Alaska Cooperative Fish and Wildlife Research Unit

Annual Research Report—2020

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Not for Publication: Because this report is one of progress, the data presented are often incomplete, and the conclusions reached may not be final.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

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Unit Roster

Federal Scientists
- Jeff Falke: Unit Leader
- Shawn Crimmins: Assistant Unit Leader-Wildlife
- Mark Wipfli: Assistant Unit Leader-Fisheries

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

Unit Students and Post-Doctoral Researchers

Current Students
- Taylor Cubbage, MS Fisheries Student (Falke)
- Olivia Edwards, MS Fisheries Candidate (Falke)
- Dan Govoni, PhD Biological Sciences Candidate (Wipfli; University of Iceland)
- Elizabeth Hinkle, PhD Fisheries Student (Falke)
- Jason Leppi, PhD Fisheries Candidate (Wipfli)
- Christopher Sergeant, PhD Fisheries Candidate (Falke)

Post-Doctoral Researchers
- Charlotte Gabrielsen (Griffith)
- Stephen Klobucar (Falke)

Graduated in CY 2020
- Donald Arthur, MS Fisheries (Falke)
- Jess Grunblatt, PhD Interdisciplinary Studies (Wipfli and Adams)
- Ben Meyer, MS Fisheries (Wipfli)

University Cooperators
- Peter Bieniek, IARC
- Robert Bolton, IARC
- Amy Breen, IARC
- Todd Brinkman, DBW, IAB
- 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, Interim Vice Chancellor for Research, UAF
- Paul Layer, Vice President for Academics, Students, and Research (UA Statewide)
- Mark Lindberg, DBW, IAB

- 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, IAB
- Diana Wolf, IAB

Affiliated Students
- Iris Cato, MS Biology Candidate (Ruess and Wolf)
- Matthew Kynoch, MS Biology and Wildlife Candidate (Kielland)
- Christopher Latty, PhD Marine Biology Candidate (Hollmén)
- Elyssa Watford, MS Wildlife Biology and Conservation Candidate (Hollmén and Lindberg)
- Wilhelm Wiese, MS Wildlife Conservation Candidate (Hollmén and Lindberg)
- Graham Frye, PhD Student (Lindberg)
- Gwendolyn Quigley, MS Student (Brinkman)
- Willie Dokai, MS Student (McPhee)
- Derek Arnold, PhD Student (Kielland)

Affiliated Post-Doctoral Researchers
- Heather Greaves (Breen)
- Yue Shi (McPhee)

Cooperators
- Brian Barnes–Director, Institute of Arctic Biology, University of Alaska Fairbanks
- Doug Vincent-Lang–Commissioner, Alaska Department of Fish and Game
- Greg Siekaniec–Director, Region 7, US Fish and Wildlife Service
- Chris Smith–Western Field Representative, Wildlife Management Institute
- Kevin Whalen–Unit Supervisor, Cooperative Research Units, US Geological Survey

This is the Annual Report for the Alaska Cooperative Fish and Wildlife Research Unit, highlighting activities for calendar year 2020. The Unit engages in research on living natural resources for a variety of State and Federal agencies. As an unbiased research organization, the Unit provides information requested and funded by these agencies. When studies are completed, the agencies use the information to assist in their natural resource management efforts. Most of the research is conducted by graduate students, many of whom go on to work for the agencies upon graduation.

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

Land Acknowledgement

We acknowledge the Alaska Native nations upon whose ancestral lands our campus resides. In Fairbanks, our Troth Yeddha' Campus is located on the ancestral lands of the Dena people of the lower Tanana River.

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: 3 (advised by Unit faculty)
Presentations: 19
Scientific and Technical Publications: 7

Courses Taught

Jeff Falke: Freshwater Habitat Dynamics (3 credits, Fall 2020)

Papers Presented

[1]Arthur, D, Falke, J., Blain-Roth, B, Beaudreau, A., and Sutton, T. 2020. Fecundity of Yelloweye Rockfish in Prince William Sound and the Northern Gulf of Alaska. 45th Annual Meeting for the Alaska Chapter of the American Fisheries Society, Fairbanks, Alaska, 23-26 March, 2020.

[1]Cubbage, T., Falke, J., Kappenman, K., Bradley, P., and M. Albert. 2020. Physiological performance of Northern Pike (*Esox lucius*): implications for barrier design in invaded systems. Alaska Chapter American Fisheries Society Annual Meeting, Fairbanks, Alaska, 24-26 March, 2020.

Cubbage, T., Falke, J., Kappenman, K., Bradley, P., M. Albert, and K. Dunker. 2020. Physiological performance of Northern Pike (*Esox lucius*): implications for barrier design in invaded systems. Mat-Su Salmon Science & Conservation Symposium, Virtual Meeting, 19 November, 2020.

[1]Edwards, O.N., J.A. Falke, J.W. Savereide, and A.C. Seitz. 2020. Summer growth and movement behavior of juvenile Chinook Salmon in the Chena River, Alaska. Alaska Chapter of the American Fisheries Society Annual Meeting, Fairbanks, Alaska, 23 March to 26 March, 2020.

[1]Falke, J.A., Sergeant, C.J., and J.R. Bellmore. 2020. Ecological drought and implications for salmon and riverine habitats in Alaska. Alaska Chapter American Fisheries Society Annual Meeting. Fairbanks, Alaska, 23-26 March, 2020.

[1]Falke, J.A., Sergeant, C.J., Bellmore, J.R., and R.A. Bellmore. 2020. Ecological drought and implications for salmon and riverine habitats in Southeast Alaska. ASLO-SFS Joint Summer Meeting, Madison, Wisconsin, 7-12 June, 2020.

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

[1]Klobucar, S.L., Falke, J.A., Rupp, T.S., & Bieniek, P.A 2020. Playing with fire? Predicting wildland fire effects on thermal habitat and juvenile Chinook Salmon growth in interior Alaska riverscapes. Association for the Sciences of Limnology and Oceanography-Society of Freshwater Science Joint Meeting. Madison, WI, 7 – 12 June, 2020.

