Development of an Arctic Lake Observatory at Teshekpuk Lake

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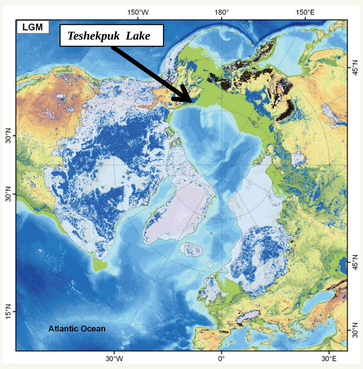
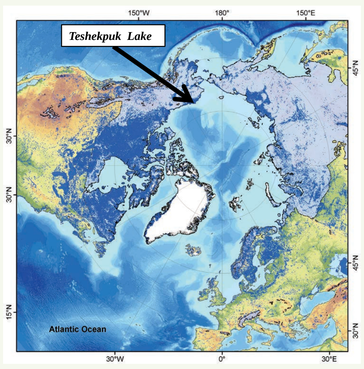
Location of Teshekpuk Lake in the Arctic

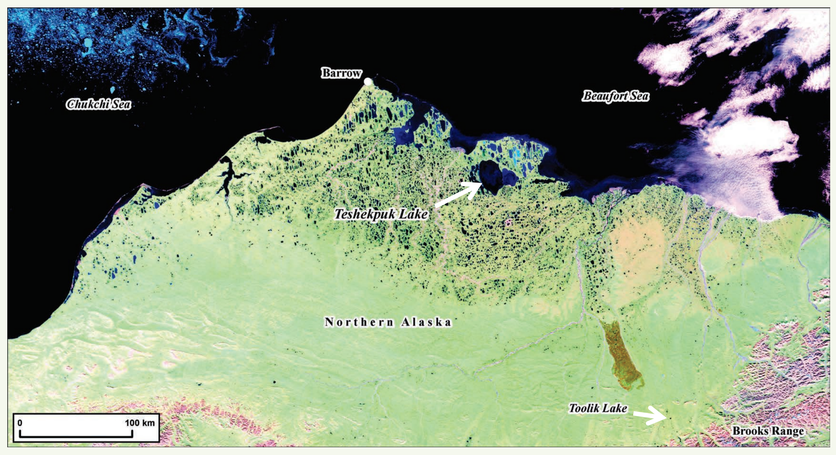
Nearly 25% of the lakes on Earth are located in the Arctic (Lehner and Doll, 2004), with their occurrence and distribution largely controlled by glacial history and the presence of permafrost (Smith et al., 2007). Arctic ponds and lakes play an important role in human water and food supply, hydrologic and biogeochemical cycling, and wildlife habitat provision, and are vulnerable to both climate change and local anthropogenic pressures. However, long-term observations from Arctic lakes are relatively sparse (Culp et al., 2012).



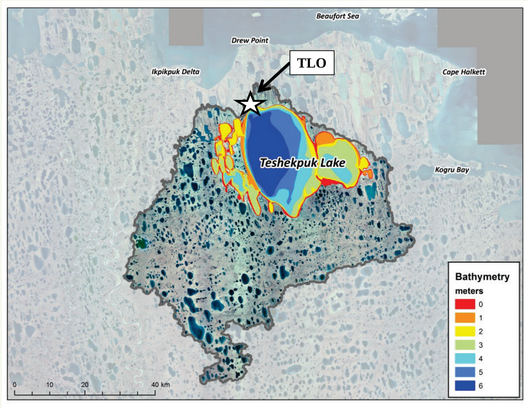
Lakes vs. LGM Glacial Extent



Lakes vs. Permafrost Distribution

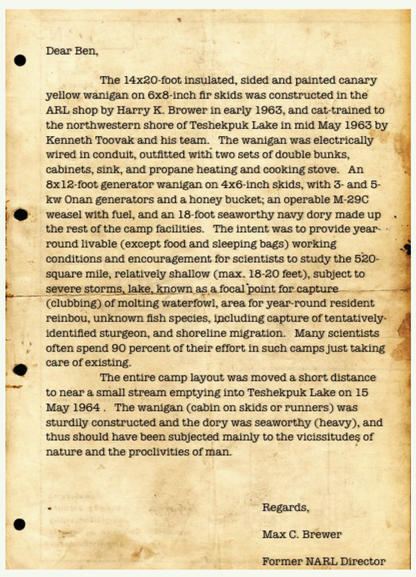


The Arctic Coastal Plain of northern Alaska is located between the Chukchi Sea, Beaufort Sea, and the foothills of the Brooks Range mountains. The region contains the second largest lake district in the state of Alaska (Arp and Jones, 2009). The more than 150,000 lakes and ponds cover ~20% of the landscape. Teshekpuk Lake is the largest lake in this region. It is an ideal location for establishing an Arctic lake observatory - given sea-level rise projections, rapid erosion along the Beaufort Sea coast, the presence of permafrost, as well as the potential for nearby oil and gas development.



