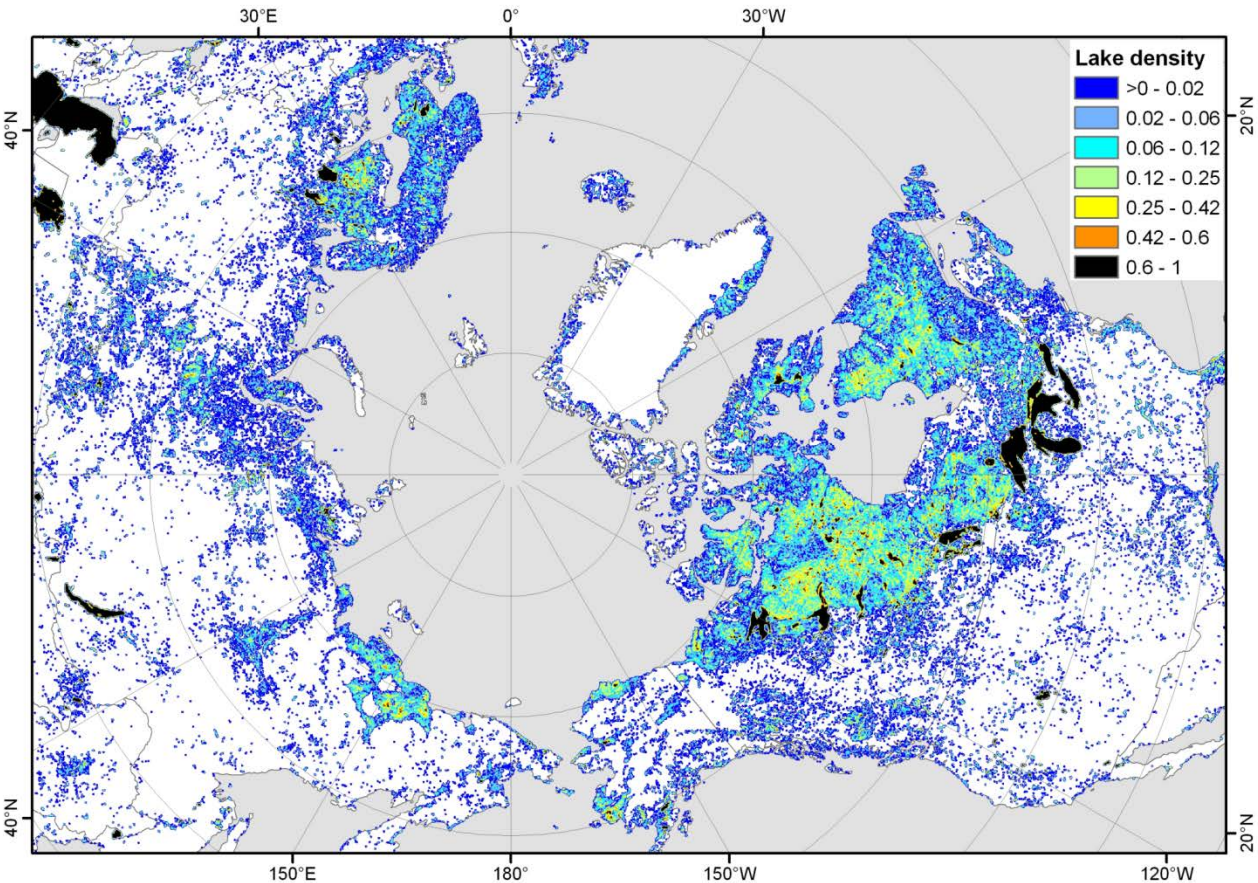
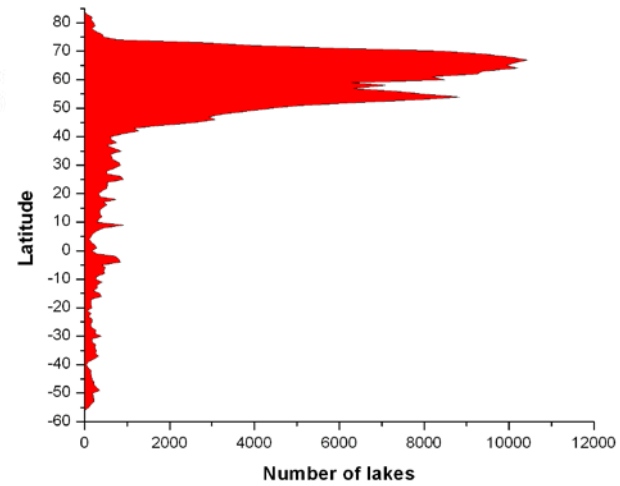
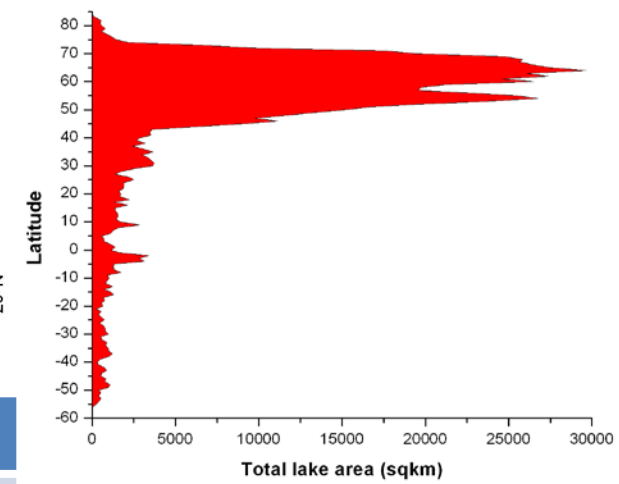
Arctic lake distribution and density



