

IMPLEMENTATION & DEVELOPMENT OF ALASKA REGIONAL COASTAL OCEAN OBSERVING SYSTEM (AOOS)

I. AOOS OVERALL APPROACH & PRIORITIES & RESPONSIVENESS TO FUNDING ANNOUNCEMENT

The Alaska Ocean Observing System (AOOS) is the Alaska Regional Association (RA), one of 11 federal, regional and private-sector partnerships that are part of the national Integrated Ocean Observing System (IOOS), working to enhance our ability to collect, deliver and use ocean information (see Appendix A for Acronyms used). AOOS has been operating as the Alaska RA and its regional coastal ocean observing system since 2004 and was certified by the IOOS program as a Regional Integrated Coordinating Entity in 2017. As a regional partner in a national system, AOOS' goals and priorities are consistent with national IOOS goals. The overall goals of AOOS are to:

- Increase observing and forecasting capacity throughout Alaska waters;
- Increase access to existing coastal and ocean data; and
- Package information and data to meet the needs of all users.

For FY21-25, AOOS has adopted these priorities to:

- Increase our partnerships in order to sustain existing and planned observations and activities;
- Support new observational build-outs among existing AOOS programs using innovative technologies, and especially in support of harmful algal blooms (HABs), ocean acidification (OA) and ocean sound;
- Expand engagement networks and renew commitment to make outreach and engagement and program implementation more diverse, equitable and inclusive;
- Increase participation of local workforces when possible; and
- Expand focus on product and service development and on shifting models and technologies into operational status.

Process for developing this proposal

In preparation for this 5-year proposal, AOOS held meetings and listening sessions with key stakeholders to identify gaps in ocean observing and inform product needs and development. While not all the recommendations were incorporated directly into the proposal, documenting these needs allows AOOS to continue to pursue and fill gaps through outside funding sources and collaborative partnerships. In March 2020, AOOS invited input for new project ideas to be included in the 5-year proposal. Over 100 project ideas were submitted and reviewed by an external panel for the benefits, risks, leveraging, impact, cost, and overall fit for each project in the context of the AOOS mission and goals. Recommendations from these efforts, as well as AOOS mission clarification, goals and objectives, new priorities and emphasis, observing build-out maps, product and service updates, and engagement commitments were compiled into a draft strategic direction document. This was broadly circulated for public review with additional outreach to Regional Tribal Non-Profit partners. Input from this effort was compiled and provided to the AOOS Board for its September 2020 meeting, during which a final proposal framework was approved.

Thematic focus areas

In addition to providing general, statewide programs, the AOOS Board adopted these four programmatic focus areas: marine operations; coastal hazards; ecosystems, fisheries and climate, with a new focal area of ocean sound; and water quality, which includes OA and HABs, and could include marine debris and mariculture in the future.

Relationship to regional, national and international goals, observing frameworks and policy priorities

AOOS programs are closely aligned and consistent with the goals, frameworks and priorities of other regional, national and international networks and plans, particularly those for the Arctic (Appendix B).

Project Team (See Appendix C)

In addition to the AOOS Board and staff described in Section II.A., the AOOS project team consists of:

- **Engagement leads.** Each thematic focal area has an engagement lead responsible for ensuring active engagement with agencies, organizations, businesses and individuals as partners in achieving AOOS goals and objectives and meeting stakeholder needs for that theme.
- **Co-Investigators** who are subaward leads. Most of AOOS' work is done by an experienced group of Co-PIs who implement more than 40 subawards and contracts as the core of the AOOS program.
- **Collaborators** who represent partner programs. Not all AOOS partners are co-PIs or board members. Other partner programs include the *Exxon Valdez* Oil Spill Trustee Council's (EVOSTC) two long-term monitoring programs - GulfWatch Alaska and Herring Research and Monitoring, the Arctic Marine Biodiversity Network (AMBON), National Science Foundation's (NSF) two coastal Long Term Ecological Research (LTER) sites - the Beaufort Coastal Lagoons and Gulf of Alaska (GOA), the Arctic Domain Awareness Center (ADAC), the Alaska Center for Climate Assessment and Policy (ACCAP).
- **Partnerships with other Regional Associations.** Because we share a common data manager, AOOS is a natural partner with Southeast Coastal Ocean Observing System (SECOORA) and Central and Northern California Ocean Observing System (CeNCOOS) on several pan-regional data products, AOOS is also partnering with other RAs on several other pan-regional products. See Section III.C.5.
- **Federal partners.** Four federal agencies are founding members of AOOS and have seats on the AOOS board. AOOS works closely with the National Oceanic and Atmospheric Administration (NOAA)'s Alaska Fisheries Science Center (AFSC), Kasitsna Bay Lab, Pacific Marine Environmental Lab (PMEL) and Arctic Research Program, and several of their scientists are funded for AOOS projects. AOOS is frequently a Co-PI on environmental study projects funded by the Bureau of Ocean Energy Management (BOEM).

Tiered approach

This proposal is submitted for the maximum amount of funding allowed in the Notice of Funding Opportunity of **\$6 million per year**, an amount that reflects the cost of implementing AOOS' strategic direction for the next five years. Board and staff have committed to seeking funding from all sources, including private partnerships, to implement the goals laid out in this proposal. Priorities at the **\$3M level** are described in a notional budget included in Detailed Budget Information (Appendix K) if full funding is not immediately achieved.

II. SUBSYSTEM APPROACHES

A. Governance and Management Subsystem

The Alaska Ocean Observing System (AOOS) is the regional association for Alaska, begun in July 2003 as a consortium of partners operating under a Memorandum of Agreement (adopted in 2005, and revised 2009, see www.aos.org), and federally certified in 2017.

- **Board:** AOOS is governed by a Board of Directors, made up of 19 federal and state agencies, research entities, and private sector and tribal organizations (see www.aos.org for members). All 19 board members set AOOS' direction and actively engage in helping implement AOOS priorities. An Executive Committee made up of the AOOS officers and a representative of the fiscal sponsor acts on behalf of the AOOS Board between meetings. A Diversity and Inclusion Working Group is currently reviewing the Board makeup and considering the addition of other members to broaden board diversity.
- **Program staff:** AOOS currently employs three and a half full-time staff: an Executive Director, a Director of Operations and Development, a Director of Administration and Outreach, and a half-time Program Director who primarily runs the Alaska OA Network. Two other staff are funded with special funds as part of the HAB Observing Network pilot program and the Regional Ocean Data Sharing

Initiative. At the \$6M level, the Administration and Outreach position would become two separate, full-time positions, and the program director position would become full-time.

- **Fiscal sponsor:** The Alaska SeaLife Center (ASLC), an incorporated nonprofit, acts on behalf of AOOS as its fiscal sponsor, and performs all its legal, financial and administrative functions. The fiscal sponsor fee is based on the direct costs of those services.
- **Operating procedures:** AOOS functions according to Operating Procedures adopted by the AOOS Board in 2015, which include policies for stakeholder engagement, equipment management (including inventory and use of best practices), conflict of interest, and ocean observing asset inventories and gap analyses for the Alaska region.
- **Project funding risk assessments:** The Operating Procedures also established a method for assessing project funding risks. Since most AOOS projects rely on leveraged funding, AOOS staff assess the costs of each proposed project in relation to its benefits to the AOOS mission and goals, whether in-kind resources are used, the risks to the project of losing leveraged funding, and the potential for sustained funding. After these considerations, a final assessment is made whether a project still has value, even if shorter-term. If a new component is added to an existing project, AOOS usually commits to a minimum of three years of funding, assuming sustained annual funding levels.

B. Engagement, Education and Outreach Subsystem

The AOOS program relies on a variety of avenues to engage stakeholders and solicit recommendations. This feedback allows AOOS to both identify gaps in ocean observing and enhance AOOS tools and products. Due to the enormous geographic size of Alaska and the diversity of coastal and marine issues, the AOOS board determined it would be more effective to use existing communication pathways and forums (advisory committees, professional organizations, conferences and workshops), as well as specific stakeholder engagement events, to provide input to AOOS rather than maintain a standing “stakeholder committee.” This method has allowed AOOS to interact in a focused way with multiple interest groups and hear specific needs. Additional ongoing activities include presentations, scoping groups, user surveys and the feedback tab found on every AOOS data portal page as well as the AOOS website and Facebook pages, with specific activities described in Section III.A. and in the Engagement Summary (Appendix D). Also see Appendix E for Letters of Support.

AOOS serves a major role as a convener and facilitator of Alaska information and data sharing at the regional, national, and international levels. In Alaska this includes supporting the Alaska Water Level Watch (AWLW), the Alaska OA Network and the Alaska HAB (AHAB) Network. AOOS will continue to co-lead the Alaska Marine Policy Forum with Alaska Sea Grant and help to advance regional interdisciplinary engagement and data usage with the new Regional Ocean Data Sharing Initiative.

AOOS proposes to have a full-time outreach coordinator (currently half-time), as well as designated engagement leads for each thematic section of the AOOS portfolio: water levels and other coastal hazards, marine operations, ecosystems, OA, and HABs.

