Alaska Cooperative Fish and Wildlife Research Unit

Annual Research Report—2017

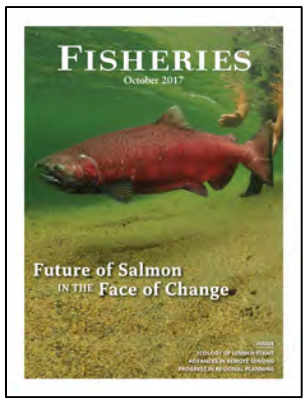

Photo by JR Ancheta UAF

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Photo 1: Skiffs loaded with gear for a nest-searching trip down the ice-laden Beaufort Sea coast, field season 2017. Photo by Elyssa Watford.

Photo 2: Schoen, E., M. Wipfli, and 15 other coauthors. 2017. Future of Pacific Salmon in the face of environmental change: Lessons from one of the world's remaining productive salmon regions. Fisheries 42(10):538-553.

Photo 3: Fisheries research technicians preparing to examine large woody debris in the Chena River, field season 2017. Photo by JR Ancheta, UAF.

Not for Publication: Because this report is one of progress, the data presented are often incomplete, and the conclusions reached may not be final. Consequently, permission to publish any of the information herein is withheld pending approval from the Alaska Cooperative Fish and Wildlife Research Unit.

Unit Roster

Federal Scientists

- Brad Griffith: Leader
- Jeff Falke: Assistant Leader-Fisheries
- Dave McGuire: Senior Scientist
- Mark Wipfli: Assistant Leader-Fisheries

University Staff

- Monica Armbruster: Fiscal Professional
- Kathy Pearse: Administrative Generalist

Unit Students and Post-Doctoral Researchers

Current

- Megan Boldenow, MS Biological Sciences Candidate (Powell)
- Chelsea Clawson, MS Fisheries Candidate (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)
- Chase Jalbert, MS Fisheries Candidate (Falke)
- Philip Joy, PhD Fisheries Candidate (Wipfli)
- Sarah Laske, PhD Fisheries Candidate (Wipfli and Rosenberger)
- Jason Leppi, PhD Fisheries Candidate (Wipfli)
- Benjamin Meyer, MS Fisheries Candidate (Wipfli)
- Kristin Neuneker, MS Fisheries Candidate (Falke)
- Kelly Overduijn, MS Wildlife Biology and Conservation Candidate (Powell)
- Vijay Patil, PhD Biological Sciences Candidate (Griffith and Euskirchen)
- Matt Sexson, PhD Biological Sciences Candidate (Powell and Peterson)
- Eric Torvinen, MS Fisheries Candidate (Falke)

Post-Doctoral Researchers

- Charlotte Gabrielsen (Griffith)
- Erik Schoen (Wipfli)

Graduated in CY 2017

- Chelsea Clawson, MS Fisheries (Falke)
- Sarah Laske, PhD Fisheries (Wipfli and Rosenberger)
- Kristin Neuneker, MS Fisheries (Falke)
- Eric Torvinen, MS Fisheries (Falke)

University Cooperators

- Barbara Adams, Independent Studies Program-UAF
- Milo Adkison, College of Fisheries and Ocean Sciences (CFOS)-UAF
- Chris Arp, Institute of Northern Engineering-UAF
- Ron Barry, Mathematics and Statistics-UAF
- Robert Bolton, International Arctic Research Consortium (IARC)-UAF
- Amy Breen, IARC
- F. Stuart Chapin, III, Emeritus Institute of Arctic Biology (IAB)-UAF
- Eugénie Euskirchen, IAB

- Hèléne Genet, IAB
- Teresa Hollingsworth, Boreal Ecology Cooperative Research Unit-UAF
- Tuula Hollmen, CFOS/Institute of Marine Science (IMS), Alaska SeaLife Center
- Karsten Hueffer, Department of Veterinary Medicine-UAF
- Kris Hundertmark, Department of Biology and Wildlife (DBW) and IAB
- Katrin Iken, CFOS
- Knut Kielland, IAB
- Paul Layer, College of Natural Sciences and Mathematics (CNSM)
- Mark Lindberg, DBW and IAB
- J. Andrés López, CFOS
- Sergey Marchenko, Geophysical Institute (GI)-UAF
- Dmitry Nicolsky, Research Assistant Professor, GI
- Abby Powell, Florida CFWRU
- Anupma Prakash, GI and CNSM
- Daniel Rinella, University of Alaska Anchorage
- James Reynolds, Emeritus UAF
- Vladimir Romanovsky, GI
- Amanda Rosenberger, Missouri CFWRU
- Roger Ruess, DBW and IAB
- T. Scott Rupp, Scenarios Network for Alaska and Arctic Planning (SNAP)-UAF
- 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)
- Graham Frye, PhD Biological Sciences Candidate (Lindberg)
- Christopher Latty, PhD Marine Biology Candidate (Hollmen)
- Wilhelm Wiese, MS Wildlife Conservation Candidate (Hollmenn and Lindberg)

Affiliated Post-Doctoral Researchers

- Heather Greaves (Breen)
- Cristina Hansen (Hueffer)
- Mark Lara (Euskirchen)

Cooperators

- Brian Barnes–Director, Institute of Arctic Biology, University of Alaska Fairbanks
- Sam Cotten–Commissioner, 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 2017. 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 among the Ecosystems Discipline 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: 4 (advised by Unit faculty)
Presentations: 37
Scientific and Technical Publications: 20

Courses Taught

Jeff Falke: Physical Processes in Freshwater Ecosystems (3 credits, Fall 2017)

Honors and Awards

Chelsea Clawson (MS Fisheries candidate advised by Jeff Falke) received a Eugene Maughan Scholarship for $2500 from the Western Division, American Fisheries Society. She also received 2nd place for Best Long Talk at the March 2017 Student Symposium, Fairbanks.

Jeff Falke, December 2017, Annual Performance Award, Cooperative Research Unit Program, USGS, Reston, VA.

Chase Jalbert (MS Fisheries candidate advised by Jeff Falke) received Best Student Poster at the annual meeting of the Alaska Chapter, American Fisheries Society, March 2017.

Dave McGuire, March 2017, Unit Award for Excellence of Service, Department of Interior The LandCarbon Team earned the Unit Award for Excellence of Service by greatly expanding our knowledge of biological carbon sequestration and successfully conducting the first ever comprehensive national assessment of biological sequestration, as required by the Energy Independence and Security Act of 2007.

Ben Meyer (MS Fisheries candidate advised by Mark Wipfli) received Best Introduction at the March 2017 Student Symposium, Fairbanks.

Kristin Neuneker (MS Fisheries candidate advised by Jeff Falke) received an IAB/UAF Graduate Summer Research Award for $7000. She also tied for 3rd place for Best Long Talk at the March 2017 Student Symposium, Fairbanks.

Wilhelm Wiese (MS Wildlife Conservation candidate advised by Tuula Hollmenn and Mark Lindberg) received the Angus Gavin Migratory Bird Research Grant for $11,000 from the University of Alaska Foundation.

Papers Presented

Bolton, W.R., H. Genet, M. Lara, V. Romanovsky, A.D. McGuire, and A.L. Breen. 2017. Projected change in landscape evolution in response to warming on the Alaskan Arctic Coastal Plain: Progress towards assessing impacts for distributions of shorebirds and waterfowl. The International Conference on Arctic Science: Bringing Knowledge to Action. 24-27 April 2017, Reston, VA. (Contributed Oral)

Breen, A.L., W.R. Bolton, A.D. McGuire, T.S. Rupp, E. Euskirchen, H. Genet, S. Marchenko, V.E. Romanovsky, and the IEM Team. 2017. The Integrated Ecosystem Model for Alaska and Northwest Canada: An interdisciplinary decision support tool to inform adaptation to Arctic environmental change. The International Conference on Arctic Science: Bringing Knowledge to Action, Reston, VA. 24-27 April 2017. (Contributed Oral)

Calef, M.P., A. Varvak, and A.D. McGuire. 2017. How human fires differ from lightning fires in Interior Alaska. American Association of Geographers' Annual Meeting, Boston, MA. 5-9 April 2017. (Contributed Oral)

Calef, M.P., A. Varvak, and A.D. McGuire. 2017. Differences in human versus lightning fires with human proximity at two spatial scales in Interior Alaska. Fall Meeting American Geophysical Union, New Orleans, LA. 11-15 December 2017. (Contributed Poster)

Clawson, C., J. Falke, J. Rose, A. Martin, and A. Prakash. 2017. A remote sensing and occupancy estimation approach to quantify spawning habitat use by fall Chum Salmon (*Oncorhynchus keta*) along the Chandalar River, Alaska. Alaska Chapter American Fisheries Society Annual Meeting, Fairbanks, AK. 19-23 March 2017. (Contributed Oral)

