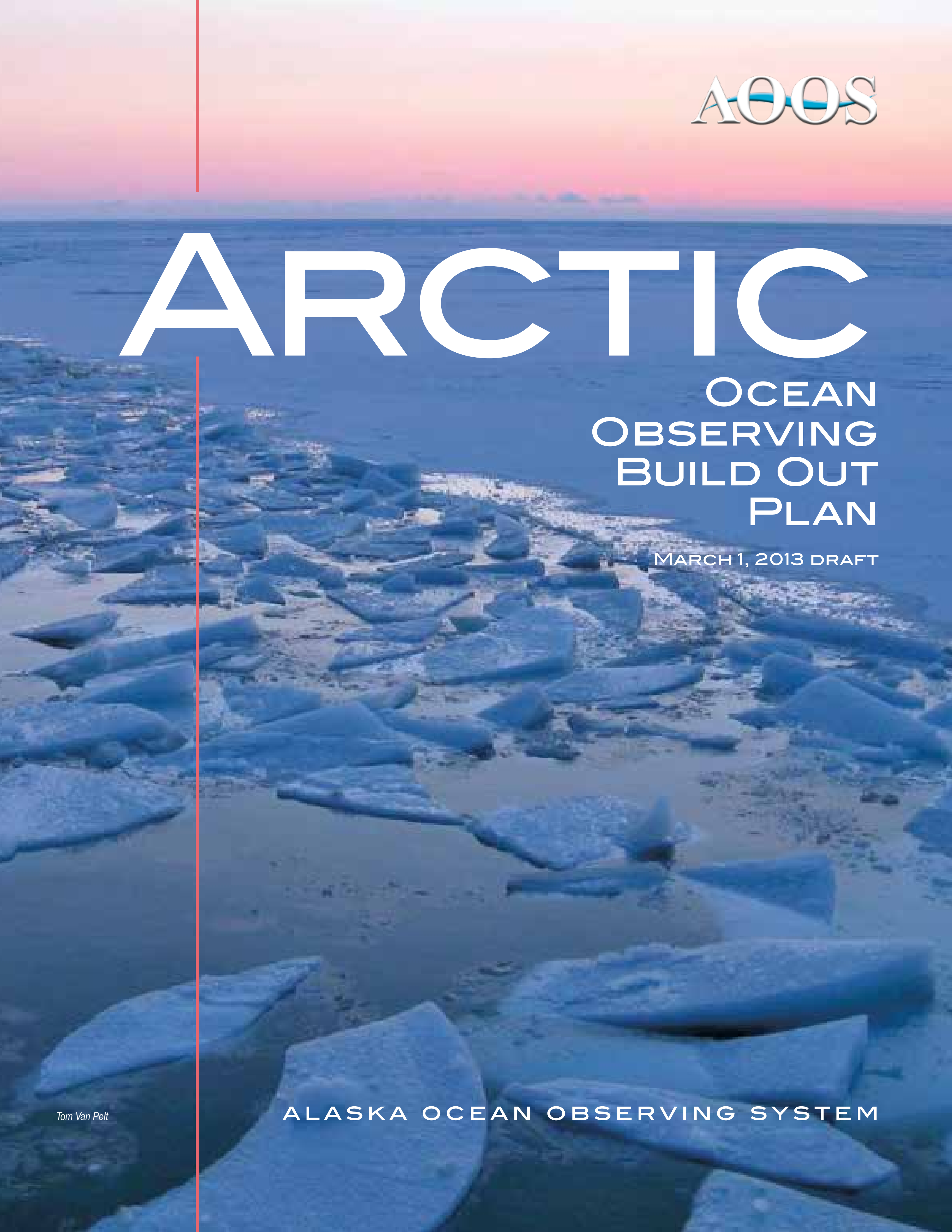


Tom Van Pelt

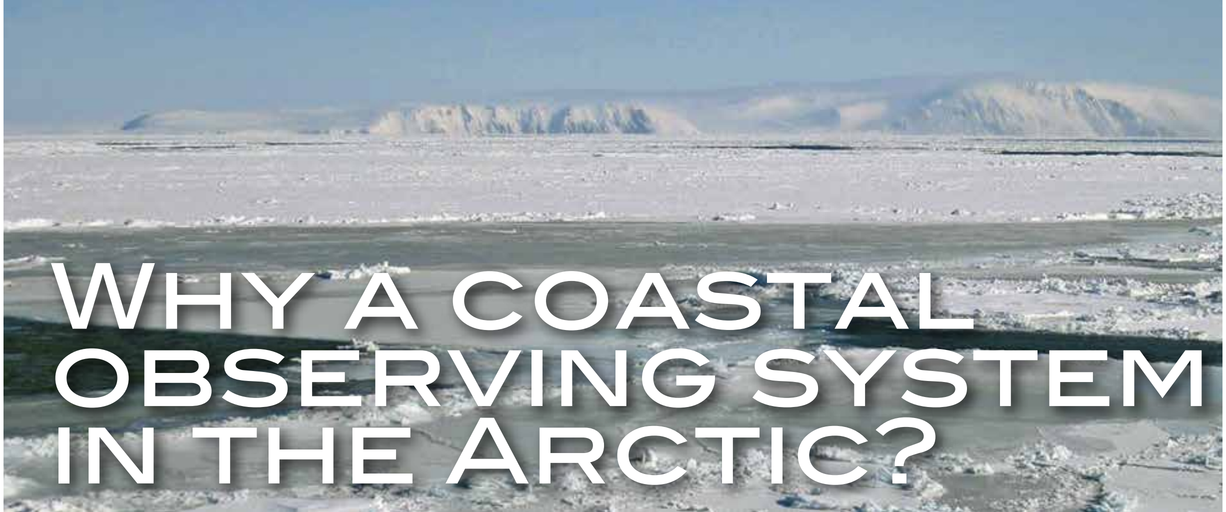
AOOS

ARCTIC

Ocean Observing Build Out Plan

March 1, 2013 draft

ALASKA OCEAN OBSERVING SYSTEM



Tom Van Pelt

Why a coastal observing system in the Arctic?

The Arctic is booming with increased activity due to declining sea ice, a longer open water season and increased vessel traffic, and new oil and gas exploration and development. Many of the issues and products described in the adjacent table are being responded to with funding from government agencies and private industry. However, information gaps remain, especially those relying on real-time data and consistent time series data for an ecosystem that is rapidly changing. This document describes a conceptual Arctic coastal ocean observing system that builds on these efforts with a "core"—or "bare-bones"—system that could be funded by AOOS, and "enhancements" that could be opportunistically funded by government and industry partners.

What do stakeholders care about?

- **Marine Operations:** support safe shipping and energy development, and improved spill response and search and rescue operations
- **Coastal and Offshore Hazards:** improve the ability to forecast and address changing storm and sea ice conditions, and their impacts on coastal communities
- **Ecosystems, Fisheries and Water Quality:** contribute to integrated ecosystem assessments with sustained monitoring of key biological, chemical and physical variables
- **Climate Variability and Change:** track changing ocean conditions over time, especially ocean acidification, sea level rise, temperature, salinity and sea ice

Table 1 lists the products for each issue identified by AOOS through numerous stakeholder workshops over the past five years.

Our approach

- National themes meeting Alaska specific stakeholder needs
