Alaska Cooperative Fish and Wildlife Research Unit

Annual Research Report—2019

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Not for Publication: Because this report is one of progress, the data presented are often incomplete, and the conclusions reached may not be final.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 (hired October 2019)
- Mark Wipfli: Assistant Unit Leader-Fisheries

University Staff

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

Unit Students and Post-Doctoral Researchers

Current

- Donald Arthur, MS Fisheries Candidate (Falke)
- Olivia Edwards, MS Fisheries Candidate (Falke)
- Dan Govoni, PhD Biological Sciences Candidate (Wipfli)
- Jess Grunblatt, PhD Interdisciplinary Studies Candidate (Wipfli and Adams)
- Elizabeth Hinkle, PhD Fisheries Student (Falke)
- Jason Leppi, PhD Fisheries Candidate (Wipfli)
- Benjamin Meyer, MS Fisheries Candidate (Wipfli)
- Christopher Sergeant, PhD Fisheries Student (Falke)

Post-Doctoral Researchers

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

Graduated in CY 2018

- Joelle Hepler, MS Wildlife Biology and Conservation (Griffith and Falke)
- Philip Joy, PhD Fisheries (Wipfli)
- Kelly Overduijn, MS Wildlife Biology and Conservation Candidate (Powell)

University Cooperators

- Peter Bieniek, IARC
- Robert Bolton, IARC
- Amy Breen, IARC
- Eugénie Euskirchen, DBW, IAB
- Hélène Genet, IAB
- Brad Griffith, IAB
- Larry Hinzman, Vice Chancellor for Research (UAF)
- Tuula Hollmén, CFOS, IMS, Alaska SeaLife Center
- Knut Kielland, DBW, IAB

- 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 and Post-Doctoral Researchers

Current

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

Affiliated Post-Doctoral Researchers

- Heather Greaves (Breen)

Cooperators

- Brian Barnes–Director, Institute of Arctic Biology, University of Alaska Fairbanks
- 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 2019. The Unit engages in research on living natural resources for a variety of State and Federal agencies. As an unbiased research organization, the Unit provides information requested and funded by these agencies. When studies are completed, the agencies use the information to assist in their natural resource management efforts. Most of the research is conducted by graduate students, many of whom go on to work for the agencies upon graduation.

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

Statement of Direction

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

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

Unit Cost-Benefit Statements

In-Kind Support

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

Benefits

Students Graduated: 3 (advised by Unit faculty)
Presentations: 17
Scientific and Technical Publications: 8

Courses Taught

Mark Wipfli: Aquatic Entomology (3 credits, Fall 2019)

Papers Presented

Arthur, D., Falke, J., Beaudreau, A., Sutton, T., and Blain-Roth, B. October 2019. Reproductive life history of Yelloweye Rockfish (Sebastes ruberrimus) in Prince William Sound and the northern Gulf of Alaska. 149th Annual Meeting of the American Fisheries Society, Reno, Nevada, 29 September - 3 October, 2019. (Contributed Oral)

Arthur, D., Falke, J., Beaudreau, A., Sutton, T., and Blain-Roth, B. March 2019. Reproductive life history and potential modeling for Yelloweye Rockfish (Sebastes ruberrimus) in Prince William Sound and the northern Gulf of Alaska. Alaska Chapter American Fisheries Society Annual Meeting, Sitka, Alaska, 19-22 March, 2019. (Contributed Oral)

Edwards, O., Falke, J., Savereide, J., and A. Seitz. March 2019. Juvenile Chinook Salmon (Oncorhynchus tshawytscha) movement, overwinter survival, and outmigration timing in the Chena River, Alaska. Alaska Chapter American Fisheries Society Annual Meeting, Sitka, Alaska, 19-22 March, 2019. (Contributed Poster)

Edwards, O.N., J.A. Falke, J.W. Savereide, and A.C. Seitz. October 2019. Juvenile Chinook Salmon (Oncorhynchus tshawytscha) movement, overwinter survival, and outmigration timing in the Chena River, Alaska. American Fisheries Society and The Wildlife Society Joint Annual Conference, Reno, Nevada, 29 September to 3 October, 2019. (Contributed Oral)

Falke, J.A., Cathcart, C.N., Fox, J., Henzsey, R., and K. Lininger. October 2019. Longitudinal patterns of logjams and occupancy by juvenile Chinook Salmon along a sub-Arctic boreal riverscape. American Fisheries Society Annual Meeting, Reno, Nevada, 29 September – 3 October, 2019. (Contributed Oral)

Hepler, J., B. Griffith, J. Falke, J. Roach, J. Caikoski, and M. Cameron. October 2019. Validating a GPS collar-based method to estimate calving locations and parturition rates in the Porcupine caribou herd. American Fisheries Society and The Wildlife Society Joint Annual Conference, Reno, Nevada, 29 September - 3 October, 2019. (Contributed Oral)

Hinkle E., and J. Falke. March 2019. The effects of fire disturbance on stream fish community structure, site fidelity, life history, and genetic relatedness in boreal stream ecosystems.

