge the influence of environmental factors, including harvest, on elk populations.

THE EFFECTS OF HABITAT CHANGE ON IDAHO'S UNGULATE POPULATIONS

Principal Investigators: Paul Gessler, Ph.D.
Student Investigator: Jeff Lonneker
Funding Agency: Idaho Department of Fish and Game
Completion: 30 June 2010

Objectives:

- Describe the past and present ungulate habitat changes in Idaho.
- Evaluate quantity and location of forage for animal populations to consider fire suppression, human encroachment, noxious weed invasion, and other changes including climate.

Summary:
Habitat change is a natural process that animals have not only adapted to, but have become dependent upon. Past efforts to document these changes have been expensive and time consuming. To evaluate how an entire landscape has changed, satellite data is proving to be a valuable tool. We acquired satellite data from two different sensors. The Landsat Thematic Mapper (TM) was chosen to document the type of habitat change while the Advanced Very High Resolution Radiometer was chosen to asses any changes in the timing of the growing season. We are using this satellite information in conjunction with aerial survey data of elk and mule deer from within the state of Idaho. We are studying whether landscape changes have influenced ungulate populations in the past. If so, we hope to use past relationships to predict what might happen in response to changing climate.

DEVELOPING AN INDEX OF ABUNDANCE FOR PYGMY RABBITS

Principal Investigator: Janet Rachlow, Ph.D.
Student Investigator: Amanda Price
Funding Agency: Idaho Department of Fish and Game
Completion Date: September 2010

Objectives:

- Calibrate an index of abundance of pygmy rabbits based on burrow systems by correlating the index with estimates of population density.
- Design standardized protocols for monitoring abundance.
- Evaluate the effect of pygmy rabbits on vegetation around burrow systems.

Summary:
The pygmy rabbit (*Brachylagus idahoensis*) is a cryptic, non-gregarious, burrowing lagomorph of conservation concern. As part of ongoing research aimed at understanding this species, we evaluated several attributes of the ecology of pygmy rabbits and developed an index that can be used to estimate rabbit abundance.

First, we examined factors potentially influencing survival of juvenile pygmy rabbits. We modeled survival of radio-tagged juveniles captured shortly after emergence from their natal burrows, and we evaluated the effect of variables (sex, year, study area, and relative date of birth) on survival through 18 weeks of age. Survival varied substantially across multiple

factors, and although model selection results did not indicate strong support for any single combination of variables, juveniles born later in the summer experienced lower survival.

Second, we evaluated the effects of foraging and burrowing by pygmy rabbits on the structure and composition of a sagebrush community. Because of their foraging and burrowing behaviors, pygmy rabbits have the potential to markedly influence the sagebrush-steppe environment in which they live, and such effects might become more pronounced around burrows over time. We evaluated whether duration of occupancy affects vegetation characteristics around burrow systems and if effects of occupancy were more pronounced close to the center of burrowing activity. We detected no influence of distance from center of burrowing activity on the structure and composition of sagebrush habitat across two study sites in east central Idaho. However, vegetation differed with the duration of occupancy of burrow systems. Vegetation around burrows occupied longer had higher browsing intensity, increased seedling density, more open understory, and less visual obstruction. The changes we observed in vegetation as duration of burrow occupancy by pygmy rabbits increased establishes their role as ecosystem engineers in sagebrush-steppe communities, and suggests that pygmy rabbits have the potential to influence habitat quality for themselves and sympatric species.

Finally, although understanding various aspects of the ecology and habitat relations of pygmy rabbits is important for understanding the basic biology of this species, in order to truly evaluate the status and population dynamics of pygmy rabbits, we need a method for estimating their abundance and monitoring populations. We developed an index of abundance based on density of active burrow systems at 7 study sites in east central Idaho by conducting censuses of burrow systems and using mark-resight surveys and snow-track surveys to estimate abundance of rabbits on each site. We evaluated patterns of burrow use by individuals, and we used the estimated abundance data to examine the relationship between vegetation structure and density of rabbits. Density of active burrow systems and density of rabbits varied across sites and the number of burrow systems used by individuals increased with density of available burrows. Population density increased curvilinearly with density of active burrows accounting for over three-quarters of the variation ($r^2 = 0.79$) in population estimates across sites.

Overall, this work supports the idea that pygmy rabbit populations might shift across the landscape due to changes in vegetation structure and composition and that high variability in survival over relatively small spatial and temporal scales might contribute to marked fluctuations in their populations. As a result, in order to understand and conserve populations of pygmy rabbits, researchers and managers might consider monitoring multiple populations across broader geographic areas to assess regional trends in abundance and habitat use. Additionally, the density of burrows can serve as an index for monitoring changes in abundance of pygmy rabbits in east central Idaho and also might be useful for monitoring changes in relative abundance over time at other locations. To assess abundance at larger spatial scales or across different regions, however, the index should be calibrated under regional conditions and site-level covariates should be evaluated.

MOUNTAIN QUAIL TRANSLOCATIONS

Principal Investigator: Kerry Reese, Ph.D.
Student Investigator: John Stephenson
Funding Agency: Idaho Department of Fish and Game
Completion Date: 31 December 2009

Objectives

- Reintroduce mountain quail into Asotin Creek Wildlife Management Area in Washington and Craig Mountain Wildlife management Area in Idaho.
- Analyze data comparing reintroduced to native mountain quail in Idaho.

Summary:

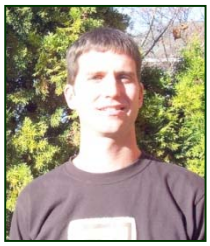
We translocated 322 mountain quail into the two areas on 12 March 2005 (n = 145) and 17 March 2006 (n = 177) with the goal of establishing self-sustaining populations. We radio-marked 199 quail and monitored them for up to 6 months until batteries failed. The major research objectives were to investigate survival, movements, habitat use, and productivity of translocated birds in the spring-summer period, and to compare these to native mountain quail studied during the 1990s in west-central Idaho. The known spring and summer survival rate was 13%, confirmed mortality was 76% and 11% of radio-marked birds went missing or had faulty transmitters. Spring-summer survival was 22% in 2005 and 15% in 2006. When cause of death could be determined, 74% of mortalities were by avian predators, 22% were by mammals, and 3% were human caused. Movement rate was negatively correlated with survival.