[1]Klobucar, S.L., Falke, J.A., Rupp, T.S., & Bieniek, P.A. 2020. 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. American Fisheries Society, Alaska Chapter, Annual Meeting. Fairbanks, Alaska, 23 – 26 March, 2020.

Klobucar, S., Falke, J., Rupp, S., Bieniek, P., Genet, H., Bennett, M., Hinkle, E., and D. Klobucar. Aquatic ecosystem vulnerability to fire and climate change in Alaskan boreal forests. Strategic Environmental Research and Development Program Annual Symposium. 30 November - 4 December, 2020. Washington, D.C.

Lopez, J.A., Jalbert, C., Campbell, M., Falke, J., and P. Westley. 2020. Population Genetics of a Northern Pike Invasion. American Fisheries Society Virtual Meeting, 14-25 September, 2020.

Merems, J.L., A. Brose, S.M. Crimmins, J.L. Price Tack, T.R. Van Deelen. 2020. Effects of wolves on elk habitat use in Wisconsin. Annual Conference of The Wildlife Society. Annual Conference of The Wildlife Society. September 29 – October 3, Reno, NV.

[1]Meyer, B, M Wipfli, D Rinella, E Schoen, J Falke. 2020. Landscape diversity filters climate change influence on juvenile Chinook and Coho salmon rearing habitat in the Kenai River. Alaska Chapter of the American Fisheries Society, Fairbanks, AK.

Meyer, B, E Schoen, J Neuswanger, C Volk, M Wipfli, B McKenna. Short-term effects of wildfire on juvenile Chinook salmon in the Chena River. 2020 Mat-Su Salmon Symposium. 19 Nov 2020.

Neuswanger, JR, ER Schoen, CJ Volk, MS Wipfli, JW Savereide. 2020. Spatiotemporal and flow-related variability in invertebrate drift and Chinook Salmon growth in the Chena River, Alaska. Western Division American Fisheries Society annual meeting, Vancouver, BC, April 2020.

[1]Schoen, ER, JR Neuswanger, CJ Volk, MS Wipfli, JW Savereide. 2020. Stream temperature and flow-related variability in invertebrate drift and Chinook Salmon growth in the Chena River, Alaska. Alaska Chapter American Fisheries Society annual meeting, Fairbanks, AK, March 2020.

[1]Sergeant, C. J., J. A. Falke, J. R. Bellmore, and R. A. Bellmore. 2020. How will Pacific salmon in Alaska respond to changes in streamflow and water temperature? ASLO-SFS Joint Summer Meeting, Madison, Wisconsin, 7-12 June, 2020.

[1]Strohm-Klobucar, D.D., and J.A. Falke. 2020. Gaging the importance: characterizing hydrologic regimes of headwater streams in changing boreal ecosystems. Alaska Chapter of the American Fisheries Society Annual Meeting, Fairbanks, Alaska, 23-26 March, 2020.

[1]Trevor J. Krabbenhoft, Bonnie J.E. Myers, Jesse Wong, Cindy Chu, Ralph W. Tingley III, Jeffrey A. Falke, Thomas J. Kwak, Craig P. Paukert, Abigail J. Lynch. 2020. Fish and Climate Change (FiCli) Database: Informing climate change adaptation and management actions for freshwater fishes. World Fisheries Congress, Adelaide, Australia. 11-15 October, 2020.

[1]Meeting canceled or postponed owing to COVID-19 pandemic.

Scientific Publications

Collins, S.F., C.V. Baxter, A.M. Marcarelli, L. Felicetti, S. Florin, M.S. Wipfli, G. Servheen. 2020. Reverberating effects of resource exchanges in stream-riparian food webs. Oecologia, 192:179–189. doi.org/10.1007/s00442-019-04574-y.

Courtney, K.R., Falke, J.A., Cox, M.K., and J. Nichols. 2020. Energetic status of Alaskan Chinook Salmon: interpopulation comparisons and predictive modeling using bioelectrical impedance analysis. *North American Journal of Fisheries Management* 40:209-244. https://doi.org/10.1002/nafm.10398.

Dunlop, K., A.P. Eloranta, E. Schoen, M.S. Wipfli, J.L. Jensen, R. Muladal, G.N. Christensen. 2020. Evidence of energy and nutrient transfer from the invasive pink salmon (*Oncorhynchus gorbuscha*) spawners to juvenile Atlantic salmon (*Salmo salar*) and brown trout (*Salmo trutta*) in northern Norway. Ecology of Freshwater Fish 30: 270-283. https://doi.org/10.1111/eff.12582.

Dunlop, K., M. Wipfli, R. Muladal, G. Wierzbinski. 2020. Terrestrial and semi-aquatic scavengers on Pacific pink salmon (*Oncorhynchus gorbuscha*) carcasses in a riparian ecosystem in northern Norway. Biological Invasions 23:973-979. https://doi.org/10.1007/s10530-020-02419-x.

Krabbenhoft, T., Myers, B., Wong, J., Chu, C., Tingley, R., Falke, J., Kwak, T., Paukert, C., and A. Lynch. 2020. FiCli, the Fish and Climate Change Database, informs climate adaptation and management for freshwater fishes. *Scientific Data* 7:124. https://doi.org/10.1038/s41597-020-0465-z.

Sergeant, C.J., Falke, J.A., Bellmore, R.A., Bellmore, J.R., and R.L. Crumley. 2020. A classification of streamflow patterns across the coastal Gulf of Alaska. *Water Resources Research* e2019WR026127. https://doi.org/10.1029/2019WR026127.

Shaftel, R., Mauger, S., Falke, J., Rinella, D., Davis, J., and L. Jones. 2020. Thermal diversity of salmon streams in the Matanuska-Susitna Basin, Alaska. *Journal of the American Water Resources Association* 56:630-646. https://doi.org/10.1111/1752-1688.12839.