Alaska Chapter American Fisheries Society Annual Meeting, Sitka, Alaska, 19-21 March, 2019. (Contributed Poster)

Hinkle, E.G., and J.A. Falke. October 2019. Aquatic food web and community response to wildfire in interior Alaska boreal streams. American Fisheries Society and The Wildlife Society Joint Annual Conference, Reno, Nevada, 29 September to 3 October, 2019. (Invited Oral)

Klobucar, D.D., and J.A. Falke. March 2019. Gaging the importance: characterizing hydrologic regimes of headwater streams in changing boreal ecosystems. Alaska Chapter of the American Fisheries Society Annual Meeting, Sitka, Alaska, 19 – 21 March, 2019. (Contributed Poster)

Klobucar, D.D., and J.A. Falke. October 2019. Gaging the importance: hydrologic regime characterization for wildfire- impacted streams in changing boreal ecosystems. American Fisheries Society Annual Meeting, Reno, Nevada, 29 September – 3 October, 2019. (Invited Oral)

Klobucar, S., Falke, J., Rupp, S., Bieniek, P., Genet, H., Lindgren, M., Hinkle, E., and D. Klobucar. December 2019. Aquatic ecosystem vulnerability to fire and climate change in Alaskan boreal forests. Strategic Environmental Research and Development Program Annual Symposium. 3-5 December, 2019. Washington, D.C. (Invited Poster)

Klobucar, S.L., Falke, J.A., Rupp, T.S., Bieniek, P.A., Genet, H., and M.A. Lindgren. October 2019. Fo'real changes in boreal streams: a multifaceted modeling approach to predict the effects of forest fire on aquatic habitat vulnerability in interior Alaska. 149th American Fisheries Society Annual Meeting, Reno, Nevada, 29 September – 3 October, 2019. (Invited Oral)

Klobucar, S.L., Falke, J.A., Rupp, T.S., Bieniek, P.A., Genet, H., and M.A. Lindgren. March 2019. Integrating at the interface(s): modeling the effects of fire and climate change to support management and conservation of fish habitat and populations in Alaskan boreal forests. Alaska Chapter of the American Fisheries Society Annual Meeting, Sitka, Alaska, 19 – 21 March, 2019. (Contributed Poster)

Leppi, JC, DJ Rinella, MS Wipfli, MS Whitman. March 2019. Diverse foraging niches and habitat use by Broad Whitefish (Coregonus nasus) in Arctic Alaska. Alaska Chapter of the American Fisheries Society Annual Meeting, Sitka, Alaska, 19 – 21 March, 2019. (Contributed Poster)

Meyer, B, M Wipfli, D Rinella, E Schoen, J Falke. November 2019. Climate warming effects on juvenile Chinook and Coho salmon growth are modulated by glacial-coverage in sub-basins of the Kenai River watershed. Mat-Su Salmon Symposium. Nov 2019, Palmer, AK. (Contributed Oral)

Overduijn, K. S., C. M. Handel, and A. N. Powell. March 2019. Sympatric plovers partition nesting habitat with minimal effect on nest survival. 18th Alaska Bird Conference, Fairbanks, AK, 4 March – 18 March 2019. (Contributed Oral)

Sergeant, C. J., J. A. Falke, R. L. Crumley, and J. R. Bellmore. March 2019. Fuzzy streamflow classification of Gulf of Alaska coastal watersheds to support aquatic research and monitoring. Alaska Chapter American Fisheries Society Annual Meeting, Sitka, Alaska, 19-21 March, 2019. (Contributed Oral)

Scientific Publications

Falke, J.A., Bailey, L.T., Fraley, K.M., Lunde, M.J., and A.D. Gryska. 2019. Energetic status and bioelectrical impedance modeling of Arctic grayling *Thymallus arcticus* in interior Alaska rivers. Environmental Biology of Fishes 102:1337-1349. https://doi.org/10.1007/s10641-019-00910-6.

Falke, J.A., Huntsman, B.M., and E. R. Schoen. 2019. Climatic variation drives growth potential of juvenile Chinook Salmon along a sub-Arctic boreal riverscape. Pages 57-82 in R. Hughes and D. Infante, editors. Advances in understanding landscape influences on freshwater habitats and biological assemblages. American Fisheries Society Symposium 90, Bethesda, MD.

