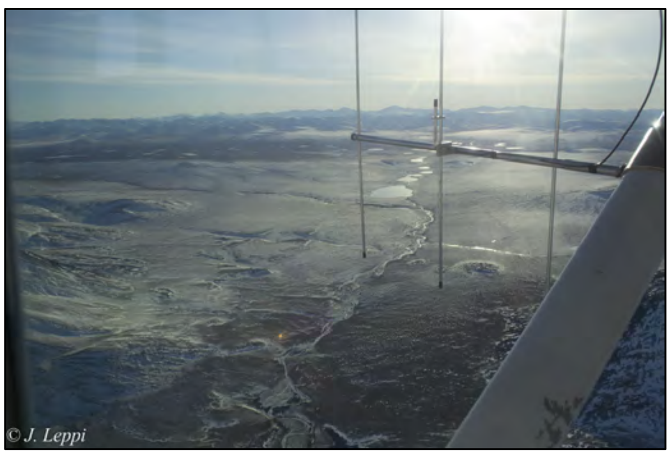
Alaska Cooperative Fish and Wildlife Research Unit Annual Research Report—2016



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Cover Photos:

Top: A beautiful fall day on the Chandalar River, Alaska, September 2016. Photo by Jeff Falke.

Bottom: Jason Leppi flies back from an aerial telemetry survey overlooking a tributary of the Colville River, Alaska. Photo by Jason Leppi.

Unit Roster

Federal Scientists

- Brad Griffith: Leader
- Jeff Falke: Assistant Leader-Fisheries
- Dave McGuire: Assistant Leader-Ecology
- 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)
- Chase Jalbert, MS Fisheries Student (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

- Trevor Haynes (Wipfli)
- Brock Huntsman (Falke)
- Jennifer Roach (Griffith)
- Erik Schoen (Wipfli)

Graduated in CY 2016

- Christopher Harwood, MS Wildlife Conservation (Powell)
- Erin Julianus, MS Biology (McGuire and Hollingsworth)
- Allison (Martin) Matter, MS Fisheries (Falke)
- Brian Robinson, MS Wildlife Biology and Conservation (Powell)
- Morgan Sparks, MS Fisheries (Falke and Westley)

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)
- Karsten Hueffer, IAB
- 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
- 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)

Graduated in CY 2016

- Matthew Albert, MS Fisheries (Sutton)
- Dana (Nossov) Brown, PhD Biological Sciences (Kielland)

Affiliated Post-Doctoral Researchers

- Jana Canary (Euskirchen)
- 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
- F. Joseph Margraf–Unit Supervisor, Cooperative Research Units, US Geological Survey (retired August 2016)
- Chris Smith–Western Field Representative, Wildlife Management Institute
- Kevin Whalen–Unit Supervisor, Cooperative Research Units, US Geological Survey (effective August 2016)

This is the Annual Report for the Alaska Cooperative Fish and Wildlife Research Unit, highlighting activities for calendar year 2016. 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: 7 (5, advised by Unit faculty, and 2, advised by cooperating faculty)
Presentations: 40
Scientific and Technical Publications: 36

Honors and Awards

Dave McGuire, 2016 Star (Special Thanks for Achievement) Award for development of a U.S. Geological Survey White Paper on Landscape Ecology. Awarded by the U.S. Geological Survey.

Papers Presented

Andresen, C.G., C.J. Wilson, D. Lawrence, and A.D. McGuire. 2016. Wetter or drier? A model inter-comparison of future soil moisture and runoff projections in permafrost landscapes. American Geophysical Union Fall Meeting, San Francisco, CA, 12-16 December 2016. (Contributed Poster)

Bolton, W.R., A.L. Breen, A.D. McGuire, T.S. Rupp, E. Euskirchen, S. Marchenko, V. E. Romanovsky, and the IEM Team. 2016. The Integrated Ecosystem Model for Alaska and Northwest Canada: An interdisciplinary decision support tool to inform adaptation to Arctic environmental change. The Ecosystem Approach to Management International Conference, Fairbanks, AK, 23-24 August 2016. (Contributed Oral)

Bolton, W.R., H. Genet, M. Lara, V. Romanovsky, and A.D. McGuire. 2016. Conceptualization and simulation of arctic landscape evolution using the Alaska Thermokarst Model. American Geophysical Union Fall Meeting, San Francisco, CA, 12-16 December 2016. (Contributed Oral)

Bolton, W.R., M. Lara, H. Genet, V. Romanovsky, and A.D. McGuire. 2016. Conceptualization and application of the Alaska Thermokarst Model. Eleventh International Conference on Permafrost, Potsdam, Germany, 20-24 June 2016. (Contributed Poster)

Bond-Lamberty, B., D. Epron, J. Harden, M.E. Harmon, F. Hoffman, J. Kumar, A.D. McGuire, and R. Vargas. 2016. The challenge of establishing decomposition functional types to estimate heterotrophic respiration at large scales. American Geophysical Union Fall Meeting, San Francisco, CA, 12-16 December 2016. (Invited Oral)

Calef, M.P., A. Varvak, L. DeWilde, A. David McGuire, and F.S. Chapin III. 2016. Geographic distribution of fire ignitions and area burned in interior Alaska considering cause, human proximity, and level of suppression. Association of American Geographers Annual Meeting, San Francisco, CA, 29 March-2 April 2016. (Contributed Oral)

Chen, Y., R. Kelly, H. Genet, A.D. McGuire, and F.S. Hu. 2016. Resilience and sensitivity of carbon stocks to increased fire frequency in arctic tundra. American Geophysical Union Fall Meeting, San Francisco, CA, 12-16 December. (Contributed Poster)

Euskirchen, E.S., A.L. Breen, A. Bennett, H. Genet, M. Lindgren, T.A. Kurkowski, A.D. McGuire, and T.S. Rupp. 2016. Consequences of changes in vegetation and snow cover for climate feedbacks in Alaska and Northwest Canada. American Geophysical Union Fall Meeting, San Francisco, CA, 12-16 December. (Contributed Oral)

Falke, J.A., B.M. Huntsman, and A.N. Martin. 2016. The role of geomorphic and hydrologic processes in structuring spawning and rearing habitats for Chinook Salmon in a boreal stream network. American Fisheries Society Annual Meeting, Kansas City, MO, 22-26 August 2016. (Contributed Oral)

Genet, H., M. Lara, W.R. Bolton, A.D. McGuire, V. Romanovsky, and M. Turetsky. 2016. Modeling landscape vulnerability to thermokarst disturbance in boreal Alaska. Eleventh International Conference on Permafrost, Potsdam, Germany, 20-24 June 2016. (Contributed Poster)

Genet, H., M. Lara, W.R. Bolton, and A.D. McGuire. 2016. Modeling vulnerability to thermokarst disturbance and its consequences on regional land cover dynamics in boreal Alaska. American Geophysical Union Fall Meeting, San Francisco, CA, 12-16 December 2016. (Contributed Poster)

Genet, H., Y. He, A.D. McGuire, Q. Zhuang, Z. Zhu, N. Pastick, B. Wylie, and K. Johnson. 2016. Quantifying the impact of permafrost dynamics on soil carbon accumulation in response to climate change and wildfire intensification in Alaska. Eleventh International Conference on Permafrost, Potsdam, Germany, 20-24 June 2016. (Contributed Poster)

Govoni, D.P., Kristjánsson, J.S. Ólafsson, and M.S. Wipfli. 2016. Surface and subsurface macroinvertebrate community differences across a thermal gradient in Icelandic streams at two spatial scales. Nordic Societ OIKOS Conference, Turku, Finland, 2-4 February 2016. (Contributed Poster)

Griffith, B., J. Roach, and A.N. Powell. 2016. Identifying climate change and cross-seasonal research priorities for waterfowl. In Symposium: Climate Change and Migratory Birds: Connecting Management Challenges to Research Programs. The Wildlife Society Annual Meeting, Raleigh, NC, 15-19 October 2016. (Invited Oral)

Grosse, G., A.B.K. Sannel, B. Abbott, C. Arp, P. Camill, J. O'Donnell, L. Farquharson, F. Günther, D. Hayes, B.M. Jones, M.T. Jorgenson, S. Kokelj, P. Kuhry, H. Lee, J. Lenz, A. Lewkowicz, L. Liu, A.D. McGuire, et al. 2016. A synthesis of thermokarst and thermo-erosion rates in northern permafrost regions. American Geophysical Union Fall Meeting, San Francisco, CA, 12-16 December 2016. (Invited Oral)

Hayes, D.J., J.B. Fisher, E.J. Stofferahn, C.R. Schwalm, D.N. Huntzinger, and A.D. McGuire. 2016. A model-data integration framework for NASA-ABoVE: The role of remote sensing in process-based model representation of Arctic ecosystem dynamics. Fourteenth International Circumpolar Remote Sensing Symposium, Homer, AK, 12-16 September 2016. (Contributed Oral)

Hayes, D.J., P. Kuhry, S. Goswami, G. Grosse, A.D. McGuire, and E.A.G. Schuur. 2016. The Permafrost Regionalization Map (PeRM): How well do observations, models and experiments represent the circumarctic-scale spatial variability in permafrost carbon vulnerability? Eleventh International Conference on Permafrost, Potsdam, Germany, 20-24 June 2016. (Contributed Poster)