Based on GLWD-1 and -2 (Lehner & Doell, 2004)



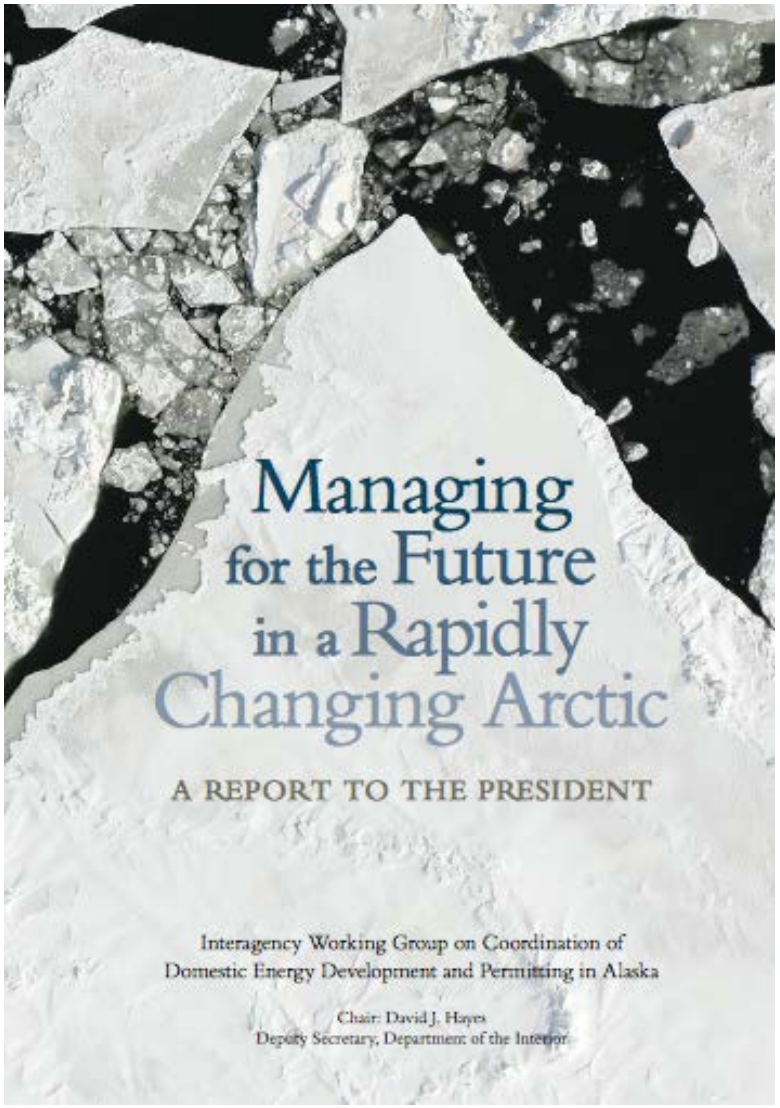


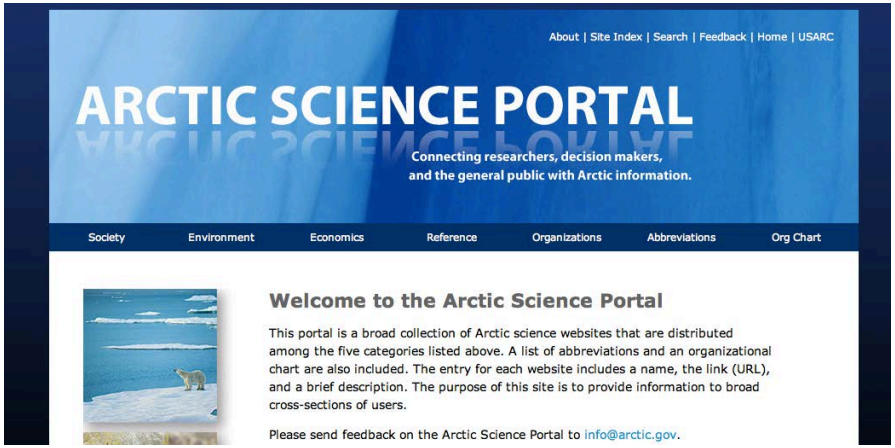
GLWD-2 with 1 degree bin size

Lakes in permafrost	Number of lakes	Total lake area
GLWD-2 Lakes 0.1-50 km^2	150, 838	427,994 km^2
GLWD-1 Lakes >50 km^2	1,454	434,302 km^2