- Based on information requirements and AOOS 10-year build out design
- Bare bones implementation with potential for enhancements
- Assumes existing federal assets, including satellites, will continue
- Assumes leveraging oil & gas industry assets will continue
- Depends on sustainable long-term funding

Table 1. Ocean observing components proposed for use by AOOS to address each information product.

User Needs/ Goals	Products/ Services	Arctic Observing System Components: Instrumented Moorings	Transects	HF Radars	Satellites	Models	Data Management
Marine Operations							
Vessel Safety	Observations of weather, sea, and ice	✓	✓	✓	✓		✓
	Nowcasts and forecasts for weather, sea, and ice	✓	✓	✓	✓	✓	✓
Search and rescue	Observations of weather, sea, and ice	✓		✓	✓	✓	✓
	Nowcasts and forecasts for weather, sea, and ice	✓		✓	✓	✓	✓
Spill response	Observations of weather, sea, and ice	✓		✓			✓
	Nowcasts and forecasts for weather, sea, and ice	✓		✓		✓	✓
Offshore energy	Climatologies and syntheses	✓	✓	✓	✓	✓	✓
	Nowcasts and forecasts for weather, sea, and ice	✓	✓	✓	✓	✓	✓
Coastal, Beach, and Nearshore Hazards							
Emergency response and preparedness	Hazard forecasts for coastal communities	✓		✓	✓	✓	✓
	Climatologies and syntheses	✓	✓	✓	✓	✓	✓
	Sea ice thickness, extent, and trajectory	✓			✓	✓	✓
Ecosystems, Fisheries, and Water Quality							
Health and productivity	Integrated datasets and displays						✓
	Regional ecosystem assessments or syntheses		✓				✓
	Distributed Biological Observations (DBO)		✓				✓
	Early warnings: hypoxia, harmful algal blooms, pollution	✓	✓	✓	✓	✓	✓
Long Term Change and Variability							
Ocean acidification	Status and trends of acidification (pH)	✓	✓			✓	✓
Shoreline and water level changes	Improved sea level forecasts	✓					✓
Ecosystem conditions	Coastal climate records	✓	✓	✓	✓	✓	✓