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. The North American carbon budget past, present and future. American Geophysical Union Fall Meeting, San Francisco, CA, 12-16 December 2016. (Contributed Oral)

Hewitt, R.E., D.L. Taylor, H. Genet, A.D. McGuire, and M.C. Mack. 2016. Deep nitrogen acquisition in warming permafrost soils: Contributions of belowground plant traits and fungal symbioses in the permafrost carbon feedback to climate. American Geophysical Union Fall Meeting, San Francisco, CA, 12-16 December 2016. (Contributed Oral)

Hugelius, G., A.D. McGuire, T.J. Bohn, E.J. Burke, S. Chadburn, G. Chen, X. Chen, D.J. Hayes, E.E. Jafarov, C.D. Koven, A.H. MacDougall, S. Peng, and K.M. Schaefer. 2016. Comparing permafrost soil carbon pools from coupled earth system models to empirically derived datasets. Eleventh International Conference on Permafrost, Potsdam, Germany, 20-24 June 2016. (Contributed Oral)

Koven, C.D., D.M. Lawrence, A.D. McGuire, A.G. Slater, G. Hugelius, and N. Parazoo. 2016. Permafrost in earth system models: Recent progress and future challenges. American Geophysical Union Fall Meeting, San Francisco, CA, 12-16 December 2016. (Invited Oral)

Lara, M.J., H. Genet, A.D. McGuire, E.S. Euskirchen, Y. Zhang, D.R.N. Brown, M.T. Jorgenson, V. Romanovsky, A. Breen, and W.R. Bolton. 2016. Thermokarst rates intensify due to climate change and forest fragmentation in an Alaskan boreal forest lowland. Eleventh International Conference on Permafrost, Potsdam, Germany, 20-24 June 2016. (Contributed Oral)

Lara, M.J., P. Martin, and A.D. McGuire. 2016. Mapping polygonal tundra geomorphology across the Arctic Coastal Plain of Alaska. Eleventh International Conference on Permafrost, Potsdam, Germany, 20-24 June 2016. (Contributed Poster)

Laske, S.M., A.E. Rosenberger, M.S. Wipfli, and C.E. Zimmerman. 2016. Hydrology and fish composition drives lentic food web structure in Arctic Alaska. Society for Freshwater Science Annual Meeting, Sacramento, CA, 21-26 May 2016.

Marchenko, S., H. Genet, E. Euskirchen, A.D. McGuire, T.S. Rupp, W.R. Bolton, A. Breen, et al. 2016. High resolution soil temperature and active layer dataset for estimating rates of permafrost degradation and their impact on ecosystems, infrastructure, CO2 and CH4 fluxes and net C storage following permafrost thaw in Alaska and Northwest Canada. Eleventh International Conference on Permafrost, Potsdam, Germany, 20-24 June 2016. (Contributed Oral)

Marchenko, S.S., H. Genet, E.S. Euskirchen, A.L. Breen, A.D. McGuire, S.T. Rupp, V.E. Romanovsky, W.R. Bolton, and J.E. Walsh. 2016. Estimating rates of permafrost degradation and their impact on ecosystems across Alaska and northwest Canada using the process-based permafrost dynamics model GIPL as a component of the Integrated Ecosystem Model (IEM). American Geophysical Union Fall Meeting, San Francisco, CA, 12-16 December 2016. (Contributed Oral)

Martin, A.N., J.A. Falke, J.W. Savereide, and J.A. Lopez. 2016. Estimating the distribution of juvenile Chinook Salmon (*Oncorhynchus tshawytscha*) using habitat modeling and eDNA in an interior Alaska river basin. American Fisheries Society Annual Meeting, Kansas City, MO, 22-26 August 2016. (Contributed Oral)

McGuire, A.D., D. Lawrence, E. Burke, G. Chen, E. Jafarov, C. Koven, A. MacDougall, D. Nicolsky, S. Peng, and D. Ji. 2016. The temporal evolution of changes in carbon storage in the northern permafrost region simulated by carbon cycle models between 2010 and 2300: Implications for atmospheric carbon dynamics. Eleventh International Conference on Permafrost, Potsdam, Germany, 20-24 June 2016. (Invited Oral)

McGuire, A.D., H. Genet, Y. He, S. Stackpoole, D. D'Amore, T.S. Rupp, B. Wylie, X. Zhou, and Z. Zhu. 2016. The Alaska Land Carbon Assessment: Baseline and projected future carbon storage and greenhouse-gas fluxes in ecosystems of Alaska. Interagency Arctic Research Policy Committee (IARPC) Wildfire Collaboration Team Meeting, Fairbanks, AK, February 2016. (Invited Oral)

McGuire, A.D., T. Schuur, and C. Schadel. 2016. Thawing, greening, browning, and other issues affecting C dynamics in the permafrost region. Third Carbon from Space Workshop: Reconciling the Land, Ocean, and Atmospheric Components of the Carbon Cycle, University of Exeter, Exeter, United Kingdom, 26-28 January 2016. (Invited Oral)

Meyer, B., M.S. Wipfli, D.J. Rinella, J. Falke, and E. Schoen. 2016. Spatial and temporal patterns of growth and foraging in juvenile Chinook and Coho Salmon in three geomorphically distinct sub-basins of the Kenai River. 2016 Mat-Su Salmon Science and Conservation Symposium, Palmer, AK, 16 November 2016. (Contributed Oral)

Myers, B.J.E., A.J. Lynch, T.J. Krabbenhoft, R.P. Kovach, T.J. Kwak, J.A. Falke, C. Chu, D.B. Bunnell, and C.P. Paukert. 2016. Global synthesis of climate change effects on inland fish. American Fisheries Society Annual Meeting, Kansas City, MO, 22-26 August 2016. (Invited Oral)

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. 2016. Historical and projected trends in landscape drivers affecting carbon dynamics in Alaska. American Geophysical Union Fall Meeting, San Francisco, CA, 12-16 December. (Contributed Oral)

Schuur, E.A.G, A.D. McGuire, and V.E. Romanovsky. 2016. Arctic and boreal carbon stocks and vulnerability. American Geophysical Union Fall Meeting, San Francisco, CA, 12-16 December 2016. (Contributed Oral)

Sparks, M., P. Westley, J. Falke, and M. Adkison. 2016. Predicting Sockeye Salmon (*Oncorhynchus nerka*) hatch timing by incorporating natural variability into an existing model. Western Alaska Interdisciplinary Science Conference, Dillingham, AK, 9-12 March 2016. (Contributed Oral)

Sparks, M., P. Westley, J. Falke, and T. Quinn. 2016. Experimental tests for thermal local adaptation and heritable phenotypic plasticity in hatching timing by sockeye salmon using a common garden approach. Evolution 2016, Austin, TX, 17-21 June 2016. (Contributed Oral)

Torvinen, E. 2016. Lake Trout (*Salvelinus namaycush*) otoliths as biochronological indicators of recent climate patterns in Arctic lakes. Midnight Sun Science Conference, Fairbanks, AK, 8 April 2016. (Poster)

Turetsky, M., A.D. McGuire, and D. Olefeldt. 2016. Upscaling permafrost carbon loss from thermokarst and thermal erosion across the northern permafrost domain. Eleventh International Conference on Permafrost, Potsdam, Germany, 20-24 June 2016. (Contributed Poster)

Wang, W., A. Rinke, J.C. Moore, X. Cui, D. Ji, Q. Li, N. Zhang, C. Wang, S. Zhang, D.M. Lawrence, A.D. McGuire, et al. 2016. Diagnostic and model dependent uncertainty of simulated Tibetan permafrost area. Eleventh International Conference on Permafrost, Potsdam, Germany, 20-24 June 2016. (Contributed Oral)

Westley, P., A. Lopez, C. Jalbert, and J. Falke. 2016. Towards an understanding of population structure and adaptation by invasive Northern Pike: An overview of an emerging research program. 2016 Mat-Su Salmon Science and Conservation Symposium, Palmer, AK, 16 November 2016. (Contributed Oral)

Scientific Publications

Abbott, B.W., J.B. Jones, E.A.G. Schuur, F.S. Chapin III, W.B. Bowden, M.S. Bret-Harte, H.E. Epstein, M.D. Flannigan, T.K. Harms, T.N. Hollingsworth, M.C. Mack, A.D. McGuire, et al. 2016. Biomass offsets little or none of permafrost carbon release from soils, streams, and wildfire: An expert assessment. Environmental Research Letters 11, paper 034014, 13 pp., doi:10.1088/1748-9326/11/3/034014.

Bond-Lamberty, B., D. Epron, J. Harden, M.E. Harmon, F. Hoffman, J. Kumar, A.D. McGuire, and R. Vargas. 2016. Estimating heterotrophic respiration at large scales: Challenges, approaches, and next steps. Ecosphere 7, Article e01380,13 pp., doi:10.1002/ecs2.1380.

Breen, A.L., A. Bennett, T. Kurkowski, M. Lindgren, J. Schroder, A.D. McGuire, and T.S. Rupp. 2016. Projecting vegetation and wildfire response to changing climate and fire management in interior Alaska. Alaska Fire Science Consortium Research Summary 2016-1, 7 pp..

