

I. REGIONAL MANAGEMENT

The Alaska Ocean Observing System (AOOS) is the regional association for Alaska as part of the national Integrated Ocean Observing System (IOOS). Within AOOS are three geographically, culturally and economically diverse regional coastal and ocean observing sub-systems (Gulf of Alaska, Bering Sea/Aleutian Islands and Arctic). AOOS began in July 2003 as a consortium of partners operating under a Memorandum of Agreement (adopted in 2005, and revised 2009, see www.aos.org). It is the intent of AOOS to become formally certified as the Regional Association for Alaska.

- *Board:* AOOS is governed by a Board of Directors, currently made up of its membership of federal and state agencies, research entities, and private sector organizations (see www.aos.org for members). Once the membership reaches 25 or more members, the Board may choose to elect a subset of members to serve as directors. An Executive Committee, made up of the AOOS officers and a representative of the fiscal agent, acts on behalf of the AOOS Board between meetings.
- *Committees and Advisory Groups:* AOOS uses two standing committees and numerous ad hoc committees for guidance (see Figure 1, Appendix C). The Data Management Advisory Committee is composed of technical experts, including both data users and data providers, from a variety of agencies and organizations. They provide technical advice to the AOOS Data Team and program staff. The AOOS board approved formation of a statewide stakeholder/user advisory committee in 2009, but for the purposes of developing this proposal, a larger community of users was tapped. Three workshops were convened, organized along the priority themes adapted from those identified by the National Federation of Regional Associations for Coastal and Ocean Observing (NFRA) in 2009. These included Marine Operations, Coastal Hazards, and Ecosystems and Climate Trends. Representative stakeholder entities who participated in these thematic workshops will become members of the longer-term Stakeholder Advisory Committee (see www.aos.org).
- *Program staff:* AOOS currently employs two full-time staff: an Executive Director and a Program Manager for Partnerships and Outreach. A third full-time staff, a Program Manager for Operations and Science, will be hired in 2011 to facilitate the development of the observations and modeling systems of AOOS. Staff will manage all program components, implement the observing system to meet stakeholder needs, work with the data team to develop products for users, and collaborate with other regional, national and international ocean observing initiatives, including the national IOOS office and NFRA. Staff will focus much of its efforts on integration of Arctic observing activities and the statewide ecosystem and climate trends monitoring, and developing information products for stakeholders.
- *Fiscal agent:* The Alaska SeaLife Center, an incorporated nonprofit, acts on behalf of AOOS as its fiscal agent, and performs all its legal, financial and administrative functions. The fiscal agent fee is based on the direct costs of those services.
- *Geographic approach:* The AOOS Board strongly believes that Alaska should have at least three, if not five, separate regional coastal and ocean observing systems (see Appendix D), based on the Large Marine Ecosystem concept (Sherman 1991). These include the Gulf of Alaska, Bering Sea and Aleutian Islands (BSAI), and Chukchi and Beaufort Seas (Arctic). The Board has placed a priority on expanding observation capacity in the Arctic and in the northern portion of the Gulf of Alaska (GOA). The GOA includes Prince William Sound and Cook Inlet, two regions with high vessel traffic and dynamic circulation systems that border the main population centers of Alaska.

- *The Arctic as a national priority:* One of the priority objectives in the recently adopted National Ocean Policy highlights changing conditions in the Arctic. It specifically calls upon the nation to: “Address environmental stewardship needs in the Arctic Ocean and adjacent coastal areas in the face of climate-induced and other environmental changes.” Additionally, NOAA is developing an Arctic Vision and Strategy, as well as an Implementation Plan. AOOS will look towards these initiatives in developing its Arctic monitoring program.
- *Planning challenges:* Developing an integrated ocean observing system at high latitudes creates unique challenges. In addition to the harsh environment, the marine system encompassed by AOOS is larger than the combined marine systems in the rest of the United States (nearly 44,000 miles of coastline). No other observing system in the United States has such climate extremes, significant geographic distances, and limited observing infrastructure. Although the population of Alaska is small (about 675,000), 80% of the residents live on the coast, including a large indigenous population.
- *Proposal approach and key objectives:* This proposal builds upon existing efforts, and takes into account the paucity of real-time observations in Alaska by relying extensively on collaborations. This includes leveraging with other programs, and providing coordination and synthesis services to better integrate existing activities. The proposal represents the priorities identified by the stakeholder workshops and adopted by the AOOS Board: 1) increase access to existing coastal and ocean data; 2) package information and data in useful ways to meet the needs of stakeholders; and 3) increase observing and forecasting capacity in all regions of the state, with a priority on the Arctic and the northern Gulf of Alaska. The proposed work plan is described under the following components: observations and products; data management; modeling and analysis; and communication, education and outreach.

II. OBSERVATIONS AND PRODUCTS

A. MARINE OPERATIONS

Goals: Due to the geographic extent of Alaska, many areas frequently travelled by vessels do not have routine observations, accurate forecasts, or efficient ways for mariners to receive the forecasts. To improve safety, AOOS will focus on sustaining weather observations, improving weather and marine forecasts, and more effectively disseminating information to users.

Background: Alaska’s marine operations are diverse. The state is home to a \$6 billion fishing industry, offshore oil exploration in Cook Inlet and the Arctic, a Marine Highway System serving local and visitor traffic, and cruise ships carrying a million cruise passengers per year. As Arctic sea ice retreats and the Northwest and Northern Route passages stay open for longer periods, more vessels pass through Alaska waters, taking shipments to international destinations or touring the Arctic for recreation. Weather conditions in Alaska change quickly, are locally specific, and aren’t always captured by Alaska’s limited coastal and marine weather stations. While Alaska’s geography will remain a challenge, AOOS has identified several key objectives for immediate improvements.