Theses and Dissertations of Unit-Sponsored Graduate Students

Arthur, D.E. 2020. The reproductive biology of yelloweye rockfish (*Sebastes rubberrimus*) in Prince William Sound and the Northern Gulf of Alaska. Master's Thesis. University of Alaska Fairbanks. 110 pages.

Grunblatt, Jesse E. Science, Perception and Scale: An Interdisciplinary Analysis of Environmental Change and Community Adaptive Capacity. PhD dissertation, University of Alaska Fairbanks. 90 pages.

Meyer, B.E. 2020. Landscape characteristics influence climate change effects on juvenile Chinook and coho salmon rearing habitat in the Kenai River. Master's Thesis. University of Alaska Fairbanks. 74 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

The Reproductive Biology of Yelloweye Rockfish (*Sebastes rubberrimus*) in Prince William Sound and the Northern Gulf of Alaska

Student Investigator: Donald Arthur, MS Fisheries
Advisor: Jeff Falke
Funding Agencies: ADF&G Sport Fish Division (Region 2)

Note: Donald Arthur graduated from the University of Alaska Fairbanks in December 2020. His thesis abstract follows:

Over the last half century, Yelloweye Rockfish Sebastes ruberrimus have experienced dramatic declines along the West Coast of the United States and British Columbia. Efforts have been made throughout the species' range to rebuild and sustainably manage stocks, including the introduction of a Statewide Rockfish Initiative by the State of Alaska, which intends to develop management strategies for Yelloweye Rockfish in the Gulf of Alaska. To support this effort and address information gaps in Yelloweye Rockfish reproductive biology throughout their range, I estimated important reproductive parameters and life history information for Yelloweye Rockfish in Prince William Sound and the Northern Gulf of Alaska, Alaska, that included maturity, parturition timing, skip spawning, and fecundity relationships. I identified that ages-at- 50% maturity (A50) for males and females were similar (A50 = 15 years and A50 = 16, respectively), but males reached full maturity (A95) earlier than females (male A95 = 19 years and female A95 = 31 years). Female Yelloweye Rockfish fork length-at-50% and 95% maturity (L50 and L95) was greater in the Northern Gulf of Alaska (L50 = 46.7 cm and L95 = 55.8 cm) than in Prince William Sound (L50 = 41.1 cm and L95 = 50.2 cm). Similarly, male L50 and L95 was greater in the Northern Gulf of Alaska (L50 = 44.0 cm and L95 = 49.2 cm) relative to Prince William Sound (L50 = 40.8 cm and L95 = 46.0 cm), and males matured at a smaller size than females. Female L50 was consistent with data from southern populations, but A50 was younger than predicted based on a latitudinal trend, indicating that Yelloweye Rockfish in this region may experience greater than expected growth rates. Yelloweye Rockfish underwent parturition between May and August and peaked in June and July, and parturition timing was earlier for larger and older females. I documented that female Yelloweye Rockfish skip-spawned at a rate of 9.8%. Skip spawning rate was associated with fork length and peaked at sizes between 40.2 cm and 52.3 cm; the peak in stock reproductive potential is shifted toward larger females in response to skip spawning. I conducted egg and larvae counting in an image-analysis software, which was more than four times faster than manual counting and was equally accurate and precise. Yelloweye Rockfish fecundity scaled hyperallometrically with FL and relative fecundity increased with length, indicating that spawning stock biomass may not be proportional to total egg production. Combining these results, I found that ignoring the hyperallometric fecundity

relationship and skip spawning could overestimate reproductive potential by as much as 66% and 45% for Prince William Sound and the Northern Gulf of Alaska, respectively. The results of this study will improve the estimates of stock-recruitment dynamics and can be readily integrated into a stock assessment that will guide the sustainable management of Yelloweye Rockfish in Prince William Sound and the Northern Gulf of Alaska.

Landscape Characteristics Influence Climate Change Effects on Juvenile Chinook and Coho Salmon Rearing Habitat in the Kenai River

Student Investigator: Benjamin Meyer, MS Fisheries
Co-Advisors: Mark Wipfli and Dan Rinella (USFWS)
Funding Agencies: EPSCoR (NSF), State of Alaska, and Department of Biology and Wildlife, and Institute of Arctic Biology, UAF
In-Kind Support: Kenai Peninsula College, Kenai Watershed Forum, Cook Inletkeeper

Note: Benjamin Meyer graduated from the University of Alaska Fairbanks in August 2020. His thesis abstract follows:

Changes in temperature and precipitation as a result of ongoing climate warming in south-central Alaska are affecting juvenile salmon rearing habitat differently across watersheds. Work presented here simulates summer growth rates of juvenile Chinook and coho salmon in streams under future climate and feeding scenarios in the Kenai River (Alaska) watershed across a spectrum of landscape settings from lowland to glacially-influenced. I used field-derived data on water temperature, diet, and body size as inputs to bioenergetics models to simulate growth for the 2030-2039 and 2060-2069 time periods, comparing back to 2010-2019. My results suggest decreasing growth rates under most future scenarios; predicted changes were of lower magnitude in the cooler glacial watershed and main stem and more in montane and lowland watersheds. The results demonstrate how stream and landscape types differentially filter a climate signal to juvenile rearing salmon habitat and contribute to a broader portfolio of habitats in early life stages. Additionally, I examined two years of summer water temperature data from sites throughout our study tributaries to assess the degree to which lower reach sites are representative of upstream thermal regimes. I found that the lower reaches in the lowland and glacial study watersheds were reasonably representative of daily and seasonal main stem thermal conditions upstream, while in the montane study watershed (elevation and gradient mid-way between the lowland watershed) upstream conditions were less consistent and thus less suitable for thermal characterization by a lower-reach site alone. Together, this work highlights examples of the importance of accounting for habitat diversity when assessing climate change impacts to salmon bearing streams.

Ongoing 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

Broad Whitefish (*Coregonus nasus*) were caught and implanted with a radio transmitter to help determine spawning habitat in the Colville River.