Collins, S.F., C.V. Baxter, A.M. Marcarelli, and M.S. Wipfli. 2016. Effects of experimentally added salmon subsidies on resident fishes via direct and indirect pathways. Ecosphere 7(3):e01248. 10.1002/ecs2.1248

Euskirchen, E.S., A.P. Bennett, A.L Breen, H. Genet, M.A. Lindgren, T.A. Kurkowski, A.D. McGuire, and T.S. Rupp. 2016. Consequences of changes in vegetation and snow cover for climate feedbacks in Alaska and northwest Canada. Environmental Research Letters 11, paper 105003, 19 pp., doi:10.1088/1748-9326/11/10/105003.

Falke, J.A., Dunham, J.D., and D. Hockman-Wert. 2016. A simple prioritization tool to diagnose impairment of stream temperature for coldwater fishes in the Great Basin. North American Journal of Fisheries Management 36:147-160.

Flitcroft, R.L., Falke, J.A., Reeves, G.H., Hessburg, P.F., McNyset, K.M., and L.E. Benda. 2016. Wildfire may increase habitat quality for spring Chinook salmon in the Wenatchee River subbasin, WA, USA. Forest Ecology and Management 359:126-140.

Genet, H., Y. He, A.D. McGuire, Q. Zhuang, Y. Zhang, F. Biles, D.V. D'Amore, X. Zhou, and K.D. Johnson. 2016. Terrestrial carbon modeling: Baseline and projections in upland ecosystems. Chapter 6 (pp. 105-132) *in* Z. Zhu and A.D. McGuire, eds. Baseline and

Projected Future Carbon Storage and Greenhouse-gas Fluxes in Ecosystems of Alaska. U.S. Geological Survey Professional Paper 1826, 196 pp., http://dx.doi.org/10.3133/pp1826.

Grosse, G., S. Goetz, A.D. McGuire, V.E. Romanovsky, and E.A.G. Schuur. 2016. Changing permafrost in a warming world and feedbacks to the Earth System. Submitted to Environmental Research Letters 11, paper 040201, 10 pp., doi:10.1088/1748-9326/11/4/040201.

Grunblatt, J., and L. Alessa. 2016. Role of perception in determining adaptive capacity: Communities adapting to environmental change. Sustainability Science 12(1):3-13, doi:10.1007/s11625-016-0394-0.

He, Y., H. Genet, A.D. McGuire, Q. Zhuang, B.K. Wylie, and Y. Zhang. 2016. Terrestrial carbon modeling: Baseline and projections in lowland ecosystems of Alaska. Chapter 7 (pp. 133-158) *in* Z. Zhu and A.D. McGuire, eds. Baseline and Projected Future Carbon Storage and Greenhouse-gas Fluxes in Ecosystems of Alaska. U.S. Geological Survey Professional Paper 1826, 196 pp., http://dx.doi.org/10.3133/pp1826.

He, Y., J. Yang, Q. Zhuang, J.W. Harden, A.D. McGuire, Y. Liu, G. Wang, and L. Gu. 2016. Incorporating microbial dormancy dynamics into soil decomposition models to improve quantification of soil carbon dynamics of northern temperate forests. Journal of Geophysical Research - Biogeosciences 120:2596-2611, doi:10.1002/2015JG003130.

Kelly, R., H. Genet, A.D. McGuire, and F.S. Hu. 2016. Paleodata-informed modeling of large carbon losses from recent burning of boreal forests. Nature Climate Change 6:79-82, doi:10.1038/nclimate2832.

Kliske, A., L. Alessa, S. Wandersee, P. Williams, E.J. Trammell, J. Powell, J. Grunblatt, and M. Wipfli. 2016. A science of integration: Frameworks, processes, and products in a place-based, integrative study. Sustainability Science 12(2):293-303, doi:10.1007/s11625-016-0391-3.

Lara, M.J., H. Genet, A.D. McGuire, E.S. Euskirchen, Y. Zhang, D.R.N. Brown, M.T. Jorgenson, V. Romanovsky, A. Breen, and W.R. Bolton. 2016. Thermokarst rates intensify due to climate change and forest fragmentation in an Alaskan boreal forest lowland. Global Change Biology 22:816-829, doi:10.1111/gcb.13124.

Laske, S., T. Haynes, A. Rosenberger, J. Koch, M. Wipfli, M. Whitman, and C. Zimmerman. 2016. Surface water connectivity structures Arctic lake fish assemblages: Influence of local and regional drivers. Freshwater Biology 61:1090-1104.

Liang, J., T.W. Crowther, N. Picard, S. Wiser, M. Zhou, G. Alberti, E.-D. Schulze, A.D. McGuire, et al. 2016. Positive biodiversity-productivity relationship predominant in global forests. Science 354:6309, 12 pp., doi:10.1126/science.aaf8957.

Luo, Y., A. Ahlstrom, S.D. Allison, N.H. Batjes, V. Brovkin, N. Carvalhais, A. Chappell, P. Ciais, E.A. Davidson, A. Finzi, K. Georgiou, B. Guenet, O. Hararuk, J.W. Harden, Y. He, F. Hopkins, L. Jiang, C. Koven, R.B. Jackson, C.D. Jones, M.J. Lara, J. Liang, A.D. McGuire, et al. 2016. Toward more realistic projections of soil carbon dynamics by Earth system models. Global Biogeochemical Cycles 30:40-56, doi:10.1002/2015GB005239.

Lynch, A.J., B.J.E. Myers, C. Chu, L.A. Eby, J.A. Falke, R.P. Kovach, T.J. Krabbenhoft, T.J. Kwak, J. Lyons, C.P. Paukert, and J.E. Whitney. 2016. Climate change effects on North American inland fish populations and assemblages. Fisheries 41(7):346-361, doi: 10.1080/03632415.2016.1186016.

McGuire, A.D., B.K. Wylie, D.V. D'Amore, X. Zhou, T.S. Rupp, H. Genet, Y. He, S. Stackpoole, and Z. Zhu. 2016. Executive Summary-Baseline and Projected Future Carbon Storage and Greenhouse-Gas Fluxes in Ecosystems of Alaska. Pp. 1-3 *in* Z. Zhu and A.D. McGuire, eds. Baseline and Projected Future Carbon Storage and Greenhouse-gas fluxes in ecosystems of Alaska. U.S. Geological Survey Professional Paper 1826, 196 pp., http://dx.doi.org/10.3133/pp1826.

McGuire, A.D., C. Koven, D.M. Lawrence, J.S. Clein, J. Xia, et al. 2016. Variability in the sensitivity among model simulations of permafrost and carbon dynamics in the permafrost region between 1960 and 2009. Global Biogeochemical Cycles, 30:1015-1037, doi:10.1002/2016GB005405.

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Zhu, Z., and McGuire, A.D., eds. 2016. Baseline and Projected Future Carbon Storage and Greenhouse-gas Fluxes in Ecosystems of Alaska. U.S. Geological Survey Professional Paper 1826, 196 pp., http://dx.doi.org/10.3133/pp1826.

Theses and Dissertations of Unit-Sponsored Graduate Students

Albert, Matthew. 2016. Seasonal movements of northern pike in Minto Flats, Alaska. MS thesis, University of Alaska Fairbanks. 78 pp.

Brown, Dana. 2016. Climate-induced changes in ecological dynamics of the Alaskan boreal forest: A study of fire-permafrost interactions. PhD dissertation, University of Alaska Fairbanks. 114 pp.

Harwood, Christopher. 2016. Breeding ecology of Whimbrels (*Numenius phaeopus*) in interior Alaska. MS thesis, University of Alaska Fairbanks. 96 pp.

Julianus, Erin. 2016. Moose (*Alces alces*) browse availability and use in response to post-fire succession on Kanuti National Wildlife Refuge, Alaska. MS thesis, University of Alaska Fairbanks. 63 pp.

Matter, Allison. 2016. A rapid assessment method to estimate the distribution of juvenile chinook salmon (*Oncorhynchus tshawytscha*) in an interior Alaska river basin. MS thesis, University of Alaska Fairbanks. 66 pp.

Robinson, Brian. 2016. Feeding ecology of Black Oystercatcher (*Haematopus bachmani*) chicks. MS thesis, University of Alaska Fairbanks. 71 pp.

Sparks, Morgan. 2016. Climate, embryonic development, and potential for adaptation to warming water temperatures by Bristol Bay sockeye salmon. MS thesis, University of Alaska Fairbanks. 98 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

Seasonal Movements of Northern Pike in Minto Flats, Alaska

Student Investigator: Matthew Albert, MS Fisheries
Advisor: Trent Sutton
Funding Agency: Sport Fish Division, ADFG
In-Kind Support: Personnel, boats, and logistics provided by Sport Fish Division, ADFG Region 3

Note: Matthew Albert graduated from the University of Alaska Fairbanks in August 2016. His thesis abstract follows:

Abstract: Northern pike *Esox lucius* is a large, long-lived piscivorous species that are harvested in sport and subsistence fisheries in Alaska. My study described the seasonal movements of northern pike that inhabit the Minto Lakes portion (Goldstream Creek drainage) of the Minto Flats wetland complex, Alaska, from May 2008 through January 2010. Very high frequency (VHF) radio tags (n = 220) were surgically implanted in northern pike in Minto Flats in May 2007, 2008, and 2009, and fish were relocated with fixed telemetry stations and aerial- and boat-based telemetry surveys. Radio-tagged northern pike displayed a distinct spring pre-spawning migration into the Minto Lakes study area, where they remained for the duration of the open-water season. A protracted out-migration occurred between late September and early December, with downstream movements peaking in November and October of 2008 and 2009, respectively. Radio-tagged fish present in the Minto Lakes study area during the open-water season overwintered exclusively in a 26-km reach of the Chatanika River from its confluence with Goldstream Creek upstream to the Murphy Dome Road access point. Daily movement rates were greatest during May and August. In addition to providing a better understanding of northern pike life history in Minto Flats, these results will aid managers and researchers by identifying critical habitats and providing information to better design future population assessment experiments.