Heim, K.C., McMahon, T.E., Calle, L., Wipfli, M.S., and J.A. Falke. 2019. Phenology of water as a life-history filter for fishes in temporary aquatic habitats. Fish and Fisheries 20:802-816. https://doi.org/10.1111/faf.12386.

Heim, K.C., Arp, C.D., Whitman, M.S., and M.S. Wipfli. 2019. The complimentary role of lentic and lotic habitats for Arctic Grayling in a complex stream-lake network in Arctic Alaska. Ecology of Freshwater Fish. 28: 209-221. https://doi.org/10.1111/eff.12444.

Huntsman, B.M., and J.A. Falke. 2019. Main stem and off-channel habitat use by juvenile Chinook salmon in a sub-Arctic riverscape. Freshwater Biology 64: 433-446. https://doi.org//10.1111/fwb.13232.

IPCC, 2019: Chapter 3: Arctic Regions. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate [H.-O. Pörtner, D.C. Roberts, V. Masson-Delmotte, P. Zhai, M. Tignor, E. Poloczanska, K. Mintenbeck, M. Nicolai, A. Okem, J. Petzold, B. Rama, N. Weyer (eds.)]. 173 pages.

Laske, S. M., A.E. Rosenberger, M.S. Wipfli, and C.E. Zimmerman. 2019. Surface water connectivity controls fish food web structure and complexity across local-and meta-food webs in Arctic Coastal Plain lakes. Food Webs e00123. https://doi.org/10.1016/j.fooweb.2019.e00123.

Sparks, M.M., Falke, J.A., Westley, P.A.H., Adkison, M.D., Bartz, K., Quinn, T.P., Schindler, D.E., and D. Young. 2019. Influences of spawning timing, water temperature, and climatic warming on early life history phenology in western Alaska sockeye salmon. Canadian Journal of Fisheries and Aquatic Sciences. 76:123-135. https://dx.doi.org/10.1139/cjfas-2017-0468.

Theses and Dissertations of Unit-Sponsored Graduate Students

Hepler, J.D. 2019. Validating a GPS collar-based method to estimate parturition events and calving locations for two barren-ground caribou herds. MS Thesis. University of Alaska Fairbanks. 107 pp.

Joy, P.J. 2019. The response of juvenile coho and Chinook salmon stocks to salmon spawner abundance: marine nutrients as drivers of productivity. PhD Dissertation. University of Alaska Fairbanks. 186 pp.

Overdjuin, K.S. 2019. Reproductive success of American and Pacific golden-plovers (*Pluvialis dominica* and *P. fulva*) in a changing climate. MS Thesis. University of Alaska Fairbanks. 86 pp.

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

Completed Aquatic Studies

Marine-Derived Nutrient Effects on Chinook and Coho Salmon Productivity

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

Note: Philip Joy graduated from the University of Alaska Fairbanks in December 2019. His thesis abstract follows:

Resource subsidies from spawning Pacific salmon (Oncorhynchus spp.) in the form of marine-derived nutrients (MDN) benefit juvenile salmonids while they rear in fresh water, but it remains unclear if the abundance of spawners in a watershed affects the productivity of salmon stocks that rear in those riverine systems. This dissertation aimed to provide a better understanding of these dynamics by evaluating whether the response of juvenile salmon to MDN is sufficient to enhance overall stock productivity. In Chapter 1, I examined correlative relationships in the abundance of Pink (O. gorbuscha) and Coho (O. kisutch) salmon and simulated spawner-recruit dynamics to determine if those correlations were produced by a Coho Salmon response to marine subsidies from Pink Salmon, a shared response to marine conditions, and/or autocorrelations in the returns of both species. Results demonstrated that observed correlative patterns most closely resembled simulated freshwater effects, providing evidence that marine subsidies from Pink Salmon influence Coho Salmon productivity. In Chapter 2, I examined the relationship between spawner abundance and MDN assimilation by juvenile Coho and Chinook (O. tshawytscha) salmon in the Unalakleet River watershed. Stable isotope analysis demonstrated that after salmon spawned, MDN assimilation by juvenile salmon in the fall was a function of adult Pink and Chinook salmon spawner abundance, regardless of the habitat occupied by rearing juveniles. However, by the following summer, high retention of MDN in complex habitat masked seasonality of MDN assimilation in sloughs and river sections with abundant lentic-lotic exchanges. As such, MDN assimilation in the summer (prior to arrival of spawners) bore only a faint relationship to spawner abundance and distribution from the previous year. In chapter 3 I examined the relationship between MDN assimilation (Chapter 2) and juvenile salmon growth, size, body condition, and abundance. Prior to salmon spawning, residual MDN from past years offered little advantage to juvenile salmon. However, after the arrival of spawning salmon, MDN enhanced juvenile salmon size, growth, and condition in fall and winter. The collective results from this dissertation thus provides compelling evidence that MDN from spawning Pink Salmon may enhance the productivity of Coho and Chinook salmon. Management agencies should explore modified spawner-recruit models that incorporate MDN relationships to determine if they more accurately describe population dynamics. Where they do, such models may be used to forecast salmon returns and

possibly adjust escapement goals (the number of spawners desired on the spawning grounds) to improve maximum-sustained yields (MSY).

