CeNCOOS:
Integrating Marine Observations for Decision Makers and the General Public

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Topic Area:
FY 2011 Implementation of the U. S. Integrated Ocean Observing System (IOOS): Topic Area 1: Continued Development of Regional Coastal Ocean Observing systems.

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Project Summary

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Brief Project Summary:

Covering over six hundred miles of coastline from the California-Oregon border south to Point Conception, the Central and Northern California Ocean Observing System (hereafter CeNCOOS) encompasses a dynamic ocean environment and a large, diverse group of stakeholders. Originally founded in 2004, CeNCOOS is one of the eleven Regional Associations (RAs) comprising the national Integrated Ocean Observing System (IOOS). IOOS finds it legal basis in the Omnibus Public Land Management Act of 2009, which was signed into law by President Barack Obama on March 30, 2009. The task of the RAs is to "coordinate State, Federal, local, and private interests at a regional level with the responsibility of engaging the private and public sectors in designing, operating, and improving regional coastal and ocean observing systems in order to ensure

the provision of data and information that meet the needs of user groups from the respective regions."

CeNCOOS has matured greatly during the past three years under grants from the National Oceanic and Atmospheric Administration totaling $4.8M. The *Basic Operating Principle* is that CeNCOOS fosters solid working relationships between scientists and end-users to establish and maintain the societal relevance of the work. These bonds are forged by conducting face-to-face interviews, sponsoring workshops, collecting written surveys of user needs, responding to environmental emergencies, networking through CeNCOOS boards, working groups, and committees, and by addressing the needs established by the State of California's Marine Life Protection Act (MLPA) and the West Coast Governor's Agreement. CeNCOOS has forty-four partners (http://www.cencoos.org/sections/about/partners.shtml) who are signatories to the Memorandum of Agreement as well as a user-based forty-six member Joint Strategic Advisory committee (http://www.cencoos.org/sections/about/JSAC.shtml) (with SCCOOS) which determines and prioritizes stakeholder needs. CeNCOOS then implements an appropriate observing strategy to address these needs.

Moving ahead for 2011-2016, CeNCOOS has established a multi-purpose observational scheme that collectively addresses user needs in the general categories of **climate and ecosystem health, water quality, marine operations, and coastal hazards**. A sampling of CeNCOOS products to address these issues includes:

- Long time series of temperature and coastal sea level to address global warming and sea level rise
- Sustained observations of the carbon variables to assess ocean acidification
- Observing, predicting, and mitigating the impacts of harmful algal blooms (HABs)
- Creating harbor information pages for marine operators
- Publishing inundation warnings for coastal communities
- Providing real-time currents for search and rescue
- Predicting the movement and fate of harmful spills of all kinds
- Providing ocean data products for the marine spatial planning (MSP) enterprise

The core observation suite used to address these issues includes automated pier stations, coastal buoys, the HF radar surface current mapping network, and a coast-wide network of autonomous vehicles. High resolution bottom maps from towed and autonomous vehicles also make a valuable contribution. The data are moved in real time to the CeNCOOS Data Management and Communications (DMAC) system and assimilated into numerical models for now-casts and forecasts of ocean conditions. By this proposal we plan to maintain and expand this network as well as incorporating more innovative approaches such as environmental sampling from marine mammals and fish. The modeling and prediction capability will be advanced from the physical to the ecosystem level. Our complete observing system will be used to understand and preserve the health of the ocean for generations to come.

Background

Covering over six hundred miles of coastline from the California-Oregon border south to Point Conception, the Central and Northern California Ocean Observing System (CeNCOOS) encompasses a dynamic ocean environment and a large, diverse group of stakeholders. Originally founded in 2004, CeNCOOS is one of the eleven Regional Associations (RAs) comprising the national Integrated Ocean Observing System (IOOS). The *Basic Operating Principle* is that CeNCOOS fosters solid working relationships between scientists and end-users to establish and maintain the societal relevance of the work. These bonds are forged by conducting face-to-face interviews, sponsoring workshops, collecting written surveys of user needs, responding to environmental emergencies, networking through CeNCOOS boards, working groups, and committees, and by addressing the needs established by the State of California's Marine Life Protection Act (MLPA), Ocean Protection Council (OPC), and the West Coast Governor's Agreement on Ocean Health (WCGA) (see attached letters of support). CeNCOOS then implements an appropriate observing strategy to address these end-user needs. A sustained (to be maintained indefinitely) observational presence in the coastal ocean is required in order to: a) provide baseline information by which to quantify change; b) capture large, transient, unpredictable, and important events; and c) facilitate breakthroughs in knowledge not possible without these long-term observations.

The core observation suite used to address these issues includes automated pier stations, coastal buoys, the high-frequency (HF) radar surface current mapping network, and a coast-wide network of autonomous vehicles (Figure 1). The data are moved in real-time to the CeNCOOS Data Management and Communications (DMAC) system and assimilated into numerical models for now-casts and forecasts of ocean conditions. Under this new funding, the network will be expanded to include more ecosystem variables such as dissolved oxygen, nitrogen, the carbon variables (ocean acidification) and marine toxins. Innovative approaches such as environmental sampling from marine mammals and fish will also be incorporated. The modeling and prediction capability will be advanced from the physical to the ecosystem level. A major emphasis will be on producing unique, specific products that meet the needs of end-users. CeNCOOS already has thirteen such products on our web site (see http://www.cencoos.org/sections/products/index.html) and more will be developed.

CeNCOOS is well coordinated with our neighbors to the south, the Southern California Ocean Observing System (SCCOOS) via the Joint Technical Implementation Committee, the Joint Strategic Advisory Committee (JSAC) (see http://www.cencoos.org/sections/about/JSAC.shtml) and numerous ad-hoc Executive Committee meetings. These teams provide expertise, guidance, and user feedback to the state-wide surface current monitoring network, the glider network, the HAB/water quality monitoring network, and the numerical modeling. We are further coordinated with the entire west coast (AOOS, NANOOS, PacIOOS) on issues such as climate change, large marine ecosystems, numerical modeling, and data sharing. Some concrete examples include CeNCOOS and SCCOOS partnering with the National Weather Service to develop and enhance its One Stop Marine Page (http://www.wrh.noaa.gov/eka/salmon/)

by including OOS data and models that are currently not included. The goal is to engage the local marine community to provide feedback so as to assure that the site is relevant to their operations. On the DMAC front, all the Pacific RAs have formally agreed to improve access to existing data services (products, map-based visualizations, and information) through a collaborative effort to establish common website linkages. Future effort will focus on the development of shared visualization services that focus on data and products common to all regions such as glider data, model nowcasts and forecasts, key climate variables and HF radar.

