

5. Federal Arctic Observing Activities: Today

To describe current Federal Arctic observing activities, this section is organized according to the SEARCH Implementation Plan (SEARCH, 2005) categories: Atmosphere; Ocean and Sea Ice; Hydrology and Cryosphere; Terrestrial Ecosystems; Human Dimensions; Paleoenvironment; and Data and Information Management. Each subsection includes a general description of each agency's activities, maps of observing sites, a list of Web links for data and information sources, and other useful links.

As America's Arctic state, Alaska can play an important role as an AON partner and contributor. Relevant observing activities of State of Alaska and local government agencies are described in Appendix 2. The USGS has significant Earth Science (earthquakes, volcanoes, geomagnetism) observing activities in Alaska. Though not directly related to SEARCH, these activities are described in Appendix 3.

a. Atmosphere

Land- and space-based observations of the Arctic atmosphere are made by numerous Federal agencies. The NASA satellite constellation is illustrated in Figure 13, and the observing sites at the Earth's surface are illustrated in Figures 13, 14, 15 and 16 at the end of this section. In addition to land-based observing activities, the NOAA Marine Observational Programs monitor atmospheric variables along the near-shore and oceanic waterways.

The NOAA focus is on data to support weather forecasts, monitor atmospheric constituents that change the radiative balance of the atmosphere, and contribute to other climate products and services. The Federal Aviation Administration (FAA) also supports the acquisition of weather data. The DOE focus is on analysis of cloud and radiative processes to improve climate models. National Park Service (NPS) atmosphere observing activities focus on air quality, including aerosols, chemistry, contaminants and ultraviolet radiation. A large inter-agency group

consisting of the Bureau of Indian Affairs (BIA), Bureau of Land Management (BLM), NPS, US Fish and Wildlife Service (USFWS), and US Forest Service (USFS) maintains a Remote Automated Weather Station (RAWS) network in Alaska for monitoring air quality, rating fire danger and research applications. NSF objectives are improved understanding of climate processes and development of new technologies and approaches for observing.

The NOAA and FAA land-based and marine weather observations are considered "operational" and are performed continuously and reliably to support weather forecasts that are updated every 6 hours or more often as conditions warrant. The primary observing systems include ASOS (Automated Surface Observing System), weather radars, radiosondes and wind profilers. All of the other observations fall into the "research" category, with variable periods of observation, and without a specific requirement to support a forecast or other product. NOAA's newest network in Alaska, the Climate Reference Network (CRN), is designed to measure a few key climate variables with very high quality and reliability, and report data in real-time; it is still classified as a research system at this time.

A highlight of the research observations is a network of atmospheric observatories whose results have greatest applicability to climate-scale processes. NOAA, DOE and NSF are supporting observations and data analysis at Barrow, Alaska. The NOAA facility collects data primarily on trace gases and aerosols and also hosts a number of visiting activities supported by NSF and other agencies. NOAA, NSF and Canadian agencies are supporting similar observations and analysis at Eureka and Alert in Nunavut, Canada. The DOE ARM Climate Research Facility (ACRF) site at Barrow extends south to the vicinity of *Atqasuk* and collects cloud, aerosol and radiation data continuously, and reports data in near real-time. The ACRF is a national user facility that provides logistics support to national and international users

for ground-based and aerial measurements in support of short-term field campaigns or long-term guest instrument deployment at the Barrow and Atkasuk sites and/or adjacent Arctic and ocean areas. NASA and NSF support the Greenland Climate Network (GC-Net), a series of automatic weather stations that monitor conditions on the ice sheet.

At Tiksi in Yakutia, Russia, NOAA, NSF and Russian agencies are developing an observatory to match the efforts at Eureka and Alert. NSF and NOAA operate the Summit, Greenland, Observatory that is occupied year round (NASA has a small atmospheric aerosol monitoring program at Summit). Together, these and a few observatories operated by other countries constitute a network called “International Arctic Systems for Observing the Atmosphere” (IASOA), a network developed for the International Polar Year. A primary objective of this network is to provide high quality data that can serve to validate satellite observations and model outputs, as well as provide new insights for understanding how the Arctic atmosphere operates.

The Minerals Management Service (MMS), in cooperation with the University of Alaska Fairbanks, maintains meteorological stations on barrier islands along the Beaufort Sea coast, and collects and synthesizes wind time-series data from other North Slope stations into compatible data sets as part of its Beaufort Sea observations. These coastal stations contribute to the planned larger network of operational observing stations that will span the entire North Slope. The MMS atmospheric science program component includes integration of the empirical data in the development and testing of mesoscale forecast models that will provide wind fields across the Beaufort Sea and a portion of the Chukchi Sea.

NPS monitors aerosols at Denali National Park and Preserve (DNPP) to calculate and track visibility trends (1988 to present). The aerosol program is part of the Interagency Monitoring of Protected Visual Environments (IMPROVE) network. Wet deposition has been monitored at DNPP (Site ID AK03) since 1980 as part of the National Atmospheric Deposition Program/National Trends Network (NADP/NTN). In order to estimate dry deposition at DNPP (Site DEN417), weekly concentrations of

sulfur and nitrogen compounds have been measured since 1998 as part of the Clean Air Status and Trends Networks (CASTNet). UV-B radiation has been monitored at DNPP since 1997 as part of the EPA UV-B Monitoring Program. The NPS Western Airborne Contaminants Assessment Project (WACAP) is currently evaluating water, snow, sediments, willow bark, fish, and moose tissue in a number of western US and Alaska national parks, including DNPP, for the presence of metals (including mercury) and organic compounds.

NSF is contributing to the development of atmosphere observing activities that are driven by science questions that underline the need for long-term observations that enable SEARCH by measuring changes occurring in the Arctic. NSF AON projects include: core atmospheric measurements at Summit, Greenland; UV spectral irradiance monitoring at Barrow, Alaska, and Summit; development of data products from the high spectral resolution lidar at Eureka, Canada; surface and satellite measurements of clouds across the Arctic Basin; lidar studies of pan-Arctic coupling of tropospheric, stratospheric and mesospheric circulation; development of atmospheric chemistry sensors for deployment on sea ice floes; halogen chemistry and *ocean-atmosphere-sea ice-snowpack (OASIS) chemical exchange*.

Both NOAA and NASA operate satellites with coverage of the Arctic region. The major observations and products are:

1. Daily, near real-time plots of surface, cloud, and radiative properties from AVHRR;
2. Near real-time MODIS and AVHRR polar winds;
3. Daily, near real-time plots of clear sky, low-level temperature inversions from MODIS;
4. Daily profile plots of Arctic temperature, humidity and winds;
5. Near-daily plots of surface winds over open water; and
6. Surface temperatures for land, sea and sea ice.

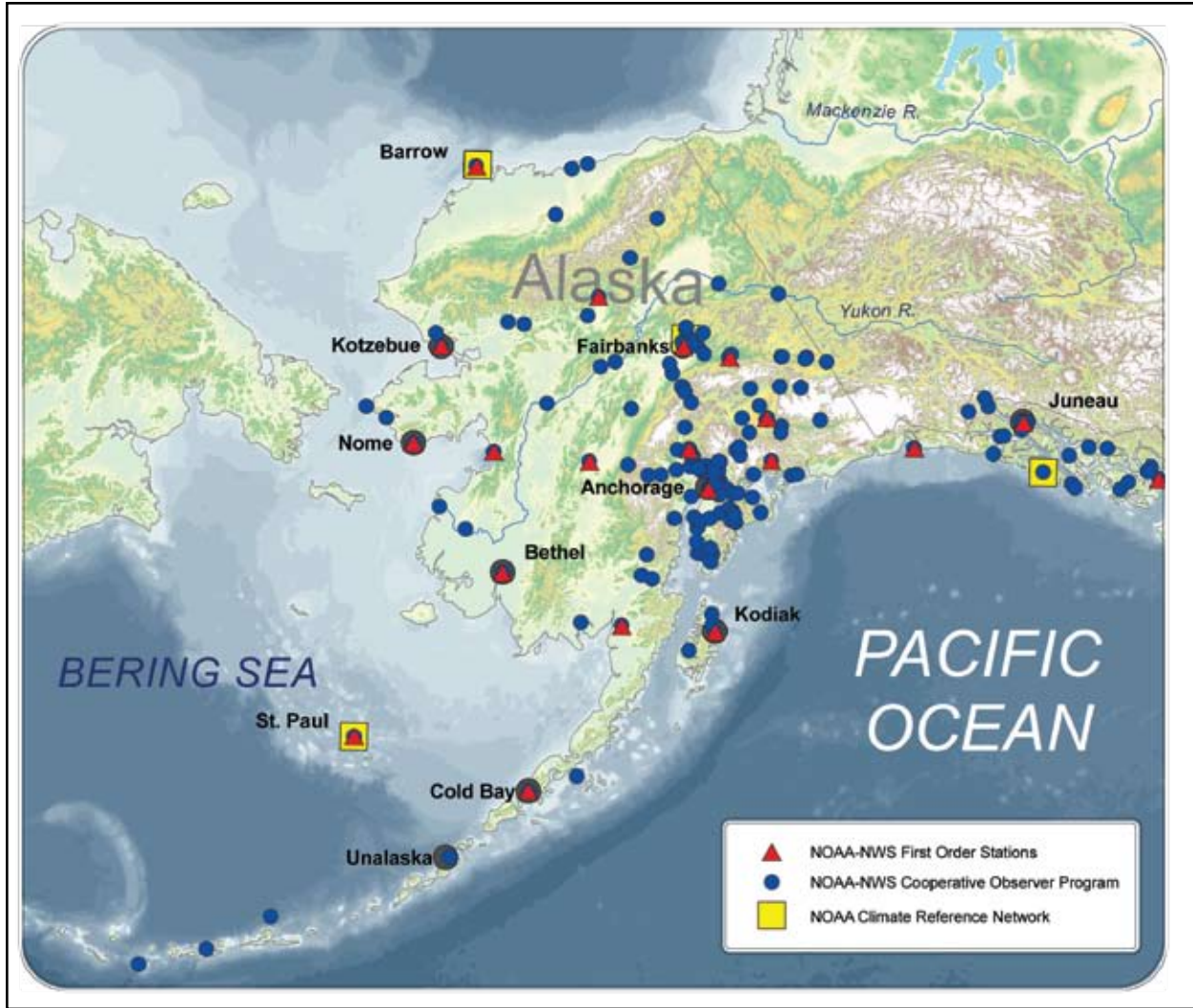


Figure 14. Location of NOAA-NWS first-order weather stations and Cooperative Observer Program participants, and NOAA CRN sites in Alaska. The Cooperative Observer Program locations are those that reported in FY07 (October 2006 – September 2007).

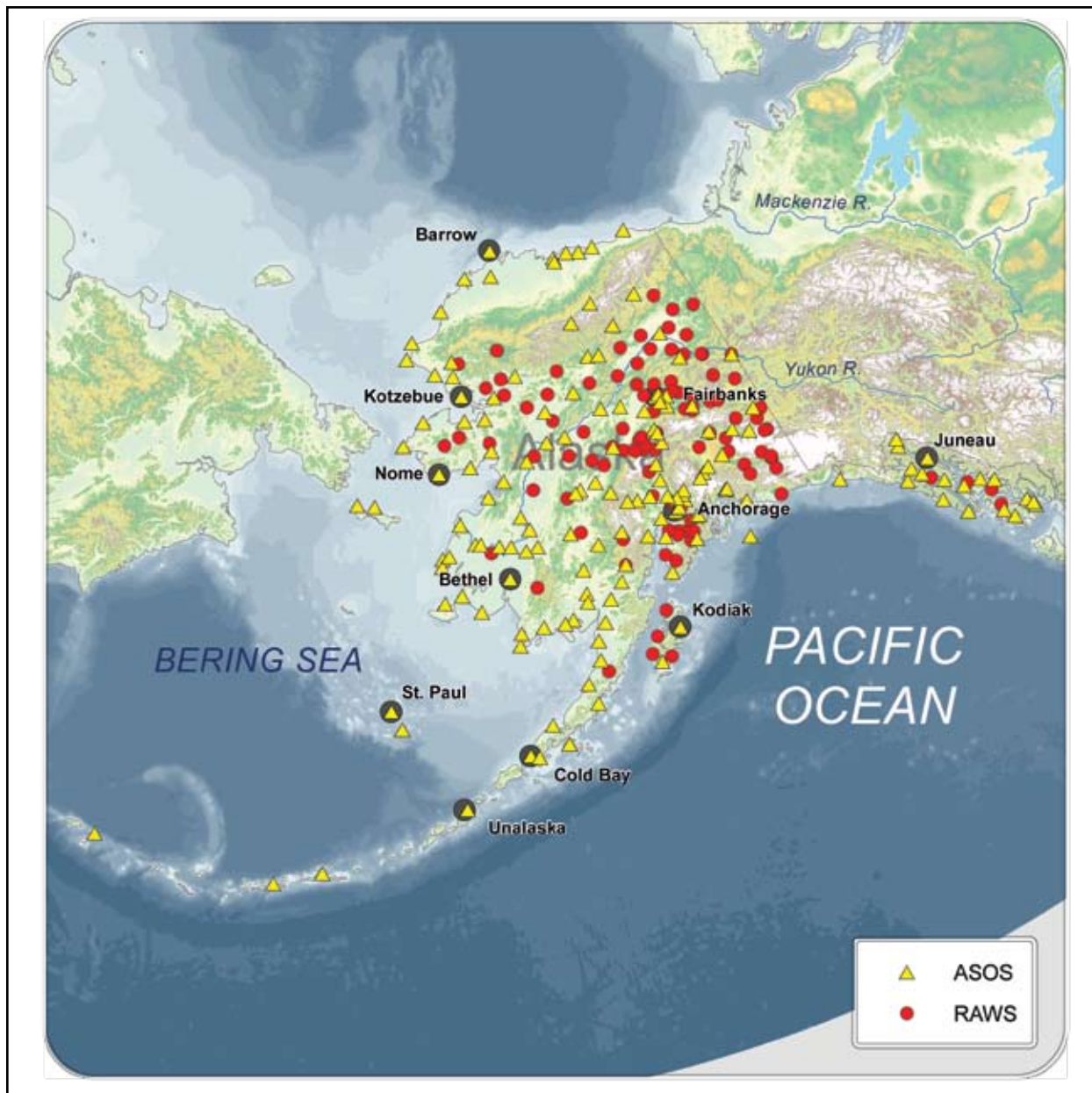


Figure 15. Location of automated weather stations in Alaska. ASOS includes equipment supplied and maintained by NWS, FAA, US Air Force, US Army and corporations. The RAWS program is supported by BIA, BLM, NPS, USFS and USFWS.