Of 24 nests found, 9 were incubated by females, 13 by males, 1 was started by a female and completed by a male, and 1 was not incubated. Clutch size was 8.5 for females and 9.5 for males. Overall nest success was 75% and was higher in 2005 (92%) than 2006 (58%), higher at Asotin Creek (81%) than Craig Mountain (63%), and higher for hatch year birds (94%) than after hatch year birds (29%). Mean hatch date for successful nests was 30 June (range: 15 June – 13 July). Brood success was 61% with a mean of 5.8 chicks per successful brood at 28 days of age. We located 15 (63%) of nests in Douglas fir-dominated plant associations, 4 (17%) in ponderosa pine, 2 (8%) in talus/garland, and 1 (4%) in each of rose/snowberry, bluebunch wheatgrass, and cottonwood/alder riparian communities. Additional releases of birds would likely be necessary for these populations to be self-sustaining. Altering release protocols, locations and number of birds could increase survival of translocated birds and provide for establishing self-sustaining populations.

The second portion of this work dealt with comparison of native mountain quail to translocated quail. We calculated survival rates for 181 native mountain quail in west-central Idaho from 1992-1996 and for 199 translocated quail in western Idaho and eastern Washington in 2005 and 2006. Spring-summer survival of native birds over 4 years ranged from 0.237 (SE = 0.069) to 0.826 (SE = 0.086) and their fall-winter survival in 2 years was 0.576 (SE = 0.064) and 0.213 (SE = 0.063). Annual survival rates were 0.532 (SE = 0.078) and 0.278 (SE = 0.074). Higher mortality due to predation coincided with movements to breeding habitat, breeding and incubation in the spring, periods of higher temperatures in the spring and summer, and periods

of deeper snow and colder temperatures during fall-winter. Spring-summer survival rate of translocated quail was 0.183 (SE = 0.029), which was lower than rates of native populations in our study. Mountain quail can experience low and variable survival, stressing the potential need for multiple releases in restoration efforts. Mature, well-developed riparian communities may be essential for protection from predators and mountain quail survival during all seasons.

PREDICTING THE ATTENDANCE PROBABILITY OF GREATER SAGE-GROUSE AT LEK SITES IN IDAHO



Principal Investigator:	Kerry Reese, Ph.D.
Student Investigator:	Jeremy Baumgardt
Funding Agency:	Idaho Department of Fish and Game
Completion Date:	30 June 2010

Objectives:

- Estimate the probability of birds attending leks and the probability of detecting attending birds during a lek route count.
- Estimate survival of nests and survival of yearling and adult birds.

Summary:

Recent trends based on lek counts indicate that populations of greater sage grouse (*Centrocercus urophasianus*) are generally declining across their range. We used mark-resighting techniques to model the probability of male greater sage-grouse attending leks and counts of birds from blinds located within 20 m of leks to estimate detectability. Birds were captured in the winters of 2006 – 2009 and fitted with 16.5 g necklace style radio transmitters. Triangulation from two locations of each lek was used to "re-sight" marked birds. We fit a Cormack-Jolly-Seber model to these data using program MARK. We restricted our predictor variables to time (Julian date), year, age of birds (adult or yearling), fate of the birds during the breeding season, a measure of winter severity, lek-specific covariates, and length of time each bird had carried a transmitter. Preliminary analysis of these data suggests that annual variation does exist in lek attendance, and may be related to winter severity.

Preliminary analysis of our detectability study indicate that between 79% and 91% of the birds actually attending a lek are included in the counts performed during a lek route. Nest success for our study area varied from 13.3% and 27.6% during the period from 2007-2009. Further analysis of these data should produce estimates of yearling and adult survival, in addition to identifying variables that affect the probability of individual birds being included in lek route counts, adult and yearling survival, and nests surviving to hatch.

NPSCAPE – A BASIS FOR LANDSCAPE MONITORING

Principal Investigators:	J. Michael Scott, Ph.D.
Student Investigator:	Leona K. Svancara
Funding Agency:	National Park Service
Completion Date:	December 2009

Objectives:

- Assess the ecological context, or landscape condition, of the National Park System
- Develop data, measures, standard operating procedures, and processing scripts to economically and efficiently achieve landscape monitoring of park units

Summary:

The ecological setting and context of parks can be described by the broad-scale context in which the park exists, and the "ecological footprint" of human activities that can affect park natural resources. The size of habitat patches, the intensity of development along park boundaries, and population density in nearby areas are examples of landscape features that will very likely affect park resources and visitor experiences. This study (NPScape) addresses these broad-scale factors, focusing on a limited number of attributes that have been linked to the condition of park natural resources. These variables provide information that is useful at local, regional, and broader scales, and that is often not readily available because the data are difficult to acquire, process, or evaluate.

The overall goal of NPScape is to report and evaluate broad-scale measures that improve our understanding and management of park resources. Reports produced by the NPScape project team focus on individual parks or groups of close-by parks, but the overall scope of the project encompasses more than 270 park units with significant natural resources. The scope of the project requires the use of data that are consistent over large areas and can be relatively easily processed and interpreted. Because NPScape can address only a small number of questions and we have a limited ability to customize analyses and reports to address park-specific situations, a core goal of NPScape is to provide data and methods that empower parks and Inventory and Monitoring (I&M) Networks to enhance and extend these results if they wish to do so.

The measurements and analyses we are providing fall into three broad categories: natural systems, human footprint, and conservation status. We produced a Measurement Description Summary for each category of measurements (e.g., Land Cover, Population/Housing, Roads, and Landscape Pattern) to provide additional information about the data used and other data sources evaluated. Data sets, results, graphics, and algorithms are available to NPS staff. We documented data processing and analyses in standard operating procedures consistent with NPS I&M guidance, in the format of standard operating procedures that facilitate incorporation of our methods into I&M protocols. We developed an interpretive guide to assist park managers in understanding the landscape context analysis and effects of landscape-scale effects on the condition and potential future condition of natural resources in their parks. This guide and other documents will be published in the NPS Natural Resources Report series.

