Alaska Cooperative Fish and Wildlife Research Unit

Annual Research Report—2021

Alaska Cooperative Fish and Wildlife Research Unit
P.O. Box 757020, University of Alaska Fairbanks
Fairbanks, AK 99775-7020
uaf-iab-akcfwru@alaska.edu
https://uaf.edu/akcfwru/

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Unit Roster

Federal Scientists

- Jeff Falke: Unit Leader
- Shawn Crimmins: Assistant Unit Leader-Wildlife
- Jeff Muehlbauer: Assistant Unit Leader-Fisheries (Started April 2021)
- Mark Wipfli: Assistant Unit Leader-Fisheries (Retired September 2021)

University Staff

- Monica Armbruster: Fiscal Professional
- Deanna Strohm: Research Professional
- Vacant: Administrative Generalist

Unit Students and Post-Doctoral Researchers

Current Students

- Taylor Cubbage, MS Fisheries Candidate (Falke)
- Claire Delbecq, MS Fisheries Student (Falke)
- Kevin Fitzgerald, MS Fisheries Student (Falke)
- Sara Germain, MS Wildlife Biology & Conservation Student (Crimmins)
- Olivia Edwards, MS Fisheries Candidate (Falke)
- Elizabeth Hinkle, PhD Fisheries Candidate (Falke)
- Will Samuel, MS Fisheries Student (Falke)
- Rebecca Shaftel, PhD Fisheries Student (Falke)
- Christopher Sergeant, PhD Fisheries Candidate (Falke)
- Jeff Wells, MS Wildlife Biology & Conservation Student (Crimmins)
- Mike Wheeler, PhD Biological Sciences Student (Crimmins)
- Sebastian Zavoico, MS Wildlife Biology & Conservation Student (Crimmins)

Post-Doctoral Researchers

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

Graduated in CY 2021

- Jason Leppi, PhD Fisheries (Wipfli)

University Cooperators

- Peter Bieniek, IARC
- Robert Bolton, IARC
- Greg Breed, DBW, IAB
- Amy Breen, IARC
- Todd Brinkman, DBW, IAB

- Curry Cunningham, CFOS
- Eugénie Euskirchen, DBW, IAB
- Hélène Genet, IAB
- Brad Griffith, IAB
- Tuula Hollmén, CFOS, IMS, Alaska SeaLife Center
- Knut Kielland, DBW, IAB
- Nettie La Belle-Hamer, Vice Chancellor for Research, UAF
- Paul Layer, Vice President for Academics, Students, and Research (UA Statewide)
- Mark Lindberg, DBW, IAB
- Andrés López, CFOS
- Sergey Marchenko, GI
- A. David McGuire, IAB
- Megan McPhee, CFOS
- Anupma Prakash, CNSM and Provost UAF
- Vladimir Romanovsky, GI
- Roger Ruess, DBW, IAB
- T. Scott Rupp, IARC, SNAP
- Erik Schoen, IARC
- Andy Seitz, CFOS
- Diana Wolf, IAB
- Peter Westley, CFOS

Affiliated Students

- Derek Arnold, PhD Biological Sciences Student (Kielland)
- Iris Cato, MS Biological Sciences Student (Ruess and Wolf)
- Cody Deane, PhD Biological Sciences Student (Breed)
- Willie Dokai, MS Fisheries Student (McPhee)
- Graham Frye, PhD Wildlife Biology & Conservation Student (Lindberg)
- Margaret Harings, MS Fisheries Student (López and Schoen)
- Matthew Kynoch, MS Wildlife Biology & Conservation Student (Kielland)
- Luke Porter, MS Wildlife Biology & Conservation Student (Breed)
- Gwendolyn Quigley, MS Wildlife Biology & Conservation Student (Brinkman)
- Luke Metherell, MS Wildlife Biology & Conservation Student (Brinkman)
- Benjamin Rich, MS Fisheries Student (Westley)
- Joe Spencer, MS Fisheries Student (Seitz)
- Lindsay Turner, MS Fisheries Student (Cunningham)
- Elyssa Watford, MS Wildlife Biology & Conservation Student (Hollmén and Lindberg)
- Wilhelm Wiese, MS Wildlife Biology & Conservation Student (Hollmén and Lindberg)

Affiliated Post-Doctoral Researchers

- Heather Greaves (Breen)
- Yue Shi (McPhee)

Graduated in CY 2021

- Chris Latty, PhD Marine Biology (Hollmén)

Cooperators

- Diane O'Brien–Interim Director, Institute of Arctic Biology, University of Alaska Fairbanks
- Doug Vincent-Lang–Commissioner, Alaska Department of Fish and Game
- Greg Siekaniec–Director, Region 7, U.S. Fish and Wildlife Service
- Chris Smith–Western Field Representative, Wildlife Management Institute
- Kevin Whalen–Unit Supervisor, Cooperative Research Units, U.S. Geological Survey

This is the Annual Report for the Alaska Cooperative Fish and Wildlife Research Unit, highlighting activities for calendar year 2021. 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 nearly three-quarters of 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 U.S. Department of the Interior's Cooperative Research Unit Program. Established in 1935, Cooperative Research Units were created to fill the vacuum of wildlife management information and the shortage of trained wildlife biologists. In 1960, the Unit Program was formally sanctioned by Congress with the enactment of the Cooperative Units Act. Each unit is a partnership between the Ecosystems Mission Area of the U.S. 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.

Land Acknowledgement

We acknowledge the Alaska Native nations upon whose ancestral lands our campus resides. The University of Alaska Fairbanks' Troth Yeddha' Campus, where the Unit is located, is on the traditional lands of the Dena people of the lower Tanana River. Our research throughout Alaska takes place on the unceded lands of the Haida, Tsimshian, ŁingítTlingit, Eyak, Athabascan, Yup'ik, Cup'iq, Sugpiaq/Alutiiq, Unangax̂/Aleut, and Iñupiaq peoples. We respect and appreciate their past and present stewardship of these lands and waters.

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 this assistance is provided for each project in this report.

Benefits

Students Graduated: 1 (advised by Unit faculty)
Presentations: 19
Scientific and Technical Publications: 8

Courses Taught

Shawn Crimmins: Population Dynamics of Vertebrates (3 credits, Spring 2021)
Jeff Falke: Research Design (3 credits, Fall 2021)

Papers Presented

Bennett, A.P., Alexeev, V.A., Dugger, A.L., Bennett, K.E., and J.A. Falke. 2021. Using future streamflow to inform decision-making efforts in Arctic River systems. Poster presentation. American Geophysical Union Annual Meeting, 13-17 December, 2021. New Orleans, LA and Virtual.

Cubbage, T., Falke, J., Bradley, P., Albert, M., Dunker, K., and P. Westley. 2021.Physiological drivers of invasion success in Alaskan Northern Pike (***Esox lucius***). Mat-Su Salmon Science & Conservation Symposium, 17 November, 2021. Virtual.

Cubbage, T., Falke, J., Kappenman, K., Bradley, P., M. Albert, and K. Dunker. 2021. Physiological performance of Northern Pike (***Esox lucius***): implications for management in invaded systems. Alaska Chapter of the American Fisheries Society Annual Meeting, 22-25 March, 2021. Virtual.

Deemer, B.R., Yackulic, C.B., Hall, R.O., Dodrill, M.J., Kennedy, T.A., Muehlbauer, J, Topping, D, Voichick, N., and M. Yard. 2021. An experimental flow increases gross primary production up to 400 kilometers downstream in a regulated river. Association for the Sciences of Limnology and Oceanography Annual Meeting, 22-27 June 2021. Virtual

Edwards, O.N., Falke, J.A., Savereide, J.W, Hander, R.F., and A.C. Seitz. 2021. Juvenile Chinook Salmon (*Oncorhynchus tshawytscha*) spring outmigration timing and fish size in the Chena River, Alaska. Alaska Chapter American Fisheries Society Annual Meeting, 22-25 March, 2021. Virtual.

Falke, J., Klobucar, S., Rupp, S., Bieniek, P., Genet, H., Bennett, A., Strohm-Klobucar, D., and E. Hinkle. Aquatic ecosystem vulnerability to fire and climate change in Alaskan boreal forests. Strategic Environmental Research and Development Program Annual Symposium. 30 November-3 December, 2021. Washington, D.C. and Virtual.

Falke, J., Rupp, S., Genet, H., Bieniek, P., Bennett, A., Klobucar, S., Strohm-Klobucar, D., and E. Hinkle. 2021. Wildfire in changing boreal stream ecosystems: a friend or foe for fishes? Alaska Chapter American Fisheries Society Annual Meeting, 22-25 March 2021. Virtual.

Falke, J.A. 2021. Bayesian networks to assess vulnerability of salmonids to climate change and wildfire in Washington and Alaska. Association for Fire Ecology International Fire and Ecology Congress. 30 November-4 December 2021. Virtual.

Falke, J.A., Perkin, J.S., Gido, K.B., Crockett, H.J., Sanderson, J.S., Johnson, E.R., and K.D. Fausch. 2021. Groundwater declines are linked to changes in Great Plains stream fish assemblages. Western Division of the American Fisheries Society Annual Meeting. 11-13 May, 2021. Virtual.

