PPA Title: Arctic Research Program, FY2008 Progress Report
March 3, 2009
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Arctic Research Program Initiation Year: 1999

Arctic Research Program Summary:

The Arctic Research Program (ARP) strives to develop and maintain a suite of climate observing networks (ocean, sea ice, and atmosphere) in the Arctic region to support climate change analysis, forecasts and services. The ARP works in association with national and international partners to contribute to a sustained Arctic Observing Network focused on issues of societal importance. The ARP also supports continuing analysis of Arctic climate data derived from the ARP itself and from other sources and provides both the data and analytical results to climate assessment activities and the science community. Using web-based approaches, the ARP participates in public education and outreach (see www.arctic.noaa.gov)

Accomplishments in FY2008

Atmospheric Observatories:

Contact: Taneil Uttal, ESRL

The purpose of these observatories is to support studies of both Arctic climate change attribution (why things are changing), and long-term trends (how things are changing). Data are obtained to address a number of key questions:

(1) How do clouds, aerosols and atmospheric chemistry interact to force the Pan-Arctic surface energy balances and albedo-temperature feedback?

(2) What is the relative role of tropospheric dynamics and stratospheric linkages in controlling the Arctic surface variability?

(3) What portion of the recent changes in the Arctic weather and climate can be attributed to increases in anthropogenic sources?

(4) How does the Arctic atmosphere interact with the rest of the Arctic (marine, cryospheric and terrestrial) system?

(5) To answer these questions (and others), all of the available observational resources represented by surface and upper air network observations, intensive observatories, satellite observations, manned and unmanned airborne measurements, and focused field campaigns must be utilized.

In 2008, the successful collaboration between the U.S. NOAA-SEARCH Atmosphere Program, the Canadian CANDAC Program, Meteorological Services Canada and the University of Wisconsin Lidar Group saw continued operation of a cloud radar and cloud-aerosol lidar in Eureka, Canada, first installed in August of 2004. The lidar failed for three months but has been repaired. At Alert, a set of radiometers continued to observe the energy balance and aerosol properties were monitored also. When combined with the work being done by Canadian colleagues, a very comprehensive set of data is being returned on a year-round basis.

As of 2008, the **Observatory in Tiksi, Russia** has undergone the following changes:

- The clean air facility was constructed,
- Specifications were developed for the surrounding site infrastructure,
- A dedicated satellite communications system was installed between Tiksi and St. Petersburg,
- A U.S.-Russian operations team was established,
- A U.S.- Russian-Finnish science team was established,
- The U.S. shipped additional instruments to Russia, and
- Roshydromet digitized hourly Tiksi station meteorological data from 1935 to the present.

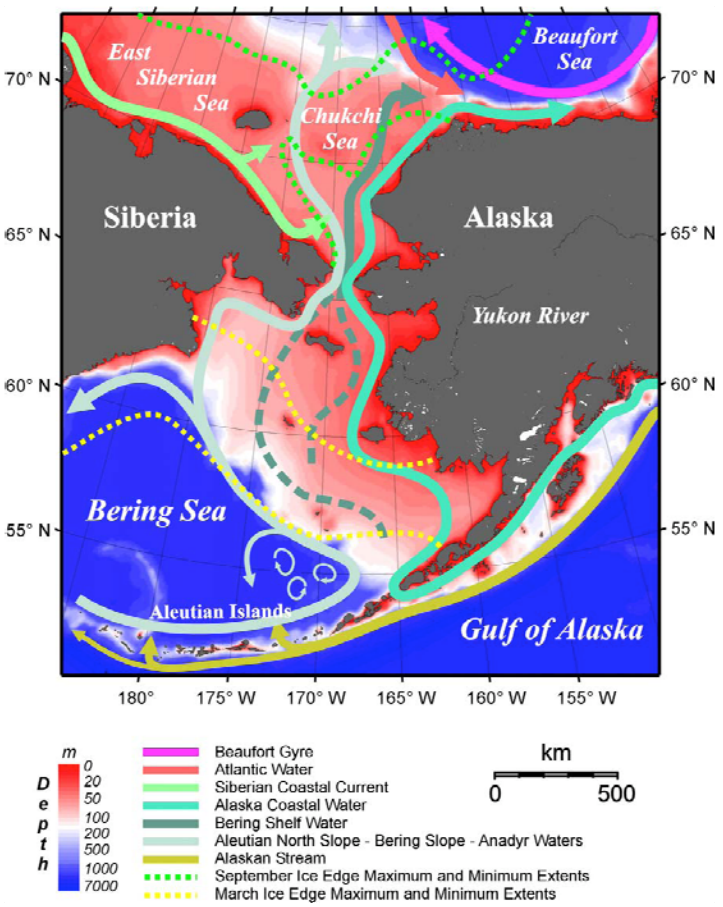
Bering and Chukchi Seas Ocean and Ecosystem Observatory:

Contact Persons: K. Crane, kathy.crane@noaa.gov and J. Calder, john.calder@noaa.gov

The NOAA Arctic Program is also working with partners to implement the Ocean part of the **Arctic Observing Network (AON).** The NOAA portion of the AON will be a subcomponent of the NOAA Integrated Ocean Observing System and is represented in the SEARCH implementation plan. There are 3 NOAA-supported elements to the AON:
A) ***ship- based*** observations focused on ecosystem-physical interrelated indicators of climate change in the Northern Bering Sea and the Chukchi Sea. NOAA conducted its first Arctic Ocean research cruise with the Russian Academy of Sciences in summer 2004 through what has become known as the RUSsian-American Long-term Census of the Arctic (RUSALCA) project. A chain of eight moorings is maintained across the Bering Strait and these are serviced annually.
B) **Moorings** along the Russian-Arctic Shelf slope monitor the flux of Atlantic water into the Arctic Ocean (NABOS)
C) The state of **methane flux** from the East Siberian Sea has been part of our observations in the Arctic. These measurements are carried out by the Siberian Shelf Survey.
Element A) is supported by ARP funds and progress is reported below. Elements B) and C) are supported by earmarked funds and progress is reported in an appendix to this report.

A. THE PACIFIC GATEWAY TO THE ARCTIC – QUANTIFYING AND UNDERSTANDING BERING STRAIT OCEANIC FLUXES. Russian American Long-term Census of the Arctic
Contact People: Rebecca Woodgate (UW), Tom Weingartner (UAF), Terry Whitledge (UAF)

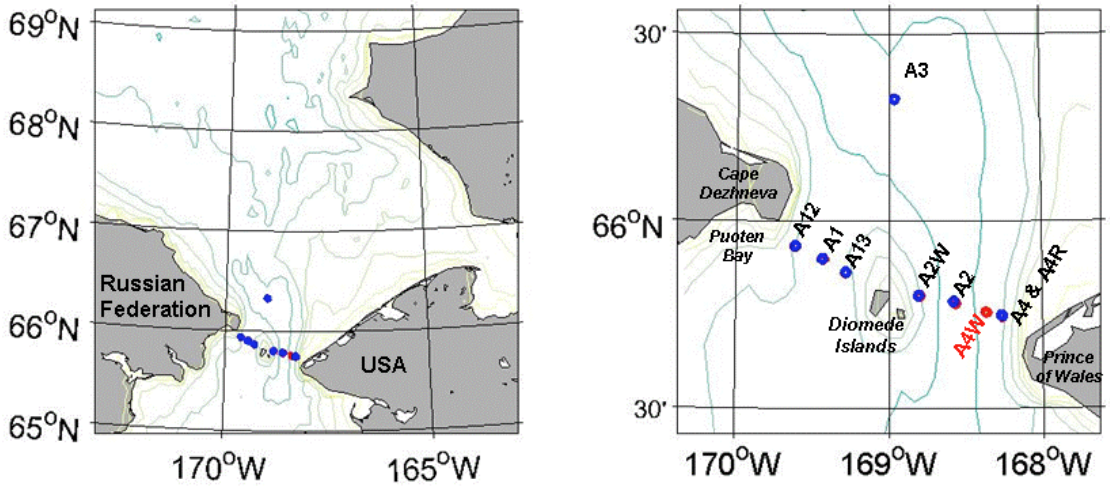
The Bering Strait, a narrow (~ 85 km wide), shallow (~ 50 m deep) strait at the northern end of the Pacific, is the only ocean gateway between the Pacific and the Arctic. Although the flow through the strait is small in volume (~ 0.8 Sv northward in the annual mean), due to its remarkable properties (high heat and freshwater content, low density, high nutrients) it has a startling strong influence, not only on the Chukchi Sea and the Arctic Ocean, but also on the North Atlantic overturning circulation and possibly world climate. Draining the Bering Sea shelf to the south, the Bering Strait throughflow is an integrated measure of Bering Sea change. The comparatively warm, fresh throughflow contributes ~ 1/3rd of the freshwater input and possibly ~ 1/5th of the oceanic heat input to the Arctic, and provides the most nutrient-rich waters entering the Arctic Ocean. Furthermore, the low density of these waters keeps them high in the Arctic water column, giving them a key role in upper ocean ecosystems and physical processes including ice-ocean interactions.