Clawson, C., J. Falke, J. Rose, A. Martin, and A. Prakash. 2017. A remote sensing and occupancy estimation approach to quantify spawning habitat use by fall Chum Salmon (*Oncorhynchus keta*) along the Chandalar River, Alaska. Western Division American Fisheries Society Annual Meeting, Missoula, MT. 22-25 May 2017. (Contributed Oral)

Euskirchen, E.S., S. Serbin, T. Carman, C. Iversen, V. Salmon, H. Genet, and A.D. McGuire. 2017. Predicting changes in Arctic tundra vegetation: Towards an understanding of plant trait uncertainty. Fall Meeting American Geophysical Union, New Orleans, LA. 11-15 December 2017. (Contributed Poster)

Falke, J.A., B.M. Huntsman, E.R. Schoen, and K.E. Bennett. 2017. Growth potential of juvenile Chinook Salmon (*Oncorhynchus tshawytscha*) across a boreal riverscape. Alaska Chapter American Fisheries Society Annual Meeting, Fairbanks, AK. 20-24 March 2017. (Invited Oral)

Falke, J., M. Sparks, E. Torvinen, and P. Westley. 2017. Climate vulnerability and salmonids in Alaska: Hind- and forecasting freshwater growth and phenology across species and habitats. Western Division American Fisheries Society Annual Meeting, Missoula, MT. 23-25 May 2017. (Invited Oral)

Fraley, K.M., J.A. Falke, and A.R. McIntosh. 2017. Management and community ecology of trophy freshwater salmonids in New Zealand and Alaska: Correlations and contrasts. 50th Anniversary Symposium of the Fisheries Society of the British Isles, Exeter, UK. 3-7 July 2017. (Contributed Oral)

Genet H., M. Lara, A.D. McGuire, R.W. Bolton, E.S. Euskirchen, and V. Romanovsky. 2017. Integrated evaluation of the vulnerability to thermokarst disturbance and its implications for the regional carbon balance in boreal Alaska. Fall Meeting American Geophysical Union, New Orleans, LA. 11-15 December 2017. (Invited Oral)

Gray, S.T., A.D. McGuire, J.S. Littell, A.L. Breen, K. Timm, and T.S. Rupp. 2017. Balancing the demands of knowledge co-production and basic research for large projects in the North American Arctic. Arctic Summit Science Week 2017, Prague, Czech Republic. 31 March-7 April 2017. Oral Presentation. (Contributed Oral)

Hayes, D.J., R. Vargas, S. Alin, R.T. Conant, L.R. Hutyra, A.R. Jacobson, W.A. Kurz, S. Liu, A.D. McGuire, B. Poulter, and C.W. Woodall. 2016. SOCCR-2, Chapter 2: A synthesis of the North American carbon budget. Fall Meeting American Geophysical Union, New Orleans, LA. 11-15 December 2017. (Contributed Poster)

Hewitt, R.E., H. Genet, D.L. Taylor, A.D. McGuire, and M.C. Mack. 2017. The role of deep nitrogen and dynamic rooting profiles on vegetation dynamics and productivity in response to permafrost thaw and climate change in Arctic tundra. Fall Meeting American Geophysical Union, New Orleans, LA. 11-15 December 2017. (Contributed Oral)

Jalbert, C., J. Falke, P. Westley, A. López, K. Dunker, and A. Sepulveda. 2017. Landscape genetic diversity of native and invasive Northern pike in Alaska. Alaska Chapter American Fisheries Society Annual Meeting, Fairbanks, AK. 19-23 March 2017. (Contributed Poster)

Jalbert, C., J. Falke, P. Westley, A. López, K. Dunker, and A. Sepulveda. 2017. Landscape genetic diversity of native and invasive Northern pike in Alaska. Alaska Invasive Species Workshop, Anchorage, AK. 24-26 October 2017. (Contributed Poster)

Jalbert, C., J. Falke, P. Westley, J.A. López, K. Dunker, and A. Sepulveda. 2017. Landscape genetic diversity of native and invasive Northern pike in Alaska. MatSu Science Symposium, Palmer, AK. 8-9 November 2017. (Contributed Oral)

Laske, S., A. Rosenberger, M. Wipfli, and C. Zimmerman. 2017. Generalist feeding strategies of Arctic fishes stabilize lentic food webs. Alaska Chapter American Fisheries Society Annual Meeting, Fairbanks, AK. 19-23 March 2017. (Contributed Oral)

Laske, S., A. Rosenberger, M.S. Wipfli, and C. Zimmerman. 2017. Surface water connectivity among Arctic lakes drives patterns of fish species richness and composition, and food web structure. American Water Resources Association Spring Specialty Conference 2017, Snowbird, UT. 30 April-3 May 2017. (Invited Oral)

Li, Z., J. Xia, A. Ahlstrom, A. Rinke, C. Koven, D.J. Hayes, D. Ji, G. Zhang, G. Krinner, G. Chen, 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. 2017. Recent slowdown of atmospheric CO2 amplification due to vegetation-climate feedback over northern lands. Fall Meeting American Geophysical Union, New Orleans, LA. 11-15 December 2017. (Contributed Poster)

Lynch, A.J., B.J.E. Myers, T.J. Krabbenhoft, R.P. Kovach, T.J. Kwak, J.A. Falke, C. Chu, D.B. Bunnell, and C.P. Paukert. 2017. Global synthesis of the projected and documented effects of climate change effects on inland fishes. 50th Anniversary Symposium of the Fisheries Society of the British Isles. Exeter, UK. 3-7 July 2017. (Contributed Oral)

Lyu, Z., H. Genet, Y. He, Q. Zhuang, A.D. McGuire, A. Bennett, A. Breen, J. Clein, E.S. Euskirchen, K. Johnson, T. Kurkowski, N. Pastick, T.S. Rupp, B. Wylie, Z. Zhu. 2017. The role of driving factors in historical and projected carbon dynamics in wetland ecosystems of Alaska. Fall Meeting American Geophysical Union, New Orleans, LA. 11-15 December 2017. (Contributed Poster)

Meyer, B., M. Wipfli, D. Rinella, E. Schoen, and J. Falke. 2017. Growth and foraging patterns of juvenile Chinook and Coho Salmon in three geomorphically distinct sub-basins of the Kenai River. Alaska Chapter American Fisheries Society Annual Meeting, Fairbanks, AK. 19-23 March 2017. (Contributed Oral)

Meyer, B., M. Wipfli, D. Rinella, E. Schoen, and J. Falke. Growth and foraging patterns of juvenile Chinook and Coho Salmon in three geomorphically distinct sub-basins of the Kenai River. 2017. Western Division American Fisheries Society Annual Meeting, Missoula, MT. 22-25 May 2017. (Contributed Oral)

Meyer, B., M. Wipfli, D. Rinella, E. Schoen, and J. Falke. 2017. Growth and Foraging Patterns of Juvenile Chinook and Coho Salmon in Three Geomorphically Distinct Sub-Basins of the Kenai River. Alaska Chapter American Fisheries Society Annual Meeting, Fairbanks, AK. 19-23 March 2017. (Contributed Oral)

Meyer, B., M. Wipfli, D. Rinella, E. Schoen, and J. Falke. 2017. Growth and foraging patterns of juvenile Chinook and Coho Salmon in three geomorphically distinct sub-basins of the Kenai River. Society for Freshwater Science Annual Conference, Raleigh, NC. 4-8 June 2017. (Contributed Oral)

Neuneker, K., J. Falke, J. Nichols, and P. Richards. 2017. Migration patterns of adult Chinook Salmon in two Southeast Alaska transboundary rivers. Alaska Chapter American Fisheries Society Annual Meeting, Fairbanks, AK. 19-23 March 2017. (Contributed Oral)

Neuneker, K., J. Falke, J. Nichols, and P. Richards. 2017. Migration patterns of adult Chinook Salmon in two Southeast Alaska transboundary rivers. Western Division American Fisheries Society Annual Meeting, Missoula, MT. 22-25 May 2017. (Contributed Oral)

Schoen, E., K. Sellmer, M. Wipfli, A. López, and R. Ivanoff. 2017. Freshwater predation of juvenile Chinook Salmon in the Arctic-Yukon-Kuskokwim region of Alaska. Alaska Chapter American Fisheries Society Annual Meeting, Fairbanks, AK. 19-23 March 2017. (Invited Oral)