Fitzgerald, K., Delbecq, C., Fellman, J., Bellmore, R., and J. Falke. 2021. Implications of a changing flow paradigm on juvenile salmon growth in Southeast Alaska. Alaska Chapter of the American Fisheries Society Annual Meeting. 22-25 March, 2021. Virtual.

Fitzgerald, K., Delbecq, C., Fellman, J., Bellmore, R., and J. Falke. 2021. Implications of a changing flow paradigm on juvenile salmon growth in Southeast Alaska. American Fisheries Society Annual Meeting. 6-10 November, 2021. Baltimore, Maryland.

Hinkle, E.G., Strohm-Klobucar, D.D., and J.A. Falke. 202**1**. Aquatic food web and community response to wildfire in interior Alaska boreal streams. Alaska Chapter of the American Fisheries Society Annual Meeting. 22-25 March, 2020. Fairbanks, Alaska.

Klobucar, S.L., Falke, J.A., Rupp, T.S., and P.A**.** Bieniek. 2021. Quantifying the spark before the fire: a modeling approach to predict future effects of forest fire on aquatic habitat availability and juvenile Chinook Salmon growth in interior Alaska. Alaska Chapter of the American Fisheries Society Annual Meeting. 22-25 March, 2021. Virtual.

Klobucar, S.L., Falke, J.A., Rupp, T.S., & Bieniek, P.A. 2021. Quantifying the spark before the fire: a modeling approach to predict future effects of forest fire on aquatic habitat availability and juvenile Chinook Salmon growth in interior Alaska. Western Division of the American Fisheries Society Annual Meeting. 11-13 May, 2021. Virtual**.**

Lynch, A. J., Myers, B. J. E., Wong, J., Chu, C., Falke, J.A., Kwak, T.J., Paukert, C.P., Tingley III, R.W., and T.J. Krabbenhoft. 2021. Reducing uncertainty in climate change responses for inland fisheries management: a decision-path approach. Midwest Fish and Wildlife Conference. 1-4 February, 2021. Virtual.

Lynch, A. J., Myers, B. J. E., Wong, J., Chu, C., Falke, J.A., Kwak, T.J., Paukert, C.P., Tingley III, R.W., and T.J. Krabbenhoft. 2021. Examining Climate Change Impacts using the Fish and Climate Change Database (FiCli). Western Division of the American Fisheries Society Annual Meeting. 11-13 May, 2021. Virtual**.**

Sergeant, C. J., Bellmore, J. R., Bellmore, R. A., and J. A. Falke. 2021. How will Pacific salmon in Alaska respond to changes in streamflow and water temperature? Alaska Chapter of the American Fisheries Society Annual Meeting. 22-25 March, 2021. Virtual.

Strohm-Klobucar, D.D., Falke, J.A., and J.W. Stone 2021. Monitoring Arctic Grayling (***Thymallus arcticus***) demographics and vital rates in a boreal headwater tributary. Alaska Chapter of the American Fisheries Society Annual Meeting. 22-25 March, 2021. Virtual.

White, K., Lonsinger, R. C., Crimmins, S. M., Anderson, E. M., and T. M. L**i**vieri. 2021. Fine-scale space use by swift foxes on a black-footed ferret recovery site. Swift Fox Conservation Team Meeting.

Scientific Publications

Abernethy, E.F., Muehlbauer, J.D., Kennedy, T.A., Tonkin, J.D., Van Driesche, R., and D.A. Lytle. 2021. Hydropeaking intensity and dam proximity limit aquatic invertebrate diversity in the Colorado River Basin. Ecosphere 12:e03559. https://doi.org/10.1002/ecs2.3559.

Borg, B.L., Arthur, S.A., Falke, J.A., and L.R. Prugh. 2021. Determinants of gray wolf (*Canis lupus*) sightings in Denali National Park. Arctic 74:51-66. https://doi.org/10.14430/arctic72208.

Jalbert, C., Falke, J.A., Lopez, J.A., Dunker, K.J., Sepulveda, A.J., and P.A.H. Westley. 2021. Vulnerability of Pacific salmon to invasion of northern pike (*Esox lucius*) in Southcentral Alaska. PLOS ONE 16(7):e0254097. https://doi.org/10.1371/journal.pone.0254097.

Paukert, C. P., Olden, J. D., Lynch, A. J., Brashears, D., Chambers, R. C., Chu, C., Daly, M., Dibble, K. L., Falke, J., Isaak, D., Jacobson, P., Jensen, O. P., and D. Munroe. 2021. Climate change effects on North American fish and fisheries to inform adaptation strategies. Fisheries 46: 449-464. https://doi.org/10.1002/fsh.10668

Scharhag, J.M., Sartini, C., Crimmins, S.M., Hygnstrom, S.E., and J.B. Stetz. 2021. Characteristics of non-fatal attacks by black bears: conterminous United States, 2000-2017. Human-Wildlife Interactions 15:191-202. https://doi.org/10.26077/f70c-9dbf

Stratton, M.E., Finkle, H., Falke, J.A., and P.A.H. Westley. Tracking adult Coho Salmon (*Oncorhynchus kisutch*) to investigate the presence of stock structure and extent of premature migration in the Buskin River Watershed, Alaska. North American Journal of Fisheries Management 41:1423-1435. https://doi.org/10.1002/nafm.10658.

Thompson, L. M., Lynch, A. J., Beever, E. A., Engman, A. C., Falke, J. A., Jackson, S. T., Krabbenhoft, T. J., Lawrence, D. J., Limpinsel, D., Magill, R. T., Melvin, T. A., Morton, J. M., Newman, R. A., Peterson, J., Porath, M. T., Rahel, F. J., Sethi, S. A., and J. L. Wilkening. 2021. When is resistance futile? Resisting, accepting, or directing ecosystem transformation. Fisheries. 46:8-21. https://doi.org/10.1002/fsh.10506

Wheeler, M.E., Barzen, J.A., Crimmins, S.M., and T.R. Van Deelen. 2021. Population responses to harvest depend on harvest intensity, demographics, and mate replacement in sandhill cranes. Global Ecology and Conservation 30:e01778. https://doi.org/10.1016/j.gecco.2021.

Theses and Dissertations of Unit-Sponsored Graduate Students

Leppi, J.C. 2021. Broad whitefish (*Coregonus nasus*) ecology and habitat use in Arctic Alaska: spawning habitat suitability, isotopic niches, life-history variations, and climate change risks to subsistence fisheries. PhD dissertation, University of Alaska Fairbanks. 201 pages.

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

Broad Whitefish (*Coregonus nasus*) Ecology, Habitat Use and Potential Impacts of Climate Change in Arctic Alaska

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

Note: Jason Leppi graduated from the University of Alaska Fairbanks in August 2021. His dissertation abstract follows:

Broad Whitefish (Coregonus nasus) is a critically important subsistence species for Alaska's Indigenous communities, yet little is known about the basic ecology of this species at the individual level. Understanding habitat use by Broad Whitefish is challenging due to their mobility and our limited ability to track fish throughout their lives as they move among a suite of habitats that are spatially dispersed, change over time, and are often temporary. The Arctic is undergoing major landscape and ecosystem transformation from climate change and oil and gas development, which may threaten Arctic ecosystems used by Broad Whitefish. This dissertation presents new information on the ecology of Broad Whitefish captured in the Colville River, Alaska. In Chapter 1, an intrinsic potential (IP) model for Broad Whitefish was used to estimate the potential of streams across the watershed to provide spawning habitat. Results were compared with movement patterns of radio-tagged prespawn Broad Whitefish. In Chapter 2, ecological niches utilized by Broad Whitefish were investigated via stable isotope analyses of muscle and liver tissue and otoliths from mature fish. In Chapter 3, strontium isotope (87Sr/86Sr, 88Sr) otolith chronologies across individuals' lives were used to quantify life-history attributes and reconstruct migration patterns of fish. Finally, in Chapter 4, the current understanding of ongoing and future changes to the habitat, productivity, and behavior of Broad Whitefish were summarized to assess risks facing Arctic freshwater ecosystems and fishes more broadly. IP model results showed the majority of habitat with high IP (≥ 0.6) was located within the braided sections of the main channel, which encompassed > 1,548 km, and starting in mid-July, prespawn fish used habitats in the middle and lower watershed. Stable isotope analysis revealed a range of $\delta^{13}C$ (-31.8 – -21.9‰) and $\delta^{15}N$ (6.6 – 13.1‰) across tissue types and among individuals. Cluster analysis of muscle tissue $\delta^{13}C$, $\delta^{15}N$, $\delta^{18}O$, and δD indicated that Broad Whitefish occupied four different foraging niches that relied on marine- and land-based (i.e., freshwater and terrestrial) food sources to varying degrees across the summer period. Strontium isotopes revealed six main life histories, including three anadromous types (59%), one semi-anadromous type (28%), and two nonanadromous types (13%),

suggesting greater complexity in life-history types than previously documented. Climate change is expected to continue to alter Arctic hydrology and, therefore, suitability, connectivity, and availability of habitats critical for Broad Whitefish population persistence. Warming and lengthening of the growing season will likely increase fish growth rates; however, the exceedance of threshold stream temperatures will likely increase physiological stress and alter life histories, which is likely to have mixed effects on Arctic subsistence fishes and fisheries. This information on Broad Whitefish spawning intrinsic potential, foraging niches, and life histories provides crucial knowledge to understand critical habitats used across time and space, which will help managers and conservation planners better understand the risks of anthropogenic impacts, such as climate change and oil and gas development, and help conserve this vital subsistence resource.

