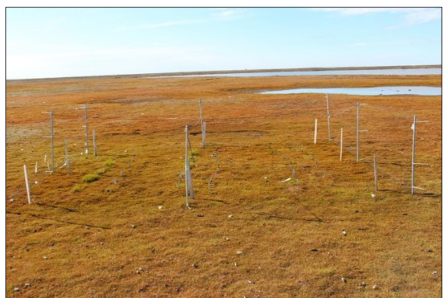
Alaska Cooperative Fish and Wildlife Research Unit

Annual Research Report—2018



Alaska Cooperative Fish and Wildlife Research Unit
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Photo 1: Researcher Elyssa Watford surveying a barrier island along the Beaufort Sea coast for nesting common eiders. Photo credit: Claire Montgomerie.
Photo 2: Research garden on the North Slope for the "Morphological, Genetic, and Physiological Variation among Arctic and Subarctic *Carex"* research project.
Photo 3: Joelle Hepler prepares to head north for calving surveys. Photo credit: Dennis Miller (Super Cub pilot).

Unit Roster

Federal Scientists

- Brad Griffith: Leader (Retired June 2018)
- Jeff Falke: Acting Leader (Effective July 2018) and Assistant Leader-Fisheries
- Dave McGuire: Senior Scientist (Retired April 2018)
- Mark Wipfli: Assistant Leader-Fisheries

University Staff

- Monica Armbruster: Fiscal Professional
- Deanna Klobucar: Project Biologist and Laboratory Manager

Unit Students and Post-Doctoral Researchers

Current

- Donald Arthur, MS Fisheries Student (Falke)
- Olivia Edwards, MS Fisheries Student (Falke)
- Dan Govoni, PhD Biological Sciences Candidate (Wipfli)
- Jess Grunblatt, PhD Interdisciplinary Studies Candidate (Wipfli and Adams)
- Joelle Hepler, MS Wildlife Biology and Conservation Candidate (Griffith and Falke)
- Elizabeth Hinkle, PhD Fisheries Student (Falke)
- Philip Joy, PhD Fisheries Candidate (Wipfli)
- Jason Leppi, PhD Fisheries Candidate (Wipfli)
- Benjamin Meyer, MS Fisheries Candidate (Wipfli)
- Kelly Overduijn, MS Wildlife Biology and Conservation Candidate (Powell)
- Christopher Sergeant, PhD Fisheries Student (Falke)

Post-Doctoral Researchers

- Charlotte Gabrielsen (Griffith)
- Stephen Klobucar (Falke)

Graduated in CY 2018

- Megan Boldenow, MS Biological Sciences (Powell)
- Chase Jalbert, MS Fisheries (Falke and Westley)
- Vijay Patil, PhD Biological Sciences (Griffith and Euskirchen)

University Cooperators

- Barbara Adams, Independent Studies Program-UAF
- Milo Adkison, College of Fisheries and Ocean Sciences (CFOS)-UAF
- Robert Bolton, International Arctic Research Consortium (IARC)-UAF
- Amy Breen, IARC
- Eugénie Euskirchen, IAB
- Hélène Genet, IAB

- Brad Griffith, IAB
- Larry Hinzman, Vice Chancellor for Research (UAF)
- Tuula Hollmén, CFOS/Institute of Marine Science (IMS), Alaska SeaLife Center
- Kris Hundertmark, Department of Biology and Wildlife (DBW) and IAB
- Katrin Iken, CFOS
- Knut Kielland, IAB
- Paul Layer, Vice President for Academics, Students, and Research (UA Statewide)
- Mark Lindberg, DBW and IAB
- J. Andrés López, CFOS
- Sergey Marchenko, Geophysical Institute (GI)-UAF
- A. David McGuire, IAB
- Dmitry Nicolsky, GI
- Abby Powell, Florida CFWRU
- Anupma Prakash, CNSM and Provost UAF
- James Reynolds, Emeritus UAF
- Vladimir Romanovsky, GI
- Amanda Rosenberger, Tennessee Cooperative Fishery Research Unit
- Roger Ruess, DBW and IAB
- T. Scott Rupp, Scenarios Network for Alaska and Arctic Planning (SNAP)-UAF
- Erik Schoen, IAB
- Andy Seitz, CFOS
- Trent Sutton, CFOS
- Dave Verbyla, School of Natural Resources and Extension-UAF
- Peter Westley, CFOS
- Diana Wolf, IAB

Affiliated Students and Post-Doctoral Researchers

Current

- Iris Cato, MS Biology Candidate (Ruess and Wolf)
- Genevieve Johnson, MS Fisheries Candidate (López)
- Matthew Kynoch, MS Biology and Wildlife Student (Kielland)
- Christopher Latty, PhD Marine Biology Candidate (Hollmén)
- Elyssa Watford, MS Wildlife Biology and Conservation Candidate (Hollmén and Lindberg)
- Wilhelm Wiese, MS Wildlife Conservation Candidate (Hollmén and Lindberg)

Affiliated Post-Doctoral Researchers

- Heather Greaves (Breen)

Cooperators

- Brian Barnes–Director, Institute of Arctic Biology, University of Alaska Fairbanks
- Sam Cotten–Commissioner, Alaska Department of Fish and Game

- Doug Vincent-Lang–Acting Commissioner (effective December 2018), Alaska Department of Fish and Game
- Greg Siekaniec–Director, Region 7, US Fish and Wildlife Service
- Chris Smith–Western Field Representative, Wildlife Management Institute
- Kevin Whalen–Unit Supervisor, Cooperative Research Units, US Geological Survey

This is the Annual Report for the Alaska Cooperative Fish and Wildlife Research Unit, highlighting activities for calendar year 2018. The Unit engages in research on living natural resources for a variety of State and Federal agencies. As an unbiased research organization, the Unit provides information requested and funded by these agencies. When studies are completed, the agencies use the information to assist in their natural resource management efforts. Most of the research is conducted by graduate students, many of whom go on to work for the agencies upon graduation.

The Alaska Unit was established in 1950, providing over half a century of research dedicated to helping conserve and enhance the living natural resources of the State and the Arctic Region. The Unit is part of a larger and even older program, the US Department of the Interior's Cooperative Research Unit Program. Established in 1935, Cooperative Research Units were created to fill the vacuum of wildlife management information and the shortage of trained wildlife biologists. In 1960, the Unit Program was formally sanctioned by Congress with the enactment of the Cooperative Units Act. Each unit is a partnership between the Ecosystems Mission Area of the US Geological Survey, a State fish and game agency, a host university, and the Wildlife Management Institute. Staffed by Federal personnel, Cooperative Research Units conduct research on renewable natural resource questions; participate in the education of graduate students destined to become natural resource managers and scientists; provide technical assistance and consultation to parties who have legitimate interests in natural resource issues; and provide continuing education for natural resource professionals. Presently, there are 40 Cooperative Research Units in 38 states, conducting research on virtually every type of North American ecological community. The Program is staffed by more than 100 PhD scientists who advise as many as 675 graduate student researchers per year.

Statement of Direction

The research program of the Unit will be aimed at understanding the ecology of Alaska's fish and wildlife; evaluating impacts of land use and development on these resources; and relating effects of social and economic needs to production and harvest of natural populations.

In addition to the expected Unit functions of graduate student training/ instruction and technical assistance, research efforts will be directed at problems of productivity, socioeconomic impacts, and perturbation on fish and wildlife populations, their habitats and ecosystems. Fisheries research will emphasize water quality, habitat characteristics, and life history requirements of northern fish populations. Wildlife research will focus on the ecology of northern birds and mammals and their habitats. Unit research will also be directed at integrated studies of fish and wildlife at the ecosystem level.

Unit Cost-Benefit Statements

In-Kind Support

In-kind support, usually operational support of field activities, is critical to the success of the Alaska Cooperative Fish and Wildlife Research Unit. Although the monetary value of this support is not known, a listing of the assistance is provided for each project in this report.

Benefits

Students Graduated: 3 (advised by Unit faculty)
Presentations: 19
Scientific and Technical Publications: 17

Courses Taught

Jeff Falke: Fisheries and Ocean Sciences Seminar (1 credit, Spring 2018)
Jeff Falke: Research Design (3 credits, Fall 2018)

Papers Presented

Bellmore, J.R., R. Bellmore, D. Holen, C. Sergeant, and J. Falke. August 2018. Southeast Alaska freshwater temperature monitoring. Southeast Environmental Conference, 28 August 2018. Juneau, AK.