Objectives and Approaches:

1. *Sustain and increase access to weather observations in key locations.* AOOS will continue its efforts to provide accurate and real-time observations to boaters in Prince William Sound. In partnership with the Oil Spill Recovery Institute, AOOS will provide funding to maintain a set of eight SnoTel stations providing real-time web accessible data. The images from the webcams are juxtaposed on the AOOS website and accessed daily by pilots, boaters, lodge owners, fishermen, and recreationists, serving as one of the most popular pages on the

AOOS website. We will assess the value of each of these stations, and focus our funding efforts on those with the broadest use.

AOOS will also work towards improving observation and forecast dissemination. Presently most vessels receive weather data over VHF radio, which has limited coverage in Alaska and is not always efficient. AOOS will partner with the Marine Exchange of Alaska to implement Automatic Identification System (AIS) transmitters to disseminate real-time weather data, buoy data, and weather forecasts to vessels. The Marine Exchange operates a network of over 80 AIS receiving stations, covering most of the state. By establishing joint WX/AIS stations at existing AIS locations, and installing new stations in remote areas, real-time information can be digitally displayed on a vessel's AIS Minimum Keyboard Display or integrated into the vessel's chart plotter for immediate use in navigation. Three stations would be equipped the first year, with six additional stations per year in the remaining years.

2. Improve forecasts. AOOS will maintain and enhance wind and circulation models in Prince William Sound and Cook Inlet. AOOS will maintain funding for the high resolution PWS/Cook Inlet WRF model, which provides daily wind forecasts critical for other regional modeling efforts. AOOS will also partner with Texas A&M University to continue development of a SWAN wave forecasting model for PWS and Cook Inlet, run operationally to produce 36-hour forecasts every 24 hours.

AOOS will continue its partnership with NASA Jet Propulsion Lab (JPL) to maintain an operational ROMS forecasting model and data assimilation system in the Gulf of Alaska. This consists of a 3-level nested configuration covering PWS at 1-km resolution, the northeastern Gulf of Alaska (GOA) at 3-km, and the northeastern Pacific Ocean at 9-km. ROMS nowcasts and forecasts are produced daily, and images, analysis and model output will be published at JPL and with AOOS's Model Explorer (see Section IV). The ROMS relies on accurate hydrological data for PWS, which to date does not exist. AOOS will provide funding to help validate the existing hydrological model by incorporating glacial run-off and river gauge data.

The existing ROMS model will be used to provide critical support for the NOAA Coastal Survey Development Lab's (CSDL) FY11-12 project to develop a real-time forecasting system for Cook Inlet based on ROMS. The JPL multi-scale 3DVAR data will enhance the NOAA CSDL modeling effort by assimilating observational data into the model on a periodic basis to improve forecasting. Additionally, AOOS will partner with NOAA's Kasitsna Bay Lab to install and maintain a current meter in the central inlet. This meter will support CSDL's model validation, product development, and regional coastal science and management efforts.

3. Tools and Products. A statewide surface trajectory tool will be developed by NASA JPL to aid in oil spill response as well as search and rescue operations. Users will be able to drop particles and track their trajectories using an interactive web interface. The tool will be derived from forecast models, as well as from surface currents generated from the U.S. Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE) four-year HF radar project on the Arctic coast, until AOOS has the resources and partners to deploy its own HF radar arrays. The tool will build off JPL's drifter trajectory tool currently focused on PWS.

AOOS will also increase public access to real-time data through user-friendly tools, including a real-time sensor map, web cam maps, and smart phone applications using emerging communications technologies. An AOOS priority will be to develop methods to "push" relevant data to users on a routine basis.

Audience and Benefits: Numerous weather-related marine casualties in Alaska have led to the loss of life, property and environmental harm. Many of these could have been avoided if the mariners had been able to access better real-time observations and forecasts. Some regions of

the state, notably Prince William Sound and Cook Inlet, receive a diversity of vessel traffic from oil tankers and container ships, to ferries, commercial and charter fishing boats, and recreation vessels. Ninety-five percent of Alaska's goods cross Cook Inlet, navigating through dynamic sea ice and extreme tidal and circulation variation, to arrive at the Port of Anchorage. The prospect of an accident in these waters has massive environmental, regulatory, and human consequences.

Further offshore, mariners in Alaska routinely encounter 30-foot seas, long-term darkness and far distances to the nearest vessel. As ice and sea state conditions fluctuate due to changes in climate, observing and forecasting needs become even more relevant.

Representative stakeholders include commercial fishermen and recreational boaters, the U.S. Coast Guard, Marine Exchange of Alaska, the Alaska Energy Authority, the U.S. BOEMRE, the Prince William Sound and Cook Inlet Citizens Advisory Councils, the National Weather Service (NWS), Alaska Ports and Harbors, the Oil Spill Recovery Institute (OSRI), and offshore oil and gas companies such as Shell and Conoco Phillips. AOOS has also received staunch support and information requests from charter boat associations, remote lodge owners, and small aviation companies.

B. COASTAL HAZARDS

Goals: The goal of AOOS's coastal hazards component is to improve the ability to forecast and plan for changing storm and sea ice conditions, and their impacts on coastal communities. AOOS will focus on water level and wave observations, and sea ice data products.

Background: The impacts of climate change have become readily apparent in Alaska. As our nation's only Arctic state, Alaska is experiencing dramatic reductions in sea ice cover, increased storm surge, thawing coastal permafrost, and consequent coastal erosion. These conditions are endangering coastal communities, most of which are home to Alaska Natives. In a statewide assessment, flooding and erosion affects 184 out of 213 Native villages (GAO 2003). While some villages may need to be permanently moved, relocation is usually prohibitively expensive. Meanwhile, better forecasting for storm surge and inundation is needed to help local people prepare for dangerous storm events.

Sea ice plays an active role in both the coastal processes described above, and impacts to the safety of subsistence hunters and commercial operations offshore. Ice extent and thickness is on a stochastic trend downward, and ice dynamics are complex and difficult to predict. Although progress has been made in past years, current efforts of monitoring real-time ice conditions and analyzing past ice conditions are insufficient to meet user needs.

