

Observing Arctic Freshwater Habitat Dynamics in the Fish Creek Watershed, Alaska

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<http://www.fishcreekwatershed.org>



Abstract:

The Fish Creek Watershed drains a 4500 km² region of the Arctic Coastal Plain in northern Alaska. Composed of abundant lakes, wetlands, beaded streams, and alluvial rivers set atop permafrost soils, the area provides diverse freshwater habitats. Almost entirely roadless and *de facto* wilderness, it is entirely within the **National Petroleum Reserve – Alaska (NPR-A)**, and a focal area for future petroleum development. Accordingly, the Bureau of Land Management in partnership with University of Alaska Fairbanks, the U.S. Geological Survey and other agencies have gradually developed the **Fish Creek Watershed Observatory (FCWO)** to track responses to climate change and establish a baseline prior to land development. This expanding network is helping to understand hydroclimatic and biological changes in the Arctic, and provides an ideal framework for hypothesis driven research. Projects include studies of fish foraging and migration, a watershed-scale analysis of aquatic habitat, and an investigation of lake-ice interactions with permafrost and climate. Continuation of the **FCWO** will focus on sustaining climate, hydrologic, permafrost, and biological observations to capture the coupled responses of land-use and climate change in Arctic Alaska.

Barrow

Loon Distribution & Behavior

- Behavioral studies of loon sensitivity to disturbance
- How does loon distribution relate to fish habitat and lake connectivity to stream networks?

Fish Migration & Food Webs

- Research on Arctic grayling migration and foraging focused on beaded stream systems prior to oil development
- New research seeks to understand broad whitefish (migration) in river systems and lake trout growth and thermal tolerance in relation to climate change

Recent Publications on Fish Ecology from the FCWO:
 McFarland, J. 2015. Trophic pathways supporting Arctic Grayling in a small stream on the Arctic Coastal Plain, Alaska. M.S. Thesis. University of Alaska Fairbanks, Fairbanks, AK.
 Heim, K.G., Wipfli, M.S., Whitman, M.S., Seitz, A.C. 2015. Body size and condition influence migration timing of juvenile arctic grayling. *Ecology of Freshwater Fishes*. DOI:10.1111/eff.12199.
 Heim, K. C., M. S. Wipfli, M. S. Whitman, C. D. Arp, J. Adams, and J. A. Falke. 2015. Environmental cues of Arctic grayling seasonal movement in a small Arctic stream: the importance of surface water connectivity. *Environmental Biology of Fishes* DOI 10.1007/s10641-015-0453-x.

Arctic Lake Ice Systems Science (ALISS)

- New NSF research project (ARO-1417300) focused on winter lake dynamics and interactions with permafrost, hydrology, and climate
- Integrates remote sensing, field studies, geophysical measurements, ecosystem manipulations, and models
- First field season focused on FCWO (Inigok) using Nuclear Magnetic Resonance (NMR-ETM) to image sublake permafrost and taliks (see figure below)

Recent Publications on Lake Ice Dynamics from the FCWO:
 Arp, C. D., B. M. Jones, Z. Lu, and M. S. Whitman. 2012. Shifting balance of thermokarst lake ice regimes across the Arctic Coastal Plain of northern Alaska. *Geophysical Research Letters* 39 (L16503):1-5.
 Arp, C. D., B. M. Jones, and G. Grosse. 2013. Recent lake ice-out phenology within and among lake districts of Alaska, U.S.A. *Limnology and Oceanography* 58(6): 2013-2026.
 Jones, B. M., A. Gusmeroli, C. D. Arp, T. Sirozzi, G. Grosse, B. V. Gaglioti, and M. S. Whitman. 2013. Classification of freshwater ice conditions on the Alaskan Arctic Coastal Plain using ground penetrating radar and TerraSAR-X satellite data. *International Journal of Remote Sensing* 34(23): 8253-8265.
 Arp, C. D., B. M. Jones, A. K. Liljedahl, K. M. Hinkel, and J. A. Welker. In review. Depth, Ice Thickness, and Ice-out Timing Cause Divergent Hydrologic Responses among Arctic Lakes. *Water Resources Research*.

Climate & Permafrost Monitoring

U.S. Geological Survey: Real-time Permafrost and Climate Monitoring Network – Arctic Alaska

- Two stations (Fish Creek & Inigok) co-located with deep bores
- Data indicate increasing air and permafrost temperature, wetter summers and snowier winters

<http://data.usgs.gov/climate/monitoring/region/show?region=alaska>

Circumarctic Lakes Observation Network (CALON)

- Nested intensity, multi-scale observations of Arctic lakes funded by NSF's Arctic Observing Network (ARC-1107481) from 2012-15
- Year-round monitoring & field measurements N-S transects (including FCWO) (snow depth, ice thickness, water temperature, lake levels, biogeochemistry)
- Remotely sensed observations of lake area, temperature, and ice informed by field measurements