Ongoing Aquatic Studies

Juvenile Chinook Salmon Outmigration Timing and Summer Movement and Growth in the Chena River, Alaska

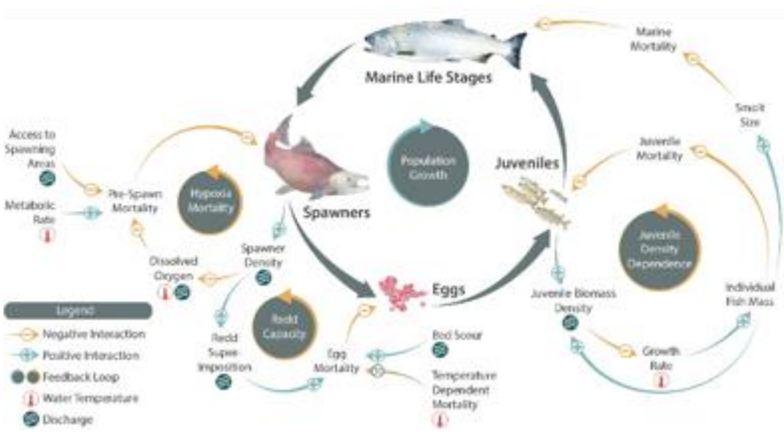
Student Investigator: Olivia Edwards, MS Fisheries
Advisor: Jeff Falke
Funding Agency: Region 3 ADFG (Sport Fish Base)
In-Kind Support: ADFG

Olivia Edwards samples juvenile Chinook salmon on the Chena River.

Since 2001, Chinook Salmon returning to the Yukon River drainage have been designated as a stock of concern by the Alaska Board of Fisheries, and the Chena River supports one of the largest spawning stocks in the Alaskan portion of the Yukon River drainage. Juvenile Chinook Salmon research in the Yukon River basin has been generally limited to the open water season and continuous monitoring of juvenile abundance, outmigration timing, and survival has not been conducted. The overall goal of this research is to enhance the understanding of juvenile Chinook Salmon ecology in the Chena River. We PIT tagged individuals in four rearing areas in the upper Chena River watershed during late summer of 2018 and 2019 and 200 individuals were euthanized in 2019 for growth analysis. Tagged individuals were tracked with in river PIT tag arrays. Spring sampling occurred in the lower river in 2019 using minnow traps and 2020 using both minnow traps and a rotary screw trap. Early results confirm movement of individuals among the four rearing areas and show mid- to late-May peak outmigration timing, with variation in timing among years. We also have evidence that individuals are overwintering in summer rearing areas. We are currently working on summer growth results. The results of this study will help to identify and prioritize areas for freshwater habitat conservation, inform future monitoring projects, and may contribute information to state-space stock-recruit models used to manage fisheries in Alaska.

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

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



A life cycle model simulating the cumulative effects of shifting streamflow and water temperature patterns on coho salmon. Illustration by Cecil Howell.

Southeast Alaska's forest streams are home to some of the strongest remaining Pacific salmon runs on earth, but the impacts of climate change on these populations are uncertain. Life cycle models designed to predict salmon population response to alterations to streamflow patterns and water temperature are relatively common in the conterminous United States, but rarely used in Alaska. Land use planners, fishery managers, and community harvesters need predictions of how salmon populations will respond to cumulative changes in the freshwater environment. We have created a life cycle model (manuscript will be submitted to a peer-reviewed journal in early 2022) to evaluate the extent to which current and projected streamflow and water temperature patterns will affect salmon at each freshwater life stage (adult spawners, eggs, and juveniles). The life cycle model combines water temperature, streamflow, and salmon life history parameters for streams driven by glacier, snow, and rain water sources. Model results suggest that salmon in these three stream types will display variable responses to climate change. Some populations may experience near-term losses in abundance while others will stay static or even improve. In our next phase of research, we will extend the results of the life cycle model to identify watersheds at highest risk of losses. Our ultimate hope is that people dependent on salmon will be better prepared to adapt to salmon population responses to climate change.

Effects of Wildfire Disturbance on Fish Movement, Physiology, and Genetic Relatedness

Student Investigator: Elizabeth Hinkle, PhD Fisheries
Advisor: Jeff Falke
Funding Agency: DoD Strategic Environmental Research and Development Program (RWO 227)
In-Kind Support: ADF&G

At a 2020 fire site, Elizabeth Hinkle takes a discharge measurement through a drift net, which traps macroinvertebrates and organic particulate (photo by Seth Adams).

Wildfire is the primary natural disturbance in boreal forest stream ecosystems and fires are expected to continue to increase in duration and frequency owing to climate change. Wildfires have immediate and lasting effects on streams that can be both positive and negative. Increased productivity because of recent fire may lead to more complex aquatic communities owing to higher food resource availability. To understand the lasting effects of fire on streams, we investigated habitat and community responses to wildfire during summer 2019 at 26 wadeable streams in interior Alaska with varying time since fire disturbance (recent: 0-15 years, historic: 50-75, control: 80+). To observe the immediate effects of fire on streams, we sampled six headwaters (three burned one year before, three were unburned) monthly during summer 2020. At all sites, we measured physical habitat and water chemistry, and quantified community assemblage. At 2019 sites, macroinvertebrate and fish density, and fish diversity were highest at recently burned sites. Recently burned sites had more in-channel wood, less fine sediment, lower canopy cover, less phosphorous and warmer water temperatures. Findings from 2020 revealed that macroinvertebrate diversity was higher at control sites, but burned sites had higher macroinvertebrate abundance. Recently burned headwaters had less canopy cover, less in-stream wood and lower nitrogen, but had more organic matter, and higher carbon and phosphorous. Knowledge of how aquatic communities relate to variables associated with fire disturbance may promote a better understanding of how climate change and fire interact to impact boreal stream ecosystems.

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

Post-doctoral Researcher: Stephen Klobucar (IAB)
Advisor: Jeff Falke
Funding Agency: DoD Strategic Environmental Research and Development Program (RWO 227)


Juvenile Chinook salmon.

With current and expected climate-driven shifts in Alaska fire regimes (e.g., increased frequency, severity), understanding future fire impacts on stream regulating processes are critical for managing fire, aquatic habitats, and fish populations. Because stream temperatures and habitat quality affect juvenile salmon growth and survival, we require an understanding of how changing forest fire regimes will alter future stream temperatures and habitat availability across temporal and spatial scales, and how fire management might influence these changes. The objective of this study is to assess aquatic population vulnerability to fire in boreal aquatic ecosystems through spatially-explicit predictions of fire effects on aquatic habitats under current and future vegetation and permafrost scenarios. We integrated predictions from dynamically-downscaled climate models with stream temperature models to assess juvenile Chinook Salmon (*Oncorhynchus tshawytscha*) habitat and growth across a 1,300 km boreal riverscape in interior Alaska. We predicted reach-scale stream temperatures every 1 km using aggregated 8-day remotely-sensed land surface temperature observations and coupled these predictions with mid- (2038 – 2047) and late- (2068 – 2077) century climate projections and riverscape bioenergetics to quantify juvenile salmon thermal habitat availability and growth potential under a range of fire and climate scenarios. Warming stream temperatures increased suitable habitat in headwater reaches, however, headwater streams at the highest elevations were tempered by changing seasonal precipitation (e.g., increased snowpack). In downstream reaches. Summer temperatures approached but did not exceed thermal limits (> 20 °C) of juvenile salmon, suggesting increased growth potential. Although growth potential varied temporally and spatially across our study area, models generally indicated growth will increase in a warmer climate as long as food is not limiting. Our results also indicate potential range expansion of salmon to stream reaches that become thermally suitable for spawning and rearing, an important consideration for fire management decisions regarding one of Alaska's most valuable commercial, sport, and subsistence fish species.

Characterization of Hydrologic Regimes for Wildfire-Impacted Streams in Changing Boreal Ecosystems

Staff Scientist: Deanna Strohm (IAB)
PI: Jeff Falke
Funding Agency: DoD Strategic Environmental Research and Development Program (RWO 227)

Measuring fall discharge in Wolverine Creek, one of the burn treatment sites.