Cathcart, C.N., J.A. Falke, B. Crabill, and J. Fox. May 2018. Longitudinal patterns of logjams and occupancy by juvenile Chinook Salmon in the Chena River, Alaska. Western Division American Fisheries Society Annual Meeting, 21–25 May 2018. Anchorage, AK. (Invited Oral)

Clawson, C.M., J.A. Falke, P.A.H. Westley, J. Rose, and A.E. Martin. May 2018. Spawning habitat characteristics and phenology of fall Chum Salmon (*Oncorhynchus keta*) on the Teedriinjik River, Alaska. Western Division American Fisheries Society Annual Meeting, 21–25 May 2018. Anchorage, AK. (Invited Oral)

Collins, S.F., A.M. Marcarelli, C.V. Baxter, and M.S. Wipfli. August 2018. A critical assessment of the ecological assumptions underpinning compensatory mitigation of salmon-derived nutrients. Special session: Habitat Enhancement for Conservation and Management in Marine and Freshwater Environments: Effects and Mechanisms of Response. American Fisheries Society Annual Meeting, 20–24 August 2018. Atlantic City, NJ. (Contributed Oral)

Falke, J.A., B.M. Huntsman, and E.R. Schoen. August 2018. Growth potential of juvenile Chinook Salmon (*Oncorhynchus tshawytscha*) across a boreal riverscape. American Fisheries Society Annual Meeting, 20–24 August 2018. Atlantic City, NJ (Invited Oral)

Genet, H., A.D. McGuire, R.W. Bolton, E.S. Euskirchen, and V. Romanovsky. June 2018. Modeling vulnerability to thermokarst disturbance in boreal Alaska. Polar 2018 Conference, 22–26 June 2018. Davos, Switzerland. (Contributed Oral)

Heim, K.C., T.E. McMahon, J.A. Falke, and M.S. Wipfli. August 2018. Unexpected places: the use of temporary aquatic habitats by fish, implications for conservation, and research needs. American Fisheries Society Annual Meeting, 20–24 August 2018. Atlantic City, NJ. (Contributed Oral)

Hewitt, R.E., H. Genet, D.L. Taylor, A.D. McGuire, and M. Mack. June 2018. The effects of deep nitrogen and root traits on arctic vegetation dynamics. Polar 2018 Conference, 22–26 June 2018. Davos, Switzerland. (Contributed Oral)

Jalbert, C., J. Falke, P. Westley, J.A. López, K. Dunker, and A. Sepulveda. May 2018. Assessing vulnerability of salmonids to invasion of Northern Pike in Southcentral Alaska. Western Division American Fisheries Society Annual Meeting, 21–25 May 2018. Anchorage, AK. (Invited Oral)

Jalbert, C., J. Falke, P. Westley, J.A. López, K. Dunker, and A. Sepulveda. August 2018. Assessing vulnerability of salmonids to invasion of Northern Pike in Southcentral Alaska. American Fisheries Society Annual Meeting, 19–23 August 2018. Atlantic City, NJ. (Contributed Oral)

Leppi, J., M. Wipfli, A. Liljedahl, D. Rinella, and M. Whitman. May 2018. Potential implications of climate change for Broad Whitefish (*Coregonus nasus*) in arctic Alaska. Western Division American Fisheries Society Annual Meeting, 21–25 May 2018. Anchorage, AK. (Invited Oral)

Meyer, B., M. Wipfli, D. Rinella, E. Schoen, and J. Falke. May 2018. Growth and foraging patterns of juvenile Chinook and Coho Salmon in three geomorphically distinct sub-basins of the Kenai River. Western Division American Fisheries Society Annual Meeting, 21–25 May 2018. Anchorage, AK. (Contributed Oral)

Neuneker, K., J. Falke, M. Cox, and J. Nichols. May 2018. Proximate composition and bioelectrical impedance analysis of Yukon River Chinook Salmon. Western Division American Fisheries Society Annual Meeting, 21–25 May 2018. Anchorage, AK. (Invited Oral)

Neuswanger, J., M. Wipfli, and A. Rosenberger. May 2018. Feeding ecology of juvenile Chinook Salmon in the Chena River, interior Alaska. Western Division American Fisheries Society Annual Meeting, 21–25 May 2018. Anchorage, AK. (Invited Oral)

Schoen, E., M. Wipfli, E. Trammel, D. Rinella, A. Floyd, J. Grunblatt, et al. May 2018. Future of salmon in the face of change: Lessons from one of the world's remaining productive salmon regions. Western Division American Fisheries Society Annual Meeting, 21–25 May 2018. Anchorage, AK. (Contributed Oral)

Sergeant, C.J., and J.A. Falke. May 2018. A flexible and intuitive approach for categorizing streamflow patterns in Southeast Alaska. Western Division American Fisheries Society Annual Meeting, 21–25 May 2018. Anchorage, AK. (Contributed Oral)

Sparks, M.M., J.A. Falke, P.A.H. Westley, M.D. Adkison, K. Bartz, T.P. Quinn, D.E. Schindler, and D. Young. February 2018. Predicting developmental phenology in wild populations: a case study with western Alaska sockeye salmon. Indiana Chapter American Fisheries Society Annual Meeting, 12–13 February 2018. Lafayette, IN. (Contributed Oral)

Tibbles, M., J.A. Falke, A.R. Mahoney, M.D. Robards, and A.C. Seitz. May 2018. An InSAR habitat suitability model to identify overwinter conditions for coregonine whitefishes in Arctic lagoons. Western Division American Fisheries Society Annual Meeting, 21–25 May 2018. Anchorage, AK.

Wipfli, M. May 2018. Patterns of food web responses to marine nutrients in stream ecosystems. Western Division American Fisheries Society Annual Meeting, 21–25 May 2018. Anchorage, AK. (Invited Oral)

Scientific Publications

Calef, M.P., A. Varvak, and A.D. McGuire. 2017. Differences in human versus lightning fires between urban and rural areas of the boreal forest in Interior Alaska. Forests 8, paper 422, 15 pages. doi:10.3390/f8110422.

Fraley, K.M., J.A. Falke, M.V. McPhee, and A. Prakash. 2018. Rainbow trout movement behavior and habitat occupancy are influenced by sex and Pacific salmon presence in an Alaska river system. Canadian Journal of Fisheries and Aquatic Sciences 75:525-537. dx.doi.org/10.1139/cjfas-2016-0459.

Genet, H., Y. He, Z. Lyu, A.D. McGuire, Q. Zhuang, J. Clein, et al. 2018. The role of driving factors in historical and projected carbon dynamics of upland ecosystems in Alaska. Ecological Applications 28:5-27. doi:10.1002/eap.1641.

Lara, M.J., I. Nitze, G. Grosse, P. Martin, and A.D. McGuire. 2018. Reduced arctic tundra productivity linked with landform and climate change interactions. Scientific Reports 8, Article number 2345, 10 pages. doi:10.1038/s41598-018-20692-8.

Lara, M.J., I. Nitze, G. Grosse, and A.D. McGuire. 2018. Tundra landform and vegetation productivity trend maps for the Arctic Coastal Plain of northern Alaska. Scientific Data 5: Article number: 180058, 10 pages. doi:10.1038/sdata.2018.58.

Laske, S.M., A.E. Rosenberger, M.S. Wipfli, and C.E. Zimmerman. 2018. Generalist feeding strategies in Arctic freshwater fish: a mechanism for dealing with harsh environments. Ecology of Freshwater Fish 27:767-784. doi: 10.1111/eff.12391.

Li, Z., J. Xia, A. Ahlstrom, A. Rinke, C. Koven, D.J. Hayes, D. Ji, G. Zhang, G. Krinner, G. Chen, W. Cheng, J. Dong, J. Liang, J.C. Moore, L. Jiang, L. Yan, P. Ciais, S. Peng, Y.-P. Wang, X. Xiao, Z. Shi, A.D. McGuire, and Y. Luo. 2018. Non-uniform seasonal warming regulates vegetation greening and atmospheric CO_2 amplification over northern lands. *Environmental Research Letters* 13, paper 124008, 10 pages. doi:10.1088/1748-9326/aae9ad.

Lyu, Z., H. Genet, Y. He, Q. Zhuang, A.D. McGuire, A. Bennett, et al. 2018. The role of environmental driving factors in historical and projected carbon dynamics of wetland ecosystems of Alaska. Ecological Applications 28:1377-1395. doi:10.1002/eap.1755.

Matter, A.N., J.A. Falke, J.A. López, and J.W. Savereide. 2018. A rapid-assessment method to estimate the distribution of juvenile Chinook salmon in tributary habitats using eDNA and occupancy estimation. North American Journal of Fisheries Management 38:223-236. doi:10.1002/nafm.10014.

McGuire, A.D., H. Genet, Z. Lyu, N. Pastick, S. Stackpoole, R. Birdsey, et al. 2018. Assessing historical and projected carbon balance of Alaska: A synthesis of results and policy/management implications. Ecological Applications 28:1396-1412. doi:10.1002/eap.1768.