Objectives and Approaches:

- 1. Increase water level observations in Western Alaska.* To date, the only permanent water level gauges north of the Aleutians are at Nome, Red Dog, and Prudhoe Bay. This leaves three data points for almost half the distance of Alaska's coast. AOOS will install water level sensors at new village sites, likely using a bottom mount and a shore-based bubbler system at each site. Data from the bottom mount will be retrieved bi-annually while the bubbler will stream real-time data seasonally during ice-free seasons. These data will be used by the NWS for forecasting, and by the USACE for wave and inundation models to help inform safe development and community relocation plans. AOOS is investigating the most effective way to accomplish this activity and will consider a partnership with the fledgling Alaska Harbor Observation Network, which was initiated by AOOS in 2007. Another possibility is a partnership with NOAA's Center for Operational Oceanographic Products and Services (CO-OPS) to install and maintain the sensors, with potential matching funds from the U.S. Army Corps of Engineers (USACE).

2. Increase wave observations. AOOS will purchase and install three WaveRider buoys (1) in the Chukchi Sea off the coast of the Red Dog Mine port site south of Kivalina, (2) in Bristol Bay, and (3) off the coast of Yakutat in the Gulf of Alaska. These locations cover missing gaps for NWS forecasters as well as USACE modelers, and will help implement the IOOS National Operational Waves Observation Plan in Alaska. The buoys will measure wave height, period, and direction. Real-time data from the buoys will be telemetered to AOOS and streamed through the AOOS web portal, as well as pushed to the NWS for ocean forecasting. The data will also be archived by AOOS, and accessible for historical research.

3. Develop sea ice data products. Many requests for historical and climatological sea ice information for Alaskan coastal waters presently go unanswered because such an atlas does not exist, in either hard copy or electronic form. AOOS will partner with the Alaska Center for Climate Assessment and Policy (ACCAP) to produce an atlas consisting of digitally stored sea ice concentration data on a grid covering all Alaska coastal waters to a distance of approximately 300 n mi (500 km) from shore. The spatial resolution will be 5-10 km, and the time-resolution will be weekly, spanning the period from the early 1950s through 2010 with the allowance for subsequent updates. The accompanying statistical software will enable probabilistic depictions of ice coverage of various concentrations on specific calendar dates at user-specified locations. Mapping software will be included with the digital database. The software will include the capability for computation of area totals of ice coverage, opening and closing dates for various shipping corridors, seasonal severity indices, and other measures to be determined through discussions with potential users.

Additionally, AOOS will promote the collection of coastal ice information by supporting a community-based coastal ice observation program led by University of Alaska Fairbanks (UAF) scientists. This project, combining a key set of standardized geophysical and local expert-driven observations, will improve the understanding of interannual to decadal-scale change in coastal ice conditions and their impact on human activities. The work will create the tools and templates that will enable cooperative, community-based observers to contribute to a growing database. The methodology for advancing these goals has been developed with strong community engagement. UAF is currently working with the Exchange for Local Environmental Knowledge in the Arctic (ELOKA) to develop a database, with web-based data entry and a public access portal. This eventually will be integrated with the AOOS Data Portal. The observations will augment the sea ice radars funded by NSF with additional real-time data that will be available through AOOS.

Audience and Benefits: Changes in sea ice affect activities ranging from subsistence hunting and coastal travel to community safety and the use of ice as a platform by industry. Multiple entities are looking for information on sea ice conditions at spatial-temporal resolutions higher than standard products from the NWS Ice Desk, and the topic of sea ice forecasting was raised at every AOOS scoping workshop. Stakeholders include coastal subsistence communities from Dillingham to Nuiqsut, as well as Shell, Conoco and other oil and gas companies active in offshore drilling and exploration, coastal managers, the U.S. Army Corps, the U.S. Navy, and researchers in the Earth/Arctic system science field.

The need for wave buoys and water levels sensors has also been loudly voiced. Alaska's existing wave buoys cover only a small fraction of Alaska's 44,000 mile coastline, creating major challenges in forecasting storms, reporting conditions, and effectively responding to spills. NOAA's National Data Buoy Center (NDBC) has struggled to maintain its existing buoys in Alaska, and several key buoys are not operational. Representative stakeholders for wave buoys

include National Weather Service forecasters, the U.S. Army Corps of Engineers, coastal communities, shippers, fishermen, the U.S. Coast Guard, and USGS wave hindcast modelers.

C. ECOSYSTEMS/FISHERIES AND CLIMATE TRENDS

Goal: The goal of this component is to build upon and leverage existing activities to develop an integrated network of physical, chemical and biological observations off Alaska to meet short- and long-term needs. AOOS will focus statewide on enhancing a Distributed Biophysical Observatory (DBO) and expanding ocean acidification observations. In the northern Gulf of Alaska (GOA), the focus will be on advancing sentinel monitoring.

Background: Alaska has a need to understand marine climate variability and ecosystem change in the long term, as well as how conditions affect ocean circulation and productivity in the short term. Additionally, ocean acidification (OA) has emerged as a new and potentially high impact issue in Alaska, with the relatively shallow shelf seas in the northern Gulf of Alaska, the Bering Sea, and the Chukchi Sea already experiencing seasonal manifestations of OA. Because of Alaska's remoteness and the high cost of ship time, consortia are forming to maintain support of long-term time series of physical, biological and chemical oceanographic conditions to understand climate variability and ecosystem change, including funding for equipment replacement. Sentinel monitoring in the GOA enhances past AOOS-funded activities in the most-heavily used ocean region of Alaska.