Teshekpuk Lake has a surface area of ~850 km² and a maximum measured depth of 7 m. The lake drains an area of 2,750 km². The lake provides summer and winter habitat for more than a dozen fish species and likely influences the regional climate creating important habitat for caribou, geese, and other wildlife. The wetland complexes surrounding the lake provide some of the most important goose molting habitat in the circumpolar Arctic. A research station was established on the northwest shore of the lake in the early 1960s but abandoned shortly thereafter. In 2007, we began to refurbish the abandoned research station in an effort to develop the Teshekpuk Lake Observatory.

Rehabilitation of an Abandoned Naval Arctic Research Laboratory (NARL) Station



Dear Ben,

The 14x20-foot insulated, sided and painted canary yellow wanigan on 6x8-inch fir skids was constructed in the ARL shop by Harry K. Brower in early 1963, and cat-trained to the northwestern shore of Teshekpuk Lake in mid May 1963 by Kenneth Toovak and his team. The wanigan was electrically wired in conduit, outfitted with two sets of double bunks, cabinets, sink, and propane heating and cooking stove. An 8x12-foot generator wanigan on 4x6-inch skids, with 3- and 5-kw Onan generators and a honey bucket; an operable M-29C weasel with fuel, and an 18-foot seaworthy navy dory made up the rest of the camp facilities. The intent was to provide year-round livable (except food and sleeping bags) working conditions and encouragement for scientists to study the 520-square mile, relatively shallow (max. 18-20 feet), subject to severe storms, lake, known as a focal point for capture (clubbing) of molting waterfowl, area for year-round resident reinbou, unknown fish species, including capture of tentatively-identified sturgeon, and shoreline migration. Many scientists often spend 90 percent of their effort in such camps just taking care of existing.

The entire camp layout was moved a short distance to near a small stream emptying into Teshekpuk Lake on 15 May 1964 . The wanigan (cabin on skids or runners) was sturdily constructed and the dory was seaworthy (heavy), and thus should have been subjected mainly to the vicissitudes of nature and the proclivities of man.

Regards,

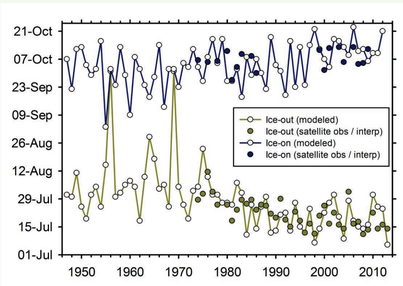
Max C. Brewer

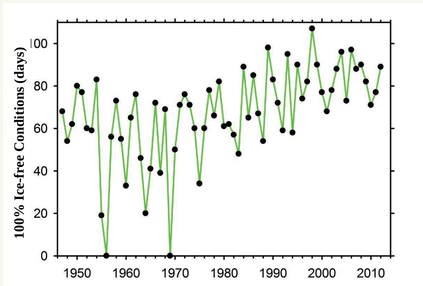
Former NARL Director

The research station has been outfitted to accommodate six researchers comfortably. There is a cooking area and sleeping area in the main cabin. The shed has been converted to a communications building providing a satellite-based internet connection. The system is powered by solar panels and wind turbines and is capable of supporting daily camp activities. Access to the remote station is via air charter in the summer and snowmachine in the winter.