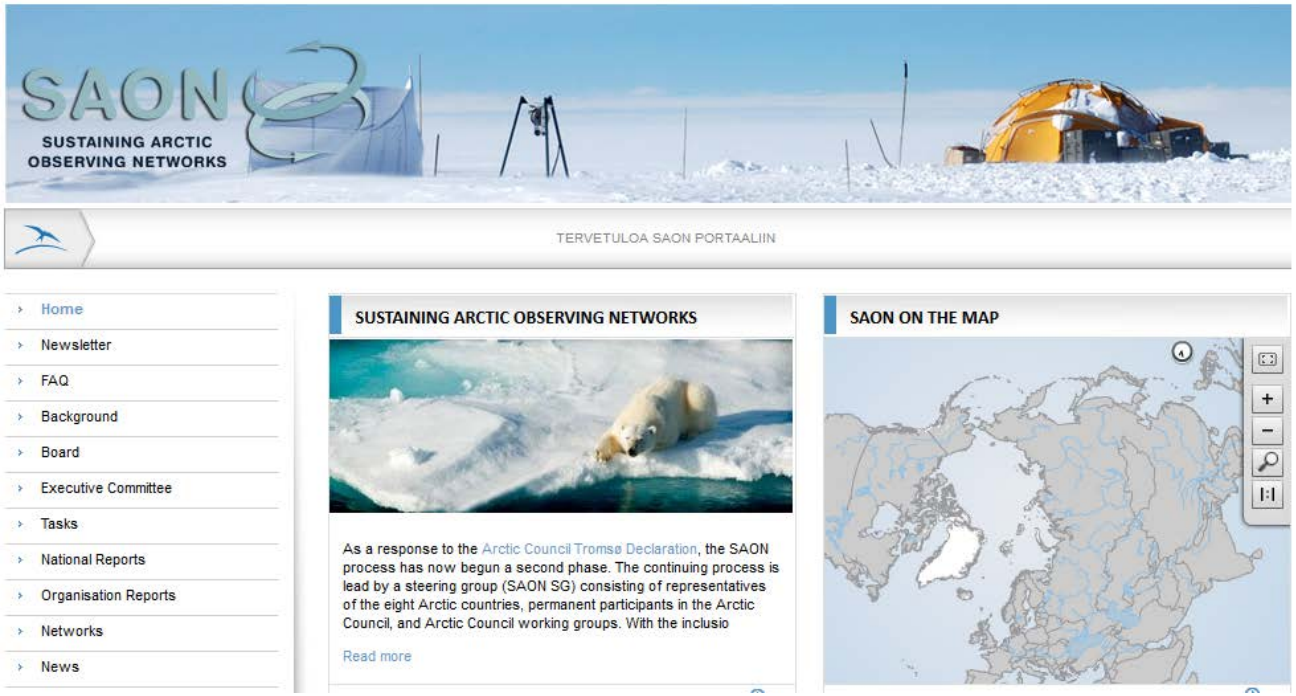
Grosse et al., 2013, Treatise on Geomorphology

Motivation to study Arctic lakes





The Arctic Observing Network



What is the Arctic Observing Network (AON)?

AON is envisioned as a system of atmospheric, land-based, and ocean-based environmental monitoring capabilities – from ocean buoys to satellites – that will significantly advance our observations of Arctic environmental conditions. Data from AON will enable the interagency U.S. government initiative – the Study of Environmental Arctic Change (SEARCH) – to get a handle on the wide-ranging series of significant and rapid changes occurring in the Arctic.

Importance of Multi-Scale Observations

ECOLOGY

Understanding Lakes Near and Far

Satellite and in situ sensor data complement long-term studies of individual lakes to provide insights into the effects of climate change and pollution.

Stephanie E. Hampton

Scientists have long viewed lakes as microcosms in which to study fundamental ecosystem processes (*1*). A large, heterogeneous body of multidecadal data has been accumulated around the world, documenting historical conditions, capturing temporal dynamics of complex ecological phenomena that could not be observed within shorter time periods. Building on this legacy of long-term data collection, innovations in sensor applications and computing are creating new opportunities for integrating data across different scales in space and time, enriching long-term research and stimulating collaboration.

A shared characteristic of long-term lake studies is that they address questions far beyond those posed at inception. Lake Washington is a famous story of lake restoration (*2*). In 1955, Edmondson and colleagues noted a sudden shift in microalgae suggestive of nutrient pollution, and so began long-term studies that examined algal-nutrient relationships, informed the public process leading to sewage diversion, and documented the restoration of water clarity. The case could have been closed here, but further water clarity increases shifted attention to food web interactions that transpired across decades, providing insights into trophic cascades (*2*) and continuing through the present to reveal subtle responses to climate change, such as temperature controls on the timing of plankton growth that appear to be general across many lakes (*3*).

Meanwhile in Siberia, three generations of a family of Russian scientists and their colleagues were maintaining comparable records on the world's most voluminous freshwater lake—Lake Baikal—to study drivers of plankton dynamics (*4*). From 1945 to the present, the exceptional duration and continuity of the temperature record turned out to be uniquely suited for deciphering seasonal timing shifts attributable to decadal climate oscillations. The detailed data revealed that changes in the timing of seasonal transitions in lake temperature, and potentially throughout the region, are predictably forced by changes in the trajectory and strength of the jet stream and its storm tracks (*5*).