Objectives and Approaches:

1. *Distributed Biophysical Observatory.* AOOS will support a network of long-term moorings, ship and glider transects, instrumented fish and marine mammals, passive acoustic sampling and other platforms in Alaska waters. These assets provide ocean condition information to assess climate trends, and support ecosystem-based management of fisheries and endangered and threatened species. The goal is to unite these platforms into one system. These long-term projects are not funded by any agency's base funding. Rather, funding is cobbled together annually from a multitude of sources. Most agencies are reluctant to fund new equipment purchases, including the addition of biological and chemical sensors to existing moorings already monitoring physical parameters. Agencies are also unlikely to fund support for coordination and integration efforts. AOOS is the entity best suited to maximize the value of these initiatives, both to maintain long time series data collection, and to provide funding for staff to synthesize new and existing data. AOOS is placing a special emphasis on the synthesis and integration of research and monitoring information in the Arctic, since agency and industry scientists are implementing multiple short-term activities as a result of the recent interest in potential offshore oil and gas development. AOOS will support coordination and integration efforts, fund some equipment purchases and contribute funding to three consortia supporting long-term data collection: the Seward Line, Bering Sea moorings, and Arctic glider transects.

(a). To achieve the goal of a united network, AOOS will partner with the North Pacific Research Board, UAF, NOAA, USGS and others by funding two positions: a full-time staff assigned to the Distributed Biophysical Observatory (DBO), and a post-doc at UAF. The DBO is envisioned as a "change detection array", designed to measure biological responses to physical changes in the Pacific Arctic marine ecosystem. AOOS's goal is to ensure that data from the sampling efforts are accessible to all researchers and the public, as well as marine spatial planning efforts. AOOS staff have already developed a web-based mapping application, which provides access to metadata for sensor platforms and known cruise and sample efforts in the Beaufort and Chukchi Seas. AOOS will support one full-time staff person at a location still to be determined to assist with overall coordination of these efforts.

In addition, AOOS will support one post-doc or technician at the University of Alaska Fairbanks School of Fisheries and Ocean Sciences (UAF SFOS) to work with this initiative to incorporate data from existing mooring and glider work done in the Beaufort and Chukchi. The current version of this system is publically available at: http://data.aos.org/maps/arctic_assets.html and will soon be expanded statewide. AOOS will collaborate with the other Pacific Ocean RAs to develop integrated products from our complementary initiatives.

(b). AOOS will contribute to a consortium led by UAF SFOS to support sampling along the Seward Line, the longest multidisciplinary time series in Alaska. The line provides a critical long-term data series on oceanographic conditions in the GOA and how the region may be changing with climate impacts. It has been sampled continuously since October 1997, with some measurements going back to late 1970's. Funding supports the cost of two cruises a year (May and August/September), sample/data processing and analysis. In addition funding is included for a new, telemetered mooring at GAK 1 station, as well as a glider for opportunistic sampling during El Nino and La Nina events.

(c). AOOS will contribute to the consortium led by NOAA's Pacific Marine Environmental Laboratory (PMEL) to support the Bering Sea moorings, which provide data used by nearly every scientist working in the Bering Sea. Each mooring site has a bottom-mounted ADCP and measures temperature, salinity, nutrients, and fluorescence throughout the water column. These moorings provide moorings-of-opportunity to a number of other investigators including: passive acoustic listening devices for marine mammals (National Marine Mammal Lab), instruments to measure zooplankton (University of Pennsylvania), acoustic devices to measure rain (Applied Physics Lab, University of Washington), and in 2011, pCO₂ sensors (UAF). AOOS funding will be used to purchase equipment for new measurements (ice thickness and moored oxygen) for the moorings, and replace various pieces of equipment (hardware, anchors, floats) that were lost or damaged. Each April/May, PMEL recovers and redeploys moorings at M2, M4 and M5 (ice extent permitting). In September/October PMEL recovers all moorings and deploys winter moorings.

(d). AOOS funds will also be used to help a consortium led by UAF SFOS establish a high-latitude observation node in the central Chukchi Sea offshore of Wainwright. This is a critical section for observing the through-flow of water between the northern Bering Sea and the interior Arctic, and is a location of large primary productivity in an Arctic shelf sea. The core mooring design will be similar to the Bering Sea moorings, equipped with a bottom-mounted ADCP and a Seabird SBE-16 measuring temperature, salinity, nutrients, pCO₂ and fluorescence. Spatial information around the single point core mooring will be collected using Webb Slocum gliders that will operate throughout the ice-free season, with small-vessel support based out of Wainwright. AOOS funds will be used to purchase two moorings, sensors and two additional gliders for this project.

(e.) To add context to the research described above, and to help Alaskans understand potential climate scenarios, AOOS will partner with the University of Alaska Fairbanks to extend the downscaling of climate projections to include the Alaskan coastal zone. In addition to the conventional downscaled variables of temperature and precipitation, stakeholder-relevant variables such as storminess (wind) and sea ice will be included. This information will be made accessible to coastal managers and other users through a website where users can query by location, variable, time-slice (decade, through 2100) and greenhouse scenario (A2, A1B, B1).

2. *Ocean acidification monitoring.* AOOS will partner with the new UAF Ocean Acidification Center, the Alliance of Coastal Technology (ACT) and NOAA to support the fledgling statewide OA research monitoring program, and make data available through AOOS.

(a). AOOS will maintain OA sampling of an existing, ongoing oceanographic time series transect (Seward Line) in the northern Gulf of Alaska two times per year to quantify the physical and biogeochemical controls on OA. This will fund the completion of eight years of monitoring on the Seward Line, the minimum amount of time necessary to capture definitive changes in ocean carbonate chemistry. Samples of dissolved inorganic carbon, total alkalinity, partial pressure of CO₂, pH, carbonate mineral saturation states, particulate organic carbon, dissolved organic carbon, and oxygen isotopes will be collected and analyzed. OA data can then be combined with observations of specific pelagic and benthic calcifying organisms to monitor how keystone species in the food web are responding to increased intrusion of atmospheric CO₂.

(b). AOOS will also support expanding the Center's observational capabilities by using autonomous moorings to quantify the seasonal and interannual variability in the ocean carbonate system. AOOS support will allow for two new systems to be deployed in 2013 and 2014, and maintained for the duration of the project. This brings the total OA/physical oceanography mooring network in Alaska to a minimum of five. Each mooring will be equipped with a surface and bottom sensor package that will measure *p*CO₂, pH, temperature, salinity, nitrate, oxygen, chlorophyll, and turbidity. In addition, the surface package will contain a meteorological and atmospheric monitoring station, and will be capable of transmitting both surface water and atmospheric parameters in real-time via satellite telemetry. The two most likely places for the next mooring deployments are southeastern Alaska and lower Cook Inlet.