- **Engagement staff:** Staff for the Alaska OA Network and the AHAB Network are AOOS employees, now partially supported with other funds. The Coastal Hazards and Marine Operations engagement lead is the AOOS Operations Director, with additional support through a subaward to the AK Department of Natural Resources (ADNR) for the AWLW. A new Ecosystems Engagement staff position is included, as well as a Product and Services Lead. Staff members manage all program components, engage with stakeholders to identify program requirements, implement the observing system with contractors 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 other IOOS Regional Associations.

- **Advisory Groups:** AOOS uses three coordinating networks (AWLW, Alaska OA Network, and AHAB Network), participation in other regional organizations, and ad hoc working groups for guidance. See section III.A. below for additional detail on stakeholder engagement. In 2020 the AOOS Board established two ad hoc working groups that will continue their work into 2021. These include (1) a Diversity and Inclusion Working Group, charged with reviewing AOOS board membership, policies and procedures for engagement and subawards and contracts to ensure maximum inclusion; and (2) a Nonprofit Status Working Group to examine the pros and cons of AOOS establishing its own legal entity, rather than continued use of the Alaska SeaLife Center.
- **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 ACCAP Steering Team (ACCAP is the NOAA RISA for Alaska), Alaska Sea Grant and its advisory committee (ASG), the Northern Latitudes Partnership, and NOAA's regional collaboration team. AOOS will continue to be an active participant in all of these initiatives.

C. Observing Subsystem

Given Alaska's immense geographic scope and the paucity of existing, agency-supported observations, the AOOS Board has chosen largely to sustain and augment existing observation programs, contribute to observing consortia and fill in key observation gaps with new assets as additional and sustainable funding becomes more readily available. This includes supporting alternative technology trials that can ultimately increase observing capacity by providing more cost-effective alternatives to traditional methods that are difficult and expensive to operate and maintain in Alaska (e.g., National Data Buoy Center [NDBC] moorings and National Water Level Observation Network [NWLONs]). A variety of platforms are used in the AOOS observing subsystem to observe essential ocean variables (EOVs), described in Appendix F. These include moorings and shore-based systems, some with real time capability, wave buoys, ship-based surveys, autonomous underway shipboard systems, autonomous underwater vehicles such as gliders, and community-based observations. The majority of observing assets are co-funded with AOOS partners, as described in Appendix K which includes individual project Statements of Work (SOWs) and budgets, the Asset Deployment Costs Table (Appendix K, Attachment 2), and the AOOS Projects NEPA Information Table (Appendix L).

D. Data Management and Cyberinfrastructure (DMAC) Subsystem

AOOS works with its DMAC contractor, Axiom Data Science, to provide advanced data management support, data systems architecture, software engineering and cyberinfrastructure operational services to meet the U.S. IOOS DMAC mandates. Axiom operates and continuously improves the federally certified regional Data Assembly Center (DAC), and provides a statewide web-based data portal (called the Ocean Data Explorer) for access to ocean and coastal environmental data and information products. This cyberinfrastructure is leveraged across a spectrum of partners to provide a common data management solution, including IOOS, CeNCOOS, SECOORA, Marine Biodiversity Observation Network (MBON), North Pacific Research Board (NPRB), EVOSTC, BOEM, NOAA, the Department of Homeland Security (DHS), and NSF's LTER Network and Ocean Observatories Initiative.

The individual components of the AOOS data system have been developed from open-source technologies and are designed to be scalable relative to IOOS data management standards and best practices. More information on AOOS's adherence to the NOAA Environmental Data Management Framework can be found in the Data Sharing Plan (Appendix G), in addition to the AOOS Data Management Plan (Appendix H). The core components of the AOOS data system include:

- **Data Assembly and Quality** - automated software systems to interface with other devices or teams producing data. Axiom has developed automated systems to harvest data from sensor networks,

mobile platforms, satellites, and modelling centers and transform those heterogeneous sources to common data and metadata representation. These systems also apply IOOS's Quality Assurance of Real Time Oceanographic Data (QARTOD) tests to real time in situ observations to generate, visualize, and distribute quality flags. See Sections 1 & 4, Appendix G.

- **Implementation of Community Standards and Systems** - building off the collective work of the community to ensure data discovery and reuse by enforcing data standards such as NetCDF simple feature specification, Climate Forecast conventions, Darwin Core, Ecological Metadata Language, and ISO 19115/19110 metadata formats. Following these standards enables other national cyberinfrastructures to discover and use the data resources through interoperable systems and protocols such as THREDDS, ERDDAP, and OPeNDAP. See Sections 2-3, Appendix G.
- **High Performance Computing (HPC)** - operation of provisionable compute and storage, including a mid-sized data center with 6,000 processing cores and 5 petabytes of disk storage. See Section 5, Appendix G.
- **Modern Big Data Analysis and Machine Learning Techniques** - scalable computing executed in proximity to data storage. The technology stack supports running scalable analysis engines, such as Apache Spark, Dask and Pangeo on HPC compute clusters alongside the data. See Section 6, Appendix G.
- **Data Product Support** - ontological database (OnDB) approach to drive end-user applications and analysis tools. The OnDB approach uses a unified metadatabase to describe the provenance, context, and properties of all AOOS datasets, which allows for data endpoints, catalogs, and interactive maps to be available through the connected software (such as cloud-hosted Jupyter Notebooks) for generating value-added data products within the data system itself. See Section 4.1, Appendix H.
- **Integration with Other National Cyberinfrastructure** - facilitating the research data lifecycle. The AOOS data system covers all lifecycle steps, from initial observations, ingestion into the DMAC system, quality control (QC), and sharing via the AOOS data portals or reuse of data for products or models. The Axiom cyberinfrastructure stack integrates directly with DataONE, NDBC and NCEI, providing access to archiving and packaging tools for data analysis products. See Section 5, Appendix G.
- **Human Expertise and Capacity** - data management and analysis expertise. Axiom and AOOS have allocated personnel and committed financial resources (see Appendix K, Budget Narrative - Staff Travel) for staff to participate in the Annual IOOS DMAC meeting and other national activities that require regional expertise and input (e.g., AWLW, MBON). See Section 2.3, Appendix H.
- **Product Usage Statistics** - AOOS uses Google Analytics to track usage statistics for the data portal, webpage, and products. AOOS will post monthly summaries of these statistics (number of sessions, page views, etc.) on the AOOS web page.

E. Modeling, Analysis, Products and Services Subsystem

With a new emphasis on engagement and product development and a full-time Product Development Lead supported with Regional Ocean Data Sharing funds, AOOS will expand its capacity to identify stakeholder needs and requirements, and develop and host products and services using AOOS data, as well as regional models, largely developed by AOOS partners. With the technical capacity of Axiom Data Science, AOOS will serve as a Modeling Testbed for the National Weather Service (NWS), the Arctic Domain Awareness Center, and other entities seeking to transition research models to operational status. To that end, regional and national modeling products can be downloaded from data providers and processed by Axiom into netCDFs and cloud-optimized geotiffs that are optimized for fast, web-based data exploration and visualization. In addition, metadata is added to most model results to achieve compliance with cross-catalog Climate and Forecast (CF) and Attribute Conventions Dataset Discovery (ACDD) standards. Jupyter Notebooks hosted on the Research Workspace have seamless access to model results for code-

based analyses. A major effort will include expanding the capacity of the Cook Inlet Operational Forecast System (CIOFS), Alaska's only operational ocean model.

F. Research, Development and Innovation

Given the logistical and technical challenges of operating observing assets in Alaska's remote ocean waters, including seasonal sea ice coverage, many of AOOS' observing assets could be considered some form of research and development. AOOS investigators continue to look for ways to improve buoy, glider and sensor technology under harsh environmental (e.g., Arctic) conditions. Ten significant projects that AOOS has been or is currently implementing involve research and development efforts or the use of novel sensors: (1) the Chukchi marine mammal glider for mapping oceanographic conditions and marine mammal species and occurrence with passive acoustic devices; (2) real time ice detection buoys for monitoring water column conditions through freeze-up in real time; (3) iGage downward looking acoustic water level sensors; (4) rapid deploy storm surge sensors installed ahead of a storm at benchmarks and along beaches; (5) use of AIS stations to observe and report weather and other sea-state observations; (6) shorebased GPS/GNSS receiver observing platforms using reflected satellite signals to derive water level measurements; (7) eDNA samplers on eco-moorings for the detection of fish species and other ecosystem parameters; (8) Hydroball towed bathymetric mapping tool for shallow water; (9) webcams for coastal monitoring and observing storm surge induced changes in coastal communities; (10) high-performance cloud computing resources and artificial intelligence for developing data and information products (e.g., machine learning using Saildrone data). Given the tremendous costs for operation and maintenance in Alaska and the Arctic, AOOS reviews all of its projects with an eye towards reducing future costs and improving transmission efficiencies with novel approaches and technologies.

III. WORK PLAN

This section identifies specific tasks for each component of the AOOS program, the technical approach needed to accomplish the tasks, and the roles of partners and collaborators.