Schoen, E., M. Wipfli, B. Meyer, K. Rine, and K. Sellmer. 2017. Future of Alaskan salmon in the face of change: Bringing a food-web perspective to management and conservation. Western Division American Fisheries Society Annual Meeting, Missoula, MT. 22-25 May 2017. (Invited Oral)

Schoen, E., M. Wipfli, J. Trammell, D. Rinella, and 11 authors. 2017. Pacific salmon in the face of climate and landscape change: Insights from the Kenai River. Alaska Chapter

American Fisheries Society Annual Meeting, Fairbanks, AK. 19-23 March 2017. (Contributed Oral)

Shaftel, R., S. Mauger, J. Falke, D. Rinella, J. Davis, and L. Jones. 2017. Characterization of thermal regimes in the Mat-Su Basin. MatSu Science Symposium, Palmer, AK. 8-9 November 2017. (Contributed Oral)

Timm, K., J. Reynolds, J.S. Littell, K. Murphy, E.S. Euskirchen, A.L. Breen, S.T. Gray, A.D. McGuire, S.T. Rupp and the Integrated Ecosystem Model for Alaska and Northwest Canada Team. 2017. Co-production and modeling landscape change—successes and challenges in developing useful climate science. Fall Meeting American Geophysical Union, New Orleans, LA. 11-15 December 2017. (Invited Poster)

Torvinen, E., J. Falke, C. Arp, T. Sutton, and C. Zimmerman. 2017. Using Lake Trout (*Salvelinus namaycush*) otoliths to recreate past patterns of recent climate and growth in Arctic lakes. Alaska Chapter American Fisheries Society Annual Meeting, Fairbanks, AK. 19-23 March 2017. (Contributed Oral)

Wipfli, M., E. Schoen, and B. Meyer. 2017. Variation in resource subsidies along ecological and latitudinal gradients in Alaska. American Fisheries Society Annual Meeting, Tampa, FL. 20-24 August 2017. (Invited Oral)

Wipfli, M., E. Schoen, B. Meyer, S. Laske, and P. Joy. 2017. Can we manage resource subsidies and food webs to benefit fishes and fisheries? Western Division American Fisheries Society Annual Meeting, Missoula, MT. 22-25 May 2017. (Invited Oral)

Zhu, Z., A.D. McGuire, H. Genet, P. Selmants, and B. 2017. Carbon balance of boreal and arctic Alaska and tropical Hawaii ecosystems. The 10th International Carbon Dioxide Conference, Interlaken, Switzerland. 21-15 August 2017. (Contributed Poster)

Scientific Publications

Barrett, K., T. Loboda, A.D. McGuire, H. Genet, E. Hoy, and E. Kasischke. 2016. Static and dynamic controls on fire activity at moderate spatial and temporal scales in the Alaskan boreal forest. Ecosphere 7, Article e01572, 21 pages, doi:10.1002/ec2.1572. — IPDS: IP-071622; BAO Date: December 29, 2015

Chen, G., D.J. Hayes, and A.D. McGuire. 2017. Contributions of wildland fire to terrestrial ecosystem carbon dynamics in North America from 1990 – 2012. Global Biogeochemical Cycles 31:878-900, doi:10.1002/2016GB005548. — IPDS: IP-084072; BAO Date: September 27, 2016

Fraley, K.M., J.A. Falke, R. Yanusz, and S. Ivey. 2016. Seasonal movements and habitat use of potamodromous rainbow trout across a complex Alaska riverscape. Transactions of the American Fisheries Society 145:1077-1092. — IPDS: IP-071545; BAO Date: December 22, 2015

Gustine, D., P. Barboza, L. Adams, B. Griffith, R. Cameron, and K. Whitten. 2017. Advancing the match-mismatch framework for large herbivores in the Arctic: Evaluating the evidence for a trophic mismatch in caribou. PLoS ONE 12(2): e0171807. doi:10.1371/journal.pone.0171807 — IPDS: IP-061147

Haynes, T., T. Jones, M. Robards, J. Lawler, A. Whiting, M. Tibbles, M. Wipfli, and P. Neitlich. 2016. Understanding the Ecology of Arctic Coastal Lagoons through Fisheries Research and Monitoring. Alaska Park Science report, NPS. — IPDS: IP-080790; BAO Date: October 21, 2016

Huntsman, B.M., J.A. Falke, J.W. Savereide, and K.E. Bennett. 2017. The role of density-dependent and -independent processes in spawning habitat selection by salmon in an Arctic boreal stream network. PLoS ONE 12(5): e0177467. https://doi.org/10.1371/journal.pone.0177467 — IPDS: IP-077611; BAO Date: July 11, 2016

Laske, S.M., A.E. Rosenberger, W.J. Kane, M.S. Wipfli, and C.E. Zimmerman. 2017. Top-down control of invertebrates by Ninespine Stickleback in Arctic ponds. Freshwater Biology DOI: 10.1086/690675. — IPDS: IP-076980; BAO Date: June 21, 2016

Leppi, J., M. Lunde, M. Wipfli, and D. Rinella. 2017. In search of Arctic Bonefish. Report in Fisheries magazine. — IPDS: IP-086184

McFarland, J., M. Wipfli, and M. Whitman. 2016. Trophic pathways supporting Arctic Grayling in a small stream on the Arctic Coastal Plain, Alaska. Ecology of Freshwater Fish. — IPDS: IP-066080; BAO Date: June 1, 2015

McGarvey, D.J., J.A. Falke, H.W. Li, and J.L. Li. 2017. Fish assemblages. Pages 321-354 in F.R. Hauer and G.A. Lamberti, editors. Methods in Stream Ecology, 3rd edition. Academic Press. — IPDS: IP-070364; BAO Date: August 30, 2015

McGuire, A.D., B.P. Kelly, and L. Sheffield Guy. 2017. Resolving a methane mystery in the Arctic. Eos 98, https://doi.org/10.1029/2017EO076733. — IPDS: IP-086522

McGuire, A.D., B.P. Kelly, L. Sheffield Guy, H.V. Wiggins, L. Bruhwiler, J. Frederick, H. Huntington, R. Jackson, R. Macdonald, C. Miller, D. Olefeldt, E.A.G. Schuur, and M.R. Turetsky. 2017. Final Report: International Workshop to Reconcile Methane Budgets in the Northern Permafrost Region. Arctic Research Consortium of the United States (ARCUS), Fairbanks, Alaska. 14 pages. Available through the International Arctic Research Center (IARC) Data Archive at http://climate.iarc.uaf.edu/geonetwork/srv/en/main.home?uuid=e436b77a-b0db-44c1-bd18-260c5b076b43. — IPDS: IP-086397; BAO Date: April 17, 2017

McGuire, A.D., T.S. Rupp, A. Breen, E.S. Euskirchen, S. Marchenko, V. Romanovsky, A. Bennett, W.R. Bolton, T. Carman, H. Genet, T. Kurkowski, M. Lara, D. Nicolsky, R. Rutter, and K. Timm. (2016). Final Report: Integrated Ecosystem Model (IEM) for Alaska and Northwest Canada Project. Fairbanks, AK; Scenarios Network for Alaska and Arctic Planning. 71 pages. doi: http://doi.org/10.21429/C9RP43. — IPDS: IP-080463

Myers, B.E., A.J. Lynch, D.B. Bunnell, C. Chu, J.A. Falke, R.P. Kovach, T.J. Krabbenhoft, T.J. Kwak, and C.P. Paukert. 2017. Global synthesis of the projected and documented effects of climate change on inland fishes. Reviews in Fish Biology and Fisheries 27:339–361.DOI 10.1007/s11160-017-9476-z — IPDS: IP-079917

Olefeldt, D., E.S. Euskirchen, J. Harden, E. Kane, A.D. McGuire, M.P. Waldrop, and M.R. Turetsky. 2017. A decade of boreal rich fen greenhouse gas fluxes in response to natural and experimental water table variability. Global Change Biology 23:2428-2440, doi:10.1111/gcb.13612. — IPDS: IP-075210; BAO Date: April 15, 2016

Pastick, N.J., P. Duffy, H. Genet, T.S. Rupp, B.K. Wylie, K.D. Johnson, M.T. Jorgenson, N. Bliss, A.D. McGuire, E.E. Jafarov, and J.F. Knight. 2017. Historical and projected trends in landscape drivers affecting carbon dynamics in Alaska. Ecological Applications 27:1383-1402, doi:10.1002/eap.1538. — IPDS: IP-076738

Perkin, J.S., K.B. Gido, J.A. Falke, K.D. Fausch, H. Crockett, E.R. Johnson, and J. Sanderson. 2017. Groundwater pumping shrinks Great Plains stream fish assemblages. Proceedings of the National Academy of Sciences 114(28):7373-7378. doi: 10.1073/pnas.1618936114 — IPDS: IP-081390; BAO Date: November 14, 2016

Schoen, E., M. Wipfli, and 15 other coauthors. 2017. Future of Pacific Salmon in the face of environmental change: Lessons from one of the world's remaining productive salmon regions. Fisheries 42(10): 538-553. DOI:10.1080/03632415.2017.1374251 — IPDS: IP-084989; BAO Date: March 6, 2017

Sparks, M.M., P.A.H. Westley, J.A. Falke, and T.P. Quinn. 2017. Thermal adaptation and phenotypic plasticity in a warming world: Insights from common garden experiments on Alaskan sockeye salmon. Global Change Biology 23:5203-5227.