Boreal stream ecosystems, which span much of Alaska and western Canada, are changing rapidly; Alaska is warming faster than any other state in the U.S. Shorter winters, and warmer springs and summers have lengthened Alaska's fire season, increasing wildfire frequency, intensity, and severity. Understanding how climate change and wildfire influences hydrologic patterns (e.g., timing, magnitude) in boreal streams is important for effective aquatic habitat and species management under a rapidly changing climate. The objectives of this study are to use field observations to quantify and characterize hydrologic regimes in a subsample of headwater streams with different fire histories in interior Alaska, and use existing stream gage data to classify boreal streams and rivers based on statistics that describe the flow regime. We installed stream gages to measure flow and water temperature in 9 tributaries with different fire histories (no burn, historic burn, recent burn) in interior Alaska. We also compiled existing stream gage data for statistical analysis. We estimated mean daily discharge (m^3/s) for the 2019 and 2020 open water year for the gaged tributaries, and classified streams into three size classes and ten distinct subclasses based on streamflow characteristics. We found that historic and contemporary flow regimes have changed since the mid-1970's. In addition, seasonal flow patterns (e.g., timing, magnitude, and duration) from our gaged streams differed between the 2019 and 2020 open water season. Describing flow regimes in headwater tributaries will provide a benchmark with which to detect potential shifts that may result from continued climate warming and increased fire disturbance, and provide valuable information toward management and conservation of important boreal fish species.

Freshwater Habitat Potential for Chinook Salmon in the Yukon and Kuskokwim River Basins, Alaska

Staff Scientist: Josh Paul (IAB)
PI: Jeff Falke
Funding Agency: USFWS (RWO 230)


The Yukon River during spring breakup.

Chinook salmon (*Oncorhynchus tshawytscha*) are an important commercial, subsistence, and recreational fishery resource in Alaska. Knowledge of the distribution, amount, and relative importance of habitat features is critical for management of Chinook salmon stocks. Substantial declines in escapement from many Alaskan watersheds in recent years have resulted in closure of Chinook salmon fisheries in more imperiled drainages. The Yukon and Kuskokwim River basins are the largest in Alaska, and comprise 2 of 12 statewide indicator stocks. However, a lack of information on freshwater habitat in these two basins is a critical information gap. The overarching goal of this project is to develop spawning and rearing habitat potential estimates for the Yukon and Kuskokwim river basins in Alaska. To accomplish this goal, we will compile georeferenced data on Chinook salmon juvenile and adult habitat use from existing databases, and incorporate input from agencies and community members solicited through targeted workshops to develop habitat potential models. NetMap [Earth Systems Institute (ESI), Mt. Shasta, CA], a digital watershed terrain database and set of analysis tools, delivered the final synthetic stream networks for the Yukon and Kuskokwim basins in June 2020 to facilitate classification of watershed attributes and aquatic environments for this system. Further steps to address objectives are ongoing. Information gathered throughout model development and workshops will contribute toward development of a spatially-explicit decision-support tool to facilitate conservation and management of Chinook salmon in the Yukon and Kuskokwim river basins in Alaska.

Physiological Performance of Northern Pike (*Esox lucius*): Implications for Management in Invaded Systems

Student Investigator: Taylor Cubbage, MS Fisheries
Advisor: Jeff Falke
Funding Agency: USFWS (RWO 233)
In-Kind Support: ADFG

Pike acclimating to the flume prior to a leap trial at the USFWS Bozeman Fish Technology Center.

Invasive northern pike (*Esox lucius*) in southcentral Alaska threaten native fishes and the communities that rely on this resource. Although current management of pike (e.g., rotenone and gillnetting) is effective in isolated waterbodies, reinvasion risk following eradication is high in interconnected aquatic habitats. Selective barriers that prevent pike movement may reduce reinvasion following pike eradication efforts. To inform such barrier designs, we quantified abiotic and biotic factors that influence pike leaping ability at the USFWS Bozeman Fish Technology Center with pike collected in Montana. In southcentral Alaska, invasive pike consume more fish prey and occupy preferred habitat relative to native populations north and west of the Alaska Range. To understand how pike may benefit from abundant food and ideal habitat in the invasive range, we quantified and compared physiological traits of invasive and native pike. Invasive pike in Alaska tended to be smaller and younger, but grow faster, mature quicker, and have greater lipid stores than native pike depending on river or lake occupancy. In leaping studies, pike were unable to ascend 40 cm barriers with 40 cm pool depths regardless of flow rates tested (180 – 680 gpm). Pike condition, metabolism, and growth may also influence leap success, which can further inform initial barrier designs in southcentral Alaska. Incorporating the physiological traits of pike in management efforts can increase efficacy and ultimately reduce the impacts of pike on native species in Alaska and elsewhere they are invasive.

Predation impacts of Common Merganser on Chinook Salmon in the Yukon River Basin Revealed Using Genetic Analyses

Research Technician: Justin Hill, IAB
Advisors: Erik Schoen and Andrés López
Funding Agency: USFWS (RWO 238)

Common mergansers swimming.

Piscivorous ducks such as the Common Merganser (*Mergus merganser*) can be important predators of juvenile salmonids. Mergansers are regularly observed feeding near known Chinook Salmon (*Oncorhynchus tshawytscha*) rearing areas in the Yukon River Basin. However, it is unclear whether merganser predation in these areas may be inhibiting recovery of depressed Chinook Salmon populations. To assess potential predation impacts of mergansers on salmon populations, we 1) inferred the presence of Chinook Salmon in merganser diets using species-specific genetic assays on merganser scat samples collected from the Chena and Salcha rivers 2) conducted piscivorous bird surveys along approximately 90 km of each river. The minimum post-breeding Common Merganser density was 0.78 birds / river km on the Chena River and 1.68 birds / river km on the Salcha River. Chinook Salmon DNA was present in 63% of the Chena scat samples (*n*=32) and 97% of the Salcha scat samples (*n*=32), indicating that Chinook Salmon parr is a frequent component of the Common Merganser's diet. A subset of the scat samples is currently undergoing Next-Generation Sequencing to determine the presence of other fish species in the merganser diet, in which a pilot study has already yielded evidence of Slimy Sculpin and Arctic Lamprey. We plan to incorporate this data into a bioenergetics assessment to estimate whether mergansers consume enough salmon parr to represent a meaningful source of mortality to Chinook Salmon populations, providing valuable context for managers to further investigate this potentially important predator-prey relationship.

Combining Genetics, Otolith Microchemistry, and Vital Rate Estimation to Inform Restoration and Management of Fish Populations in the Upper Mississippi River System

Post-doctoral researcher: Yue Shi, CFOS
Advisor: Megan McPhee
Funding Agency: USGS Region 2 (RWO 240)
In-Kind Support: USGS

Upper Mississippi River fishes. Photo by Eric Gittinger.

Characterizing genetic and trait diversity within and among fish populations is critical for managing populations from a 'portfolio effect' perspective, because this diversity is important for maintaining resilience of populations and species. How diversity is structured determines the most appropriate management units and defines expected consequences of habitat restoration for fishes with different life histories. Our objectives are to 1) combine population genomic structure with natal origin and demographic data to understand how population structure varies across species with different life histories; and 2) define management units based on these differences. Six fish species were sampled in six different locations within the upper Mississippi River. Individuals were genotyped at thousands of genetic markers that were developed as part of the project, and adaptive and neutral genetic structure was identified. These results will be combined with otolith and life-history data to define management units for species or guilds with differing population structure. Genotypes from 48 individuals per species and site combination reveal considerable differences in population structure, ranging from low genetic differentiation across sites (Emerald Shiner, Gizzard Shad) to high (Bullhead Minnow, Bluegill). Genetic structure correlated well with life history. We are waiting on the otolith data (natal origin) to finalize analyses. Results from this study will be used to define species- or guild-specific management units within the upper Mississippi River, and the genetic marker panels are available for future research.

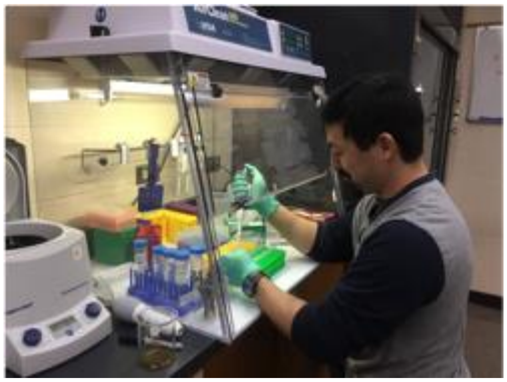
Developing a DNA-Based Tool to Estimate the Number of Salmon Consumed by Piscivores in the Sacramento Delta

Post-doctoral researcher: Yue Shi, CFOS
Advisor: Megan McPhee
Funding Agency: USFWS Region 6 (RWO 239)
In-Kind Support: USGS

Understanding the impacts of predation is vital for investigating the population dynamics of important species. In the Sacramento River, salmonids migrating downstream are predated upon by numerous piscivores, but the impacts of this predation are difficult to quantify using existing methods. Here, we investigated the utility of using molecular tools to determine the number of individual salmon consumed by piscivores in the Sacramento River. This study represents an initial step towards the goal of using genetics to quantify salmonid predation in the Sacramento Delta. We constructed "mock mixtures" containing multiple Chinook salmon (up to 14) and used a previously developed microhaplotype panel containing 125 loci to genotype those mixtures. We then developed a bioinformatic pipeline to analyze these data. Results demonstrated that detecting near the correct number of contributors was feasible, but also illustrated that sampling individuals from mixed populations can bias estimates (especially as more contributors are included). Although the mixture trials did not go exactly as planned, the development of the analytical pipeline is key for further developing this method for examining predation in aquatic ecosystems.