A Rapid Assessment to Estimate the Distribution of Juvenile Chinook Salmon (*Oncorhynchus tshawytscha*) in an Interior Alaska River Basin

Student Investigator: Allison (Martin) Matter, MS Fisheries
Advisor: Jeff Falke
Funding Agency: Sport Fish Division, ADFG
In-Kind Support: Personnel, boats, logistics provided by Sport Fish Division, ADFG Region 3

Note: Allison Matter graduated from the University of Alaska Fairbanks in August 2016. Her thesis abstract follows:

Abstract: Identification and protection of water bodies used by anadromous species in Alaska are critical in light of increasing threats to fish populations, yet challenging given budgetary and logistical limitations. Non-invasive, rapid assessment sampling techniques may reduce costs and effort while increasing species detection efficiencies. I used an intrinsic potential (IP) habitat model to identify high quality Chinook Salmon *Oncorhynchus tshawytscha* rearing habitats and select sites to sample throughout the Chena River basin

for juvenile occupancy using environmental DNA (eDNA) and distribution within tributaries using snorkel surveys. Water samples were collected from 75 tributary sites in 2014 and 2015. The presence of Chinook Salmon DNA in water samples was assessed using a quantitative polymerase chain reaction (qPCR) assay targeting that species. Snorkel surveys were conducted and physical habitat was measured for a subset of tributaries examined with the eDNA approach. Juvenile salmon were counted within 50 m reaches starting at the tributary confluence and continuing upstream until no juvenile salmon were observed. The IP model predicted over 900 stream km in the basin to support high quality (IP ≥ 0.75) rearing habitat. Occupancy estimation based on eDNA samples indicated that 80.2% (± 4.3 SE) of previously unsampled sites classified as high IP and 56.4% of previously unsampled sites classified as low IP were occupied. The probability of detection of Chinook Salmon DNA from three replicate water samples was high (0.76 ± 1.9 SE) but varied with drainage area. A power analysis indicated power to detect proportional changes in occupancy based on parameter values estimated from eDNA occupancy models. Results of snorkel surveys showed that the upper extent of juvenile Chinook Salmon within tributaries was from 200 to 1,350 m upstream of tributary confluences. Occurrence estimates based on eDNA and snorkel surveys generally agreed, but care should be taken to ensure that little temporal gap exists between samples as juvenile salmon use of tributary habitats is likely often intermittent. Overall, the combination of IP habitat modeling, occupancy estimation based on eDNA, and snorkel surveys provided a useful, rapid-assessment method to predict and subsequently quantify the distribution of juvenile salmon in previously unsampled tributary habitats. These methods will provide tools for managers to rapidly and efficiently map critical rearing habitats and prioritize sampling efforts to expand the known distribution of juvenile salmon in interior Alaska streams.

The Role of Environmental Processes in Structuring the Distribution of Chinook Salmon Spawning and Rearing Habitats across a Large Alaska River Basin

Post-doctoral Researcher: Brock Huntsman
Advisor: Jeff Falke
Funding Agency: State of Alaska
In-Kind Support: Logistical support provided by ADFG Region 3; USFWS

Chinook Salmon (*Oncorhynchus tshawytscha*) are an important commercial, subsistence, and recreational fishery resource in Alaska. Substantial declines in escapement from many Alaskan watersheds in recent years have resulted in closures of Chinook Salmon fishing in more imperiled drainages, such as the Chena River, Alaska. Environmental factors such as flow and temperature are important mechanisms that influence fish population dynamics in stream ecosystems. A better understanding of the relative role of physical processes in Chinook Salmon population distribution and dynamics in the Chena River basin is warranted. Our objectives were to (1) develop spatially continuous metrics that describe historic, current, and future physical habitat, and flow and temperature regimes within the Chena River basin, and (2) investigate the relative role of spatial, physical, and biological processes in describing Chinook Salmon population dynamics and distributions. Stream temperature loggers were deployed at >50 sites throughout the Chena watershed in summers 2013 and 2014, and retrieved during summer 2015. Based on these data we developed a predictive model of stream thermal regimes to investigate riverscape-scale patterns in juvenile salmon bioenergetic performance. Flow regimes were modelled with a rainfall-runoff hydrologic model downscaled to stream reaches of 100-1000 m. Lastly, juvenile Chinook Salmon were collected from 24 sites longitudinally along the Chena main stem in the summer of 2015 to assess environmental and density-dependent factors influencing population dynamics and distributions. A manuscript on density-dependent habitat selection of spawning Chinook Salmon has been submitted, and three other papers regarding juvenile Chinook population dynamics and secondary production, riverscape bioenergetics modeling, and ecological flow analyses and climate change predictions are in preparation, respectively. The results of this study will help identify mechanisms limiting Chinook Salmon productivity within the Chena watershed.

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

Post-doctoral Researcher: Erik Schoen, IAB
Faculty: Mark Wipfli
Funding Agencies: ADFG, USFWS
In-Kind Support: Norton Sound Economic Development Corporation (NSEDC); ADFG; 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, Tanana, Yukon, and Unalakleet Rivers. We identified prey items through taxonomic identifications and genetic sequencing. We identified Chinook Salmon in stomachs of Arctic Grayling, Burbot, and Northern Pike sampled from the Chena River, but not from other rivers. Predation was primarily documented in sloughs, not in the mainstem. Predation was observed only during a year of record-high river discharge (2014), and not during a more typical year (2015). Predation was observed primarily during late May-early June and September, periods of salmon movement among habitats. These results suggest that predation on juvenile Chinook Salmon does occur in some habitats in spring and summer, and that high-water events force juvenile salmon into off-channel habitats where they appear more vulnerable to predation. 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.

Ongoing Aquatic Studies

Marine-Derived Nutrient Effects on Chinook and Coho Salmon Productivity

Student Investigator: Philip Joy, PhD Fisheries Candidate
Advisor: Mark Wipfli
Funding Agencies: Alaska Sustainable Salmon Fund (AKSSF): Sport Fish Division, ADFG; NSEDC

Marine-derived nutrients (MDN) imported to freshwater systems 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 was assessed with stable isotopes and compared to salmon escapements. Gut fullness was assessed through stomach contents, growth was assessed through RNA:DNA ratios and condition assessed via length:weight relationships. The relationship between performance metrics and MDN content 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 gut fullness, 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.

A Remote Sensing and Occupancy Estimation Approach to Quantify Spawning Habitat Use by Fall Chum Salmon (*Oncorhynchus keta*) along the Chandalar River, Alaska

Student Investigator: Chelsea Clawson, MS Fisheries Candidate
Advisor: Jeff Falke
Funding Agency: USFWS (RWO 216)

Chelsea Clawson using a metal detector to locate temperature loggers in the substrate, Chandalar River, Alaska, September 2016.
Photo: Jeff Falke

Groundwater upwellings provide stable temperatures for overwinter salmon egg development, and this process may be particularly important in cold, braided, gravel-bed Arctic rivers. Understanding how salmon utilize thermal heterogeneity as spawning habitat is critical for effective management and conservation, but data collection in these systems is difficult due to their remote and inaccessible setting. Mapping groundwater upwellings as warmwater thermal refugia on the Chandalar River and the occurrence of spawning fall chum salmon will help guide future management decisions to mitigate against future population declines. Study objectives are to (1) delineate habitats and map thermal variability across fall chum salmon spawning areas to identify warm groundwater thermal refugia; (2) evaluate fall Chum Salmon detectability and site occupancy; and (3) assess the relative importance of thermal variability and geomorphic channel type to spawning habitat selection by fall Chum Salmon. Aerially collected thermal and orthoimagery were used to identify different habitats and map thermal variability in 2014. Aerial surveys in 2013, 2014, and 2015 were performed to quantify fall chum spawning distribution and abundance. Triplicate surveys in 2014 were used to examine detectability, and these results were incorporated into multi-state, multi-season occupancy models to examine the dynamics of habitat occupancy as related to temperature and channel type. We delineated 330 unique river segments and found mean temperature for each segment. Small abundance aggregations were detected 36.7% of the time, and large abundance aggregations were detected 71.7% of the time. The occupancy analysis indicated that temperature was an important factor in spawning site selection. Sites occupied at high abundance remained occupied from year to year about 33% of the time, but sites occupied at low abundance were much more dynamic and rarely remained occupied for all three seasons. Results of this work will contribute toward a long-term monitoring plan for important spawning habitat on the Chandalar River and provide information and techniques for methods of monitoring salmon and habitat in remote Arctic systems.

