U.S. Integrated Ocean Observing System (IOOS) Implementation
Southern California Coastal Ocean Observing System (SCCOOS)
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1) PROJECT SUMMARY

The Southern California Coastal Ocean Observing System (SCCOOS) is one of eleven regions that contribute to the national U.S. Integrated Ocean Observing System (IOOS®). The regional observing systems work to collect, integrate, and deliver coastal and ocean observations in order to improve safety, enhance the economy, and protect the environment. The principal goal of the Southern California Coastal Ocean Observing System (SCCOOS) is to provide observations and products to a diverse stakeholder community of managers and planners, operational decision makers, scientists, and the general public. As the regional observing system for Southern California, SCCOOS, has developed the capabilities to support short-term decision-making and long-term assessment by implementing and leveraging biological, chemical and physical observations and models, many of which are available in near real-time. SCCOOS priorities and objectives are aligned with the seven societal goals as outlined in the IOOS Summit Report[i]. The focus themes, as designated by IOOS, highlight these priorities and are designed to improve safety, enhance the economy, and protect our environment.

- **Ecosystems and Climate:** to monitor ocean climate trends and environmental changes in the Southern California Bight by collecting physical, chemical and biological variables.

- **Water Quality:** to provide monitoring, tracking, and prediction tools for harmful algal blooms, outfall and storm water plumes and surf zone contaminants.

- **Marine Operations:** to advance integrated, customized products that are critical for safe and efficient navigation, search and rescue and oil spill response.

- **Coastal Hazards:** to provide accurate, validated inundation models and information with the long-term goal of improving coastal safety.

- **Science Education and Communication:** to provide a way for the public to learn, educate and promote scientific research using data obtained from SCCOOS.

2) PROGRESS AND ACCOMPLISHMENTS

SCCOOS continues to have the ability to achieve its milestones by providing access to high-quality integrated data and support regional user needs while complying with the standards and protocols for sharing and archiving data that are developed nationally. SCCOOS actively participates in IOOS Data Management efforts such as the Thematic Real-Time Environmental Distributed Data Services (THREDDS). By leveraging the Coastal Data Information Program (CDIP) and the HF Radar National Network programs, SCCOOS targets THREDDS distribution for wave, surface currents and most recently, shore station data. SCCOOS also continues to implement QARTOD data quality control standards. Wave and surface current data have associated XML and FDGC compliant metadata.

The following goals/milestones have been met.

Ecosystems and Climate:
- Underwater glider surveys collect offshore measurements of temperature, salinity, chlorophyll, and current velocity.
- As part of CalCOFI-LTER program, SCCOOS displays parameters that are measured in the nearshore region of Southern California including temperature, salinity, zooplankton, phytoplankton, fish eggs and invertebrate larvae.
- Meteorological station data are displayed on the SCCOOS website to provide wind speed and direction, air temperature, sea surface temperature, barometric pressure, humidity and rainfall levels for public consumption.

Water Quality:
- Monitor and distribute data regarding Harmful Algal Blooms (HABs) at six pier stations by collecting weekly measurements of temperature, salinity, chlorophyll, nutrients and toxic species.
- Continue automated sampling at four shore stations to measure temperature, salinity, chlorophyll, turbidity and water level.
- Display the 3-km California statewide Regional Ocean Modeling System (ROMS) for real-time operations and conduct a systematic validation of the model. 3-km California state-wide ROMS model with data assimilation and real-time forecasting capabilities have been running continuously. This state-wide ROMS model is assimilating both the HF radar surface current data and the vertical profiles of temperature and salinity from four Spray gliders as well as other available observational data sets including satellite sea surface temperature and vertical profiles of temperature and salinity from moorings, ships and floats. On the daily basis, we are making on the order of 20 ensemble model forecast in order to quantify errors. Six hourly nowcasts and 72-hour forecast files are available via OpenDAP/THREDDS.
- Analyze pollution dispersal in finescale, nearshore, and shelf ROMS for the San Pedro and Santa Monica Bays.
- Provide HF radar-based trajectory tracking tool for Tijuana River Plume.