Xia, J., A.D. McGuire, D. Lawrence, E. Burke, G. Chen, X. Chen, C. Delire, C. Koven, A. MacDougall, S. Peng, A. Rinke, K. Saito, W. Zhang, R. Alkama, T.J. Bohn, P. Ciais, B. Decharme, I. Gouttevin, T. Hajima, D.J. Hayes, K. Huang. D. Ji, G. Krinner, D.P. Lettenmaier, P.A. Miller, J.C. Moore, B. Smith, T. Sueyoshi, Z. Shi, L. Yan, J. Liang, L.

Jiang, Q. Zhang, and Y. Luo. 2017. Terrestrial ecosystem model performance in simulating productivity and it vulnerability to climate change in the northern permafrost region. Journal of Geophysical Research – Biogeosciences 122:430-446, doi:10.1002/2016/JG003384. — IPDS: IP-070881; BAO Date: November 25, 2015

Theses and Dissertations of Unit-Sponsored Graduate Students

Clawson, Chelsea. 2017. Using remote sensing, occupancy estimation, and fine-scale habitat characterization to evaluate fall chum salmon (*Oncorhynchus keta*) spawning habitat usage in Arctic Alaska. MS thesis, University of Alaska Fairbanks. 107 pp.

Laske, Sarah. 2017. Surface water connectivity of Arctic lakes drives patterns of fish species richness and composition, and food web structure. PhD dissertation, University of Alaska Fairbanks. 171 pp.

Neuneker, Kristin. 2017. Migration patterns and energetics of adult Chinook Salmon *Oncorhynchus tshawystcha* in Alaska rivers. MS thesis, University of Alaska Fairbanks. 115 pp.

Torvinen, Eric. 2017. Lake trout (*Salvelinus namaycush*) otoliths as indicators of past climate patterns and growth in arctic lakes. MS thesis, University of Alaska Fairbanks. 97 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

Predation Mortality as a Potential Source of Chinook Salmon Declines in the Arctic-Yukon-Kuskokwim Region

Post-doctoral Researcher: Erik Schoen (IAB)
Advisor: Mark Wipfli
Funding Agencies: ADFG and USFWS
In-Kind Support: Norton Sound Economic Development Corporation; ADF&G; and subsistence and sport fishers in Eagle, Unalakleet, and Fairbanks

Chinook Salmon population declines have caused economic and cultural hardship throughout Alaska, particularly in the Arctic-Yukon-Kuskokwim (AYK) region. Predation can represent an important source of mortality for juvenile salmon during their freshwater residence, but little is known about the predators of juvenile Chinook Salmon in the AYK region. Research is necessary to understand whether Chinook Salmon survival in freshwater could be influenced by harvest of piscivorous fishes or conserving or restoring particular habitat types. The objectives of this study were to (1) quantify the diet composition of key piscine predators in the AYK region, with a focus on predation on juvenile Chinook Salmon, and (2) determine if predation varies by season, habitat, or predator size. We analyzed stomach contents from 548 Arctic Grayling, Burbot, Dolly Varden, and Northern Pike collected during 2014–2015 in the Chena, Yukon, and Unalakleet Rivers. We identified prey items through taxonomic identification and genetic sequencing. We found Chinook Salmon in stomachs of Arctic Grayling, Burbot, and Northern Pike sampled from the Chena and Yukon Rivers, but not from the Unalakleet River. Juvenile Chinook Salmon densities were greater in mainstem habitats than sloughs, but predation was documented almost exclusively in sloughs. Predation was also more common during a year of record-high river discharge (2014) than during a year of more typical flows (2015). Predation was observed primarily during late May–early June, and September, periods of salmon movement among habitats. Juvenile Chinook Salmon may be more vulnerable to predation in sloughs than in mainstem habitats, in large part because of greater densities of pike in sloughs. If high stream flows force salmon to leave mainstem habitats and seek refuge in sloughs, this may help explain why high flows during juvenile rearing are associated with low population productivity of Chinook Salmon in the Yukon River basin. These findings provide some insight into how a changing climate, harvest of piscivorous fishes, and habitat conservation and restoration may affect Chinook Salmon productivity within the AYK region.

Using Remote Sensing, Occupancy Estimation, and Fine-Scale Habitat Characterization to Evaluate Fall Chum Salmon (*Oncorhynchus keta*) Spawning Habitat Usage in Arctic Alaska Seasonal Movements of Northern Pike in Minto Flats, Alaska

Student Investigator: Chelsea Clawson, MS Fisheries
Advisor: Jeff Falke
Funding Agency: USFWS
In-Kind Support: Personnel, boats, and logistics provided by Fairbanks Fish and Wildlife Field Office, USFWS

Note: Chelsea Clawson graduated from the University of Alaska Fairbanks in August 2017. Her thesis abstract follows:

Abstract: Groundwater upwellings provide stable temperatures for overwinter salmon embryo development and this process may be particularly important in cold, braided, gravel-bed Arctic rivers where rivers may freeze solid in the absence of upwellings. Aerial counts and remote sensing were used during 2013-2015 to estimate fall chum salmon (*Oncorhynchus keta*) spawner abundance states (e.g., low or high), classify river segments by geomorphic channel type (primary, flood, and spring), and map thermal variability along a 25.4 km stretch of the Chandalar River in interior Alaska. Additionally, I used on-the-ground examination of fine scale variation in physical habitat characteristics at 11 representative sites to characterize habitat variability, placed temperature loggers to assess overwinter thermal conditions in redds, and used a developmental model to predict hatching and emergence timing given known spawning dates and incubation temperatures. I delineated 330 unique river segments (mean length = 536 m) and used a multi-season multistate occupancy model to estimate detectability, occupancy, and local colonization and extinction rates. Triplicate surveys performed in 2014 allowed me to estimate detectability and the influence of observer bias. I found that detectability did not vary by observer, channel type, or segment length, but was better for high abundance (0.717 ± 0.06 SE) relative to low abundance (0.367 ± 0.07 SE) aggregations. After correcting for imperfect detection, the proportion of segments occupied by spawning fall chum salmon was highest in 2014 (0.41 ± 0.04 SE), relative to 2013 (0.23 ± 0.04) and 2015 (0.23 ± 0.04). Transition probabilities indicated unoccupied segments were likely to remain so from year to year (2013→2014 = 0.67; 2014→2015 = 0.90), but low abundance spawning segments were dynamic and rarely remained in that state. One-third of high abundance sites remained so, indicating the presence of high quality spawning habitat. Mean segment temperatures ranged from -0.5 to 4.4°C, and occupancy varied positively with temperature. I predicted a 50% probability of occupancy in segments with temperatures of 3°C. With my on-the-ground work, I found that habitat characteristics varied among the three channel types, with most significant differences between main channel and off-channel habitats. Dissolved oxygen and pH decreased with increasing temperature, and conductivity increased with temperature. Predicted hatching and emergence timing ranged from 78 and 176 days (December 11th and March 18th) to 288 and 317 days (July 8th and August 6th), respectively, post-spawning, and were highly variable within sites and among channel types owing to high habitat thermal heterogeneity. Because the Chandalar River supports 30% of the fall chum salmon run in the Yukon River Basin, information such as provided by this study will be critical to allow resource managers to better understand the effects of future climate and anthropogenic change in the region.

Surface Water Connectivity of Arctic Lakes Drives Patterns of Fish Species Richness and Composition, and Food Web Structure

Student Investigator: Sara Laske, PhD Fisheries
Co-Advisors: Amanda Rosenberger and Mark S. Wipfli
Funding Agency: Alaska Science Center, USGS (RWO 188)

Note: Sarah Laske graduated from the University of Alaska Fairbanks in August 2017. Her thesis abstract follows.