The major objective of the 2008 RUSALCA mission was mooring work in the Bering Strait region, i.e., the recovery and redeployment of 8 moorings, a joint project by University of Washington (UW) and University of Alaska, Fairbanks (UAF), and the Arctic and Antarctic Research Institute (AARI), a unit of Roshydromet in St. Petersburg, Russia. The mooring program is a collaboration of between the NSF, which supports the U.S. science team, and the ARP, which supports the Russian collaboration and provides the logistic support. This arrangement will be suspended in 2009, while the NSF reviews new proposals from the science team, and NOAA will cover all costs in 2009.

Despite the expected bad weather and darkness in October 2008, the moorings were successfully recovered and redeployed during the cruise. Unfortunately, weather prevented the taking of the related high-resolution CTD sections, although surface bucket samples were taken for salinity and nutrients at the mooring sites, and some benthic grab work was done opportunistically. Also, underway temperature and pCO2 data was collected by the Bermuda Institute of Ocean Sciences (BIOS), one of the ARP partner institutions.

At the time when dramatic change, especially the retreat of sea-ice, is observed in the Bering and Chukchi seas and the Arctic, we have measured significant increases of Bering Strait fluxes of volume, freshwater and heat. The data from 2007, from moorings recovered in 2008, show that 2007 had the highest heat flux ever recorded, with volume and fresh water fluxes matching previous highs



RUSALCA *Map of the Bering Strait region (left) and detail of the Strait (right) showing Lavrentiev RUSALCA 2008 mooring locations for the eight moorings deployed in 2008 (A12, A1, A13, A2W, A2, A4, A4R and A3) and the eight moorings recovered in 2008 (A12, A1, A13, A3, A2W, A2, A4W, A4, and A3). Blue dots indicate a site of recovery and deployment. Red dot (A4W) indicates recovery only. Depth contours are every 10m from International Bathymetric Chart of the Arctic Ocean.*