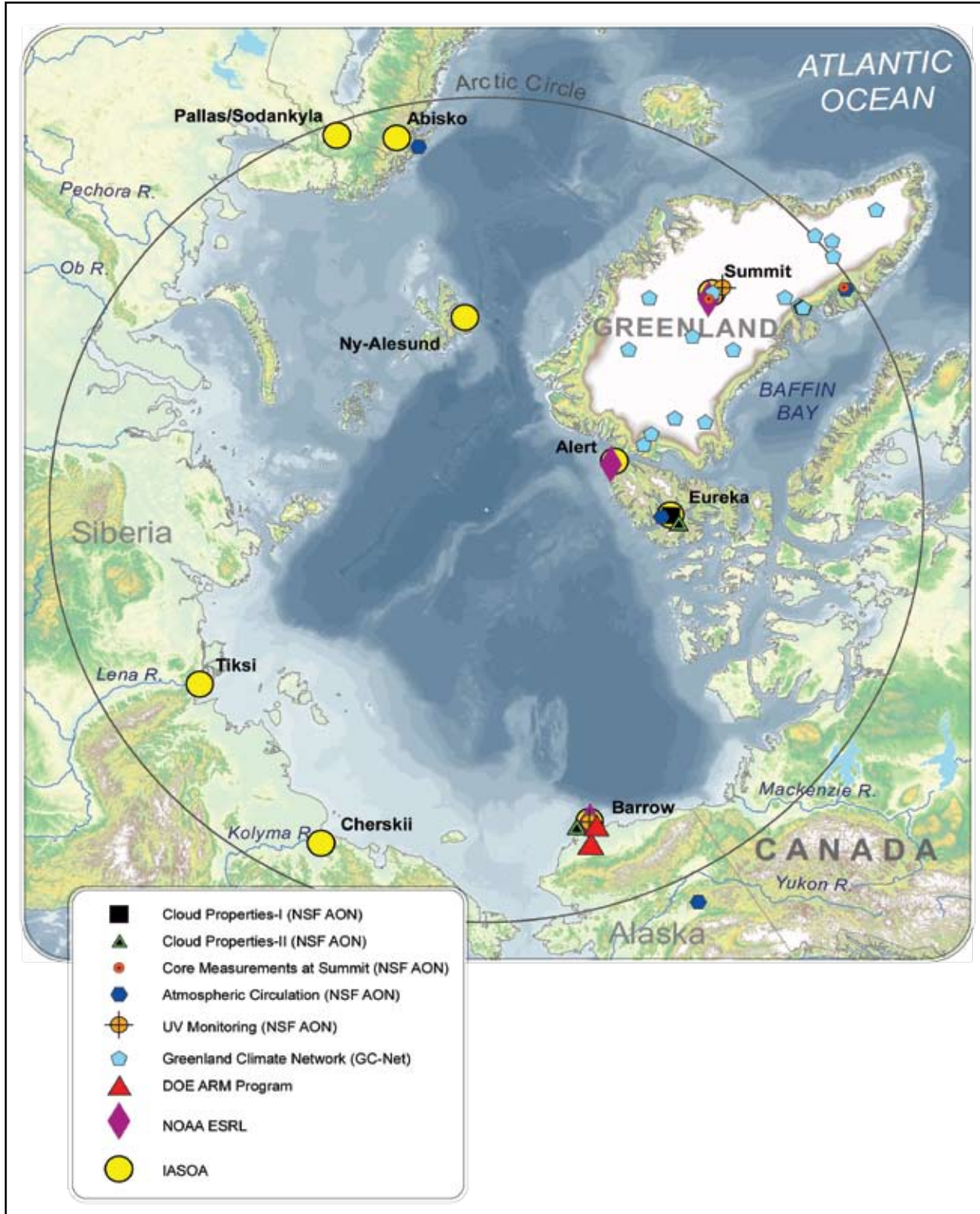


Figure 16. Location of circum-Arctic atmosphere observing sites.

Data and Information Management

Atmosphere data and information are available at the following Web sites:

Alaska Ocean Observing System

ASOS: http://ak.aos.org/op/data.php?region=AK&name=met_awos

RAWS: http://ak.aos.org/op/data.php?region=AK&name=met_raws

Denali National Park and Preserve, Air Quality

<http://www2.nature.nps.gov/air/Permits/ARIS/denal/>

DOE Atmospheric Radiation Measurement Program

<http://www.arm.gov/data/>

Greenland Climate Network (GC-Net)

<http://cires.colorado.edu/science/groups/steffen/gcnet/order/admin/station.php>

NASA Goddard Earth Sciences Data and Information Services Center

<http://daac.gsfc.nasa.gov/>

NASA MODIS Level 1 and Atmosphere Archive and Distribution System

<http://ladsweb.nascom.nasa.gov/>

NASA Atmospheric Science Data Center

<http://eosweb.larc.nasa.gov/>

NOAA Climate Reference Network

<http://www.ncdc.noaa.gov/oa/climate/uscrn/>

NOAA ESRL Global Monitoring Division

Data products

<http://www.esrl.noaa.gov/gmd/dv/>

Data archive

<http://esrl.noaa.gov/gmd/dv/ftpdata.html>

NOAA National Climatic Data Center

<http://www.ncdc.noaa.gov/oa/ncdc.html>

NSF UV Monitoring Network

<http://www.biospherical.com/nsf/login/login.asp>

Polar Satellite Meteorology and Climatology at the Cooperative Institute for Meteorological Satellite Studies,
University of Wisconsin, Madison

<http://stratus.ssec.wisc.edu/>

Remote Automated Weather Stations – Alaska

<http://www.raws.dri.edu/wraws/akF.html>

Arctic Research of the United States

NASA Goddard Earth Sciences Data and Information Services Center

<http://daac.gsfc.nasa.gov/>

NASA MODIS Level 1 and Atmosphere Archive and Distribution System

<http://ladsweb.nascom.nasa.gov/>

NASA Atmospheric Science Data Center

<http://eosweb.larc.nasa.gov/>

National Snow and Ice Data Center (NSIDC)

<http://nsidc.org/>

Other Useful Links

Alaska Climate Research Center

<http://climate.gi.alaska.edu/>

Alaska State Climate Center

<http://climate.uaa.alaska.edu/>

International Arctic Systems for Observing the Atmosphere

<http://iasoa.org/iasoa/>

MMS Beaufort Sea Meteorological Study

<http://mms-meso.gi.alaska.edu>

NSF UV Monitoring Network

Barrow

<http://www.biospherical.com/nsf/barrow/barrow.asp>

Summit

<http://www.biospherical.com/nsf/summit/summit.asp>

NOAA ESRL Global Monitoring Division, Barrow

<http://esrl.noaa.gov/gmd/obop/brw.html>

NOAA National Weather Service Alaska Region Headquarters

<http://www.arh.noaa.gov>

OASIS, Ocean-Atmosphere-Sea Ice-Snowpack

<http://www.oasishome.net/>

Remote Automated Weather Stations

<http://www.fs.fed.us/raws/>

Summit, Greenland

<http://www.summitcamp.org/>

b. Ocean and Sea Ice

In the SEARCH Implementation Plan, ocean and sea ice observing includes marine ecosystems (ocean and ice), as well as the physical characteristics of the ocean and ice. Ocean and sea ice observations are currently being made by several agencies, including the US Coast Guard (USCG), within the Department of Homeland Security; the Department of Defense, the Department of Interior (DOI MMS); NASA, NOAA and NSF. Ocean and sea ice observing activities are illustrated in Figures 17, 18, 19 and 20 at the end of this section.

The USCG contributes to ocean and sea ice observations through a number of activities. First, USCG supports Arctic research through its icebreaking operations. Assets include three polar class icebreakers, of which HEALY operates in the Arctic, POLAR SEA has recently completed drydock work, and POLAR STAR is in caretaker status pending an Administration decision on how the US can best meet polar icebreaking requirements.

USCG carries out the annual International Ice Patrol (IIP). The activities of the IIP are governed by treaty and US law to encompass only those ice regions of the North Atlantic Ocean through which the major trans-Atlantic shipping lanes pass. There remain other areas of ice danger where shipping must exercise extreme caution. Information concerning ice conditions is collected primarily by air surveillance flights and from ships operating in the ice area. All iceberg data, together with ocean current and wind data, are entered into a computer model that predicts iceberg drift. Every 12 hours, the predicted iceberg locations are used to estimate the limit of all known ice. This limit, along with a few of the more critical predicted iceberg locations, is broadcast as an "Ice Bulletin" from radio stations around the US, Canada, Europe and over the Worldwide Web for the benefit of all vessels crossing the north Atlantic. In addition to the Ice Bulletin, a radio facsimile chart of the area, depicting the limits of all known ice, is broadcast twice daily.

USCG has begun the Arctic Domain Awareness (ADA) program to prepare for increased maritime activity as climate changes provide greater access to

the Arctic. Understanding the Arctic Maritime Domain is part of a DOD and DHS effort to improve Maritime Domain Awareness (MDA) by developing an effective understanding of the global maritime domain and supporting effective decision-making as outlined in the National Strategy for Maritime Security. MDA includes both environmental conditions and human activities that could affect maritime safety, security, the economy or environment. As MDA is expanded to the Arctic, there are likely overlaps in resource needs and sensors that could apply to both MDA/ADA and AON, and coordination of their activities will be mutually beneficial.

The IIP works closely with the National Ice Center (NIC), a multi-agency operational center operated by the US Navy, NASA, NOAA and the USCG. The NIC mission is to provide the highest quality strategic and tactical ice services tailored to meet the operational requirements of Federal agencies. The NIC also coordinates and represents the many funding agencies and partners of the US Interagency Arctic Buoy Program (IABP). NIC also funds the coordinator of the program, and NSF supports IABP data management and coordination at the University of Washington. US buoy contributions to the IABP are funded by NOAA and the Office of Naval Research (ONR). NSF supports the fabrication and deployment of drifting ice mass balance buoys by the Cold Regions Research and Engineering Laboratory (CRREL), US Army Corps of Engineers.

The Department of Defense (US Submarine Force, ONR, and Arctic Submarine Laboratory) and NSF have been supporting the Submarine Arctic Science Program (SCICEX). The overall goal of SCICEX, now in its second phase, is to improve understanding of Arctic Ocean processes and their role in the earth's climate system. This is accomplished by dual use of nuclear submarines, capitalizing on existing national platform capabilities and planned submarine missions, to mutually support the objectives of both the civilian science and military communities. The primary focus of the accommodation cruises is to collect baseline data, providing continued monitoring of evolving oceanographic and seafloor conditions, ice distribution, and contaminant concentrations in the Arctic Ocean. All data collected as part of SCICEX are made publicly available as soon as possible after collection.

MMS Arctic research program observing activities complement AON and SEARCH. Historical data from the 1970s through the 1990s have been digitized and compiled into a sea ice atlas. Using satellite imagery and field data, MMS is characterizing the recurrence of spring leads and landfast ice in the Beaufort and Chukchi Seas, and the overflow phenomenon on Beaufort Sea nearshore landfast ice. Also, MMS has partnered with NASA and ONR to improve sea-ice modeling to accurately depict ice lead openings and the range of ice thickness one that might be encountered.

MMS continues to observe ocean circulation, principally in the nearshore Beaufort and Chukchi seas. Deployment of HF radar through a National Ocean Planning Partnership (NOPP) with NOAA to map nearshore circulation provides the groundwork for future continued activity. Instrumented moorings deployed in the nearshore Beaufort Sea are obtaining current, temperature and salinity information in the landfast ice zone to quantify the magnitude of current variability and describe the relationship between currents and local winds. These observations will be extended to the nearshore Chukchi in the future, and have already been expanded to the offshore shelf region through joint funding with ONR and NSF under the 2007 NOPP program on “Coastal Effects of a Diminished-Ice Arctic Ocean”. By using field observation data for model assimilation, MMS model development considers long-term hindcast data for oil-spill risk assessment.