User Needs/Goals | Products/ Services | Instrumented Moorings | Transects | HF Radars | Satellites | Models | Data Management

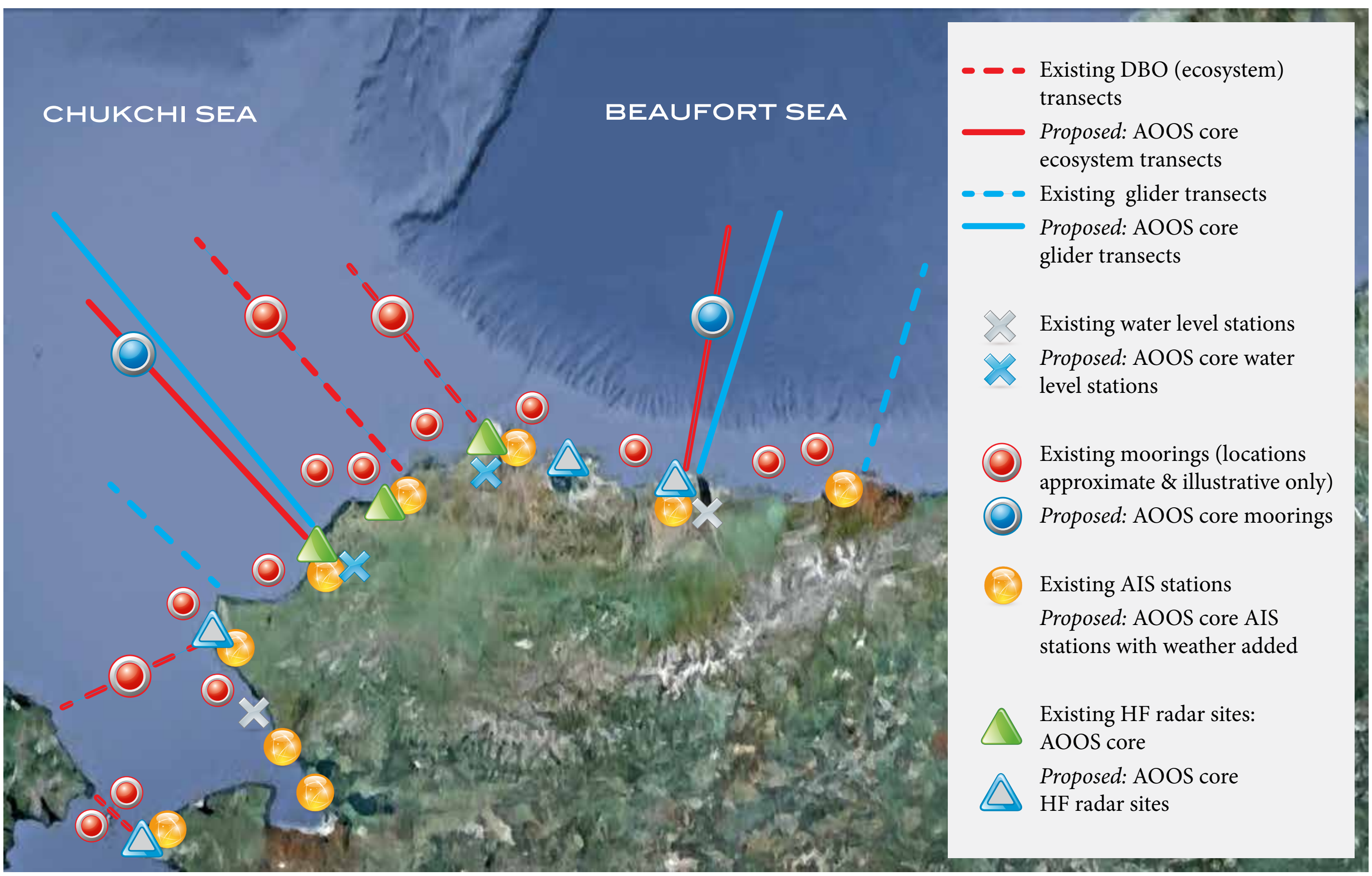
Monitoring the coastal ocean

An Arctic Ocean observing system needs to provide information on several aspects of the temporal and spatial structure of the ocean water column in the Chukchi and Beaufort Seas, especially under different wind and sea ice conditions. Current studies show that the circulation in this region is complex, especially at the junction between the Chukchi and Beaufort continental shelves. Not only is there an abrupt change in the orientation of the isobaths and in shelf width, but also the mean westward wind-driven flow over the western Beaufort Sea converges with the mean northeastward flow along the eastern boundary of Barrow Canyon.

Baseline information will be acquired using both fixed (e.g., moorings, HF Radars, weather stations) and mobile platforms (e.g., gliders, towed vehicles, etc.). The data will be valuable for maritime operations, oil spill response, forecasting ocean currents and sea ice trajectories, and better understanding the dynamics of the Arctic ecosystem.

Fixed platforms

Fixed platforms including moorings and shore-based assets, such as radars and weather stations, are essential components of an Arctic coastal ocean observing system, because they can provide critical real-time data.



Existing and proposed fixed platforms for Arctic ocean observing.

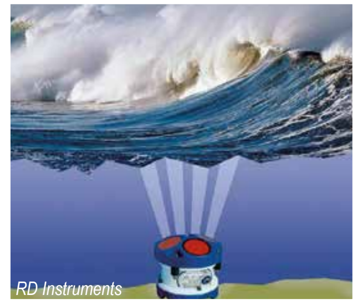

NOAA

Met ocean buoys

Fully instrumented ocean and coastal monitoring buoys will be deployed during the open water season (August–October) and the data made available on the AOOS website. The buoys will collect data on:

- Wind direction and speed
- Air temperature and humidity
- Multi-plate radiation
- Atmospheric pressure
- Surface water temperature and salinity
- Surface water pH

Acoustic Wave and Current Profilers (AWACs)


RD Instruments