McGuire, A.D., D.M. Lawrence, C. Koven J.S. Clein, E. Burke, G. Chen, et al. 2018. Dependence of the evolution of carbon dynamics in the northern permafrost region on the trajectory of climate change. Proceedings of the National Academy of Sciences 115:3882-3887. doi:10.1073/pnas.1719903115.

McGuire, A.D., Z. Zhu, R. Birdsey, Y. Pan, and D. Schimel. 2018. Introduction to the Alaska Carbon Cycle invited feature. *Ecological Applications* 28:1938-1939. doi:10.1002/eap.1808.

Melvin, A.M., G. Celis, J.F. Johnstone, A.D. McGuire, H. Genet, E.A.G. Schuur, T.S. Rupp, and M.C. Mack. 2018. Fuel-reduction management alters plant composition, carbon and nitrogen pools, and soil thaw in Alaskan boreal forest. Ecological Applications 28:149-161. doi:10.1002/eap.1636.

Powell, J., M. Wipfli, K. Criddle, and E. Schoen. 2018. Will Alaska's fisheries regime prove resilient? Kenai River fishery management as a model for adaptive governance. Fisheries 43:26-30. doi:10.1002/fsh.10022.

Romanovsky, V., K. Isaksen, D. Drozdov, O. Anisimov, A. Instanes, M. Leibman, A.D. McGuire, N. Shiklomanov, S. Smith, D. Walker, and contributing authors. 2017. Changing permafrost and its impacts. Chapter 3 in Snow, Water, Ice, and Permafrost in the Arctic (SWIPA) 2017. Pages 65-102. Arctic Monitoring and Assessment Programme (AMAP), Oslo, Norway.

Roon, D., M. Wipfli, and J. Kruse. 2018. Riparian defoliation by the invasive green alder sawfly influences terrestrial prey subsidies to salmon streams. Ecology of Freshwater Fish 27:963–975. doi: 10.1111/eff.12407.

Tibbles, M., J.A. Falke, A.R. Mahoney, M.D. Robards, and A.C. Seitz. 2018. An interferometric synthetic aperture radar (InSAR) habitat suitability model to identify overwinter conditions for Coregonine whitefishes in Arctic lagoons. Transactions of the American Fisheries Society 147:1167-1178. doi:10.1002/tafs.10111.

Theses and Dissertations of Unit-Sponsored Graduate Students

Boldenow, Megan L. 2018. Do wintering conditions drive population trends in semipalmated sandpipers (*Calidris pusilla*)? Evidence from a corticosterone biomarker. MS Thesis, University of Alaska Fairbanks. 148 pp.

Jalbert, Chase S. 2018. Impacts of a top predator (*Esox lucius*) on salmonids in southcentral Alaska: Genetics, connectivity, and vulnerability. MS thesis, University of Alaska Fairbanks. 137 pp.

Patil, Vijay P. 2018. Shrinking boreal lakes as agents of change: Untangling structure and function in hydrologically-coupled lakes and wetlands. PhD dissertation, University of Alaska Fairbanks. 192 pp.

Reports are listed as Completed or Ongoing in the categories of Aquatic, Terrestrial, or Ecological Studies. The List of Abbreviations appears on the final page of the report.

Completed Aquatic Studies

Impacts of a Top Predator (*Esox lucius*) on Salmonids in Southcentral Alaska: Genetics, Connectivity, and Vulnerability

Student Investigator: Chase Jalbert, MS Fisheries
Co-Advisors: Jeff Falke and Peter Westley (CFOS)
Funding Agencies: Sport Fish Division, Region 2 ADF&G (Sport Fish Base); USGS Northern Rocky Mountain (NOROCK) Science Center (RWO 226)
In-Kind Support: Personnel and operational support provided by ADF&G

Note: Chase Jalbert graduated from the University of Alaska Fairbanks in December 2018. His thesis abstract follows:

Abstract: Worldwide invasion and range expansion of northern pike (pike; *Esox lucius*) have been linked to the decline of native fishes and new techniques are needed to assess the effects of invasion over broad geographic scales. In Alaska, pike are native north and west of the Alaska Mountain Range but were introduced into Southcentral Alaska in the 1950s and again in the 1970s. To investigate the history of the invasion into Southcentral Alaska, I identified 7,889 single nucleotide polymorphisms (SNPs) from three native and seven introduced populations in Alaska and examined genetic diversity, structure, and affinities of native and invasive pike. Pike exhibited low genetic variability in native populations (mean heterozygosity = 0.0360 and mean π = 0.000241) and further reductions in introduced populations (mean heterozygosity = 0.0227 and mean π = 0.000131), which suggests a bottleneck following introduction. Population differentiation was high among some populations (global F_{ST} = 0.424; max F_{ST} = 0.668) when compared to other freshwater fishes. I identified five genetically distinct clusters of populations, consisting of three native groups, a single Susitna River basin invasive group, and a Kenai Peninsula group, with little evidence of admixture among groups. The extremely reduced genetic diversity observed in invasive northern pike populations does not appear to affect their invasion success as the species range Southcentral Alaska continues to expand. To assess the vulnerability of five species of Pacific salmon (*Oncorhynchus* spp.) to the invasion, I combined intrinsic potential habitat modeling, connectivity estimates, and Bayesian networks across 22,875km of stream reaches in the Matanuska-Susitna basin, Alaska, USA. Pink salmon were the most vulnerable species, with 15.2% (2,458 km) of their range identified as “highly” vulnerable. They were followed closely by chum salmon (14.8%) and coho salmon (14.7%). Finally, analysis of the intersection of vulnerable salmon habitats revealed 1,001 km of streams that were highly vulnerable for all five Pacific salmon. This framework is easy to implement, adaptable to any species or region, and cost effective. With increasing threats of species introductions, fishery managers need new tools like those described here to efficiently identify critical areas shared by multiple species, where management actions can have the greatest impact.

Ongoing Aquatic Studies

Chena River Juvenile Chinook Salmon Large Wood Habitat Mapping

Student Investigator: NA, technicians only
Advisor: Jeff Falke
Funding Agency: USFWS Subsistence Fisheries Branch (RWO223)
In-Kind Support: USFWS Fisheries and Habitat Restoration Branch; Tanana Valley Watershed Association

Technicians traveling to their study sites along the Chena River. Photo by J.R. Ancheta, UAF.

Large woody debris (e.g., logjams, rootwads; LWD) within the channel provide important rearing habitat for fishes, and especially for juvenile Chinook Salmon in interior Alaska rivers, including the Chena River. For juvenile salmon, LWD provides cover from predation, refuge from high flow velocities, and high-quality habitat for invertebrate prey items. However, the distribution, abundance, and characteristics of LWD, particularly within stream reaches where juvenile Chinook Salmon are known to rear, have yet to be quantified in the Chena River basin. Our objectives are to (1) georeference and make simple measurements of LWD along the entire rearing distribution of juvenile Chinook Salmon in the upper Chena River, and potential rearing distribution in the lower river, during June 2017; (2) relate characteristics (e.g., size, location, composition) of LWD to use (i.e., presence) by juvenile Chinook Salmon for a subset of LWD habitats identified in Objective 1 during July and August 2017; and (3) communicate the importance of LWD as juvenile Chinook Salmon habitat to the public. We floated the distribution of juvenile Chinook Salmon rearing habitats within the Chena River basin and made a rapid categorical estimate of LWD characteristics. The result of this survey will be a digital map with the location and attributes of individual LWD throughout the juvenile rearing area. Subsequently, we will randomly select LWD to sample for occurrence and abundance of juvenile Chinook Salmon using snorkeling and videography. Finally, we will share the progress of our work with the community by hosting Chena River Chinook Salmon activities in conjunction with major community events along the riverfront in Fairbanks, create a website aimed at the local community to disseminate the results of our study, develop fact sheets about using LWD for streambank restoration by homeowners, and provide educational materials about Chinook Salmon in the Yukon River drainage. We measured habitat attributes (e.g., submerged area, formative fluvial process, etc.) for all logjams (N=429) and conducted fish snorkel counts for a randomly-selected subset (N=189) of logjams within the known distribution (283 stream-km) of juvenile Chinook Salmon rearing in the Chena River basin, Alaska, during summer 2017. Logjam density and potential wood recruits (i.e., downed trees) declined downstream (33 recruits/km, 6 logjams/km; 6 recruits/km; 0.3 logjams/km, respectively), particularly below Moose Creek Dam, which is thought to intercept wood from the upper basin. Logjam size (submerged area; m2) increased downstream. In upstream reaches smaller logjams formed on fallen trees or gravel bars in higher velocity channel units (i.e., riffles, runs), and larger logjams downstream formed on fallen trees or meanders in pools. We found no evidence of snorkeling observer bias, and juvenile salmon were present at 68% of logjams and their density (fish/ m2) ranged from 0.0002 to 9.0000. The highest densities occurred in the middle reaches of the network and corresponded with high quality adult spawning habitats. Our current work focuses on modeling juvenile salmon density as a function of logjam characteristics and unbiased population estimates using a spatial-stream-network model. Results of this project will be used to evaluate the potential for reintroduction of LWD to reaches of the Chena River below Moose Creek Dam, provide juvenile salmon rearing capacity estimates for the basin, and contribute towards efforts to monitor LWD based on remote 5sensing and link the distribution and abundance of wood along the river to wildfire and land management practices.