Subsistence fisheries provide an important food resource for communities on Alaska's Arctic Coastal Plain. Despite the importance of the Colville River's summer run of Broad Whitefish (*Coregonus nasus*) to Native communities and the potential habitat impacts associated with climate change and petroleum development, the basic ecology of this migratory species remains poorly understood. The objectives of this ongoing study were to characterize and assess spawning habitat potential, investigate the foraging niches utilized, describe migration patterns and life histories used across individual's lives, and conceptualize how ongoing climate change will likely influence Broad Whitefish behavior, phenology, and their habitats. We are studying adult migratory fish in summer riverine habitats, using radio telemetry and intrinsic potential models to estimate spawning habitat, analyzing stable isotopes in body tissue to understand habitat and food resource use, and using otolith microchemistry to reconstruct migration patterns and determine life history type. Telemetry relocations and intrinsic potential models suggest that the lower and middle mainstem Colville River offers high-quality habitat. Stable isotope analysis revealed a large range of δ13C and δ15N values across tissue types and among individuals suggesting that Broad Whitefish utilized several different foraging niches, utilizing varying degrees of marine and land-based (i.e., freshwater and terrestrial) food sources across the summer period. Strontium isotopes revealed six main life histories, including three anadromous types, one semi-anadromous type, and two freshwater types, suggesting greater complexity in life-history types. Findings from this research will be coupled with a conceptual model to provide insights into potential effects from climate and landscape change to conserve better this valuable subsistence resource on the Arctic Coastal Plain.

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

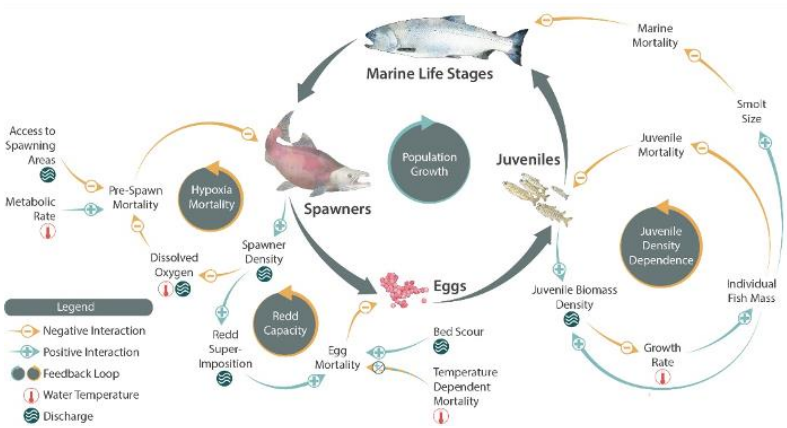
Student Investigator: Olivia Edwards, MS Fisheries
Advisor: Jeff Falke
Funding Agency: Region 3 ADF&G (Sport Fish Base)
In-Kind Support: ADF&G

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: US 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 require rigorous predictions of how salmon populations will respond to cumulative changes in the freshwater environment. We have created a life cycle model (manuscript in preparation) 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). Based in part on our findings from previous work categorizing streamflow patterns for over 4,000 watersheds in coastal southern Alaska, the life cycle model combines water temperature, streamflow, and salmon life history parameters for streams driven by glacier, snow, and rain water sources. The model reveals that salmon in these three stream types are likely to 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: Department of Defense (DoD) Strategic Environmental Research and Development Program (RWO 227)
In-Kind Support: ADF&G


Elizabeth Hinkle holds an Arctic Grayling caught via angling in 2020.

Climate change is expected to increase wildfire frequency and duration in boreal forest ecosystems. While fire may benefit stream organisms by stimulating greater food resources, complex ecological interactions make it challenging to predict how fire ultimately shapes the diversity of macroinvertebrate and fish communities. Interactions among fire, climate, aquatic communities, and watershed processes are poorly understood, yet critical for conservation and management of boreal aquatic habitats. Our objective is to characterize differences in physical and biological mechanisms driving boreal stream dynamics across a gradient of fire disturbance. In summer 2020, to determine physiological and movement responses of fish to wildfire, we sampled Arctic Grayling (n=31) from four Chena River tributaries within a mosaic of recent wildfire activity (2006-2019). During site visits, we recorded fish length, weight, sex, maturity status, lipid content, and nonlethally collected fin ray clips and caudal fin tissue. During later visits in the season (mid-July to early September), as Arctic Grayling began preparing gametes for next year's spawn, we used endoscopy to determined maturity status and sex of individual fish (n=19), and validated the technique on 50 sacrificed fish with 96% accuracy. To determine movement patterns of Arctic Grayling in response to fire, we collected Slimy Sculpin otoliths (n=58) from 23 sites in the Chena River basin, encompassing our Arctic Grayling sampling sites. We will laser ablate the Slimy Sculpin otoliths to determine strontium values throughout the Basin, and these values will be used to make an isoscape (i.e., a map). We will then laser ablate Arctic Grayling fin-ray clips to determine the location of individual fishes throughout their lifetime and during wildfire events. These values will be compared to the isoscape and wildfire data to determine fish movement in response to fire. The Arctic Grayling caudal fin clips will be used to determine genetic relatedness among populations that have and have not experienced fire, to understand relatedness as a function of fire-induced movement. Our research will provide natural resource managers with a better understanding of how wildfires impact boreal stream fish and how aquatic communities may change in response to various wildfire response strategies.

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

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

Erick Dela Rosa and Jeremiah Stone performing a benchmark survey at Shaw Creek.

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

Post-doctoral Researcher: Stephen Klobucar (IAB)
Advisor: Jeff Falke
Funding Agency: U.S. Fish and Wildlife Service (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: ADF&G

Taylor Cubbage collects physiological metrics from a pike collected in the invasive range.