WILD LANDS FOR WILD BIRDS: A 50-YEAR VISION FOR THE NATIONAL WILDLIFE REFUGE SYSTEM IN REGION 3

Principal Investigators:	J. Michael Scott
Post Doctoral Researcher:	Katherine Strickler
Student Investigator:	David Rupp
Funding Agency:	U.S. Fish and Wildlife Service
Completion Date:	30 May 2010

Objectives:

- Conduct landscape scale conservation assessments across the Midwest Region of the U. S. Fish and Wildlife Service's National Wildlife Refuge System.

Summary:
The U.S. Fish and Wildlife Service has a long-term goal of permanently conserving breeding, wintering, and migration habitat sufficient to meet migratory bird population targets, and contributing to the conservation of the ecosystems of the United States. We reviewed bird species of concern to the Midwest region and assessed current bird distributions and presence on National Wildlife Refuge System (NWRS) lands alone and in regard to other protected areas, including National Park Service (NPS) lands. We used this information to identify gaps in the current NWRS conservation estate with regard to the current and predicted future distribution of high priority bird species. By collaborating with NPS resource specialists, we were able to identify the degree to which NPS complements the NWRS in bird conservation. We found that targeting national wildlife refuge acquisition and management toward specific groups of species has resulted in good representation of some groups within the NWRS, particularly waterfowl and shorebirds, and has resulted in additional protection for other priority wetland-reliant bird species. However, gaps in the current NWRS conservation estate cannot be understood independently from the representation and redundancy of occurrences on the national network of conservation lands.

IMPLICATIONS OF CLIMATE VARIABILITY FOR OPTIMAL MONITORING AND ADAPTIVE MANAGEMENT IN WETLAND SYSTEMS.

Principal Investigators:	J. Michael Scott, Ph.D. Brad Griffith, Ph.D. USGS, Alaska
Student	Leona K. Svancara
Funding Agency	USGS – RWO 136
Completion:	31 December 2009

Objectives:

- Consult with refuges to determine programs for monitoring.
- Document feasible management actions.

Summary:
We designed and executed a survey for each of the four refuges for two regions. The surveys: 1) identified existing monitoring programs and their rationale, priorities, uses, evaluation methods, and costs; 2) identified climate related system drivers, their mode of action and

relative magnitude effect compared to non-climate drivers; and 3) documented the management actions that were feasible, climate related and the relative costs of actions. We then held 2-day face-to-face meetings with refuge personnel from each region where we: 1) presented a primer on adaptive management and 2) developed a "Decision Elements Worksheet" for each region. The Decision Element Worksheets outlined a regional refuge objective, the expected benefits from achieving the objective, monitoring actions that were available and hypothetical models of how the monitored system was expected to work and the expected environmental drivers and the monitoring elements and expected costs of monitoring. The summary objectives were to 1) maintain an optimum mix of water depth classes in managed wetlands during the spring to fall period for Region 6 refuges and 2) monitor seasonal trends in wetland ponds for Region 7 refuges. Specific details of each regional refuge objective were specified. These details helped to identify the tasks necessary to attain our second objective of identifying the spatial and temporal frequency of sampling necessary to attain reasonable statistical power for detecting relevant changes in habitats/populations. Some trepidation by refuges regarding the exact nature of the project was overcome by the face-to-face meetings. It is likely that we will need to specify a range of potential variance in monitored attributes of refuges rather than estimate the variance directly from data.

BRUNEAU DUNES TIGER BEETLE TAXONOMY

Principal Investigator:	Lisette Waits
Student Investigator:	Caren Goldberg
Funding Agency:	Idaho Department of Fish and Game
Completion Date:	June 2010

Objectives:

- Design a protocol to efficiently and successfully extract high quality DNA from Bruneau Dunes tiger beetle samples while preserving as much tissue as possible for morphological analysis.
- Extract DNA and collect mitochondrial sequence data for over 100 beetles collected by IDFG .
- Conduct phylogenetic analyses to determine the genetic relationships of these samples.

Summary:

We collected samples and analyzed DNA from 147 Bruneau Dunes tiger beetles (*Cicindela waynei*) and St. Anthony Dunes (*C. arenicola*) tiger beetles. We extracted DNA from one middle and one rear leg of these samples using a DNeasy Tissue Kit (Qiagen, Inc., Valencia, CA), substituting PBS (pH 7.2) for ATL and macerating tissue with a mortar and pestle in the presence of PBS, Proteinase K, and AL. We amplified three regions of the mitochondrial genome: cytochrome oxidase III and adjacent $tRNA^{gly}$ and ND3; cytochrome b; and the 16S rRNA gene, adjacent $tRNA^{leu}$ and ND1, totaling 1751 base pairs. Complete sequences were obtained for all 147 samples for each of the three gene regions sequenced, COIII, CytB, and 16S. The COIII alignment was 624 bp in length, the CytB alignment was 407 bp in length, and the 16S alignment was 720 bp in length. Each of these regions aligned unambiguously, requiring no gaps to be introduced into the alignment. The combined, 3-gene alignment had a total aligned length of 1751 bp. Thirty-five variable sites were observed, and these sites defined 30 unique haplotypes

We combined these data with published sequences from closely related tiger beetle species and estimated phylogenetic relationships using maximum likelihood analysis. The Bruneau Dunes tiger beetles formed a distinct, monophyletic clade (81% bootstrap support) that is nested within are larger clade of St. Anthony Dunes tiger beetles. Sequence divergence between individuals of *C. waynei* and *C. arenicola* ranged from 0.11 – 0.57% which is equal to or large than divergences seen between other tiger beetle species. Thus, our phylogenetic analyses revealed strong support for the Bruneau Dunes tiger beetle as a species distinct from the St. Anthony Dunes tiger beetle. We are currently working on a manuscript to submit for publication of this work.

Bruneau Sand Dune tiger beetle, Bruneau Sand Dune State Park, Idaho. Photo © Kent Fothergill 2009.