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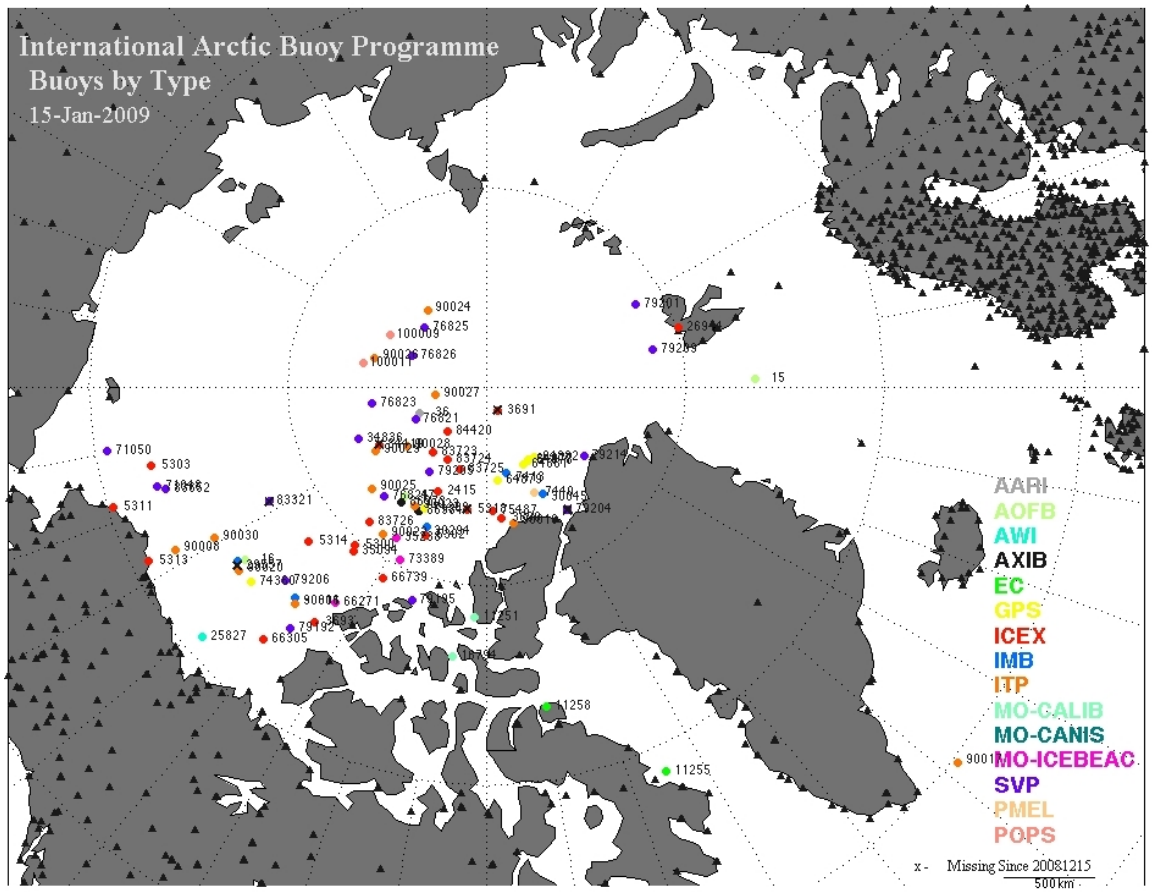
<u>Sea Ice Observations:</u>
Contact Persons: Ignatius Rigor, UW and Jackie Richter-Menge, CRREL

The Arctic Research Program funds efforts to expand the International Arctic Buoy program and to carry out ice mass balance measurements of the perennial Arctic sea ice to measure sea ice drift, thickness and melt processes and basic meteorology. Data from the IABP have many uses. For example:
1. Research in Arctic climate and climate change,
2. Forecasting weather and ice conditions,
3. Validation of satellites,
4. Forcing, validation and assimilation into numerical climate models, and
5. Tracking the source and fate of samples taken from the ice.