A. Statewide Engagement, Education and Outreach

Goals: To increase awareness of ocean and coastal issues in Alaska and partner agency missions, including NOAA's; to understand and protect the Nation's natural resources; and to engage with stakeholders and respond to their needs for ocean and coastal observations and information products.

Objectives: (1) AOOS will continue to facilitate topic-based working groups, host meetings and workshops, and pursue other methods of outreach including presentations, user surveys, data portal feedback, production of user-friendly outreach products, and engagement through the AOOS website and Facebook pages. (2) AOOS will also seek to expand Diversity and Inclusion and use of local workforces. Thematic-specific engagement activities are described in Sections III.D-G. below.

Activities:

1. Outreach Coordinator. *With full funding, AOOS will support a full-time Outreach Coordinator to work with a new full-time Product Development Lead, as well as the thematic engagement leads to further expand on the following activities as well as those described in thematic work plans.*

2. AOOS website, Facebook and publications. AOOS uses its website as its primary outreach tool to feature ocean observing news and highlight data resources and new user products. The site archives all meeting documents and reports and connects users with the data tools developed by the AOOS data team. AOOS also maintains an active Facebook page, disseminating news and resources to a broad audience. Hard copy and electronic documents continue to make up a central part of the outreach approach, including an annual report, quarterly newsletters, monthly Executive Director updates and topic-specific handouts.

3. Stakeholder interaction. Stakeholder activities include hosting AOOS meetings and workshops on specific topics, providing demonstrations of the AOOS data portal to targeted user groups around the state, and circulating online surveys to get input on projects and observing gaps. The Regional Ocean Data Sharing initiative will continue to engage with stakeholders in the Bering Sea region to develop new data products and ensure data are accessible and useful. AOOS also uses a feedback tab on the AOOS data portal to solicit input on portal development. *At the \$6M level, Alaska Sea Grant community liaisons will serve as key collaborators on the local level and provide support for identified outreach activities - University of Alaska Fairbanks Alaska Sea Grant (UAF/ASG (Eckert) Community Outreach Support).*

4. Education activities. AOOS will continue to partner with marine education and outreach entities such as the Sitka Sound Science Center, Prince William Sound Science Center (PWSSC), ASLC, Kachemak Bay National Estuarine Research Reserve (KBNERR), and the Kasitsna Bay Laboratory to develop education materials and share curriculum, particularly related to ocean acidification and harmful algal blooms. This includes maintaining an OA “For Educators” page on the Alaska OA Network website providing relevant OA curriculum, partnering with the ASLC to circulate a hands-on OA kit in communities in Alaska, pursuing HABs education efforts through the Center for Alaska Coastal Studies, and participating in NOAA’s Alaska Live TV Programs, targeting grades 6-8.

5. Alaska Marine Policy Forum. Co-hosted with Alaska Sea Grant, AOOS supports bi-monthly teleconferences with participants from across the state interested in marine funding, legislation and state and federal policy issues. Speakers include congressional and legislative staff, as well as other contributors discussing timely topics.

6. Workforce development. AOOS will work with the other IOOS regions, IOOS Program Office and IOOS Association on workforce development initiatives to expand and diversify the ocean, coastal and Great Lake workforces and to improve our ability to provide relevant ocean and coastal data and information to underserved or underrepresented communities.

7. Diversity and Inclusion Working Group. AOOS has initiated a new working group to analyze AOOS’ policies to make sure as an organization we are inclusive of the diverse communities in our state in both the ways we engage and provide resources. The working group includes both AOOS board members and representatives from the Alaska Native community.

8. IOOS Outreach Committee. AOOS continues to serve on this forum to discuss effective outreach strategies and techniques, share products and coordinate efforts among the 11 RAs and the IOOS Program Office. AOOS works with other RAs using shared success stories, training and shared experiences with social media and other tools. The committee intends to meet in person once during the next five years to develop common outreach materials that reflect the federal-regional IOOS partnership, and to develop a strategy for shared outreach (conferences, exhibitions, etc.) and user engagement.

Products: Outreach products include websites and network sites, peer reviewed publications, 1-page flyers, e-news, newsletters, workshop reports, and presentations. See additional products under themes.

B. Statewide Data Management and Cyberinfrastructure

Goal: To serve as the federally certified Alaska regional data assembly center and provide broad access to Alaska coastal and ocean data. This includes data collected by AOOS as well as other federal, state, local, private and tribal entities as part of a larger national IOOS system, feeding into global data systems.

Objectives: AOOS’ data contractor Axiom Data Science will (1) provide technical support for the AOOS cyberinfrastructure, data portals, and ingested data streams; (2) support the AOOS website and other programmatic websites; and (3) collaborate with other regional, national, and international data initiatives, including IOOS DMAC.

Engagement: AOOS and Axiom staff engage extensively with academic and agency researchers and managers as well as the general public to identify overall data needs and capabilities.

Activities: *Axiom Data Science (Bochenek) - Data Management Support:*

1. Support the AOOS Data Assembly Center (DAC) and its underlying cyberinfrastructure. Axiom will: (1) ensure that the AOOS data system, including both hardware and software, is healthy, secure and monitored; (2) respond to system problems, and (3) identify future upgrade and expansion strategies. Axiom staff will explore and implement new software server technology and optimize physical hardware configurations and server resources. The intent is to power applications and functionality that are requested by the user community and required for the multiple, integrated-research efforts that AOOS supports.
 2. Maintain and enhance the Ocean Data Explorer (ODE) and other regional data portals. The ODE is the flagship statewide data portal for AOOS and includes tools to visualize and explore oceanographic and coastal data across Alaska. The custom-built tools allow for dataset cataloging, elastic searches, automated and custom visualization, time-series exploration and extraction, data downloading using interoperable web services, map representation of multiple data layers and more. This activity focuses on maintaining the portal's backend data storage and enhancing the front-end user interface. It also includes monitoring and documenting the use of the portal, delivering and expanding upon automated QARTOD tests and flag visualizations for real time and historical data streams, and integrating user feedback and emerging technologies into future system iterations. These include new, modern methods for creating and serving gridded data products, implementing user log-in authentication and "myAOOS" personalized functions, and implementing custom mapping tools.
 3. Maintain and provide access and archiving to existing and new datasets, including data rescue projects. As the regional DAC for Alaska, AOOS has prioritized ingestion of all real time data, as well as valuable physical, biological and chemical datasets collected primarily by federal and state agencies, academic partners and large ecosystem research programs. AOOS provides data management services for many of those programs, and through use of the Research Workspace, AOOS has access to all data for inclusion in the AOOS Data Portals. AOOS sets aside a small amount of funding each year for ingesting new and historic datasets, including QA/QC, metadata capture, archiving, and visualization (where possible) on the AOOS Data Portal. *At \$6M in Year 1, AOOS will support the opportunistic data rescue of Chukchi Sea trawl data conducted by UAF (Mueter) from 2004-2018. In Years 2-5 other potential data rescue projects could include collating historic (2000) shipboard ecosystem data from the Bering Strait region to provide long-term temporal and spatial context of regional mooring data; Alaska Department of Fish and Game fisheries-related data that are currently not publicly accessible or in usable formats; and data from oceanography cruises conducted in Glacier Bay from 2011-2014.*
 4. Support AOOS website and other programmatic websites. Axiom will host and maintain the AOOS web portal at www.aos.org, in addition to working with AOOS staff to make periodic updates to improve content, use, and the overall "look and feel". Axiom will also provide web-presence support for user interface and visualization tools, data products, decision-support tools, IOOS Registry tools, and other research or project-specific products, such as the [Gulf of Alaska data portal](#), [Alaska Water Level Watch](#), [Automated Information Systems \(AIS\) for Prioritizing in the Arctic](#), [Western Alaska Storm Models](#), etc.
 5. Collaborate with other state, regional, national and international data management activities. Axiom will actively participate in national IOOS data management committees and teams. They will also develop partnerships with other existing data management systems in Alaska and the Arctic, including NSF's Arctic Data Center, the USGS Oceanographic Biological Information System, MBON, the Arctic Observing Network and the Sustained Arctic Observing Network Arctic Data Committee, and the Polar Data Forum.
- Products:** These include the AOOS DAC, Data Portals, new data access and visualization tools, and ingestion of new datasets and rescued data.

C. Statewide Modeling Analysis, Products and Services

Goal: Our goal is to increase the utility of Alaska ocean and coastal observation data for user products, models and forecasts, and decision support tools.

Objectives: AOOS will (1) support and enhance existing models and data products; (2) develop new products and services; and (3) serve as a modeling testbed.

Activities: Statewide activities are described below; thematic models, products and services are included within the thematic sections.

1. Support existing models, data products and applications developed with prior AOOS funding (Axiom and Partners). In addition to thematic products described in Sections III. D-G, AOOS will continue to support the AOOS Real Time Sensor Map, Virtual Sensor time-series extraction tool, interseasonal statistics (climatologies) for sensors, plotting tools for sensor observations and QC flags, 3D visualization of moving platforms, portal data views (user-generated shareable aggregations of data streams), and the hosting of the Animal Telemetry Network (ATN) DAC and regional data portals.