Development of eDNA Metabarcoding Methods for Freshwater Mussels

Student Investigator: Willie Dokai, MS Fisheries
Advisor: Megan McPhee
Funding Agency: USFWS Region 2 (RWO 237)
In-Kind Support: USFWS



Freshwater mussels (Unionidae) have unique life cycles that make them especially vulnerable to habitat degradation. Successful management of unionids requires tools for effective and rapid assessment of their distribution across watersheds. Current monitoring methods such as snorkel surveys are labor-intensive and subject to high flow events and observer bias. Having a validated eDNA tool would enhance freshwater mussel monitoring efficiency, safety, and effectiveness. The objectives of this study are to 1) develop an eDNA metabarcoding protocol, 2) validate it with a well-characterized mussel aggregation near Lyons, MI, and 3) test it in multiple localities with known presence/absence of mussels in Lake Michigan tributaries. The unionid mussel colony in Lyons was sampled twice in summer 2020, and water samples were obtained in both spring and fall 2020 from 69 additional locations in Lake Michigan tributaries. DNA was extracted from these samples, and mitochondrial DNA segments were sequenced from mussel and fish DNA. Results were used to catalog presence/absence of mussel and fish taxa in each site. We showed that eDNA was an efficient and effective way to monitor unionid mussel presence across a number of sites in the Great Lakes region. We were able to add fish presence/absence data with no additional sampling and minimal additional lab work. The metabarcoding tools developed, validated, and tested during this study provide an efficient and safe monitoring method for unionid mussels, and fishes, within the Great Lakes region.

Hydrologic Variability Drives Riverine Materials Export from a Coastal Southeast Alaskan Catchment

Student Investigator: Claire Delbecq, MS Fisheries
Advisor: Jeff Falke
Funding Agency: USGS Alaska Climate Adaptation Science Center (RWO 244)
In-Kind Support: USFS Pacific Northwest Research Station, University of Alaska Southeast, Alaska Coastal Rainforest Center

Sorting drifting stream invertebrate samples at Montana Creek near Juneau.

The coastal watersheds of Southeast Alaska have diverse patterns in flow that are driven by differences in the contribution of glacial, snow, and rainwater input. A changing climate is shifting the primary source of precipitation towards rainfall rather than snowmelt and increasing the likelihood of extreme weather events. These changes to watershed hydrology have the potential to impact the source, processing, and export of materials from watersheds to the nearshore marine ecosystem. These materials can provide important energy sources and nutrients for freshwater and marine food webs. However, the impact of different patterns of flow, such as droughts and floods, on material transport is poorly understood. Our study evaluates how the sequence, magnitude, and timing of stream flows impacts the magnitude and composition of nutrients, particulate organic matter, and organisms (aquatic and terrestrial macroinvertebrates) exported from a predominantly rain-fed watershed in Juneau, Alaska. We collected stream drift and water samples at least twice per week from late April through October 2021, capturing peaks and troughs in stream flow during the main runoff season. Our preliminary results suggest that nutrient and particulate organic matter concentrations vary substantially with season and flow. Stream water drift composition was dominated by terrestrial material (e.g., conifer needles, twigs), and appears to be linked to patterns in high and low flows. Our research will provide insight into the relationship between flow and material fluxes and aid in our understanding of how changing climate will impact materials export to nearshore ecosystems in Southeast Alaska.

Exploring Impacts of Hydrologic Variability on Juvenile Salmon Growth in Watersheds of Southeast Alaska

Student Investigator: Kevin Fitzgerald, MS Fisheries
Advisor: Jeff Falke
Funding Agency: USGS Alaska Climate Adaptation Science Center (RWO 244)
In-Kind Support: U.S. Forest Service Pacific Northwest Research Station, University of Alaska Southeast, Alaska Coastal Rainforest Center


Flood event and land-slide in Montana Creek near Juneau in 2021.

Climate change is shifting hydrologic regimes in watersheds of Southeast Alaska, which collectively support one of the most productive salmon populations in the world. It is expected that these coastal drainages will experience more severe droughts interspersed with larger, more frequent flooding. This raises the important question: how will juvenile salmon and their freshwater ecosystems respond? Because it is challenging to observe fish in natural settings during intense flooding, little is known about how the timing, magnitude, and sequence of these flow events influence juvenile salmon growth. The goal of this research is to investigate how hydrologic patterns influence the availability of drifting fish prey, and in turn, the proportion of juvenile Coho Salmon growth attributed to periods of high and low flow. We conducted an intensive field study where we frequently sampled (e.g., hourly to weekly) invertebrate drift, fish diets, and fish growth from late April through the end of October in a dynamic rain-fed watershed in Juneau, Alaska. Initial results from diet sample analysis indicate that fish growth is influenced by hydrologic conditions, and that flow regime plays a significant role in shaping annual growth trajectories of juvenile salmon. We expect that completed findings will help parse out complex relationships among stream flows, prey fluxes, and fish growth, thus improving our understanding of how shifting flow regimes may impact salmon productivity in Southeast Alaska.

Climate Vulnerability of Aquatic Species to Changing Stream Temperatures and Wildfire Across the Yukon and Kuskokwim River Basins, Alaska

Student Investigator: Rebecca Shaftel, PhD Fisheries
Advisor: Jeff Falke
Funding Agency: USGS Alaska Climate Adaptation Science Center (RWO 246)

Alaska is experiencing climatic change faster than any other area of the United States, but across the state, comprehensive environmental monitoring is logistically difficult and expensive. During the record heat of 2019, adult salmon mortalities were observed across the state and closely linked to temperatures in the mainstem Yukon that have been shown to induce heat stress in Chinook Salmon. There is growing concern that warming stream temperatures and extreme events may be negatively impacting adult salmon, while effects on other life stages or stream fishes are unknown due to limited monitoring data and a lack of stream temperature predictions. The objective of this study is to compare machine learning methods for predicting weekly streams temperatures under current and future climate scenarios across the Yukon and Kuskokwim River basins (YKRB) at the stream reach (~ 1 km) scale. The models will be derived from satellite remotely-sensed land surface temperatures coupled with regional Weather Research and Forecasting (WRF) model projections. This project builds upon current projects focused on understanding 1) boreal aquatic ecosystem vulnerability to wildland fire and climate change and 2) freshwater habitat potential for Chinook salmon. Predictions will be applied across synthetic river networks developed from five-meter IFSAR data for the YKRB. Important project outputs will include geospatial layers and an online results viewer of aquatic habitat potential for important commercial, sport, and subsistence fish species. Managers and researchers can use the project outputs to identify areas in the YKRB to focus future resources and effort for conservation and management of aquatic habitats and species.

When Beavers Get Burned, Do Fish Get Fried? The Role of Beavers to Mediate Wildfire Effects on Freshwater Fish Habitat in Boreal Alaska

Student Investigator: Will Samuel, MS Fisheries
Advisor: Jeff Falke
Funding Agency: Department of Defense (DoD) Strategic Environmental Research and Development Program (RWO 227), Alaska EPSCoR

Burned hillslope along the Middle Fork Chena River near Fairbanks in 2021.

Wildfire is a dominant natural disturbance process throughout boreal North America and fires are increasing in frequency, size, and severity, attributable to climate warming. However, little is known about how wildfire affects fish habitat and populations despite the substantial impacts of fire on ecosystem processes, and even less is known about how fire effects may be mediated by species interactions. For example, North American beavers (Castor canadensis) are affected by and can influence wildfire dynamics, and they have complex effects on aquatic habitats. Therefore, beavers have the potential to mediate wildfire effects on aquatic systems and may magnify or reduce the effects of wildfire on fish populations. Here I investigate the role that beavers may play in mediating the effects of wildfire in Interior Alaska on a ubiquitous boreal fish species, Arctic Grayling (Thymallus arcticus). This study aims to: 1) quantify how the use of beaver ponds influences Arctic Grayling size, abundance, and body condition, and 2) examine the potential for beavers to act as a mechanism to amplify or dampen the effects of wildfire on boreal streams. These objectives will be accomplished by conducting an empirical, field-based study paired with a broader remote sensing/geospatial analysis to understand beaver-fire-fish interactions at various spatial scales. This study is expected to make novel contributions to the fields of fisheries, aquatic ecology, wildlife biology, and fire ecology, and will provide a better understanding of the role of beavers in maintaining diverse and productive aquatic habitats in riverscapes under changing wildfire conditions.