Spawning Potential Ratio Assessment and Sensitivity Analysis Utilizing Estimates of Age at Maturity and Fecundity for Yelloweye Rockfish in Prince William Sound, AK

Student Investigator: Donald Arthur, MS Fisheries
Advisor: Jeff Falke
Funding Agency: Region 2 ADF&G (Sport Fish Base)
In-Kind Support: Personnel and operational support provided by ADF&G

Yelloweye Rockfish (*Sebastes ruberrimus*) are a highly valued catch in recreational and commercial fisheries throughout Alaska and make up an important portion of the subsistence harvest in communities along the Gulf of Alaska. However, no management or assessment strategies exist for Yelloweye Rockfish in Prince William Sound, and to date no abundance estimates have been made. In this study, we intend to create a framework or threshold for harvest that can be applied to the management of Yelloweye Rockfish in Prince William Sound. A Spawning Potential Ratio (SPR) model will be used to compare the spawning production per recruit at the current harvest level over its life time when compared to an unfished population. The model requires inputs such as the age (A50) or length (L50) at which 50% of the population is sexually mature. Our objectives are to (1) generate estimates of A50/L50 through histological examination of Yelloweye Rockfish ovaries and generate a model for age-specific fecundity of the species in Prince William Sound, and (2) use the results from Objective 1 to build an SPR model for Prince William Sound Yelloweye Rockfish. Age or length at 50% maturity will be determined through histological (microscopic) examination of Yelloweye Rockfish ovaries. Due to a complex reproductive biology, not all female Yelloweye Rockfish can be determined to be sexually mature based on macroscopic observations. For example, rockfish are known to skip spawn (do not reproduce every year), and if assessment was strictly based on macroscopic observations, a skip-spawning mature fish would be falsely assigned an immature rating due to absence of eggs that given year. Work with the SPR model will be performed primarily using statistical/quantitative software such as Program R. The parameters entered into the model need to be accurate for a specific population. For example, age at 50% maturity is known to vary with latitude. In the southern range, Yelloweye Rockfish mature at 7 years of age and in Southeast Alaska, they mature at 22 years of age. Prince William Sound is the northernmost distribution of this species, so we expect that the age at 50% maturity will be greater than the rest of the range. It is important to have accurate and representative estimates of these parameters because an overestimate of spawning production in the SPR model could result in a prescribed fishing level greater than the population can truly sustain. The recreational harvest of Yelloweye Rockfish in Prince William Sound has been increasing for over 15 years. This harvest coupled with commercial removals could result in harvest level that is already exceeding a sustainable level. The project is directed towards the conservation of this specific species in a particular region where it has economic and cultural importance.

Juvenile Chinook Salmon Movement, Overwinter Survival, and Outmigration Timing in the Chena River, Alaska

Student Investigator: Olivia Edwards, MS Fisheries
Advisor: Jeff Falke
Funding Agency: Region 3 ADF&G (Sport Fish Base)
In-Kind Support: Personnel and operational support provided by ADF&G

Since 2001, Chinook Salmon returning to the Yukon River drainage have been designated as a stock of concern by the Alaska Board of Fisheries, and the Chena River supports one of the largest spawning stocks in the Alaskan portion of the Yukon River drainage. The Chena River juvenile Chinook Salmon study will provide a method to estimate the outmigration timing and magnitude of smolt production from several rearing areas on a highly utilized stock. These estimates will lead to a mark-recapture study design that generates accurate and precise estimates of smolt abundance and marine survival that can improve the stock assessment models that are used to establish sustainable escapement goals. These improved models will aid managers when making decisions about the Yukon River's important subsistence, commercial, and sport fisheries. Objectives are to (1) describe immigration and/or emigration from designated fall rearing areas by Chinook Salmon parr, (2) quantify outmigration timing for Chinook Salmon smolts originating from different rearing areas across the Chena River basin, and (3) estimate relative overwinter survival of Chinook Salmon parr to smolt among rearing areas located throughout the Chena River basin. We will capture and PIT tag Chinook Salmon parr during fall 2018 at sites located in the designated rearing areas (North, Middle, and South Forks, upper mainstem, and the Little Chena River). Within each area, one or more streams and/or reaches will be selected to represent the rearing area. Movements of PIT tagged fish throughout the winter and during outmigration will be monitored using PIT tag antenna arrays that are placed on the river bottom at the mouth of the designated rearing area or the stream(s) that represent the area and the Moose Creek Dam. Fish passing over the array will activate their PIT tag and individual tag number, timing, and swimming direction (upstream or downstream) will be recorded. PIT arrays will be installed and tested during late-July and early August prior to juvenile fish collection and tagging. Travel times from each rearing area above the dam will be calculated from the PIT tag arrays at each area and the Moose Creek Dam. In addition, detection and survival probabilities will be calculated for all rearing areas above the dam using a single release-recapture model that has been successfully implemented on the Snake and Columbia rivers. This sampling design will generate accurate and precise estimates of timing into and out of the rearing areas as well as relative overwinter survival. These improved models will aid managers when making decisions about the Yukon River's important subsistence, commercial, and sport fisheries. The project will also identify and characterize important fall rearing areas for juvenile Chinook Salmon. All components of this study are identified by the Yukon River Panel as information needs/actions. In addition, the ADF&G Chinook Salmon Initiative has identified juvenile Chinook Salmon information as an information gap for the Yukon River, and the Chena River is one of the largest contributors to this stock.

Assessing the Resilience of Southeast Alaskan Salmon to Shifting Temperature and Discharge Regimes Using a Life-cycle Perspective Coupled with Community-based Monitoring

Student Investigator: Chris Sergeant, PhD Fisheries
Advisor: Jeff Falke
Funding Agency: Alaska SeaGrant
In-Kind Support: US Forest Service, PNW Research Station; Southeast Alaska Watershed Coalition

Salmon that spawn and rear in southeast Alaska (SEAK) forest streams are critically important to the region's economic vitality and cultural identity. Environmental changes that compromise the ability of these streams to support salmon could have dramatic consequences for the region. In particular, there is concern that climate change could undermine the capacity of SEAK streams to support productive fisheries via alterations to water temperature and flow regimes via impacts on multiple freshwater life stages. Although life-cycle models that track salmon growth and survival across life stages have been developed for many at-risk populations throughout the southern range of salmon, there have been limited efforts to expand this approach northward to Alaska. Broad-scale stream temperature and flow monitoring networks are beginning to provide much-needed data to quantify the effects of climate variability on salmon growth and survival. However, gaps exist and many watersheds that provide critical subsistence opportunities for local communities are not monitored. Our objectives are to (1) create models to predict future stream temperature and flow regimes for approximately 50 locations within different watersheds that vary in key landscape factors (e.g., glacial presence, wetland coverage, gradient) based on existing downscaled climate change scenarios for SEAK; (2) evaluate the extent to which current and projected future stream temperature and flow regimes affect salmon at each freshwater life stage (adult spawners, eggs, and juveniles) based on published models and relationships; (3) quantify the cumulative effects of future water temperature and flow regimes on population productivity in each study watershed for pink, chum, and coho salmon by summarizing the effects at each freshwater life stage using a life-cycle modeling approach; and (4) present life-cycle models and model results to SEAK community members and project partners to facilitate discussion of priority management actions to preserve healthy salmon populations. We will assess > 50 watersheds across the region currently monitored under the SEAK Stream Temperature Monitoring Network. These sites incorporate variations in landscape characteristics known to control stream temperature and flow regime. Additionally, priority streams outside of the temperature network will be identified by project partners for inclusion in the study. The models will be designed to easily incorporate newly collected data, so the spatial extent and precision of predictions will increase as monitoring efforts expand. The study will occur in four stages:

Stage 1—Current stream temperature regimes will be summarized from logger data collected at local sites within the Stream Temperature Monitoring Network. For each location where data are available, flow regime descriptors will be generated using existing gauge data or regional discharge models that predict streamflow based on watershed physical characteristics and downscaled air temperature and precipitation. Climate change effects on stream temperature and flow will be evaluated using downscaled projections of future air temperature and precipitation.