Distribution, Migration Rates, and Energetics of Spawning Chinook Salmon (*Oncorhynchus tshawytscha*) in the Stikine and Taku Rivers

Student Investigator: Kristin Neuneker, MS Fisheries Candidate
Advisor: Jeff Falke
Funding Agency: ADFG
In-Kind Support: ADFG

The Stikine and Taku Rivers and their tributaries in southeastern Alaska and western British Columbia are important producers of wild Chinook Salmon that are targeted in U.S. and Canadian fisheries. This project seeks to gain a better understanding of movement patterns (e.g., spawning distribution, dropout and movement rates) and energetics for individual Chinook Salmon during their spawning migration. It is important to collect this baseline information owing to potential threats from climate change and mining activities in these watersheds. Study objectives are to (1) quantify movement patterns of Chinook Salmon during their spawning migration on the Stikine and Taku Rivers; (2) parameterize a bioelectric impedance analysis (BIA) model for Chinook Salmon; and (3) relate movement patterns to Chinook Salmon energetics. Adult Chinook Salmon will be captured using drift gillnets; measured for sex, body size, and condition (using bioelectrical impedance analysis); and outfitted with a radio telemetry tag. Individuals will be tracked via stationary datalogging towers and aerial surveys. A sample of adult Chinook Salmon will be collected and returned to the lab for proximate composition analysis. A predictive model will be generated based on proximate composition metrics and field-collected BIA measurements. Data collection for the project is complete. We captured, tagged, collected sex and size information, and determined spawning locations for 673 Chinook Salmon from the Stikine and Taku Rivers in 2015 and 2016. Migration rates and timing will be determined for these fish and compared to biological and hydrologic descriptors to evaluate differences in these responses among years and rivers. Bioelectrical impedance analysis measurements were taken using needle and piston electrode devices from 83 Chinook Salmon from the Nushagak and Chena Rivers and the Whitman Hatchery during summer 2016. Proximate composition analysis has been completed and will be used to create a predictive model to non-lethally estimate body condition in this species. Results from this project will be used to validate current escapement estimates and help fisheries managers set more accurate harvest limits for Chinook Salmon in both American and Canadian fisheries. Moreover, we will produce a non-lethal method to precisely estimate body condition of adult Chinook Salmon. This technique can be incorporated into monitoring efforts to track energy density of migrating salmon across space and through time.

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 Candidate
Co-Advisors: Jeff Falke and Andrés López (CFOS)
Funding Agency: NPS (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. Methods include:

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 multi-locus 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 2017. 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 multi-locus 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.

Landscape Genetic Diversity of Native and Invasive Northern Pike in Alaska

Student Investigator: Chase Jalbert, MS Fisheries Student
Co-Advisors: Jeff Falke and Peter Westley (CFOS)
Funding Agency: Sport Fish Division, Region 2 ADFG, USGS Northern Rocky Mountain (NOROCK) Science Center
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 Basin (MatSu) 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. Study objectives 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 distribution model and assess potential impacts on salmon populations in the MatSu. We will characterize genetic diversity among native and introduced 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. 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. This study will provide estimates of the future impact of Northern Pike on salmonids in southcentral Alaska.

Chena River Juvenile Chinook Salmon Large Wood Habitat Mapping

Student Investigator: N/A, technicians only
Principal Investigator: Jeff Falke
Funding Agency: Subsistence Fisheries Branch, USFWS
In-Kind Support: Fisheries and Habitat Restoration Branch, USFWS; 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. Study 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. 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.

Completed Wildlife Studies

Breeding Ecology of Whimbrels (*Numenius phaeopus*) in Interior Alaska

Student Investigator: Christopher M. Harwood, MS Wildlife Biology
Advisor: Abby Powell
Funding Agencies: USFWS; UA Foundation; Arctic Audubon Society
In-Kind Support: AKCFWRU

Note: Christopher Harwood graduated from the University of Alaska Fairbanks in December 2016. His thesis abstract follows:

Abstract: Whimbrels *Numenius phaeopus* breed in tundra-like habitats, both beyond treeline and within the boreal forest of interior Alaska. Despite their widespread distribution and designation as a species of conservation concern, their ecology has been particularly understudied in Alaska. During 2008–2012, I initiated the first dedicated study of Whimbrel breeding ecology in Alaska, and the first such study of any boreal-breeding shorebird in the state. Within a habitat mosaic of forest, woodlands, muskeg, scrub, and ponds within the floodplain of the Kanuti River in north-central Alaska, Whimbrels bred in the three largest (of nine) patches of discontinuous tussock tundra. These Whimbrels exhibited a compressed annual breeding schedule with the first birds arriving about 6 May and nests hatching about 17 June. Evidence for clustered and synchronous nesting, which may aid in predator defense, was equivocal. Most (69%) Whimbrels nested in mixed shrub-sedge tussock bog. I modeled nest-site selection at multiple spatial scales for 39 nests; however, the only variables important in the models were at the finest scale around the nest, namely that nests tended to be located on hummocks and exhibited lateral cover. Model results for nest ssurvival of 67 nests over 4 years revealed a considerable difference in nest success (92% vs. 41%) at the two largest patches studied; this site effect was largely unexplained.

To investigate Whimbrel ecology more broadly in the boreal biome, in 2013 I designed and conducted a Whimbrel-specific survey comprising 279 point counts within 28 transects along the road system of interior Alaska. I detected Whimbrels on just 32% of transects and 11% of count points. Although I detected Whimbrels at 3 sites where they had not been reported previously, I failed to detect them at several historically occupied sites. Dwarf shrub meadow was the most commonly observed habitat for all points visited. I modeled Whimbrel presence based on coarse habitat and avifaunal community features; no models were well supported.

Between the local and regional surveys, my results tended to reinforce several widespread, but not necessarily investigated, descriptions about the breeding ecology of Whimbrels. My studies supported the premises that Whimbrels are patchily distributed on the landscape and often breed in clusters. Breeding of individuals and occupancy of some patches may be annually variable. Despite analyses of multiple habitat features at multiple spatial scales, I mostly observed a lack of specificity in where they bred among tundra-like patches, and where they nested specifically within such patches. This suggests that Whimbrels are tundra habitat generalists on their breeding grounds. Such phenotypic plasticity may be particularly adaptive in the dynamic, wildfire-prone landscape of interior Alaska.

Feeding Ecology of Black Oystercatcher (*Haematopus Bachmani*) Chicks

Student Investigator: Brian Robinson, MS Wildlife Biology
Advisor: Abby Powell
Funding Agency: Kenai Fjords National Park, NPS

Note: Brian Robinson graduated from the University of Fairbanks Alaska in May 2016. His thesis abstract follows:

Abstract: The Black Oystercatcher is an internationally recognized bird species of conservation concern and the focus of multiple monitoring programs due to its small global population size, restricted range, vulnerability to human and natural threats in nearshore marine ecosystems, and the important role it plays as a top-level consumer in the intertidal food web. I studied a population of Black Oystercatchers in Kenai Fjords National Park, Alaska in 2013 and 2014, examining variation in chick diet, assessing methods used to monitor diet, and investigating the influence of provisioning on brood survival. To better understand the biases and limitations associated with the quantification of prey remains, I compared diet estimates from prey remains with two other methods: direct observation of adults feeding young, and diet reconstruction by stable isotope analysis. Estimates from collected prey remains over-represented the proportion of limpets in the diet, under-represented the proportion of mussels and barnacles, and failed to detect soft-bodied prey such as worms. I examined age- and habitat-specific variation in chick diet and found no relationship between diet and age of chicks; however, diet differed between gravel beach and rocky island nesting habitats. To determine the importance of diet on brood survival, I modeled daily survival rates of broods as a function of energy intake rate and other ecological factors and found that broods with higher intake rates had higher growth rates and daily survival rates. Given the consequences of reduced energy intake on survival, changes in the abundance and composition of intertidal macroinvertebrates as a result of climate change may have significant impacts on Black Oystercatcher populations. These findings highlight the importance of diet and provisioning to chicks and identify limitations of using prey remains to characterize Black Oystercatcher diet.

Ongoing Wildlife Studies

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).

Prevalence, Sources, and Effects of Strontium in Waterfowl Eggs

Student Investigator: Christopher Latty, PhD Marine Biology Candidate
Advisor: Tuula Hollmen
Funding Agency: USFWS (RWO 205)
In-Kind Support: USFWS

Strontium (Sr) is a naturally occurring element, chemically similar to calcium (Ca). Stable strontium in environmental samples derives from weathering of local sources and atmospheric deposition. Strontium's chemical similarity to calcium leads to substitution for calcium in biota. Strontium has been implicated as a potential contaminant of concern for wild birds, and effluent from power generation has been linked to elevated concentrations in avian eggs. Previous research has suggested that high concentrations of strontium in eggs may affect eggshell quality and reduce hatchability by interference with normal calcium metabolism and bone growth. Although elevated levels of strontium have been documented in waterfowl in interior Alaska, concentrations are highly variable, and it is unclear if strontium is causing deleterious effects. The objectives of this study are to assess the sources and effects of elevated strontium in waterfowl eggs in interior Alaska. We analyzed strontium in the eggshells of 9 species of waterfowl collected over a 5-year period in interior Alaska. Data analysis is ongoing, but preliminary results suggest strontium may be correlated with reduced eggshell quality. We also found that eggshell strontium is partly driven by the chemistry of the local environment and may also be affected by the use stored reserves during egg production. The results of this project will be used to assess strontium as a contaminant of concern for waterfowl breeding in interior Alaska.