Goals and Objectives

- Maintain existing automated shore stations for water quality and climate change
- Add harmful algal bloom (HAB) and carbon variables to the shore stations
- Improve indices for upwelling response and chlorophyll-a from shore stations
- Maintain existing HF radar Surface Current Mapping (SCM) stations
- Improve reliability, reduce down-time for the SCM network
- Add new SCM stations to fill gaps (i.e. San Francisco Bay, Morro Bay)
- Refine products derived from SCM for search and rescue, hazardous spill response, marine operations, HABs, MPA connectivity, fisheries, etc.
- Continue operating the Monterey Bay glider transect 24/7
- Add new glider lines at Bodega Bay and Morro Bay
- Add new sensors to gliders for dissolved oxygen and ocean acidification
- Generate ENSO and climate change indices from glider lines
- Continue populating the CeNCOOS DMAC
- Implement smarter front end GUI (data discovery tool) to the DMAC
- Integrate CeNCOOS DMAC with DMACs from the rest of the Pacific region
- Diversify access points for products and information from beyond the CeNCOOS home page to include phone apps, podcasts, Facebook, etc.)
- Continue running 3-km COAMPS atmospheric model for the CeNCOOS region
- Expand COAMPS coverage to state-wide
- Maintain COAMPS CeNCOOS web portal for atmospheric forcing data
- Expand 3-km ROMS model from southern California to state-wide
- Implement 3-km NCOM CCS Navy real-time model, coast-wide
- Conduct process-oriented modeling serving ecosystem and MPA needs
- Conduct repeat seafloor mapping surveys in key areas such as MPAs and canyons
- Continue developing user-driven information products serving the needs of the marine operations, ecosystems and climate, water quality, and coastal hazards communities
- Expand Education and Outreach efforts by increasing educational/marketing materials and audience, partnership development, collaborative efforts with formal and informal centers, and establishing an E&O Committee.
- Position CeNCOOS to respond to Coastal and Marine Spatial Planning (CMSP) initiatives and to respond to future coastal management needs

For the year-by-year implementation plan, please refer to the milestone schedule below.

Audience and Benefits

Information and products provided by CeNCOOS have wide-ranging applications. The potential breadth of the user community served is as diverse as the data collected and spans from local to global. The CeNCOOS Governing Council and Joint Strategic Advisory Committee (JSAC) are charged with identifying priority target audiences where the CeNCOOS ocean observing system will have the greatest impact. Overall, that audience includes state and national policy makers, resource managers, and the general public. The CeNCOOS products are grouped according to the four focus areas shared with SCCOOS and described throughout this proposal: **Ecosystems and Climate, Water Quality, Marine Operations, and Coastal Hazards**.

The four focus area themes were developed through an extensive process focused on designing an efficient observing system that addresses data gaps and also meets the highest priority user needs and coastal issues. User needs are obtained through a variety of methods including hosting workshops and open Council meetings, leading surveys, collaborating with programs gathering similar information (NOAA Sea Grant), participating in meetings, and conducting interviews with individual organizations. Examples of workshops hosted include: Modeling in the CeNCOOS Community, Ocean Observing Systems for Marine Protected Areas and Water Quality, and the biennial Humboldt Bay Symposium. Examples of collaborative efforts where user needs and product ideas are also obtained include on-going projects such as the Gulf of the Farallones Climate Change Initiative, the West Coast Governors Agreement Action Teams such as HABs and Marine Energy, the CA Harmful Algal Bloom Monitoring and Alert Program (Cal-HABMAP), the Monterey Bay Aquarium Research Institute (MBARI) Teacher Training programs, and the MPA/IOOS Task Team with the NOAA MPA Center. Meeting participation occurs on an almost daily basis and ranges from quarterly events with the Harbor Safety Committee and the CA Ocean Protection Council to monthly meetings with the State Water Resources Control Board and the CA Office of Spill Prevention and Response (OSPR). An example of a one-time event that builds partnerships would be the Coastal and Marine Spatial Planning workshop, hosted by the Center for Ocean Solutions, The Nature Conservancy, and the NOAA Coastal Services Center (CSC). CeNCOOS staff continually conduct individual partner interviews and have been aided in this process by two summer interns each year. Information booths set up at major conferences reach many people who may benefit from CeNCOOS information and programs. A perfect example of this would be the recent California and the World Ocean 2010 Conference held in San Francisco, CA.

The outreach methods described above aid the staff, Council and JSAC in prioritizing efforts that ultimately guide the development of CeNCOOS products. Product designs are based on user needs and/or requests and go through an iterative evaluation process in collaboration with the intended user. For example, CeNCOOS worked with the Exploratorium in San Francisco and the local NOAA Environmental Research Division (ERD) office to design a product that delivers real-time data in a format suitable for their specific educational mission and environment. Several meetings among the partners led to product changes, upgrades, and improvements that ultimately

provided a great product that really meets their needs. (see http://las.pfeg.noaa.gov/SFBay_CeNCOOS/)

Monitoring efforts designed to address the four themes stand to provide extensive short and long-term benefits. Sustained, long-term monitoring is essential for addressing today's main concerns: Climate change and human impacts on the ocean. Long time series from shore stations, ocean buoys, and glider transects can quantify ocean warming, ocean acidification, and sea level rise to a level of accuracy not previously possible. Warmer or cooler oceans on the time scales of ENSO and the Pacific Decadal Oscillation (PDO) impact overall ecosystem health including the success of fish populations. This fundamental environmental information is essential to evaluating management outcomes such the effectiveness of Marine Protected Areas. It is also essential input to effective Coastal Marine Special Planning (CMSP) to avoid conflicts between fishing, offshore energy development, recreation, and ecosystem health.

