

**Appendix F**  
**Alaska Ocean Observing System (AOOS)**  
**Phased Implementation Strategy (2005-2011)**

**INTRODUCTION**

Implementation of an Alaska Ocean Observing System (AOOS) presents an enormous challenge due to the vastness of the region. Alaska's nearly 47,000 miles of coastline is about two-thirds of the total U.S. coastline and supports a wide variety of different habitats and user communities. To make this challenge more tractable, AOOS' first approach is to organize along three large marine ecosystem boundaries: Arctic, Bering Sea/Aleutian Islands and Gulf of Alaska. These regional classifications tend to be natural divisions that are differentiated by physical and biological characteristics [e.g., Large Marine Ecosystems of the World ([www.lme.noaa.gov/](http://www.lme.noaa.gov/))], management schemes (North Pacific Fishery Management Council), and use by stakeholders. Even the size of these three regions however, poses challenges.

Due to Alaska's remoteness and extreme weather conditions (frigid temperatures, precipitation, storms, high sea state, and sea ice), designing, installing and operating an ocean observing system throughout the three Alaska regions is the most difficult undertaking of any shelf area in U.S. waters. The extremely long distances render any plan for periodic servicing or unscheduled maintenance/repairs of observing arrays very costly and logistically often impractical. The dearth of nearby infrastructure, such as villages or other semi-permanent settlements, makes power availability, real-time data retrieval and routine equipment maintenance extremely challenging for almost every installation. Winter conditions challenge instrument capabilities because of the extreme temperature changes and the concomitant high winds/seas, ice, snow, and fog that accompany them. Extensive cloud cover associated with frequent passage of storms also contributes to the lack of ocean color, AVHRR and other visible remote sensing products that are typically available in other coastal areas.

In spite of the challenges with establishing an integrated ocean observing system in Alaska, the opportunities and needs warrant national attention. Presently, the Alaskan fishery provides > 40% of the U.S. and about 5% of the world harvest of fish and shellfish; Bristol Bay supports the world's largest sockeye salmon fishery; and the snow crab fishery is currently the largest crustacean (by weight) fishery in the U.S. In addition to supporting a large portion of the nation's fishery production, Alaska waters also support > 80% of the U.S. seabird population. Another crucial point for implementing AOOS is that greenhouse gas related global warming is thought to be amplified in polar regions, thereby making Alaska conditions a harbinger for climate change.

**STAKEHOLDERS**

The AOOS stakeholders cover a broad range of subsistence, commercial, cultural, and economic interests. User groups include a wide array of commercial and recreational fishers; subsistence hunters and fishers; marine transportation such as barges, ferries,

cruise ships, and oil/gas tankers; oil and gas developers, coastal communities and their residents; and resource managers, including the U.S. Coast Guard performing its full range of regulatory, safety and security missions. The user groups have a wide range of needs for data and information products. For example, some of these groups require precise navigation and real-time information, while others need only rudimentary knowledge of currents and water masses. While these needs exist today, others lie in the future, such as possible Northwest Passage transits under reduced Arctic ice cover. Increased surveillance, security and safety of transportation and commercial shipping activities (offshore, in ports, and in sea lines of communication between Alaska and the continental U.S.) are a recent and emerging area of concern for the U.S. that will be addressed by many of the proposed AOOS activities. All of the above information needs are closely tied to forecasting of weather and oceanographic conditions as most weather systems, including extreme events, transit across marine waters before entering our state.

The use of AOOS observations and products for science applications is also important. It is important to develop a better understanding of the variability of Alaska's ocean waters and diverse ecosystem dynamics that produce the nation's most abundant fish and shellfish harvests, as well as important birds and marine mammal populations. Many of the science applications are directed toward the sustainability of commercial and subsistence fishing, especially in the Bering Sea/Aleutian and Gulf of Alaska regions. Other examples of how AOOS products will contribute to scientific understanding include addressing the need to better understand the biophysical processes (e.g., wind mixing, upwelling, eddy formation) that contribute to the sustained high productivity of the shelf and continental slope waters, and improved assessment of biota. Weather and climate forecasts will benefit greatly from a much larger set of real-time observations in coastal areas that are presently missing. Modeling of long time series data would result in an improved and more comprehensive understanding of icing phenomena, shelf currents, shoreline erosion, tsunami hazards, and the evolution of catastrophic spill trajectories. In addition, longer term climate change scenarios will become more "testable" given a more comprehensive and complete set of observations.