Marine Operations:
- The live feed of HF radar data are now available on the national HFR network for oil and hazardous spill response in the Environmental Response Management Application® (ERMA) map viewer for the southwest region. Near real-time and archived surface current measurements have been used in the National Preparedness for Response Exercise Program (NPREP) drill scenarios led by the U.S. Coast Guard in San Diego, Los Angeles and Ventura.
- Customized and expanded interactive map displays of wave and surface currents with multi-layered views of observations, nowcasts, and forecasts were developed for Naval Air Systems Command (NAVAIR), at Point Mugu.
- The customized, interactive map display of ocean conditions and forecasts for the Port of Los Angeles and Long Beach Harbor is used to improve navigation, safety and efficiency for commercial vessels, harbor pilots and port operations.
- Surface current measurements and surface wind analyses are integrated into the General NOAA Operational Modeling Environment (GNOME) for oil spill trajectory analysis.

Coastal Hazards:
- Develop Shoreline inundation forecast, validation, and dissemination of warnings.
- Display inundation development and integration information online.
- Expand development and integration of inundation web site.

Science Education and Communication
- SCCOOS ocean data inform classroom curriculum and informal education programs.
- SCCOOS regularly participates in tours, workshops, and meetings within Southern California in order to further collaboration and provide data and information when requested.
- SCCOOS updated the statewide 'flooding index' forecast plots in accordance with the CDIP current research on wave run-up. The new plots are not based only on the tide and wave height, but also take the wave period into account. The resulting water level predictions are generally lower than those from the old model, but they should be significantly more representative of the actual water levels observed at the coast. The Cardiff CDIP water level page has been updated to include mild and moderate flood thresholds. Additionally, plots of Southern California beach widths are being regularly updated.
- On July 9, the Senate Ocean Caucus alongside the U.S. IOOS Association, sponsored an informational briefing in the Russell Senate Office Building. Captain Kip Louttit (Executive Director for the Marine Exchange of Southern California/SCCOOS Board of Governors member) and Dr. Michael Macrander (Shell Arctic Program) all spoke about the value of sustaining ocean observations and the practical application of those observations in their daily operations. Kip provided an overview of the Under Keel Clearance (UKC) project for the Ports of Long Beach and Los Angeles. Capt. Louttit explained decisions to hold tankers off-shore when wave swell conditions place ships at a heightened risk of grounding. Previously, there was little capability to accurately forecast these events in advance. He informed the audience of the Under Keel Clearance (UKC) project, and how the regional IOOS contribution to this project will enable a forecast of dangerous wave conditions in advance of an event that may ground tankers. The UKC project increases the safety, efficiency, and reduce emissions of tankers entering the Ports. The caucus was moderated by Molly McCammon, Executive Director of the Alaska Ocean Observing System with over 90 people in attendance—including the SCCOOS Executive Director, Julie Thomas.
- In June 2015 the book titled, Coastal Ocean Observing Systems was released in response to a 2014 Ocean Sciences meeting session #009 called, Scientific and Societal Benefits for Integrated Coastal Ocean Observations and Networked Marine Laboratories". The lead authors for Chapter 10 called, "How High-Resolution Wave observations and HF Radar-Derived Surface Currents are Critical to Decision-Making for Maritime Operations" are Julie Thomas (SCCOOS Executive Director) and Lisa Hazard (Operations

Manager, Coastal Observing Research and Development Center—CORDC/SCCOOS Ex-Officio Advisor). The book emphasizes a healthy relationship with the ocean requires that we understand it and one way is through Ocean Observing.

U.S. IOOS regional awards that are ongoing.