Other examples of research have been a resul
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research since the 1930s h
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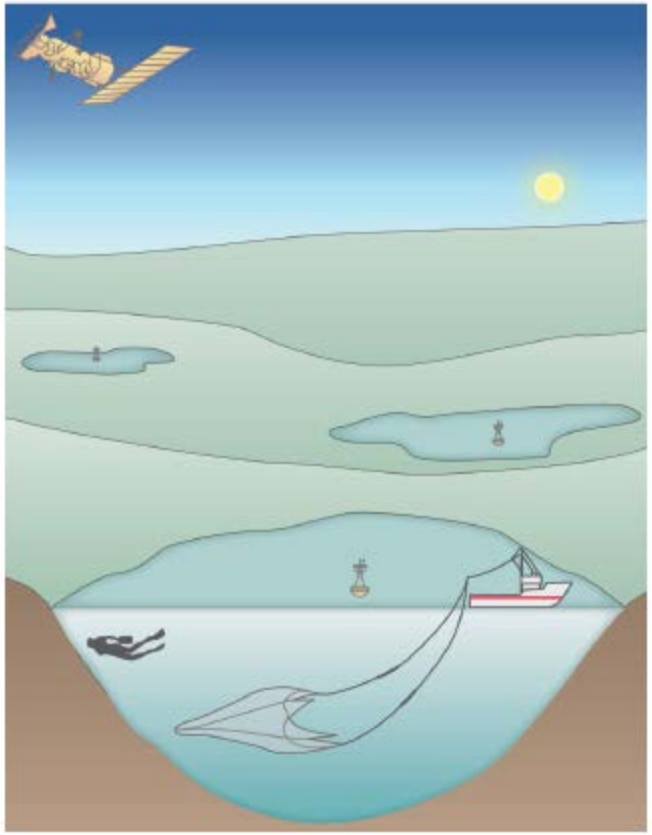
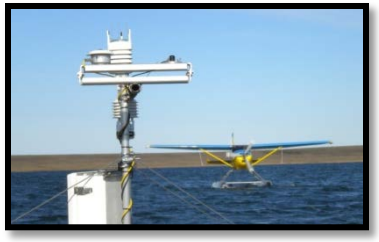
National Center for Ecological Analysis and Synthesis, University of California, Santa Barbara, CA 93101, USA. E-mail: hampton@nceas.ucsb.edu

www.sciencemag.org SCIENCE VOL 342 15 NOVEMBER 2013

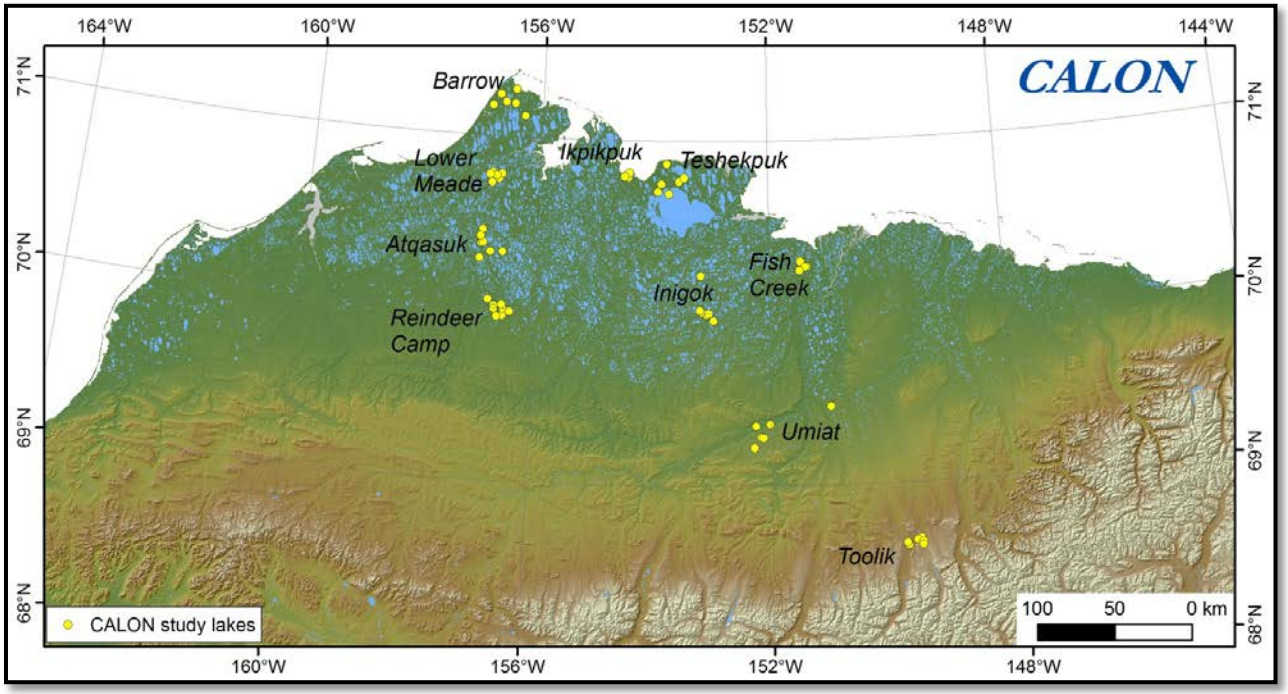


Complementary routes: Remote sensing approaches allow broad spatial coverage, complementing the finer-scale understanding facilitated by long-term in situ lake monitoring programs. In situ programs may include sensors deployed in the water and collections carried out by hand, and can be particularly powerful when coordinated across multiple lakes.