#### STATEWIDE PRIORITY NEEDS

- Throughout Alaska waters, a system to acquire, process, integrate, and present remote sensing products that incorporate scatterometer, sea surface height, sea ice cover, ocean color, wave height and direction, water column currents, water column salinity, and water column temperature data.
- Data management and communications systems that provide real-time data for use by Alaska stakeholders, including the assimilation of data into models that provide information products such as ocean circulation patterns (taking into account waves, eddies and fronts) and improved nearshore forecasts to minimize impacts of coastal erosion on development; and systems that store the data and metadata from the observing network in formats that provide ready access to researchers, regulators, educators, and public and commercial users.

- Develop models that assimilate data to simulate circulation, including features such as upwelling, eddies and fronts.
- Systems to connect marine data and models with terrestrial data, especially given the importance both of fresh water input into the marine system and anadromous fish such as salmon which rely on both freshwater and marine waters.
- Comprehensive coastal and offshore mapping and charting.
- Shoreside capabilities to develop, stage, deploy, operate, and maintain observing systems to include AUVs, cabled and moored systems, and ground- and air-based remote sensors throughout Alaska.

## GULF OF ALASKA REGION PRIORITY NEEDS

### National Backbone:

- Increase the number of meteorological/oceanographic buoys/moorings to obtain a density of observations comparable to at least *half* that in the rest of the U.S. coast. The Gulf of Alaska coastline is more than twice as long as that of the northern California/Oregon/Washington coast, yet has about half the number of buoys/C-MAN stations. At present, areas in the Gulf of Alaska region that have an extreme paucity of buoys are Southeast and Inland Passage, Cross-Sound to Prince William Sound, Kodiak, and Alaska Peninsula. All oceanographic observations should be expanded to include salinity, oxygen, depth-resolved currents, temperature, chlorophyll, nitrate, biological variables (e.g., plankton density using acoustics), visibility, wave height/direction, and incoming solar radiation.
- Deploy long range High Frequency (HF) radar surface current mappers to the equivalent of *half* the density of the rest of the coastal US.
- Enhance fisheries and ecosystem information collection and products.
- Increase the number of stream gauges, and enhance them to include monitoring water quality and sediment load in real-time, particularly on large rivers.

### Regional:

- Integrate, enhance, and sustain existing estuarine and coastal monitoring, particularly in Cook Inlet, Outer Kenai Peninsula and Prince William Sound, adding real-time capabilities.
- Develop new monitoring capacity in Kodiak and Southeast areas.
- Enhance and sustain periodic lines of oceanographic surveys on the shelf and in estuaries, and especially along the Seward Line and GLOBEC transects. These can initially be done by ship, but eventually gliders could be used.
- Enhance and sustain ship of opportunity program for monitoring of physical, chemical and biological parameters.
- Implement short range HF radar surface current mappers in local areas such as Cook Inlet, Outer Kenai Peninsula and Prince William Sound.
- Improve estimates of non-point (line) source coastal freshwater fluxes into the Gulf of Alaska and quantify freshwater fluxes from tidewater and coastal range glaciers.

### Information Products:

- Nowcasting/forecasting capabilities for improved input to search and rescue operations and improved response to hazardous waste releases and oil spills.
- Marine sea state and icing conditions for vessel use.
- Predictions of coastal erosion based on weather, wave, and geological data.
- Real-time access to data from moorings and HF radar systems.
- Ancillary data stream for National Weather Service.

## BERING SEA/ALEUTIAN ISLAND REGION PRIORITY NEEDS

### National Backbone:

- Enhance and sustain the number of monitoring buoys over the Bering Sea shelf, each with the capability to measure meteorological, water property, and biological parameters that provide real-time data. Two additional buoys on the eastern shelf and the enhancement of the two existing buoys to real-time capability would greatly improve the existing coverage. All oceanographic observations should be expanded to include salinity, oxygen, depth-resolved currents, temperature, chlorophyll, nitrate, biological variables (e.g., plankton density using acoustics), visibility, wave height/direction, and incoming solar radiation.
- Install five C-MAN stations along the Bering Sea coastline between Bristol Bay and Bering Strait.
- Deploy several long range HF radar surface current mappers at pulse points (e.g., Bering Strait, Aleutian Straits) in circulations and major fishing grounds.
- Enhance fisheries and ecosystem information collection and presentation by expanding the area covered by surveys and increasing the oceanic parameters collected.