Chena River Juvenile Chinook Salmon Large Wood Habitat Mapping

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

Large woody debris (e.g., logjams, rootwads; LWD) within the channel provide important rearing habitat for fishes, and especially for juvenile Chinook Salmon in interior Alaska rivers, including the Chena River. For juvenile salmon, LWD provides cover from predation, refuge from high flow velocities, and high-quality habitat for invertebrate prey items. However, the distribution, abundance, and characteristics of LWD, particularly within stream reaches where juvenile Chinook Salmon are known to rear, have yet to be quantified in the Chena River basin. Our objectives were to (1) georeference and make simple measurements of LWD along the entire rearing distribution of juvenile Chinook Salmon in the upper Chena River, and potential rearing distribution in the lower river, during June 2017; (2) relate characteristics (e.g., size, location, composition) of LWD to use (i.e., presence) by juvenile Chinook Salmon for a subset of LWD habitats identified in Objective 1 during July and August 2017; and (3) communicate the importance of LWD as juvenile Chinook Salmon habitat to the public. We measured habitat attributes (e.g., submerged area, formative fluvial process, etc.) for all logjams (N=429) and conducted fish snorkel counts for a randomly-selected subset (N=189) of logjams within the known distribution (283 stream-km) of juvenile Chinook Salmon rearing in the Chena River basin, Alaska, during summer 2017. Logjam density and potential wood recruits (i.e., downed trees) declined downstream (33 recruits/km, 6 logjams/km; 6 recruits/km; 0.3 logjams/km, respectively), particularly below Moose Creek Dam, which is thought to intercept wood from the upper basin. Logjam size (submerged area; m^2) increased downstream. In upstream reaches smaller logjams formed on fallen trees or gravel bars in higher velocity channel units (i.e., riffles, runs), and larger logjams downstream formed on fallen trees or meanders in pools. We found no evidence of snorkeling observer bias, and juvenile salmon were present at 68% of logjams and their density (fish/ m^2) ranged from 0.0002 to 9.0000. The highest densities occurred in the middle reaches of the network and corresponded with high quality adult spawning habitats. Neighborhood- and reach-scale covariates, but not characteristics of individual logjams, best predicted juvenile salmon counts. A qualitative assessment indicated that the Moose Creek Dam has likely influenced physical complexity and the capacity of the channel to trap wood in logjams in downstream reaches. Results of this project will be used to evaluate the potential for reintroduction of LWD to reaches of the Chena River below Moose Creek Dam, provide juvenile salmon rearing capacity estimates for the basin, and contribute towards efforts to monitor LWD based on remote sensing and link the distribution and abundance of wood along the river to wildfire and land management practices.

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 Indigenous 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 study were to: 1) characterize and assess spawning habitat potential, 2) investigate the foraging niches utilized, 3) describe migration patterns and life histories used across individual's lives, and 4) 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 analyses revealed a large range of $\delta^{13}C$ and $\delta^{15}N$ values across tissue types suggesting that Broad Whitefish utilized several different foraging niches, utilizing varying degrees of marine and land-based (i.e., freshwater and terrestrial) food sources. Strontium isotopes revealed a diverse pattern of time spent in freshwater, estuarine, and marine habitats suggesting complex and diverse life-history types. Findings from this research are being coupled with a conceptual model to provide insights into potential effects from climate and landscape change to better conserve this valuable subsistence resource on the Arctic Coastal Plain 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

Ben Meyer checks a minnow trap.

Shifts in water temperature regime influence juvenile salmon freshwater rearing habitat differently depending on local temperature and food conditions, but neither are well-characterized in the Kenai River watershed. Regional stakeholders in the Kenai Peninsula are concerned about the future of salmon populations in the face of climate change. A more detailed understanding of how environmental variables influence juvenile salmon growth rates will help inform us on how these fish will fare in a changing landscape. Objectives were to (1) characterize how juvenile Chinook and coho salmon growth rates respond to projected rising water temperatures across diverse landscape settings, and (2) examine the degree to which stream temperature monitoring sites in lower reaches are representative of upstream thermal conditions. We surveyed growth and diet patterns of juvenile Chinook and coho salmon throughout three tributaries and main stem of the Kenai River with markedly differing water temperature regimes. We used field data to parameterize a model that projects growth rates under future climate and diet scenarios. Model results indicate decreasing size at end of summer in most future warming scenarios. The magnitude of decrease was generally smaller in populations with high feeding rates, especially of marine and terrestrial food subsidies, and in the glacial and main stem habitats. The magnitude of decrease was greater in the montane and lowland habitats. These data support the growing consensus that diverse habitats within a watershed support diverse early-life history opportunities for juvenile salmon. Results underscore the regional variability of climate change influence on Pacific salmon lifecycles.