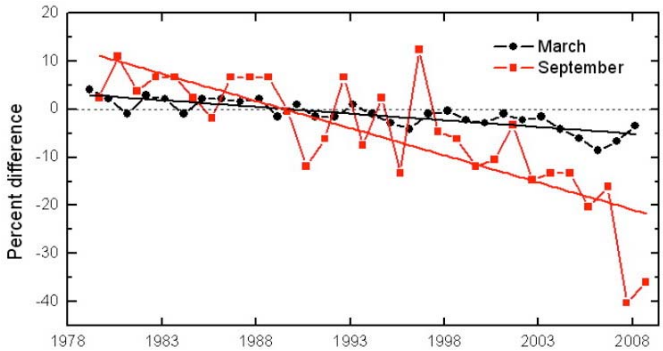


*Location of the Arctic Ice buoys, January, 15, 2009***.**
The participants of the IABP work together to maintain a network of drifting buoys in the Arctic Ocean to provide meteorological and oceanographic data for real-time operational requirements and research purposes including support to the World Climate Research Programme (WCRP) and the World Weather Watch (WWW) Programme. The ARP provides financial support for buoys labeled AXIB, ICEX, IMB, SVP, PMEL, and also support for the coordination function at U. W. Deployment are mostly by ship of opportunity, using ships from several countries. The AXIB buoys are air-dropped by the Air National Guard.

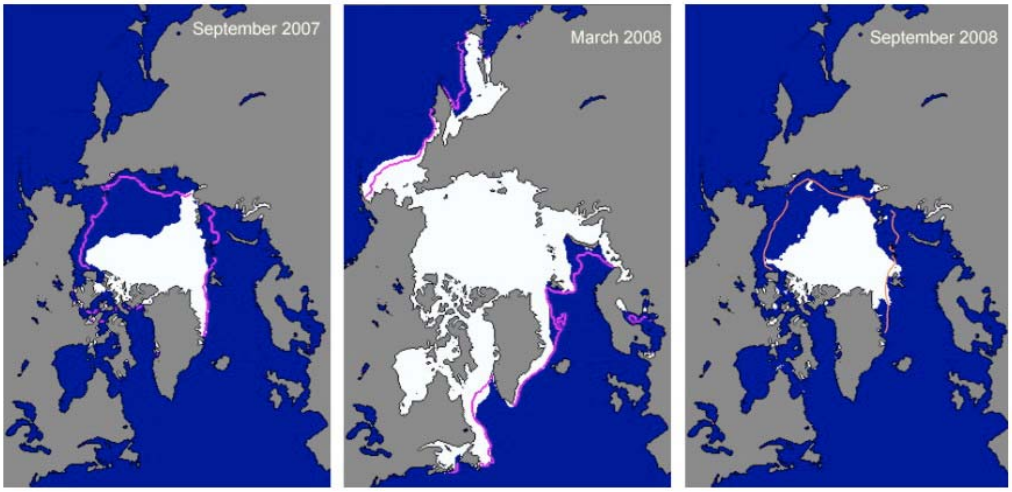
Sea Ice Cover 2008 and Ice Mass Balance

J. Richter-Menge, J. Comiso W. Meier, S. Nghiem, and D. Perovich carried out an assessment of the state of Arctic sea ice. In 2008 there was a continued significant reduction in the extent of the summer sea ice cover; a dramatic illustration of the pronounced impact increased global temperatures are having on the Arctic regions. In 2008 there was also a significant reduction in the relative amount of older, thicker ice. During 2008 the summer minimum ice extent, observed in September, reached 4.7 million km2 . While slightly above the record minimum of 4.3 million km2, set just a year earlier in September 2007, the 2008 summer minimum further reinforces the strong negative trend in summertime ice extent observed over the past thirty years. Sea ice