The spread of invasive species has caused drastic ecological and economic consequences on a global scale, including the expansion of northern pike (*Esox lucius*) throughout southcentral Alaska where they threaten native salmonid fisheries and the communities that rely on them. Pike are native north and west of the Alaska Mountain Range and coexist with salmonids, therefore comparing physiological and ecological traits between invasive and native pike may help to explain the deleterious impacts of invasive populations. Although current management of pike in Alaska (e.g., rotenone and gillnetting) is effective in isolated waterbodies, alternatives are needed in the greater Cook Inlet region where reinvasion risk following eradication is high due to interconnected lotic habitats. A proposed method to prevent pike reestablishment following eradication is fish barrier construction; however, to confidently design and install such barriers, it is essential to quantify the maximum leaping capabilities of pike. We propose to 1) compare physiological metrics between invasive and native pike populations in Alaska to better understand mechanisms of invasion success, and 2) determine, across a range of water temperatures and pike sizes, height and pool depth combinations of vertical drop structures that prevent pike ascent, using an adjustable waterfall apparatus. Barrier specifications will be provided to interested agencies in Alaska and elsewhere pike are invasive. Incorporating the physiological limitations of pike into management tactics to prevent their further spread and inhibit reintroduction to restored waters will ultimately reduce the impacts of pike on native species.

Assessing Avian Predation on Chinook Salmon in the Chena and Salcha Rivers

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

Common mergansers swimming (photo credit: Roland Zh).

Recent declines of Yukon River Chinook salmon populations have raised interest in factors that could inhibit their recovery, including predation. Common and red-breasted mergansers are potentially important salmon predators that may be increasing in density, based on increasing counts in aerial surveys throughout Alaska. Yet, little is known about the density, diet, or predatory impacts of these species on salmon in the Yukon River Basin. This study will help resource managers to evaluate whether predation by mergansers, at their current densities, could potentially influence Chinook salmon populations. The objectives of this study are to 1) estimate merganser densities on two major Chinook salmon-producing tributaries; 2) characterize the diet composition of mergansers; and 3) estimate the population-level consumption rates of mergansers in the study area, to assess their potential impacts on Chinook salmon populations. During summer 2021, we will estimate the densities of mergansers and other fish-eating birds using boat-based visual surveys in the Chena and Salcha rivers. Next, we will determine their diet composition using genetic analysis of feces and stomach contents. Finally, using this information, we will estimate potential predation rates of the merganser population on juvenile Chinook salmon using a bioenergetics model. In preparation for the field season, we have assembled a library of species-specific genetic assays for all fish species present in our study areas, and the lead technician has learned the necessary laboratory techniques that will be required for this study. Understanding whether mergansers consume enough juvenile Chinook salmon to potentially influence population recovery has important management implications. This information will allow managers to evaluate the potential benefits of monitoring or managing merganser densities in important juvenile Chinook salmon rearing habitats throughout the Yukon River Basin.

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

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. Analyses of natal origin have yet to be completed. 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 will be 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: Field sampling provided by USGS

Juvenile salmon die at high rates while migrating through the Sacramento-San Joaquin Delta, most likely by predation. Predation studies typically use visual inspection of predator stomachs, which requires specialized expertise and is subject to bias. We take a validated DNA-based approach to quantify the number of individual Chinook salmon found in predator stomachs. This method can be used by biologists to rapidly quantify predation rates of juvenile salmon during critical periods. The objective is to test a DNA-mixture approach to quantifying the number of Chinook salmon individuals found in the stomachs of fish predators sampled in the Sacramento Delta. Stomach contents have been sampled from predatory fish captured in the Sacramento delta, DNA will be extracted from these contents, and these pooled samples will be genotyped at several hundred Chinook salmon-specific genetic markers. Genotypic information will be used to estimate the number of individuals contributing to each pooled stomach content sample. We tested this approach using known Chinook salmon DNA mixtures and developed a bioinformatic pipeline to calculate the maximum likelihood estimate of number of contributors. The pipeline works well and we are beginning to test this approach in real stomach samples. This method can be used to monitor predation of juvenile salmon in the Sacramento Delta, allowing assessment of management interventions including habitat restoration, hatchery release practices, and predator control.

Development of eDNA Metabarcoding Methods for Freshwater Mussels

Student Investigator: Willie Dokai, CFOS
Advisor: Megan McPhee
Funding Agency: USFWS Region 2(RWO 237)
In-Kind Support: Field sampling provided by 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 colony 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 once PCRs have been optimized libraries will be prepared and sequenced, and bioinformatics analyses will be used to determine the presence/absence of unionid mussel DNA within samples. Results are expected to include a validated eDNA metabarcoding protocol as well as the degree to which the eDNA protocol matches presence/absence data from previous field surveys. The metabarcoding tools developed, validated, and tested during this study will provide an efficient and safe monitoring method for unionid mussels within the Great Lakes region.

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
Co-Advisors: Roger Ruess and Diana Wolf
Funding Agency: USGS Changing Arctic Ecosystem Initiative (RWO 217)

Matt Kynoch installs a radio transmitter on a lynx.

The Canada lynx (*Lynx canadensis*) is an iconic furbearer species of the north and Alaska, yet the spatial ecology and behavior of lynx in the northwest boreal forest is largely unknown and diel activity patterns of the species as a whole are not well documented. Furthermore, lynx activity has only been investigated near the southern extent of their range, where daylength and other environmental characteristics can be drastically different than populations at their northernmost extent. 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. The objectives of this work are to determine, 1) if Canada lynx at arctic latitudes exhibit changes in diel activity patterns throughout the year and if activity patterns are variable between individuals, and 2) 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. Analysis is still ongoing, but preliminary results show that lynx in the Arctic do change their patterns of diel activity seasonally. Though some individuals phase shift between crepuscular and nocturnal activity patterns at different times of year, results at this time show that most individuals maintain a crepuscular activity schedule with the timing of peaks of activity shifting throughout the year closely following rapidly changing light conditions in the region. The results of analysis will provide a more complete picture of species biology to inform future management decisions. Also, the results will demonstrate the efficacy of triaxial accelerometers as a research and management tool.

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

Student Investigators: Graham Frye, PhD Biological Sciences, Joe Eisaguirre, Postdoctoral Fellow, Sebastian Zavoico, MS Wildlife Biology
Advisor: Mark Lindberg
Funding Agency: USFWS Region 7 (RWO 232)


Moose in interior Alaska.