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

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

Donnie Arthur weighs a yelloweye rockfish.

Rockfish are characterized by slow growth, late maturity, and low natural mortality rates. These life history characteristics are especially pronounced in Yelloweye Rockfish (*Sebastes ruberrimus*), which has contributed to the species' overfished status throughout its southern range from California to British Columbia. Northern stocks in Alaska are presumed to be healthy, but there is a lack of critical information on life history characteristics and therefore no stock assessments have been conducted for this species in this region. This study focuses on northernmost distribution for the species, Prince William Sound (PWS) and the Northern Gulf of Alaska (NGOA).The objectives of this project are to (1) generate estimates of age and size at maturity, (2) produce age and size-specific fecundity relationships, and (3) use the results from objectives 1 and 2 to build an Reproductive Potential (RP) model for Yelloweye Rockfish in PWS and the NGOA. Age or length at 50% maturity will be determined through histological (microscopic) examination of Yelloweye Rockfish ovaries. Fecundity estimates will be produced using the gravimetric method with eggs counts conducted in an image analysis software. Work with the RP model will be performed primarily using statistical/quantitative software such as Program R. The RP model will be used to evaluate assumptions associated with the fecundity-weight relationship and conduct a sensitivity analysis of life history parameters such as natural mortality, skip-spawning, and maturity on RP. These results will be used to inform future stock assessment modeling and guide the conservative management of Yelloweye Rockfish in PWS and NGOA.

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

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

Olivia Edwards measures a 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 Chena River 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 and recaptured using minnow traps and screw traps the spring following tagging. Early results confirm movement of individuals among the four rearing areas and show mid to late May peak outmigration timing. We are currently working on growth and survival results. The results of this study will help to identify and prioritize areas for freshwater habitat conservation 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

One of thousands bordering the Gulf of Alaska, a small coastal stream enters the ocean in Lynn Canal, Alaska.

Southeast Alaska's forest streams are home to some of the strongest remaining Pacific salmon runs on earth, but the impacts of climate change 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, fisheries managers, and community harvesters require rigorous predictions of how salmon populations will respond to cumulative changes in the freshwater environment. Our goal is to create user-friendly life cycle models 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). We categorized streamflow patterns for over 4,000 watersheds in coastal southern Alaska and are working to combine water temperature, streamflow, and salmon life history parameters to create the life cycle model. The diversity of freshwater habitat types in southern coastal Alaska will result in variable responses to climate change. Some salmon populations may experience near-term losses in abundance while others will stay static or even improve. It will be important to pinpoint these population responses and identify watersheds at highest risk of losses. Land use planners, fisheries managers, and communities dependent on salmon will be better prepared to adapt to salmon population responses to climate change.

Aquatic Food Web and Community Response to Wildfire in Interior Alaska Boreal Streams

Student Investigator: Elizabeth Hinkle, PhD Fisheries
Advisor: Jeff Falke
Funding Agency: Department of Defense (DoD) Strategic Environmental Research and Development Program (RWO 227)


Elizabeth Hinkle holds an Arctic grayling collected from a minnow trap.

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 2018 we investigated community responses to wildfire at 26 sites in interior Alaska with varying time since fire disturbance (recent: 0-10 years, historic: 10-50, control: 50+). At each site, we measured physical habitat and water chemistry, quantified macroinvertebrate and fish communities, and assessed aquatic food web structure using stable isotopes. Mean fish species diversity, overall density, and mean biomass were higher at recently burned sites relative to control or historic sites. Recently burned sites also had more woody debris, less percent fines, lower mean percent canopy cover, and warmer water temperatures than control and historic sites. 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)


Interior Alaska boreal stream with recently burned area on the right.

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 influences 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, permafrost. 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 two-fold by mid-century and three-fold by late-century but in downstream reaches summer temperatures approached thermal limits (> 20 °C) of juvenile salmon. 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)

Marta Ree collects stream velocity measurements.

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 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. 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)

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. To date, we have contracted with NetMap [Earth Systems Institute (ESI), Mt. Shasta, CA], a digital watershed terrain database and set of analysis tools, 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 a spatially-explicit decision-support tool to facilitate conservation and management of Chinook salmon in the Yukon and Kuskokwim river basins in Alaska.