Stage 2—Evaluate the influence of current and future stream temperature and flow regimes on pre-spawning mortality, egg development and survival, and juvenile growth and survival using site-specific temperature and flow information to parameterize a series of models that link temperature and flow to survival/growth/development at each freshwater life-stage for coho, pink, and chum salmon.

Stage 3—Simulate relative differences in population sizes under current and projected conditions by integrating changes across all freshwater life stages into simple life-cycle models.

Stage 4—Construct user-friendly versions of life-cycle models to be used for conservation and management planning, future analyses, and explorations by project partners and communities for their local streams. This step entails creating an “interface page” where model users can upload environmental conditions for local streams to simulate how temperature and flow influences survival and relative differences in population productivity. Current and future stream temperature and flow descriptors will increase the shared body of knowledge of SEAK watershed ecosystems, with an emphasis on stakeholder interests and concerns, and provide critical information for local-scale salmon conservation and management activities. Quantitative predictions of relationships among flow and temperature regimes and salmon growth and survival in freshwater will increase the shared body of knowledge on these important population characteristics. Results of our life-cycle modeling for pink, chum, and coho salmon will increase the shared body of knowledge of Alaska watershed ecosystems and enhance community resilience. By presenting user-friendly versions of life-cycle models and model results to SEAK community members and project partners, the project will enhance communities’ capacity to prepare for and adapt to environmental change by (1) sharing knowledge of which systems are likely at-risk to help communities decide whether and how to mitigate and/or adapt to changes to local salmon resources; (2) training communities to use and adapt the life-cycle models themselves, while continuing to serve as a resource for communities using the models; and (3) supporting community adaptation planning efforts via a climate scenarios planning session.

Aquatic Ecosystem Vulnerability to Fire and Climate Change in Alaskan Boreal Forests

Student Investigators: Elizabeth Hinkle, PhD Fisheries
Post-doctoral Researcher: Stephen Klobucar
Advisor: Jeff Falke
Funding Agency: Department of Defense (DoD) Strategic Environmental Research and Development Program (RWO 227)

Fire is the dominant ecological disturbance process in boreal forests and is natural and widespread. However, fire frequency, size, and severity are increasing in Alaska owing to climate warming. Interactions among fire, climate, permafrost, vegetation, and hydrologic and watershed processes are poorly understood, yet critical for conservation and management of boreal aquatic habitats in a changing environment. Our research will address this challenge on and around DoD lands in interior Alaska by combining a detailed field experiment and measurements with an integrated suite of spatially- and temporally-explicit climate, terrestrial, and aquatic habitat models to better our understanding of the effects of fire and climate change on aquatic communities in interior Alaska boreal ecosystems. Our objectives are to (1) investigate the effects of fire in boreal watersheds through empirical studies focused on characterizing physical and biological mechanisms driving aquatic habitat dynamics and productivity (PhD student), (2) assess aquatic population vulnerability to fire in boreal aquatic ecosystems through spatially-explicit predictions of fire effects on aquatic habitats under current and future vegetation, permafrost, and climate scenarios (Post-doc), and (3) develop decision support tools to translate results of this research, assist management decision-making, and meet conservation objectives (Post-doc and PI's). To address Objective 1, we will quantify fire effects on watershed- and local-scale aquatic habitats and the response of aquatic organisms on and adjacent to DoD lands in interior Alaska by (1) conducting a space-for-time substitution field experiment to quantify hydrologic, thermal, and turbidity regimes in headwater catchments to varying levels of fire disturbance, (2) investigating the response of a characteristic and widespread boreal fish species to variation in energy flow through fire-affected catchments, and (3) predicting fish population responses to changing fire, thermal, and hydrologic regimes using individual-based and food web modeling. For Objective 2, we will integrate models that predict climate, fire, vegetation, hydrologic, and thermal dynamics to assess aquatic habitat and population vulnerability under a changing climate on and adjacent to DoD lands in interior Alaska by (1) integrating a spatially- and temporally-explicit downscaled rainfall-runoff hydrologic model and riverscape stream temperature model based on output from fire, vegetation, and permafrost models, and (2) predicting fire and climate change impacts on aquatic habitats and population vulnerability across a broad extent in the interior Alaska boreal forest. Finally we will conduct two activities designed to engage and support natural resource managers in evaluating the potential effects of fire management on aquatic habitats and productivity under a changing climate by (1) utilizing and further developing previously developed fire management scenarios to explore interactions between fire management and future climate scenarios and the effects on aquatic habitats, and (2) using a structured decision making (SDM) approach to define management objectives, decision options, and management scenarios, and to conduct cost-benefit analyses. In support of this activity a web-based decision support tool will be developed to inform decision making. Past an improved understanding of how fire impacts aquatic environments in boreal ecosystems, our results will be translated into practical tools with which managers can evaluate the effects of fire and climate change focusing on mechanistic relationships among ecosystem drivers and the biological response to those drivers. Using a web-based mapping and visualization tool our approach will allow for spatially explicit representations of results from Objectives 1 and 2 under different management scenarios from Objective 3. An initial conceptual model will be developed in a workshop designed to elicit and define a set of management objectives and decision options from our collaborators and other local expert input. Management scenarios identified and simulated in Objective 3 will allow for cost-benefit analysis of specific decision options and quantification of which scenarios optimize the management objectives. The final product will incorporate a combination of expert opinion and quantitative information resulting from Objectives 1, 2, and 3.

Marine-Derived Nutrient Effects on Chinook and Coho Salmon Productivity

Student Investigator: Philip Joy, PhD Fisheries
Advisor: Mark Wipfli
Funding Agencies: Alaska Sustainable Salmon Fund (AKSSF); ADF&G, Sport Fish Division; Norton Sound Economic Development Corporation (NSEDC)

Marine derived nutrients (MDN) imported to freshwater ecosystems by migrating adult salmon can affect growth and survival of juvenile salmon. However, the relationship between salmon escapements and juvenile performance at the population level is unclear. Given that larger smolt are associated with higher marine survival, understanding how salmon escapements relate to juvenile growth, size, and abundance may ultimately improve management. The objectives of this study were to identify how salmon escapements relate to MDN assimilation and juvenile salmon performance in a naturally rearing salmon population in the Unalakleet River, western Alaska. A simulation study of spawner-recruit data was used to examine if MDN from Pink Salmon were influencing productivity of Coho Salmon in Norton Sound. MDN assimilation of juvenile Coho and Chinook Salmon was assessed with stable isotopes and compared to salmon escapements. Growth was estimated via RNA:DNA ratios, mean size was calculated with a Bayesian mixing model, and body condition determined by Ricker's condition factor. The relationship between performance metrics and MDN content of juvenile Coho Salmon was analyzed. Simulation results demonstrated that observed relationships between Pink and Coho Salmon are most likely from MDN. Fluctuations of MDN were related to salmon spawner density and escapement levels, with MDN retention greatest in areas with substantial off-channel habitat. Juvenile salmon size, growth, and condition were correlated with MDN levels. Results from this study help quantify the relationship between salmon escapements, MDN content, and Chinook and Coho Salmon stock productivity and provide a basis for improving management in a multi-species framework.

Completed Wildlife Studies

Do Wintering Conditions Drive Population Trends in Semipalmated Sandpipers (*Calidris pusilla*)? Evidence from a Corticosterone Biomarker

Student Investigator: Megan Boldenow, MS Wildlife Biology and Conservation
Advisor: Abby Powell
Funding Agencies: USGS and NPS [through the Natural Resources Preservation Project (NRPP)] (RWO 210)
In-Kind Support: USFWS Selawik NWR and Migratory Bird Management (MBM) and NPS

Note: Megan Boldenow graduated from the University of Alaska Fairbanks in May 2018. Her thesis abstract follows:

Abstract: Some of the most extreme long-distance migrants, Arctic-breeding shorebirds are disproportionately represented in tallies of declining species worldwide. For many shorebirds, including the semipalmated sandpiper (*Calidris pusilla*), the specific causes and mechanisms behind population declines have not been identified. Stressful conditions affecting birds during wintering are often implicated. Interactions between events and processes occurring in the disparate locations used throughout the annual cycle also may be critical in shaping both individual life histories and population demographics. The main objectives of my graduate research were a) to examine whether semipalmated sandpipers wintering in specific locations incur differential levels of stress; and b) to test whether stressful conditions may carry over between different stages of an individual's life cycle. Using measurements of corticosterone (the primary avian stress hormone) deposited in winter-grown feathers, I examined the contribution of breeding season and fall migration to winter-incurred stress, and looked for evidence of carryover effects from wintering conditions to spring migration and subsequent reproductive performance. In Chapter 1, I compared the levels of stress exposure of 40 semipalmated sandpipers that bred at five Arctic sites and spent the austral summer in distinct regions (identified via light-sensing geolocators) across their tropical 'wintering' range. I found stress exposure varied by wintering region, and birds using locations along the Atlantic coast of northeastern South America and the Pacific coast of Central America had the highest feather corticosterone levels. I did not find evidence that carryover effects from the breeding season and/or fall migration influenced birds' physiology during winter. In Chapter 2, I investigated whether greater stress exposure during winter might subsequently affect birds during spring migration and/or breeding. I found that geolocator-tracked birds with increased stress levels delayed spring migration and initiated nests later. However, results for a larger dataset (including 254 birds breeding at seven sites across the North American Arctic) suggested low-stress birds nested later. It is possible the larger dataset included replacement clutches that could have confounded relationships with feather corticosterone, as only birds in better condition are likely to re-nest after clutch failure. In addition, I found evidence that stressful wintering conditions carryover to affect reproductive performance: females that accrued high levels of stress during wintering subsequently laid fewer eggs. In confirmed first nests, we found evidence for a clutch size-egg volume tradeoff, with high-stress females producing fewer offspring but potentially investing more in individual offspring. This research represents the first

instance of the feather corticosterone technique being used to compare conditions across the wintering range of a calidrid shorebird and reveals specific wintering locations with high levels of stress exposure. This is also the first research that provides a mechanistic perspective on carryover effects between the wintering and breeding stages in a shorebird, through measurements of feather corticosterone. Finally, by showing that poor environmental conditions at wintering sites far from Arctic breeding areas may be detrimental to the reproductive performance of a species with declining populations, this research emphasizes the importance of considering full annual cycles in conservation and research efforts for migratory species.

Ongoing Wildlife Studies

Validating a GPS Collar-based Method to Estimate Calving Locations and Parturition Rates in the Porcupine Caribou Herd

Student Investigator: Joelle Hepler, MS Wildlife Biology and Conservation
Advisors: Brad Griffith and Jeff Falke
Funding Agency: USFWS (RWO 221); ADF&G
In-Kind Support: ADF&G

Telemetry study of the Porcupine caribou herd–looking for VHF-collared females with calves. Photo by J. Hepler.

Inclement weather, remote locations, and difficulty refueling survey aircraft often compromise aerial survey estimation of calving sites and dates, and parturition rates of barren-ground caribou. Recently developed methods based on minimum travel rates of GPS-collared caribou (DeMars et al. 2013; Ecol. Evol. 3:4149–4160) have shown promise for remotely monitoring calving, but the method was developed for non-migratory rather than migratory caribou. The objectives were to compare calving locations and dates, parturition rates, and annual calving areas estimated from aerial survey data to those estimated with two models of the GPS movement rate methods. Aerial surveys in 2017 and 2018 used telemetry to estimate parturition status and calving locations of 46 and 50 VHF collared females (≥3 years old), respectively. We used these data and GPS locations of the same caribou to make our comparisons. The individual-based model of the DeMars et al. (2013) method had slightly better agreement with results from aerial surveys in terms of parturition rate and annual calving ground area overlap (88% and 94%, respectively) than the population-based model (84% and 92%, respectively), averaged across both years. Managers may use these results to implement a new tool for remote monitoring of migratory caribou parturition rates, calving locations and dates.

Identifying Causes of Nest Failure for Pacific Common Eiders on the Beaufort Sea Coast

Student Investigator: Wilhelm Wiese, MS Wildlife Biology
Co-Advisors: Tuula Hollmén and Mark Lindberg
Funding Agency: Arctic National Wildlife Refuge, USFWS (RWO 215)
In-Kind Support: Personnel and logistical support provided by Arctic NWR, USFWS

Polar bear eating eider eggs.

Pacific Common Eider populations decreased over 50% from the 1950s to 1990s. Although Pacific common eiders have declined throughout their range, those breeding on barrier islands in the Beaufort Sea are considered particularly vulnerable. Nest failure caused by predators or flooding may be an important limiting factor to common eider population recovery. Previous attempts to quantify causes of nest failure have been limited in geographic scale and/or have relied on methods that may induce bias. Our objectives are to quantify specific causes of nest failure and test the accuracy of two "evidence based" methods for determining nest predator species. In 2015-17, we surveyed barrier islands of Arctic NWR for common eider nests and placed small, time-lapse cameras at approximately 100 nests each year to record causes of nest failure. Glaucous gulls, polar bears, arctic foxes, and grizzly bears were the most common nest predators. Using a traditional method of evaluating nest site evidence, we correctly identified nest predators only 40% of the time. Discriminant function analysis based on evidence left at nest sites only allowed us to accurately identify predator species only 41% of the time. Understanding the importance of specific causes of nest failure in limiting common eider reproduction is critical for developing management plans aimed at species recovery. Accurate assessments of nest failure rates may not be achievable using "evidence-based" methods.

Energetic Impacts of Storm Surges to Pacific Common Eiders along the Arctic Coastal Plain

Student Investigator: Elyssa Watford, MS Wildlife Biology and Conservation
Co-Advisors: Tuula Hollmén and Mark Lindberg
Funding Agencies: Arctic National Wildlife Refuge, USFWS (RWOs 215 and 228); National Fish and Wildlife Foundation; North Pacific Research Board; UA Foundation
In-Kind Support: Student Conservation Association, Wildlife Conservation Society

Pacific Common Eiders (eiders) nest on barrier islands along the Arctic Coastal Plain where higher magnitude storm surges are predicted to occur more frequently during the breeding season as sea ice continues to retreat. This may result in increased nest failure due to flooding at lower elevation nest sites. Continued monitoring will help fill in critical information gaps about eider reproductive ecology and provide a better understanding of how eiders may be affected by climate change. The goals of this project are to assess nest microclimate variability and the associated energetic costs and characterize body condition during incubation. We will walk barrier islands along the Arctic Coastal Plain searching for nesting eiders and will monitor their heart rate, collect information about their nest microclimate, and obtain a blood sample. I expect results to indicate what nest microclimate characteristics are attributed to variations in nest wind speed, discern if nest microclimate alters the energetic costs of incubation, and obtain baseline data about eider body condition during incubation. These results will provide a better understanding of how vulnerable eiders are to climate change and help inform management decisions.

Completed Ecological Studies

Shrinking Boreal Lakes as Agents of Change: Untangling Structure and Function in Hydrologically-Coupled Lakes and Wetlands

Student Investigator: Vijay Patil, PhD Biology and Wildlife
Co-Advisors: Brad Griffith and Eugénie Euskirchen
Funding Agencies: USGS (RWO 172)

Note: Vijay Patil graduated from the University of Alaska Fairbanks in May 2018. His dissertation abstract follows:

Abstract: Widespread lake shrinkage has occurred over the last 30 years throughout interior Alaska and other boreal regions. This trend has been broadly linked to climate change, via multiple proximate drivers including permafrost thaw, shifting water balance, and terrestrialization caused by peat growth. The ecological effects of shrinking boreal lakes are still poorly understood. I used space-for-time substitution based on field surveys from a spatially balanced random sample of lakes (n=130) to examine the implications of shrinking lakes in the lowland floodplain of the Yukon River within the Yukon Flats National Wildlife Refuge in northern Alaska. Historical lake shrinkage over the last 30 years increased plant functional diversity, woodiness and aboveground biomass in lake-margin wetlands, despite a significant loss of wetland and lake area. Shrinking lakes appeared to have decreased hydrological connectivity with surrounding wetlands, and reduced organic carbon and nitrogen inputs from the surrounding landscape. However, land cover and bathymetry were better predictors of water chemistry than lake shrinkage. Continued reductions in lake surface area, combined with terrestrial succession, may reduce wetland area and increase the relative abundance of woody wetland vegetation compared to herbaceous plants. Lake shrinkage could also reduce below-ground C stocks, because lake sediments contain more organic C per m2 than terrestrial soils, and lake sediment C appears vulnerable to aerobic decomposition. Overall, lake shrinkage will most likely affect plant and animal biodiversity, waterfowl and wildlife habitat quality, and C storage in contrasting ways, and management of drying landscapes may require difficult tradeoffs to be made as a result. These decisions would be aided by process-based modeling that accounts for the role of plant functional traits and explicitly represents hydrological interaction between terrestrial and freshwater ecosystems.