2. Develop new data products and applications that are priorities for Alaska stakeholders (Axiom and Partners). Potential products would be identified during an annual call for product ideas, as well as through AOOS engagement activities. These products could include phone apps, maps of habitat and other ecosystem and human activity characterization, seascapes, additional salmon run timing forecasts, data visualizations, etc. *At \$6M per year more products could be developed. In Year 1, the following products would be developed: (a) Whale Alert App enhancement; (b) Marine Exchange of Alaska mariner app; and (c) Chukchi seascape for AMBON. See thematic work plans for details. In Years 2-5, additional potential products for development include: (a) Mapping Marine Mammals and Vessel Traffic Patterns and Trends in the Arctic aimed at understanding the year-round vulnerability of marine mammals to increasing vessel traffic in the rapidly changing Alaskan Arctic; (b) Soundscape visualization products for Chukchi Glider and moorings; and (c) Adding satellite AIS to the existing AIS PAC Data Portal to provide vessel tracking information beyond terrestrial AIS range of 50 miles.*

3. Develop a "State of Alaska's Coasts and Oceans Report" (Axiom and Partners). Using Regional Ocean Data Sharing funds and starting with the Bering Sea, AOOS has begun development of a State of AK's Coasts and Oceans Report that is electronic and web accessible, and will be updated and maintained on the AOOS Data Portal. The report will draw from existing NOAA Ecosystem Status Reports and Indicators, the Arctic Report Card, state of Alaska community reports, and other documents and reports. *At \$6M this product would be enhanced and become a signature AOOS product and complement the existing AOOS Data Portals, providing an annual assessment of the state of Alaska's oceans and coast.*

4. Expand the Alaska Modeling Testbed (Axiom and Partners). Similar to the IOOS Coastal Ocean Modeling Testbed (COMT), the mission of the AOOS Modeling Testbed effort will be to accelerate the transition of advances from the coastal ocean modeling research community to improved operational ocean products and services for Alaska, and thereby increase the accuracy, reliability, and scope of Alaska operational coastal and ocean forecasting products. The AOOS team is already using its High Performance Compute capacity to run and host the operational High Resolution Ice-Ocean Modeling and Assimilation System (HIOMAS) model in cooperation with the Department of Homeland Security's Arctic Domain Awareness Center (DHS ADAC), as well as working on a sea ice intermodal comparison with the NWS Arctic Modeling Testbed. A future priority is to develop a generalized model skill assessment toolkit for oil spill models and general circulation models. The toolkit may include new codebases that incorporate machine-learning techniques for model assessment as well as new, web-based model evaluation tools for more public audiences. *At \$6M, AOOS annually will solicit modeling project proposals for the testbed.*

5. Pan-regional Products (Axiom and regional partners). AOOS is planning collaborations with several IOOS Regional Associations (RAs) and with the Canadian Integrated Ocean Observing System (CIOOS-Pacific) (see Appendix E) to develop user-products of common interest, building on pan-regional expertise.

Over five years, depending on funding levels, these will include (a) a new user-friendly portal, the “Oyster Dashboard,” to be customizable by region and site, incorporating data, model output, or content tailored to the area and user group (with west coast RAs and interest from the CIOOS-Pacific); (b) a Maritime Operators app from Baja to Utqiagvik (with west coast and Canada RAs); (c) a potential unified West Coast acoustic receiver network allowing sharing of pan-regional observations of tagged coastal sharks, fish, and marine mammal movement (with west coast RAs); (d) a West Coast Ocean Sound Observation Network leveraging existing and historic passive acoustic monitoring infrastructure and expertise for coordinated sound monitoring and standardized sound data product generation to track marine mammals and vessels; and (e) development of a Coastal Climate Signal (with west coast and Canada Pacific RAs), building on [NOAA’s West Watch initiative](#) to include the northern Pacific Ocean and Alaska Coastal Current.

D. Marine Operations

Five Year Goal: To improve safety at sea for maritime, aviation and coastal operators, and emergency responders using real time data, information products and decision support tools.

Objectives: AOOS will: (1) sustain existing assets and increase new weather and sea-state observations (waves, currents, webcam and optical sensor imagery) to fill critical information gaps; (2) promote new observations to improve regional forecasts (e.g., Cook Inlet Operational Forecast System model); and (3) share observational data and model and forecast products through the AOOS Data Portals to support related decision support tools, especially for oil spill response and search and rescue.

Engagement: Safe maritime operations are of economic value to Alaska, home to a multi-billion dollar fishing industry, oil/gas development and marine tourism. A dedicated AOOS staff lead (Janzen) will continue devoting time to engagement for this theme, working closely with Alaska’s maritime stakeholders, including commercial fishermen, cruise ships, tourism providers, recreational and subsistence users, coastal communities, research institutes, oil and gas industries, regional citizens advisory councils established under the Oil Pollution Act of 1990, marine pilots, port and harbor managers, Waterways Safety Committees, emergency responders, and many federal, state and municipal agencies.

Related Plans: AOOS Weather Stations Build-Out Plans (AIS & Other) and the AOOS Wave Observing and Surface Current Radars Build-Out Plans for 2021-2026 (Appendix I). Consistency with national plans and guidance documents including the 2009 National Operational Wave Observation Plan and the 2015 Plan to Meet the Nation’s Needs for Surface Current Mapping (Appendix B).

Observational Assets and Activities:

1. Sustain SNOTEL weather and climate observations in the Gulf of Alaska (GOA) - PWSSC (Pegau)

Weather & Fish Monitoring. AOOS will continue to provide accurate, real time weather and climate observations in Prince William Sound (PWS) and Cook Inlet (CI). In partnership with the Oil Spill Recovery Institute (OSRI), the PWS Science Center (PWSSC) and the CI and PWS Regional Citizens Advisory Councils (RCAC), eight SNOTEL (snow telemetry) stations in CI and PWS have provided real time web-accessible weather data and webcam images since 2004, used by regional aviators and mariners and for modeling, forecasting and regional climatology assessments.

2. Dissemination of maritime and harbor safety information to increase access to weather and sea state conditions using AIS - MXAK (Mauldin) AIS & Harbor Safety.

The Marine Exchange of Alaska (MXAK) manages the Automatic Identification System (AIS) network in Alaska with over 130 terrestrial AIS receiving stations tracking vessels and communicating safety and environmental information (weather, waves, sea-state conditions) to mariners. AOOS will continue to partner with MXAK to install, operate, maintain and upgrade/recapitalize co-located weather stations at AIS sites. *At \$6M, MXAK will continue installing weather stations, and will provide other navigational safety and sea-state observing capabilities (e.g., installing and reporting out information from current meters, and maritime domain awareness optical imagery).*

3. Wave buoy support and new buoys for navigation safety and wave forecast models - Contract (TBD)

Wave Buoy Support. Continued funding will support a private contractor to help operate and maintain three existing Coastal Data Information Program (CDIP) wave buoys in Cook Inlet, the Port of Nome, and off Kodiak Island, which are part of a larger nationwide US Army Corps of Engineers (USACE) wave monitoring program. The buoys provide essential real time sea state conditions for fishermen, recreational, commercial and subsistence mariners as well as for wave and storm surge forecast modelers. At \$6M, two new CDIP wave buoys will be purchased for deployment at potential sites in Bristol Bay, PWS near Cape Hinchinbrook, or Southeast Alaska (See Budget Narrative - Equipment - New Wave Buoys).

4. Map surface currents with high frequency and short-range radars - UAF (Danielson) Chukchi Radar, UAF (Danielson) Bering Strait Radar. AOOS will continue support for operation and maintenance of three high frequency radar (HFR) sites on the Chukchi and Beaufort Sea coasts, and two sites in the Bering Strait region. These five sites are part of the National HFR Network, with data used to guide development and evaluation of oil spill trajectory models, ocean research, and real time operational applications. At \$6M, AOOS would leverage development of new HFR sites with other partners (e.g., BOEM, CIRCAC, PWSRCAC) at two priority locations: (1) Cook Inlet - with active oil and gas exploration/development interests, supporting the Port of Alaska and active operational forecast modeling and (2) PWS - supporting navigation/maritime safety, oil/gas transportation activities and spill modeling, emergency response efforts, fishing and tourism activities. See also PWSRCAC (Sorum) PWS Maritime Safety, CIRCAC (Saupe) Observations for CI Models.

5. Improving maritime safety operations in Prince William Sound (PWS) by increasing real time weather and sea-state observations - PWSRCAC (Sorum) PWS Maritime Safety. The Port of Valdez is the southern terminus of the trans-Alaska oil pipeline, and supertankers navigate the deep, ice-free waters entering PWS and Valdez Arm each day, handling more than 1.5 million barrels of crude oil. At \$6M, AOOS will fund activities to support safe maritime operations, including operations and maintenance for two existing metocean buoys in Valdez Arm in partnership with PWSRCAC and the City of Valdez. A share-funded WaMoS short-range wave and surface current radar is proposed to support maritime safety and also provide circulation information for oil spill and emergency response activities. The Port of Valdez NOAA NWLON station is now a NOAA [Physical Oceanographic Real Time System \(PORTS\)](#) site, and metocean data are already reported in real time on the AOOS Data Portal. Three new weather sensors and one or more wave installations will fill other navigational data needs.