Ecosystems and Climate

- Operating and maintaining long-term time series of physical, biological, and chemical ocean data are critical in monitoring climate trends and determining ecosystem health.
- Conduct shipboard observations three times yearly to count seabirds and marine mammals in conjunction with CalCOFI-LTER surveys. Data, products and modeling page display results on the SCCOOS website.
- Physical and ecological ocean patterns and processes constitute valuable information for Coastal and Marine Spatial Planning and marine protected areas monitoring. Under the auspices of SCCOOS, the California Current Ecosystem Long Term Ecological Research (CCE_LTER) program, and in conjunction with the California Cooperative Ocean Fisheries Investigation (CalCOFI), the distribution and abundance of seabirds during 3 seasonal surveys were studied. Survey reports and maps of species' distribution and abundance are published on SCCOOS website.
- Dissolved oxygen sensors are in the research and development phase to aid gliders in monitoring hypoxia and ocean acidification. The integration of dissolved oxygen sensors on the gliders is proceeding for the purpose of monitoring hypoxia in coastal waters. The dissolved oxygen data also allow an estimate of parameters relevant to ocean acidification through proxy relationships. Using relationships developed by scientists at Scripps Institution of Oceanography, NOAA Pacific Marine Environmental Laboratory, Universidad Autonoma de Baja California and University of Washington, the glider data have been used to estimate pH and aragonite saturation. Aragonite is important to organisms that form shells, as saturation levels below one may lead to dissolution of the shells.
- Conduct automated sampling at four shore stations of temperature, salinity, chlorophyll, turbidity and water level.
- SCCOOS works closely with staff from the California Ocean Science Trust's Marine Protected Area Monitoring Enterprise on the development and successful execution of a monitoring program for Southern California's newly established network of marine protected areas.
- Maintain and validate the pCO_2-DIC system (Burkolator). Train a representative at the Carlsbad Aquafarm to operate and maintain the prototype instrument. Begin development of data management and communication for data collection, quality control, quality assurance, and data archive. Initiate the IOOS marine sensor program with the long-term goal of creating a sustainable and coordinated U.S. West Coast wide ocean acidification effort.

Water Quality

- Provide accurate forecasts, measurements and reports of water quality, for coastal pollutants and harmful algal blooms, inform beach closures and warnings which can affect tourism revenue and the local economy.
- Tracking impacted or polluted sources such as rivers and sewage outfalls can influence public health and ecosystem health (For example, areas of special biological significance and marine protected areas).
- A systematic effort has been carried out to validate the 3-km state-wide ROMS model. A manuscript describing this validation effort is in progress and expected to be submitted early 2016. Three validation products have been developed and are being tested on the PI's web site. On the daily basis, there are on the order of 100,000 satellite SST data that are assimilated into ROMS. The RMS difference between the ROMS nowcast and the original satellite SST data is slightly less than 1°C, comparable to the 0.5°C-1°C errors specified for the satellite retrieved SST data.
- Analyze pollution dispersal in finescale, nearshore, and shelf ROMS for the San Pedro and Santa Monica bays.

- The SCCOOS HAB program contributes to the statewide HAB Monitoring and Alert Program (HABMAP) initiated by NOAA, the California Ocean Science Trust, and the Southern California Coastal Water Research Project (SCCWRP). The HAB program generates a baseline time-series of ocean properties to monitor ocean conditions in the very near shore zone of the Southern California Bight. These measurements are used to develop forecast models for short term warnings. They also increase our knowledge of the sign, frequency and magnitude of variation of temperature, salinity, density, nutrients and pollutants.
- Weekly reports are derived from a year long time series of sampling for HAB species and related water quality measurements and are provided to the California HAB Monitoring and Alert Program Group.
- In conjunction with autonomous glider and boat sampling *Pseudo-nitzscha* blooms that produce domoic acid are being monitored. The Caron lab at the University of Southern California (USC), is responsible for the analysis of domoic acid from the 5 SCCOOS HAB monitoring sites.
- Expand HABs website to include Central and Northern California.
- Fine-scale simulations with ROMS are being analyzed at UC, Los Angeles to examine two phenomena. First, pollution effluent dispersal from the Orange County and Hyperion discharge outfalls we examined. This includes alternative near shore outfalls planned in the coming years. The second examined area was a storm river plume dispersal near Santa Barbara. In both situations the material stays mainly on the continental shelf and slope, and the near shore outfall materials stay very near the coast.
- The County of San Diego's Department of Environmental Health uses the SCCOOS Tijuana River Plume Tracker to inform water quality warnings and beach closures.