Other users require real-time data which are necessary for planning and emergency response. In marine operations, this includes the CA Office of Spill Prevention and Response (OSPR), the U.S. Coast Guard, NOAA OR&R, the San Francisco Bar Pilots, and harbor masters and yacht clubs coast-wide. There are numerous examples within CeNCOOS using HF radar-derived surface current maps to provide trajectories for oil spill response and search and rescue. The surface current data are integrated into the NOAA GNOME trajectory model which was used during responses to both the *Cosco Busan* and *Deepwater Horizon* oil spills. It is also being integrated into the USCG's SAROPS search and rescue tool. Near real-time and forecast wave data are crucial to recreation, coastal inundation, beach erosion, and safe maritime operations. The organizations using this information include the SF Bar Pilots Association, the National Weather Service, the CA Coastal Commission, and the Monterey County Water Resources Control Board. CeNCOOS and SCCOOS recently attended a 'Building Relationships' workshop with NWS and users to enhance and design new shared marine pages for planning and emergency response.

While long-term monitoring benefits all levels of coastal management, many users require a product that provides forecasting skill. This is where data management and ocean modeling come into play. The CeNCOOS models to be developed under this proposal provide particle trajectories useful for search and rescue, hazardous spills, and bloom and contaminant tracking to protect beaches, seafood, and public health. The agencies monitoring water quality, such as the State and Regional Water Boards, California Department of Public Health, County Environmental Health programs, citizen monitoring programs, Harmful Algal Bloom (HAB) researchers and aquaculture growers all depend on long-term data and forecasts to understand ocean conditions that impact lives and livelihoods.

All of the information discussed here is available online and in a user-friendly format that each of the individuals and agencies described above can easily access. Since the audience ranges beyond managers, outreach tools have been developed that communicate and disseminate the science described above in formats that inform policy

makers and aid educators. These products improve decision making that impacts safety, the economy, marine diversity, and public health. Once again, readers are encouraged to visit the web page at http://www.cencoos.org.

Work Plan

The CeNCOOS PIs are organized into teams around the four primary focus areas of climate and ecosystems, water quality, marine operations, and coastal hazards. While there is obviously some (intended) overlap surrounding each observing capability, we have chosen to group them according to the primary topic area addressed (see below and cost proposal tables). The CeNCOOS philosophy is that quality control is best left in the hands of the data collector. This has led to the web-services based DMAC approach such that the most recent version of the data is always being accessed. Some additional automated QA/QC is also being implemented by the Science Applications International Corporation (SAIC) at the DMAC level.

CeNCOOS understands that some flexibility is required to meet emerging coastal management needs, such as Coastal Marine Spatial Planning (CMSP), a key plank in the new plan for ocean action presented by President Obama's Interagency Ocean Policy Task Force. While CeNCOOS does not anticipate leading the CMSP effort in central and northern California, it does aspire via its observational and modeling efforts to be the definitive source of accurate, unbiased ocean data and information for the region, which will be necessary input to the CMSP team as they prepare their plan for the state. CeNCOOS will collaborate with the state's team leaders on the CMSP process as the future Federal Funding Opportunities emerge.

CeNCOOS is organized around institutions, rather than individuals, who can carry out a needed task and are committed to maintaining the continuity of the observing system over a period of many years. Here follows a listing of the institutions grouped by task, followed by additional detail of what is expected of each institution.

1. Maintain automated coastal shore stations for water quality, long term trends in temperature, salinity, sea level, chlorophyll fluorescence, and ocean acidification; Harmful Algal Bloom monitoring, forecasting, and mitigation. *Humboldt State University, UC Davis – Bodega Marine Lab, San Francisco State – Romberg Tiburon Center, UC Santa Cruz, Moss Landing Marine Laboratories (MLML), California Polytechnic State University (CalPoly), Sonoma State University.*

2. Continuously operate a series of across-shore glider transects 24/7 to monitor temperature, salinity, chlorophyll fluorescence, dissolved oxygen, and the carbon variables. These transects will be used to track ENSO events and climate change, and to feed data assimilating ocean circulation models. *Monterey Bay Aquarium Research Institute, Bodega Marine Lab, Farallon Institute, California Polytechnic State University*

3. Harden the HF radar surface current mapping (SCM) network to reduce down time, improve accuracy, and produce products (Figure 2). The SCM network is used in

virtually all our products for search and rescue, marine operations, and ecosystem forecasting. *Humboldt State University, UC Davis – Bodega Marine Lab, San Francisco State – Romberg Tiburon Center, The Naval Postgraduate School, California Polytechnic State University*

4. Coastline and sea floor mapping for coastal hazards, marine ecosystems, and marine protected areas. *California State University Monterey Bay.*

5. Run state-wide data assimilating ocean circulation models to forecast currents, state variables, and ecosystem parameters. Expanding into ecosystem modeling is a large task but the aim is to get started under the present grant. *The Naval Research Laboratory – Monterey, CA, The Naval Research Laboratory – Stennis Space Center, MS, JPL/UC Los Angeles, UC Santa Cruz*

6. Implement a data management and communications (DMAC) system to facilitate easy data access and use by researchers, modelers, product developers, managers, and the general public. An interoperable data system, both within the regional association and across RAs, is an integral and important part of the national IOOS process. *Science Applications International Corporation*

Roles of each partner (sub-award), fully-funded at the $4M level

Monterey Bay Aquarium Research Institute (Ramp) This line item supports the CeNCOOS front office previously supported under the separate "CeNCOOS Leadership" grant. This funding is to provide salary for the Executive Director (Ramp, 6 mo), the Coordinator (Kerkering, 12 mo) the Product Developer (Bahr, 6 mo), and the Communications Manager (Wadsworth, 10 mo). This team administers the CeNCOOS region including fiscal oversight, conducts education and outreach, maintains and develops the web site, and creates products for end users. Support for travel, education and outreach, and miscellaneous supplies is also included. This funding also allows the central office to administer a community instrument pool to add new sensors and/or replace old worn out equipment, and to purchase wave buoys to calibrate the CDIP wave model at strategic locations along the California coast. [$3535K]