6. Filling data gaps for improving Cook Inlet operational forecast modeling capabilities, oil spill response and maritime safety - CIRCAC (Saupe) Observations for Models. At \$6M, new ocean observations will be made to better characterize Cook Inlet's physical and chemical environments for testing and improving oceanographic modeling capabilities, and to further develop an "open-access" oil spill and particle trajectory tool/model for Cook Inlet oil spill planning and response. Activities include coordinating with partners to deploy up to two surface current mapping radar systems (e.g., HFR) in mid- and lower Cook Inlet to provide near real time measurements of surface flow fields in a region of existing and new oil and gas exploration and extraction activities as well as significant shipping activity.

7. Alaska Webcam Network - AOOS & Partners (TBD) Webcams. AOOS will continue to support webcam operations on existing infrastructure and host AOOS and other publicly available webcam imagery on the AOOS Data Portal. Webcam imagery is used by mariners, harbormasters, aviators and weather forecasters. At \$6M, AOOS will increase webcam installations at visual gap locations, including locations overlooking the water near ports and harbor entrances and busy maritime transit routes.

Products and Services:

Sustained - (a) AIS Vessel Tracking Tools as extension of ADAC AIS PAC historical AIS data project - MXAK (Mauldin) AIS & Harbor Safety and Axiom Data Science. The AIS Prioritizing Arctic Charting [data portal](#), developed with funding from the DHS ADAC and AOOS, provides access to a historical record

(2013-2019) of Arctic MXAK AIS information, which includes vessel type queries and Vessel Traffic Heatmaps. AOOS will continue to support annual updates to this valuable data archive. (b) Webcam imagery will continue to be supported and incorporated into AOOS website Portal Highlights Data Views, a recent AOOS website product designed to quickly inform mariners and aviators of local visual and atmospheric and sea-state conditions (weather, waves, water level). (c) Shorezone maps and visualizations - the visual map of coastal Alaska at low tide, a collaboration with NOAA and other federal and state partners and used for planning - will continue to be a key online planning tool.

New or Improved - (a) Cook Inlet Operational Forecast System (CIOFS) Hindcast Decision Support Tools - AOOS will use Axiom's Modeling Testbed to add value to the NOS Coast Survey Development Laboratory's CIOFS circulation model by using hindcast model runs to develop decision support tools. These models are needed for particle trajectory analysis (oil spill response planning, larval transport for shellfish), residence time (HABs, oil spills), resource management (current/future environmental conditions for crab and groundfish distribution and herring spawning) and climate change scenario testing (impact of snowpack melt and precipitation changes, timing of seasonal changes). Two projects: NOAA (*Holderied*) *Lower CI Observing* and *CIRCAC (Saupe) Observations for CI Models*, if funded would support this effort by providing necessary collaboration activities and model validation and by filling critical data gaps. At \$6M, AOOS could support (b) Commercial and recreational sea-state boating apps - (b1) In Year 1, IO. Conserve (*Zetterlind*) *Whale Alert App* to add regional content from AOOS real time information resources to this operational mobile application. (b2) In Year 1, MXAK (*Mauldin*) *AIS & Harbor Safety* to develop an Alaska Maritime Information application providing cell phone access to AOOS and MXAK data. (b3) In Year 1, collaborations on pan-regional apps with several IOOS RAs and with the Canadian Integrated Ocean Observing System (CIOOS-Pacific) to develop a West Coast boater app. See Section C (Activities 5) for details. (c) Bering Strait Transboundary Incident Response Tool - AOOS is working with World Wildlife Fund Alaska and Russia to develop a tool for planning, response, and restoration in the event of an incident (e.g., oil spills, disabled vessel, etc.) in the Bering Strait. The tool will include data layers from both the Russian and Alaska sides of the Strait and will be publicly available for use by emergency responders, the general public, NGOs, and community members to assist with or monitor the response.

E. Coastal Hazards

Five Year Goals: To improve forecasts and planning for changing storms, waves and water levels, and sea ice conditions and their impacts on coastal communities and habitats, especially storm surge, coastal erosion and flooding events; and to support the Alaska Coastal Mapping Initiative with nearshore mapping.

Objectives: AOOS will focus on (1) increasing water level and wave observations and nearshore bathymetry and (2) providing access to data and developing related products for decision-making.

Engagement: In 2018, AOOS helped establish the [Alaska Water Level Watch](#) (AWLW), a collaborative group working to improve the quality, coverage, and accessibility to water level observations in Alaska's coastal zone, which are essential for storm-surge forecasting, informed emergency response, ecosystem management, safe navigation, and efficient mapping/charting. AWLW is a partnership with the Alaska Department of Natural Resources Division of Geological and Geophysical Surveys (ADNR DGGS), NOAA Center for Operational Oceanographic Products and Services (CO-OPS), Office of Coast Survey (OCS) and NWS, emergency response planners from local municipalities, state and federal agencies, private industry, research institutions, regional Native corporations, and nonprofits concerned with water level inundation and other coastal hazard impacts. AOOS staff (Janzen) will continue to support ADNR in leading AWLW coordination efforts. AOOS also collaborates with NOAA's Alaska Regional Collaboration Team and the Alaska Mapping Executive Committee and its Coastal Subcommittee.

Related Plans: AOOS Water Level and Datum Observations Build-Out Plan for 2021-26, aligned with priorities established by the AWLW, and the Wave Observing and Sea Ice Observing Build-Out Plans

(Appendix I). Consistency with national plans and guidance documents, including the Alaska Coastal Mapping Strategy, the NOAA CO-OPS NWLON gap analysis, the 2009 National Operational Wave Observation Plan, and the 2020 National Strategy for Mapping, Exploration, Characterizing the United States Exclusive Economic Zone (Appendix B).

Observational Assets and Activities:

1. Implementation of AWLW Priorities for Alaska - ADNR (Overbeck) Coastal Hazard Projects. AOOS will support ADNR to implement AWLW priorities including maintaining the AWLW Build-Out plan, leading the AWLW coordination, installing alternative water level technologies in remote areas, and working with local communities on mapping strategies and community observing. Other ADNR tasks include:

1(a). Support operations and maintenance of six existing alternative-technology (e.g., iGage, iRadar) water level installations. *At \$6M, up to four new water level sensor installations will be added at village and coastal sites most vulnerable to inundation, flooding and erosion.*

1(b). Pilot water level camera monitoring system to monitor changing coastlines and storm surge induced changes. AOOS will support ongoing operations and maintenance of trial water level monitoring cameras in two communities through 2022. *At \$6M, should the trial prove successful, AOOS will support future systems, including one new water level monitoring camera system in western Alaska. This project is affiliated with efforts underway by the US Geological Survey (USGS) with an opportunity for collaboration.*

1(c). Support Hydroball bathymetric survey trials in Years 1 and 2 in two communities a year. In 2019, AOOS funded field trials of a towed bathymetry mapping instrument (Hydroball) that could eventually be deployed by locally trained and compensated community observers, AOOS partners, or agency personnel, to provide regular nearshore bathymetry updates from remote Alaska communities. *At \$6M, a Hydroball Bathymetry Program will be developed to expand the use and application of this mapping tool in remote communities. The program will enlist community observers in up to six new priority communities.*

2. Water level technical support - Contracts with JOA Surveys, LLC (Wardwell) Water Level Tech /Install, and possible contracts with UNAVCO, ASTRA, LLC. AOOS has contracted directly with three primary external contractors to make water level installations (non-NWLON gauges and GNSS-R satellite reflectometry) at sites based on AWLW priorities, and to process satellite data from opportunistic GNSS-R installations in Alaska. GNSS-R is an innovative, lower cost solution for making water level observations and has been demonstrated by AOOS in previous field trials, as well as by the academic research community. AOOS will support the following projects:

2(a). Continued support of existing AOOS funded GNSS-R water level installation at St. Michaels - UNAVCO, completed in 2018 using NWS support. UNAVCO maintains systems and provides the real time data link for raw satellite data. Funding supports general operations and maintenance, site visits and data telemetry costs. *At \$6M, AOOS will support contracts for water level data derivation using satellite data from opportunistic UNAVCO GNSS-R stations that can provide acceptable accuracy water level data. Data processing efforts will be completed by contractors (e.g., ASTRA, JOA Surveys, or academic partners).*

2(b). Support ongoing operations and maintenance of two existing non-NWLON water level installations in Naknek and Dillingham - JOA Surveys. This project will support activities required for validation of station data in order to derive accurate tidal datums. *At \$6M, up to seven additional non-NWLON water level stations will be considered in communities with the appropriate infrastructure, based on AWLW recommendations.*

2(c). Support ongoing operations and maintenance of the Utqiagvik GNSS-R station (2021), including site visits and data telemetry costs - JOA Surveys and ASTRA. This station is using hardware already purchased for AOOS GNSS-R pilot studies. *At \$6M, a second ASTRA GNSS-R system owned by AOOS will be upgraded and installed at a location to be determined based on AWLW priorities, and annual funding will support operations, maintenance and data telemetry.*

3. Increase wave observations for water level and storm surge forecasting and planning (See section D. Marine Operations, Observations and Assets, Activities #3 and #5 above for more details).