Awards, Publications, Service and Other Activities of Unit and Unit Collaborating Scientists and Students 1 July 2009 – 30 September 2010

HONORS AND AWARDS

Jessica Buelow

Travel Award, Equal Opportunity Section of American Fisheries Society, to attend 140th American Fisheries Society Meeting, Pittsburgh, PA, September 2010.

Lubia Cajas Cano

Alumni Award for Excellence, Alumni Association University of Idaho. December 2009.

Christine Moffitt

American Fisheries Society Emmeline Moore Prize for Lifetime Contributions to Diversity. American Fisheries Society, September 2010.

American Fisheries Society Special Achievement Award, for steering committee of Symposium 69 Challenges for Diadromous Fishes in a Dynamic Global Environment, April, 2010.

Alumni Award for Excellence, Mentor for Outstanding Graduate Student, Lubia Cajas Cano, University of Idaho, December 2009.

Headquarters Diversity Award, U.S. Geological Survey, September 2009.

Outstanding AFS student subunit, American Fisheries Society - International and Western Division, August 2009.

Michael Quist

Early Achievement in Research Award, College of Agriculture and Life Sciences, Iowa State University, May 2010.

Best Student Poster Award (co-author with undergraduate student, N. P. Johnson), Annual Meeting of the Iowa Chapter of the American Fisheries Society, joint meeting with The Wildlife Society, January 2010.

Best Student Paper Award (co-author with graduate student, J. R. Fischer), Annual Meeting of the Iowa Chapter of the American Fisheries Society, joint meeting with The Wildlife Society, January 2010.

Carl L. Hubbs Best Paper Award (co-author with graduate student, M. C. Dzul), 41st Annual Meeting of the Desert Fishes Council, November 2009.

J. Michael Scott

Spirit of Defenders Award for Public Policy, Defenders of Wildlife, September 2010.

Alumni Award for Excellence, Mentor for Outstanding Graduate Student Leona Svancara, University of Idaho, December 2009.

George Fell Award, Natural Areas Association, September 2009.

Kelly Stockton

Travel Award from Graduate and Professional Student Association to attend American Fisheries Society Pittsburgh, PA, September 2010.

Honorable Mention, Student Scholarship, Equal Opportunity Section of the American Fisheries Society, Pittsburgh, PA, September 2010.
Skinner Memorial Travel Award to attend 140th American Fisheries Society Meeting, Pittsburgh, PA, September 2010.
Travel Award from Graduate and Professional Student Association to attend the Western Division American Fisheries Society Meeting, Salt Lake City, Utah, April 2010.
Student Travel Award to attend Western Division of the American Fisheries Society Meeting Salt Lake City, Utah, April 2010.
Ted Bjornn Scholarship of the Idaho Chapter of the American Fisheries Society, 2010-2011.

Zachary Penney
Puget Sound Anglers Fisheries Scholarship, April 2010.
Skinner Memorial Travel Award to attend 140th American Fisheries Society Meeting, Pittsburgh, PA, September 2010.
Bonneville Power Administration Tribal Student Scholarship.
Truman D. Picard Scholarship, Intertribal Timber Council.
Susan B. Martin Scholarship, Idaho Chapter of the American Fisheries Society.

Leona Svancara
Alumni Award for Excellence, Alumni Association University of Idaho. December 2009.

PEER REVIEWED PUBLICATIONS

Anlauf, K. A., and C. M. Moffitt. 2010. Modeling of landscape variables at multiple extents to predict fine sediments and suitable habitat for *Tubifex tubifex* in a stream system. Freshwater Biology 55:794–805.

Bruce, R. L., and C. M. Moffitt. 2010. Quantifying risks of volitional consumption of New Zealand mudsnails by steelhead and rainbow trout. Aquaculture Research 41:552-558.

Bruce, R. L., C. M. Moffitt, and B. Dennis. 2009. Survival and passage of ingested New Zealand mudsnails through the intestinal tract of rainbow trout. North American Journal of Aquaculture 71:287–301.

Cassinelli, J. and C. M. Moffitt. 2010. Growth and physiology of selected desert and montane adapted populations of redband trout (*Oncorhynchus mykiss gairdneri*). Transactions of the American Fisheries Society 139:339–352.

Colvin, M. E., and C. M. Moffitt. 2009. Evaluation of irrigation canal networks to assess stream connectivity in a watershed. River Research and Applications 25:486-496.

Estes-Zumpf, W. A. J. L. Rachlow, L. P. Waits, and K. I. Warheit. 2010. Dispersal, gene flow, and population genetic structure in the pygmy rabbit (*Brachylagus idahoensis*). Journal of Mammalogy 91:208-219.

Estes-Zumpf, W. A. J. L. Rachlow. 2009. Natal dispersal by pygmy rabbits (*Brachylagus idahoensis*). Journal of Mammalogy 90:363-372.

Fischer, J. R., M. C. Quist, S. L. Wigen, A.J. Schaefer, T.W. Stewart, and T.M. Isenhart. 2010. Assemblage and population level responses of stream fish to riparian buffers at multiple spatial scales. Transactions of the American Fisheries Society 139:185-200.

Fischer, J.R., N.P. Johnson, R.D. Schultz, and M.C. Quist. In press. A comparison of modified fyke nets for evaluating fish assemblages and population structure. Journal of Freshwater Biology.

Haines, A. M., M. Leau, L. K. Svancara, G. Wilson, and J. M. Scott. 2010. Using a distribution and conservation status weighted hot spot approach to identifying areas in need conservation action to benefit Idaho bird species. Northwest Science 84:169-181.

Jackson, Z. J., M. C. Quist, J. A. Downing, and J. G. Larscheid. 2010. Common carp (*Cyprinus carpio*), sport fishes, and water quality: ecological thresholds in agriculturally eutrophic lakes. Lake and Reservoir Management 26:14-22.

Koch, J. D., and M. C. Quist. 2010. Current status and trends in the shovelnose sturgeon (*Scaphirhynchus platorynchus*) management and conservation. Journal of Applied Ichthyology 26:491-498.