Reconstructing Changes using Short and Long-Term Archives

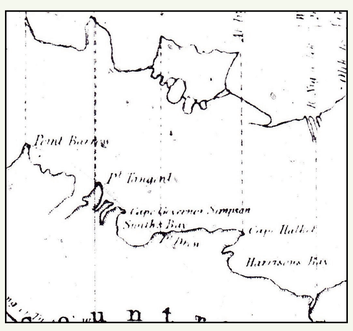
Ice Cover Duration - 1947 to 2012



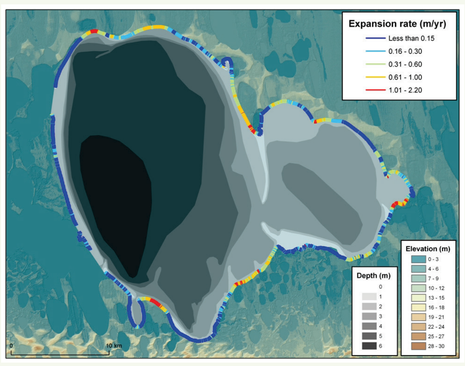


Ice-off and ice-on was determined using a variety of remotely sensed imagery from the satellite image archive. Data are displayed as the mid-point between images bracketing changes in complete ice cover conditions. Simple models are being developed using climate data from Barrow, AK and calibrated satellite image observations to estimate ice cover conditions back to the late 1940s.

Evolution of Teshekpuk Lake since the 1800s?



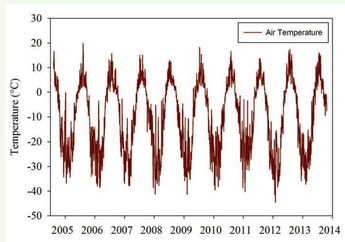
The first available map of Teshekpuk Lake dates to the early 1800s. The top map shows the Beaufort Sea coast and Teshekpuk Lake drawn as three separate basins by a native Alaskan Elder. The bottom map shows the good agreement between the native map and a map drawn of the coastline by British Explorers (Simpson, 1843).



Teshekpuk Lake is surrounded by bluffs with permafrost that contains varying amounts of ground-ice. Typically, lake expansion rates have been highest where ice content is greatest. The mean annual expansion rate between 1955 and 2002 was 0.30 m/yr based on delineation of the bluffline in aerial photography in both time periods. Changes in lake morphometry have likely been influenced by the degradation of permafrost as well as fluctuations in water level during the past two hundred years.

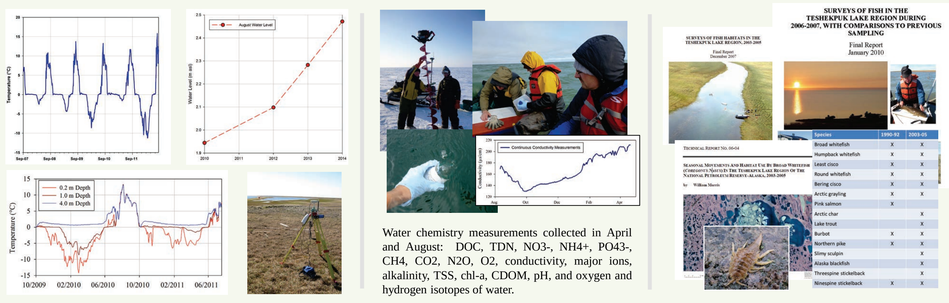
Developing the Observation Network and Collection of Baseline Datasets

Meteorological Observations



A meteorological station has been in operation since 2004. The station measures air temperature, precipitation, wind speed and direction, incoming and reflected radiation, pressure, snow, and soil moisture (Urban and Clow, 2013).

Lake Physical, Chemical, and Biological Data Collection



Water chemistry measurements collected in April and August: DOC, TDN, NO3-, NH4+, PO43-, CH4, CO2, N2O, O2, conductivity, major ions, alkalinity, TSS, chl-a, CDOM, pH, and oxygen and hydrogen isotopes of water.

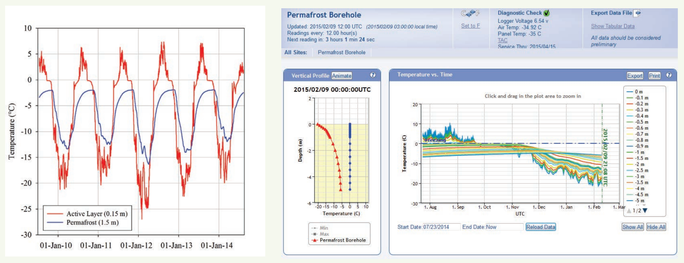
Hourly surface and bed water temperature observations have been made since 2007, water levels have been monitored since 2010, spring and summer water chemistry data have been collected since 2012, and reconnaissance-level biological surveys were conducted in the 1990s and 2000s (Morris, 2006; Moulton et al., 2007). A near-real time data buoy will be deployed in the summer of 2015 to measure water temperature, water level, and atmospheric conditions.