Monterey Bay Aquarium Research Institute (Chavez): This funding is to maintain an existing glider line in the Monterey Bay and to expand the glider network to two additional lines off Bodega Bay and Morro Bay. It includes salary for the Glider Technician (Wahl, 6 mo), annual operating costs for one additional glider line, and two new gliders to be purchased directly from SIO. The glider technician will maintain operations off Monterey Bay and the additional lines mentioned above. The Bodega line will be collaborative with UC Davis, the Farallon Institute, and the Sonoma County Water Agency (SCWA) (see other work plans). This funding will also help facilitate the next generation NDBC/IOOS offshore buoy, being jointly developed by MBARI and the National Data Buoy Center (NDBC). The CeNCOOS contribution will provide the biogeochemical sensors and labor (Rienecker, 4 mo) and leverages an additional $500K investment by MBARI and NDBC. [$779K]

UC San Diego/Scripps Institution of Oceanography (Rudnick): This subaward is for glider hardware and expendables as described in the paragraph for MBARI (Chavez) above. [$1051]

Humboldt State University (Shaughnessy): HSU will maintain coastal water quality stations along the north coast at Trinidad Head and Humboldt Bay, sampling T, S, P, Chl-a, Turbidity, DO, and pH every 6 minutes. The information page for Humboldt Bay Oyster growers will be maintained and expanded. HSU will work with the Sonoma State University (SSU), MLML, and the CeNCOOS home office to establish a Chl-a prediction scheme for the Humboldt Bay. HSU will also receive limited support for minor maintenance of the northernmost node of the HF radar network although the bulk of this work will now be transferred to the Bodega Marine Lab (Largier) and San Francisco State University (Garfield) [$666K]

San Francisco State University (Garfield, Robinson): The SFSU Romberg Tiburon Center (RTC) will maintain and upgrade water quality stations in the San Francisco Bay. This will eventually become a HAB station via cooperation with the larger CeNCOOS Cal-HABMAP effort. RTC has also been a leader in developing the DMAC for the pier stations (PierDAC) which they continue to maintain and cooperate with primary DMAC contractor SAIC. RTC will also receive $200K to maintain and operate the SF Bay and lower central coast HF radar surface current mapping stations. This is the amount that SCCOOS and CeNCOOS have agreed all the "node" operators will receive. The spare parts budget for the CeNCOOS HF radar network (NPS, BML, SFSU, HSU, CalPoly), with some sites now over twelve years old, will also reside at SFSU [$1742K]

The California Polytechnic University, San Luis Obispo (Moline): CalPoly will maintain 6 southern region water quality stations (Pismo Beach, 4 in Morro Bay, San Luis Obispo Bay, Estero Bay), provide manpower to operate existing autonomous underwater vehicle (AUV) transects, and a new glider transect. These data streams are also used in local community outreach. With currents from HF radar, examine the ecosystem health and connectivity between Marine Protected Area (MPA) sites. This work is a continuation and expansion of products started last year at Cal Poly. Cal Poly will also begin regular glider operations off Morro Bay using a glider to be centrally maintained at the MBARI glider center. They will also receive funding for HF radar operations and maintenance via SCCOOS. [$644K]

Moss Landing Marine Lab (Coale, McPhee-Shaw, Nevins): Maintain existing water quality stations in the Monterey Bay, to include establishment of a new water quality monitoring station at the Monterey Commercial Wharf. This station will include stratification to serve the needs of the abalone farming industry. The weather station at MLML will be maintained. The Moss Landing sea water intake sampling station (T, DO) will be improved to include pH and pCO_2. McPhee-Shaw will continue refining an algorithm for computing nitrogen from temperature using a T/N relationship, at stations where there is no nitrogen sensor. The Monterey Bay stations will be added to the CeNCOOS PierDAC and the nitrogen product will be expanded to include other

CeNCOOS stations in the PierDAC. This program will also mobilize a citizen network to assess the impacts of HABs on sea birds and marine mammals (Nevins). [$1268K]

Sonoma State University (Nielsen): SSU will maintain two northern California stations at Bodega Head and Kibessilah Hill (near Ft. Bragg); expand sampling to include phytoplankton and additional variables for Cal-HABMAP; and support participation in the Chl-a productivity and forecast effort (with Shaughnessey and McPhee-Shaw). The work includes establishing a protocol for calibrating fluorescence data to in situ Chl-a, which will ensure uniformity of results across the CeNCOOS region. [$592K]

California State University, Monterey Bay (Kvitek): This effort is a value-added partnership with the $25M California Seafloor Mapping Project to conduct repeat multibeam surveys of previously mapped areas to document where significant shoreline and seafloor change has taken place. The same bathymetric sonar and mobile topographic LiDAR will be used as were used for the original CSMP base maps. The priority locations for re-mapping will be determined based on input from the various stakeholder groups with a vested interest in obtaining change-detection data. [$370K]

University of California at Santa Cruz (Kudela, Carr, Edwards, Moore):
The UCSC team will operate several products supporting the needs of water quality, ecosystem health, and ocean modeling and prediction. Kudela will establish the first *bona fide* CeNCOOS harmful algal bloom (HAB) monitoring station at the Santa Cruz Wharf. This involves expanding the existing facilities to include dissolved oxygen, turbidity, fecal indicator bacteria, nutrients, HAB species information, sentinel mussels, and flow cytometry. The standard physical variables will be sampled at 6-minute intervals, the weather station at 5 minutes, and the biological variables requiring lab work weekly. Funds will also be directed to Kudela to continue downloading and processing satellite ocean color data, and to produce value-added products from same. This includes a Google-based "smart query" system for satellite imagery. The funds for the CeNCOOS-wide community HAB effort will also reside at UCSC. Under these funds, the HAB team (Kudela, McPhee-Shaw, Shaughnessey, Nielsen, Garfield, Cochlan, and, Smith) will provide coordinated HAB sampling along the central and northern California coast for the purpose of HAB monitoring, forecasting, and predictive tool assessment. This effort will be coordinated with efforts already underway in the SCCOOS region. Funding for Carr (last three years only) will support ocean acidification sensors on ocean buoys, a joint project with NSF. The four buoys will span Tomales Bay to Sand Hill Bluff and complement other buoys being deployed off Santa Barbara and Oregon to form a coast-wide ocean acidification array. Edwards and Moore will expand their modeling efforts using the 4DVAR data assimilating version of the community ROMS model. Edwards effort will focus on larval connectivity between MPAs while Moore will focus on the details of the data assimilation. New for this funding cycle will be to expand the physical model to include lower trophic level ecosystem variables. [$3111K]