Bottom mounted moorings (schematic, right) will be deployed year around and recovered once a year for data download and calibration. The sensors are anchored on the seafloor and will collect or provide:

- Ocean current speed and direction throughout (most of) the water column
- Wave heights and periods
- Bottom water temperature and salinity
- Bottom water pH
- Water level
- Backscatter data-based information on mixed layer depth and presence/absence of zooplankton)

Ice profilers


NSDIC

Bottom mounted moorings will use upward looking sonar (ULS) and an acoustic doppler current profiler (ADCP) deployed year around and recovered once a year for data download and calibration.

The sensors are anchored on the seafloor and will collect data on:

- Ice thickness
- Ice velocities

High Frequency (HF) radars


HF Radar at Wainwright.
UAF

Measurements of surface currents using HF Radar systems during the open water period are made along the Chukchi coast at Point Lay, Wainwright and Pt. Barrow with maximum observable range to approximately 250 km to capture the summer and fall surface current flow over the Chukchi shelf and around Hanna Shoal. Additional systems along the Beaufort coast, the southern Chukchi Sea, and the Bering Strait are key gaps to be filled.

AIS/Weather stations

Presently, most small coastal vessels operating in Alaska receive weather data over VHF radio, which has limited coverage in Alaska and is not the most efficient or clear way to transmit data. The Marine Exchange of Alaska (MXAK) has developed an extensive network of over 95 Automatic Identification System (AIS) receivers to track vessels operating in Alaska to aid safe, secure, efficient, and environmentally responsible maritime operations. MXAK and AOOS have partnered to initiate development and implementation of real-time weather data transmission via AIS to vessels operating in coastal waters out to 50 miles offshore. There are currently nine AIS stations north of the Bering Strait, but more are needed to provide continuous coverage.