### Regional:

- Establish and maintain a north-south array of five profiling real-time telemetry moorings along the 70m isobath with physical, chemical, biological, and met sensors. – make real time as much as possible and include measurements of entire water column where possible.
- Establish and maintain a set of moorings across the Alaska Stream south of the Aleutian Islands, including shelf break (the interface between oceanic and shelf regimes and the location of substantial trawl fishing) buoys to measure entire water column. Consider deploying 2-3 moorings each in Unimak Pass, Amukta/Samalga Pass and Amchitka Pass to study the relationship between fluxes through the passes, conditions in the Bering Sea, and timing and/or duration of the Bristol Bay sockeye runs.
- Expand coverage (both spatial and data type) of Alaska Fisheries Science Center's bottom trawl surveys and BASIS project surveys for the U.S. shelf regions including the Chirikov Basin.
- Record in real-time (passive microphone) key indicator species such as whales under all weather conditions, and thus greatly improve the knowledge of their behavior and habitat utilization.

- Establish and sustain ship of opportunity program for monitoring of physical, chemical and biological parameters using commercial fishing vessels, ships using the great circle route, and barge traffic.
- Develop sustained atmosphere/ocean cable-linked observatories on the Pribilof Islands and Little Diomed Island

#### Information Products:

- Improved sea ice forecasts that predict the maximum extent and the timing for the advance and retreat of sea ice to better understand the relationship between sea ice and ecological processes, assess the impact of climate change, and give up-to-date information for coastal residents, managers and subsistence users.
- Vessel icing forecasts that use real-time observations of air and water temperatures, wind and sea state to create vessel warning scenarios when dangerous conditions prevail.
- Further identification of sentinel species and development of a monitoring network to assess changes.
- Real-time recordings of sentinel species such as whales under all weather conditions and thus greatly improve the knowledge of their behavior and habit utilization.
- Predictive capabilities of coastal erosion based on weather and wave data.
- Real-time access to data from moorings and HF radar systems.
- Ancillary data stream for National Weather Service

#### ARCTIC REGION PRIORITY NEEDS

##### National Backbone:

- Four C-MAN stations along the Arctic coastline including Bering Strait, Barrow, Prudhoe Bay, and the Mackenzie River.
- Stream flow gauges at key sites.
- Better bathymetry and nearshore topography measurements.
- Moored oceanographic buoys along the Arctic coast with meteorological and water sensors (including sea-level) to provide real-time data.
- Network of ice-tethered buoys with real-time data reporting to measure radiation balance, surface meteorology, ice mass balance, and ocean physical properties in multi-year ice regions for climate and weather observation and forecasting.
- Continuity of RADARSAT or similar year-round monitoring of sea ice conditions, and extension to include ice characteristics and thickness.
- Validation, calibration and ground-truthing for Arctic conditions of national space-based sensors.
- Routine access to Navy's submarine-based Arctic research program, including under-ice observations of water mass, ice and bottom conditions and in particular, under-ice bathymetry and geophysics to address the U.N. Convention on the Law of the Sea Article 76.

Regional:

- Improved forecasting of near-shore sea ice and fog via satellite and coastal observations.
- Develop cabled ocean observatories at Barrow Canyon (first), Prudhoe Bay region and Mackenzie Canyon for yearlong data acquisition because of sea ice cover during winter.
- Deploy sea gliders and AUVs for autonomous ocean data gathering in all seasons. This would likely begin offshore of Barrow and must take into account sea and shore-fast ice.
- Aerosondes for remote observation of near-shore ice and leads and biological surveys.
- Moorings offshore at selected locations with ice profiling sonars (ULS) for yearlong measurement of sea ice draft.
- HF (microwave) radar coverage (Barrow, Prudhoe Bay) for monitoring of nearshore ice edge and surface currents as an aid to navigation/shipping and local subsistence and commercial use.
- Establish ship of opportunity program for ocean and weather monitoring.
- Wind and wave measurements as part of a program to mitigate coastal erosion and improve navigation safety.

Information Products:

- Improved forecasts of sea ice extent and timing of the annual and episodic advance and retreat to help the fisheries, shipping and oil and gas industries as well as for better public safety.
- Real-time recording (passive microphone) of key indicator species such as endangered whales can be recorded under all weather conditions and thus greatly improve the knowledge of their behavior and habit utilization.
- Real-time access to data from moorings and HF radar systems.
- Real-time access to data from cabled systems for assessment of Arctic water mass and sea characteristics, and for monitoring of marine mammals.
- Ancillary data stream for National Weather Service.

Approximate Costs:

Alaska Ocean Observing System					
Year	Total	Gulf of Alaska	Bering Sea	Arctic	Data Management
2005	4	2.7	0.8	0.2	0.3
2006	8	4.5	1.5	1.5	1
2007	16	5	5	5	1
2008:2011	31	10	10	10	1

Additional ship costs (estimate of 8 days at \$20k per day x 3 regions x 3 times per year = \$1.4M) related to maintenance and service to the installed equipment three to four times each year are not included.