Marine Operations
- Operate and maintain the network of short, medium and long range HF radar systems and deliver data streams to the National HFR Network.
- Ocean conditions, surface currents measurements and surface wind analyses can be used to aid in spill response as well as generate trajectories to inform search and rescue (SAR) operations.
- Customized, interactive map displays of ocean conditions with multilayer views of observations, nowcasts and forecasts can improve navigation and safety for military regions and testing ranges.
- Ocean observing data can be used to inform and validate ocean models used by the military and federal agencies.
- Customized, interactive map displays of ocean conditions can improve navigation, safety and efficiency for commercial vessels, harbor pilots and port operations.
- Implementation of surface currents measured by the SCCOOS HF radar network are now accessible by U.S. Coast Guard for search and rescue (SAR) applications using their Environmental Data Server.
- Glider data are provided to the Naval Oceanographic Office (NAVO) for assimilation into operational models.
- Annually provide training to first responders of maritime incidences in the use of SCCOOS products.
- Currently an HF radar quality assurance/quality control(QAQC) Development Project is underway with the goals to:
    1. Provide real-time baseline comparisons of radial HF radar velocities;
    2. Provide other real-time comparisons of radial HF radar velocities;
    3. Provide real-time validation of elliptical HF radar velocities.

All three aspects are in progress. Software developed for 1) is operational in beta mode for UC, Santa Barbara, and USC sites. Software for 2) has also been developed and is operational, with preliminary visualizations for University of California System, USC and California Polytechnic State University - San Luis Obispo sites. Work is currently focused on improving the efficiency of the computations, managing data and improving visualizations. A donation of server hardware was obtained and used upgrade the server that is running computations, increasing its memory capacity and expanding its single hard drive to a 1Tb RAID array. Regarding 3), we've been in contact with Codar Ocean Sensors about obtaining software for producing elliptical data on HF radar site computers, and about obtaining any real-time

elliptical data for use in development. Finally, we've been developing an international collaboration with researchers from Tianjin University, who sent a student to visit for 5 weeks. This group is using data from Chinese built HF radars and are interested in our validation techniques.

Coastal Hazards
- Expand development and integration of inundation web site.
- Use surveys of sand levels on beaches and monitor storm inundations at selected locations to validate and refine coastal data and forecast models of erosion, flooding, and inundation levels can be used to protect and improve beaches, real estate, and highways.
- Validate and refine inundation models based on surveys of beach sand and water levels.

Science Education and Communication
- SCCOOS has started a citizen science project and webpage called storm photo to get the help of the general public to document flooding events from Imperial Beach in San Diego County to Point Conception via emailed cell phone pictures.
- SCCOOS collaborates with Scripps Institution of Oceanography Center for Marine Biodiversity and Conservation (CMBC) on their graduate student projects. CMBC promotes interdisciplinary research and educational approaches to maintain the integrity of ocean ecosystems and manage their use in the face of rapid and inevitable global change.

3) SCOPE OF WORK
SCCOOS operates as a system of partnerships and projects that are facilitated by technical and programmatic staff. Organized by the four focus areas, the SCCOOS scientific and technical approach is based on a system of core ocean observing technologies and the delivery of useful data products and tools. System components include sub-surface ocean observations from underwater gliders, nearshore and coastal measurements, wave measurements and models, pier-based monitoring, satellite imagery, high frequency (HF) radar surface current mapping and data assimilative ocean modeling. The projects described in this report represent the multi-disciplinary and collaborative efforts of the research teams that contribute data and information to SCCOOS.

4) PERSONNEL AND ORGANIZATION STRUCTURE
- Tony Koslow replaced Eric Terrill on the IOOS Federal Advisory Committee.
- SCCOOS added 7 new Board of Governors members;
    1. Bruce Cornuelle – Scripps Institution of Oceanography
    2. Mas Dojiri – City of Los Angeles
    3. Michael Jones – The Maritime Alliance
    4. Kip Louttit – Marine Exchange of Southern California
    5. Anne Sturm – U.S. Army Corps of Engineers
    6. Cisco Werner – NOAA Southwest Fisheries Science Center.

5) BUDGET ANALYSIS
In FY 2015, SCCOOS received an increase of funds of $58,456 from FY14. The SCCOOS Executive Steering Committee (ESC) has designated additional funds to manage SCCOOS Data Feeds and Outside Data Integration, Data Delivery, Online products, IOOS DMAC and the SCCOOS website. The remainder of SCCOOS projects received level funding from FY14.

FY15 funding will provide a valuable investment in important assets and will strengthen regional partnerships and national program planning. SCCOOS will continue providing its core observations and expand data products when possible within budget constraints. SCCOOS is also committed to contributing to larger ocean observing efforts regionally, nationally, and internationally.