(c). Previous AOOS funds were used to add additional OA sensors to a mooring in the Chukchi Sea, funded through NSF. This mooring will now be collecting OA data year-round, which will be made available on the AOOS website.

3. *Sentinel monitoring in northern GOA.* AOOS seeks to meet short-term and long-term fisheries and ecosystem-based management needs by partnering with the Prince William Sound Science Center (PWSSC), the Oil Spill Recovery Institute (OSRI), NOAA/UAF's Kasitsna Bay Laboratory, Cook Inlet and PWS Regional Citizens Advisory Councils, and the Kachemak Bay NERR to maintain intensive sentinel monitoring in Prince William Sound and Cook Inlet.

(a). AOOS proposes to contract with PWSSC to purchase, test, and deploy a profiling mooring at the central Prince William Sound (PWS) site that has been used as a CTD station for most research programs conducted in PWS. This effort is focused on providing high frequency depth-specific information on hydrographic properties, both for model assimilation and ground-truthing and also to augment a long-term dataset.

(b). In addition, AOOS will place a thermosalinograph on a vessel of opportunity to collect measurements of surface water properties. A second thermosalinograph will be installed on the PWSSC research vessel *New Wave*. In later years (2013-15), partial support from AOOS will maintain these surveys, verifying that the oceanographic model continues to represent conditions. The combination of the transiting vessel data, CTD cruises, and chemical/biological data will help advance PWS's circulation and biological models.

(c). Three nearshore moorings previously installed in PWS had to be removed in 2010 due to excessive corrosion and biofouling affects. The moorings and their deployment and maintenance strategy will be redesigned so that data collection can continue. New monitoring packages will be tested to determine their suitability for longer deployments with

reduced maintenance. New partnership opportunities for deployment will be explored, particularly with oyster farmers, who would benefit from real-time temperature data.

(d). Many of the tide stations in PWS provide long-term records of water temperature and meteorological variables. AOOS will work to identify an appropriate technology for expanding the existing observational capabilities. This effort will begin with a partnership with the Oil Spill Recovery Institute (OSRI) and NOAA to test the use of conductivity sensors at the Cordova tide station. This work will be combined with monitoring efforts of the Cordova school students to test the accuracy of the sensors over time.

(e). AOOS will also fund mooring turnovers for biological monitoring. The Ocean Tracking Network (OTN) and Pacific Ocean Shelf Tracking network (POST) have plans to install acoustic monitoring equipment at the entrances to PWS in the spring of 2011. The monitoring equipment will be used to identify tags on salmon, sharks, whales, and other organisms that pass through Prince William Sound. Proper operation of the equipment requires annual downloads of the data, and is best done in a systematic manner. Presently, there is no funding budget by POST or other partners for this data ingestion, leaving AOOS with the opportunity to make a small investment in maintaining a biological monitoring network in Alaska.

(f). The need for additional oceanographic (temperature/salinity) observations in Cook Inlet has been identified as a high priority by the AOOS-sponsored Cook Inlet modeling working group, the 2005 Cook Inlet Physical Oceanography Workshop, and other stakeholder meetings. In this project, we propose to collect oceanographic data along repeated transects in Kachemak Bay and lower Cook Inlet, through deployment of CTDs. This sampling would support development and validation of the NOAA operational circulation forecast model, as well as the understanding of variability in estuarine and coastal ocean acidification. We propose to conduct repeated small boat CTD surveys in Kachemak Bay and lower Cook Inlet. CTD data will be provided to NOAA's CSDL to support development of an operational NOAA circulation model and to the AOOS data management team. The project will leverage an existing CTD provided by the Kasitsna Bay Lab.

(g). For ecosystem modeling, we propose to maintain the coupled ROMS and CoSiNE (Carbon, Silicate and Nitrogen Ecosystem) model, developed and run operationally for PWS and the GOA by Yi Chao at NASA JPL/UCLA, and Fei Chai at the University of Maine. Both models were tested during the 2009 field experiment. We will systematically evaluate the performance of the coupled models using available in situ and satellite observations in order to improve performance.

Audience and Benefits: Alaska's coastal waters support a rich and diverse ecosystem, home to one of the world's largest fisheries, as well as abundant populations of seabirds and protected marine mammals. The region has already demonstrated its susceptibility to climate-driven change when the relative dominance of the commercially important fish species changed in the mid-1970s. Unexpectedly, crab and shrimp declined while salmon and groundfish populations increased. These changes coincided with the beginning of decadal-scale adjustments in the atmosphere and ocean in the North Pacific. Ultimately, commercial fishers had to invest heavily in infrastructural adjustments to remain economically viable.

Ecosystem change in Alaska has direct social and economic implications that are likely to be more profound with the advances of climate change. As research questions abound, great benefits can be gained by enhancing research and monitoring initiatives and integrating the data they produce. Synthesis products developed from existing and new data will be used to identify seasonal and interannual cycles in carbonate, physical ocean parameters, planktonic productivity,

and other processes, well as for indices to be included in the new Alaska Coasts and Oceans Report. Representative stakeholders include the fishing industry, federal and state management entities, and subsistence-based communities, and academic and agency researchers.

D. COASTAL & MARINE SPATIAL PLANNING

In response to the new National Ocean Policy recommendation for Coastal and Marine Spatial Planning (CMSP), AOOS will focus a significant portion of its data management efforts to provide the capacity to integrate data. This involves working with diverse partners to create spatial visualization tools specific to Alaska. The tools will provide a common platform for stakeholders, including industry, regulatory agencies and the public to access relevant information about the oceanography, ecology, and human activities. The tools will be multidimensional, and include the elements of depth and seasonality. Formation of the tools will involve in-depth stakeholder input, streamlined and integrated data from multiple sources, and an open source, non-proprietary data management system. AOOS will work closely with state and federal agencies, private industry, and any Alaska regional partnership that might develop.