Abstract: Hydrological processes regulate fish habitat, largely controlling availability and suitability of habitat for freshwater fishes. Seasonal fluctuations in surface water distribution and abundance on the Arctic Coastal Plain, Alaska, influence individual fish species

occupancy in lentic habitats. On low-relief tundra, permafrost processes and climate are chiefly responsible for lake formation and surface water dynamics, such as the timing, duration, and availability of water that affects fish species distributions. However, it is unclear how these relationships scale up to influence fish community richness and composition, or food web structure. Further, each of these processes is also likely to change with rapid climate warming occurring in the Arctic. By observing patterns of fish species occupancy, we examined how fish species richness and composition in Arctic lakes varied with surface water connectivity at coarse and spatial fine scales. Through experiments and observation, we determined the structure of food webs as they related to surface water connectivity and foraging habits of associated fish species. We found surface water connectivity was a driver of fish species richness and assemblage patterns. Permanently connected lakes contained nearly twice as many species as disconnected lakes; and the most strongly connected lakes contained an average of four additional species compared to isolated lakes. Functional traits of fishes, like life history or body morphology, likely dictate their ability to colonize habitats. Given reduced colonization potential, isolated lakes either never supported or could not retain larger predatory fishes. In isolated systems only one fish predator occurred consistently, and this species showed strong top-down control of invertebrate prey in experimental systems. Yet, in natural environments single-predator systems have fewer trophic links than multi-predator systems, and therefore, less trophic redundancy across species. The loss of species due to isolation reduced the total number of trophic links and shortened food chains. However, I argue that the complexity and addition of top-predators in surface water connected lakes adds trophic redundancy, stabilizes energy flow, and potentially enhances persistence within in food webs and across the meta-community of food webs. Changes to fish species richness, composition, or food web structure from climate warming may be dampened by the resilience of food webs locally, but across the broader landscape it is likely that some food webs will be restructured due to changes in colonization potential regulated by surface water connectivity.

Migration Patterns and Energetics of Adult Chinook Salmon *Oncorhynchus tshawystcha* in Alaska Rivers

Student Investigator: Kristin Neuneker, MS Fisheries
Advisor: Jeff Falke
Funding Agency: ADFG, Sport Fish Division, Region 1

Note: Kristin Neuneker graduated from the University of Alaska Fairbanks in December 2017. Her thesis abstract follows.

Abstract: Adult Chinook Salmon *Oncorhynchus tshawytscha* undertake extensive and energetically costly migrations between food resources in the ocean and their freshwater spawning habitats, requiring them to adapt behavioral and physiological traits that allow them to successfully reach their spawning streams and reproduce. Such adaptations may be shaped by physical factors in the environment and individual- and population-specific biological characteristics. Chinook Salmon in North America are important resources for both United States and Canadian stakeholders, but relatively little is known about their freshwater migration patterns and energetic status in many rivers across their range. This research explored variation in migration timing and migration rates of Chinook Salmon in two Southeast Alaska transboundary rivers (Taku River, Stikine River), examined energetic status at multiple sampling locations in Alaska, and created and tested a predictive model for energetic status using bioelectrical impedance analysis (BIA). Migration timing was earlier for fish that spawned in more distant tributaries in both transboundary systems and the Taku River was earlier compared to the Stikine River. Migration rates decreased during

periods of high flows, were slower for fish in the Taku River, and were slower in both systems in 2016 compared to 2015. Migration rates were faster for fish with spawning sites farther upstream when compared to those that spawned closer to the river mouth, but these rates decreased over time as fish swam farther upriver. Chinook Salmon (N = 129) sampled for energetic status at the beginning of their freshwater spawning migration had higher total percent lipid than those near the spawning grounds (ANOVA: F = 202.1, df = 3, P < 0.001), and total percent lipid and water were precisely predicted based on BIA measurements (R^2 = 0.82, RMSE = 5.33; R^2 = 0.78, RMSE = 2.43 respectively). The BIA model was tested to determine if it could be generalized between similar species, but this was found to be less precise than species-specific models. The BIA measurement technique was also easily implemented into an existing study on a remote Chinook Salmon population. Given threats from climate change and mining activities, this information will be useful for fisheries researchers as a benchmark for understanding migration behaviors in these Chinook Salmon populations, and indicates that integration of BIA into population monitoring may be a useful tool for creating management practices targeted at facilitating successful migration behaviors and increasing or maintaining energetic status for these fish.

Lake Trout (*Salvelinus namaycush*) Otoliths as Indicators of Past Climate Patterns and Growth in Arctic Lakes

Student Investigator: Eric Torvinen, MS Fisheries
Advisor: Jeff Falke
Funding Agency: USGS Alaska Climate Science Center

Note: Eric Torvinen graduated from the University of Alaska Fairbanks in May 2017. His thesis abstract follows:

Abstract: The effects of climate change on freshwater ecosystems are amplified in high-latitude regions; however, Alaska climate data are limited due to the remote location of the Arctic. Predictions have indicated that warming temperatures owing to climate change could increase fish growth, but the magnitude and factors influencing these changes remain uncertain. Here I investigated the relationship between Lake Trout *Salvelinus namaycush* growth and physical and biological characteristics, fish community structure and climate patterns. I applied biochronology techniques to predict recent climate patterns from annual growth increments recorded on Lake Trout otoliths. Growth increments were also used to perform length-at-age back-calculations and to estimate the growth coefficient *K*, as described by a von Bertalanffy growth model. Lake Trout were captured from 13 climate-sensitive lakes in the Fish Creek watershed in Arctic Alaska during 2014 and 2015. Individual Lake Trout (*N* = 53) ranged from 471–903 mm fork length (FL; mean = 589.3 mm) and their readable annuli, representative of age, ranged from 9-55 annual growth increments. I constructed a growth chronology for the period 1977–2014 and used model selection to identify the best predictive model of relative Lake Trout growth (ring width index; RWI) as a function of climate descriptors. A single covariate model was the best predictor and indicated that RWI tracked mean August air temperature recorded at a local weather station from 1998–2013 ($P < 0.001$; $R^2_{adj} = 0.55$; $RMSE = 0.048$). Lake Trout growth (*K*) was subsequently modeled as a function of physical and biological characteristics, and fish community structure, using multiple linear regression. The highest ranked model included physical (i.e., depth, distance to river and coast, connectivity class, and number of stream intersections) and biological (sex) covariates. Model averaging indicated *K* was higher in deeper, well connected lakes, located further from the coast and was lower with increasing distance from a large river, though the relationship with depth was found to be the single significant covariate. This study demonstrated the utility of

biochronology techniques to estimate past climate patterns in remote regions, and provided valuable knowledge regarding growth-environment relationships for Lake Trout. In turn, this information can be used to better understand the effects of a changing environment in sensitive Arctic lake ecosystems.

Ongoing Aquatic Studies

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; ADFG, Sport Fish Division; Norton Sound Economic Development Corporation

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 and body condition determined by length:weight relationships. 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 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.

Landscape Genetic Diversity of Native and Invasive Northern Pike in Alaska

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

The introduction and expansion of invasive Northern Pike in southcentral Alaska has driven declines of salmonids in the Matanuska-Susitna (MatSu) Basin and led to the extirpation of a rare form of three spine stickleback in Praetor Lake near Wasilla. Because Northern Pike are piscivores that favor salmonids, their invasion has led to a change in the quality and quantity of salmon habitat in southcentral Alaska. Objectives for this work are to (1) test hypotheses regarding the origins of invasive populations, their levels of genetic variability relative to native populations, and inferred size of founding populations, and (2) develop a Northern Pike habitat suitability model and assess potential impacts on salmon populations in the MatSu Basin. We will characterize genetic diversity among native and introduced

ChaseJalbert: First Northern Pike sample, on the fly, for his research project.

populations using a genotyping-by-sequencing approach to generate multilocus genotype datasets. We will use NetMap to characterize and rank habitat suitability for Northern Pike within the MatSu Basin. Presence-absence data will be used to parameterize and evaluate the accuracy of the habitat suitability model. Additionally, we will quantify habitat connectivity throughout the MatSu Basin to predict areas were Northern Pike are likely to invade. Finally, our habitat suitability model and connectivity estimates will be compared to known distributions of juvenile salmonid rearing habitats. We expect to detect a significant degree of genetic differentiation between native and introduced populations. We will produce maps of salmon population vulnerability to Northern Pike invasion by species and provide these to ADFG. Objective 1: We characterized genetic diversity among three native and six invasive populations collected from lakes and streams in the MatSu Basin and the species native range in Alaska using a genotyping-by-sequencing approach and generated an extensive multilocus genotype dataset comprised of genotypes from over 6000 loci. Based on samples of 20 to 25 individuals per population, the dataset provided sufficient resolution for differentiating population structure and genetic diversity between populations. Results show that populations within the invasive range host lower genetic diversity than those in the native range, indicating a small population of founders. Interestingly, one invaded lake population hosted levels of diversity similar to those of native populations, suggesting the introduction of a larger number of individuals and/or ongoing introductions. Furthermore, this population appears to have different genealogical affinities than other invasive populations, providing further evidence for a separate source population. Objective 2: We developed a Northern Pike intrinsic habitat potential (IP) model for the MatSu Basin using NetMap, an integrated set of watershed terrain parameters and analysis tools. Attributes representing climatic, hydrologic and topographic features were generated across 24,300 stream-km and used to characterize and rank habitat suitability for Northern Pike. Presence data were compiled from the Alaska Department of Fish and Game’s Northern Pike Waters Catalog and used to inform and evaluate the accuracy of the IP model. We used these predictions to assess the potential vulnerability of five Pacific salmon species to Northern Pike invasion across the MatSu Basin as a function of distance to invaded waterbody, invasion likelihood via human transport, juvenile salmon life history, and the extent of overlap between high quality pike and juvenile salmon habitats. This study will provide estimates of the future impact of Northern Pike on salmonids in southcentral Alaska.