Completed Wildlife Studies

Reproductive Success of American and Pacific Golden-Plovers (*Pluvialis dominica* and *P. fulva*) in a Changing Climate

Student Investigator: Kelly Overduijn, MS Wildlife Biology and Conservation
Advisors: Abby Powell and Colleen Handel
Funding Agency: USGS Alaska Science Center

Note: Kelly Overduijn graduated from the University of Alaska Fairbanks in May 2019. Her thesis abstract follows:

Climate change is increasing air temperatures and altering hydrologic systems in arctic environments, which will create positive feedbacks on shrub growth and advance the phenology of arthropods, important prey for many arctic-breeding birds. Little is understood about how such climate-induced changes in habitat and prey availability may affect reproductive success of migratory birds during the short arctic breeding season. Worldwide, declines in shorebird populations, including arctic-breeding species, have recently become apparent. Projected changes in climate are expected to benefit arctic-breeding shorebirds in the short-term by increasing reproductive success and survival, primarily through prolongation of summer. Over time, however, reductions in the quantity and quality of open tundra habitat and changes in prey availability may adversely affect shorebird reproduction and exacerbate current population declines. I evaluated the reproductive success of two shorebird species, American (Pluvialis dominica) and Pacific (P. fulva) Golden-Plovers, in relation to vegetation extent and phenology. I collected data over two field seasons (2012–2013) on the Seward Peninsula, Alaska. Both species selected nest sites with less cover of tall shrubs and other tall vegetation than available at random sites within their territories. American Golden-Plovers selected territories and nest sites that were higher in elevation and had more rocky substrates and less graminoid vegetation than those selected by Pacific Golden-Plovers. Nest survival was equivalent in the two species and similar to that found in other arctic-breeding shorebirds. Over the 27-d incubation period the probability of a nest having at least one egg survive to hatch averaged 0.39 (95% CI: 0.28, 0.49). Nest survival was not explicitly associated with habitat features at nest sites; however, nest survival was lower during the year with earlier spring phenology and declined with the age of the nest, both of which may have been at least partially related to growth of vegetation. Future research should examine reproductive success in a comprehensive manner, in which multiple aspects of a species' reproductive ecology is evaluated, allowing a more complete understanding of the effects of climate change on

recruitment into populations through the combined effects of habitat structure, food resources, and climate.

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

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

Note: Joelle Hepler graduated from the University of Alaska Fairbanks in December 2019. Her thesis abstract follows:

In remote landscapes, it is difficult and expensive to document animal behaviors such as location and timing of parturition. When aerial surveys cannot be conducted as a result of weather, personnel or fiscal constraints, analyses of GPS collar movement data may provide an alternate way to estimate parturition rates and calving ground locations. I validated two methods (population-based method and individual-based method), developed to detect calving events of sedentary woodland caribou, on multiple years of data for two different migratory barren-ground caribou herds in Alaska, the Porcupine and Fortymile herds. I compared model estimates of population parturition rates, individual calving events, calving locations and calving dates to estimates from aerial survey data for both herds. For the Porcupine herd we also compared model estimates of annual calving ground sizes and locations of concentrated calving area centroids to those found with aerial survey. More years of data would be required for additional statistical power but for both the Porcupine and Fortymile herds, we found no significant difference between the population-based and individual-based method in: 1) individual classification rate accuracy (0.85 vs. 0.88, respectively; $t = -7$, $P = 0.09$, df = 1 and 0.85 vs. 0.83, respectively; $t = 0.46$, $P = 0.69$, df = 2) or 2) annual average distance from aerial survey calving locations (8.9 vs. 7.8 km, respectively; $t = 0.16$, $P = 0.90$, and 5.2 vs. 3.7 km, respectively; $t = 1.03$, $P = 0.20$). Median date of calving was estimated within 0-3 days of that estimated by aerial survey for both methods. Population parturition rate estimates from aerial survey, the population-based and individual-based methods were not significantly different for the PCH or FCH (0.91, 0.88 and 0.95, respectively; $F = 0.67$, $P = 0.60$, df = 2, and 0.83, 0.83 and 0.96, respectively; $F = 3.85$, $P = 0.12$, df = 2). Ultimately, more years of data would be required to support or reject the lack of significant differences between methods that we observed.

Ongoing Wildlife Studies

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

Student Investigator: Wilhelm Wiese, MS Wildlife Biology
Co-Advisors: Tuula Hollmén and Mark Lindberg
Funding Agency: Arctic National Wildlife Refuge, USFWS (RWO 215)

In-Kind Support: Personnel and logistical support provided by Arctic NWR, USFWS

A summer day in eider nesting areas in the high Arctic.