Expenditures are progressing as expected, with no major discrepancies between actuals and budgeted on both the main award and the subawards.

6) ANNUAL SUPPLEMENTALS
Products and Services
- SCCOOS created an [integrated webpage](#) in support of the response for the oil spill that began on May 19, 2015 and deposited 142,800 US gallons of crude oil near Refugio State Beach in Santa Barbara County. Also, there were three SCCOOS technologies that supported the response in those critical initial hours.

    1. **HF Radar**: derived surface currents were sent to NOAA Office of Response and Restoration (ORR) and CA State Office of Spill Prevention and Response (OSPR). SCCOOS HF radar visualizations were used by local News Channel 3 in Santa Barbara during the weathercast in order to show circulation patterns in the area. A temporary HF Radar site was quickly installed by UC, Santa Barbara to fill in coverage north of the spill and ran a local trajectory model adverting simulated particles through the current field to visualize the potential path of the slick. The data was easily ingested because of the work IOOS has done to establish HF Radar as a national network.

    2. **Gliders**: There are 5 Spray underwater gliders off the coast of California at all times sending back data on temperature, salinity and ocean currents. These missions are funded through IOOS and NOAA's Climate Program Office/Climate Observation Division. These data were used to feed the models that predict currents to help responders know where the oil will go. This demonstrates the importance of having a persistent observing asset that can immediately be used in an emergency.

    3. **ROMS Model**: Like weather forecast, oceanographic data collected by HF radar, gliders, other in-water platforms and satellites are assimilated into a 3D ocean model to provide oceanographic information (e.g. ocean current to estimate oil spill trajectories) not only at those data collection locations but, also in data gap areas. Three day forecasts of ocean conditions are provided by the California ROMS, developed under IOOS and supported by SCCOOS and CeNCOOS help NOAA and the U.S. Coast Guard plan response strategies.

- On September 16, 2015 earthquake occurred off the north coast of Chile with a magnitude of 8.3 resulting in a clear tsunami signal arriving approximately 11:50 UTV on Sept. 17th. SCCOOS integrated data related to the Tsunami on a [webpage](#) along with information regarding mechanics of a tsunami for public consumption.
- The Hyperion Treatment Plant 5-Mile Outfall and associated Effluent Pumping Plant (EPP), were activated in 1960, and are critical components of the wastewater treatment system. The discharge from the Hyperion Treatment Plant is typically 300-350 million gallons per day, with a total estimated volume of discharge to approach 875 million gallons. During the planned 2015 Hyperion Diversion Project, SCCOOS data management team developed a [project page](#) to support the diversion. A web portal was developed to provide a centralized, interactive web presence for performers, decision makers, and the general public to access information and observations playing an integral role in the diversion monitoring program. Daily use of an online webpage that displays near real-time observations can help guide monitoring activities. The [web portal](#) included visualizations and links to background physical parameters such as wind, waves, currents, and temperature; daily summaries of monitoring efforts; and data products such as trajectories or models. Having access to these observations allows participants and program managers to make educated decisions regarding asset placement and go/no go field operations. The portal had a participant only area to upload and disseminate data allowing for scientific

collaborations. Integrated information management systems are critical tools to efficiently assess and manage observational programs and studies.
- The first NE Pacific Anomalies Science and Technology was held on May 5th and 6th a workshop was held at Scripps Institution of Oceanography that brought together the Pacific Ocean regional associations of IOOS, the IOOS program office, as well as federal, state, and regional (including Alaska, Canada, Washington, Oregon, California, Mexico, and Hawaii) subject matter experts and coastal managers to discuss prevailing atmospheric and oceanographic conditions that have been prevailing in the NE Pacific Ocean since October 2014. SCCOOS provided a [website](#) to house supporting documents, webcast, presentations and news related to the warm water anomaly.
- In support of El Niño education and outreach SCCOOS developed an a [website](#) that integrates, glider data, ENSO diagnostic discussion, Dan Rudnick's SoCal Niño index, flooding indices and videos. SCCOOS Principle Investigator, Dan Rudnick, has been leading the effort of tracking the El Niño to inform preparation efforts in Southern California. Dan and program staff at SCCOOS has been participating in El Niño bi-monthly conference calls with partners within NOAA to coordinate efforts and data collection.