The goal of this project is to analyze existing long-term moose population datasets in an Integrated Population Model (IPM) framework to assess the role of individual demographic rates on population trajectory and identify the effects of harvest over time in relation to these rates. Successful completion of this project will provide insight into the effects of harvest on moose population dynamics under a range of densities, which may have broad and important implications for moose management in Alaska. We will develop and analyze a moose population IPM for the target population, and document and clarify the development stages, data needs and information benefits (including estimation of parameters not directly observed in the data collection processes and potential improved precision for key parameters relative to 'standard' separate data stream analyses). We are using long-term moose data sets (1994-2019) from Togiak NWR and GMU 21D to develop the IPM. Initial results indicate that data are likely adequate for development of an IPM. However, as the project evolved it became apparent that the suite of questions would be best addressed by additional field data, notably on habitat conditions. Therefore, the project will continue beyond the postdoc who was doing most of the model development into a MS project under the supervision of Shawn Crimmins. Results of this work will be used for harvest and habitat management of moose.

Explorations of Polar Bear Behavior and Tourism in Kaktovik, Alaska

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

Polar bear presence along the northern coast of Alaska is increasing as a result of climate-driven habitat changes. The annual influx of polar bears to communities on the North Slope has created opportunities for economic development through tourism, and challenges for the host communities. Specifically, in the last decade, a boat-based polar bear viewing industry was established in the Inupiaq community of Kaktovik. As it currently stands, the behavioral and cultural impacts of the tourism industry have yet to be quantified. Although the tourism industry in Kaktovik is currently regulated by the US Fish and Wildlife Service, an official tourism management plan has yet to be finalized and implemented. Our objective is to quantify and identify potential behavioral impacts on polar bears, as well as document community perspectives, in order to develop a comprehensive, defensible tourism management plant. In August-October of 2021, we will travel to Kaktovik to 1) collect behavioral observation data and 2) host focus group discussions to identify community concerns. Our results will inform the development of the first tourism management plan for the community of Kaktovik. This plan will not only serve Kaktovik, but also create a framework for timely, effective, and adaptive tourism management plans across the Arctic.

Completed Ecological Studies

Science, Perception and Scale: An Interdisciplinary Analysis of Environmental Change and Community Adaptive Capacity.

Student Investigator: Jess Grunblatt, PhD Interdisciplinary Studies
Advisor: Mark Wipfli
Funding Agencies: EPSCoR, State of Alaska
In-Kind Support: Alaska Center for Conservation Science, University of Alaska Anchorage

Note: Jess Grunblatt graduated from the University of Alaska Fairbanks in May 2020. His dissertation abstract follows:

The discrepancy between science-based assessments of climate change and public acknowledgement of climate change has been extensively documented at a national level. The relationship of science-based assessments and public awareness of environmental change at the local community level is less studied. An understanding of how science-based information informs local perception is important to ensure that science communication effectively supports community decision making.

This dissertation explores the gap between science-based assessments and local perception of environmental change within a framework of adaptive capacity. The research is divided into three interrelated studies that provide: 1) an assessment of community perception of local environmental change, 2) a local study that illustrates science-based assessment and reporting, and 3) an evaluation of the role news media play in communicating science to the public.

The first study implemented a survey of residents on Alaska's Kenai Peninsula to evaluate individual perception of environmental change as well as attitudes regarding climate change and natural resource management. Differences in perception of local environmental change were identified among respondents as well as shared perceptions. The use of property regulation to protect the Kenai River was identified as a divisive issue; however, there was a shared concern regarding the condition of local salmon populations. A second science-based ecological study was developed that examined those issues and linked conservation of riparian vegetation to juvenile salmon rearing habitat. This study examined the diet of stream-rearing juvenile Coho Salmon (*Oncorhynchus kisutch)* and determined that the proportion of invertebrates which enter the stream from riparian habitats varied based on vegetation type for three streams in the Kenai watershed. The third study investigated how news media play a role in the interpretation of technical, science-based reporting for the public. It demonstrated that local news media provide a unique opportunity to promote communication of science-based information to their audiences by providing content that is familiar and relevant, offering a variety of topical framings, developing authoritative or trusted voices, and providing frequent exposure to content.

Ongoing Ecological Studies

Genetic and Physiological Variation among Arctic and Subarctic Carex

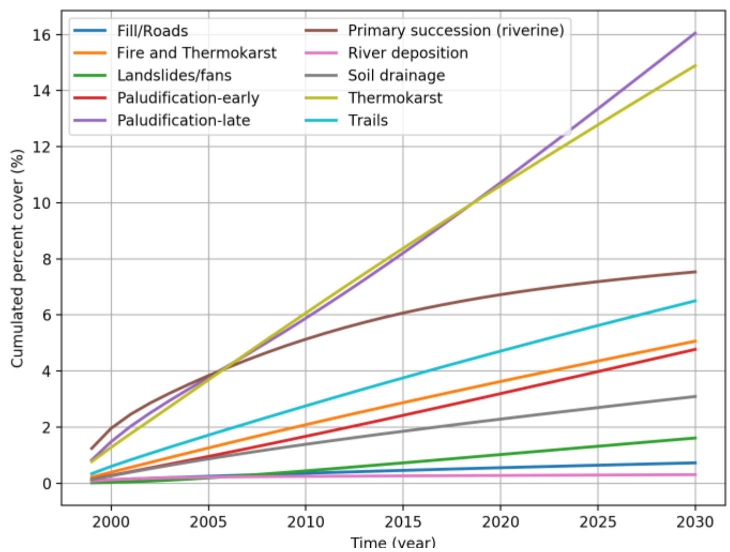
Student Investigator: Iris Cato, MS Biological Sciences
Co-Advisors: Roger Ruess and Diana Wolf
Funding Agency: USGS Changing Arctic Ecosystem Initiative (RWO 217)

Carex subspathacea short (left) and tall (right) growth form on the Yukon-Kuskokwim Delta, Alaska.