Koch, J. D., M. C. Quist, K. A. Hansen. 2009. Precision of hard structures used to estimate age of bowfin in the upper Mississippi River. North American Journal of Fisheries Management. 29:506-511.

Lindstrom, N. M. D. R. Call, M. L. House, C. M. Moffitt, and K. D. Cain. 2009. A quantitative enzyme-linked immunosorbent assay (ELISA) and filtration-based fluorescent antibody test (FAT) as potential tools to screen broodstock for *Flavobacterium psychrophilum* infection. Journal of Aquatic Animal Health 21:43-56.

Neebling, T. E., and M. C. Quist. 2010. Relationships between fish assemblages and habitat characteristics in Iowa's non-wadeable rivers. Fisheries Management and Ecology 17:369-385.

Price, A. J, W. A. Estes-Zumpf, and J. L. Rachlow. 2010. Survival of juvenile pygmy rabbits. Journal of Wildlife Management. 74:43-47.

Quist, M. C., J. L. Stephen, S. T. Lynott, C. S. Guy, J. M. Goeckler, and R. D. Schultz. In press. Exploitation of walleyes in a Great Plains reservoir: harvest patterns and management scenarios. Fisheries Management and Ecology.

Quist, M. C., J. L. Stephen, S. T. Lynott, J. M. Goeckler, and R. D. Schultz. 2010. An evaluation of angler harvest of walleye and saugeye in a Kansas reservoir. Journal of Freshwater Ecology 25:1-7.

Sanchez, D. M., J. L. Rachlow, A. P. Robinson, and T. R. Johnson. 2009. Survey indicators for pygmy rabbits: temporal trends of burrow systems and pellets. Western North American Naturalist 69:426-436.

Scott, J. M., D. D. Goble, A. M. Haines, J. A. Wientz, and M. Neel. 2010. Conservation reliant species and the future of conservation. Conservation Letters 3(2):91-97.

Sindt, A. R., J. R. Fischer, M. C. Quist, and C. L. Pierce. In press. Ictalurids in Iowa's streams and rivers: status, distribution, and relationships with biologic integrity. Catfish 2010: Ecology, Conservation, and Management.

Smith, C. D., T. E. Neebling, and M. C. Quist. In press. Population dynamics of sand shiners in Iowa's non-wadeable rivers. Journal of Freshwater Ecology.

Sparkman, A. J., T. Adams, L. Steury, L. Waits, D. Murray. In press. Helper effects on pup lifetime fitness in the cooperatively breeding red wolf (*Canis rufus*). Proceedings of the Royal Society London, Series B.

Sparkman, A., J Adams, T. Steury, L. Waits, and D. Murray. In press. Direct fitness benefits of delayed dispersal in the cooperatively breeding red wolf (*Canis rufus*). Behavioral Ecology.

Spiegel, J. R., M. C. Quist, and J. E. Morris. 2010. Precision of scales and pectoral fin rays for estimating age of highfin carpsucker, quillback carpsucker, and river carpsucker. Journal of Freshwater Ecology 25:271-278.

Stenglein, J. L., M. De Barba, D. E. Ausband, and L. P.Waits. 2010. Impacts of sampling location within a faeces on DNA quality in two carnivore species. Molecular Ecology Resources 10:109-114.

Svancara, L. K., J. M. Scott, T. R. Loveland and A. B. Pidgorna. 2009. Assessing the Landscape Context and Conversion Risk of Protected Areas Using Satellite Data Products. Remote Sensing of Environment 113:1357-1369.

Williams, C. J., and C. M. Moffitt. 2010. Estimation of fish and wildlife disease prevalence from imperfect diagnostic tests on pooled samples with varying pool sizes. Ecological Informatics 5:273-280.

Zaroban, D., and S. Anglea. 2010. Efficacy of using passive integrated transponder technology to track individual shorthead sculpins. Western North American Naturalist 70:218-223.

BOOKS AND BOOK CHAPTERS

Haro, A. J., K. L. Smith, R. A. Rulifson, C. M. Moffitt, R. J. Klauda, M. J. Dadswell, R. A. Cunjak, J. E. Cooper, K. L. Beal, and T. S. Avery, editors. 2009. Challenges for diadromous fishes in a dynamic environment. American Fisheries Society, Symposium 66. Bethesda, Maryland.

Hubert, W. A. and M. C. Quist, editors. *In press*. Inland fisheries management in North America, Third edition. American Fisheries Society, Bethesda, Maryland.

Mills, L. S., J. M. Scott, K. M. Strickler, and S. A. Temple. 2010. Ecology and Management of Small Populations. Pages 1-41 *in* N. Silvey, editor, Techniques in Wildlife Investigation and Management 7th edition. N. Silvey, ed. The Wildlife Society Bethesda, Maryland.

Moffitt, C. M., G. Whelan, and R. Jackson. 2010. History of inland fisheries management. Pages 1-41 in W. A. Hubert, and M. C. Quist, editors. Inland fisheries management, in North America, third edition. American Fisheries Society, Bethesda, Maryland.

Moffitt, C. M. 2009. Climate change and anthropogenic influences – preamble. Pages 151–153 in A. J. Haro, K. L. Smith, R. A. Rulifson, C. M. Moffitt, R. J. Klauda, M. J. Dadswell, R. A. Cunjak, J. E. Cooper, K. L. Beal, and T. S. Avery, editors. Challenges for diadromous fishes in a dynamic global environment. American Fisheries Society, Symposium 69, Bethesda, Maryland.

Quist, M. C., M. A. Pegg, and D. R. DeVries. *In press*. Age and growth. *In* A. Zale, D. Parrish, and T. Sutton, editors. Fisheries techniques, third edition. American Fisheries Society, Bethesda, Maryland.

TECHNICAL AND SEMI-TECHNICAL REPORTS

Rosenblum. E., C. M. Moffitt, and M. Gaikowski. 2010. Environmental Assessment. Phase II. Detailed assessment of toxicity and risk. Submittal February 2010.

THESES AND DISSERTATIONS

Dixon, Rita D. 2010. Status and conservation of white-headed woodpecker (*Picoides albolarvatus*) in the interior west, USA: A metapopulation. PhD. University of Idaho. Oz Garton.