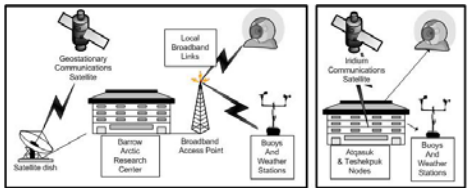
Toward a Circum-Arctic Lakes Observation Network (CALON)

Short-term goal (< 5 years): Expand and integrate an existing lake monitoring network across Arctic Alaska



Key Components

1. *In Situ* Observations
2. Remote Sensing
3. Traditional Knowledge

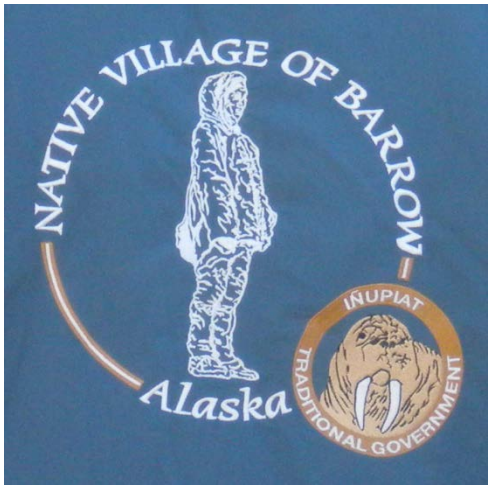


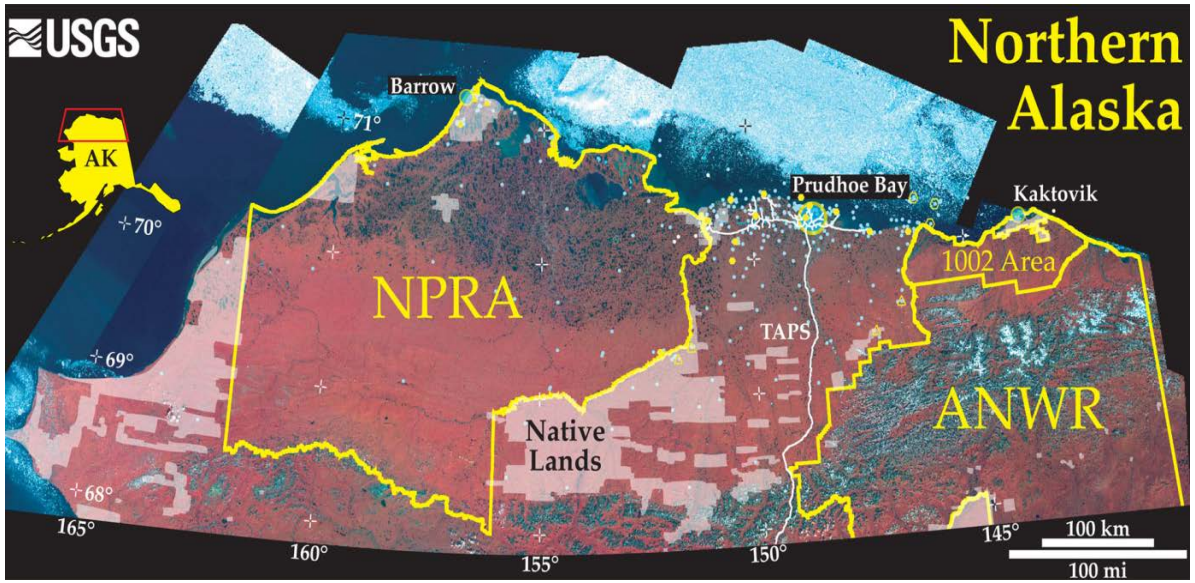
Long-term goal: Monitor lakes throughout the Arctic