Pacific Common Eider populations decreased over 50% from the 1950s to 1990s. Although Pacific common eiders have declined throughout their range, those breeding on barrier islands in the Beaufort Sea are considered particularly vulnerable. Nest failure caused by predators or flooding may be an important limiting factor to common eider population recovery. Previous attempts to quantify causes of nest failure have been limited in geographic scale and/or have relied on methods that may induce bias. Our objectives are to quantify specific causes of nest failure and test the accuracy of two "evidence based" methods for determining nest predator species. In 2015-17, we surveyed barrier islands of Arctic NWR for common eider nests and placed small, time-lapse cameras at approximately 100 nests each year to record causes of nest failure. Glaucous gulls, polar bears, arctic foxes, and grizzly bears were the most common nest predators. Using a traditional method of evaluating nest site evidence, we correctly identified nest predators only 40% of the time. A quantitative method based on evidence left at nest sites only allowed us to accurately identify predator species 41% of the time. Neither the traditional method, nor quantitative method for assessing evidence at nest sites was effective for accurately assigning predator species or class.

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

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

Collecting habitat data at an eider nest site on a barrier island

Sea levels are predicted to rise and the intensity and frequency of storm surges in the Beaufort Sea are increasing. Pacific 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. As part of our work to investigate risk factors associated with these climate-mediated changes, this summer we placed heart rate monitors housed in artificial eggs in a cohort of nests to determine energetic investment and collected information on nest microclimate using wind speed loggers. This data will provide insight into how much energy birds use and allow us to predict the bird's capacity to respond to increased storm surges by moving higher on the islands or if such a response would lead to greater energetic costs.

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 spatial ecology and behavior of Canada lynx (*Lynx canadensis*) in the northwest boreal forest are largely unknown. Improvements in GPS technology are rapidly increasing our understanding of the general movement behavior of animals. New sensors such as triaxial accelerometers are further allowing us to probe the details of unobserved animal behavior. These data will improve our understanding of how habitat complexity and changing environmental conditions alter predator-prey interactions. We captured and deployed GPS collars on 40 lynx in 2019 and deployed triaxial accelerometers on 21. We snow tracked a sample of accelerometer-equipped individuals between GPS locations obtain observations synchronized with accelerometer recordings to validate how hunting behavior corresponds with measurements of acceleration. This is the first study of lynx in Alaska implementing triaxial accelerometers. Analyses of GPS, accelerometer, and field tracking data are ongoing. We plan to investigate the effects of habitat, life history events, weather, and other variables on behavior and diel activity pattern of lynx.

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
Advisor: Mark Lindberg
Funding Agency: U.S. Fish and Wildlife Service (RWO 232)

Moose in interior Alaska.

Moose are vitally important to Alaska's subsistence and recreational hunters, wildlife viewers, and economy. Both the State of Alaska and federal government are mandated to manage moose populations. Specific information needs include the ability to monitor the size, trend, and composition of moose populations. The goals of this project are to analyze existing long-term moose population datasets in an Integrated Population Management (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. A secondary goal is to develop a moose survey planning tool that evaluates combinations of simulated sampling intensities and data streams that can be used to most efficiently inform management objectives, and to assess the viability of existing moose data from the Togiak and Galena region for an IPM. We will conduct an IPM in a Bayesian framework to determine the adequacy of the data and future needs. We organized and managed data sets during the fall 2019 in preparation for consultation with world IPM experts in February 2020. Results of this work will guide future monitoring and management of moose.

Ongoing Ecological Studies

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

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

Iris Cato in the Arctic Garden, located on Alaska's North Slope

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), which has lower nitrogen content and is avoided by geese. It is currently unclear whether these sedges are actually different species or different growth forms of the same species. On the Yukon-Kuskokwim Delta, Alaska, (YKD), there appears to be a positive feedback loop, where increases in goose populations cause increased grazing and lawns of short, palatable sedges. In the last century, extensive grazing lawns of YKDSUB have converted to a tall, less palatable form due to reduced grazing. This may subsequently cause further reductions in YKD Brant goose populations. However, on the North Slope (NS), NSSUB does not need to be grazed to maintain its short stature. We want to learn more about the feedback loop between Brant geese and the sedges they graze by determining whether there are genetic and physiological differences between tall and short morphs growing on the YKD and NS. Our project objectives are to determine the morphological, genetic, and physiological differences among SUB and RAM from Arctic and subarctic Alaska. A morphological study was conducted on SUB and RAM herbarium specimens. Common gardens in Arctic and subarctic Alaska are being used to test for physiological differences. Next Generation Sequencing will be used to quantify genetic differences between SUB and RAM. Morphological measurements of herbarium specimens indicate that SUB is morphologically distinct from RAM. In the Arctic garden, height and tiller density are significantly different for all growth forms and clipping had a significant effect. In the subarctic garden, heights are significantly different for all growth forms, but tiller density for NSSUB and YKDSUB are not significantly different from each other but are significantly higher than RAM. Clipping did not have an effect in the subarctic garden. Genetic data has been successfully sequenced and will be used to clarify the relationships between NSSUB, YKDSUB, and RAM growth forms. Understanding the differences between these grazing systems is critical for predicting population dynamics of Department of Interior trust species (migratory geese) in the regions 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: Heather Greaves
Funding Agency: USGS Land Carbon Program (RWO 220)
Collaboration: Partner of a NASA-ABoVE project led by Dr. Rob Striegl (USGS)

Attendees to the soil moisture workshop at the Alaska Peatland Experiment bog site.