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

Post-doctoral Researcher: Cristina Hansen
Principal Investigator: Karsten Hueffer
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. Processes involved are poorly understood. Route(s) of infection, infectious dose, geographic extent, and bacterial species involved in embryo infection 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. Finally, we aim to determine whether infection by the most common bacteria isolated (a *Neissera* species) is vertical or horizontal. Samples from the 2014 hatching season (n=470) were assessed in 2014 and 2015. This year, tissue samples from 20 nesting females were assayed for *Neisseria arctica* bacteria using PCR. Additionally, laboratory-based infection studies using fertilized chicken eggs were conducted to attempt to determine route of infection and infectious dose of *N. arctica*. Finally, antibiotic resistance patterns and genetic characterization of another commonly isolated bacteria (*Streptococcus uberis*) were explored. 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 is still being conducted, but we have documented some antibiotic resistance in our 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.

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: 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" methods for determining causes of nest fate, and (3) investigate the relationship between nest site habitat and specific causes of nest failure. In 2015-16, we surveyed barrier islands of Arctic NWR for common eider nests and placed small, time-lapse cameras at approximately 100 nests each year to record causes of nest failure. In 2015, glaucous gulls and arctic foxes were the primary nest predators. In 2016, polar and grizzly bears caused most nest failures. Additionally, we recorded a large storm surge in mid-July that inundated almost all of the surveyed nesting areas. In 2017 we will conduct a similar survey of islands and assess the effect of nest site habitat on specific predation outcomes. Understanding the relative importance of specific causes of nest failure in limiting common eider reproduction is critical for developing management plans aimed at species recovery.

Completed Ecological Studies

Moose (*Alces alces)* Browse and Habitat Availability and Use in Response to Post-Fire Succession on Kanuti National Wildlife Refuge, Alaska

Student Investigator: Erin Julianus, MS Biology
Co-Advisors: A. David McGuire and Teresa Hollingsworth
Funding Agency: USFWS Region 7 (RWO 204)
In-Kind Support: Personnel and project support provided by USFWS

Note: Erin Julianus graduated from the University of Alaska Fairbanks in August 2016. Her thesis abstract follows:

Abstract: I examined post-fire moose habitat dynamics on Kanuti National Wildlife Refuge in interior Alaska with the objective of increasing understanding of local moose habitat characteristics. I estimated browse density, biomass, and summer browse use in a 2005 burn, 1990 burn, 1972 burn, and an unburned area. I revisited each site the following spring to estimate browse availability and removal during winter. In addition to evaluating browse production and use, I estimated proportional habitat use of varying-aged burns by 51 VHF-collared moose. I found that summer browse production and winter browse availability were highest in the 1990 and 2005 burns. I found that summer and winter browse use was highest in the 1990 burn. Collared moose generally avoided recently burned stands and demonstrated preference for >30 year old stands in both summer and winter. Moose demonstrated preference for unburned stands during calving. Although biomass production and availability were highest in 11 – 30 year old stands, disproportionate use of food resources in burns was evident. This disproportionate use of burns and food resources could be due to a variety of reasons including resource type, historic moose distribution patterns, and predation avoidance strategies.

Climate, Embryonic Development, and Potential for Adaptation to Warming Water Temperatures by Bristol Bay Sockeye Salmon

Student Investigator: Morgan Sparks, MS Fisheries
Co-Advisors: Jeff Falke and Peter Westley (CFOS)
Funding Agency: Western Alaska Landscape Conservation Cooperative, USFWS
In-Kind Support: Data and logistical support provided by University of Washington and National Park Service Southwest Alaska Network

Note: Morgan Sparks graduated from the University of Alaska Fairbanks in August 2016. His thesis abstract follows:

Rapidly warming water temperatures associated with climate change represent a substantial disturbance to the habitat of aquatic ectothermic organisms. For salmonid fishes (family *Salmonidae*), early life history survival and timing of reproduction and development are closely tied to temperature, such that altered thermal regimes could alter patterns of survival or shift phenology into a mismatch with the environment. Because temperature is the dominant driver of developmental rates, empirical statistical models have been developed to predict the timing ofhatching and fry emergence based on incubation temperature. In this thesis I explored how the timing of hatching and emergence may shift in response to warming temperatures and how spawning timing across an Alaskan landscape is shaped by incubation temperatures experienced by sockeye salmon (*Oncorhynchus nerka*) embryos and alevin. Additionally, I quantified the relative roles of genetics and environmentally induced plasticity on the timing of hatching in two populations

of sockeye salmon from the Iliamna Lake system, Alaska by rearing them in common garden conditions in the laboratory. To meet these goals I reformulated a widely cited developmental model to incorporate variability in natural regimes and use it to predict hatching timing over the course of the spawning duration for 25 populations of Bristol Bay sockeye salmon. Additionally, I hind- and forecasted lake temperature based off historical and predicted air temperatures to estimate and predict hatching for a single population. I found that predicted hatching timing for wild populations varied between 58 and 260 days, and was largely variable as a result of habitat thermal heterogeneity and parental spawn time. I also predicted a three-week decrease in hatching timing over the course of the next century for a single beach spawning population, which was just beyond historic variability. Counter to expectations, for a subset of populations hatching and emergence timing variability exceeded that of spawning timing, indicating the relationship between spawning timing and incubation temperature may be weaker than expected. The results of the common garden experiment revealed indistinguishable differences between populations in hatching timing across five temperature scenarios, but strong plasticity as timing differed between 74 and 189 days in the warmest to coolest treatment. Furthermore, I detected family-specific differences in hatching timing both within and among treatments consistent with heritable developmental rates and gene by environment interactions in days to hatch, where the interaction between treatment and family was as high as 10 days difference in hatching. Population or family-specific survival in this experiment did not differ in response to temperature suggesting a lack of thermal adaptation in this regard during this life stage in these populations. Alevin mass and length upon hatching varied little among treatments (<10%), but did significantly decrease with cooling temperatures. Taken as a whole this study indicates that the effects of climate change during the early life history stages may be buffered byphenotypic plasticity and variability in populations and habitats will be important for maintaining diversity in the face of climate change.

Pacific Salmon in the Face of Climate and Landscape Change: Insights from the Kenai River

Post-doctoral Researcher: Erik Schoen, IAB
Faculty: Mark Wipfli
Funding Agencies: NSF/EPSCoR with matching funds from State of Alaska
In-Kind Support: USFWS, Kenai Peninsula College, Kenai Watershed Forum, Cook Inlet Keeper

Most Pacific salmon populations throughout Alaska continue to fare well but face uncertain futures as climate and landscapes change. However, recent declines in Chinook Salmon abundance and body size have prompted fishery closures and raised concerns about resilience of salmon ecosystems and fisheries to fishing pressures and environmental change. The objective of this study was to identify trends, vulnerabilities, and management opportunities likely to affect Kenai River salmon fisheries, with particular attention to Chinook Salmon. We synthesized 30-70 years of changes in climate, land cover, salmon populations, and fisheries, as well as downscaled climate model projections for the region. Climate models predict continued warming, drier summers, and wetter falls and winters. The landscape is also changing rapidly due to melting glaciers, wetland loss, wildfire, forest insect outbreaks, and human development. These changes will likely cause winners and losers among salmon populations and the fisheries they support. Lowland salmon streams are particularly vulnerable, but retreating glaciers are allowing salmon to colonize new habitats. Loss of productivity from weak salmon runs can compel managers to limit harvest of stronger runs in mixed-stock fisheries. 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. Policymakers face challenges in managing highly productive ecosystems and fishing communities to withstand future risks and capitalize on opportunities.