MMS is currently sponsoring monitoring of living marine resources including marine mammals (bowhead whale, right whale, polar bear, ringed seal) marine birds (loons, eiders) and marine fishes. Field surveys broadly describe population, distribution and abundance, and reproduction and health. Much of the research is undertaken in collaboration with federal partners including NOAA and USGS.

NASA satellites (Figure 13) and numerous instruments provide high accuracy, stable, circum-Arctic measurements for ocean and sea ice observing, including surface vector winds over the ice-free

ocean, sea surface temperature, marine phytoplankton and sea ice temperature. The NASA satellites and ocean and sea ice data sets include:

1. Passive microwave time series of sea ice extent begin in 1978 and are archived at NSIDC.
2. The major Synthetic Aperture Radar (SAR) time series is from the Canadian RADARSAT satellite launched in 1995. RADARSAT data of the Arctic Ocean are processed by the RGPS (RADARSAT Geophysical Processing System, yielding high-resolution charts of ice motion, age/thickness and deformation. All RGPS data are archived at the NASA-supported Alaska Satellite Facility (ASF), University of Alaska Fairbanks.
3. GRACE is a joint NASA/German mission that measures the changes in gravity associated with the changing mass of the ocean, land, and ice sheets. In experimental measurements, GRACE has measured the changes of mass associated with the shift of ocean currents in the Arctic Ocean.
4. The ICESat satellite is in a high latitude orbit (86°N) and can determine the free surface height of the Arctic Ocean up to that latitude. These laser measurements can be used to determine the geostrophic flow. ICESat also measures the height of the snow/air interface of the sea ice, which can be used to estimate sea ice thickness when combined with other data, e.g., snowfall and ice motion, or radar altimeter measurements of the sea ice freeboard.
5. Sea surface temperature (SST) and ice surface temperature (IST) are measured by NASA with the MODIS instrument aboard the Aqua and Terra satellites. The AMSR-E instrument on Aqua measures all-weather sea surface temperature. The follow-on instrument to MODIS is the Visible Infrared Imaging Radiometer Suite (VIIRS), scheduled for launch in 2010 on NPP (NPOESS Preparatory Project). The NPP follow-on satellite is the NPOESS (National Polar-orbiting Environmental Satellite System) series beginning in 2013.
6. Satellite-derived ocean color is used in combination with environmental data to provide primary productivity. NASA currently provides ocean color from observations taken by the MODIS instrument on Aqua. Under present plans, the

MODIS replacement is VIIRS on the NPP and NPOESS satellites. Because VIIRS on NPP is not expected to yield the same high quality of ocean color measurements as MODIS, there may be a gap in the high accuracy of these measurements.

Current NOAA Arctic Ocean observations include the following external-grant funded programs: the deployment of the IABP's buoys (funded by the NOAA Climate Program Office and NIC, see below); Ice Mass balance buoys (through CRREL, Department of Defense); deployment of eight moorings across the Bering Strait (NOAA's Climate Office together with NSF and Russian Agencies and Institutions); and RUSALCA (Russian-American Long-term Census of the Arctic) Ecosystem Census and oceanographic change in the Chukchi Sea and Bering Strait region, (NOAA Climate Office, Ocean Exploration, and Russian Agencies). The goals of the latter include: quantify oceanic throughflow from the Pacific to the Arctic via the Bering Strait, including fluxes of volume, heat, freshwater, nutrients and chlorophyll biomass; quantify change in the throughflow; design an optimum monitoring system for the Bering Strait throughflow; and to understand ecosystems changes in this region as a function of climate change. NSF also supports the RUSALCA Bering Strait mooring program.

The NOAA Office of Ocean Exploration has carried out baseline observations in the Arctic which have contributed significantly to the Census of Arctic Marine Life in the Canada Basin in 2002 and 2005, and with the RUSALCA program in 2004 in the Chukchi Sea. These data are fundamental to long term monitoring of Arctic ecosystems (including many formerly unknown species), which are being subjected to climate change and a dramatic loss of sea ice cover.

The Alaska Fisheries Science Center (AFSC), under NOAA's National Marine Fisheries Service (NMFS) is responsible for the development and implementation of NOAA's scientific research on living marine resources in Alaskan waters. Research addresses more than 250 fish and 42 marine mammal stocks distributed on the US continental shelf and in adjacent pelagic waters. Twenty-seven commercially-important

fish and crab stocks are assessed annually. The study of the effects of climate change on marine resources evidenced by loss of sea ice and ocean acidification in the Bering and Chukchi seas is a key research area.

The AFSC leads a suite of fisheries research and assessment cruises in the Gulf of Alaska, Aleutian Islands and Bering Sea, which include:

1. Annual eastern Bering Sea shelf bottom trawl survey
2. Biennial (even number years) survey, eastern Bering Sea
3. Biennial (even number years) bottom trawl survey, Aleutian Islands
4. Biennial (even number years) summer Pollock survey, eastern Bering Sea shelf
5. Annual winter Aleutian basin Pollock survey
6. Annual winter Shumagin Islands Sanak Trough Pollock survey
7. Annual winter Shelikof Strait Pollock survey
8. Annual sable fish longline survey
9. Bering-Aleutian Salmon International Survey extended to the Chukchi Sea and the Eastern Bering Sea Shelf (BASIS).

BASIS is a gridded fisheries oceanography survey that includes CTD and NPZ observations in addition to catches from epipelagic (0-20m) trawls. The AFSC is expanding marine fish survey effort in the Arctic Ocean, including:

1. Beaufort Sea Marine Fish Survey planned for August 2008, a cooperative project of NOAA, UA, UW and MMS (providing funding);
2. Inter-tidal and sub-tidal Marine Fish and Habitat ("ShoreZone") Surveys near Point Barrow (Beaufort and Chukchi Seas) in 2006 and 2008; and
3. Chukchi Sea Marine Fish Survey, an extension of BASIS possible for August 2008, contingent on NOAA ship availability.

In conjunction with these activities, the North Pacific Fishery Management Council (NPMC) is developing a fishery management plan (FMP) for the Arctic. The Council does not currently have a FMP for the Arctic region and the proposed plan would cover Federal marine waters 3-200 nm offshore Alaska in

the Chukchi and Beaufort Seas. If an Arctic FMP is adopted, long-term plans for fisheries surveys will follow. Finally, the AFSC and Alaska Region provide observations of nearshore fish species over the Web via Fish Atlas, with plans to include observing stations occupied by the RUSALCA network, if possible.

FOCI (Fisheries Oceanography Coordinated Investigations) is a joint research program between the NOAA AFSC and the NOAA Pacific Marine Environmental Laboratory PMEL). The goal is to improve understanding of ecosystem dynamics and apply that understanding to the management of marine resources. Much of the information that FOCI collects about the biophysical environment is gathered by oceanographic-biophysical moorings. Mooring sensors include: wind and temperature gauges; sea water temperature sensors; salinity sensors; current, light, nitrate and chlorophyll meters; sediment samplers; and others. Since 2004, autonomous recorders have been included on FOCI moorings on the Bering Sea middle shelf to provide year-round observations of marine mammal calls and underwater ambient noise. Calls of endangered whale species have been detected, in some cases year round. These recorders complement temporary deployments in the Gulf of Alaska and Beaufort Sea, and are part of the nascent Passive Acoustics Ocean Observing System (PAOOS) in development at NOAA Fisheries Office of Science & Technology. When equipped with satellite transmitters, such moorings can relay information about the current environmental state. Moorings such as these are imperative for any program that requires long-term, systematic monitoring of the marine environment in the Arctic.

The NOAA Center for Operational Oceanographic Products and Services (CO-OPS) currently operates 200 permanent National Water Level Observation Network (NWLON) stations with continuous, real-time coastal oceanographic and meteorological data collection throughout the US and island territories. This network provides high quality, long term water level and meteorological data for climate and sea level change monitoring, in addition to validation for satellite sea surface height observations and oceanographic model outputs. There are 28 NWLON stations in Alaska. Continuously operating

stations located in or near the Arctic Circle include Prudhoe Bay (since 1988), Red Dog Mine (since 2003) and Nome (since 1992). CO-OPS has been investing in new methods, state-of-the-art sensor technologies and innovative designs for the harsh polar environment. These include the impending installation of two submerged water level systems offshore of Barrow, Alaska, and two control stations onshore. There is a plan to determine the rate of relative mean sea level change at the Arctic stations; this will complement work already completed elsewhere in NWLON (Zervas, 2001).

The NOAA National Data Buoy Center (NDBC) has three moored buoys in the Bering Sea; measurements include sea level pressure, wave height and period, and surface water temperatures.

NOAA's NWS Weather Forecast Office (WFO) in Fairbanks provides marine forecasts and warnings for northwest Alaska and the Arctic coastal waters. These products and services extend out to 100 nautical miles. The WFO Anchorage Ice Desk produces graphic analyses of sea surface temperatures and sea ice as well as five day sea ice forecasts year round. Scheduled sea ice analyses and 5-day sea ice forecasts are also produced as well as a sea surface temperature chart of Alaskan waters.

NSF is contributing to the development of ocean and sea ice observing activities that are driven by science questions that require long-term observations to meet the research goals of SEARCH. NSF AON projects include: the Seasonal Ice Zone Network (SIZONET); the Arctic Ocean ice mass balance buoy network; ice-tethered profilers to sample upper Arctic Ocean properties and heat/salt fluxes; Arctic Ocean aerial hydrographic surveys; the North Pole Environmental Observatory; the Beaufort Gyre Observing System; the Switchyard project in the waters between the North Pole and Ellesmere Island/Greenland; moorings and sea-gliders in Davis Strait between Baffin Island and Greenland; and moorings in the Bering Strait (with NOAA).

NOAA, NSF and ONR fund the NABOS program, a major initiative involving IARC and international partners (Canada, Germany, Japan, Poland, Russia). It is a long-term program intended to provide a

quantitative, observation-based assessment of circulation, water mass transformations, and transformation mechanisms along the principal pathways transporting water from the Nordic Seas into the central Arctic Basin. The primary monitoring tool of the NABOS program is the series of moorings along the edge of the continental margin from the Barents Sea to the East Siberian Sea. Analysis of NABOS data has already provided evidence that the Arctic Ocean has entered a new warm state, with potential implications for the melting of Arctic sea ice (Figure 3; Polyakov et al., 2007).

NSF and the North Pacific Research Board (NPRB) are partners in the “Bering Sea Ecosystem Study” (BEST) and the “Bering Sea Integrated Ecosystem Research Program”. They will collect large amounts of data over the next few years throughout all levels of the Bering Sea ecosystem. Although they are not observing programs *per se*, the data will be a baseline for the future and perhaps provide guidance for future monitoring efforts, e.g., what ecosystem components are most important to monitor.

The Alaska Ocean Observing System (AOOS) is the umbrella association for multiple regional observing networks (Gulf of Alaska, Bering Sea/Aleutian Islands, Prince William Sound, Cook Inlet, Southeast and Arctic) that are being developed as part of the national Integrated Ocean Observation System (IOOS) under the NOPP and Ocean.US. AOOS began operations in July 2003 with support from university, federal and private partners, as well as several NOAA planning grants. The observing system gathers physical and biological data related to the state of the weather (via weather stations, buoyed weather stations, surface current measurements, ocean moorings, satellite imaging, SAR) and to the state of the marine ecosystem (nutrients, phytoplankton, zooplankton, benthic plants and animals, fishes and shellfishes, aquaculture, marine birds, and marine mammals). Year-round acoustic observations of marine mammals in the Bering Sea are planned for 2008 and beyond via inclusion of autonomous recorders on AOOS moorings.