Carex subspathacea (SUB) is a short-statured sedge and a preferred food source for Brant geese along Alaska's coast. In the absence of grazing, SUB grows taller and resembles a closely-related species, Carex ramenskii (RAM). It was unclear whether these sedges are actually different species or different growth forms of the same species. On the Yukon-Kuskokwim Delta, Alaska, (YKD), there appears to be a positive feedback loop, where increases in goose populations cause increased grazing and increased lawns of short, palatable sedges. In the last century, extensive grazing lawns of YKD SUB have converted to a tall, less palatable form due to reduced grazing. This may subsequently cause further reductions in YKD Brant goose populations. However, on the North Slope (NS), NS SUB does not need to be grazed to maintain its short stature. We wanted to learn more about the feedback loop between Brant geese and the sedges they graze by determining whether there are genetic and physiological differences between tall and short morphs on the YKD and NS. The objectives were to determine the genetic and physiological differences among SUB and RAM from Arctic and subarctic Alaska. Reciprocal common gardens in Arctic and subarctic Alaska were used to test for physiological differences. Next Generation Sequencing was used to quantify genetic differences between SUB and RAM. Genetic research has recently shown that the sedges on the YKD and NS are not two separate species, but actually one species (C. subspathacea) exhibiting two growth forms (short and tall). Data from the common gardens suggest substantially different effects of climate change on these two grazing systems and demonstrate that the conversion of short to tall may not occur under arctic conditions, or at the very least the conversion rate increases with temperature. This implies that the feedback relationship with grazing will also be temperature dependent. Under warming conditions more frequent grazing may be required to prevent this conversion from occurring. Understanding the differences between these grazing systems is critical for predicting population dynamics of Department of Interior trust species (migratory geese) in the regions were these sedges are prevalent.

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)



Cumulated impact of various drivers of land cover change across the YFNWR, from 1999 to 2030 (at a 30-m resolution).

In addition to widespread active layer deepening, ice rich permafrost can thaw laterally, often triggering abrupt thermokarst and subsidence of the ground surface. In boreal forest, thermokarst can lead to the development of collapse scar bogs, fens, or lakes inducing large changes in the hydrological regimes. With projected climate warming and change in precipitation regime, thermokarst disturbance may increase in frequency. The geomorphological changes associated with thermokarst disturbance will have local and regional impacts on a number of ecosystem services such as carbon dynamic, wildlife habitat, water availability, wildfire risks, and infrastructure development. Developing a modeling framework to predict thermokarst disturbances and their ecological consequences will help guide management decisions to integrate land cover change and hydrological changes across the landscape. The goal of this project is to build upon a modeling framework to represent the key-processes that will help improve our understanding of the impacts of thermokarst disturbance on ecosystem structure and function at the regional scale. We developed a state and transition model that represents land cover change associated with thermokarst, related paludification, drainage, wildfire, and succession (Figure 1). The model is coded in python and has been applied across the Yukon Flats NWR at a 30-m resolution. The Alaska Vegetation and Wetland composite map has been used for model initialization. We conducted simulations with constant historical rates of land cover change. We also used results from a regional analysis of active layer depth records to include the effect of climate on thermokarst probability to assess the effect of climate warming and change in precipitation regimes on land cover dynamics. Finally, we conducted simulations with and without wildfire occurrence. These simulations are being analyzed to assess the relative impact of climate change and disturbances on land cover dynamic in the YFNWR. The results of this modeling study will be useful in guiding the integration of future land cover and hydrological changes across the landscape in critical areas.

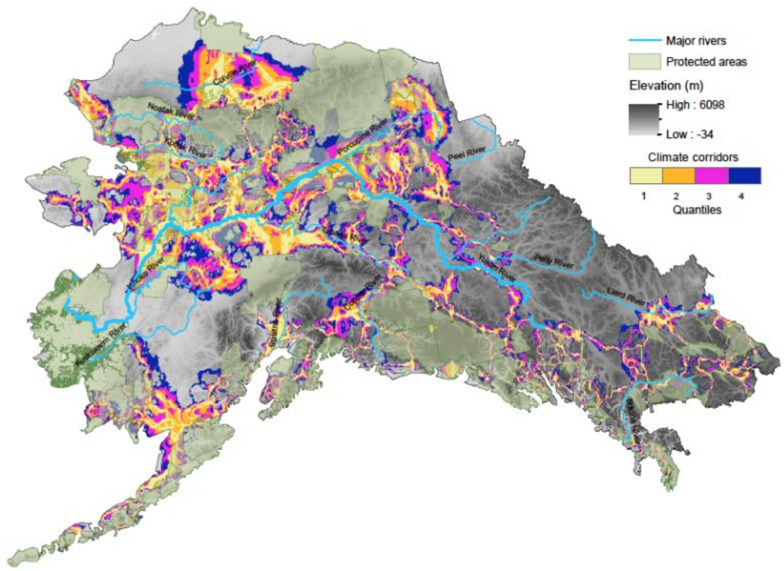
Application of an Integrated Ecosystem Model: A Multi-Institutional and Multi-Disciplinary Effort to Understand Potential Landscape, Habitat, and Ecosystem Change in Alaska and Northwest Canada

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)**

Natural resource managers and decision makers require an improved understanding of the potential response of ecosystems due to a changing climate in Alaska and northwest Canada. We created a modeling framework – the Integrated Ecosystem Model (IEM) for Alaska and Northwest Canada to meet this need. The IEM integrates the driving components for, and the interactions among, disturbance regimes, permafrost dynamics, hydrology, and vegetation succession and to provide an improved understanding of the potential response of ecosystems to a changing climate. Our study methods include: (1) coupling stand-alone models for specific regional areas of interest, and for the full IEM domain when computationally feasible, (2) developing input data sets for the study region, (3) providing model result summaries through an online data portal, and (4) phasing in additional capabilities as necessary. In 2020, we selected four test areas of ~2,500 km^2 spread across the tundra region of Alaska (Utqiaġvik, Toolik Lake, Seward Peninsula, and YKD) and conducted model simulations of ecosystem dynamics using the latest emissions and climate projections (RCP 8.5, CMIP5 respectively). The four test areas were selected for (1) the availability of field observations used for model testing, and (2) representativeness of the range of eco-climatic conditions of Northern Alaska. The projections produced by the IEM are facilitating the integration of how landscapes may respond to climate change into resource management decisions.