Zeni Lite

Automatic Identification System aid to navigation.


Henry Huntington


NOAA


At-Sea Processors


Dave Rugh


B. Sheiko


AlaskaStock.com


USGS


NOAA

Tide stations

NOAA currently operates two year-round tide stations in the Arctic Ocean—one at the Red Dog Dock near Kivalina and another at Prudhoe Bay. These measure tide levels in real-time and make forecasts of future levels, and are key data for modeling and forecasting storms, waves and the potential for coastal erosion. AOOS would support operations of at least two more stations if the technology is developed to display the data in real-time at sites that have seasonal ice and do not have infrastructure extending into deeper waters.


Jan Van Der Woning/TCS/Zuma Press

Kivalina shoreline fortified with sandbags.

Mobile platforms

Autonomous gliders, drifters, and towed sensors

Surface current observations from HF Radars are supplemented by water column profile data collected by gliders, surface drifters, and towed CTDs to characterize the temperature and salinity structure, and circulation of ocean currents, under varying conditions of wind forcing and sea ice coverage. Gliders and/or towed sensors will measure:

- Water temperature
- Salinity
- Chlorophyll fluorescence
- Transmissivity
- Nutrients

AOOS would support two glider transects as a core part of the program.


PWS Science Center


PWS Science Center

Autonomous glider (above) and drifter (left).

Monitoring the ecosystem

The Pacific sector of the Arctic Ocean is experiencing major changes in the timing of sea ice formation and retreat, along with increasing seawater temperatures. These changes are driving shifts in hydrographic conditions, biological processes, and marine species composition and may signal the start of a large-scale marine ecosystem reorganization. Potential biological impacts include shifts in species composition, abundance and biomass, food web changes, and northward range expansions. Ecosystem information is needed to inform local communities about the species, size composition and age structure of the birds, mammals and fishes along their coast and provide ecosystem-based information to decision makers. This knowledge is needed to assess potential risks of exploitation, oil and gas development, commercial fisheries development and climate change.

Oceanographic transects

A network of international partners, using ice breaker research vessels, are coordinating standardized hydrographic measurements and biological observations of select trophic levels as part of a Distributed Biological Observatory (DBO) initiative at key regions of high biological production, biodiversity and observed areas of change. The DBO is envisioned as a change detection array for the identification and consistent monitoring of biophysical responses.

AOOS will support two DBO-type oceanographic transect lines in the Arctic – one in the Chukchi Sea and another in the Beaufort Sea. The following quantitative data will be collected every 1–3 years, depending on seasonal conditions and vessel availability, at fixed stations along the transects to assess abundance and distribution of biological resources that occupy the Beaufort and Chukchi Seas during the open-water season:

- Water column hydrography: CTD casts
- Water samples: chlorophyll, nutrients, ocean acidification (pH), phytoplankton (size, biomass and composition)
- Plankton nets: Zooplankton (size, biomass and composition)
- Mid-water trawl: Small pelagic fishes (size, biomass and composition)
- Bottom trawls: Demersal fishes and epibenthic invertebrates (size, biomass and composition)
- Benthic invertebrate infauna (size, biomass and composition)
- Seabirds (no additional shiptime)
- Marine mammal observations (no additional ship time)
- Fishery acoustics (less effort than standardized bottom trawling)