Time-Lapse Camera Observations

Breakup - 2013 Freezeup - 2013

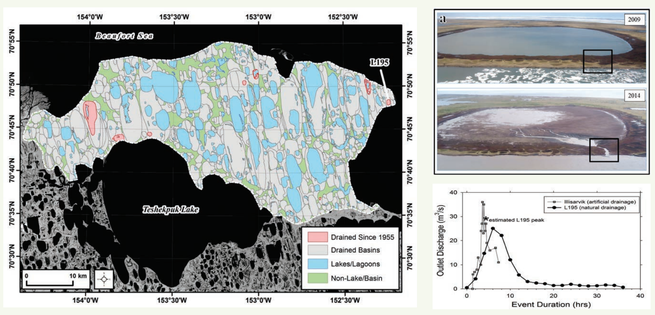
A remote, time-lapse camera network has been in operation since 2011 and is being used to make seasonal and annual observations of lake ice and snow cover. Near-real time observations are available on the TLO webpage between April and November.

Near-Surface Ground Temperature Data



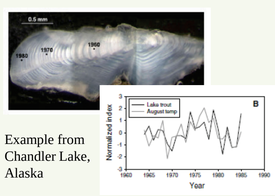
Ground temperature data has been measured in the active layer (0.15 m) and permafrost (1.5 m) between 2009 and 2014 (Left). A recently deployed near-real time data logger measures ground temperature at 0.1 m increments down to 1 m and 0.5 m increments down to 5 m (Right).

Regional Thermokarst Lake Dynamics



The Teshekpuk Lake region is an ideal location to study short term and long term dynamics associated with thermokarst lake formation, expansion, and drainage. Thermokarst lakes cover 22% and drained thermokarst lake basins cover 62% of the ice-rich permafrost terrain north of Teshekpuk Lake. During July 2014, a natural catastrophic lake drainage event was observed in the region using *in situ* observations (Jones and Arp, 2015).

Reconstructing Temperature using Lake Trout



Example from Chandler Lake, Alaska

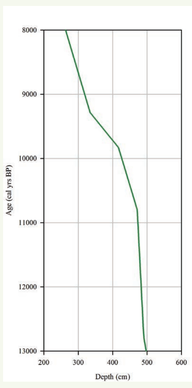
Black et al. 2013

Christian Zimmerman (USGS) and Eric Torvinen (UAF Masters Student)

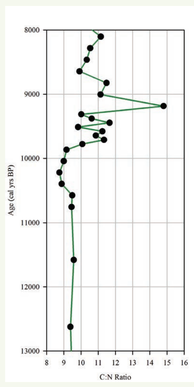
Long-lived lake trout have been documented in Teshekpuk Lake. Recent research on lake trout in a Brooks Range, Alaska lake indicate a relation between growth, as recorded in their otoliths, and late summer temperature conditions (Black et al., 2013). A lake trout growth chronology will be developed for Teshekpuk Lake and the surrounding region and compared to available air temperature data from nearby climate stations as well as temperature data collected from lake monitoring buoys over the past decade. These comparisons will potentially allow us to reconstruct past lake conditions as well as the response of lake trout to climate.

Collecting and Analyzing Lake Sediment and Peat Cores

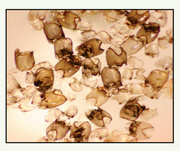
~13,000 Year Lake Sediment Record



Preliminary chronology for a portion of a 5 m long lake core collected in April 2010

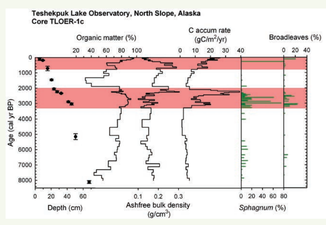


Changes in C:N ratio likely reflect changes in organic matter source inputs



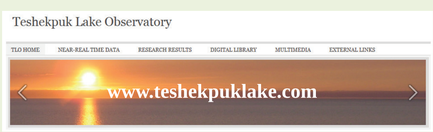
Using chironomid head capsules to reconstruct temperature

~8,000 Year Peat Core Record



Potentially indicates the impact of sea ice loss on regional ecosystem dynamics

For Additional Information, Please Visit:



Or contact: bjones@usgs.gov