University of California at Davis (Largier): The three major tasks here are to 1) Continue operating coastal water quality stations (T, S, Fl, transmission) and two buoy-mounted water quality stations (same plus a T-string) in Marine Protected Areas in the Bodega

Bay / Point Reyes sector; 2) to operate the north coast (Bodega Bay to the Oregon Border) HF radar surface current mapping nodes, and provide information products from same; and 3) Conduct surveys of ocean conditions off the Russian River to improve understanding of salmon stock recruitment. The surveys include bi-weekly to monthly boat-based plankton and larval fish sampling and continuous autonomous (glider) transects. This work will be a partnership with the Farallon Institute (Sydeman), the Sonoma County Water Agency (SCWA), and MBARI. The focus will be on providing information on ocean conditions and inter-annual variability to fisheries resource managers. The glider line will be a key piece of the state-wide glider network. [$1350K]

Jet Propulsion Laboratory / UC Los Angeles (Chao): Priorities in order for JPL/UCLA are 1) expanding the 3-km Regional Ocean Modeling System (ROMS) model from southern California to the whole coast; 2) implement a web-based do-it-yourself drifter tracking tool for spill response, search and rescue, and biological patch tracking; and 3) begin adding an ecosystem module into the ROMS physical model output. The existing JPL/UCLA wind product will be transitioned to CeNCOOS to be maintained there. [$625K]

Stanford University / Hopkins Marine Station (Block, Fringer): This is another two-part sub-award. Block will unify the extensive animal tag-based environmental database of TOPP with the CeNCOOS database for improved community access and availability for data assimilation in numerical models. The goal is to streamline the data assimilation process via a one-stop shop in IOOS compatible NetCDF format. Fringer will facilitate a real-time circulation model for the San Francisco Bay. Under separate funding Fringer (Stanford) and Stacey (UC Berkeley) are developing an open-source hydrodynamic model (SUNTANS) for the SF Bay. Under partial CeNCOOS funding Fringer will set up and run three-dimensional hindcasts of SF Bay for the period 2010-2014. Three-dimensional datasets of currents and salinity from these hindcasts will be posted online and made available to the community. [$750K]

The Farallon Institute for Advanced Ecosystem Research (Farallon Institute) (Sydeman): This sub-award to institute the Bodega Ocean Observing Line is a partnership between the UC Davis Bodega Marine Lab (see UC Davis above), the Sonoma County Water Agency (SCWA) and MBARI. There is a $100K cost share from SCWA on this sub-award. The Bodega Line represents an opportunity for a coordinated effort to collect, analyze, and disseminate oceanographic information, critical to fisheries and ecosystem management, MPA monitoring, and in understanding the potential ecological risks associated with hydrokinetic energy development in the region. The sampling along the Bodega line is intended to complement the Newport, OR line which has been operating for twelve years and has proven invaluable for charting and understanding ecosystem changes off Oregon. As described above (UC Davis) a combination of ship and AUV-based sensors conduct the sampling. Many partners are served including fisheries, offshore energy, National Marine Sanctuaries, and Marine Protected Areas. The Farallon Institute will also handle the bird and marine mammal observing requirements of the observing line. Changes in seabird and mammal breeding success, diet and foraging

behavior, and abundance have all been shown to be sensitive indicators of ecosystem and food web change, with some responses related to climate change. [$645K]

Science Applications International Corporation (SAIC) (Le, Ramsayer): Under the previous three-year CeNCOOS grant, SAIC took the lead in developing the CeNCOOS Data Management and Communications (DMAC) system. The basic system architecture and web services were established according to national IOOS standards, some of the available data were populated, and a GUI-based web portal to access the data was implemented. (Please refer to http://204.115.180.244/CeNCOOS/DataPortal.html). Under Phase II (this grant) SAIC will be transitioning the CeNCOOS DMAC to a fully operational system. The plan for transitioning the current CeNCOOS environment to operational readiness requires:

- Adding additional CeNCOOS data sets such as surface current maps, glider data, PISCO data, etc.
- A long-term hosting solution with continuous 24x7 data operations and services
- Data storage and archive
- Automated data QA/QC
- Comprehensive data services of current and historical data including oceanographic physical, chemical, geological, and biological data
- Improved data base access by developing applications for via mobile devices, tablets, and future technologies

Mr. Steven Le also acts as the CeNCOOS representative to the National IOOS DMAC technical committee, the Alliance for Earth Observations, and other groups. [$1190K]

Naval Research Laboratory (NRL, Doyle, Shulman): Doyle, NRL Monterey, will continue running 3-km Coupled Ocean Atmosphere Mesoscale Prediction System (COAMPS®) atmospheric model in near real time for the CeNCOOS region, and expand the system to state-wide. This model is used to force all the ocean circulation models used by CeNCOOS. He will also work with NRL Stennis to implement a fully coupled air/sea version of the model. NRL Monterey maintains the COAMPS wind products web site on the CeNCOOS home page. Shulman (NRL Stennis) will re-start and run the 3.5 km version of the Navy Coastal Ocean Model (NCOM) California Current System (CCS) super-regional ocean circulation model, which spans the entire coast from 30° to 52°N. This model is already in high demand by SCCOOS, CeNCOOS, and NANOOS, and includes an ecosystem module. A direct pass-through from NOAA to NRL is requested for these funds [$875K].

Roles of each partner (sub-award), level funded for 2011 (base capacity)

Level funded means business as usual, with a plan for 2011 that closely follows the plan for 2010. The only significant change will be to carve out $40K for an instrument pool which is desperately needed to replace old equipment that is now failing. The pier station operators collectively agreed to this plan.