Climate-Induced Changes in Ecological Dynamics of the Alaskan Boreal Forest: A Study of Fire-Permafrost Interactions

Student Investigator: Dana (Nossov) Brown, PhD Biological Sciences
Co-Advisors: Knut Kielland and Torre Jorgenson
Funding Agency: USGS (RWO 189)
In-Kind Support: Bonanza Creek LTER, DoD

Note: Dana R. N. Brown graduated from the University of Alaska Fairbanks in August 2016. Her dissertation abstract follows:

Abstract: A warming climate is expected to cause widespread thawing of discontinuous permafrost, and the co-occurrence of wildfire may function to exacerbate this process. Here, I examined the vulnerability of permafrost to degradation from fire disturbance as it varies across different landscapes of the interior Alaskan boreal forest using a combination of observational, modeling, and remote sensing approaches. Across all landscapes, the severity of burning strongly influenced both post-fire vegetation and permafrost degradation. The thickness of the remaining surface organic layer was a key control on permafrost degradation because its low thermal conductivity limits ground heat flux. Thus, variation in burn severity controlled the local distribution of near-surface permafrost. Mineral soil texture and permafrost ice content interacted with climate to influence the response of permafrost to fire. Permafrost was vulnerable to deep thawing after fire in coarse-textured or rocky soils throughout the region; low ice content likely enabled this rapid thawing. After thawing, increased drainage in coarse-textured soils caused reductions in surface soil moisture, which contributed to warmer soil temperatures. By contrast, permafrost in fine-textured soils was resilient to fire disturbance in the silty uplands of the Yukon Flats ecoregion, but was highly vulnerable to thawing in the silty lowlands of the Tanana Flats. The resilience of silty upland permafrost was attributed to higher water content of the active layer and the associated high latent heat content of the ice-rich permafrost, coupled with a relatively cold continental climate and sloping topography that removes surface water. In the Tanana Flats, permafrost in silty lowlands thawed after fire despite high water and ice content of soils. This thawing was associated with significant ground surface subsidence, which resulted in water impoundment on the flat terrain, generating a positive feedback to permafrost degradation and wetland expansion. The response of permafrost to fire, and its ecological effects, thus varied spatially due to complex interactions between climate, topography, vegetation, burn severity, soil properties, and hydrology. The sensitivity of permafrost to fire disturbance has also changed over time due to variation in weather at multi-year to multi-decadal time scales. Simulations of soil thermal dynamics showed that increased air temperature, increased snow accumulation, and their interactive effects, have since the 1970s caused permafrost to become more vulnerable to talik formation and deep thawing from fire disturbance. Wildfire coupled with climate change has become an important driver of permafrost loss and ecological change in the northern boreal forest. With continued climate warming, we expect fire disturbance to accelerate permafrost thawing and reduce the likelihood of permafrost recovery. This regime shift is likely to have strong effects on a suite of ecological characteristics of the boreal forest, including surface energy balance, soil moisture, nutrient cycling, vegetation composition, and ecosystem productivity.

Development and Application of an Integrated Ecosystem Model for Alaska

Post-doctoral Researchers: Hèléne Genet and Yanjiao Mi
Faculty and Research Associates: A. David McGuire, T. Scott Rupp, Vladimir Romanovsky, Eugénie Euskirchen, and Sergey Marchenko
Funding Agencies: USGS and USFWS (RWO 190)

Our primary goal in this project was to develop a modeling framework that integrates the driving components for and the interactions among disturbance regimes, permafrost dynamics, hydrology, and vegetation succession/migration for the state of Alaska. This framework will couple (1) a model of disturbance dynamics and species establishment (the Alaska Frame-Based Ecosystem Code, ALFRESCO), (2) a model of soil dynamics, hydrology, vegetation succession, and ecosystem biogeochemistry (the dynamic organic soil/dynamic vegetation model version of the Terrestrial Ecosystem Model, TEM), and (3) a model of permafrost dynamics (the Geophysical Institute Permafrost Lab model, GIPL). Together, these three models comprise the Integrated Ecosystem Model (IEM) for Alaska and Northwest Canada. The IEM provides an integrated framework to provide natural resource managers and decision makers an improved understanding of the potential response of ecosystems due to a changing climate and to provide more accurate projections of key ecological variables of interest (e.g., wildlife habitat conditions). In this study our objectives were to (1) synchronously couple the models, (2) develop data sets for Alaska and adjacent areas of Canada, also known as the Western Arctic, and (3) phase in additional capabilities that are necessary to address effects of climate change on landscape structure and function. The scenario data for IPCC AR4 climate model simulations was downscaled and is available online. The data group has downscaled the IPCC AR5 climate model simulations. Production runs that include improved fire and treeline dynamics have been conducted over the entire IEM domain to (1) drive TEM with fire disturbance outputs from ALFRESCO and (2) drive GIPL with the soil organic horizon outputs from TEM. Progress has been made in the synchronous coupling of the models so that ALFRESCO can make use of fire severity information from TEM in its simulations and so that TEM can make use of permafrost dynamics from GIPL. The thermokarst modeling group has completed the development of conceptual models of thermokarst dynamics and has started implementing those conceptual models in proof of concept studies in both the Barrow Peninsula, the Arctic Coastal Plain of Alaska, the Tanana Flats, and the Yukon Flats. The thermokarst group has also developed a thermokarst predisposition model for application across the entire IEM domain.

Ongoing Ecological Studies

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

Postdoctoral Researchers: To be determined (UAF) and Mark Lara (University of Illinois)
Faculty: Hélène Genet, A. David McGuire, T. Scott Rupp
Funding Agency: USGS Land Carbon Program (RWO 220)

The overarching goal of this project is to build upon an existing modeling framework (the Integrated Ecosystem Model for Alaska and Northwestern Canada, IEM) to represent the key-processes that will help improve our understanding of the impacts of thermokarst disturbance on ecosystem structure and function at the regional scale. This project will be conducted in the Yukon Flats National Wildlife Refuge in Alaska in two phases. The first phase (years 1 to 3) will be focused on improving the IEM to represent thermokarst dynamics and their consequences on landcover dynamic and the carbon cycle. The second phase (year 4 and 5) will be focused on applying the improved model framework across the refuge from 2000 to 2100 and developing and applying an impact model that will help determining how the changes in landcover will alter wildlife habitat and subsistence resources in the refuge.

The IEM couples 3 models to produce a realistic picture of ecosystem conditions by accurately simulating known interactions of ecosystem components and physical processes. In this study our objectives are (1) to improve the IEM to represent key landcover types (i.e. thermokarst bog, fen and lake) and processes (methanogens activity, lake environmental, and biogeochemical dynamics) associated with thermokarst disturbance, (2) to dynamically couple a stand-alone model of thermokarst disturbance – namely the Alaska Thermokarst Model, ATM – to the IEM so that landcover change associated with thermokarst disturbance can affect biogeochemistry, (3) to apply the improved IEM and predict thermokarst dynamics in the Yukon Flats National Wildlife Refuge, and quantify its impact on landcover dynamic and the carbon cycle from 2000 to 2100, and (4) to develop and apply an impact model to assess how thermokarst disturbance affect wildlife habitat.

The development of the ATM is completed and a preliminary implementation of the model is now conducted across the refuge, at a 1km spatial resolution, from 2000 to 2100 using IPCC AR5 climate scenarios prepared by the Scenario Network for Alaska Planning. These simulations will provide preliminary estimates of land cover dynamic in response to thermokarst across the refuge. A one-dimension lake thermal model has been developed to simulate the vertical profile of lake temperature at a pseudo-daily time step. This model is now tested and will be integrated into the Terrestrial Ecosystem Model of the IEM. The project is collaborating closely with the IEM project phase 3 and a project led by R. Striegl and supported by the NASA-ABoVE program, to provide information on lake carbon dioxide and methane dynamics that will be used to develop a predictive model of thermokarst lake carbon dynamic within TEM. The project will provide salary of a postdoctoral scientist who will be responsible for the model developments, testing and simulations. The selection of the candidate is ongoing and should be completed early this Spring.

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

Post-Doctoral Researcher: Jennifer Roach
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. We are currently awaiting dynamically downscaled winter weather projections and NPP outputs from the IEM model. 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

Post-doctoral Researcher: Jennifer Roach
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: MS, to be decided
Faculty: Brad Griffith
Funding Agency: USFWS, SSP (RWO 221)
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. We expect a graduate student to begin work in summer 2017.

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: To be determined
Faculty: Amy Breen, Eugenie Euskirchen, Robert Bolton, Helene Genet, T. Scott Rupp, Vladimir Romanovsky, Sergey Marchenko, Dave McGuire, and Brad Griffith
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, (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 have increased in recent years across Alaska and northwest Canada, and the trend is projected to continue for the rest of the century for both climate models. 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 at some locations. The projections produced by the IEM will facilitate 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: To be determined
Faculty: Brad Griffith
Funding Agency: Northwest Boreal and Western Alaska Landscape Conservation (LCC) Cooperatives (LCCs), USFWS (RWO 225)
In-kind Support: ADFG

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. We are in the final stages of selecting the Post-doctoral Researcher and expect that work will begin in fall 2017.

Influence of Surface Water Connectivity on Arctic Freshwater Fish and Food Webs in a Changing Climate

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

The rapid rate of climate warming in the Arctic requires knowledge of ecological baseline conditions. In freshwater systems, hydrological processes and associated species responses are predicted to change, affecting surface water distribution and connectivity, and fish species distributions. Understanding how fish distributions and freshwater food webs shift as a result of climate-induced change to hydrological processes is important not only for aquatic biota, but also for the many species of wildlife that rely upon them for food. To assess current biotic and abiotic controls on Arctic freshwater food webs we investigated the following hypotheses: (1) food web structure differs with the degree of surface water connectivity; (2) fish predation and number of consumer levels affect food web structure; and (3) the effect of fish species in structuring food webs depends on their feeding strategy and diet breadth. We sampled fish and their stomach contents and muscle tissue from 32 water bodies at two locations within the Chipp River drainage on the Arctic Coastal Plain. Water bodies varied in size and degree of surface water connectivity to surrounding water bodies. Fish food web complexity increased with the strength and permanence of surface water connectivity due to increased fish species richness and addition of one trophic level. Generalist feeding habits increased the number of trophic links in associated food webs. Information from this study will provide important baseline data, inform us about potential long-term changes in ecosystem services, and help guide fish and wildlife management as the Arctic landscape responds to climate change.