Cook Inlet and the Arctic are the two areas most likely to see some form of CMSP due to their multiple – and sometimes conflicting - uses. The AOOS data team has already developed a prototype tool focusing on Cook Inlet. The prototype provides access to a wide array of multidisciplinary data including bathymetry, hydrography, wildlife surveys, real-time river gauge data and ocean conditions, and contaminant sampling programs. The data was acquired from government agencies, non-governmental organizations, and tribal communities. The data access system relies upon a four-dimensional (three space dimensions, plus time) standards-based data management framework and can be accessed at <http://dev.axiomalaska.com/CIRCAC>.

III. DATA MANAGEMENT & PRODUCTS

Goal: The goal of AOOS Data Management is to serve as a regional data hub for Alaska coastal and ocean information to meet the needs of a variety of stakeholders.

Background: Following an open competition to provide AOOS data management services, the AOOS Board awarded a five-year contract to Axiom Consulting and Design of Anchorage in August 2010, led by chief information architect Rob Bochenek. Axiom will work with the program staff and other partners to support the AOOS data system and products developed for users, consistent with IOOS standards and protocols. The overarching strategy for this effort involves implementing an end-to-end technological solution, which allows data and information to be channeled and distilled into usable and functional products. Simultaneously, the underlying data will be assimilated and used by the IOOS data assembly system through interoperability protocols (see Figure 2 in Appendix C for details).

Objectives and Approaches:

1. *Provide support for AOOS website and data portal.* AOOS is developing a new integrated website, data portal and user interface that will be fully functional by FY11. The objective will then be to maintain the site and portal, monitor and document use, and integrate user feedback and emerging technologies into future system iterations.

2. *Ingest prioritized datasets, warehouse, archive and provide access through query and mapping tools.* The AOOS Data Team will work closely with program staff, the Data Management Advisory Committee, project PIs and regional data providers to ensure that prioritized datasets are ingested into the system and made available for access. This includes descriptive metadata, and appropriate and easily accessible archives. In order for the data management framework to be effective, users must be able to visualize spatial components of

datasets and collection parameters filtered by space and time on a web based mapping system. The system will ultimately need to provide synthesis by allowing data types to be discovered, homogenized and integrated across individual data sources. Approaching the task in a phased, periodic software development cycle will ensure that the system will evolve rapidly with periodic redirection informed by review and feedback from the stakeholder community.

3. *Maintain and provide access to a variety of products described in this proposal.*

Emerging products from AOOS include the Real-time Sensor Map, Arctic Assets Map, Model and Remote Sensing Explorer, Sea Ice Atlas, and CMSP visualization tools. Future products will be launched through a rapid-development process based on user needs. Focusing development efforts on using interoperability systems (WMS, WCS, WFS and SOS) will ensure that information stored in the AOOS data system will be available for both the user community and data assimilation systems such as IOOS and the World Meteorological Organization World Telecommunication System. Existing AOOS data serving applications can be accessed off the AOOS website at <http://data.aos.org/>.

4. *Develop multi-regional products with other regional associations (RAs).* AOOS will actively collaborate with the other IOOS RAs along the Pacific Ocean coastlines (PacIOOS, NANOOS, CENCOOS, and SCCOOS) over the course of the funding cycle to advance stakeholder access to cross-regional data services as defined by commonalities in specified user requirements. Initially and at a minimum, AOOS and the other Pacific RAs propose to improve access to existing data services (products, map-based visualizations, and information) through collaborative effort to establish common website linkages. Future effort will focus on the development and coordination of shared visualization and data-serving systems (common Application Programming Interface (APIs) and interoperability systems (WMS, WFS, WCS and SOS)) that focus on data and products common to all regions (i.e., glider data, model nowcasts and forecasts, key climate variables).

5. *Continue the Alaska Department of Fish and Game (ADF&G) prototype and explore expansion to other agencies.* AOOS is partnering with the ADF&G Division of Commercial Fisheries (ADF&G) to establish a data-serving node feeding into the AOOS system. The resulting distributed data management framework will enable AOOS, and other external data assimilation systems, to access up-to-date ADF&G biological sampling and fishery data within the department's internal data management system. During the project, ADF&G staff will integrate AOOS real-time and historical data feeds describing ocean conditions directly into their internal data management applications. Data and information will be marshaled between AOOS and ADF&G through interoperability systems and protocols. The goal is to improve research and resource management decisions by leveraging the power of distributed data exchange. If successful, this prototype and methodology would be expanded to serve data existing in other regional resource management agencies.

6. *Collaborate with other state, regional, national and international data management programs.* The AOOS Data Team staff will work closely with the AOOS Data Management Committee and participate in the Federal-State Data Integration Working Group. They will also develop partnerships with other existing data management systems in Alaska and the Arctic, including those for the Arctic Observing Network (AON) and the Sustained Arctic Observing Network (SAON). Additionally, the Data Team will actively participate in NFRA and national IOOS data management committees and teams, including the IOOS Data Integration Framework.

Audience and Benefits: Specifics have been described for individual products. Overall, stakeholders have consistently asked for a central location for ocean observations in Alaska.

AOOS is refocusing its efforts to ensure that the data system is serving up products specifically designed for stakeholders and users.

IV. MODELING & ANALYSIS

Goal: The goal of this component is to develop a statewide forecasting modeling framework.

Background: Expanding outside of PWS and CI, AOOS is committed to using a collaborative approach to improve and synthesize ocean circulation modeling efforts across the state. To date, models have been developed by UAF, NOAA, University of Washington, and the University of Maine, focusing on different geographic areas of Alaska. We now need to establish a collaborative effort in order to start harmonizing these models and take broader advantage of all of their capabilities. The proposed framework will provide a platform to exchange existing model output and test new models as they become available, and build upon the modeling test bed initiative funded by the national IOOS office.