Erhardt, John. 2010. Age, growth, and stock status of migratory bull trout *Salvelinus confluentus* in the North Fork Clearwater River, Idaho after 14 years of harvest protection. MS. University of Idaho. Dennis Scarnecchia.

Hammann, Ellen. 2010. Assessing spawning habitat selection and quantifying straying rates of wild Chinook salmon (*Oncorhynchus tshawytscha*) in a wilderness basin. MS. University of Idaho. Brian Kennedy.

Lambert, Karoline. 2010. DNA diagnostics for the identification of the native aquatic plant *Myriophyllum sibiricum,* and their hybrids in the Pacific Northwest. MS. University of Idaho. Cort Anderson.

Nelson, Dan. 2010. Food web structure of cave streams in southwestern, Illinois and the survival and growth of the stygophilic gammarus troglophiles (*Crustacea: amphipoda*) under laboratory conditions. MS. University of Idaho. Frank Wilhelm

Polinski, Mark. 2009. Establishing baseline disease susceptibility and diagnostic tools for burbot (*Lota lota*). MS. University of Idaho. Kenneth Cain.

Pollock, Jessica. 2009. Evaluating microclimate and occupancy of natural and artificial cavities for breeding birds. MS. University of Idaho. Kerri Vierling.

Price, A.J. 2009. Survival and burrowing ecology of pygmy rabbits: implications for sagebrush habitat and estimation of abundance. M.S. University of Idaho. Janet Rachlow.

Reyes, Paul. 2010 GIS tools to assess the risks and benefits barrier removal to native fish populations in Idaho. MS. University of Idaho. Christine Moffitt.

Schipper III, Gerrit J. 2010. Mammal diversity, threats and knowledge across spatial scales. PhD. University of Idaho. J. Michael Scott.

Svancara, Leona. 2010. Ecological content and context of the national park system. PhD. University of Idaho. J. Michael Scott.

POSTERS AND PAPERS PRESENTED AT SCIENTIFIC MEETINGS

* indicates presenter

Barenberg A., C. M. Moffitt* and K. Stockton. 2010. Efficacy of Virkon Aquatic to disinfect wading gear infested with New Zealand mudsnails. Annual Meeting of the Idaho Chapter of the American Fisheries Society. Pocatello, Idaho. March. (Poster).

Buelow, J.*, C. M. Moffitt, Z. Penney, K. Hamilton and A. Pape. 2010. Physiological and migrational characteristics of steelhead kelts in the Snake River, Idaho. 140th Annual Meeting of the American Fisheries Society. Pittsburgh, Pennsylvania. September. (Poster).

Buelow*, J., C. Moffitt, Z. Penney, K. Hamilton, A. Pape. 2010. Characteristics of steelhead kelts in the Snake River. Annual Meeting of the Idaho Chapter of the American Fisheries Society. Pocatello, Idaho. March. (Oral).

Burch*, R. M., J. R. Fischer, and M. C. Quist. 2010. Historical trends in ictalurid commercial harvest in the upper Mississippi River. Annual Meeting of the Iowa Chapter of the American Fisheries Society, joint meeting with the Iowa Chapter of The Wildlife Society, Ames, Iowa. January. (Oral).

Cajas Cano*, L. and Christine Moffitt. 2010. Integrating native freshwater mussels with salmonid aquaculture to improve sustainability. Triennial AFS, National Shellfish Association, and World Aquaculture Society Meetings. San Diego, California, March (oral).

Cajas Cano*, L. and C. M. Moffitt. 2009. Life cycle assessment for marine aquaculture production to maximize sustainability. 2nd Annual Western Division of the American

Fisheries Society Student Colloquium, Fort Collins, Colorado. **Best Student Presentation Award,** October.

Cajas Cano*, L. and C. M. Moffitt. 2009. Life cycle assessment integrating mollusks in marine finfish aquaculture to improve sustainability. 63rd Annual Pacific Coast Shellfish Conference. Growers Association, National Shellfish Association, Pacific Coast Section NSA-PCS. September (oral)

Dzul*, M. C., M. C. Quist, S. J. Dinsmore, D. B. Gaines, and K. P. Wilson. 2010. Movement of Salt Creek pupfish *Cyprinodon salinus salinus* in Salt Creek Death Valley National Park, California. 140th Annual Meeting of the American Fisheries Society, Pittsburgh, Pennsylvania. September. (Poster).

Dzul*, M. C., M. C. Quist, and S. J. Dinsmore. 2010. Past, present, and future strategies for the conservation of Devils Hole pupfish. Annual Meeting of the Iowa Chapter of the American Fisheries Society, joint meeting with the Iowa Chapter of The Wildlife Society. Ames, Iowa. January. (Oral).

Dzul*, M. C., M. C. Quist, S. J. Dinsmore, P. M. Dixon, and M. R. Bower. 2009. Sampling designs for monitoring larval Devils Hole pupfish: combining variance components and power analyses. 70th Annual Midwest Fish and Wildlife Conference. Springfield, Illinois, December. (Poster).

Dzul*, M. C., M. C. Quist, S. J. Dinsmore, P. M. Dixon, and M. R. Bower. 2009. Sampling designs for monitoring larval Devils Hole pupfish: combining variance components and power analyses. 41st Annual Meeting of the Desert Fishes Council, Death Valley. California. November. (Poster).

Dzul*, M. C., M. C. Quist, S. J. Dinsmore, P. M. Dixon, and M. R. Bower. 2009. Sources of error in adult Devils Hole pupfish surveys: results of an experimental dive. 41st Annual Meeting of the Desert Fishes Council. Death Valley, California. November. (Oral).

Fischer*, J. R., R. M. Krogman, and M. C. Quist. 2010. Guilty by association: are all benthivorous fishes created equal? 140th Annual Meeting of the American Fisheries Society. Pittsburgh, Pennsylvania. September. (Oral).

Fischer*, J. R. R. M. Burch. and M. C. Quist. 2010. Relative impacts of a native and nonnative benthivorous fish on aquatic ecosystems. Annual Meeting of the Iowa Chapter of the American Fisheries Society, joint meeting with the Iowa Chapter of The Wildlife Society. Ames, Iowa. January. (Oral).