Checking a Northern Pike net in Tyonek, AK.

Chena River Juvenile Chinook Salmon Large Wood Habitat Mapping

Student Investigator: N/A, technicians only
Principal Investigator: Jeff Falke
Funding Agency: USFWS Subsistence Fisheries Branch (RWO 223)
In-Kind Support: USFWS Fisheries and Habitat Restoration Branch; Tanana Valley Watershed Association

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 will float the distribution of juvenile Chinook Salmon rearing habitats within the Chena River Basin and make 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; m^2) 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/m^2) 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


Conducting fish snorkel counts in the Chena River Basin, Alaska. Photo by JR Ancheta, UAF.

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 sensing and link the distribution and abundance of wood along the river to wildfire and land management practices.

Genetic Diversity and Population Relationships of resident kokanee and anadromous sockeye salmon in Copper Lake (Wrangell-St. Elias National Park)

Student Investigator: Genevieve Johnson, MS Fisheries
Advisor: Jeff Falke and Andrés López (CFOS)
Funding Agency: National Park Service (RWO 208)

Copper Lake in the Wrangell-St. Elias National Park (WSTP) is thought to be home to a population of Kokanee Salmon, a non-migratory (i.e., resident) form of Sockeye Salmon. Field surveys have produced small Sockeye Salmon specimens in reproductive condition. Whether these fish belong to a self-perpetuating population of resident salmon or to a sockeye population that expresses both migratory and non-migratory life history variants remains to be determined. The specific objectives of this study are to (1) conduct an assessment of genetic variability in sockeye salmon populations of the Copper and Tanada Lakes, (2) compare measures of genetic variation in the target lakes with previously published estimates of variation in other populations of the target species, and (3) determine the degree of differentiation of Copper Lake sockeye salmon populations when compared to other populations in the drainage.

1. Field surveys — in collaboration with the National Park Service we will conduct field sampling in Tanada and Copper Lakes to obtain tissue samples from resident and migratory Sockeye Salmon. Fish that may be confidently assigned to the resident category based on size, morphology, and spawning condition will be analyzed separately. Surveys will use non-lethal sampling and will aim to assemble the largest set of individual samples feasible during one field season.
2. Generate a dataset consisting of genotypes from 14 loci (microsatellite) for a sample of at least 50 individuals from Tanada and Copper Lakes.
3. Computational analysis of multilocus genotypes. Each dataset will be checked for potential lab-generated artifacts. From genotypes in verified and vetted datasets, measures of diversity (e.g. heterozygosity, allelic richness) will be calculated. Indices of fixation (e.g. Fst and related measures) will be calculated to estimate degree of differentiation. We have obtained preserved tissue samples from 100 Copper drainage sockeye spawners and from 50 Copper Lake Kokanee. We have isolated high quality total genomic DNA from the entire sample set and evaluated quantity from each DNA preparation. We have obtained genotypes for all the samples and loci in the study. We are currently analyzing this genotype dataset to determine the level of genetic differentiation between the Kokanee population and anadromous sockeye from the Copper drainage. We will expect to complete these analyses by May 2018. This project aims to produce a thorough baseline assessment of sockeye salmon genetic variability in Copper and Tanada Lakes using suites of genetic markers widely deployed for Sockeye Salmon assessments in the state. The resulting measures of genetic diversity (from multilocus genotypes) will be summarized in indices of variation within and between groups (e.g. lakes, resident vs. migratory, drainage), which serve as estimates of the degree of genetic differentiation between groups.

LiDAR-Based Evaluation of Terrestrial Invertebrate Subsidies for Juvenile Salmon in the Kenai River Watershed

Student Investigator: Jess Grunblatt, Interdisciplinary PhD Candidate, Department of Biology and Wildlife
Advisors: Mark Wipfli and Barbara Adams
Funding Agencies: Experimental Program to Stimulate Competitive Research (EPSCoR), National Science Foundation (NSF); State of Alaska

Resource subsidies (e.g., nutrients, prey) entering streams sourced from terrestrial or marine ecosystems can strongly influence freshwater food webs and associated fish populations in a variety of ways (e.g., via growth rates, and body condition and size). For juvenile salmon, one of these subsidies is terrestrial invertebrates associated with riparian plant communities. How riparian vegetation type affects terrestrial food subsidies for juvenile salmon at the broader watershed scale is not clear. Knowledge of the effects of riparian vegetation type (herb, shrub, or tree) on terrestrial invertebrate subsidies to fish is necessary to better understand the consequences of changes in riparian vegetation for juvenile salmon resulting from riparian management and landscape change. The objective of this study is to determine how riparian plant community type affects food resources (terrestrial and aquatic invertebrates) for juvenile Chinook (*Oncorhynchus tshawytscha*) and Coho (*O. kisutch*) Salmon in the Kenai River watershed. Three streams were selected for the study representing high-gradient montane to low-gradient wetland riparian areas within the Kenai River watershed. Riparian vegetation height along each stream was determined from LiDAR and matched to fish diet sampling reaches for 2015-2016. Sample reaches were stratified by adjacent vegetation height (which differentiates herb, shrub, and tree communities), and the contribution of aquatic and terrestrial invertebrates to salmonid diet was determined. Preliminary results indicate more aquatic than terrestrial invertebrates were consumed by juvenile salmon May through September in areas where adjacent vegetation was low stature (herbaceous) while more terrestrial than aquatic invertebrates were consumed where adjacent vegetation was higher stature (shrub or tree). Climate models project that the Kenai Peninsula will continue to get warmer and drier. These changing environmental conditions, along with the expected increase in wildfires and forest insect outbreaks, will change plant cover. Forests will likely transition to herbaceous cover and wetlands to shrubs. A better understanding of how riparian vegetation type drives terrestrial prey subsidies for juvenile salmon will allow us to better predict effects of riparian management and climate change.

Growth and Foraging of Juvenile Chinook and Coho Salmon in Three Geomorphically Distinct Sub-Basins of the Kenai River

Student Investigator: Benjamin Meyer, MS Fisheries
Advisor: Mark Wipfli
Funding Agencies: EPSCoR (NSF); State of Alaska
In-Kind Support: Kenai Peninsula College, Kenai Watershed Forum, Cook Inletkeeper

Changes in air temperature and precipitation affect juvenile salmon freshwater rearing habitat differently depending on local habitat conditions. Water temperature acts as a key control on juvenile salmon growth, and some south-central Alaskan salmon streams already experience water temperatures approaching the thermal optimum threshold of 15–17°C during summer months. Food is an additional key control on growth, and temporal and spatial patterns these two variables have in combination 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. Knowing how environmental variables including temperature and food availability contribute to juvenile salmon growth rates will help inform us on how these fish may fare in a changing landscape. Objectives were to show how (1) air temperature regulates water temperature in Beaver Creek, Russian River, and Ptarmigan Creeks within the Kenai River watershed, and investigate the degree of water temperature heterogeneity in stream reaches, and (2) stream temperature and food influence growth rates of juvenile Chinook and Coho Salmon that rear in these streams. We sampled the 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. A total of 3159 juvenile Coho Salmon and 1273 juvenile Chinook Salmon were captured, with 720 and 261, respectively, sampled for scales and stomach contents. Air and water temperature data were monitored continuously at lower, middle, and upper sites in each study drainage May-September. 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. Preliminary results indicate that juvenile Chinook and Coho salmon rearing in low-elevation tributaries such as Beaver Creek may be exposed to temperatures outside physiological optimum more frequently than montane habitats as summer mean air and water temperatures rise in the future. Conversely, high-elevation, glacially influenced drainages such as Ptarmigan Creek appear less sensitive to air temperature; juvenile salmon populations there will likely experience less dramatic thermal ranges. Development activities in south-central Alaska are concentrated near low-elevation watersheds where anadromous salmon rearing habitat is potentially most sensitive to change. These data support the notion 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.