Hyporheic Community and Food Web Dynamics Across a Thermal Gradient in Small Icelandic Streams

Student Investigator: Daniel P. Govoni, PhD Biological Sciences Candidate
Advisor: Mark Wipfli
Funding Agency: Rannsóknamiðstöð Íslands (Icelandic Centre for Research – RANNIS)
In-Kind Support: Hólar University, Freshwater Fisheries Institute of Iceland, Blönduós Academic Center

Food webs and invertebrate communities have been reasonably well studied in small streams, but there has been relatively little research done on the trophic linkages between stream subsurface and surface communities. Hyporheic habitats may play a major role in shaping stream food webs and are likely very susceptible to climate warming. Climate change and resource development could alter the linkages between surface and hyporheic habitats upon which stream food webs depend. Understanding these linkages better, in the face of increasing resource development and climate change, will help inform aquatic resource management. The objectives of this study are to determine (1) how water temperature influences invertebrate communities and food webs at the stream surface-hyporheic interface, and (2) how how seasonal thermal variability shapes subsurface invertebrate communities. We are studying streams across a range of thermal regimes and taking samples from four stations within each stream. At each station, we collect benthic samples and hyporheic samples of invertebrates at 25 and 50 cm below the streambed. Gut contents will be used to construct topological food webs. For Objective 1, we are studying spring-fed streams that are thermally stable within stream but thermally variable among streams due to geothermal activity. For Objective 2, we are contrasting lake-fed streams that are thermally fluctuating seasonally with spring-fed streams that are thermally stable throughout the year. Invertebrate abundances at streambed surfaces were much greater than in hyporheic zones, but taxa richness was similar between the two habitats. Although richness was similar in the surface and hyporheos, faunal composition (assemblage) was dissimilar. Multivariate analyses indicated that seasonal thermal variability, temperature, and conductivity explained a third of the variability in community structure when comparing seasonally fluctuating and stable streams, while surface-subsurface differences were the only significant explanatory variable in thermally stable streams. The results of this study will provide insight into the community and trophic linkages between streams and hyporheic habitats and the influence of climate change on these linkages.

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 S. Wipfli and Barbara Adams
Funding Agency: NSF/Alaska EPSCoR, 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 Patterns of Juvenile Chinook (*Oncorhynchus tshawytscha*) and Coho Salmon (*Oncorhynchus kisutch*) in Three Geomorphically Distinct Sub-Basins of the Kenai River

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

Christina Mielke on the upper Russian River using a packraft to travel between juvenile salmon sampling sites, July 2016. Photo by Ben Meyer.

Ben Meyer at Lower Russian Lake using a packraft to travel between juvenile salmon samping sites, July 2016. Photo by Christina Mielke.

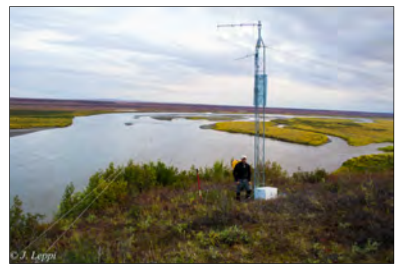
Climate change affects juvenile salmon freshwater habitat types differently, dependent on local watershed properties. Many southcentral Alaskan salmon streams already experience water temperatures above the Alaska Department of Environmental Conservation's maximum thermal criteria of 15°C during summer months. Landscape, hydrology, and physiology interact in complex ways, introducing uncertainty into how climate change influences juvenile salmon rearing habitats. Regional stakeholders in the Kenai Peninsula are concerned about the future of salmon populations in the face of climate change. Knowing how environmental variables including water temperature and food availability contribute to juvenile salmon growth rates will help inform us on potential climate change effects. Objectives are to show how (1) air temperature regulates water temperature in Beaver Creek, Russian River, and Ptarmigan Creeks, and investigate the degree of water temperature heterogeneity within the study areas, and (2) stream temperature and diet influence growth rates of juvenile Chinook and Coho Salmon that rear in these streams. Along with air and water temperature data, we collected diet samples (2015, n=452; 2016, n=504) and length/weight measurements (2015, n=1442; 2016, n=3520) from juvenile Chinook and Coho Salmon across the three focal watersheds. Prey items in diet samples were identified to the lowest reliable taxon. We are applying bioenergetics models to understand patterns of how food and water temperature influence juvenile salmon growth rates. Low-elevation tributaries such as Beaver Creek appear more influenced by air temperature, and rearing salmon in these environments are expected to be exposed to temperatures outside physiological optimum more frequently 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. Climate change-induced shifts in water temperature may either enhance somatic growth rates if thermal optimum is approached, or inhibit them if exceeded. These effects are further mediated by dietary consumption rates. Development activities in southcentral Alaska are often concentrated near low-elevation watersheds where anadromous salmon rearing habitat is potentially most sensitive to climate change. Our results underscore a growing consensus that conservation of habitat features that buffer thermal sensitivity and a diverse portfolio of intact, interconnected habitats best ensure the adaptive capacity of wild salmon populations in the face of climate change.

Movement, Habitat Selection and Foraging Ecology of Broad Whitefish (*Coregonus nasus*) in the Colville River, Alaska

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


Mike Lunde briefly holds a large Broad Whitefish before a radio transmitter is surgically implanted. All photos by Jason Leppi.


Jason Leppi and Mike Lunde camp along the lower Colville River to install a fixed radio telemetry tower.


Mike Lunde near a recently installed fixed radio telemetry tower overlooking the middle Colville River, Alaska.

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 the native community of Nuiqsut 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 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. Telemetry data showed that pre-spawning fish tagged in the middle river during September 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.

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

Student Investigator: Eric Torvinen, MS Fisheries Candidate
Advisor: Jeff Falke
Funding Agency: USGS Alaska Climate Science Center
In-Kind Support: Bureau of Land Management; USGS Alaska Science Center

High latitude ecosystems show increased effects of climate change. Long-term air temperature data only exist from a few locations, and freshwater temperature records are scarce. Studies to obtain spatially comprehensive data are needed. In terrestrial systems, tree-ring data are often used as a reliable proxy to reconstruct temperature regimes, yet most of Arctic Alaska is devoid of trees. These same techniques could be applied to growth-increment widths found in Lake Trout otoliths. These increment widths may provide a reliable multi-decadal proxy to reconstruct temperature regimes across the region. The Arctic Landscape Conservation Cooperative has identified the Fish Creek Watershed as a focal watershed due to documented effects of climate change and intensive oil and gas development. The effects of these stressors on aquatic ecosystems are largely unknown. Study objectives are to (1) construct a Lake Trout growth chronology based on otolith growth-increment analysis to reconstruct past climate patterns and, (2) evaluate Lake Trout growth across Arctic lakes with varying physical and ecosystem characteristics. Otolith increment analysis and dendrochronology techniques were used to derive a biochronology for Lake Trout collected from Arctic lakes. Individual Lake Trout growth rates were modeled as a function of physical, ecosystem, and biological lake characteristics. A sample of 53 Lake Trout was collected from 13 lakes. The best model of regional Lake Trout growth as a function of climate descriptors included mean August temperature. This relationship was used to hindcast mean August temperatures for the period of the growth chronology, 1977–2014, and using modeled air temperatures from 1950–2014. No trend in mean August temperatures was detected over the observed period, but modeled temperatures indicated increasing Lake Trout growth in the region in the recent past. Individual Lake Trout growth rates were higher in deeper, well-connected lakes, located farther from the coast. Climate patterns were estimated for a data sparse region and now encompass a longer time period than previously existed. These climate estimates can be used to make inferences with respect to the implications of climate change to Arctic aquatic ecosystems.

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

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

Carex subspathacea (CSUB) is a short-statured sedge and a preferred food source for brant geese during brood rearing 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 controlled by the presence or absence of grazing. The Yukon-Kuskokwim Delta, Alaska (YKD) and Alaska's North Slope (NS) have completely different grazing systems. On the YKD, extensive grazing lawns of CSUB have converted to a form indistinguishable from CRAM due to reduced grazing. However, on the NS CSUB does not need to be grazed to maintain its short stature. *Carex* species are notoriously difficult to identify. As such, the differences in grazing systems may be due to different species of *Carex*, or differential response to environmental conditions. The objective is to determine the morphological, genetic, and physiological differences among CSUB and CRAM from Arctic and subarctic Alaska. A morphological study has been used to see if CSUB and CRAM are morphologically distinct. Next Generation Sequencing will be used to quantify genetic differences between samples of CSUB and CRAM. Common gardens in Arctic and subarctic Alaska will be used to test for physiological differences. A cluster analysis on morphological measurements indicate that CSUB is morphologically distinct from CRAM. We hypothesize that CSUB and CRAM on the YKD are the same species, and that the NS CSUB is different. It also is hypothesized that 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 where these sedges are prevalent. Research findings will be shared with scientists at state and federal agencies that are involved in the management of Alaskan coastal ecosystems and with Native communities who have strong cultural ties to the subsistence harvest of wildlife species.

List of Abbreviations

ADFG	Alaska Department of Fish and Game
AKCFWRU	Alaska Cooperative Fish and Wildlife Research Unit
AKSSF	Alaska Sustainable Salmon Fund
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
NSEDC	Norton Sound Economic Development Corporation
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