Connectivity for Landscape Conservation Design and Adaptation Planning

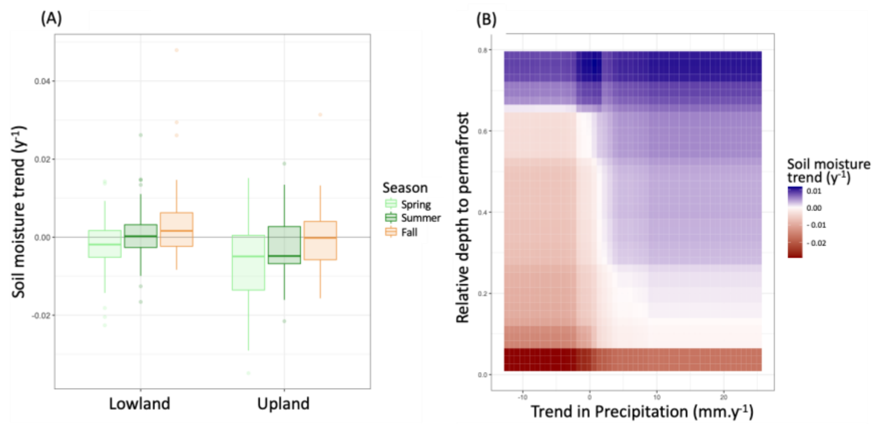
Post-doctoral Researcher: Charlotte Gabrielsen (IAB)
Advisor: Brad Griffith
Funding Agency: U.S. Fish and Wildlife Service Region 7 (RWO 226)



Climate change is projected to substantially alter ecosystem composition, structure, and function. The Arctic is warming more than twice as rapidly as the global average and the increase is accelerating, resulting in widespread ecological impacts. Northern regions, such as Alaska and northwestern Canada, present an ideal setting for landscape conservation planning. Given the region's high percentage of protected areas, highly intact landscapes, and low levels of anthropogenic disturbance, there is a unique opportunity to implement strategic landscape conservation design to facilitate projected ecosystem shifts and species movements. The primary objective of this study is to identify corridors among protected areas in Alaska and Northwest Canada that promote long-term connectivity under projected climate change. Using a cost-distance modeling approach, we characterized climate connectivity by identifying corridors that followed climatic gradients and avoided areas with high anthropogenic disturbance. In addition to identifying corridors under historical climatic conditions, we modeled corridors under a range of future projected climate change models, scenarios, and time periods. We characterized shifts between corridors identified under historical and projected climate to provide a spatially explicit assessment of changes in corridor location and area over time. Our findings demonstrate the utility of climate connectivity corridors for increasing landscape connectivity in the face of climate change, emphasize the alignment of climate and riparian corridors, and underscore the need to consider the implications of future shifts of climate corridors. Moreover, our findings demonstrate that identifying climate connectivity corridors provides a useful framework to prioritize areas that increase landscape connectivity in the face of climate change. Given anticipated development throughout the study area, protecting connectivity while habitat is still intact can advance adaptive management and planning objectives. Furthermore, by identifying areas where climate corridors may be gained under future change, the approach can aid in identifying conservation priorities falling between existing protected areas.

Wetland Carbon Assessment for Alaska

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



(a) Effect of drainage condition on seasonal soil moisture trends, (b) Heatmap representing the influence of precipitation on soil moisture trends as a function of the relative depth to the permafrost table. Soil moisture trends were estimated for 97 monitoring sites across Alaska with more than 8-years of in-situ observations. Soil moisture trends were analyzed using a boosted regression tree procedure.

Wetlands in Alaska store significant amounts of carbon in the soil and can serve as substantial carbon sinks in the global carbon budget. However, these carbon-rich ecosystems can also be hot spots of methane emissions. They are also vulnerable to changes in climate and disturbances such as wildfire and permafrost abrupt thaw. To improve understanding of carbon stocks and greenhouse gas fluxes, the Land Carbon program established the USGS Wetland Carbon Working Group to develop a methodology to conduct a national assessment of coastal and inland wetlands. The objectives of the assessment are to 1) assess baseline carbon sequestration and greenhouse gas fluxes in wetlands in Alaska, and 2) project scenarios of climate and land cover change on carbon sequestration and greenhouse gas fluxes in wetlands. In 2020, we have integrated methane dynamics in our terrestrial ecosystem model (TEM). We are calibrating the new version of the model based on field observations collected in boreal and arctic wetlands and uplands. We also finalized a regional analysis of soil moisture trends across Alaska that shows the importance of drainage conditions and permafrost dynamic on hydrological dynamics across boreal and arctic ecosystems in Alaska (Figure 2). This synthesis will be used to improve the capacity of the TEM to represent linkages between permafrost, hydrological dynamics, and ecosystem carbon balance. We started a synthesis of dissolved organic carbon observations across Alaska to develop a predictive model quantifying C transfer from terrestrial wetlands to aquatic ecosystems. This predictive model will be integrated in the TEM to complete ecosystem C assessment in wetlands. This work supports the goals of Mission Area 1 of the Department of Interior Strategic Plan to promote the conservation of land and water.

List of Abbreviations

ADF&G	Alaska Department of Fish and Game
AKCFWRU	Alaska Cooperative Fish and Wildlife Research Unit
CFOS	College of Fisheries and Ocean Sciences, UAF
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 Center
IAB	Institute of Arctic Biology, UAF
IEM	Integrated Ecosystem Model
LWD	Large, woody debris
NASA	US 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	US Bureau of Land Management
USFWS	US Fish and Wildlife Service
USGS	US Geological Survey
YKD	Yukon-Kuskokwim Delta, Alaska