4. Operation and maintenance of sea ice radar installations along the Arctic coast - TBD. Five sea ice radar systems are planned for installation in 2021-22 along the Alaska Arctic coast through an externally funded program through UAF to detect sea ice at ranges of up to 20 km. The radars will be maintained by UAF through 2022. At \$6M, AOOS will sustain operations and maintenance of up to five of these ice radar systems, possibly employing local community residents starting in Year 3 (2023).

5. Discretionary Equipment Purchases (DEP) for Coastal Hazards - Budget Narrative - MISC Equipment. These funds may be used to purchase and integrate novel coastal hazard observing systems and or support instrumentation costs for testing emerging or new technologies.

Products and Services:

Sustained - (a) Sea Ice Atlas - UAF (Walsh) Sea Ice Atlas - Continue to support annual upgrades to the Historical Sea Ice Atlas; (b) Oil Spill Risk Assessment Tools - Axiom - Continue to support the [Arctic Oil Spill Risk Assessment Tool](#) on the AOOS Data Portal for integrated data products describing vessel traffic patterns, estimated oil spill impacts, and community subsistence use data from the Beaufort Sea coast; (c) Alaska Water Level Watch Data Portal - Axiom - In collaboration with NOAA, continue supporting operation and maintenance of the AWLW Data Portal, a tiered-quality data system designed to accommodate a wide range of observational water level data including NWLON and non-NWLON and AOOS sources.

New or Improved - (a) Development of an oil spill risk assessment particle trajectory tool for Cook Inlet - CIRCAC (Saupe) Observations for Models & NOAA (Holderied) Lower CI Observing - to improve response planning and for understanding other processes such as larvae transport/recruitment and distribution of HABS and waterborne materials. (b) Transition for storm surge, water level, wave model testbed products - UND (Westerink) Water Level Wave Model - Test model forecast products building on previous IOOS-OTT modeling efforts to expand the Alaska Coastal Ocean Forecast (ALCOFS) for experimental real time implementation of Alaska coastal water level, storm surge and wave prediction. End products will be 5-day water level, currents, and wave forecasts every 6-hours across all of coastal Alaska, which will be linked to the AOOS Data Portal as a testbed product, with potential transition to NWS. (c) Nearshore bathymetry data from Hydroball Bathymetry Program - ADNR (Overbeck) Coastal Hazards Projects - AOOS will help coordinate with NOAA bathymetric data products using data delivered from Hydroball surveys. See Activity #1(c) above for details. (d) Support development of Sea Ice Radar Maps - Axiom - Axiom Data Science will provide data management for five externally funded sea ice radar installations in the Arctic, and AOOS could promote development and publication of user-friendly sea ice radar mapping products. See Activity #4 above for details.

F. Ecosystems, Fisheries and Climate Trends

Five Year Goal: To document and disseminate data about current and future ocean conditions, ocean and coastal ecosystem productivity and change, and climate trends, especially to aid commercial, subsistence and recreation fisheries, protect living marine resources and food security, and enhance the blue economy.

Objectives: AOOS will: (1) build upon and leverage existing programs to support an integrated network of physical, chemical, biological and community-based ocean and coastal observations in Alaska's Large Marine Ecosystems (LMEs; Gulf of Alaska, Bering Sea/Aleutian Islands and Arctic), with a new focus on ocean sound; (2) partner with management agencies and partners to help maintain long time series data collection with new sensors and consistent data collection protocols; and (3) synthesize new and existing data and ensure that data are accessible and usable for priority information products and decision support.

Engagement: Two dedicated AOOS staff (Janzen and Prewitt) will continue engagement for this theme, working closely with government partners, fishery organizations, local communities, and the research community as they respond and adapt to a rapidly changing ocean and coastal environment. Alaska is

home to one of the world's largest fisheries, as well as abundant populations of pelagic and migratory seabirds and protected marine mammals. Ecosystem change in Alaska has direct social and economic implications that are likely to be more profound with the advances of climate change. Program partners include the Distributed Biological Observatory (DBO), Arctic Marine Biodiversity Observing Network (AMBON), NSF Long Term Ecological Research (LTER) sites, and others.

Relevant Plans: Updated AOOS build-out plans for Ecosystems and Biophysical Moorings in Alaska's LMEs, Acoustic Tracking Moorings and Arrays for Soundscape, Shipboard Transects and Observations, Autonomous Glider Observations, and Ocean Acidification (OA) are in Appendix I. AOOS ensures consistency with national plans and guidance documents when available, including the National Ocean Service (NOS) and NWS National Strategy for a Sustained Network of Coastal Moorings, NOAA Ocean Noise Strategy Roadmap, IOOC Animal Telemetry Network Implementation Plan, Toward a U.S. IOOS Underwater Glider Network Plan (see Appendix B).

Observational Assets and Activities:

Focus Area 1: Sustain long ecosystem time series

1. Ship-based sampling along the Seward Line - UAF (Hopcroft) Seward Line. AOOS will continue support of three cruises a year along the Seward Line, the most comprehensive long-term (sampled continuously since 1997) multidisciplinary sampling program in the Gulf of Alaska (GOA), and now part of the Northern GOA LTER (NGA LTER). Data provide thermohaline, velocity, oxygen and nutrient structure; phytoplankton biomass distribution; distribution, abundance and biomass of zooplankton; and carbonate chemistry data at a subset of stations. This integrated network of observations has been critical to supporting information needs for Alaska's fisheries and subsistence and coastal community economies.
2. Lower Cook Inlet and Kachemak Bay oceanographic observing and decision support tool development - NOAA (Holderied) Lower CI Observing. AOOS will continue supporting monthly shipboard surveys for oceanographic observations in Kachemak Bay and lower Cook Inlet to monitor seasonal and interannual variability and provide oceanographic data to describe regional dynamics and assess risks from climate change, OA and HABs. AOOS collaborations with NOAA Kasitsna Bay Laboratory, Exxon Valdez Oil Spill Trustee Council (EVOSTC) and the Bureau of Ocean Energy Management (BOEM) have sustained these observations since 2010 and have contributed to development and validation of the National Ocean Service Cook Inlet Operational Forecast System (CIOFS) and HAB decision support tools.
3. Chukchi Glider - UAF (Danielson), WHOI (Baumgartner) and UW (Stafford) Chukchi Glider. AOOS will continue support of annual simultaneous marine mammal and oceanographic surveys in the Chukchi Sea using a Slocum autonomous underwater glider which has successfully transited the Chukchi Sea transect for six summers. The onboard passive acoustic system records, detects, classifies, and remotely reports marine mammal calls in near real time based on the digital acoustic monitoring (DMON) instrument and the low-frequency detection and classification system (LFDCS). Data are used to study relationships between the distribution of Arctic and sub-Arctic marine mammals and the oceanography of the Chukchi Sea.
4. Ecosystem Approach to Fisheries Management (EAFM) using gliders in the Gulf of Alaska and the Bering Sea - UAF (Danielson) EAFM Gliders. Funding will continue deployment of gliders to develop real time indices of key physical and biological parameters (e.g., plankton bloom timing and magnitude, nutrient depletion, acoustic biomass backscatter, cold pool extent, stratification and strength of mixing, and distribution of fish) to inform North Pacific Fishery Management Council (NPFMC) decisions and other fisheries management. Glider surveys will be conducted year-round in the GOA and Bering Sea, and especially in fall, winter, and spring, when limited numbers of vessel-based surveys are conducted. Gliders may also be equipped with passive acoustic receivers to map marine mammal species and occurrence complementing theme activities #13 and #14 described below.
5. Moored CTD at NOAA Tide Station in Cordova - PWSSC (Pegau) Weather & Fish Monitoring. AOOS will continue support of a moored CTD with leveraging from the NOAA tide station in Cordova. This project fills

a critical data gap necessary to understand the influence of changing coastal freshwater inputs to PWS, the GOA and the North Pacific. Data are transmitted through the NOAA CO-OPS Tides and Currents and shared on the AOOS Data Portal.

6. Seabird Monitoring and Diet Tracking on Middleton Island PWS - ISRC (Hatch) Middleton Island Seabirds. AOOS will help sustain a long-term project to monitor seabird breeding performance and forage fish dynamics as indicators of ecosystem status and trends in the northern GOA. Data and observations will provide timely results to NOAA Fisheries, NPFMC, Gulf Watch Alaska and other stakeholders.

Focus Area 2: Support ecosystem mooring Build-Out plan by enhancing existing or new moorings

7. Ecosystem Mooring Build-out Support - UAF (Danielson) Eco-Moorings. AOOS will provide continued support for ongoing build-out, addition/replacement of sensors and maintenance of the system of ecosystem moorings in four of the Large Marine Ecosystems (LMEs) in Alaska, including the Chukchi Sea Ecosystem Observatory (CEO), the GOA Ecosystem Observatory (GEO), the southern (M2) and northern (M8) Bering Sea ecosystem moorings, and eventually, one in the Beaufort Sea. These moorings collect data on physical, chemical and biological parameters, including sound for marine mammal presence and anthropogenic noise and most recently are integrating novel sensors on behalf of AMBON (e.g., eDNA, N2/O2 net community production platforms, OsmoSamplers for nutrients and trace elements). See *Budget Narrative, Table 2 "Miscellaneous Equipment"* for details on potential novel sensor purchases and *Table 3* for other equipment purchases included under this subaward (*Appendix K*).