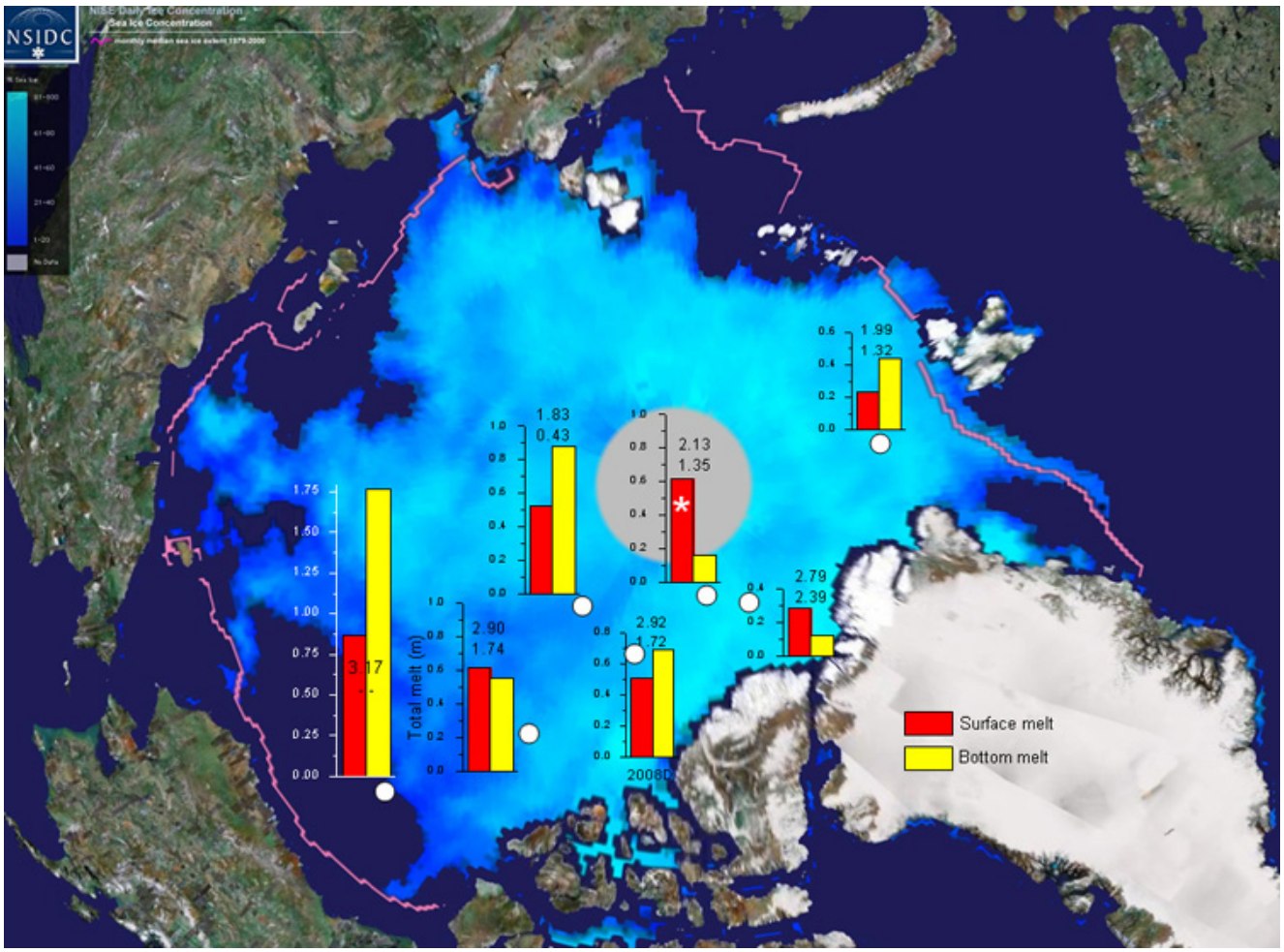
extent is determined from satellite observations. In situ measurements, such as from the IMBs are required to understand factors controlling sea ice loss.



Time series of the difference in ice extent in Mar (the month of ice extent maximum) and Sep (the month of ice extent minimum) from the mean values for the time period 1979
2007. Based on a least squares linear regression, the rate of decrease for the Mar and Sep ice extents was –2.8% and –11.1% per decade, respectively.



Sea ice extent Sep 07, Mar 08, Sep 08



Observations of surface and bottom melt were observed from IMBs in the summer of 2008. (See above Figure) There was increased bottom melt in regions of low ice concentration, such as the Beaufort Sea. The smallest amount of ablation was observed north of Greenland. The total amount of surface (red) and bottom (yellow) melt during the summer of 2008 is shown. The white dots denote an approximate position during of the buoy during summer. The two numbers associated with each plot are the ice thickness at the beginning and the end of the melt. Also displayed is the ice concentration from the National Snow and Ice Data Center.