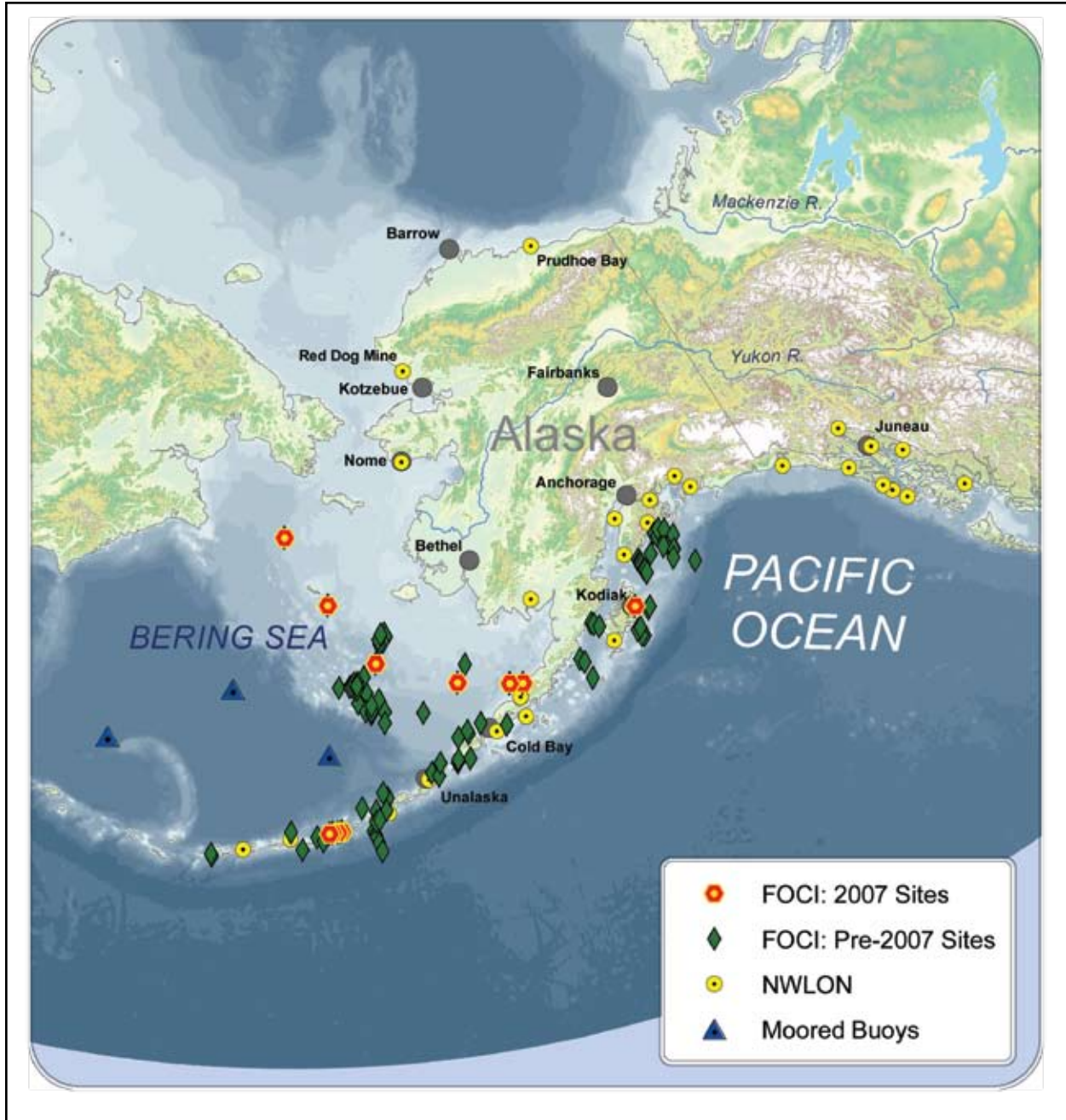


Figure 17. NOAA operational ocean observing activities in Alaska and adjacent waters, including FOCI (Fisheries Oceanography Coordinated Investigations) and NWLON (National Water Level Observation Network).

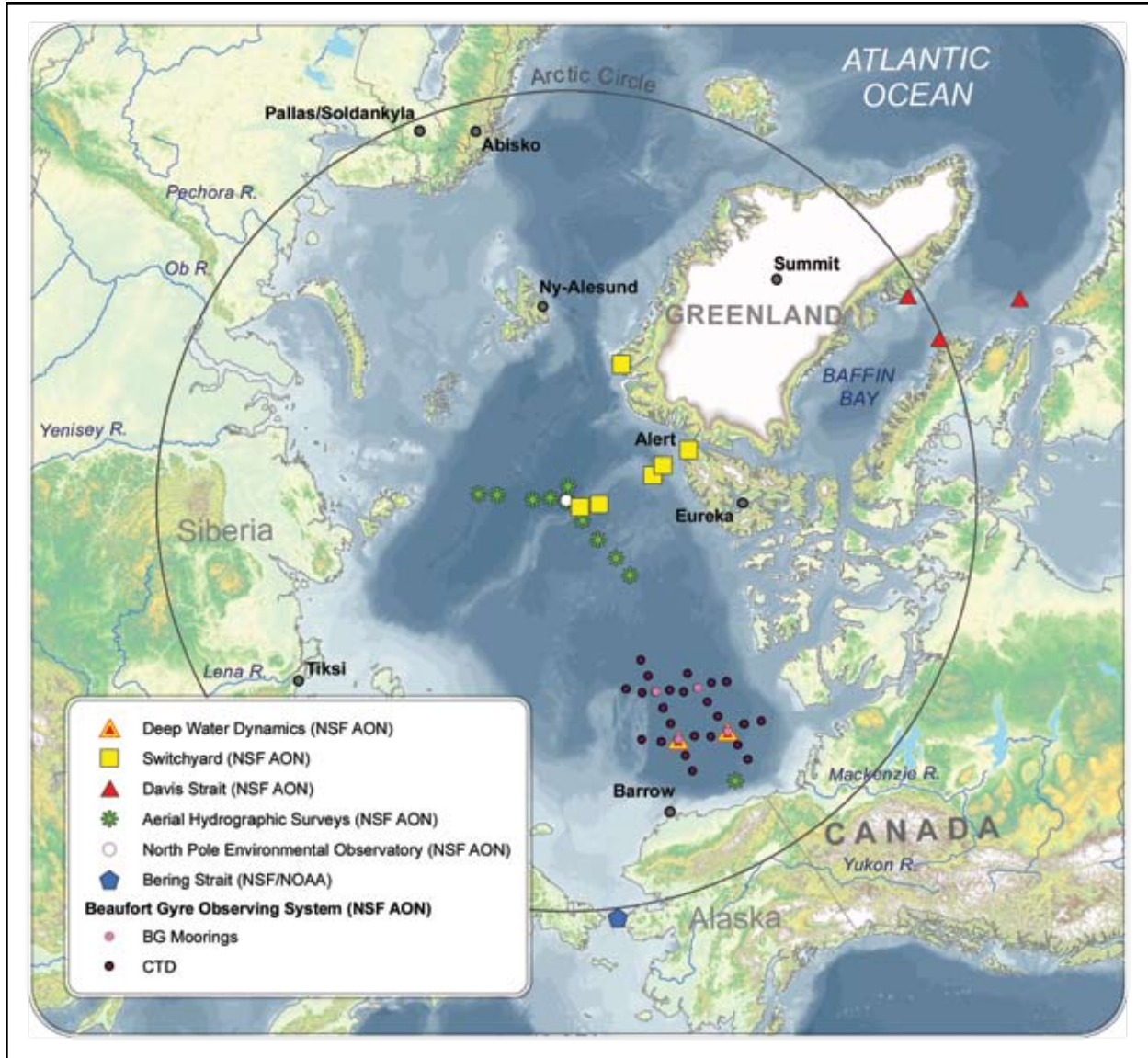


Figure 18. Instrument moorings and hydrographic stations supporting oceanographic investigations in the Arctic Ocean and adjacent seas.

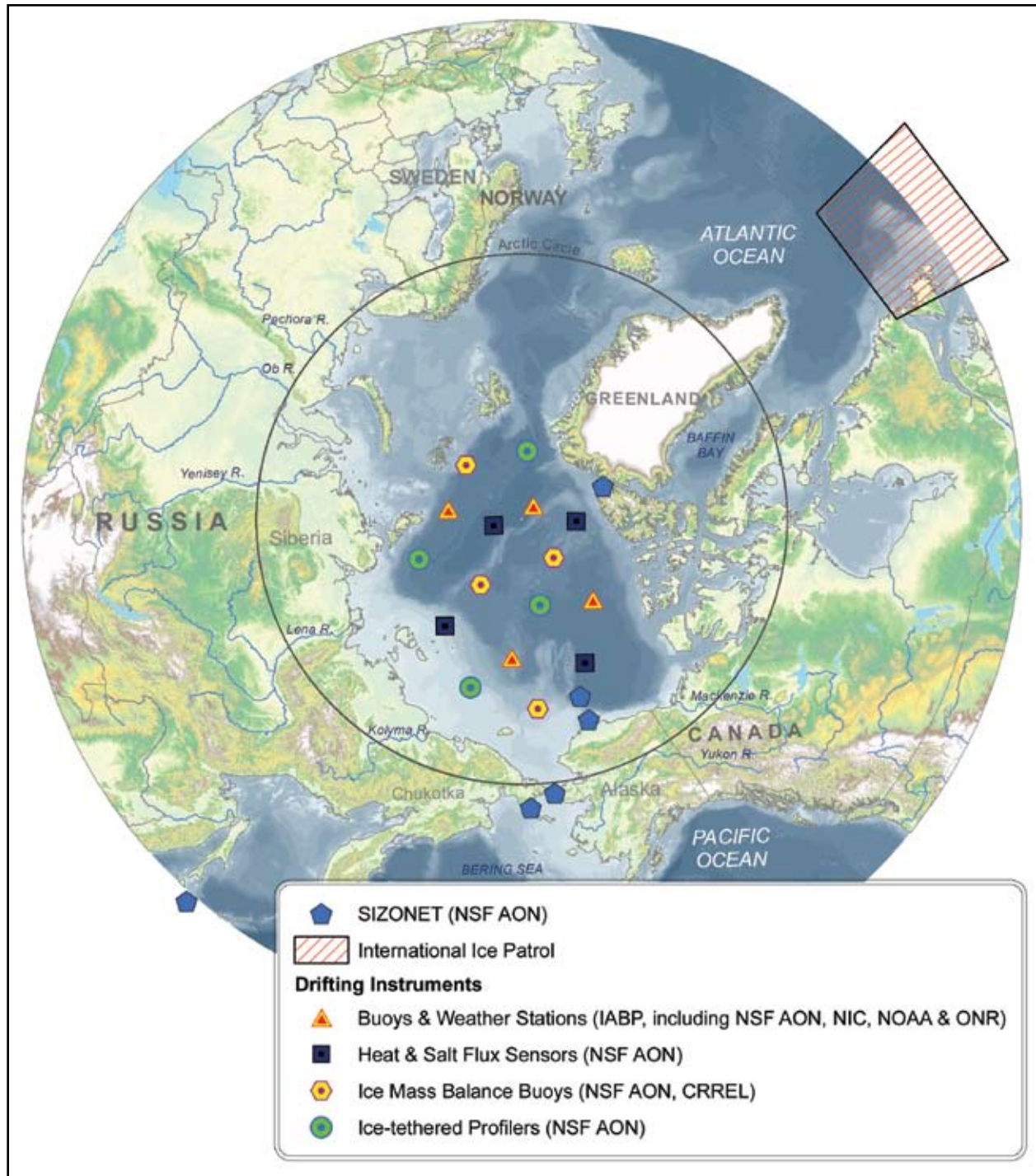


Figure 19. Location of the IIP operations area, the SIZONet, and instruments drifting with the sea ice in the Arctic Ocean. The locations of the drifting instruments are not actual positions; the symbols are intended only to represent the different types of instruments and their broad distribution around the Arctic Basin.



Figure 20. RUSALCA 2004 oceanographic moorings and hydrographic stations in the Chukchi Sea, and the NOAA 2007 Salmon Survey in the northern Bering Sea and the southeastern Chukchi Sea.

Data and Information Management

Ocean and sea ice data and information are available at the following Web sites:

Alaska Ocean Observing System

<http://ak.aos.org/>

Alaska Satellite Facility

<http://www.asf.alaska.edu>

Autonomous Ocean Flux Buoy Program, Naval Postgraduate School

<http://www.oc.nps.navy.mil/~stanton/fluxbuoy/deploy/deploy.html>

Beaufort Gyre Observing System (NSF AON)

<http://www.whoi.edu/beaufortgyre/data.html>

Bering Strait, Pacific Gateway to the Arctic (NSF AON)

<http://psc.apl.washington.edu/HLD/Bstrait/Data/BeringStraitDownloadregister.html>

Cooperative Arctic Data and Information System (NSF AON)

<http://www.eol.ucar.edu/projects/aon-cadis/>

Davis Strait Project, University of Washington (NSF AON)

<http://iop.apl.washington.edu/projects/ds/html/overview.html>

Freshwater Switchyard of the Arctic Ocean (NSF AON)

<http://psc.apl.washington.edu/switchyard/index.html>

International Arctic Buoy Program (NSF AON)

<http://iabp.apl.washington.edu/>

International Ice Patrol

http://www.uscg.mil/lantarea/iip/General/data_archive.shtml

Nansen and Amundsen Basins Observational System (NABOS)

<http://nabos.iarc.uaf.edu/data/registered/main.php>

NASA Ocean Biology Processing Group

<http://oceancolor.gsfc.nasa.gov/>

NASA Physical Oceanography DAAC

<http://podaac-www.jpl.nasa.gov/>

National Ice Center

<http://www.natice.noaa.gov/>

NOAA Alaska Fisheries Science Center

<http://www.afsc.noaa.gov/>

NOAA Fisheries Oceanography Coordinated Investigations (FOCI)

http://www.pmel.noaa.gov/foci/FOCI_data.html

NOAA National Coastal Data Development Center

<http://www.ncddc.noaa.gov/>

NOAA National Data Buoy Center – Alaska

<http://www.ndbc.noaa.gov/maps/Alaska.shtml>

NOAA Nearshore Fish Atlas of Alaska

<http://www.fakr.noaa.gov/habitat/fishatlas/>

NOAA National Ocean Data Center

<http://www.nodc.noaa.gov/>

NOAA Center for Operational Oceanographic Products and Services:

<http://www.tidesandcurrents.noaa.gov/>

NOAA Center for Operational Oceanographic Products and Services, Mean Relative Sea Level Trends, Alaska

http://www.tidesandcurrents.noaa.gov/sltrends/sltrends_states.shtml?region=ak

National Snow and Ice Data Center

<http://www.nsidc.org/>

North Pole Environmental Observatory (NSF AON)

<http://psc.apl.washington.edu/northpole/Data.html>

NASA Ocean Biology Processing Group

<http://oceancolor.gsfc.nasa.gov/>

NASA Physical Oceanography DAAC (Distributed Active Archive Center)

<http://podaac-www.jpl.nasa.gov/>

Other Useful Links

Bering Strait Environmental Observatory

<http://arctic.bio.utk.edu/AEO/>

MMS Alaska Activities

http://mms.gov/alaska/ess/ongoing_studies/ongoing_studies.HTM

NOAA Fisheries Office of Science & Technology (S&T)

<http://www.st.nmfs.noaa.gov>

NOAA National Weather Service Weather Forecast Office Fairbanks

<http://pafg.arb.noaa.gov/>

NOAA National Weather Service Ice Forecast - Alaska

<http://pafc.arb.noaa.gov/ice.php>

North Pacific Fishery Management Council

<http://www.fakr.noaa.gov/npfmc>

RUSALCA: Russian-American Long-term Census of the Arctic

<http://www.arctic.noaa.gov/arol/russian-american/>

c. Hydrology and Cryosphere

For the purpose of this report, hydrology includes the stocks, fluxes and geochemistry of freshwater, including soil moisture, of the Arctic land mass. The cryosphere includes snow, permafrost, lake ice and river ice (freshwater ice), and glaciers and ice sheets. Sea ice observing activities have been described in sub-section b. Ocean and sea ice. Hydrology and cryosphere observing activities are illustrated in Figures 21, 22 and 23 at the end of this section.

DOD, EPA, HHS, NASA, NOAA, NPS, NSF, USDA and USGS currently contribute to Arctic terrestrial hydrology and cryosphere observing. The North Slope Science Initiative (NSSI) - a local, state and federal government partnership that addresses research, inventory and monitoring needs on the North Slope of Alaska) is also contributing to hydrological observation activities.

DOD observing activities related to Arctic terrestrial hydrology and cryosphere focus mainly on permafrost at two facilities maintained by CRREL: the Permafrost Tunnel at Fox, Alaska, and the Permafrost Research Station at Fairbanks, Alaska. The permafrost tunnel is primarily a research facility, where ground temperatures have been monitored continuously since 1963. At the Permafrost Research Station, ground and air temperatures have been monitored intermittently since 1947; continuous measurements resumed in 2006 and a Circumpolar Active Layer Monitoring (CALM) site was added in 2004. CRREL also monitors shallow ground temperatures at research sites at Shishmaref and Fort Wainwright, Alaska.

The EPA National Aquatic Resource Survey (NARS) assesses the condition of the Nation's aquatic resources, including those in Alaska. NARS is an integrated and comprehensive program that monitors five different categories of aquatic resources: coasts, streams, rivers, lakes, and wetlands. Each of the five aquatic resource categories sample specific indicators to provide information on the physical, chemical and biological condition of the resource. Examples include: coasts (water chemistry, sediment quality, benthic condition, fish tissue contaminants, habitat condition); streams (benthic condition, nutrients,

sedimentation, fish habitat, riparian vegetation); rivers (fish, benthos, periphyton, nutrients, sedimentation, recreational indicators); lakes, including ponds and reservoirs (zooplankton, phytoplankton, sediment diatoms, sediment mercury, nutrients, microcystin, enterococcus, fish tissue chemistry); wetlands (to be determined). Sampling was conducted for the National Coastal Assessment in south central Alaska in 2002, in southeast Alaska in 2004, and the Aleutians in 2006-2007. Pilot surveys were conducted for the National Wadeable Streams Survey in the Tanana basin in 2004-2005, and for the National Wadeable Lakes Survey in the Kenai region in 2007-2008.

NASA satellites (Figure 13) support an extensive Global Water Cycle science focus area and contribute to high accuracy, stable, sustained observations and associated modeling for terrestrial hydrology and cryosphere studies. Derived geophysical products for terrestrial hydrology and cryosphere are available from the NSIDC's Distributed Active Archive Center (DAAC). They include: soil moisture and snow water equivalent from AMSR-E; Greenland ice sheet altimetry and global land surface altimetry from ICESat/GLAS; snow cover extent/area from MODIS; surface albedo and temperature from AVHRR Pathfinder. SAR data obtained from a variety of foreign satellites since 1991 are archived at the ASF DAAC. SAR data provide opportunities for change detection, including interferometric SAR (InSAR) studies of glacier and ice sheet surface elevation and dynamics (ice velocity maps), land surface elevation, and soil moisture.

GRACE has been used to determine the mass loss from the Greenland ice sheet and from glaciers in southeast Alaska. The surface elevation of the Greenland ice sheet is mapped using ICESat, and the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) is used to acquire imagery and topography of the ice sheet.

NOAA observations for Arctic hydrology and cryosphere in Alaska include snow depth and precipitation at NWS weather stations and Cooperative Observer locations, precipitation at NCDC CRN sites, and river forecasting. The latter is the responsibility of the Alaska-Pacific River Forecast Center

(APRFC), which monitors water levels and spring ice conditions on the major rivers in Alaska primarily for the purpose of flood and high water forecasting. The NPS Inventory and Monitoring Program in the Alaska Region includes hydrology and cryosphere observing activities. The purpose of the program includes the development of scientifically sound information on the current status and long-term trends in the composition, structure, and function of park ecosystems. The Program aims are: (1) to provide a consistent database of information about natural resources, including species diversity, distribution and abundance [basic inventories]; and (2) to determine the current condition of resources and how they are changing over time (vital signs monitoring). In the NPS Arctic Region, the conceptual framework for inventory and monitoring includes two 'vital signs' for hydrology and cryosphere monitoring: surface water dynamics and distribution; and permafrost and thermokarst. The Central Alaska Region has five vital signs for hydrology and cryosphere monitoring: snowpack, glaciers, permafrost, flood frequency and discharge, and river/stream flow.

NSF is contributing to the development of hydrology and cryosphere observing activities that are driven by science questions that underline the need for long-term observations that enable SEARCH by measuring changes occurring in the Arctic. NSF AON projects include: hydro-meteorological measurements at the Kuparuk River watershed on the North Slope of Alaska; permafrost temperature measurements at deep boreholes in Alaska and Russia; and, a prototype network for snowfall and snow accumulation measurements.

NSF also funds (1) the Center for Remote Sensing of Ice Sheets (CReSIS), a NSF Science and Technology Center established in 2005; and, (2) POLENET in Greenland. CReSIS will engage in technology development, and create times series datasets of accumulation rate, surface elevation, ice thickness and velocity, and melt rate for the Greenland ice sheet. POLENET is deploying a network of GPS sensors (GNET) that will allow scientists to 'weigh' the ice sheet and detect changes in its mass. CReSIS also benefits from NASA support for aerial missions over Greenland, and for some instrument development. NSSI is funding the installation of several stream gauges in the National Petroleum Reserve Alaska and

the Arctic National Wildlife Refuge. USGS will be responsible for gauge maintenance and data archive. The data will be available from the USGS and from the Geographic Information Network of Alaska (GINA) at the University of Alaska Fairbanks.

USDA data collection activities related to Arctic terrestrial hydrology and cryosphere are coordinated by the Natural Resources Conservation Service (NRCS). The primary operational data-collection activities are the Alaska Snow Survey Program, Soil Climate Analysis Network, and the National Soil Survey Center. The Snow Survey Program uses snow courses, precipitation gages, and SNOTEL (SNOWpack TELEmetry) sites to obtain data necessary for water supply management, flood control, climate modeling, recreation, and conservation planning. The six SCAN sites in Alaska provide data on soil moisture and meteorological parameters and serve this data real-time through the NRCS National Water and Climate Center to support many of the same activities as the Snow Survey Program. The National Soil Survey Center and academic partners monitor soil moisture, soil temperature and air temperature at nine sites on the North Slope of Alaska.

USGS Arctic hydrology and cryosphere observing activities include: (1) permafrost temperature, soil moisture and vegetation change measurements at the DOI/GTN-P (Global Terrestrial Network-Permafrost) active-layer monitoring sites in northern Alaska; (2) permafrost temperature measurements in the DOI/GTN-P deep borehole array in the National Petroleum Reserve-Alaska Alaska; (3) benchmark glacier monitoring, particularly bi-annual mass balance measurements, at Gulkana and Wolverine glaciers; and (4) stream gauging at locations throughout Alaska. The USGS National Stream Quality Accounting Network (NASQAN) includes the Yukon River, where baseline and process-based data on the concentrations and fluxes of sediments and chemicals are collected to understand the basin response to climate change. The HHS Administration for Native Americans also supports Yukon River water quality monitoring through the Yukon River Inter-Tribal Watershed Council. USGS publishes the Satellite Image Atlas of the Glaciers of the World, a multi-volume publication that establishes a baseline for the areal distribution of the Earth's glaciers.



Figure 21. Location of hydrological observing sites in Alaska. The APRFC (Alaska Pacific River Forecasting Center, NOAA-NWS) monitors the highlighted rivers from the air and by satellite in spring, and also receives information in autumn (freeze-up), winter (ice thickness) and spring (break-up) from observers in villages by the rivers. No information was provided for NPS hydrological observing locations.

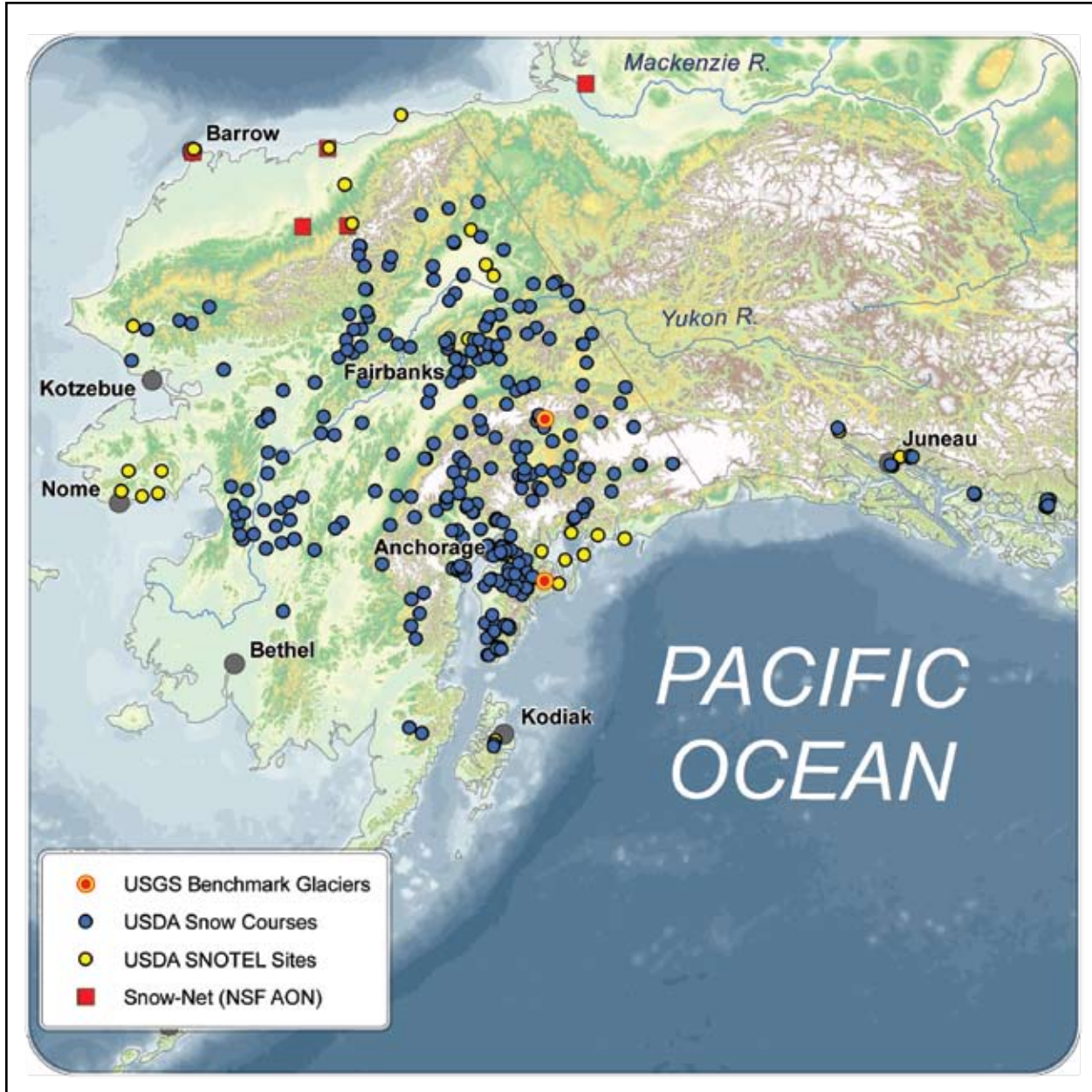


Figure 22. Location of snow and glacier observing sites in Alaska. No information was provided for NPS glacier observing locations.