8. New moorings in southeast Alaska including initiating ecosystem mooring near Sitka Sound - UAF (Simmons) SE Moorings. At \$6M, AOOS will support two new moorings to monitor the exchange of waters between Southeast Alaska and the GOA and initiate the build-out of an ecosystem moored observatory near Sitka. These moorings will initially be instrumented with Acoustic Current Doppler Profilers, salinity and temperature sensors and deployed in Icy Strait and the mouth of Sitka Sound. There are no long-term data series describing temperature and salinity in southeastern Alaska and little understanding of how basin scale processes influence productivity in the region, which supports a rich commercial fishery. See *Budget Narrative, Table 2 "Miscellaneous Equipment"* in *Appendix K* for details on equipment purchase for this project.

9. Ecosystem build-out of existing NSF supported moorings in the Bering Strait - UW (Woodgate). Bering Strait Eco-Moorings. At \$6M, AOOS would provide support for integrating biogeochemical instrumentation on two long-term physical oceanographic moorings in the Bering Strait (A2 and A3), deployed since 1991 with NSF and other funds. These moorings would provide year-round, archival-quality time-series of in situ biogeochemical oceanic observations, allowing for assessment of the total biogeochemical fluxes through the Bering Strait. Existing moorings provide year-round physical oceanographic measurements and offer AOOS an opportunity to partner with NSF-AON. See the *Budget Narrative, Table 2 "Miscellaneous Equipment"* in *Appendix K*.

10. Ecosystem Sensors and Support for Beaufort Lagoon Ecosystems (BLE) LTER - (Dunton, UTexas - no SOW, request solely for equipment support). AOOS provided initial support to purchase two SBE SeaFET sensors in 2020. At \$6M, AOOS would procure sensors (pH, DO, CTD, PAR, chlorophyll) to be added to four major lagoon system moorings, providing a continuous year-round time series of these parameters on the existing network. This project leverages support from NSF and provides AOOS an opportunity to partner on the build-out of sustained ecosystem moorings in the Arctic/Beaufort Sea region, providing the only continuous OA observing in the region. See the *Budget Narrative, Table 2 "Miscellaneous Equipment"* in *Appendix K* for details on equipment purchase for this project.

Focus Area 3: NEW focus area: Support sound & acoustic moorings to begin build-out of an ocean soundscape, complementing IOOS Topic Area 2 proposal for PAM Access Network (Wall et al.)

11. Prince William Sound (PWS) acoustic fish tracking through the Ocean Tracking Network (OTN) - PWSSC (Pegau) Weather & Fish Monitoring. AOOS funding will continue supporting six acoustic arrays

that comprise the PWS OTN, the only sustained fish tracking array in the region, to efficiently track acoustic-tagged fish and marine mammals moving into and out of PWS. Moorings also measure temperature and contribute to AOOS coordination of the ATN data node.

12. New acoustic fish, shark and mammal tracking arrays in the Kenai Fjords through the OTN - WLTF (Horning) Kenai Fjords OTN. At \$6M, AOOS will support expanding the PWS OTN acoustic receiving array to the Gulf of Alaska and into Resurrection Bay. This effort would install eight acoustic receiver moorings with the potential to add additional sensors. Data from the moorings would include tagged species that are wide-ranging and migratory, such as sleeper sharks and other fish and marine mammals, and would contribute to AOOS coordination of the ATN.

13. Sustaining Long-Term Passive Acoustic Moorings and Soundscapes at DBO Regions 1-5 - NOAA (Berchok) DBO & M2RW Soundscapes. At \$6M, AOOS will leverage existing NOAA efforts to help sustain soundscape observing in the Arctic. Support would maintain the decade-long time series of passive acoustic monitoring (PAM) data collected at DBO Regions 1-5 and at the emerging M2 Moored Ecosystem Observatory by supporting mooring maintenance, operations and data processing for annual soundscape inventories. The acoustic recordings provide a seasonal time record of daily occurrence of biological (Arctic marine mammals and encroachment of subarctic species), anthropogenic (vessels and airguns), and environmental (ice) acoustic sources, as well as producing a set of ambient noise level measurements to characterize the soundscape. See the Budget Narrative, Table 2 “Miscellaneous Equipment” in Appendix K for details about equipment purchase for this project.

14. Enhance passive acoustic monitoring (PAM) moorings in critical habitat used by endangered North Pacific Right Whales - NOAA (Berchok) DBO and M2RW Soundscapes and SII (Spiesberger) M2RW Soundscapes. At \$6M, this project will deploy a novel, expanded array of PAM moorings around the developing M2 Ecosystem Observatory in the southeastern Bering Sea, an area with seasonal occurrence of the critically endangered North Pacific right whale and other marine mammals, seabirds, and commercially important fish species. The array configuration will provide the ability to localize, provide minimum calling abundance estimates for, and potentially track marine mammals around the array, and leverages ongoing efforts (activity #13). See the Budget Narrative, Table 2 “Miscellaneous Equipment” in Appendix K for details about equipment purchase for this project.

Focus Area 4: NEW focus area: Support for community-based ecosystem observations

15. SE AK (Southeast Alaska) Community Troller CTD Surveys - UAF (Hennon) SE Troller Observations. At \$6M, AOOS will help establish a fishing community sampling program with oceanographers at UAF and Alaska Sea Grant to obtain high quality salinity and temperature measurements throughout southeast Alaska, a geographic data gap. Up to five troll-fishing vessels will be equipped with CTDs and will receive training and data management support from UAF scientists. Efforts incorporate lessons learned from the [east coast Scientist-Fisherman Partnership](#), and contribute to fishing industry engagement and outreach/education.

16. COASST Volunteer Seabird Mortality Surveys - UW (Parrish) Coastal Seabird Surveys. Seabird mortality trends are a valuable indicator of marine ecosystem health, and unusual mortality events are on the rise in Alaska. AOOS will continue support for ingesting ongoing community observed seabird survey data into a developing AOOS Data Portal datastream, initiated during the historical COASST (Coastal Observation and Seabird Survey Team) Darwin Core data rescue project. At \$6M, AOOS will co-sponsor continued monitoring of beached-bird data collection in existing Alaska communities by expanding training to increase participation and geographic coverage with new communities.

17. Coordination of Community-Based Monitoring Programs (CBMPs) - ACSP (Divine) Coordination CBMPs. At \$6M, AOOS would support coordination of the Indigenous Sentinels Network (ISN) and the Alaska Arctic Observatory and Knowledge Hub (AAOKH) that currently collect similar or complementary data (i.e., sea ice, marine mammals, CTD, and holistic traditional knowledge observations), to initiate co-

produced and coordinated monitoring and science synthesis. ISN and AAOKH will ensure coordinated and standardized data collection, data management, and data products that respect data sovereignty while providing large-scale coordinated datasets in the Alaska Arctic. This effort looks to strengthen and mobilize both networks while expanding into new communities and involving other CBMPs.

Focus Area 5: Support existing & novel ecosystem sensors and sampling packages

Discretionary Equipment Purchases (DEP) for Ecosystem, Fisheries and Climate Trends - Budget Narrative-MISC Equipment. These funds may be used to purchase and integrate novel ecosystem sensors and sampling packages onto moorings, gliders, and shipboard systems, and will support instrumentation costs for newly proposed AOOS projects at the \$6M level. Equipment support will be awarded at the time of individual project awards. See the Budget Narrative, Table 2 “Miscellaneous Equipment” in Appendix K.

Products and Services:

Sustained - AOOS will continue to support the following data products developed in prior years:

(a) Yukon River chinook salmon run timing forecast, a collaboration with the Alaska Department of Fish and Game and NOAA’s Alaska Fisheries Science Center; (b) The Cook Inlet Beluga Ecosystem Portal, a one-stop source of data relevant to managing this endangered species; (c) ATN Data Center, funded with external funding by IOOS, BOEM and ONR, and providing datasets and visualizations of tagged animals; (d) COASST community observed seabird data products (*UW (Parrish) COASST*) with annual updates.

New or Improved - AOOS will provide data to NOAA NMFS regional ecosystem assessments and indicators and input into the forthcoming Sixth National Climate Assessment, especially its Alaska chapter. *At \$6M, AOOS could support Development of Chukchi Seascapes for AMBON, new AIS/marine mammal sensitivity maps and a soundscape pilot tool for the Chukchi/Bering Seas, and historic shipboard ecosystem data rescue from the Bering Strait region to provide long-term temporal and spatial context of regional mooring data. AOOS will initiate a new effort among the multitude of ecosystem monitoring programs to identify and develop a preliminary coastal climate signal and other integrated data products.*

G. Water Quality

Five Year Goals: To understand, document and respond to current and future changes to the quality and productivity of Alaska’s marine waters and to develop Alaska capacity for ecological forecasting.