Arctic Alaska as the test bed for Phase I

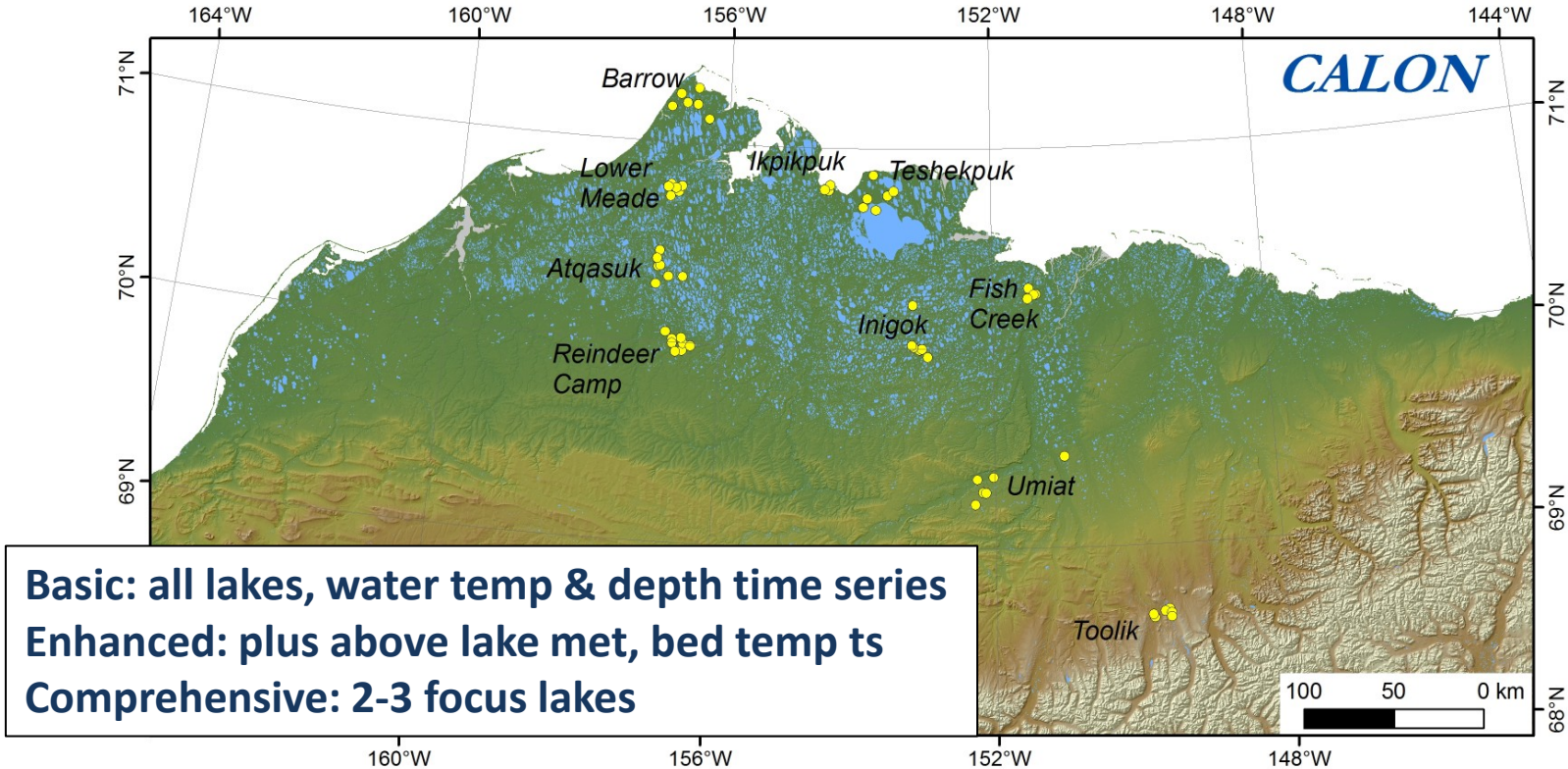
Cold, maritime climate

- Significant inland gradients
- Large seasonal contrasts
- Tundra and continuous permafrost
- Vibrant native communities
- Large tracts of DOI-managed lands





Winter and Summer Field Components



Basic: all lakes, water temp & depth time series
Enhanced: plus above lake met, bed temp ts
Comprehensive: 2-3 focus lakes

Winter (2 teams, snowmachines):
Lake ice and snow thickness, depth ~60
Deploy water quality instrumentation
Service met stations at hub
Collect water samples for biogeochemistry

Summer (3 teams, float planes):
Service & deploy water quality inst.
Deploy sediment & pf sensors
Collect water samples for biogeochem
Interview elders & hunters: IK
Collect reflectance spectra from lakes
Lake bathymetry