Fischer*, J. R. R. M. Burch. and M. C. Quist. 2009. Effects of black bullhead and common carp on aquatic ecosystems of experimental mesocosms. 70th Annual Midwest Fish and Wildlife Conference. Springfield, Illinois, December. (Oral).

Johnson*, N. P., J. R. Fischer, R. M. Schultz, and M. C. Quist. 2010. A comparison of two different modified fyke nets to sample fish assemblages in Iowa lakes. Annual Meeting of the Iowa Chapter of the American Fisheries Society, joint meeting with the Iowa Chapter of The Wildlife Society. Ames, Iowa. January. (Poster).

Krogman*, R. M., J. R. Fischer, M. C. Quist, M. J. Steuck, and M. M. Marron. 2010. Historical trends in ictalurid catfish commercial harvest in the upper Mississippi River. 2nd International Catfish Symposium. St. Louis, Missouri. June. (Oral).

Moffitt*, C. M. 2010. History of fisheries science in North America. 140th Annual Meeting of the American Fisheries Society, Special Student Colloquium. Pittsburgh, Pennsylvania. September. (Oral).

Neebling*, T. E., and M. C. Quist. 2010. Fish assemblages in Iowa's non-wadeable rivers: Gear assessment, sample size requirements, and habitat relationships. 45th Annual Meeting of the Colorado-Wyoming Chapter of the American Fisheries Society. Laramie, Wyoming. March. (Oral).

Penney*, Z. L., C. M. Moffitt. 2010. Tissue composition, condition and energy storage of sexually mature steelhead trout from the Snake River. 140th Annual meeting of the American Fisheries Society. Pittsburgh, Pennsylvania. September. (Oral).

Penney*, Z., C. M. Moffitt, J. Buelow, K. Hamilton, and A. Pape. 2010. Tissue composition and condition of sexually mature hatchery origin steelhead. Annual meeting of the Idaho Chapter of the American Fisheries Society. Pocatello, Idaho. March. (Oral).

Plumb*, J. M., C. M. Moffitt, and W.P. Connor. 2010 Quantifying the effects of Snake River dam operations on the collection and detection of subyearling fall Chinook salmon. Annual Meeting of the Idaho Chapter of the American Fisheries Society. Pocatello, Idaho. March. (Oral).

Plumb*, J. M., C. M. Moffitt, and W.P. Connor. 2010. A non-parametric assessment of Snake River fall Chinook salmon (*Onchorynchus tshawytscha*) out-migration timing. Annual meeting of the Idaho Chapter of the American Fisheries Society. Pocatello, Idaho. March. (Poster).

Price*, A. J. and J. L. Rachlow. 2009. Development of an Index for Estimating Abundance in Pygmy Rabbit Populations. Annual Meeting of the American Society of Mammalogists. Fairbanks, Alaska. June. (Oral).

Price*, A., W. Estes-Zumpf, and J. Rachlow. 2009. Survival of juvenile pygmy rabbits: factors and management implications. Annual Meeting of the Idaho Chapter of the Wildlife Society. Moscow, Idaho. March. (Poster).

Rachlow, J. L., A. J. Price, and L. A. Shipley. 2010. Effects of pygmy rabbits on vegetation. Annual Meeting of the Idaho Chapter of the Wildlife Society. Boise, Idaho. March. (Oral).

Rachlow, J. L., A. J. Price, L. A. Shipley, D. M. Sanchez, W. A. Estes-Zumpf. 2010. Influence of a dietary specialist on their habitat: pygmy rabbits and sagebrush. Annual Meeting of the American Society of Mammalogists. Laramie, Wyoming. June. (Oral).

Reyes*, P., C. M. Moffitt, and J. Brostrom. 2010. Using GIS to assess the risks and benefits of culvert removal to native bull trout (*Salvelinus confluentus*) in the upper Boise River basin. 140th Annual Meeting of the American Fisheries Society. Pittsburgh, Pennsylvania. September. (Poster).

Reyes*, P., C. M. Moffitt, and J. Brostrom. 2010. Barrier removals: tools to assess the risks of invasive species. Annual Meeting of the Western Division of the American Fisheries Society. Salt Lake City, Utah. April. (Oral).

Reyes*, P., C. M. Moffitt, and J. Brostrom. 2010. GIS tools to assess the risks and benefits of barrier removal to native fish populations in Idaho trout. Annual Meeting of the Idaho Chapter of the American Fisheries Society. Pocatello, Idaho. March. (Oral).

Scott, J. M. 2010. Conservation reliant species: our new relationship with nature. American Ornithologists' Cooper Society. San Diego, California. February. (Oral).

Scott, J. M. 2010. Conservation-reliant species: our new relationship with nature. Society for Ecological Restoration. Rutgers University. New Brunswick, New Jersey. February. (Oral).

Scott. J. M. 2010. Working across borders to conserve landscapes. Annual Meeting of the Western Governors' Association. Whitefish, Montana. June. (Oral).

Scott. J. M. 2010. Managing public lands in an era of climate change: research and management needs. Great Basin/Mojave Desert Climate Change workshop. Las Vegas, Nevada. April. (Oral).

Scott, J. M. 2009. Conservation reliant species: policy and management implications. University of Montana. Missoula, Montana. November. (Oral).

Scott, J. M. 2009. Design of natural reserves in a world change. The VII Congresso Sobre Areas Naturales Protegides. San Luis Potosi, Mexico. 13 July. (Oral).

Sindt*, A. R., C. L. Pierce, and M. C. Quist. 2010. Validation of occurrence models with emphasis on fish species of greatest conservation need in Iowa streams. 140th Annual Meeting of the American Fisheries Society. Pittsburgh, Pennsylvania. September. (Oral).

Sindt*, A. R., J. R. Fischer, M. C. Quist, and C. L. Pierce. 2010. Ictalurids in Iowa's streams and rivers: status, distribution, and relationships with biotic integrity. 2nd International Catfish Symposium. St. Louis, Missouri. June. (Oral).