Objectives: AOOS will focus on (1) supporting the Alaska Harmful Algal Bloom (AHAB) and Alaska Ocean Acidification (OA) networks; (2) sustaining and enhancing OA and HABs monitoring; and (3) developing decision support tools for stakeholders. AOOS will continue to explore our role in marine debris, invasive species, and contaminants, although no specific activities are proposed.

Engagement: Subsistence and recreational harvesters, commercial fishermen and Alaska’s developing mariculture industry are increasingly concerned about the potential environmental, human health, food security and economic impacts of OA and HABs, as well as warming ocean temperatures.

Extra Congressional funding currently supports a full-time coordinator for the AHAB Network, and AOOS/OAP funding supports a half-time Alaska OA Network director. These two networks foster Alaska-wide collaborations, data integration and standardization. They also collaborate with and provide representation in nation-wide efforts such as the emerging national HAB Observing Network, OA Information Exchange and Coastal Acidification Network (CAN) coordination. *At \$6M, AOOS would fully fund the half-time OA Network Director and contribute to a consortium for supporting the AHAB coordinator.*

Relevant Plans: AOOS updated build-out plan for OA (Appendix I) aligns with national plans and guidance documents including the 2020 NOAA Ocean and Great Lakes Acidification Research Plan (Appendix B).

Observational Assets and Activities:

1. Seward Line OA ship-based sampling in the Gulf of Alaska (GOA) - UAF (Hopcroft) Seward Line. AOOS will help sustain limited carbonate chemistry sampling at a subset of OA anchor stations along the Seward Line during May, July and September cruises. *At \$6M, AOOS will re-institute high-resolution inorganic*

carbon sampling along the Seward Line and within Prince William Sound during all three cruises to maintain efficacy of the 10-year OA time series that ended in 2016, to help validate data from nearby moorings (GAKOA, GEO), and help develop a forecast model for OA in the GOA.

2. Sustaining NOAA PMEL GOA and Southern Bering Sea OA moorings - UAF (Monacci) M2 & GAK OA Moorings. AOOS will continue contributing to a consortium with NOAA PMEL and OAP and UAF-Ocean Acidification Research Center to continue operations, maintenance and validation of two long-term Alaska OA moorings: M2 (Bering Sea) and GAKOA (GOA). Both mooring sites are equipped with surface OA sensor packages, and when available, include bottom OA sensor packages as well. They have provided continuous carbonate chemistry measurements since 2011. The surface packages on both moorings also include meteorological and atmospheric sensors and transmit data in real time via satellite telemetry.

3. Increasing carbonate chemistry monitoring at Gulf of Alaska (GOA) Bookend Moorings - UAF (Kelley) OA Bookend Moorings. At \$6M, AOOS would support adding high-frequency pCO₂ sensors to a highly leveraged sensor network in Homer (deployed in 2017) and Juneau (2019). Prior and ongoing partners include BOEM, NSF Alaska EPSCor Program, Alaska Sea Grant and the Kachemak Bay NERR. Homer and Juneau “bookend” distinct GOA regions with differing physical oceanographic conditions, providing a comparison of how these forces differentially influence the nearshore pCO₂ fluxes of each region. See the Budget Narrative, Table 2 “Miscellaneous Equipment” in Appendix K for details on equipment purchase for this project.

4. Shore-based OA Monitoring: Burke-o-Lators & Community Sampling - APSH (Hetrick) Seward Burke-o-Lator, NOAA (Long) Kodiak Burke-o-Lator, SEATOR (Lanphier) Sitka Burke-o-Lator, and Hakai (Evans) AK Burke-o-Lator Support. AOOS funding will continue to provide partial funding for three Alaska real time continuous ocean acidification monitoring systems called Burke-o-Lators (BoLs) in Seward, Sitka and Ketchikan. These systems provide shore-based time series observations of aragonite saturation and the Seward and Sitka sites analyze community OA water samples. Technical oversight of these sites, plus an additional site in Kodiak, and some associated maintenance costs will be supported, previously provided by the IOOS/NOAA OAP “Headlights” Project. At \$6M, AOOS will support expanded BoL operations at Seward and Kodiak and water sample analysis for additional communities. In Sitka, full AOOS support will mostly enhance community sampling capacity.

5. OA Ferry Monitoring on M/V Columbia - UW (Mordy) OA Ferry. Current funding will maintain collection of temporal and seasonal carbon chemistry data along the Alaska Marine Highway System ferry route from Bellingham, WA to Skagway, AK, supporting onboard transits for system calibration, outreach and maintenance. AOOS is heavily invested in this highly leveraged project, with the Tula Foundation/Hakai Institute (BC, Canada) providing capital costs and staff time, the Alaska Marine Highway System allowing installation and providing staff time, and AOOS supporting O&M. Additional partners include UAS Alaska Coastal Rainforest Center and UW-Cooperative Institute for Climate, Ocean, and Ecosystem Studies.

6. HAB Community Sampling Support. AOOS is using funding from Congress to IOOS to help with implementation of the statewide HABs action plan through 2023. At \$6M, AOOS will help implement the plan by expanding HAB community sampling and testing in the Arctic and other parts of Alaska with HAB concerns. Details will be developed with input from the AHAB Network and the Alaska Statewide HAB Action Plan currently in development.

7. Discretionary Equipment Purchases (DEP) for Water Quality - Budget Narrative - MISC Equipment. These funds may be used to purchase and integrate novel water quality sensors and sampling packages onto moorings, gliders, and shipboard systems, and will support instrumentation costs for newly proposed AOOS projects at the \$6M level. Equipment support will be awarded at the time of individual project awards. See the Budget Narrative, Table 2 “Miscellaneous Equipment” in Appendix K.

Products and Services:

Sustained (AOOS staff and Axiom) - AOOS will continue to: (a) maintain the mariculture siting tool, developed as a partnership with the state of Alaska, the Alaska Fisheries Development Foundation, and the Governor's Mariculture Task Force, to aid applicants seeking permits to site potential mariculture activities; (b) support the Alaska OA Network and AHAB Network websites, data portals, and outreach products; (c) develop the OA State of the Science annual updates; and (d) coordinate OA and HAB inputs into NOAA Integrated Ecosystem Assessments.

New or Improved - At \$6M, AOOS will support: (a) *The AHAB Coordinator, in collaboration with the AHAB Network, will complete the Statewide HABs action plan, enhance the HABs data portal to be comprehensive and statewide, and explore ways to implement HAB risk assessments and early indicator alerts; and (b) Develop Bering Sea OA forecasts (NOAA-Pilcher) - AOOS will contribute to developing and supporting consistent quarterly nowcasts and forecasts of ocean temperature and acidification variables for the Bering Sea. End products would include up-to-date hindcasts of the previously developed Bering Sea ROMS model. The project will also compare forecasts (supported through leveraged funding) to the summer/fall NOAA Fisheries survey data and provide retrospective analysis of model forecast skill.*

IV. MILESTONE SCHEDULE

AOOS's goal is to sustain our activities across all subsystems for all five years of this proposal. Detailed specifics for milestones and deliverables for each activity are listed in Appendix J.

V. PROJECT BUDGET

Budget Categories	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Personnel	638,760	657,923	677,660	697,990	718,930	3,391,263
Fringe Benefits	178,853	184,218	189,745	195,437	201,300	949,553
Travel & Per Diem	35,000	35,000	35,000	35,000	35,000	175,000
Equipment	481,762	408,310	387,512	365,957	339,132	1,982,673
Supplies	6,500	6,500	6,500	6,500	6,500	32,500
Contracts/Services	1,731,360	1,804,805	1,780,603	1,780,603	1,780,603	8,877,974
Other						
<i>Subawards</i>	<i>2,577,129</i>	<i>2,475,259</i>	<i>2,494,870</i>	<i>2,490,497</i>	<i>2,490,473</i>	<i>12,528,228</i>
<i>Other</i>	<i>157,700</i>	<i>158,700</i>	<i>158,700</i>	<i>158,700</i>	<i>158,700</i>	<i>792,500</i>
NOAA Holdbacks	192,936	269,285	269,410	269,315	269,362	1,270,308
Total Grant Request	6,000,000	6,000,000	6,000,000	6,000,000	6,000,000	30,000,000

Detailed budget information. Appendix K includes an overall project budget for \$6 million a year for 5 years and budget narrative, as well as budget information for all subawards. AOOS wishes for the IOOS Program Office to hold back \$1,270,308 over five years and transfer funds to these NOAA offices to perform activities described above: NOAA Kasitsna Bay Laboratory (Holderied), NOAA PMEL (Pilcher), NOAA AFSC (Berchok) and NOAA AFSC (Long). No equipment described in this proposal is available for lease. All items require a direct purchase.

Base capacity and enhancements. In addition to this budget request for \$30 million (Appendix K), which would minimally meet the need for ocean observing activities in Alaska, the Budget Narrative also includes a notional \$3 million a year budget, which is similar to that for current funding levels. The primary differences between the two are the extent of proposed observations and equipment purchases, resources devoted to products and services including modeling, and additions to AOOS programmatic and engagement staff.