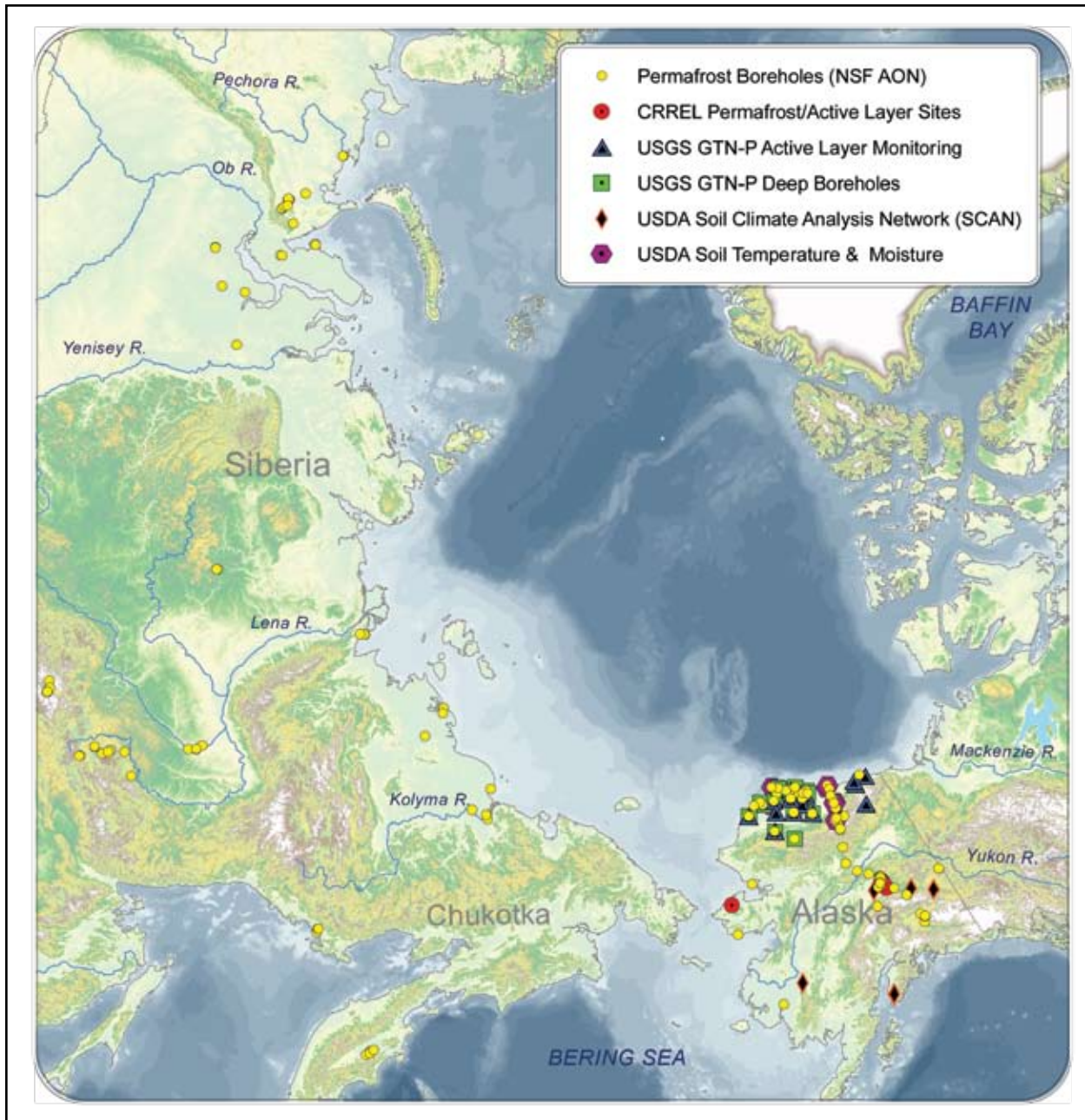


Figure 23a. Location of permafrost and active layer observing sites in Alaska and Russia. The Alaska sites are shown in more detail in Figure 22b.

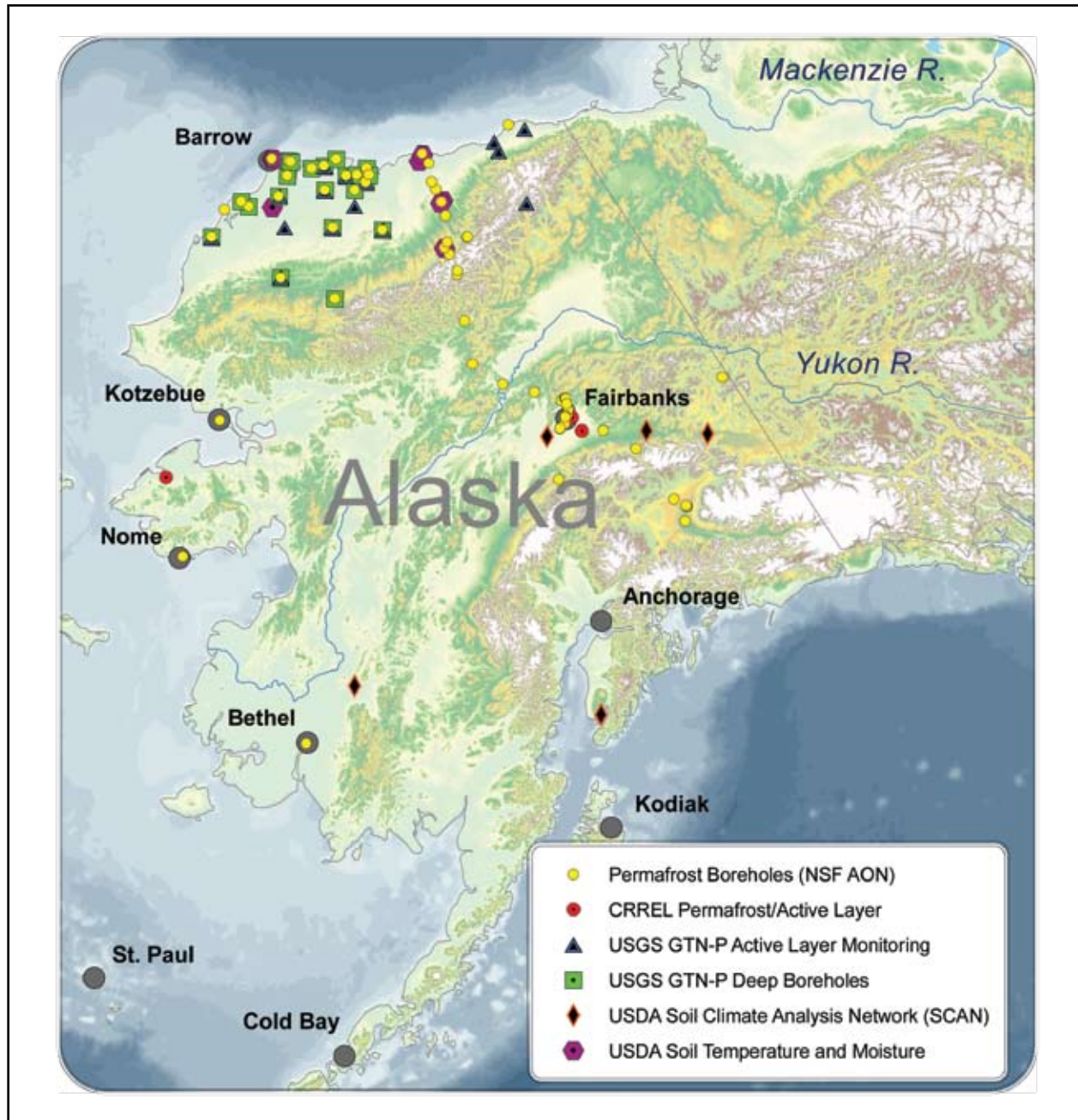


Figure 23b. Location of permafrost and active layer observing sites in Alaska. No information was provided for NPS permafrost and active layer observing locations.

Data and Information Management

Hydrology and cryosphere data and information are available at the following Web sites:

Alaska Satellite Facility

<http://www.asf.alaska.edu>

Geographic Information Network of Alaska

<http://www.gina.alaska.edu/>

NASA Global Change Master Directory

<http://gcmd.gsfc.nasa.gov/>

NASA Earth Observing System Data Gateway

<http://deleenn.gsfc.nasa.gov/~imswww/pub/imswelcome/>

NOAA National Climatic Data Center

<http://www.ncdc.noaa.gov/oa/ncdc.html>

NOAA National Geophysical Data Center

<http://www.ngdc.noaa.gov/>

NOAA National Weather Service, Alaska-Pacific River Forecast Center

<http://aprfc.arh.noaa.gov>

National Park Service, Inventory and Monitoring Program - Alaska Region

<http://www.nature.nps.gov/im/units/akrol/index.cfm>

National Snow and Ice Data Center (NSIDC)

<http://www.nsidc.org/>

USDA Alaska Snow Survey Program

<http://www.ak.nrcs.usda.gov/Snow/data/>

USDA Alaska Snow, Water and Climate Services

<http://ambsc.org>

USDA Snow Course Data

<http://www.wcc.nrcs.usda.gov/snowcourse>

USDA SNOTEL Data and Products

<http://www.wcc.nrcs.usda.gov/snow/>

USDA Soil Climate Analysis Network (SCAN)

<http://www.wcc.nrcs.usda.gov/scan/Alaska/alaska.html>

USGS Alaska Borehole (Permafrost) Temperature Logs

<http://esp.cr.usgs.gov/data/bht/alaska/>

USGS Alaska Science Center – Water Resources

<http://alaska.usgs.gov/science/water/index.php>

USGS Alaska Streamflow Statistics

<http://ak.water.usgs.gov/Projects/FloodFrq/index.php>

USGS Benchmark Glaciers

<http://ak.water.usgs.gov/glaciology/>

USGS Water Data for Alaska

<http://waterdata.usgs.gov/ak/nwis/>

USGS and NASA Land Processes Distributed Active Archive Center (LP DAAC)

<http://edcdaac.usgs.gov/main.asp>

Other Useful Links

Center for Remote Sensing of Ice Sheets

<https://www.cresis.ku.edu/>

Cold Regions Research and Engineering Laboratory: Permafrost Tunnel

<http://www.crrel.usace.army.mil/alaska-office/foxtunl.html>

Cold Regions Research and Engineering Laboratory - Permafrost Research Facility

<http://www.crrel.usace.army.mil/alaska-office/froad.html>

POLENET – Polar Earth Observing Network

<http://www.polenet.org/>

USDA NRCS National Water and Climate Center

<http://www.wcc.nrcs.usda.gov>

USGS Alaska Science Center

<http://alaska.usgs.gov/portal/>

USGS Satellite Image Atlas of the Glaciers of the World

<http://www.glaciers.er.usgs.gov/html/project.html>

Yukon River Inter-Tribal Watershed Council – Yukon River Water Quality

<http://www.yritwc.com/programs/waterQuality.htm>

d. Terrestrial Ecosystems

For the purpose of this report, terrestrial ecosystems encompass both the land and freshwater. Freshwater geochemistry is in the previous section on Hydrology and Cryosphere section. Terrestrial ecosystems observing activities are illustrated in Figure 24 at the end of this section.

BLM is responsible for the Alaska Inter-Agency Coordination Center (AICC) for wildland fire management and suppression in Alaska. Other federal agencies contributing to this operational center include NPS, US Fish and Wildlife Service, US Forest Service, Bureau of Indian Affairs, and USGS (indirectly via the National Inter-Agency Coordination Center for wildland fire). The AICC uses NASA MODIS data distributed by GINA to support its operations. As noted in Section 5a, a large interagency group (BIA, BLM, NPS, USFS, USFWS) maintains the RAWS network for rating fire danger in Alaska.

NASA operates a number of satellites (Figure 13) and instruments that contribute to Arctic observing and establishment of baseline datasets for studies of terrestrial ecosystems and their interactions with other components of the global integrated Earth system.

The NPS Inventory and Monitoring Program in the Alaska Region includes numerous terrestrial ecosystems observing activities in the Arctic Region and the Central Alaska Region. In the Arctic Region, for example, the conceptual framework for inventory and monitoring includes 12 'vital signs' for terrestrial and freshwater ecosystems monitoring: small mammals, brown bear, caribou, muskox, moose, Dall's sheep, fire extent and severity, permafrost and thermokarst, terrestrial vegetation and soils, terrestrial landscape patterns and dynamics, fish assemblages, stream communities and ecosystems, lake communities and ecosystems, and surface water dynamics and distribution. The Central Alaska Region has 22 vital signs for terrestrial ecosystems monitoring.