Roles of each partner (sub-award), de-scoped to $2.6M for 2011

The work to be performed at the $2.6M level is the same as level funding plus:
$200K to each HF radar operator to harden the network
$100K to Farallons Institute to start the Bodega line ($100K SCWA match)
$190K to MBARI, hardware and expendables to add a second glider line
$100K to NRL Stennis for the coast-wide NCOM CCS super-regional model
$55K to the HAB monitoring, prediction, and mitigation team

Collaboration with other federal entities

Our funded federal partners (under this grant) include the Naval Research Laboratory (NRL Monterey), for high-resolution atmospheric modeling; NRL Stennis, for ocean modeling, and the Naval Postgraduate School (NPS Monterey), for maintenance of the central coast node of the surface current mapping (SCM) network. NOAA has established a direct-pass to NRL Monterey so that those funds do not need to be included in this award to MBARI. This can likely be done for NRL-Stennis as well, possibly through the same financial vehicle. MBARI has established an agreement with NPS that allows them to have an MBARI sub-award similar to everyone else. Our non-funded federal partners include the National Marine Sanctuaries, (Monterey Bay, the Gulf of the Farallones, and Cordell Bank); the NOAA National Weather Service (in particular the Monterey and Eureka offices); and the NOAA National Marine Fisheries service, especially the Southwest Fisheries Science Center (SWFSC Santa Cruz), and the NOAA Environmental Research Division (ERD Pacific Grove, CA). The ERD has been a strong CeNCOOS partner since inception, sometimes funded, and has made a major contribution to the foundations of the CeNCOOS DMAC. The SWFC serves as a primary point of contact for the salmon recovery program. We collaborate with the sanctuaries primarily in the areas of education and outreach, but continually strive to collect observations which are relevant to sanctuary and other MPA goals.

Education and Outreach

Education and Outreach (E&O) is a priority for all CeNCOOS staff, Council and Committee members. For the past five years, CeNCOOS has engaged across numerous disciplines and audiences to increase ocean awareness, ocean literacy, and inform stakeholders of the value of ocean observing through well-designed, user-friendly products. Whether focusing on K-12 classroom activities (please see http://www.cencoos.org/sections/classroom/index.html), building displays for local venues, creating reports/flyers for policy makers, or training experts in using surface current information for search and rescue, CeNCOOS strives to make science available, digestible and useful. In the next five years, CeNCOOS E&O-related activities will be expanded to improve stakeholder engagement, partnership diversity, communication tools and strategies, and the feedback and evaluation process. Additionally, networking opportunities will be expanded by hosting user-focused workshops and by sharing information more frequently at partner-funded workshops, teacher training events, and through regional citizen science efforts.

Locally, CeNCOOS plans to increase exhibits and products at informal learning centers and online, work directly with teachers to provide real-time data in formal

classroom settings, and host training webinars to professional users. Regionally, CeNCOOS will continue to collaborate with NANOOS, SCCOOS and the West Coast Governor's Agreement (WCGA) on pan-coastal projects including conference exhibits, presentations and workshops. In California, CeNCOOS and SCCOOS are already poised to host local workshops and to work with two Sea Grant trainees to share knowledge of the state-wide Cal-HABMAP initiative. Nationally, CeNCOOS will remain an active member on the NFRA E&O Committee and continue to collaborate on projects and proposals with the programs listed below.

CeNCOOS proposes the following at the three potential funding levels:

Base Capacity: ▪ Utilize the JSAC and establish an E&O Committee. ▪ Continue to provide CeNCOOS presence on groups and at meetings such as: Sanctuary Research Advisory Panel, Harbor Safety Committee, Coastal Ocean Regional Roundtable, CA Ocean Protection Council, HABMAP, WCGA, Area Committee Meetings, Beach Water Quality Monitoring Groups, Bay Area Ecosystem Climate Change Consortium, etc. ▪ The Coordinator will work to be on as many partner-hosted workshop and conference agendas as possible and will leverage partnerships to maintain existing E&O efforts. ▪ Maintain active participation on the NFRA E&O Committee and work to establish a nation-wide evaluation metric of educational products and programs. ▪ Work with informal centers to leverage funds to build kiosks and interactive tools. ▪ Utilize summer interns to expand the 'Classroom' webpage.▪ Collaborate with COSEE NOW to expand social media networking, similar to the successful podcast recently created. ▪ Exchange information and technology as well as build relationships with programs such as NOAA Office of Education, National Climate Service, Sea Grant and NERR, and with nation-wide non-profits with strong educational systems, such as Oceana, Surfrider Foundation, The Ocean Conservancy, and The Center for Ocean Solutions. ▪ Work with staff, Council and Committee members on best practices for communicating ocean science and encourage participation in panels and conferences. ▪ Continue to provide one-page success stories/flyers to the policy arena, the public and in collaboration with requests from NOAA IOOS office. ▪ Keep the website up to date with current events and information.

Expanded Capacity: ▪ Base capacity plus: ▪ Travel to a 2-day NFRA E&O Workshop.▪ Coastal Community Meetings/ Road Show: set up town hall-type meetings throughout the entire CeNCOOS region to share information and introduce data exploration opportunities. ▪ Host one user-focused education workshop OR teacher training program.

Fully Funded: ▪ Expanded capacity plus: ▪ Provide funds for equipment, kiosks, product development, educational consulting and software to improve visualization and exploration of data supporting the interpretation of ocean and coastal weather and climate sciences for public audiences, professionals and learning centers. ▪ CeNCOOS has verbal collaboration agreements to create kiosks and interactive tools focused on climate change, specifically ocean acidification and sea level rise in the following venues: Seymour Marine Discovery Center, Exploratorium, Point Reyes Visitor Center, Humboldt Bay Harbor, Gulf of the Farallones Visitor Center, and the SF Bay Model Visitor Center. Ideally, one product would be build that could be placed at each venue

with minor changes based on audience levels and learning environment. ▪ Partner with the Monterey Bay Aquarium, MATE, CAMEOS, and local school programs and citizen science networks to introduce kids to ocean sciences. ▪ Host local workshops for users such as Marine Operators and Emergency Responders via in-person training and webinars. ▪ Co-host training programs for teachers (MBARI EARTH), the public and professionals (NOAA NERR's Coastal Training Program and NOAA Sea Grant), and coastal managers (The Center for Ocean Solutions Climate Change Workshops).