<http://www.arcticlakes.org/>
 Data Access: <https://www.aoncadis.org/>

Landsurface Dynamics in the Fish Creek Watershed

- Abrupt increase in permafrost degradation in Arctic Alaska (Jorgenson et al. 2006 *Geophysical Research Letters*)
- Shifting balance of thermokarst lake ice regimes across the Arctic Coastal Plain of northern Alaska (Arp et al. 2012 *Geophysical Research Letters*)
- Assessment of pingo distribution and morphometry using an IFSAR derived digital surface model, western Arctic Coastal Plain, Northern Alaska (Jones et al. 2012 *Geomorphology*)

Hydrologic Monitoring & Watershed Research

- NPR-A Hydrology**
River gauging program includes three paired subwatersheds
- Beaded Stream Monitoring**
In response to petroleum development, six catchments gauged to collect baseline hydrology, water quality, and fish habitat data

<http://me.uaf.edu/werc/projects/npra-hydrology/>

Recent Publications on Hydrology in the FCWO:
 Whitman, M., C. Arp, B. Jones, W. Morris, G. Grosse, F. Urban, and R. Kemnitz. 2011. Developing a long-term aquatic monitoring network in a complex watershed of the Alaskan Arctic Coastal Plain. Pages 15-20 in C. N. Medley, G. Patterson, and M. J. Parker, editors. *Proceedings of the Fourth Interagency Conference on Research in Watersheds: Observing, Studying, and Managing for Change*. USGS, Reston.
 Arp, C. D., M. S. Whitman, B. M. Jones, R. Kemnitz, G. Grosse, and F. E. Urban. 2012. Drainage network structure and hydrologic behavior of three lake-rich watersheds on the Arctic Coastal Plain, Alaska. *Arctic, Antarctic, and Alpine Research* 44(4): 385-398.
 Arp, C. D., M. S. Whitman, B. M. Jones, G. Grosse, B. V. Gaglioti, and K. C. Heim. 2015. Distribution and biophysical processes of beaded streams of Arctic permafrost landscapes. *Biogeosciences* 12: 1-19.

Simulating Fine-scale Hydrology

- In collaboration with Alaska EPSCoR Northern Test Case (OIA-1208927), process-based hydrologic model (WaSiM) being developed for Crea Creek catchment
- Simulations to analyze stream-lake-permafrost interactions with varying climate scenarios
- Overlap with ConocoPhillips-Alaska GMT1 Project (drilling pad & road) will allow scenarios analysis of real and evolving land-use change and affects on hydrologic connectivity and fish migration

Fish for Trees

Reconstructing Arctic Lake Temperature & Productivity Histories using Lake Trout Funding: Alaska Climate Science Center, National Institute of Water Resources (USGS)

- Trees absent from the Arctic, so other proxy records needed for decadal-scale chronologies of past climates
- Long-lived lake trout may record summer temperature
- Project seeks to reconstruct recent climate changes and understand lake trout ecology

Fish Inventory & Distribution using eDNA

- At least 12 species of fish inhabit streams, lakes, and rivers of the FCW
- Fish distribution of interest for aquatic biogeography and hydrologic connectivity
- Water-use management based on fish species present
- Current methods intensive, costly, and logistically-challenging
- New techniques being tested uses DNA from the water column
- NASA-funded grant to Desert Research Institute and Utah State University (sampling conducted by BLM & UAF)

Fish CAFE

Response of an Arctic Freshwater Ecosystem to Climate and Land-use Change in the Fish Creek Watershed

- This Arctic Landscape Cooperative funded interdisciplinary science project seeks to address species and habitat responses to climate change in focal Arctic watersheds
- The Fish CAFE team represents a wide range of disciplines integrating their knowledge and approaches
- Scenarios of habitat response to land-use and climate change will be used to inform stakeholders and adaptive management

Collaborators with the Fish Creek Watershed Observatory

- Bureau of Land Management:** Richard Kemnitz, Deb Nigro, Stacy Fritz
- U.S. Geological Survey:** Carson Baughman, Frank Urban, Gary Clow
- U.S. Fish and Wildlife Service:** Jeff Adams
- Arctic Landscape Conservation Cooperative:** Philip Martin, Dave Payer
- Cold Regions Research and Engineering Lab:** Chris Hiemstra
- Alaska Division of Geology and Geophysics:** Ronnie Daanen
- University of Alaska Fairbanks:** Anna Liljedahl, Vladimir Alexeev, Dragos Vas, Anne Gädeke, Allen Bondurant, Ben Gaglioti, Mark Wipfli, Jeff Falke, Eric Torvinen, Andres Lopez
- University of Alaska Anchorage:** Audrey Taylor, Hannah Uher-Koch
- Alfred Wegner Institute:** Guido Grosse
- University of Cincinnati:** Ken Hinkel, Amy Townsend-Small
- Clark University:** Karen Frey
- University of Wyoming:** Andrew Parsekian, Andrea Creighton
- Desert Research Institute:** John Olsen
- BSA Environmental, Inc.:** John Beaver
- ConocoPhillips-Alaska:** Caryn Rea
- The Wilderness Society:** Jason Leppi

A view of the Fish Creek Watershed Observatory from Space on 5-July-2015 (MODIS Terra Satellite Image)