Driftnet with stoneflies sampled from the Russian River on the Kenai Peninsula, AK, summer 2015.

Juvenile Chinook Salmon from the mainstem Kenai River, AK, summer 2016.

Completed Wildlife Studies

Microbial Infection as a Source of Embryo Mortality in Greater White-fronted Geese

Post-doctoral Researcher: Cristina Hansen, Department of Veterinary Medicine
Principal Investigator: Karsten Hueffer, Department of Veterinary Medicine
Funding Agency: USGS (RWO 214)
In-Kind Support: Transportation, logistics, and field sampling provided by USGS

Microbial infections cause embryo mortality in birds and may represent a threat to populations. The bacteria that we have associated with embryo mortality in greater white-fronted geese are either novel or have not been associated with bird eggs previously. Route(s) of infection, infectious dose, geographic extent, and the characterization of bacterial species involved in embryo infection in greater white-fronted geese in Arctic and subarctic settings have not been characterized. The objectives of this research are to further assess bacterial infection of avian embryos in Alaska. This study expanded the geographic scope of monitoring by cooperating with field camps in Alaska and Canada. Additionally, we aimed to determine the source of infection by testing environmental samples and tissue samples from nesting white-fronted geese. We also aim to determine whether infection by the most common bacteria isolated (a *Neissera* species) is vertical or horizontal. Finally, we aim to determine whether the *Neisseria* species isolated from many of our samples is a novel species. Samples from the 2014 hatching season (n=470) were assessed. Tissue samples from 20 nesting females were assayed for *Neisseria arctica* bacteria using polymerase chain reaction. Additionally, laboratory-based infection studies using fertilized chicken eggs were conducted to attempt to determine route of infection and infectious dose of *N. arctica*. Antibiotic resistance patterns and genetic characterization of another commonly isolated bacteria (*Streptococcus uberis*) were explored. Finally, genetic characterization, fatty acid analysis, and biochemical characteristics were performed on *Neisseria* isolates to determine whether it is a novel species. We determined that our *Neisseria* isolates were a new species and we named it *Neisseria arctica.* This was published in a peer-reviewed journal in early 2017 (see citation below). We isolated many of the same bacteria from 2014 eggs as we did in 2013 eggs, and many more species. We also isolated some of the same bacteria from different field sites in the Arctic, in Western Alaska, in Southeast Alaska, and in Canada. Results show that some tissues contain *N. arctica* DNA (ovary, uterus, jejunum, and cloaca). We attempted to infect washed and unwashed chicken eggs with *N. arctica* via the trans-shell (horizontal) route and were largely unsuccessful. This data is still being analyzed. The *Streptococcus* work shows that our isolates show considerable diversity and are likely continually introduced to the North Slope of Alaska. We also identified antibiotic resistance in *S. uberis* isolates. Many species of bacteria, most notably a *Neisseria* species, are commonly found in addled goose eggs and are likely contributing to embryo mortality in wild populations.

Publications resulting from this work:

- Hansen, C.M., S.C. Choi, J. Parker, K. Hueffer, and J. Chen. 2015. Draft genome sequence of a taxonomically unique *Neisseria* species isolated from a greater white-fronted goose (*Anser albifrons*) egg on the North Slope of Alaska. Genome Announcements 3(4):e00772-15.
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Ongoing Wildlife Studies

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

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

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 to climate-mediated factors and impacts from development, due to their small population size, ecology, and genetic and physical segregation. Shifting climate patterns may lead to increased coastal erosion, flooding events, and exposure to polar bears and other predators. 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 (1) quantify specific causes of nest failure, (2) test the accuracy of "traditional" and "quantitative" methods for determining predator species from evidence left at a nest site, and (3) investigate the relationship between nest site habitat and specific causes of nest failure. In 2015–17, we surveyed barrier islands of the Arctic National Wildlife Refuge 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. Relative importance of predator species changed from year to year. Using the "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. Extreme weather conditions and the presence of multiple predators may have contributed to ambiguous and/or misleading evidence at nest sites. We recommend continued use of time-lapse cameras for evaluating causes of nest failure. Understanding the importance of specific causes of nest failure in limiting common eider reproduction is critical for developing management plans aimed at species recovery.

Energetic Impacts of Storm Surges: How Wind Exposure May Affect Pacific Common Eiders along the Beaufort Sea Coast

Student Investigator: Elyssa Watford, MS Wildlife Biology and Conservation
Advisors: Tuula Hollmen and Mark Lindberg
Funding Agencies: Arctic National Wildlife Refuge, USFWS (RWO 215) and Angus Gavin Migratory Bird Research Grant
In-Kind Support: Student Conservation Association, Wildlife Conservation Society

Pacific Common Eiders (eiders) declined by 53% between 1976 and 1996 along the Beaufort Sea coast. Model predictions indicate higher magnitude storm surges will occur more frequently during the breeding season as sea ice continue to retreat with climate warming. 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 population dynamics and provide a better understanding of how eiders may be affected by petrochemical development and climate change. Understanding how eiders may respond to storm surges, and the energetic consequences of those responses, is important because this small population is highly vulnerable to climate change. The goals of this project are to

Recording the elevation of an active Pacific Common Eider nest along the Beaufort Sea coast, field season 2017. Photo by Elyssa Watford.

assess nest microclimate variability, the potential energetic benefits of nest shelter, and the current energetic status of incubating hens. I will search barrier islands along the Beaufort Sea coast for nesting eiders and capture hens throughout incubation. I will collect blood samples to assess their energetic status and validate novel heart rate monitoring technology. I will also collect several nest microclimate variables. I expect results to highlight the most important nest microclimate variables for thermal nest protection, discern if nest shelter reduces the energetic cost of incubation, and understand the current energetic status of incubating hens. These results will provide a better understanding of how vulnerable eiders are to climate change and help inform management decisions.

Post-Breeding Surveys of the Shorebird Community at Cape Krusenstern National Monument

Student Investigator: Megan Boldenow, MS Wildlife Biology and Conservation Candidate
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

Habitats along the coastline of Cape Krusenstern National Monument (CAKR) include areas important for migratory waterbirds. These habitats are vulnerable to potential impacts from climate change, offshore energy development, and increased arctic shipping. Waterbirds may be especially vulnerable to oil spills during the post-breeding season, given their large aggregations in concentrated areas. Post-breeding fieldwork is contributing to an updated assessment of the importance of Western Arctic Parks, particularly the Sisualik Lagoon area of CAKR, to migratory waterbirds. This work provides the NPS with critical baseline data and addresses the following objectives, focusing on shorebirds: (1) determine timing of use, (2) determine species abundance and diversity, (3) document habitat use around and within the lagoon, and (4) provide a comparison to anecdotal, historic records. Ground-based surveys were conducted during late summer 2014. Survey plots were discrete habitats that could be distinguished on the ground. We attempted to establish a sample in all unique types. We visited each plot regularly and kept a running tally of all waterbirds observed during area searches, communicating to avoid double-counting. A report was submitted to NPS for incorporation into their Natural Resource Condition Assessment (NRCA) data series. The NRCA combines data from these surveys with ground-based shorebird surveys from Bering Land Bridge (BELA), aerial shorebird surveys from CAKR and BELA, and work focused on fish and fish food webs taking place in lagoons in both parks. Of the known species occurring in CAKR and the neighboring BELA, 18 are species of concern (Alaska Shorebird Group, Boreal Partners in Flight Working Group).

Completed Ecological Studies

Future of Pacific Salmon in the Face of Environmental Change: Lessons from One of the World's Remaining Productive Salmon Regions

Post-doctoral Researcher: Erik Schoen
Advisor: Mark Wipfli
Funding Agencies: EPSCoR (NSF) with matching funds from State of Alaska
In-Kind Support: USFWS, Kenai Peninsula College, Kenai Watershed Forum, and Cook Inletkeeper

Rivers along the Gulf of Alaska produce one-third of the world's wild salmon, and overall salmon production here is near historic highs but is facing an uncertain future. Salmon face risks from a rapidly changing climate, landscape change, and ocean acidification, but may also benefit from warming temperatures and glacial retreat under some circumstances. Recent declines in Chinook Salmon abundance and body size have prompted fishery closures and raised concerns about the resilience of these populations to rapid environmental changes. Our objective was to identify trends, vulnerabilities, and management opportunities likely to affect the highly productive ecosystems and valuable fisheries of the Gulf of Alaska region, using the Kenai River watershed as a central case study. We synthesized 70 years of measured changes in climate, hydrology, land cover, freshwater habitat, salmon populations, and fisheries. We focused on the coupled terrestrial and freshwater habitats of large, complex watersheds rather than small coastal streams or marine ecosystems. The region is warming and experiencing drier summers and wetter autumns. The landscape is also changing, with melting glaciers, wetland loss, wildfires, forest insect outbreaks, and human development. This environmental transformation will likely harm some salmon populations while benefiting others. Lowland salmon streams are especially vulnerable to production losses, but retreating glaciers may allow gains in other streams. Some fishing communities are well positioned to shift among a diverse portfolio of fluctuating resources, while others have specialized over time, potentially limiting their resilience to change. Maintaining diverse habitats and salmon runs may allow ecosystems and fisheries to continue to thrive amidst these changes.