Cost Proposal

The proposal costs for each institution and fiscal year are summarized in the accompanying table. The amounts for each institution are included in the work plan. For the lead organization and top-level SF424 (MBARI), the costs break down as follows:

Personnel ($1,578,628) – For Ramp, Kerkering, Bahr, Wadsworth, Chavez, Wahl, and Rienecker for tasks and time as described above in the work plan.

Fringe Benefits ($770,215) – Computed as 53% & 10% of labor costs given above.

Travel ($75,000) – Each year: IOOS and NFRA National Meetings (6 @ $1600), National Scientific Meetings (3 @ $1600), NFRA Education Committee (1 @ $1600), Product Developer's Workshop (1 @ $1600), CA Ocean Protection Council (4 @ $350), Day Trips to local groups for coordination, outreach (20 @ $150), CeNCOOS Governing Council Meetings ($1500), CeNCOOS/SCCOOS JSAC Meetings ($1500).

Equipment over $5K
At MBARI ($154,000) – Spare parts for failing automated shore stations up to an including complete stations from YSI @ $15,000 each. Datawell Waverider wave buoy (and spare) to calibrate CDIP model in the CeNCOOS region.
Sub-award to SFSU ($100K per year 2012-2015) – Spare parts for the 25 CeNCOOS HF radar shore stations. Many of these are over 10 years old. Includes send and receive antennas, electronics, cables, weather resistant housings, communications, etc.
Sub-award to UCSD/SIO ($1051K) – Two SPRAY gliders @ $75K each in year one and one glider per year @ $75 plus inflation in years 2-5. Price is a special partnership between SIO and MBARI. Also includes batteries and expendables to maintain gliders.
Sub-award to Stanford ($20K) – Expanded computer cluster to conduct CeNCOOS model runs. Five eight-core AMD rackmount servers @ $4K each.

Contractual ($14,749,681) – Nine sub-awards to the partners listed in the work plan who will execute the observing system. Note all the funding for the 5 California State University campuses is being routed through Sonoma State University (SSU).

Indirect Costs ($1,500,850) - The institutional IDC rate is 51% MTDC. The base excludes capital items, participant support costs, and subcontract costs exceeding the first 25K of each subcontract.
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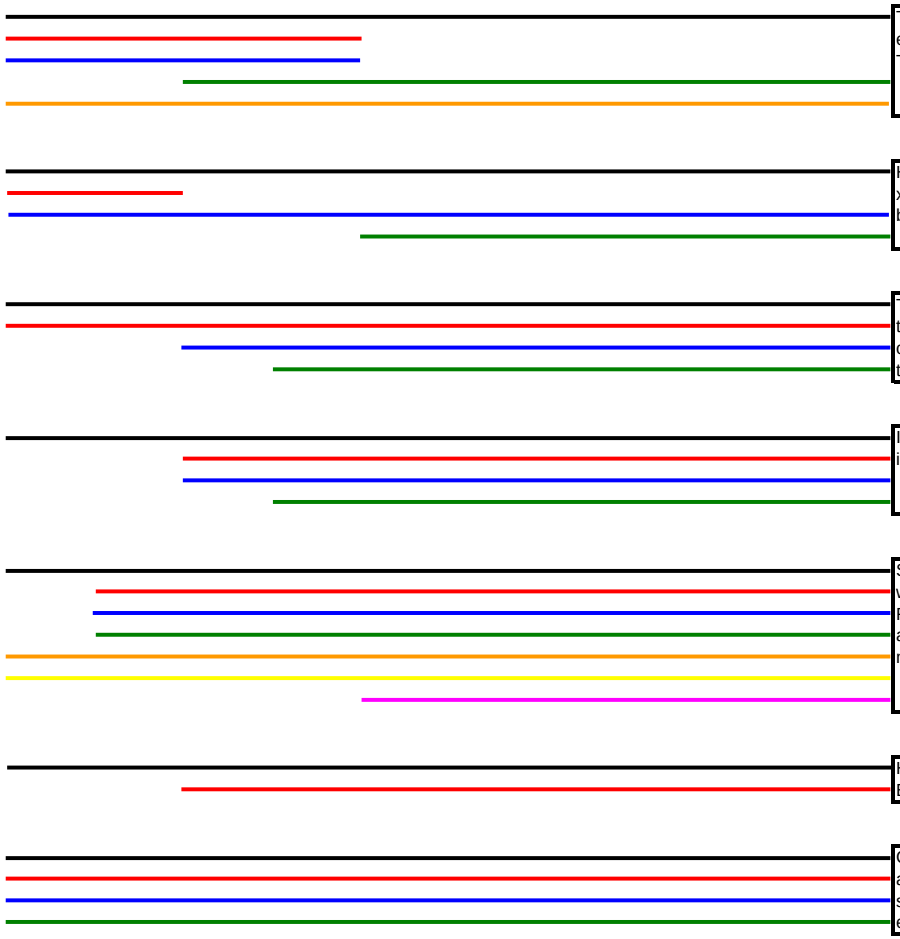
CeNCOOS Milestone Chart 2011-2016