Arctic lakes in summer…

Avon raft on Teshekpuk Lake

Perfect Pilot Jim Webster

Cessna 185 “bug-eye” on
Jim’s pond

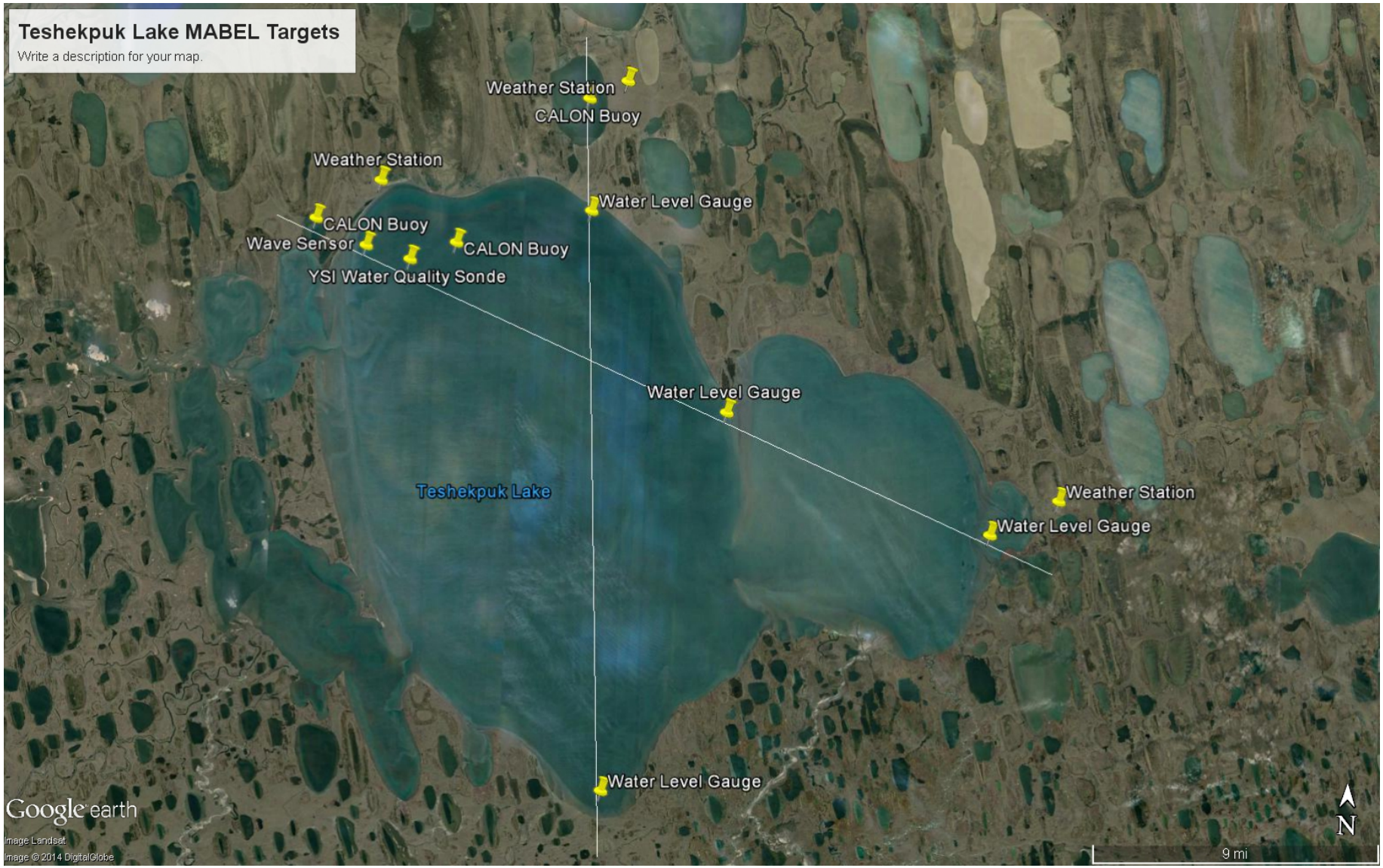
John boat on Toolik Lake

R-44 Helicopter

Alpaca Raft on small lake

Arctic lakes in winter…

Lake Targets for 2014 Summertime NASA MABEL Mission



Enhancing CALON through the Incorporation of Iñupiaq knowledge

Indigenous Knowledge and Inupiaq Web GIS

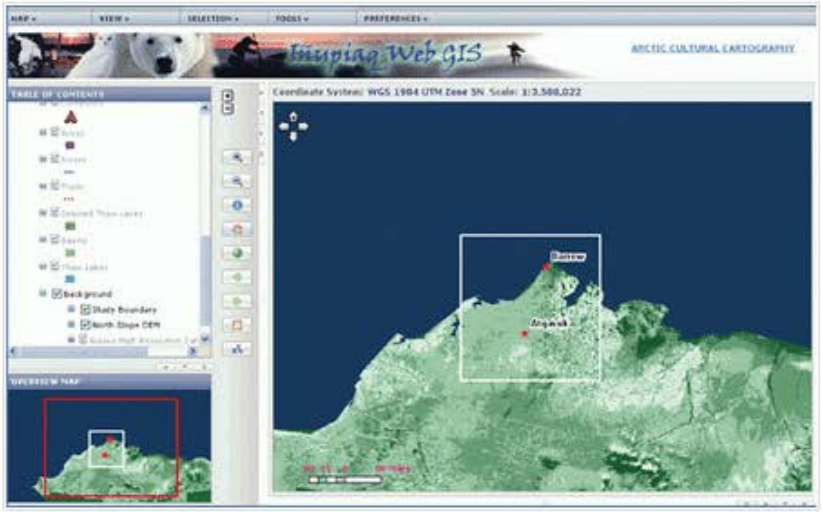
A key component of this project is to explore the intersection of native knowledge and landscape-process research in arctic Alaska. To date, we have interviewed fourteen members of the communities of Barrow and Atqasuk. Our informants have given us eye-witness accounts of changes to the lakes and the overall environment as they traveled the North Slope during all seasons of the year. The interview videos are in the process of being logged and geocoded for incorporation into the Iñupiaq Web GIS database.

Douglas M. Edwardsen

William Itta

Harry K. Brower, Jr.