Sindt*, A. R., M. C. Quist, and C. L. Pierce. 2010. The occurrence of focal Iowa stream fish species of greatest conservation need. Annual Meeting of the Iowa Chapter of the American Fisheries Society, joint meeting with the Iowa Chapter of The Wildlife Society. Ames, Iowa. January. (Oral).

Sindt*, A. R., M. C. Quist, and C. L. Pierce. 2009. The occurrence and habitat relationships of seven Iowa stream fish species of greatest conservation need. 70th Annual Midwest Fish and Wildlife Conference. Springfield, Illinois. December. (Oral).

Spiegel*, J. R., M. C. Quist, and J. E. Morris. 2010. Summer food habits and gill raker morphology of seven catostomid species in Iowa rivers. Annual Meeting of the Iowa Chapter of the American Fisheries Society, joint meeting with the Iowa Chapter of The Wildlife Society. Ames, Iowa. January. (Oral).

Stockton*, K., and C. M. Moffitt 2010. Development of biosecurity measures for aquaculture facilities to protect against invasive mollusks. 140th Annual Meeting of the American Fisheries Society. Pittsburgh, Pennsylvania. September. (Oral).

Stockton*, K., and C. M. Moffitt 2010. Hatchery biosecurity to protect against invasive mollusks. Annual Meeting of the Western Division of the American Fisheries Society. Salt Lake City, Utah. April. (Oral).

Stockton*, K., and C. M. Moffitt 2010. Development of biosecurity measures for hatcheries to protect against invasive mollusks. Annual meeting of the Idaho Chapter of the American Fisheries Society. Pocatello, Idaho. March. (Oral).

Stockton*, K., C. M. Moffitt. 2010. Development of biosecurity measures for aquaculture facilities. 140th Annual Meeting of the American Fisheries Society. Pittsburgh, Pennsylvania. September. (Oral).

Stockton*, K., C. M. Moffitt. 2010. Development of biosecurity measures for hatcheries to protect against invasive mollusks. Annual Meeting of the Western Division of the American Fisheries Society. Salt Lake City, Utah. April. (Oral).

TECHNICAL ASSISTANCE OUTREACH AND PROFESSIONAL SOCIETY ACTIVITIES

Outreach presentations and workshops

Cajas Cano, L. 2010. Workshop leader: Central American Youth Ambassador Program. U.S. Department of State, Bureau of Educational and Cultural Affairs in conjunction with Center for Intercultural Education and Development at Georgetown University, Washington, DC.

Moffitt, C. M. 2010. Snake River steelhead trout: increasing their capacity for successful return. University of Idaho Physics Department Annual Banquet. April 30. Moscow Idaho.

Moffitt, C. M. 2010. Plenary and business meeting awards ceremonies for annual meeting of the American Fisheries Society. Pittsburgh, Pennsylvania. September.

Moffitt, C. M. 2010. Webinar. Management of BKD and erythromycin drug therapy for Alaska Hatchery Managers. Anchorage, Alaska. 16 January.

Moffitt, C. M. 2010. Minority recruitment in the Cooperative Research Units. Breakout session. National Meeting Hotel Monteleone. New Orleans, Louisiana. March 1–5.

Moffitt, C. M. and K. Stockton. 2010. Workshop on invasive mollusks for Idaho Department of Fish and Game. Two-day workshop on identification of invasive mollusks, HACCP process, and quality assurance.

Penney, Zachary. 2010. Native American fishing and fishing rights in the Pacific Northwest: more than just a tradition. Guest lecturer, Fisheries Resources Seminar Fish 401. University of Idaho. March.

Penney, Zachary. 2009 An Introduction to salmon ecology and management in the Snake River subbasin. Guest lecturer for the Cultural Interpretations of the Regional Landscape Class. Washington State University. December.

Quist, M. C. 2010. Beverton-Holt yield models workshop. Iowa Department of Natural Resources. Ames, Iowa. January.

Quist, M. C. 2010. Iowa wildlife action plan implementation committee. Iowa Department of Natural Resources.

Scott, J. M. 2010. Conservation reliant species: our new relationship with nature. Honors Seminar, University of Idaho. Moscow, Idaho. 10 February. (Oral)

Scott, J. M. 2010. Science management in a world change. U.S. Fish & Wildlife Service Science Committee for National Wildlife Refuge System, Webinar. 27 September.

Scott, J. M., 2010. Science and scientists at the policy interface: roles and responsibilities. Cooperative Research Units' All Hands Meeting, Session Moderator. New Orleans Louisiana. 1 March.

Scott, J. M., 2010. Conservation reliant species, symposium chair the Wildlife Society. Monterey, California. September.

Scott, J. M., and J. Rachlow. 2010. The science policy interface: roles and responsibilities of professionals and professional societies. The Wildlife Society. September.

Stockton K., L. Cajas Cano, K. Pilcher, and J. Lords. 2010. 2nd annual Western Division student colloquium. Presented at the Idaho Chapter American Fisheries Society Annual Meeting. Pocatello, Idaho, March (Poster).

Stockton K, and N. Cathcart. 2010. 2nd annual Western Division student colloquium. Presented at the Western Division of the American Fisheries Society Annual Meeting. Salt Lake City, Utah. April. (Poster).

Editorial and Professional Society Boards, and other Activities

C. M. Moffitt.2005 – present: Associate editor *Transactions of the American Fisheries Society.*

M.C. Quist. 2009-2010. President-elect, Education Section of the American Fisheries Society.

J. M. Scott: Member editorial board American Institute of Biological Sciences.
Member publication and policy committee, Society for Conservation Biology.
Member Doris Duke Charitable Foundation Science Advisory Board
Member Lava Lake Foundation for Science and Conservation Science Advisory Board

Left: Andy Pape and Amber Barenberg take measurements at Dworshak National Fish Hatchery. Photo by Kelly Stockton.

Right: Natalie Bogues from Point of Defiance Zoo collects scat for the wolf-coyote hybridization study. Photo by Justin Bohling.

Left: Tim Copeland (IDFG) and graduate student Jessica Buelow cut a log on the weir at Fish Creek weir. Photo by Bryan Jones.