Development of an Alaska-based Research Framework for Migratory Waterfowl

Faculty: Brad Griffith and Abby Powell
Funding Agency: Alaska Climate Science Center, USGS (RWO 218)

The effects of climate change and other factors on waterfowl demography varies among seasonal ranges, and population trends result from cumulative effects throughout their annual ranges. It is unlikely that the direction or strength of climate and other effects are consistent among ranges. As a result, it is extremely difficult to unravel the most important effects on population size when potentially contrasting positive and negative influences of climate occur within a year at widely separated locations. A large-scale research framework is needed to deal with this complexity and increase the relevance, efficiency, and effectiveness of management-related research. To develop a focused and integrated multi-regional and national research program, a panel of State, Federal, and NGO managers and researchers sought to prioritize climate change information needs and enhance communication between researchers and managers from distant seasonal ranges. Speakers presented (1) an introduction to USGS Climate Science Center efforts to explicitly incorporate a changing climate into regional- to national-level frameworks for prioritizing climate-related research on migratory birds and (2) results of a questionnaire survey of State, Federal, and NGO managers and researchers that ranked research topics based on the direction and magnitude of expected climate effects on waterfowl demography and, thus, population sizes. These presentations promoted a broader discussion about ways to (1) enhance cross-seasonal communication and (2) incorporate information about climate effects into ongoing effects to develop annual life cycle models.

Ongoing Ecological Studies

Connectivity for Landscape Conservation Design and Adaptation Planning

Post-doctoral Researcher: Charlotte Gabrielsen (IAB)
Faculty: Brad Griffith
Funding Agency: Region 7 USFWS (RWO 225)

Northern regions, including those in Alaska and northwestern Canada, are frequently characterized as having high landscape conservation capacity, given their high percentage of protected areas and highly intact landscapes. However, these regions are susceptible to a growing number of pressures including climate change—where temperatures have increased twice as rapidly as the global average—and an increase in global demand for the region's natural resources. In light of pressures from climatic and anthropogenic change, there is a need to implement strategic landscape conservation design to facilitate projected ecosystem shifts and species movements. Maintaining landscape connectivity is the most frequently recommended climate change strategy for conserving biodiversity. The primary objective of this study is to model climate connectivity to identify linkages among protected areas in Alaska and Northwest Canada that promote long-term connectivity and have the potential to facilitate species movements under projected climate change. We used a cost-distance modeling approach to map corridors that followed climatic gradients and avoided areas with high anthropogenic disturbance. using downscaled climate data and a human modification resistance layer. We used downscaled climate data to identify model least-cost corridors under historical climatic conditions, and under a range of projected climate change models, scenarios, and future time periods. We found that climate corridors were primarily oriented in an east–west direction, particularly across interior Alaska, reflecting trends in climate and topography. Furthermore, we observed shifts in climate corridors under projected climate change scenarios, including constrained connectivity in the northern Arctic, and increased connectivity between the Yukon-Kuskokwim Delta and interior Alaska. Coarse-filter, large landscape-scale modeling approaches, such as those used in our study, are useful for informing proactive landscape conservation design, and offer a flexible framework that can be adapted to address diverse conservation and stakeholder priorities under projected climatic and anthropogenic change.

Differential Effects of Climate-Mediated Forest Change on the Habitats of Two Ungulates Important to Subsistence and Sport Hunting Economies

Faculty: Brad Griffith, Eugénie Euskirchen, and A. David McGuire
Funding Agency: Alaska Climate Science Center, USGS (RWO 212)

In winter, caribou rely on low stature lichens for food while moose rely on deciduous shrubs that protrude above the snow. Fire favors deciduous shrubs at the expense of lichens, and caribou movement is impeded by shallower snow than moose. Rain-on-snow may restrict access to lichens but not shrubs. As a result, effects of climate change are expected to be different between the species. Moose and caribou are the most important terrestrial species to subsistence and sport hunting economies in Alaska. Our objective is to use output from the Integrated Ecosystem Model (IEM) to project the differential effects of climate change (e.g., vegetation dynamics, snow and rain, fire frequency/severity, and successional trajectories) on the quantity of food available to these two species throughout most of Alaska and parts of Canada, ~1970-2100. We will refine IEM output to be relevant to ungulate forages. IEM NPP output will be restricted by winter weather (snow depth and icing events) derived from a dynamically downscaled daily climate dataset. Regression models will be used to estimate spatial and temporal trends in habitat value. Preliminary dynamically downscaled winter weather projections and NPP outputs from the IEM model will be obtained in spring 2018; computational requirements will necessitate sampling the study domain rather than inventorying it. Maps and models of spatial and temporal trends in habitat value will be stratified by land ownership and explicitly tailored to stakeholder needs. Maps can be used to inform conservation plans and management actions.

Modeling Landscape Vulnerability to Thermokarst Disturbance and Its Implications for Ecosystem Services in the Yukon Flats National Wildlife Refuge, Alaska

Lead: Hélène Genet
Postdoctoral Researcher: Heather Greaves
Funding Agency: USGS Land Carbon Program (RWO 220)
Collaboration: Partner of a NASA-ABoVE project led by Dr. Rob Striegl (USGS)

In addition to widespread active layer deepening, climate warming is driving thawing of ice-rich permafrost, often triggering abrupt thermokarst and subsidence of the ground surface. In boreal forest, thermokarst can lead to the conversion of permafrost plateau forest to collapse scar bogs, fens, or lakes (Figure 1) inducing large changes in the hydrological regimes.

Figure 1. Bog and fen wetlands cover large areas of low elevation Yukon River terraces near Circle, Alaska.

The poorly drained conditions of these features cause the development of peatlands, which store large amounts of carbon in thick surficial peat layers, but also produce substantial methane emissions. At the regional level, the climate warming effects of methane emissions from the newly formed wetlands could be greater than the climate cooling effects of increased soil carbon sequestration. These changes in hydrological regimes will also influence river discharge and lateral exports of dissolved carbon. Changes in wetland distribution will also impact habitat for plant and animal species, including important subsistence species such as waterfowl. The geomorphological changes associated with thermokarst disturbance will also likely have local impacts on infrastructure. This project is building upon a modeling framework to represent the key-processes that will help improve our understanding of the impacts of thermokarst disturbance on ecosystem structure and function in the Yukon Flats National Wildlife Refuge. We are improving an existing process-based ecosystem model to represent key landcover types and processes associated with themokarst disturbance. We are then using this improved model framework to predict thermokarst dynamics in the Yukon Flats National Wildlife Refuge (YFNWR), and quantify its impact on landcover and carbon dynamics from 2010 to 2100 by applying the coupled model. Finally, we will develop and apply an impact model to assess how thermokarst dynamics affect wildlife habitat. Thermokarst-related land cover change was simulated from 2000 to 2100 across the Yukon Flats. By 2100, the model predicts a mean decrease of 7.4% (sd 1.8%) in permafrost plateau forests associated with an increase in TK lakes and wetlands. The model projections will be used as a baseline by the resource managers of the YFNWR to integrate future ecosystem changes into an adaptive management strategy.

Application of an Integrated Ecosystem Model: A Multi-Institutional and Multi-Disciplinary Effort to Understand Potential Landscape, Habitat, and Ecosystem Change in Alaska and Northwest Canada

Post-doctoral Researcher: Heather Greaves (IAB)
Faculty: Amy Breen, Robert Bolton, T. Scott Rupp (IARC); Brad Griffith, Helene Genet, Eugénie Euskirchen (IAB); Vladimir Romanovsky, Sergey Marchenko, and Dmitry Nicolosky (GI)
Funding Agency: USGS Alaska Climate Science Center (RWO 224)

Natural resource managers and decision makers require an improved understanding of the potential response of ecosystems due to a changing climate in Alaska and northwest Canada. We created a modeling framework—the Integrated Ecosystem Model (IEM) for Alaska and Northwest Canada—to meet this need. The IEM integrates the driving components for, and the interactions among, disturbance regimes, permafrost dynamics, hydrology, and vegetation succession and provides an improved understanding of the potential response of ecosystems to a changing climate. The objective of this project is to provide scenarios of changes in landscape structure and function that can be used to assess the effects of climate change on natural resources. Our study methods include (1) asynchronously (Generation 1) and synchronously (Generation 2) coupling stand-alone models for specific areas of interest, and the full IEM domain when computationally feasible, (2) developing input data sets for the study region, and (3) phasing in additional capabilities as necessary. In 2018, we began work on the IEM Generation 1 coupling driven by IPCC Fifth Assessment Report (AR5) climate models. Our work is still in progress for select sites in the tundra region of Alaska (Utqiaġvik, Toolik Lake, Council, and Y-K Delta) for proof of concept. We anticipate completion of this phase of model coupling by June 2019. The projections produced by the IEM are facilitating the integration of how landscapes may respond to climate change into resource management decisions.