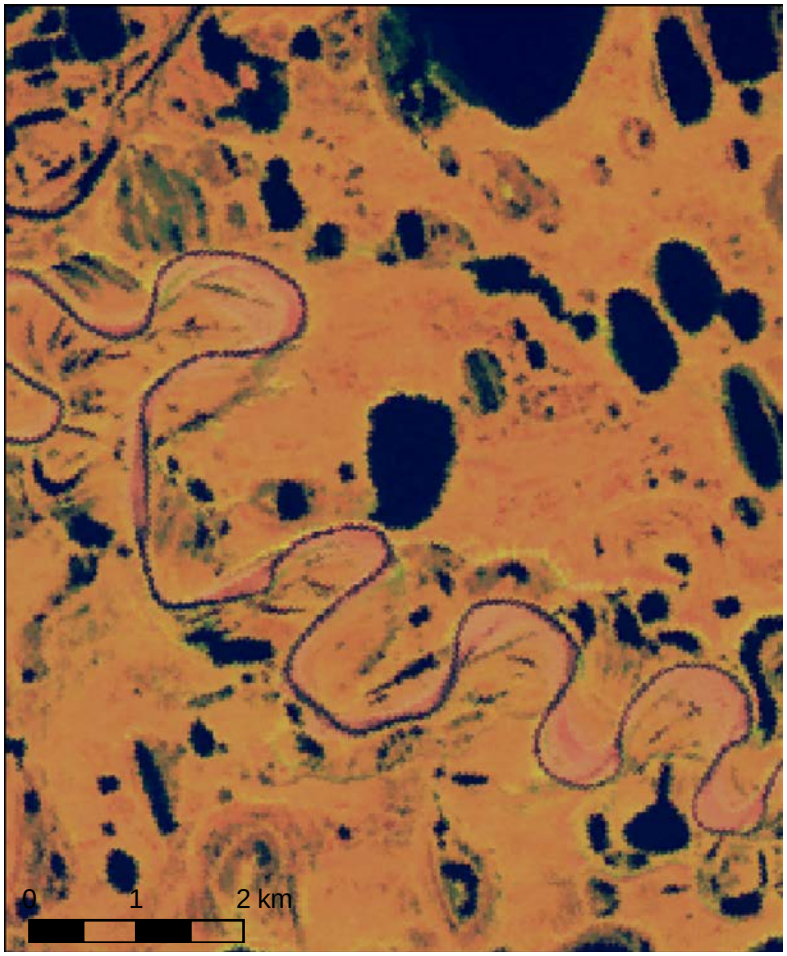
Billy Adams



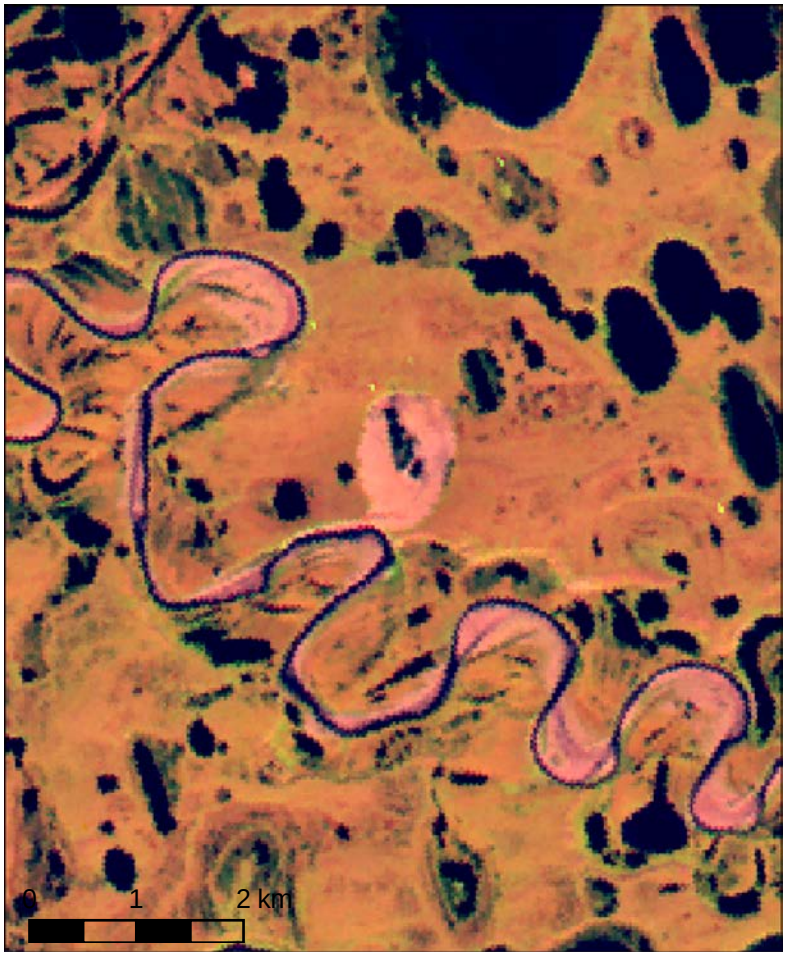
An Elders Observation of Lake Drainage Mechanism and Timing

Interview with the late Tom Brower Jr., Atqasuk, AK

Corroborating Information from Interviews using Landsat Imagery



1985 Landsat TM Image



1992 Landsat TM Image

Motivation to study Arctic lakes

- **More than 25% of the world's lakes are in the Arctic**
- **Arctic climate change is occurring at a rapid rate**
- **Systematic collection of key Arctic lake parameters is currently lacking**

CALON will allow us to:

- Record the full suite of changes occurring in a variety of Arctic lake types
- Understand the causes and consequences of changes underway
- Forecast the course, magnitude, and consequences of future changes
- Develop adaptive responses to future change and inform land and resource managers decision make processes

CALON Website: www.arcticlakes.org

Towards a Circum-Arctic Lakes Observation Network (CALON)

Home | CALON Lakes | Real Time Data | Datasets | Indigenous Knowledge | Publications | Presentations | CALON Blog

CALON

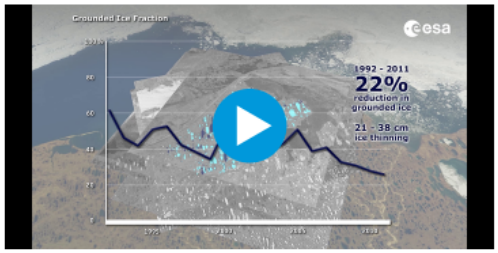
An observation network focused on better understanding Arctic lake systems.

Learn More

Arctic Lakes - Recent Findings and Updates

Arctic lakes show climate on thin ice: Ice in northern Alaska's lakes during winter months is on the decline. Twenty years of satellite radar imagery show how changes in our climate are affecting high-latitude environments. Click this link to see the article.

Courtesy of ESA



Arctic Freshwater Monitoring Plan: The Circumpolar Biodiversity Monitoring Program (CBMP), the cornerstone program under the Arctic Council's Conservation of Arctic Flora and Fauna working group, is working with partners from across the Arctic to harmonize and enhance long-term freshwater monitoring efforts. These efforts are led by a Freshwater Steering Group that has developed an Arctic Freshwater Biodiversity Plan to guide these efforts. Click this link to learn more.