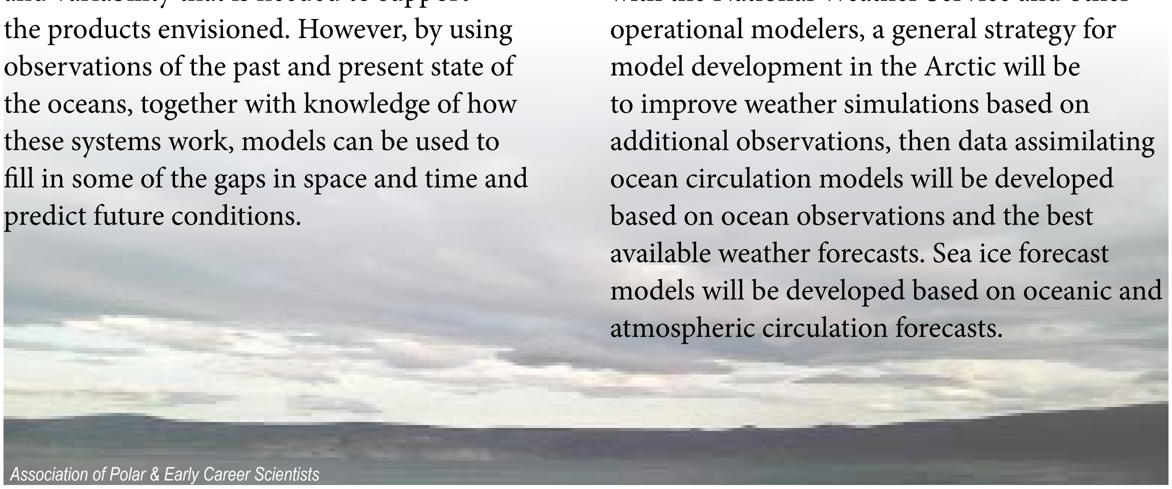
Oceanographic moorings

Each of these transects will be anchored with at least one fully-equipped met ocean mooring and one bottom mounted mooring as described under fixed platforms.

Predicting past, current, and future conditions

Even with all the previously described observing platforms in use, it is not possible to instrument the ocean at a high enough spatial density, and to sample continuously quickly enough, to capture all the structure and variability that is needed to support the products envisioned. However, by using observations of the past and present state of the oceans, together with knowledge of how these systems work, models can be used to fill in some of the gaps in space and time and predict future conditions.

Numerical models may be used for a variety of predictions, including sea level, surface waves, sediment transport, phytoplankton abundance, and nutrient concentrations, albeit with varying degrees of accuracy. Working with the National Weather Service and other operational modelers, a general strategy for model development in the Arctic will be to improve weather simulations based on additional observations, then data assimilating ocean circulation models will be developed based on ocean observations and the best available weather forecasts. Sea ice forecast models will be developed based on oceanic and atmospheric circulation forecasts.



Association of Polar & Early Career Scientists

Putting it all together: Integrating, Synthesizing, & Visualizing the Data

Data Management and Communication (DMAC) ensures that data is archived, recorded and transmitted in ways that are consistent in content and format among the various data providers. AOOS will provide data management as well as developing data visualization tools as an aid for spatial and temporal analysis of coastal ecosystems for use by industry and coastal communities.

Seasonal and annual climatologies, and ecosystem syntheses of fundamental oceanic parameters, as well as derived information products, are critical for management of coastal and ocean resources. Annual syntheses will be conducted that integrate biological, chemical and physical conditions from new and historical data to identify seasonal and interannual trends.

	Existing Capacity	AOOS Core	Potential Enhancements
Met ocean buoys	6, but varies and none are considered permanent	2, 1 anchoring each ecosystem transect	
Acoustic wave and current profilers	2, but varies and none are considered permanent	2, 1 anchoring each ecosystem transect	Seasonal wave buoys could provide more site-specific conditions
Ice profilers	2, but varies and none are considered permanent	2	
HF Radars	4, with plans for 2 more	8 permanent sites	Additional 15 sites would provide continuous coverage from Bering Strait to Canadian border
AIS /weather stations	9 without weather	9 with weather	
Water level/tide stations	2, at Prudhoe and Red Dog	2, at Wainwright or Pt. Lay and at Barrow	
Glider/drifter/towed array transects	2	2, 1 in Beaufort, 1 in Chukchi	Multiple transects, plus drifter coverage over broader geographic area
Oceanographic transects	4 DBO lines	2 DBO-type lines: 1 in Beaufort, 1 in Chukchi	10 (2 on each DBO line)
Oceanographic moorings	12	2, anchoring each of oceanographic transects	Many
Fish, seabird, and marine mammal surveys	Varies depending on funding; sporadic	None	Rely on federal and state agencies for regular surveys

This draft document was developed based on the past five years of stakeholder and scientist workshops facilitated or attended by AOOS staff.
We would appreciate your comments and suggestions on this draft.
Please send to Molly McCammon, by email: **mccammon@aoos.org.**

IOOS Integrated Ocean Observing System

AOOS Alaska Ocean Observing System

1007 W. 3rd Avenue
Suite 100
Anchorage, AK 99501
907-644-6718
www.aoos.org

facebook.com/AlaskaOceanObservingSystem