Morphological, Genetic, and Physiological Variation among Arctic and Subarctic *Carex*

Student Investigator: Iris Cato, MS Biological Sciences
Co-Advisors: Roger Ruess and Diana Wolf
Funding Agency: USGS Changing Arctic Ecosystem Initiative (RWO 217)

Carex subspathacea (SUB) is a short-statured sedge and a preferred food source for Brant goose along Alaska's coast. In the absence of grazing, SUB grows taller and resembles a closely-related species, *Carex ramenskii* (RAM), which has lower nitrogen content and is avoided by geese. It is currently unclear whether these sedges are actually different species or different growth forms of the same species. On the Yukon-Kuskokwim Delta, Alaska (YKD), there appears to be a positive feedback loop, where increases in goose populations cause increased grazing and increased lawns of short, palatable sedges. In the last century, extensive grazing lawns of YKDSUB have converted to a tall, less palatable form due to reduced grazing. This may subsequently cause further reductions in YKD Brant goose populations. However, on the North Slope (NS), NSUB does not need to be grazed to maintain its short stature, and thus there is no feedback loop between Brant goose concentration and availability of palatable food. We want to learn more about the feedback loop between Brant geese and the sedges they graze by determining whether there are genetic and physiological differences between tall and short morphs growing on the YKD and NS. The objectives are to determine the morphological, genetic, and physiological differences among SUB and RAM from Arctic and subarctic Alaska. A morphological study was conducted on SUB and RAM herbarium specimens. Common gardens in Arctic and subarctic Alaska are being used to test for physiological differences. Next Generation Sequencing will be used to quantify genetic differences between CSUB and CRAM. Morphological measurements of herbarium specimens indicate that CSUB is morphologically distinct from CRAM. In the Arctic garden, height and tiller density are significantly different for all growth forms and clipping had a significant effect. In the subarctic garden, heights are significantly different for all growth forms, but tiller densities for NSUB and YKDSUB are not significantly different from each other but are significantly higher than RAM. Clipping did not have an effect in the southern garden. Genetic data has been successfully sequenced and will be used to clarify the relationships between NSUB, YKDSUB, and RAM growth forms. Understanding the differences between these grazing systems is critical for predicting population dynamics of Department of Interior trust species (migratory geese) in the regions where these sedges are prevalent.

Anticipated Climate Change Effects on Broad Whitefish (*Coregonus nasus*) Ecology and Habitat Use in Arctic Alaska

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Subsistence fisheries provide an important food resource for communities on Alaska's Arctic Coastal Plain. Despite the importance of the Colville River's summer run of Broad Whitefish (*Coregonus nasus*) to Native communities and the potential habitat impacts associated with climate change and petroleum development, the basic ecology of this migratory species remains poorly understood. The objectives of this ongoing study were to identify key habitats and seasonal migration patterns, understand the prevalence and role of anadromy, and conceptualize how ongoing climate change will likely influence Broad Whitefish growth, phenology, and their habitats. We studied adult migratory fish in summer riverine habitats, analyzing stable isotopes in body tissues to estimate the contribution of marine food resources, assessing strontium isotopes in otoliths to determine life history type, and using radio telemetry to determine seasonal movements among freshwater habitats. We developed a conceptual model to link climate change drivers to regional habitat responses and predict associated effects on Broad Whitefish and the subsistence fishery. Stable isotope analysis revealed a large range of δ13C and δ15N values across tissue types, indicating that Broad Whitefish have a wide isotopic niche and utilize a variety of both marine and land-based food sources across both short and longer time periods. Telemetry data showed that tagged pre-spawning fish migrated upstream to utilize the lower and middle Colville River, presumably for spawning, and then moved downstream in early October through the lower river toward the delta. Findings from this research are providing insights into potential effects from climate and landscape change to better conserve this important subsistence resource on the Arctic Coastal Plain.

Implications of Shifting Water Temperature Regime for Growth of Juvenile Chinook and Coho Salmon in Three Geomorphically Distinct Sub-Basins of the Kenai River

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Shifts in air temperature and precipitation regimes as a result of ongoing climate change will affect juvenile salmon freshwater rearing habitat differently depending on local watershed conditions. Water temperature acts as a key control on juvenile salmon growth, and some south-central Alaskan salmon streams already experience water temperatures exceeding the thermal optimum threshold of 15–17°C during summer months. Food is an additional key control on growth, and the temporal and spatial patterns that these two variables have on juvenile salmon growth are not well characterized.

Regional stakeholders in the Kenai Peninsula are concerned about the future of salmon populations in the face of climate and landscape change. A more detailed understanding of how environmental variables including temperature and food availability contribute to juvenile salmon growth rates will help inform us on how these fish will fare in a changing landscape.

Objectives were to show how (1) air temperature regulates water temperature in Beaver Creek, Russian River, and Ptarmigan Creek within the Kenai River watershed and to investigate the degree of water temperature heterogeneity in stream reaches, and (2) stream temperature and food influence growth rates of juvenile Chinook and Coho rearing in these streams.

We sampled three drainages that encompass a lowland-to-montane spectrum of catchment types within the Kenai River watershed with differing potential vulnerabilities to warming air and water temperature. Air and water temperature data were monitored continuously at lower, middle, and upper sites in each study drainage during May–September 2015 and 2016. These data were used to calculate thermal sensitivity values at each site. Sensitivity values were used to model water temperatures based on projected air temperatures under four scenarios (years 2030–2039 under mid-range or high emissions scenario, and years 2060–2069 under mid-range or high emissions scenario). To investigate how juvenile salmon growth rate is influenced by diet and temperature in distinct environments, over 3000 juvenile Coho Salmon and 1200 juvenile Chinook Salmon were captured throughout the study periods, with 720 and 260, respectively, sampled for scales and stomach contents. From diet samples, nearly 9000 individual prey items composed of over 100 unique taxa/life stage combinations were identified, measured for length, and used to provide estimates of dietary caloric intake. Bioenergetics models that incorporate temperature, diet, and growth data are providing information on the degree to which growth rates of juvenile salmon are limited by prey consumption rates and water temperature.

Stream thermal sensitivity values varied across the study area. The highest sensitivity sites were in the lowland watershed (Beaver Creek) and lowest sensitivity sites were in the glacial watershed (Ptarmigan Creek). Projected overall changes in monthly mean water temperatures relative to May–September 2015–2016 means ranged from 1.0%–4.5% increase for the 2030–2039 decade and from 1.5%–9.3% increase for the 2060–2069 decade. Juvenile Chinook and Coho growth varied across the landscape, but age, year, and Julian day also help explain the observed variation. Diet content analysis revealed that terrestrial and marine subsidies contribute substantially to overall caloric intake. Field-derived estimates of juvenile Chinook and Coho Salmon growth rate correspond well with estimates from bioenergetics model outputs (r^2=0.92) and are serving to model growth under future water temperature scenarios.

Development activities in south-central Alaska are concentrated around low-elevation watersheds where anadromous salmon rearing habitat is potentially most sensitive to change. Habitat features such as riparian vegetation, glacial melt, and groundwater inputs can help buffer the sensitivity of water temperature to air temperature. Under water temperature conditions outside of physiological optimum (approximately 12°C–17°C), juvenile salmon can maintain high levels of growth if food consumption remains high, underscoring the value of marine and terrestrial prey subsidies. These data support the hypothesis that diverse habitats within a watershed support diverse early-life history opportunities for juvenile salmon, and that conservation of a broad portfolio of intact, interconnected habitats helps facilitate the adaptive capacity of wild salmon populations in the face of climate and landscape change.

List of Abbreviations

ADF&G	Alaska Department of Fish and Game
AKCFWRU	Alaska Cooperative Fish and Wildlife Research Unit
CFOS	College of Fisheries and Ocean Sciences, UAF
CRAM	*Carex ramenskii*
CSUB	*Carex subspathacea*
DBW	Department of Biology and Wildlife, UAF
DoD	US Department of Defense
EPSCoR	Experimental Program to Stimulate Competitive Research
GI	Geophysical Institute, UAF
IARC	International Arctic Research Consortium
IAB	Institute of Arctic Biology, UAF
IEM	Integrated Ecosystem Model
INE	Institute of Northern Engineering
LCC	Landscape Conservation Cooperative
LTER	Long Term Ecological Research Network, NSF
LWD	Large, woody debris
MBM	Migratory Bird Management
NASA	US National Aeronautics and Space Administration
NFWF	National Fish and Wildlife Foundation
NOROCK	Northern Rocky Mountain Science Center, USGS
NPS	US National Park Service
NRCA	Natural Resource Condition Assessment
NRPP	Natural Resources Preservation Project
NS	North Slope, Alaska
NSF	National Science Foundation
NWR	National Wildlife Refuge
NWRS	National Wildlife Refuge System
RWO	Research Work Order
TBN	To be named
UAF	University of Alaska Fairbanks
USBLM	US Bureau of Land Management
USDA	US Department of Agriculture
USFWS	US Fish and Wildlife Service
USGS	US Geological Survey
YKD	Yukon-Kuskokwim Delta, Alaska