NSF is contributing to the development of terrestrial ecosystem observing activities that are driven by science questions that underline the need for long-term

observations that enable SEARCH by measuring changes occurring in the Arctic. NSF AON projects include: (1) International Tundra Experiment (ITEX) plant phenology and community composition; (2) carbon, energy and water fluxes at flagship sites in Alaska and Russia; and (3) the Circumpolar Environmental Observatories Network (CEON). Also, NSF is the primary funding agency for the LTER sites at Toolik Lake (Arctic LTER) on the North Slope of Alaska and Bonanza Creek/Caribou-Poker Creeks in the boreal forest of central Alaska.

The USDA Forest Service is a partner in the Bonanza Creek LTER. The USDA also manages the Alaska Soil Survey, a scientific inventory of soil resources in 31 different regions of the state. The data are used for making maps, identifying physical and chemical properties of soils, and supplying current information on potential uses and limitations of soils. The Soil Survey contributes to the Natural Resources Inventory that involves monitoring of the changes and trends in natural resource use and condition.

The NSSI is also contributing to terrestrial ecosystems observation activities through its support for a land cover change detection project that covers the entire North Slope of Alaska. Data will be available via GINA.

USFWS is the lead US representative to the Arctic Council's Conservation of Arctic Flora and Fauna (CAFF) program. In the eight national wildlife refuges that fall within the CAFF-designated Arctic region, USFWS is conducting approximately 150 monitoring projects; the majority are bird and mammal studies, but there are also fish, vegetation, insect and hydrological studies. Outside the wildlife refuges, but still within the CAFF-designated Arctic region, USFWS is conducting over 100 monitoring projects; the majority are fish, bird and marine mammal studies, but there are also some contaminant, insect and vegetation studies.

The USGS maintains the Landsat satellite operations and archive mission components of the Landsat system. These data are used for a wide variety of applications including multi-temporal monitoring of Arctic and Sub-Arctic landscape conditions (coastal

erosion and land cover mapping). Since 1972, the Landsat series of satellites have captured over 2 million images of the Earth's surface (<http://landsat.usgs.gov/>).

USGS Arctic terrestrial ecosystems observing activities are concerned with Arctic landscape response to changing climate. Geographically, the focus is on the North Slope of Alaska and two projects in particular: (1) spatio-temporal variation of terrestrial and coastal habitats on the Arctic Coastal Plain; and (2) consequences of changing habitats for fish and wildlife.



Figure 24. Location of terrestrial ecosystem observing activities in Alaska, Russia and Greenland. No information was provided for NPS terrestrial ecosystem observing sites.

Data and Information Management

Terrestrial ecosystems data and information are available at the following Web sites:

Arctic LTER

<http://ecosystems.mbl.edu/ARC/>; <http://www.lternet.edu/sites/arcl/>

Bonanza Creek LTER

<http://www.lter.uaf.edu/>; <http://www.lternet.edu/sites/bnzt/>

Bureau of Land Management, Wildland Fire Dataset for Alaska

<http://agdc.usgs.gov/data/blm/fire/index.html>

Circumpolar Environmental Observatories Network (CEON)

<http://www.ceoninfo.org/>

Conservation of Arctic Flora and Fauna (CAFF)

<http://arcticportal.org/en/caff/>

Geographic Information Network of Alaska

<http://www.gina.alaska.edu/>

Long Term Ecological Research (LTER) Network

<http://www.lternet.edu/>

National Park Service Inventory and Monitoring Program

<http://science.nature.nps.gov/im/>

National Park Service Inventory & Monitoring Program: Arctic Network

<http://www1.nature.nps.gov/im/units/arcn/index.cfm>

National Park Service Inventory & Monitoring Program: Central Alaska Network

<http://www1.nature.nps.gov/im/units/cakn/index.cfm>

National Snow and Ice Data Center – ITEX

http://nsidc.org/cgi-bin1/dynomatic.pl?file=quick_sch_rslt.html&form_name=quick_search&broker1=NU LL&quick_search_2_keyword=itex&lat2=90&lon1=-180&lon2=180&lat1=-90&submit=Search

USDA Alaska Soil Survey

<http://www.ak.nrcs.usda.gov/soils/index.html>

USDA Soil Data Mart

<http://soildatamart.nrcs.usda.gov>

USDA Web Soil Survey

<http://websoilsurvey.nrcs.usda.gov/app>

USGS and NASA Land Processes Distributed Active Archive Center
<http://edcdaac.usgs.gov/main.asp>

Other Useful Links

Alaska Inter-Agency Coordination Center (for wildland fire)
<http://fire.ak.blm.gov/>

International Tundra Experiment (ITEX)
<http://www.geog.ubc.ca/itex/>

National Inter-Agency Coordination Center (for wildland fire)
<http://www.nifc.gov/nicc/>

USGS Alaska Science Center
<http://alaska.usgs.gov/science/biology/index.php>

e. Human Dimensions

Any viable observation system, no matter how sophisticated the technology, relies on people. The needs, aspirations and knowledge of Arctic residents, as well as information needs of industries active in the Arctic, must be considered in planning and carrying out environmental observations. Human dimension observing activities are illustrated in Figure 25 at the end of this section.

Young people in the Arctic become involved in environmental observing through school-based programs such as those based on GLOBE: Global Learning and Observations to Benefit the Environment. For example, the “Seasons and Biomes” Project is a partnership among Alaska elementary and secondary schools, IARC, the NASA Landsat Data Continuity and Terra Satellite Missions and NSF. This partnership uses GLOBE protocols to monitor seasonal environmental changes in different biomes, such as taiga and tundra. Efforts such as these to link environmental observing with education at the pre-college level can heighten the interest of young Arctic residents in science careers.

Over the last decade or so, Arctic residents have become increasingly involved in research as active participants. Therefore, AON must include community-based research and knowledge systems in which Arctic societies are able to collect, preserve, and exchange relevant and timely information.

The SEARCH Implementation Plan identified several aspects of environmental change of concern to Arctic societies, including the extent and nature of sea ice, storminess and erosion, marine and terrestrial ecosystems (especially fish and mammal populations), permafrost, and vegetation. The Plan considers people, both individuals and institutions, as part of the Arctic ecosystem and recognizes the importance of interactions between humans and the rest of the ecosystem to predicting social outcomes and ecosystem feedbacks.

Community Change and Arctic Development

Ongoing efforts to preserve and exchange community-based information include the Exchange for Local Observations and Knowledge of the Arctic (ELOKA). During IPY, NSF is supporting this project in addition to two others relevant to people and communities in the Arctic: the Bering Sea Sub-Network (BSSN), a pilot project for a community-based observing network focusing on marine species of subsistence interest; and ‘Arctic Observation Network: Social Indicator Project’. The goal of the latter project is to identify knowledge that will help people respond to environmental change, with a focus on four arenas likely to involve climate-human interactions: marine mammal hunting; oil, gas, and mineral development; tourism; and fisheries. A fifth project focus is on indicators of social outcomes of human interactions with environmental change.

The Arctic Borderlands Ecological Knowledge Cooperative monitors and assesses change in the range of the Porcupine Caribou Herd and adjacent Mackenzie Delta area in the Northwest Territories, the Yukon, and Alaska. The Borderlands Co-op is run by a non-profit society. Funding and support has come from Canadian, territorial and several US government agencies, co-management boards, and Inuvialuit and First Nation councils. Additional project funding is currently from Indian and Northern Affairs Canada, and the University of Alaska. Environment Canada provides in-kind support for overall program coordination. The program focuses on four main issues: ecological monitoring, climate change, contaminants, and regional development. The program brings together science and local and traditional knowledge. Community researchers conduct interviews with local experts each year. Observations about fish, berries, caribou, unusual animal sightings, weather conditions, and other aspects of the environment and communities, are drawn together and made available to the public through reports and presentations.

NMFS, and particularly the AFSC, conducts field and laboratory research on living marine resources. Scientists compile and analyze databases on fishery,

oceanography, marine mammal, and environmental research. The results of this research are of utmost importance to Alaska coastal communities.

DOI has a large and complex management and research role in Alaska. Below are just a few examples of ongoing DOI activities with respect to people and communities.

USFWS has a monitoring program to help provide information needed for effective management of subsistence fisheries on Federal public lands in Alaska. The program funds projects to address research priorities identified by management agencies and local users from around the state. Funding has been awarded to more than 70 Alaska Native organizations, rural organizations, universities, and Federal and State agencies. Projects include studies of the status of fish stocks, subsistence harvest patterns, and traditional ecological knowledge.

The Fisheries Monitoring Program also works to integrate Alaska Native and rural organizations into the management of subsistence fisheries resources through the Partners for Fisheries Monitoring Program. This program was established to help Alaska Native and rural organizations participate in subsistence fisheries management and research. Alaska Native and rural organizations represent those who depend upon subsistence fisheries resources and have perspectives and knowledge that can be valuable in identifying issues, conducting research, and managing subsistence fisheries.

The MMS, Alaska Outer Continental Shelf Region, conducts ongoing environmental studies, including socioeconomic research and multidisciplinary, participatory work to assess the potential effects of oil and gas development. The MMS incorporates local and traditional knowledge in study planning, field work, and interpretation of results, with the goal of providing better information for decision-making. Community based observations are currently collected through a continuing multiyear study which records the status of subsistence hunting activities on Cross Island during the fall bowhead whale hunt. Similar studies are planned for Chukchi sea coastal villages.

Human Health

Human health is an integral component of the Arctic ecosystem. Life expectancy in arctic populations has greatly improved over the last 50 years due to a reduction in morbidity and mortality from infectious diseases, such as tuberculosis, and the vaccine preventable diseases of childhood and improved living condition and access to health care. However, significant health disparities remain between the indigenous and non indigenous populations in the arctic. Indigenous populations experience lower life expectancy, higher infant mortality; higher suicide rates higher rates of infectious diseases such as hepatitis b and tuberculosis and higher rates of some cancers. Health concerns of arctic peoples also include potential health impacts of environmental pollution, climate variability, and the rapid rate of modernization and associated social and cultural changes which may result in higher rates of obesity, diabetes, cardiovascular diseases and suicides.

The Centers for Disease Control and Prevention, Arctic Investigations Program, has established an International Circumpolar Surveillance (ICS) system for infectious diseases by creating a network of hospital and public health laboratories throughout the Arctic. The network allows collection and sharing of uniform laboratory and epidemiologic data among Arctic countries that will describe the prevalence of infectious diseases of concern to Arctic residents and assist in the formulation of prevention and control strategies. While currently focused on prevention and control of infectious disease the system also provides a model for standardized monitoring and respond to other non infectious health conditions of concern within Arctic regions.

Many regional and national surveillance networks exist for monitoring health conditions of concern. Within the State of Alaska, the Alaska Surveillance, Epidemiology and End Results (SEER) program collects and publishes cancer data as part of the National Cancer Institute's overall SEER program, and the Alaska Native Stroke Registry is a project to increase the understanding of stroke in Alaska Natives, with the goal of improving stroke care. Circumpolar linkage of such networks would facilitate international collaboration, international standardization of data

collection international comparison of comparable data, thereby greatly adding to our knowledge of Arctic health, and enhancing design of treatment and prevention.

The above summary of Federal observing activities is far from exhaustive, but rather gives exemplars of current foci in environmental observations that are done by and/or have great consequence for Arctic residents.