Objectives and Approaches:

1. Model output exchange and intercomparisons, ensemble modeling. AOOS will partner with JPL and others to coordinate these various parties. This will involve establishing a modeling working group, hosting an annual AOOS modeling workshop, and constructing a model output exchange database and web interface. AOOS will develop a modeling plan, and assess critical observing gaps to improve the models. The anticipated results will be a comprehensive assessment of each model developed by different groups with somewhat different objectives. These results can be used to construct the “best” system that most closely meets users’ needs and requirements. It is most likely that the “best” model will be a combination of these existing models. The proposed ensemble modeling framework would provide a platform to exchange existing model output, as well as test new models as they become available.

2. Model and Remote Sensing Explorer. The AOOS data staff are exploring methods for serving four dimensional and higher datasets via THREDDS, ncWMS and other NetCDF data management and interoperability systems. The four-dimensional operational JPL ROMS model for Prince William Sound is an ideal candidate to demonstrate this type of functionality. AOOS DMAC staff have acquired and aggregated approximately 950 daily model output files (12 GB) of available NetCDF files from JPL into a single virtual dataset that can be cohesively visualized. Additionally, automated data ingestion systems have been established so that AOOS systems can assimilate new model casts as they become available from JPL, providing users with access to near real-time model data. Presently, users can explore the model parameters (temperature, salinity, current direction and velocity, and sea surface height) through space, depth and time for the entire available model time series. This application, known as the AOOS Model Explorer, also provides access to terrestrial climate models for Alaska and assimilates a wide array of atmospheric and oceanographic remote sensing data being served off of NASA Earth Observation (NEO) system. This system will be extended in Year 1 to serve additional models and remote sensing datasets in addition to developing tools for users to analyze gridded data resources. The current version of this system is openly available at <http://data.aos.org/>.

Audience and Benefits:

Many times, modelers work in isolation from each other due to the technical nature of their work, and lack of time to coordinate. The AOOS plan focuses on helping modelers improve their models, as well as facilitate a collaborative statewide modeling effort using joint resources. Fortified ocean circulation models covering the state will benefit oil spill response, search and rescue operations, boater safety, and understanding of ecosystem processes. Additionally, AOOS understands the importance of making these models publically accessible, reducing

multiplicative research efforts, and promoting the applicability of ocean science to many disciplines.

V. COMMUNICATION, EDUCATION & OUTREACH (CEO)

Goal: Our goal is to promote greater awareness of the value of ocean observing in meeting stakeholder needs and to increase ocean observing capacity in Alaska.

Background: AOOS has a strong reputation in Alaska as one of the few multi-agency, multi-disciplinary organizations designed to facilitate and coordinate marine-related efforts. The AOOS Board has made facilitation, coordination, and partnership building one of the cornerstones of the AOOS program, and the Executive Director and the Program Manager for Partnerships and Outreach devote significant time to these efforts.

Objectives and Approaches:

1. COSEE Alaska Partnership. AOOS is a founding partner in COSEE Alaska: People, Oceans and Climate Change (www.coseealaska.net). AOOS provides access to real-time data, as well as helping its scientific partners connect to broader audiences. AOOS partners in a number of COSEE Alaska activities, including the Communicating Ocean Sciences Workshop at the annual Alaska Marine Science Symposium, an event that attracts up to 800 Alaska scientists, managers and stakeholders each year. It also partners with SEANET, a website and blog featuring ocean-based climate change news.

2. Regional information initiatives. AOOS will support regional theme pages on the AOOS website, as well as regional working groups in PWS, Cook Inlet, and the Arctic.

3. AOOS website and publications. AOOS uses its website to feature ocean observing news and highlight new user products. The site archives all meeting documents and reports, and connects users with the data pages and products developed by the AOOS data team.

4. Alaska Oceans & Coast Report. Multiple stakeholders have expressed interest in a “State of the Alaska Oceans” report with summaries, trends, graphics, and an overall picture of Alaska’s oceans updated at least once per year. In addition, there is growing demand for information and scenarios on how sea level, glacio-isostatic rebound, and climate change will collectively impact our coasts and communities. AOOS will work with the Alaska Center for Climate Assessment and Policy (ACCAP) to develop, design and produce a report on the state of Alaska’s coasts and oceans. The report will be updated twice a year and accessible in electronic form, with hard copies provided to targeted user groups and stakeholders. This report would leverage other reports such as NOAA’s Arctic Report Card and Bering Sea page, the State of the U.S. Ocean report, Sea Ice Status reports and PICES State of North Pacific report. It would also draw from ACCAP’s new climate information product, developed in partnership with the Alaska Climate Research Center, SEARCH Sea Ice Outlook, the National Centers for Environmental Prediction, and the National Weather Service. AOOS and ACCAP will work with coastal managers, planners and other stakeholders to ensure the report is meeting identified user needs.

5. Alaska regional partnerships, and collaborations. Numerous collaborative initiatives have begun in Alaska designed to inform or guide science or resource management issues, particularly in the face of climate change. These include the North Slope Science Initiative (NSSI), the Alaska Climate Change Executive Roundtable (ACCER), the Alaska Center for Climate Assessment and Policy Steering Team (ACCAP is the NOAA RISA for Alaska), Alaska Sea Grant Program and its advisory group, the new Department of Interior Climate Science Center and Landscape Conservation Cooperatives, and NOAA’s regional collaboration team. AOOS has been, and will continue to be, an active participant in these initiatives.

6. *Stakeholder interaction.* AOOS has, and will continue, to seek opportunities to meet directly with stakeholders and users to ensure we are aware of their needs, and that we are designing products to meet them. Numerous opportunities abound for these efforts including the Alaska Forum on the Environment, which often attracts 1,500 participants, and many from Alaska Native villages,

Audience and Benefits: Major stakeholder groups in Alaska include commercial fishermen, harbor masters and pilots, recreational boaters, subsistence users, industry, and coastal managers, as well as collaborative initiatives such as NSSI, ACCAP, and the Alaska Climate Change Executive Roundtable. AOOS also connects with users in public forums such as the Alaska Marine Science Symposium, and the Alaska Forum on the Environment. Additionally, AOOS will continue to collaborate on a national level with the NFRA Education and Outreach Committee to build synergy with the other regions, share information and products, and develop creative outreach efforts.