Impacts of a Novel Freshwater Predator Across Time and Space in an Era of Rapid Warming

Student Investigator: Benjamin Rich, MS Fisheries
Advisor: Peter Westley
Funding Agency: Region 6/USFWS (RWO 243)
In-Kind Support: USFWS

Pike sampling on the Deshka River, Alaska

Northern Pike are a non-native invasive species to Southcentral, Alaska that prefers resident and anadromous fishes as prey. Although we know that pike have the potential to negatively impact native fish, it is not clear how their impacts may be exacerbated by warming water as a result of climate change. It is critical to understand when and where pike are having the greatest impact on native fishes to inform suppression and identify potential refugia. It is also critical to understand how pike consumption and growth may increase in the future in response to warming temperatures. Quantify Northern Pike diet by age based on time of year and landscape-scale habitat features, incorporate collected data with those available from previous years, and to model how growth and consumption have changed with warming water temperatures and how they might change in the future. We captured, euthanized, and analyzed stomach contents for 541 Northern Pike across six sites in 2021 throughout the mainstem Deshka River during four sampling events spanning the summer growing season. We found that pike predation timing varied by juvenile salmon species and coincided with out-migration. Mid-river sites tended to have the highest predation rates for juvenile salmon as inferred from Northern Pike diets and were most common in June and July. The results of this analysis can inform future spatially-explicit suppression and suppression objectives and shed light on how the impact of Northern Pike may change in a warming world.

Alaska Forage Fish Data Compilation and Modeling for Risk Assessment in Oil and Gas Development Regions

Student Investigator: Lindsay Turner, MS Fisheries
Advisor: Curry Cunningham
Funding Agency: USGS Alaska Science Center (RWO 245), Bureau of Ocean and Energy Management (BOEM)


Schools of Pacific sand lance in Cabin Bay, Prince William Sound

Forage fish are a mid-trophic level species that are crucial to the diets of marine mammals, sea birds, and commercially important fish. However, forage fish remain poorly sampled due to a lack of targeted fishing, patchy distribution, and diverse life histories. The limited resources available for assessment leave gaps in our understanding of forage fish distribution and abundance. Understanding forage fish population dynamics is critical given their key role in the transfer of energy from phytoplankton and marine predators across Alaska's marine food webs. Using data from small-mesh trawls, beach seines, plankton surveys, and predator diets, we can expand knowledge on the vulnerability of key forage species and assess potential impacts of development on critical habitat. Our first objective is to compile available Alaska forage fish data and publish a publicly available, comprehensive database. We will then compare several modeling approaches for estimating spatial and temporal variation in forage fish abundance and habitat occupancy. So far, we have gathered data from the NOAA (RACE) groundfish bottom trawl survey and related NOAA (REEM) groundfish diets, the Bering Arctic Subarctic Integrated Survey (BASIS) trawls, USGS trawls, the NOAA Nearshore Fish Atlas data, and Middleton Island seabird diets. Once compiled, we will model large-scale patterns in occurrence and gridded density of Alaska forage fish. Currently available data covers approximately 40 years and extends across the Gulf of Alaska, Bering Sea, and Aleutians islands. Compilation efforts will result in a publicly available database with associated metadata, along with species distribution models and estimated habitat occupancy. The resulting database publication will provide a necessary public resource for future forage fish assessment. Further analysis and modeling of forage fish abundance and distribution will help to assess species vulnerability and better understand a critical part of the trophic structure of Alaska's marine ecosystems.

Evaluating Environmental DNA as a Complementary Tool for Estimating Salmon Abundance in the Yukon River Basin

Student Investigator: Maggie Harings, MS Fisheries
Co-Advisors: Andrés López, Erik Schoen
Funding Agency: USGS Alaska Climate Adaptation Science Center
In-Kind Support: ADFG, TCC, USFWS, BLaST


Aquatic eDNA sampling from the Chena River near Fairbanks

Declines in salmon runs have caused hardship in subsistence fishing communities throughout the Yukon River Basin. Simultaneously, increases in stream flows have caused weir, counting tower, and sonar projects to periodically fail, leading to missed salmon counts. Missed counts create challenges for managers when making run predictions for the following year and can contribute to conservative management decisions that impact food security for subsistence fishing communities. We are developing a cost-effective tool complementary to traditional salmon escapement assessment techniques that can be used to interpolate salmon abundance where data gaps occur. In 2021, our partners collected environmental DNA (eDNA) samples and took water temperature and flow measurements from the East Fork Andreafsky River, Chena River, Salcha River, and Henshaw Creek and will do so again in 2022. We will be validating and applying species-specific quantitative PCR to these samples to quantify relative eDNA concentrations for each species. We will use these species-specific eDNA concentrations and environmental covariates to predict daily salmon counts at each site, reported with associated uncertainty. Reductions in data gaps for salmon run assessment projects may improve precision of run forecast models, allowing managers and subsistence fishing communities to better prepare for the upcoming season. Potential follow-up work to rapidly analyze eDNA samples during the spawning run could also improve in-season management.

Migrations of Dolly Varden (*Salvelinus malma*) in Northwestern Alaska Evaluated Using Otolith Microchemistry

Student Investigator: Joseph Spencer, MS Fisheries
Advisor: Andy Seitz
Funding Agency: Region 3 ADFG (Sport Fish Base); USFWS Office of Subsistence Management
In-Kind Support: ADFG, USFWS

Nakolik River, Alaska

Anadromous Dolly Varden are an important subsistence resource in northwestern Alaska. They feed in the ocean during ice-free months and rear, spawn, and overwinter in rivers. They are thought to engage in frequent inter-river movements among years for overwintering and spawning. Differences in life history and migratory strategies among populations across the region are not well understood. Movements among rearing, spawning, and overwintering habitats expose Dolly Varden to numerous subsistence, commercial, and sport fisheries. Knowledge of migratory strategies is needed to fully understand population dynamics and exposure to harvest. The objective of this study is to elucidate the migration strategies of Dolly Varden populations using otolith microchemistry. In 2021, we collected otoliths from Dolly Varden captured (n=166) in major spawning tributaries of the Noatak River and from bycatch (n=29) in the commercial Chum Salmon fishery in Kotzebue. In 2022 we will collect otoliths from subsistence and commercial fisheries (n=50 per fishery), as well as from major spawning populations in the Noatak River drainage (n=50 per tributary). Laser ablation will be performed along a transect from the core to edge of each otolith to measure strontium isotope concentrations. Strontium concentrations along the growth axis of the otolith will be used to determine the age at first seaward migration, frequency of seaward migrations, and fidelity to overwintering sites. This research will inform management of subsistence and commercial fisheries in the region and establish information about the life history and migratory strategies among populations to track future changes in a rapidly warming Arctic.

Ongoing Wildlife Studies

Ecology and Limiting Factors of Birds Breeding along the Beaufort Sea Coast: Energetic Impacts of Storm Surges to Pacific Common Eiders along the Arctic Coastal Plain

Student Investigator: Elyssa Watford, PhD, DBW
Co-Advisors: Tuula Hollmén and Mark Lindberg
Funding Agencies: Arctic National Wildlife Refuge, USFWS (RWO 228); North Pacific Research Board
In-Kind Support: Personnel and logistical support provided by Arctic NWR, USFWS

Using high-tech equipment to candle an egg.

Climate-mediated habitat changes are likely to have profound effects on the animals using the Arctic Coastal Plain, including waterfowl, shorebirds, and loons that rely on coastal habitats to breed and raise young. Common eiders nesting on low elevation barrier islands may be increasingly impacted by earlier, stronger, and more frequent storm surges. This may result in increased nest failure due to flooding at lower elevation nest sites. Pacific common eider populations decreased over 50% from the 1950s to 1990s. Although Pacific common eiders have declined throughout their range, those breeding on barrier islands in the Beaufort Sea are considered particularly vulnerable. Nest failure caused by flooding may be an important limiting factor to common eider population recovery. The goals of this project are to assess nest microclimate variability and the associated energetic costs and characterize body condition during incubation. Data are collected from barrier islands along the Arctic Coastal Plain by searching for nesting eiders and collecting information about their nest microclimate, body condition, and nesting outcomes. The 2020 field season was cancelled due to the COVID-19 pandemic. Nest data for determining incubation stage was prepared for a publication. These data are important for predicting hatch dates and examining factors affecting nest survival. These results will provide a better understanding of how vulnerable eiders are to climate change and help inform management decisions. Continued monitoring will help fill in critical information gaps about eider reproductive ecology and provide a better understanding of how eiders may be affected by climate change.

Spatial Ecology of Lynx in Interior Alaska

Student Investigator: Matt Kynoch, MS Wildlife Biology and Conservation
Advisors: Knut Kielland
Funding Agency: U.S. Fish and Wildlife Service (RWO 229)

Canada lynx in Alaska.