Data Management
- SCCOOS has completed a standards-based foundation for DMAC capabilities by converting HF radar and shore station formats into NetCDF and THREDDS.
- SCCOOS has released ncSOS service for its automated and manual shore stations.
- SCCOOS has leveraged CDIP wave data that are decimated to the NDBC for ingestion into WMO GTS
- SCCOOS has developed a Data Management Plan describing the current status of SCCOOS data streams and future goals for data quality assurance, quality control, dissemination, distribution, and archiving. In addition to the Data Management Plan, SCCOOS has developed more detailed descriptions of various data streams and products in the form of Sensor Plans. Sensor Plans follow a NOAA Data Sharing Template. Sensor Plans have been developed for Gliders, Automated Shore Stations, CalCOFI Cruises, CDIP, HFR, HABs, Manual Shore Stations, Satellite Imagery, AIS and the Burkolator.
- Ongoing program-level participation in data management planning and coordination activities are;
  - Darren Wright and Julie Thomas attended the IOOS DMAC meeting in Washington D.C. May 26-29, 2015.
  - Sarah Heim & Darren Wright attended a THREDDS training workshop on behalf of SCCOOS July 20-24, 2015.
  - Darren Wright attended a Beach Water Quality Work Group on August 14, 2013.
- Julie Thomas and Darren Wright participate in ongoing program-level data management and Julie Thomas is on the committee for IOOS DM standards.
- Julie Thomas participates in the Joint Planning DMAC.
- Darren Wright collaborates regularly with Jenn Patterson from CeNCOOS on California Ocean observations and website development.

Observation Assets
- SCCOOS subject matter expert, Todd Martz, will operate a "Burkolater" pCO2 analyzer at Carlsbad Aquafarm, to track ocean acidification impacts on shellfish aquaculture. Lessons learned from these operations will be applied to future coastal measurements of ocean acidification. All Burkolater's can be found at: http://www.ipacoa.org/.
- A mooring offshore Del Mar, California that will contribute multi-disciplinary real-time high-frequency observations to SCCOOS at a location that already has a 9-year record and which shows large climate impacts on the ecosystem. The mooring makes substantial contributions to the ocean acidification monitoring and research on the West Coast, since it operates temperature, conductivity, oxygen, and pH sensors at different depths and telemeters (among other data) near-bottom (90m depth) OA conditions to shore. The mooring will continue to serve as a collaboration platform with NOAA National Marine Fisheries Service. This collaboration will help SIO, Southwest Fisheries Science Center, and SCCOOS to

explore, develop and demonstrate autonomous systems that can complement fisheries stock assessment surveys from ships. Such observations are further intended to establish relations between habitat conditions (temperature, oxygen, pH, etc.) and the presence, abundance and health of species. Multi-disciplinary time series such as those provided by the mooring are very useful for model development, testing and validation. The continuous records of temperature, density, currents, oxygen, chlorophyll and aragonite saturation are sensitive tests of model performance and will be made available to SCCOOS modelers. The Del Mar mooring also functions as a platform of opportunity for other researchers.

- A newly deployed CDIP San Pedro South Buoy and customized website, funded by the U.S. Integrated Ocean Observing System (IOOS), is used operationally by Jacobsen Pilots for validating oceanographic conditions to ensure the safe transport of vessel traffic transiting at the Port of Long Beach. This buoy is one component of a larger project to ascertain the Under Keel Clearance (UKC) of commercial vessels. In collaboration with federal, state and industry partnerships, the Dutch company PROTIDE will develop a model that provides the UKC information. With funding from the Oil Spill Prevention and Response (OSPR) for the initial assessment, The Marine Exchange of Southern California in San Pedro will serve as the management entity for this project. Wave data are extremely important during a high swell event. Vessels can pitch and roll, affecting their draft and potentially hitting the ocean bottom. Combined, the Port of Los Angeles and the Port of Long Beach are the busiest ports in the United States for vessel transport. Assuring the safety and operations of vessel traffic is a vital component to our nation. The IOOS funding for this buoy is in collaboration with the US Army Corps of Engineers and the California Department of Parks and Recreation.

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[i] IOOS Summit Report, 2012. http://www.iooc.us/wp-content/uploads/2013/01/U.S.-IOOS-Summit-Report.pdf