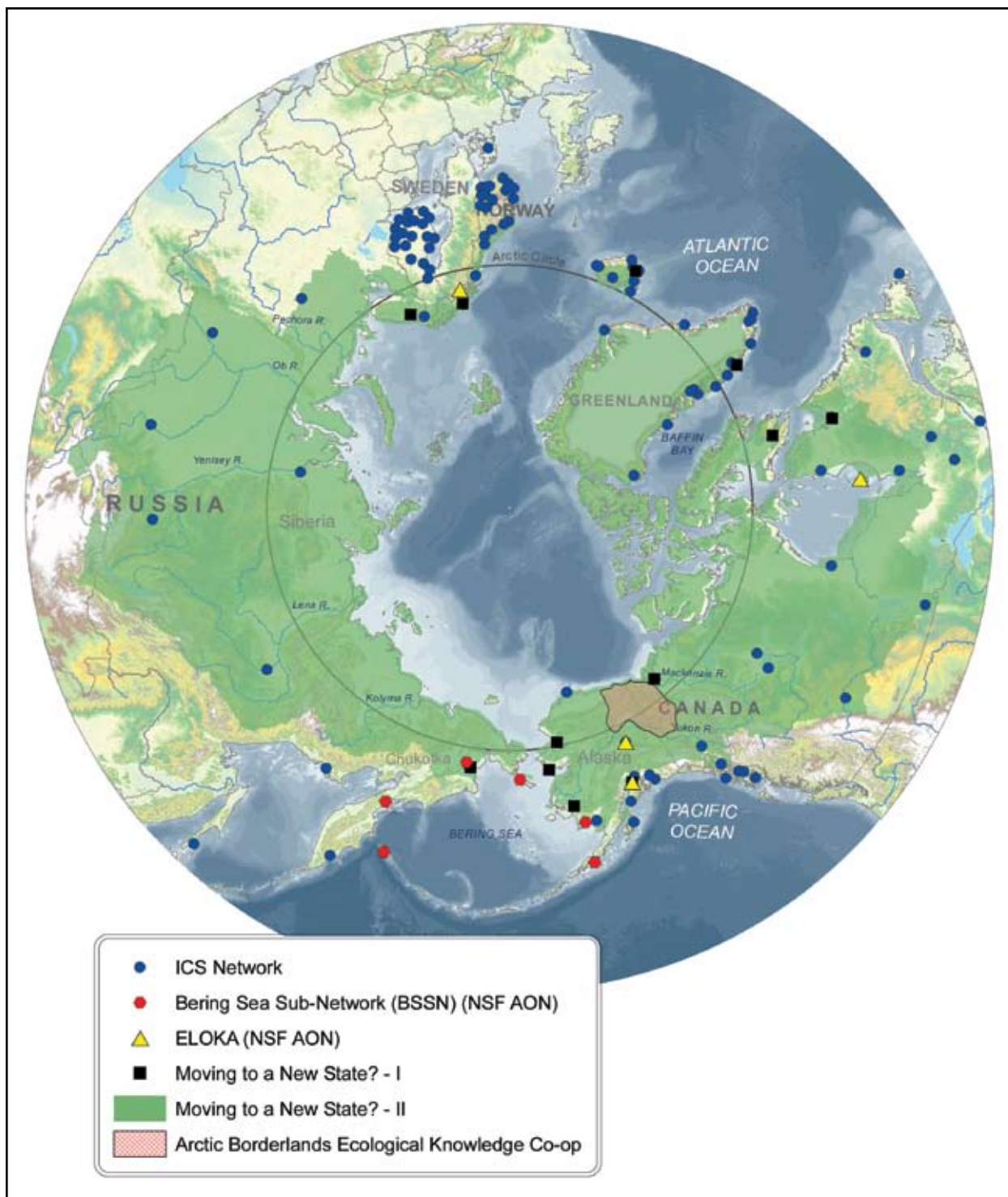


Figure 25. Community-based observing projects include the Bering Sea Sub-Network (BSSN), the Exchange for Local Observations and Knowledge in the Arctic (ELOKA), and the Arctic Borderlands Ecological Knowledge Coop. Also shown are the locations of participating and proposed hospitals and public health laboratories in the International Circumpolar Surveillance (ICS) system, and the region and locations covered by the NSF-funded project “Is the Arctic Human Environment Moving to a New State?”.

Data and Information Management:

Community Change and Arctic Development

Alaska Department of Fish and Game: Subsistence, Community Profiles
<http://www.subsistence.adfg.state.ak.us/>

Alaska Fisheries Science Center
<http://www.afsc.noaa.gov/default.htm>

Alaska Native Knowledge Network
<http://www.ankn.uaf.edu/>

Alaska Outer Continental Shelf Region, US Minerals Management Service
<http://www.mms.gov/alaska/>

Arctic Borderlands Ecological Knowledge Cooperative
<http://www.taiga.net/coop/index.html>

Exchange for Local Observations and Knowledge of the Arctic
<http://ipydis.org/elokal/>

Fisheries Monitoring Program: US Fish and Wildlife Service
<http://alaska.fws.gov/asm/fisindex.cfm>

NASA Socioeconomic Data and Applications Center
<http://sedac.ciesin.columbia.edu/>

Health

Alaska Surveillance, Epidemiology, and End Results (SEER) Program
<http://seer.cancer.gov/>

Alaska Native Stroke Registry
<http://alaskastroke.com/>

Arctic Health: An Information Portal (National Library of Medicine)
<http://www.arctichealth.org/>

International Circumpolar Surveillance of Infectious Diseases (ICS)
<http://www.cdc.gov/eid/content/14/1/18.htm>

Other Useful Links

International Arctic Social Sciences Association

<http://www.iassa.gi/index.htm>

Principles for the Conduct of Research in the Arctic

<http://www.nsf.gov/od/opp/arctic/conduct.jsp>

f. Paleoenvironment

For the purpose of this report, the primary sources of proxies for paleoenvironment observations are non-instrumental records obtained from ice cores, marine and lake sediment cores, and tree rings. The paleoenvironment network is considered to consist of (1) the sampling locations, e.g., an ice core site, (2) the samples themselves, e.g., an ice core, and (3) the sample repositories, e.g., a managed ice core repository.

In the context of SEARCH, proxy records of past climate and environmental variation and change enable investigations of key questions about the present state of the Arctic system (SEARCH, 2005). For example,

1. Is the current arctic system state unprecedented with respect to the range of natural background variability and change?
2. What are the forcing mechanisms [natural versus anthropogenic, plus intrinsic oscillations and feedbacks] and what are the links to global system variability [e.g., Pacific Decadal Oscillation, North Atlantic Oscillation, El Nino-Southern Oscillation, monsoons]?

NSF has supported Arctic paleoenvironment networks and research for many years. Examples include the Greenland ice cores and the PALE (Paleoclimates from Arctic Lakes and Estuaries) program, which combined to become PARCS (Paleoenvironmental Arctic Sciences, 2000-2005). Another significant NSF contribution to the Arctic paleoenvironment network was the IODP (Integrated Ocean Drilling Program)-supported Arctic Coring Expedition (ACEX)/Expedition 302 to the Lomonosov Ridge in 2004. USGS was also a major participant in ACEX, and it has also conducted other sediment core recovery projects, particularly in the Chukchi Borderland region.

The NSF contribution to the Arctic paleoenvironment network during IPY and beyond focuses on the North Eemian ice core project (NEEM) in Greenland. NEEM is an international effort, and the initial US contribution is a surface-based radar survey and depth/age scale modeling at the drill site in summer 2007 by CReSIS.

NSF continues to co-fund, with USGS, the US National Ice Core Laboratory, a repository for storage, curation and study of ice cores. Marine core repositories are coordinated by the IODP, of which NSF is the co-lead funding agency. Data and Information Management

Paleoenvironment data and information are available at the following Web sites:

Index to Marine and Lacustrine Geological Samples
<http://www.ngdc.noaa.gov/mgg/curator/curator.html>

Integrated Ocean Drilling Program (IODP)
<http://www.iodp.org/>

US National Ice Core Laboratory
<http://niel.usgs.gov/>

World Data Center for Paleoclimatology
<http://www.ncdc.noaa.gov/paleo/data.html>

Paleoenvironmental Arctic Sciences (PARCS)
<http://www.ncdc.noaa.gov/paleo/parcs/index.html>

g. Data and Information Management

As the many URLs in previous sections show, Federal agencies hold Arctic data and information in their own archives, or provide support to other organizations that manage archive services. DOE, for example, archives ARM Program data obtained at its North Slope of Alaska and Eureka sites. NASA has extensive high accuracy, stable Arctic remote sensing data sets, including those at NSIDC, the ASF, and at other NASA DAACs. NOAA archives all NWS data, including those from the Arctic, at its own National Climatic Data Center (NCDC), and provides support to NSIDC to manage many other NOAA Arctic datasets. NSF has provided support to NSIDC to archive data generated by Arctic System Science projects, and many other NSF-funded investigators have also deposited their data at NSIDC. Alternatively, many NSF grantees maintain their own data and information archives, which are often accessible via the Web.

As part of its IPY investment in AON, NSF is funding the development of the Cooperative Arctic Data and Information Service (CADIS: Figure 26), a joint project of NSIDC and the Earth Observing Laboratory at NCAR. Initially, CADIS is being developed to support the NSF AON projects, and their users and stakeholders. It will be a Web-based service that enables data discovery, access and use by providing a metadata archive and portal for data discovery, a data and products archive, and

tools for data manipulation and analysis. The data and products archive will not hold content from all AON projects. Many projects will archive their own data and CADIS will be a portal to those distributed archives as well as to data and information held in the CADIS data and products archive. While CADIS is being developed initially to support the NSF AON projects, and their users and stakeholders, the CADIS architecture and framework are designed to

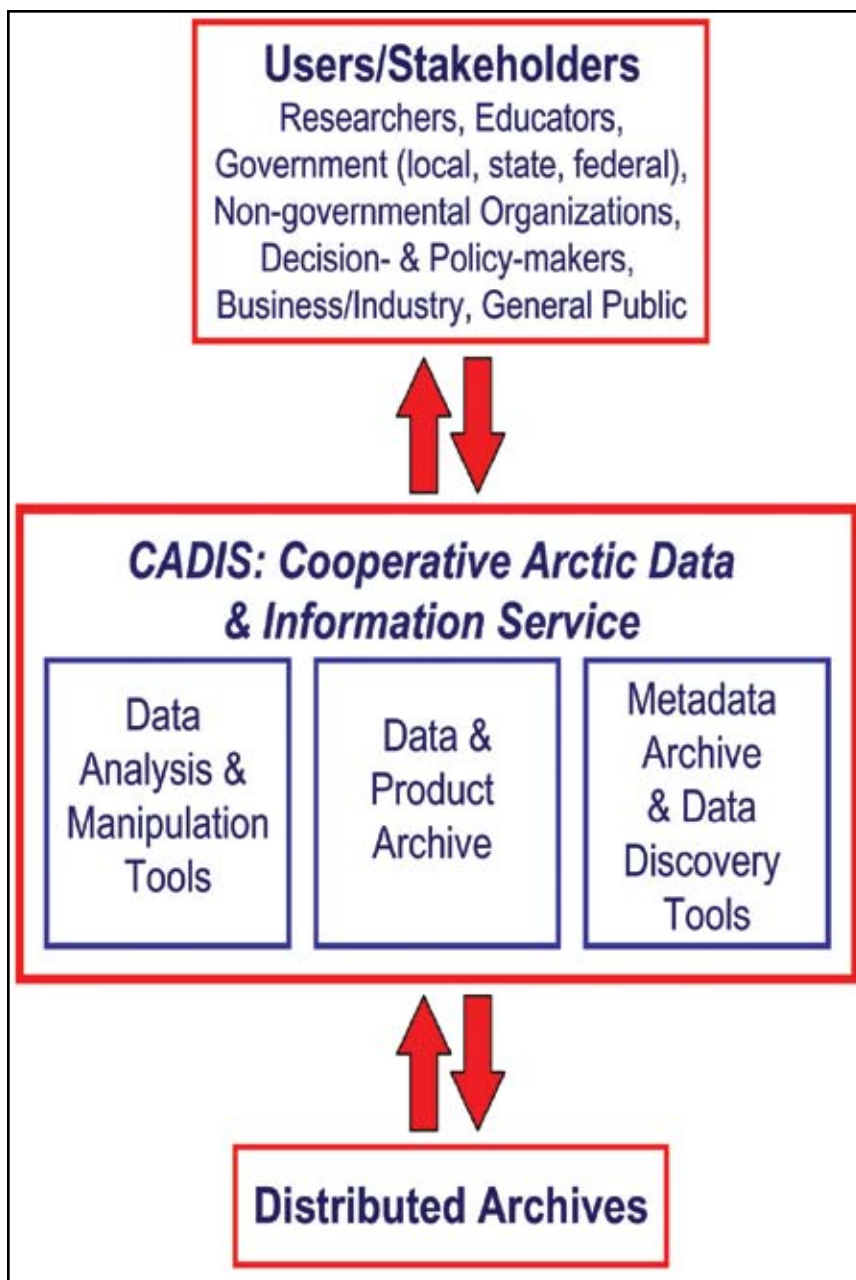


Figure 26. Conceptual diagram of CADIS, with arrows representing flows and exchanges of information among CADIS and its users/stakeholders and distributed (external) data archives and centers.

be extensible. That is, CADIS is designed to meet immediate needs during and immediately after IPY, while providing building blocks for an over-arching, interdisciplinary, and unified data and information system for the future.

NSF is also funding the ELOKA project during IPY. ELOKA is a pilot project that will provide a data management and networking service for community-based research that keeps control of data in the hands of community data providers, while still allowing for broad searches and sharing of information. NSF is also funding NSIDC participation in IPYDIS (International Polar Year Data and Information Service), a global partnership of data centers, archives and networks working to ensure proper stewardship of IPY and related data.

The NSSI is funding a node of GINA to create a portal to a distributed network of comprehensive information specific to the North Slope of Alaska and adjacent marine environments. The operations plan calls for a fully operational system by the end of FY11.

Useful links

Arctic Research Mapping Application (ARMAP)
<http://armap.org>

Cooperative Arctic Data and Information Service (CADIS)
<http://www.eol.ucar.edu/projects/aon-cadis/>

Exchange for Local Observations and Knowledge (ELOKA)
<http://ipydis.org/elokal/>

Geographic Information Network of Alaska
<http://www.gina.alaska.edu/>

International Polar Year Data and Information System (IPYDIS)
<http://www.nsidc.org/ipydis>

National Climatic Data Center (NCDC)
<http://www.ncdc.noaa.gov/oa/ncdc.html>

NASA Distributed Active Archive Centers (DAAC)
<http://nasadaacs.eos.nasa.gov>

National Park Service Data Store
http://science.nature.nps.gov/nrdata/docs/NPS_DataStore_20061030.pdf

National Snow and Ice Data Center
<http://nsidc.org>

North Slope Science Initiative
<http://quickplace.altarum.org/QuickPlace/northslope/Main.nsf/>

USGS Biological Information Infrastructure (NBII)
<http://www.nbio.gov>

USGS Geospatial One Stop
<http://www.geodata.gov>