Climate Change Detection and Analysis:

Contact Person: **-** James E. Overland and Muyin Wang
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The NOAA Arctic Research Program supports the **Arctic Climate Change Detection Protocol**. Historical and current data from diverse sources is assembled to evaluate variability and change in Arctic climate.

The Arctic Change Detection Activity had the following goals in 2008:

1) Maintain an up-to-date Arctic **climate change detection** activity for NOAA that includes improved understanding of Arctic climate variability, communication of Arctic change to policy and scientific forums, chairing committees, the Arctic Report card/State of the Arctic Report, and research publications.
2) **Support and enhance** NOAA's mission in climate variability and impacts in the Pacific sector of the Arctic. Use the North Bering and Chukchi data base to develop a paper that puts RUSALCA data in a historical context back to 1880.
3) Produce on a monthly basis an Arctic Sea Ice Outlook. The **2008 Sea Ice Outlook** produced monthly reports based on an open and inclusive process that synthesized input from a broad range of scientific perspectives:

- Each month, a request to the international arctic science community solicited information on the current and expected state of the arctic sea ice.
- Submissions were synthesized and reviewed by the Sea Ice Outlook Core Group
- An integrated monthly report was produced that summarized the evolution and expected state of arctic sea ice for September 2008, based on the observations and analyses submitted by the science community.
- The monthly Sea Ice Outlook reports were repeated through September 2008.
- A retrospective analysis will examine the success of the Sea Ice Outlook.

The intent of the SEARCH Sea Ice Outlook effort is not to issue predictions, but rather to summarize all available information from ongoing observing and modeling efforts to provide the scientific community, stakeholders, and the public the best available information on the evolution of the arctic sea ice cover.

Arctic Reportcard
The Report card is adopted as a product of the AMAP Climate Expert Group and is a service-product supported by the Arctic Research Program.

Historical Arctic climate
The Arctic Change Detection Team has a comprehensive *Journal of Climate* paper on the early 20th century warming in review, including a literature survey of what climate scientists thought about the changes that were occurring at the time and a new data synthesis. Work will continue with data from the 19th century.

Northern Bering Sea
The Arctic Change Detection Team has a goal is to bring together all oceanographic physical data for the northern Bering/southern Chukchi Seas and to make this data available and accessible through search software.

<u>National and International Coordination Activities in FY2008:</u>
contact persons: J. Calder and K. Crane

The Arctic Research Program was an active participant in several International organizations including Chairing the Arctic Monitoring and Assessment Program of the Arctic Council, the Pacific Arctic Group and the Marine Expert Monitoring Group of the Circumpolar Biodiversity Monitoring Program.

AMAP's current objective is "providing reliable and sufficient information on the status of, and threats to, the Arctic environment, and providing scientific advice on actions to be taken in order to support Arctic governments in their efforts to take remedial and preventive actions relating to contaminants".

NOAA's contributions to the Pacific Arctic Group are also significant. Organized under the International Arctic Science Committee (IASC), the PAG has as its mission to serve as a Pacific Arctic regional partnership to plan, coordinate, and collaborate on science activities of mutual interest. www.pagscience.com

Outreach:

Contact Person: Nancy Soreide, PMEL
Nancy.N.Soreide@noaa.gov

NOAA Arctic Website
The PMEL web group have continued to provide updates, new material, and web support for the NOAA Arctic Theme Page and Arctic Research Program. Timely updates are the key to information transfer, especially with recent fast moving Arctic change. The NOAA Arctic Theme Page is consistently one of the top Google results for keyword "arctic", and was visited by 91,053 unique hosts from 144 countries in March 2008.
http://www.arctic.noaa.gov/