GPS transmitters are widely used to examine the activity patterns of terrestrial animals. However, animal activity can include a range of behaviors that are not always describable by spatial displacement alone. Triaxial accelerometers can be used in addition to GPS transmitters in order to record activity in the presence or absence of spatial displacement, and this study used this approach to examine nuances in the seasonal change of diel activity patterns of Canada lynx (Lynx canadensis) in northern Alaska. Knowledge of lynx behavior at the northern extent of their range will fill gaps in what we know about this charismatic species. A more complete picture of regional lynx biology, and biology of the species as a whole, will be informative for management decisions. Furthermore, we will address the value of supplemental acceleration data to GPS spatial data in behavioral investigations of terrestrial mammals. Our objectives are to, 1) determine if Canada lynx at arctic latitudes exhibit changes diel activity patterns throughout the year and if activity patterns are variable between individuals, and 2) determine if the resolution of triaxial accelerometers allow us to discern patterns in behavior that are not easily detectable with typical GPS collars and learn what differences may mean in the context of lynx behavior. We are using GPS technology in conjunction with high resolution triaxial accelerometers to examine seasonal lynx diel activity patterns. Analysis on diel activity is done using Generalized additive mixed models, and the correlation of GPS and accelerometer data is being investigated with linear mixed models. Lynx in the arctic do change their patterns of diel activity seasonally, with peaks in activity following the twilight windows that rapidly shift throughout the year. Activity patterns become unimodal in the winter when dusk and dawn converge into a single twilight window during mid-day, and unimodal in the summer with activity peaking at the darkest part of the diel period around midnight. These peaks in activity during twilight and near-twilight conditions likely coincide with when snowshoe hares are most vulnerable to predation. Accelerometer informed activity models performed better than GPS informed models: GPS models were unable to reliably detect activity patterns in 6 of 12 individual lynx. Additionally, we found that variation in lynx space use is not explained by activity as measured by acceleration, i.e., lynx that have larger home ranges and larger spatial movements are not more active than other lynx. This suggests that lynx who have large home ranges may move in a more linear fashion, while lynx with small home ranges move in a more tortuous fashion. The results of analysis provide a more complete picture of species biology to inform future management decisions. Also, the results demonstrate the efficacy of triaxial accelerometers as a research and management tool.

Female Dall's Sheep Summer Nutrition in the Chugach Mountains

Student Investigator: Luke Mehterell, MS Wildlife Biology and Conservation
Advisors: Todd Brinkman
Funding Agency: ADFG (Wildlife Base)

Luke Metherell sights Dall's sheep in the Chugach Mountain Range

Over the last two decades, Alaska Department of Fish and Game (ADFG) has seen a decline in Dall's sheep populations across Alaska, including in the Chugach Mountain Range in Game Management (GMU) 14C. Since 2009, ADFG research has indicated reduced body conditions and variable pregnancy rates in the Chugach. To further explore this issue, we estimated annual diet compositions of female Dall's sheep (ewes) and the nutrition quality of forage in the diet. During May-August of 2016, 2017 and 2018, we used video data of ewes to identify and collect forage items, estimate bite count per forage type, and to foster collection of fecal pellets of observed individuals. Collected samples were comprised of six different forage types. We used bomb calorimetry and stable isotope analyses to quantify forage quality in the form of caloric content (cal/g) and crude protein (CP/g). Using a Kruskal-Wallis test, CP/g was significantly different between years, while cal/g was not. Apparent digestibility of both these factors was estimated with intake rates based on diet composition and fecal excretion rates. We also selected a subset of 40 samples, some from each forage type, to analyze compound specific isotope compositions of individual amino acids. The analysis of the final two parts is forthcoming. The overall goal of this study is to advance knowledge on Dall's sheep nutrition and begin to understand environmental factors affecting fitness.

Human-Polar Bear Interactions on the Northern Coast of Alaska

Student Investigator: Gwendolyn Quigley, MS Wildlife Biology
Advisor: Dr. Todd Brinkman
Funding Agency: USFWS, USGS Alaska Climate Adaptation Science Center (RWO 234)
In-Kind Support: Personnel provided by USFWS

Polar bears feast on a whale carcass near Kaktovik, Alaska

Polar bear presence along the northern coast of Alaska is increasing as a result of climate-driven habitat changes. Industrial development, anthropogenic expansion, and tourism have also escalated in this region resulting in increased human-polar bear interactions. More information is needed on human-polar bear interactions to mitigate conflict, bolster conservation, and inform management decisions related to legal stipulations under the Marine Mammal Protection Act and Endangered Species Act. The objectives of this study are to 1) describe terrestrial human-polar bear interactions in Kaktovik, Alaska and 2) quantify polar bear responses to overhead aircraft activity along the north coast of Alaska. To address our first objective, we used a 2005-2007 dataset to describe and model the behavioral response of polar bear to human activity at a popular viewing area (i.e., whale bone pile) near Kaktovik, Alaska. To address our second objective, we conducted systematic flights above polar bear from a small aircraft during September 2021. We documented polar bear response (take, no take) at different altitudes (33-500m) and modeled the effects of flight, habitat, and bear variables. For our first objective, our findings indicate that behavioral responses of polar bears change as the viewing season progresses and in relation to food availability. For our second objective, initial behavior of polar bear during aircraft approach, altitude of the aircraft, and whether the bear belongs to family group are strong predictors of if and when a take response occurs. The results of our study may help inform management guidelines for terrestrial polar bear viewing and best practices for aircraft operation above areas occupied by polar bear.

Developing a Multi-Species Monitoring Framework in Southeast Alaska

Student Investigator: Mike Wheeler, PhD Biological Sciences
Advisor: Shawn Crimmins
Funding Agency: Alaska Department of Fish and Game, USFWS (RWO 253)
In-Kind Support: ADFG

Wolf track in the mud on Prince of Wales Island.

Effective monitoring of large mammals in southeast Alaska is challenging due to accessibility and heavy forest cover. Typical monitoring approaches for wolves, black bear, and deer are largely ineffective in this region, making effective management actions challenging. Moreover, recent listing petitions for wolves in this region necessitate the development of an effective approach for identifying population status. Appropriate management of harvested species necessitates a robust understanding of population status and change through time. In the absence of such information, management programs are hindered in their ability to appropriately allocate harvest or to assess the vulnerability of threatened populations. Thus, a robust monitoring framework for large mammals in southeast Alaska is critical not only for harvest management, but also for status assessments of potentially threatened species. The objective of this study is to develop an integrated monitoring framework for large mammals on Prince of Wales Island, with an emphasis on wolves, that can be applied throughout southeast Alaska. We will deploy 100 remote cameras across the entirety of Prince of Wales Island using a tessellated sampling grid. We will use a combination of motion-capture and time-lapse images to develop density models for wolves, black bear, and black-tailed deer using a suite of analytical approaches including recently developed space-to-event and time-to-event models. We were able to deploy 21 cameras throughout Prince of Wales Island during our pilot field season in fall of 2021. An additional 79 cameras will be deployed during the 2022 field season. The results of this project will provide the basis for effective long-term monitoring of ecologically, economically, and culturally important large mammals in southeast Alaska. Additionally, this project will provide information on the ecological relationships between predator and prey species in southeast Alaska.

Demonstrating the Information Benefits and Data Requirements of an Integrated Population Model Analysis for Alaska Moose Management

Student Investigator: Sebastian Zavoico, MS Wildlife Biology and Conservation
Advisor: Shawn Crimmins
Funding Agency: USFWS (RWO 232), USGS (RWO 250)
In-Kind Support: USFWS

Preparing for an aerial telemetry survey at Togiak National Wildlife Refuge

Effective monitoring of large mammals in southeast Alaska is challenging due to accessibility and heavy forest cover. Typical monitoring approaches for wolves, black bear, and deer are largely ineffective in this region, making effective management actions challenging. Moreover, recent listing petitions for wolves in this region necessitate the development of an effective approach for identifying population status. Effective monitoring strategies can be critical for understanding the ecological drivers of population dynamics. Recent analytical advances can be applied to existing monitoring frameworks to provide more efficient and reliable estimates of demographic parameters and population status. The objectives of this study are to 1) develop and integrated population model for moose using existing monitoring data, and 2) use that model to optimize monitoring strategies and better understand the drivers of moose population dynamics in Togiak National Wildlife Refuge. We are using more than 20 years of radio telemetry data from moose on Togiak National Wildlife Refuge to develop and integrated population model from which we can estimate annual demographic rates, the effects of environmental factors on those demographic rates, and population trajectory through time. We have developed a multi-state model in a Bayesian framework from which we can estimate annual demographic rates and covariate effects. Preliminary results suggest that reproductive parameters are positively associated with forage abundance and negatively associated with winter severity. Both adult and calf survival appear to be negatively affected by age. Our preliminary results suggest that existing monitoring data can be used to better understand moose population dynamics and its ecological drivers. This could be critical for projecting the long-term impacts of climate change on moose populations in this region and elsewhere.