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, 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 represent land cover change associated with thermokarst, related paludification, wildfire and succession. We coupled this model with a process based ecosystem model to represent the consequences of thermokarst and land cover change on carbon dynamic and the hydrological regime. We are collaborating with a wildlife scientist from USFS to develop a model representing the impact of these disturbances on wildlife composition. Finally, we organized a workshop gathering experts to assess regional changes in soil moisture associated with climate change and permafrost thaw. The state and transition model shows an increase in thermokarst disturbance across the landscape in response to climate warming and spring precipitation. Thermokarst, wildfire and paludification are the main drivers of land cover change in the Yukon and Tanana Flats, leading to an increase in wetland distribution in lowland areas. A workshop on soil moisture organized in September 2019 identified a new approach to integrate in situ observation and remote sensing data in process based models to improve real-time prediction of soil moisture change. 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: Heather Greaves (IAB)
Faculty: Amy Breen, Robert Bolton, T. Scott Rupp (IARC); Brad Griffith, Helene Genet, Eugénie Euskirchen (IAB); Vladimir Romanovsky, Sergey Marchenko, and Dmitry Nicolosky (GI)
Funding Agency: USGS Alaska Climate Science Center (RWO 224)

Natural resource managers and decision makers require an improved understanding of the potential response of ecosystems due to a changing climate in Alaska and northwest Canada. We created a modeling framework – the Integrated Ecosystem Model (IEM) for Alaska and Northwest Canada to meet this need. The IEM integrates the driving components for, and the interactions among, disturbance regimes, permafrost dynamics, hydrology, and vegetation succession and 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 (3) phasing in additional capabilities as necessary. In 2019, we calibrated and validated model parameterizations for a new version of the model that includes a dynamic vegetation model. Our work is still in progress for select tundra regional analyses in Alaska (Utqiaġvik, Toolik Lake, Seward Peninsula, and Y-K Delta) for proof of concept. We anticipate completion of this phase of model coupling and manuscript prep by September 2020. 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 225)

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, including those in Alaska and northwestern Canada, are frequently characterized as having high landscape conservation capacity, given their high percentage of protected areas and highly intact landscapes. However, these regions are susceptible to a growing number of pressures from climatic and anthropogenic change. In light of pressures from climatic and anthropogenic change, there is a need to implement strategic landscape conservation design to facilitate projected ecosystem shifts and species movements. The primary objective of this study is to identify corridors among protected areas in Alaska and Northwest Canada that promote long-term connectivity and have the potential to facilitate species movements under projected climate change. We characterized climate connectivity using a cost-distance modeling approach to map climate-gradient corridors between protected areas in Alaska and Northwest Canada with the most unidirectional change in climate and the highest landscape integrity. To do so, we used regionally-derived downscaled climate data to identify climate-gradient corridors under historical climate, as well as for a range of projected future climate scenarios and time periods. We also 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. Under both historical and projected climate conditions, we observed that climate corridors were oriented primarily in an east–west direction, where connectivity was pronounced throughout interior Alaska, reflecting trends in climate and topography. Furthermore, we observed a large degree of spatial overlap between historical and projected climate corridors. The majority of areas where climate connectivity remained intact into the future comprised locations with comparatively wider climate corridors, representative of areas with many alternative favorable pathways where climate gradients were gradual. Identifying climate connectivity corridors provides a useful framework for prioritizing areas to increase landscape connectivity in the face of climate change. By modeling corridors that will facilitate movement for species tracking suitable climate conditions into the future, this approach promotes proactive conservation. 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: Heather Greaves
Funding Agency: USGS Land Carbon Program (RWO 231)

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 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. We will apply a multi-phased approach, which will focus on wetland assessment methodology development in phase 1 (FY19-FY20), and integration and assessment in phase 2 (FY21-FY22). In 2019, we developed new parameterization for the Dynamic Vegetation and Organic Soil version of the Terrestrial Ecosystem Model (DVM-DOS-TEM) for the three main wetland types in Alaska: wetsedge tundra, bog and fen. 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