VI. COST PROPOSAL

	Year 1	Year 2	Year 3	Year 4	Year 5	Total
AOOS Program Management Totals:	649,368	659,076	698,970	730,093	756,493	3,493,999
AOOS Programmatic Component Totals:	1,128,731	954,035	1,083,118	1,106,333	1,084,700	5,356,917
Axiom	439,964	493,809	541,732	539,131	539,131	2,553,767
ADF&G	100,434	46,512	0	0	0	146,946
UAF/IARC (Walsh/Trainor/Eicken)	291,414	294,365	301,249	308,895	299,560	1,495,483
UAF/SFOS (Mathis)	500,005	400,002	400,000	400,010	400,005	2,100,021
PWSSC (Pegau)	294,720	592,178	419,139	370,438	377,285	2,053,760
UCLA (Chao)	300,000	300,000	250,000	250,000	250,000	1,350,000
Alaska Marine Exchange (Page)	117,578	111,959	142,485	141,737	138,172	651,931
	3,822,213	3,851,936	3,836,692	3,846,638	3,845,345	19,202,824
NOAA/PMEL (Stabeno)	102,787	93,072	98,417	98,370	99,675	492,322
NOAA/Kasitsna Bay Lab (Holderied)	75,000	54,992	64,891	54,992	54,979	304,854
						797,176
	4,000,000	4,000,000	4,000,000	4,000,000	4,000,000	
						20,000,000

Detailed budget information. Included in Appendix A are an overall project budget and budget narrative, detailed budgets for each of the subawards and the Axiom service contract, and a descoped Budget Priorities of \$2 million a year. A holdback of \$797,176 over five years is requested for NOAA Pacific Marine Environmental Laboratory (Stabeno) and NOAA Kasitsna Bay Laboratory (Holderied) to perform activities described above. AOOS wishes for NOAA to retain these funds and have them used by the specified NOAA offices. No equipment described in this proposal is available for lease. All items require a direct purchase.

Base capacity and enhancements. AOOS has submitted a budget request for \$4 million a year for five years, which reflects the true need for ocean observing activities in Alaska. Appendix A includes a descoped budget of approximately \$2 million, which reflects Budget Priorities and minimal base capacity. Under this funding scenario, program staff and the data management team would stay roughly the same since these are AOOS Board priorities. Staff would provide some level of Arctic observation coordination and integration in-house. Major reductions would occur in nearly all proposed observations, modeling and equipment purchases.

VII. MILESTONES & DELIVERABLES *Note: see Appendix B for more detail.*

MILESTONES & DELIVERABLES	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5
Observations & Products					
<i>Marine Operations</i>					
Maintain 8 SnoTel stations in PWS; stream live data; assess use/effectiveness	*	*	*	*	*
Pilot AIS dissemination from shore station, buoy station, and AIS/wx station	*				
Install 6 AIS WX/ year; conduct field surveys for future sites		*	*	*	*
Maintain operational WRF model for wind forecasting, producing daily model runs	*	*	*	*	*
Maintain and run SWAN model in Gulf of AK, including use of “unstructured” grids	*	*	*	*	*
Validate & maintain PWS ROMS forecasting system for 24/7; incorporate hydro	*	*	*	*	*
Validate hydrological model for PWS; identify influence of rainfall; circulate data	*	*	*		
Conduct current meter surveys and small boat ADCP surveys in Cook Inlet	*	*	*	*	*
Develop surface trajectory tool; implement for statewide regions; refine interface	*	*			
<i>Coastal Hazards</i>					
Install water level sensors in w. Alaska; provide data to NWS, USACE	*	*	*	*	*
Purchase, outfit, deploy, maintain 3 wave buoys; stream real-time data	*	*	*	*	*
Develop electronic sea ice atlas; digitize maps, test interface, produce updates	*	*	*	*	*
Develop community-based monitoring sea ice observation program w/ reporting	*	*	*	*	*
<i>Ecosystems</i>					
Arctic Obs Synthesis & Reporting - hire post doc and DBO coordinator, develop report	*	*	*	*	*
Seward Line - Support ship transects twice per year, replace moorings	*	*	*	*	*
Bering Sea Moorings - Sustain biophysical moorings twice per year	*	*	*	*	*
Support Arctic node with equipment, including two gliders	*	*	*	*	*
Ocean Acidification Monitoring - 2/yr samples, deploy & maintain new moorings	*	*	*	*	*
Downscale climate models for offshore AK; develop scenarios; publish papers	*	*	*	*	*
Purchase, test, and deploy PWS profiling mooring; telemeter measurements		*	*	*	*
Install and maintain thermosalinographs on vessels of opportunity in PWS		*	*	*	*
Test new monitoring packages on nearshore moorings in PWS	*	*	*	*	*
Test conductivity sensors at the Cordova tide station	*	*	*	*	*
Recover & Disseminate Marine Animal Tagging Data - Gulf of AK	*	*	*	*	*
Cook Inlet oceanography tests - conduct monthly CTD surveys at 4 locations	*	*	*	*	*
Deploy and recover oceanographic moorings in Cook Inlet		*	*		
NPZ modeling Gulf - use in situ/satellite obs to evaluate ROMS-CoSINE model	*	*	*	*	*
Regional Management & Education/Outreach					
Regional Association Organization, Edu/Outreach	*	*	*	*	*
Produce Alaska Oceans & Coasts Report w/ Sea Level Rise Synthesis	*	*	*	*	*
Data Management					
Provide data management services, maintain web portal, stream data, archive	*	*	*	*	*
Develop & enhance data products - Arctic Map, Sensor Map, Model Explorer + new	*	*	*	*	*
Modeling & Analysis					
Statewide Circulation Model Synthesis, Ensemble Development & Assessment	*	*	*	*	*