Ongoing Ecological Studies

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.

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.

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 direction and magnitude of climate effects on the seasonal ranges of migratory species are unlikely to be consistent. Thus, the cumulative effects across annual life cycles and decades will be difficult to predict without a coordinated and focused effort to integrate research across the entire annual range. A multi-regional framework is needed to efficiently integrate management-focused research among seasonal ranges and focus limited resources on the most critical season-specific links between climate change and waterfowl population trends. Our objective is to identify and prioritize the most critical cross-seasonal information needs regarding climate effects on the factors (e.g., habitat, species interactions, distribution and phenology, among others) most likely to affect waterfowl demography. We will use a literature review; a questionnaire survey of waterfowl researchers and managers representing state, federal, and non-governmental organizations; and a panel discussion at an international conference to identify and prioritize research needs. Results from a preliminary literature review have been used to develop a questionnaire survey which was administered during fall 2016 and spring 2017. This prioritization of management-focused research needs will be used to more efficiently and effectively allocate limited resources and will enable researchers and managers from widely separated ranges to communicate in common terms.

Effects of Large-scale Climate Patterns (PDO, ENSO, AO) on Calving Ground Location, Forage Availability, and Calf Survival of the Porcupine Caribou Herd

Graduate Student: Joelle Hepler, MS Wildlife Biology and Conservation
Faculty: Brad Griffith, Jeff Falke, and Jennifer Roach (ADFG)
Funding Agencies: USFWS, SSP (RWO 221); ADFG Wildlife Base
In-kind Support: Alaska Department of Fish and Game

During 1983-2001, concentrated calving areas (CCAs) of the PCH were predominantly in Alaska. Calf survival was notably low in 2000 and 2001, the only two years during 1983-2001 when the annual calving ground was completely within Canada. As a result, calving in Canada was considered sub-optimal. However, during 2002-2015, CCAs were exclusively located in Canada in 7 of 13 years and by 2013 the population size had reached ~197K from a low of 123K in 2001. In retrospect, there appears to have been a phase shift from positive (warm) to negative (cool) in the Pacific Decadal Oscillation (PDO) index in ~1999-2000 that may have affected the distribution of forage for calving caribou. The population increase suggests that calving caribou continued to choose annual calving grounds that optimized calf survival, even when calving in Canada. Our goal is to develop a mechanistic understanding of why CCAs of the PCH shifted to Canada, 2000-2015. This goal addresses whether the eastward shift in concentrated calving, 2000-2015, is “permanent” or one phase of a cyclic phenomenon. The long-term propensity, or lack thereof, of PCH caribou to calve in Alaska in or near the 1002 Area has substantial management implications. We will assemble the data necessary to extend an existing model of calf survival (based on 1985-2001 data) through 2015 to ascertain whether calving predominantly in Canada, 2000-2015, continued to optimize calf survival. An MS student began work on estimating calving locations from GPS movement rates in fall semester 2017. This was necessary because several calving surveys 2012-2016 were incomplete. A research proposal and preliminary analyses have been completed.

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, Eugenie 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 to provide 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) synchronously coupling stand-alone models, and the full IEM domain when computationally feasible, (2) developing input data sets for the study region, and (3) phasing in additional capabilities that are necessary to address effects of climate change on landscape structure and function. Fire frequency and area burned increased in recent years across Alaska and northwest Canada, and the trend is projected to continue for the remainder of this century.

Model simulations indicate the IEM region was a small sink for carbon during the historical time period and becomes a much stronger sink for carbon in the future. Future changes in permafrost indicate that, by the end of the 21st century, late Holocene permafrost in Alaska and northwest Canada will be actively thawing at all locations and that even some Late Pleistocene permafrost will begin to thaw. The projections produced by the IEM are facilitating the integration of how landscapes may respond to climate change into resource management decisions.

Connectivity for Landscape Conservation Design and Adaptation Planning

Post-doctoral Researcher: Charlotte Gabrielsen (IAB)
Faculty: Brad Griffith
Funding Agency: Northwest Boreal and Western Alaska Landscape Conservation Cooperatives (LCCs), USFWS (RWO 225)

In the Northwest Boreal and Western Alaska region, climate is changing twice as fast as the global average. This change is coupled with an increase in global demand for the region's natural resources. The region presently has less urbanization and development and, therefore, fewer barriers to implementing a strategic landscape design for conservation. Landscape conservation design in Alaska is an opportunity for the USFWS National Wildlife Refuge System (NWRS) to work collaboratively with partners to develop and implement a landscape approach that ensures that priority resources will have the capacity to cope with and respond to future change. Once a landscape becomes fragmented, it is extremely difficult and expensive to restore connectivity. The goals are to (1) enhance and expand LCC efforts to identify current and future terrestrial and aquatic connectivity among and within NWRs and other protected areas, and (2) use connectivity models, climate change projections, and other available data to assess landscape vulnerability in LCCs. We will assess various metrics for estimating connectivity (e.g., species, topography, habitats, climate) to develop landscape vulnerability maps and a geodatabase that may be used by managers to identify the decision space and context for managing land units across a continuum of vulnerability. A Post-doctoral Researcher began work in fall 2017. Contact has been established with relevant partners and initial analyses are in progress.

Anticipated Climate Change Effects on Broad Whitefish (*Coregonus nasus*) in the Colville River, Alaska

Student Investigator: Jason Leppi, PhD Fisheries Candidate
Co-Advisors: Mark Wipfli and Dan Rinella (USFWS)
Funding Agencies and Partners: BLM; Alaska Science Center, USGS (RWO 200); The Wilderness Society; EPSCoR (NSF)
In-Kind Support: USFWS Fairbanks Field Office, Native Village of Nuiqsut

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 are 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 habitat. We are studying 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 habitats. A conceptual model is being developed to link climate change drivers to regional habitat responses and associated effects on Broad Whitefish. Sampling so far has shown that the lower Colville River is used as a corridor by both non-spawning and pre-spawning adult fish from July–October and that only pre-spawning fish continue to the middle Colville. Stable isotope analysis has shown that individual fish's diets have a large isotopic range, suggesting some fish rely upon marine food supplies. 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 will provide insights into potential impacts and key habitats to better conserve this important subsistence resource.

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 (CSUB) is a short-statured sedge and a preferred food source for Brant goose chicks along Alaska's coast. In the absence of grazing, CSUB grows taller and resembles a closely related species, *Carex ramenskii* (CRAM), 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 CSUB have converted to a tall, less palatable form due to reduced grazing. This may subsequently cause further reductions in YKD Brant goose populations. Additionally, we are studying the grazing dynamics of Brant geese on the North Slope (NS), where Brant populations are increasing. On the NS CSUB 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. The objectives are to determine the morphological, genetic, and physiological differences among CSUB and CRAM from Arctic and subarctic Alaska. A morphological study was conducted by measuring 13 characteristics on CSUB and CRAM herbarium specimens. Next Generation Sequencing will be used to quantify genetic differences between CSUB and CRAM. Common gardens in Arctic and subarctic Alaska are being used to test for physiological differences. Multiple analyses (cluster, MANOVA, PCA, DFA) were conducted on morphological measurements, and each indicates that CSUB is morphologically distinct from CRAM. We have two alternate hypotheses: CSUB and CRAM on the YKD are the same species and that the NS CSUB is different, or all are the same species and that YKD CSUB is plastic and can respond to changing climate. Understanding the differences between these grazing systems is critical for predicting population dynamics of Department of Interior trust species (migratory geese) in the regions were these sedges are prevalent. Native communities have strong cultural ties to the subsistence harvest of Brant goose eggs.

List of Abbreviations

ADFG	Alaska Department of Fish and Game
AKCFWRU	Alaska Cooperative Fish and Wildlife Research Unit
BLM	US Bureau of Land Management
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
USDA	US Department of Agriculture
USFWS	US Fish and Wildlife Service
USGS	US Geological Survey
YKD	Yukon-Kuskokwim Delta, Alaska