Task	Year 1	Year 2	Year 3	Year 4	Year 5	Delivery	Products
AUTOMATED SHORE STATIONS							
Continue existing operations						Time series of T, S, Chl, DO every 6 minutes. Add pH, pCO2, TDC, NO3, optical properties	Climate trends for temperature, ocean acidification; HAB documentation and forecasts
Replace obsolete stations							
Add New Sensors, O2, N, OA							
Create HAB stations							
Continue building user products							
SURFACE CURRENT MAPPING							
Continue existing observations						Hourly surface current maps in 1 x 5 km cells Higher resolution in bays and estuaries.	Currents in USCG and OR&R format, currents on SST and ocean color. MPA connectivity maps, many others.
Improve comms, reliability							
Improve products							
Fill gaps, add new stations							
GLIDER TRANSECTS							
Continue Monterey Line						T, S, Chl, DO, NO3, OA at transects 1000 m x 200 km offshore at key locations along the coast.	Identify ENSO anomalies, indices for strength, trends for DO and OA variables, climate change, model assimilation
Acquire new hardware							
Begin Bodega line							
Begin Morro Bay line							
DATA MANAGEMENT & COMMS							
Continue populating portal						IOOS compliant RA-wide DMAC in netCDF, openDAP format.	CeNCOOS Data Portal, smartphone applications, cross-regional data access.
Improve portal GUI							
Develop portable access/apps							
Implement cross-regional DMAC							
NUMERICAL MODELING							
Continue existing domains						State-wide 3-km atmospheric winds and heat fluxes, 3-km ROMS currents, T, S, etc. larval advection, new ecosystem models	MPA connectivity maps, drop-in drifter tool for spill response, search and rescue, HAB mapping, current predictions, water property predictions.
Expand COAMPS to state wide							
Expand ROMS to state wide							
Add NCOM CCC coast wide							
Improve data assimilation							
Study larval connectivity							
Begin ecosystem level modeling							
BOTTOM MAPPING							
Repeat bottom & coastal surveys						High-resolution Bottom Bathymetry	Maps showing bottom changes in canyons and MPAs
Make products for end users							
FRONT OFFICE							
Program Administration						Grant and sub-award administration, RA certification, state and national coordination, event response, outreach	Dynamic web site, maintain existing products, expand, design new products, new classroom material.
Maintain web site							
Produce products on demand							
Education and Outreach							



CeNCOOS Planning Letters - $4M Budget
Last Updated Sept. 29, 2010

Lead Institution	Lead PI	Task	Focus Area	Amount 2011	Amount 2012	Amount 2013	Amount 2014	Amount 2015	5-Yr Total
CeNCOOS	Ramp, Steve	CeNCOOS Office Administration	ALL	$600	$600	$600	$600	$600	$3,000
CeNCOOS	Kerkering, Heather	Education and Outreach	E&O	$50	$50	$50	$50	$50	$250
CeNCOOS	Kerkering, Heather	Roving buoy for model validation	CH	$57	$57	$0	$0	$0	$114
CeNCOOS	Ramp, Steve	Shore Station Equipment Pool	WQ	$40	$0	$0	$0	$0	$40
Cal Poly	Moline, Mark	CeNCOOS Monitoring and Products	WQ	$130	$130	$130	$130	$130	$650
CSUMB	Kvitek, Rikk	Seafloor change, erosion	CH	$75	$75	$75	$75	$75	$375
Farallons Ins.	Sydeman, Bill	Bodega Line Ocean Observing	CE	$100	$100	$100	$100	$100	$500
Farallons Ins.	Sydeman, Bill	Seabirds as ind. of ecosystem change	CE	$29	$29	$29	$29	$29	$145
JPL/UCLA	Chao, Yi	Web-based drifter tool	MO, WQ	$25	$25	$25	$25	$25	$125
JPL/UCLA	Chao, Yi	ROMS, ecosystem, nests	ALL	$100	$100	$100	$100	$100	$500
Humboldt State	Shaughnessy, Frank	Nearshore Chl index and forecast	WQ	$124	$118	$125	$125	$129	$621
Humboldt State	Shaughnessy, Frank	New Shore Station Somewhere	WQ	$30	$5	$5	$5	$5	$50
MBARI	Chavez, Francisco	Glider Technician	CE	$80	$83	$87	$90	$94	$434
SIO	Rudnick, Dan	Glider hardware and expendables	CE	$265	$192	$193	$200	$201	$1,051
MBARI	Chavez, Francisco	IOOS/NDBC Mooring Demonstration	CE, WQ	$75	$75	$65	$65	$65	$345
MLML	McPhee-Shaw, E.	Monitoring and modeling at MLML	WQ	$225	$225	$225	$225	$225	$1,125
MLML	Nevins, Hannarose	HAB impacts on birds and mammals	WQ	$30	$30	$30	$30	$30	$150
NPS	Paduan, J.	Operation of MBY HF radar	MO, WQ	$160	$165	$170	$175	$180	$850
NRL Monterey	Doyle, James	Atm. and Ocean Forecasts	MO, WQ, CH	$75	$75	$75	$75	$75	$375
NRL Stennis	Shulman, Igor	Real-time modeling for CeNCOOS	ALL	$100	$100	$100	$100	$100	$500
SAIC	Le, Stephen	CeNCOOS DMAC, Products, etc.	DMAC	$250	$245	$240	$235	$220	$1,190
SFSU	Garfield, Toby	SF Bay water quality monitoring	MO, WQ	$70	$70	$70	$70	$70	$350
SFSU	Garfield, Toby	Operation of SF Bay HF radar	MO, WQ	$200	$200	$200	$200	$200	$1,000
SFSU	Garfield, Toby	Community HF Hardware Pool	MO		$100	$100	$100	$100	$400
Sonoma State	Nielsen, Karina	Chl-a and shore stations	WQ	$115	$115	$115	$115	$115	$575
Stanford	Fringer, Oliver	ROMS-SUNTANS SF Bay Modeling	MO, WQ, CE	$75	$75	$75	$75	$75	$375
Stanford	Block, Barbara	TOPP Biologging Node	CE	$75	$75	$75	$75	$75	$375
UC Davis	Largier, John	Monitoring FRBA RSI	MO, WQ	$270	$270	$270	$270	$270	$1,350
UC Santa Cruz	Edwards, Chris	Low level trophic ecosystem modeling	CE	$100	$100	$100	$100	$100	$500
UC Santa Cruz	Edwards, Chris	Retention and Dispersion Statistics…	CE	$50	$50	$50	$50	$50	$250
UC Santa Cruz	Kudela, Raphe	Expansion of Cal-HABMAP	WQ	$195	$195	$195	$195	$195	$975
UC Santa Cruz	Kudela, Raphe	SC Wharf and related activities	WQ	$125	$125	$125	$125	$125	$625
UC Santa Cruz	Moore, Andy	4D Var modeling	CE	$100	$100	$100	$100	$100	$500
UC Santa Cruz	Carr, Mark	Ocean Acidification Mooring	WQ, CE	$0	$0	$87	$87	$87	$261
Total Requested				**$3,995**	**$3,954**	**$3,986**	**$3,996**	**$3,995**	**$19,926**

Focus Area Key: CE = Climate and Ecosystems; WQ = Water Quality; MO = Marine Operations; CH = Coastal Hazards