Habitat and Population Modeling for Game Species in the Great Lakes

Student Investigator: N/A
Advisor: Shawn Crimmins
Funding Agency: U.S. Geological Survey (RWO 241)
In-Kind Support: N/A

Otter den along the banks of the Chippewa River, Wisconsin

Relatively little is known about furbearer habitat selection in the Great Lakes region, particularly beaver and river otter. Moreover, monitoring programs for these species rely on costly aerial survey approaches that largely have not been evaluated for their accuracy. The objectives of this study are to 1) develop habitat models for harvested furbearer species in Wisconsin, and 2) identifying effective population monitoring and modeling approaches for these species. We used aerial survey data for beaver in Wisconsin to 1) develop a habitat selection model in a resource selection framework, and 2) develop a supervised classification scheme with which areas of beaver activity could be readily identified from aerial imagery. We also used repeated bridge-site surveys to develop a monitoring framework for river otters. Our habitat selection model suggested that beaver do not exhibit scale-dependent habitat selection and are positively associated with abundance forage and stream densities. Our supervised classification approach yielded beaver density estimates similar to those derived from aerial surveys. Our bridge-surveys indicated that river otters can be efficiently monitored using repeated site surveys in an occupancy modeling framework. We identified monitoring frameworks for both beaver and river otter that are more cost effective than current approaches based on aerial surveys but yield similar results. By improving our understanding of beaver and river otter habitat selection, we may be able to further improve monitoring programs by targeting areas of likely occupancy for sampling, thus reducing the costs associated with ineffective sampling.

Factors Influencing Caribou and Wolf Resource Selection and Spatial Dynamics in Eastern Interior Alaska

Student Investigator: Jeff Wells, MS Wildlife Biology and Conservation
Advisor: Shawn Crimmins
Funding Agency: ADFG (Wildlife Base)
In-Kind Support: ADFG

Bull caribou collared as part of the Fortymile caribou monitoring program.

Predator-prey spatial dynamics can have important implications for the population dynamics of both predators and prey; therefore, an understanding of these patterns can be critical for population and harvest management. Caribou are an important prey resource for wolves and an important wild game resource for humans in Interior Alaska. The effectiveness of intensive management of predators and harvest management for caribou requires an understanding of what factors influence movements and habitat use for both species. The objectives of this study are to 1) evaluate the spatial dynamics between wolves and caribou in interior Alaska, and 2) evaluate the effects of roads and hunting access on caribou spatial dynamics. We will assess wolf and caribou movements and resource selection using Integrated Step Selection Analysis from approximately 10 years of satellite telemetry data collected from the Fortymile caribou herd and 3 years of satellite telemetry data collected from wolves residing within the Fortymile caribou herd range. Preliminary analyses will begin in 2022. This study will be one of the first to assess predator-prey dynamics or the effects of hunting access on the spatial dynamics of large mammals in Alaska. These results could provide guidance for future intensive management programs and caribou harvest management throughout Alaska.

Investigating the Role of Juvenile Weight in Predicting Future Fitness in a Sub-Arctic Moose Populations

Student Investigator: Sara Germain, MS Wildlife Biology and Conservation
Advisor: Shawn Crimmins
Funding Agency: ADFG (Wildlife Base)
In-Kind Support: ADFG

Hunter harvested moose near Nome, Alaska

Moose are a valuable big game species in Alaska and serve as a critical food resource for rural communities. Moose densities near Nome, Alaska have remained low for decades despite no indications of nutritional limitations to fitness. Understanding the limitations on moose population growth is critical for developing appropriate habitat and harvest management strategies aimed at increasing harvest opportunities for local residents. Current metrics of nutritional limitations appear to be ineffective for moose populations near Nome, requiring a better understanding of the links between physical condition and demographic rates. The objectives of this study are to 1) quantify neonate moose survival in Game Management Unit 22, and 2) identify factors associated with neonatal survival, and 3) relate physical condition metrics to long-term reproductive output of adult moose. We will capture and monitor neonate moose in Game Management Unit 22 and monitor their survival through recruitment the following year. We will use Cox Proportional Hazards models to quantify the effects of maternal body condition and habitat on neonate survival. We will use long-term monitoring data to evaluate the influence of calf body condition on lifetime reproductive success. Preliminary analyses suggest a positive relationship between short-yearling weight and reproductive success the following year. However, preliminary analyses suggested a negative relationship between short-yearling weight and the probability of calf survival the following year. This study will help identify the causes behind low, long-term moose densities in Game Management Unit 22, and also help to refine nutritional and body-condition metrics used to assess nutritional limitation for moose in Alaska. Identification of the reasoning behind low moose densities will help guide management actions aimed at increasing densities and, thus, harvest opportunities.

Sea Otter Habitat Use and Response to Algal Blooms in Kachemak Bay, Alaska

Student investigator: Luke Porter, MS Wildlife Biology and Conservation
Advisor: Greg Breed
Funding Agency: USFWS (RWO 247)

Sea otters in Kachemak Bay

Sea otter (*Enydra lutris*) population dynamics have broad impacts on near-shore ecosystem In Alaska. Uncontrolled harvest, changes in predation pressure, and anthropogenic factors can cause otter population to crash. By reducing urchin populations, otters facilitate kelp forest growth and community stability. Thus, maintaining productive otter stocks is paramount to Alaskan nearshore ecosystem health. We have compiled over twenty years of otter population data (archived by U.S. Fish and Wildlife Service Marine Mammal Management Unit) form Kachemak Bay, Alaska. With this we will model and analyze the impacts contemporary climate issues have had on this population over the past two decades. Of particular concern is how increasing ocean temperatures may result in more frequent and potent Harmful Algal Blooms (HABs). Planned analyses for this in-progress project include fitting an Ornstein-Uhlenbeck biased random walk model to determine factors driving otter space use and how algal bloom events impact otter movement and space use. Otters in Kachemak Bay regularly switch between activity centers and storm avoidance does not entirely explain observed movement patterns. Novel internal biometric recording devices, particularly internal temperature time series, will also be analyzed to relate changes in body temperature to environmental conditions, including movement and exposure to HABs. We will also apply a step-selection function to determine how female otters choose habitat relative to pup dependency. Results from both these studies will inform otter management decisions throughout Alaska.

Improving Lincoln Estimates of Arctic Goose Abundance with Indirect Recoveries and a Bayesian Brownie Model that Incorporates Reporting Probability in the Likelihood

Student investigator: Cody Deane, PhD Wildlife Biology and Conservation
Advisor: Greg Breed
Funding Agency: USFWS (RWO 247)

Counting greater white-fronted geese

Estimating waterfowl population abundance was revolutionized by implementing Lincoln's method for estimating abundance of closed populations. Lincoln abundance estimates have become the metric on which harvest regulations are based for species like greater white-fronted geese (*Anser albirons*). Current implementation of Lincoln's method may be more biased, more imprecise, or more variable than preferred. We seek to show Brownie band-recovery models, which are used to estimate annual survival and harvest-recovery from tag-recovery data, can be combined with Lincoln's method to improve precision and reduce bias of abundance estimates. We have developed Brownie-Lincoln models in a Bayesian framework (Program JAGS) and have applied these models to data for the midcontinent population of greater white-fronted geese. We have also developed a simulation process for validating the results of our Brownie-Lincoln abundance estimator. Our results indicate that our Brownie-Lincoln estimator produces more precise and less variable estimates of abundance for the midcontinent greater white-fronted goose when compared to the historical application of Lincoln's method. Relying on Lincoln's method for informing waterfowl harvest management decisions requires this method be vetted to the highest degree possible. Our work will assist in streamlining the process by which U.S. and Canadian harvest regulations are set.

Movement Patterns, Dispersal Behavior, and Survival of Lynx in Relation to Snowshoe Hare Abundance in the Boreal Forest

Student investigator: Derek Arnold, PhD Wildlife Biology and Conservation
Advisor: Knut Kielland
Funding Agency: USFWS (RWO 242)

No report for this project was received for CY2021.

Ongoing Ecological Studies

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

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

No report for this project was received for CY2021.

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: **Helen Chmura (IAB)**
Faculty: **Amy Breen, Robert Bolton, T. Scott Rupp (IARC); Brad Griffith, Hélène Genet, Eugénie Euskirchen (IAB); Vladimir Romanovsky, Sergey Marchenko, and Dmitry Nicolosky (GI)**
Funding Agency: **USGS Alaska Climate Science Center (RWO 224)**

No report for this project was received for CY2021.

Wetland Carbon Assessment for Alaska

Lead: Hélène Genet
Postdoctoral Researcher: TBD
Funding Agency: USGS Land Carbon Program (RWO 231)

No report for this project was received for CY2021.

List of Abbreviations

ADFG	Alaska Department of Fish and Game
AKCFWRU	Alaska Cooperative Fish and Wildlife Research Unit
CFOS	College of Fisheries and Ocean Sciences, UAF
DBW	Department of Biology and Wildlife, UAF
DoD	U.S. Department of Defense
EPSCoR	Experimental Program to Stimulate Competitive Research
GI	Geophysical Institute, UAF
IARC	International Arctic Research Center
IAB	Institute of Arctic Biology, UAF
IEM	Integrated Ecosystem Model
LWD	Large, woody debris
NASA	U.S. National Aeronautics and Space Administration
NS	North Slope, Alaska
NSF	National Science Foundation
NWR	National Wildlife Refuge
RWO	Research Work Order
SNAP	Scenarios Network for Alaska + Arctic Planning
TBN	To be named
UAF	University of Alaska Fairbanks
USBLM	U.S. Bureau of Land Management
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
YKD	Yukon-Kuskokwim Delta, Alaska