



**U.S. Integrated Ocean Observing System (IOOS) Implementation
Southern California Coastal Ocean Observing System (SCCOOS)**

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LONG-TERM GOALS

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 Report¹. The focus themes, as designated by IOOS, highlight these priorities and are designed to improve safety, enhance the economy, and protect our environment.

- **Coastal Hazards:** Improve coastal resiliency through accurate, geo-specific and validated flooding models and critical shoreline information with the long-term goal of improving coastal safety, reducing natural hazards and environmental change impacts, and protecting coastal economics.
- **Climate Variability and Change:** Improve the understanding and track secular ocean change including sea level rise (SLR), ocean temperatures, and other climate trends in the Southern California Bight.
- **Ecosystem, Fisheries and Water Quality:** Provide physical, geochemical and biological monitoring, including harmful algal blooms (HABs) forecasts, fisheries management, and water quality pathogen and ocean acidification (OA) tracking to promote and sustain living marine resources.
- **Marine Operations:** Enhance products for safe and efficient marine commerce and transportation, search and rescue, homeland security, and events such as oil spill response.

OBJECTIVES

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, ship-based measurements, wave measurements and models, pier-based monitoring, 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.

WORK COMPLETED

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.

RESULTS

SCCOOS works interactively with local, state, and federal agencies, resource managers, industry, policy makers, educators, scientists, non-governmental organizations and the public. As a result, a framework has

been developed which provides for the complete life-cycle of the data. The information is readily available in a variety of formats to ensure that products are useful and easy to access, while preserving the necessary detail to support the scientific and educational communities. SCCOOS continues to explore new visualizations and technologies to make the information more comprehensible.

IMPACTS AND APPLICATIONS

National Security

- 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 AND improve navigation and safety for military regions and testing ranges.
- 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.
- Glider data are provided to the Naval Oceanographic Office (NAVO) for assimilation into operational models.
- SCCOOS provides training as needed to first responders of maritime incidences in the use of SCCOOS products.

Economic Development

- 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.
- 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.

Quality of Life

- Long-term time series of physical, biological, and chemical ocean data are critical in monitoring climate trends and determining ecosystem health. Physical and ecological ocean patterns and processes constitute valuable information for Coastal and Marine Spatial Planning and marine protected areas monitoring.
- Ocean conditions, surface currents measurements and surface wind analyses can be used to aid in spill response as well as generate trajectories to inform operations, and are now accessible by U.S. Coast Guard for search and rescue (SAR) applications using their Environmental Data Server.
- Surface current measurements and surface wind analyses are integrated into the General NOAA Operational Modeling Environment (GNOME) for oil spill trajectory analysis
- 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.
- NOAA CO-OPS integrated High Frequency Radar surface currents into their Tides & Currents Product
- SCCOOS continues to provide HF radar-based trajectory tracking tool for Tijuana River Plume which is accessed on a daily basis by users such as lifeguards, Department of Environmental Health, and local surfers/beach goers. 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).
- Develop Shoreline inundation forecast, validation, and dissemination of warnings. 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.

- 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.
- 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 and harmful algal blooms in the very near shore zone of the Southern California Bight. These measurements are used to inform the public and statewide agencies of current harmful algal blooms (HABs) that can impact human health, marine life, and recreational beach use. Furthermore, regional observations increase our knowledge of the sign, frequency, and magnitude of variation of temperature, salinity, density, nutrients, and harmful algal blooms.
- 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 support of the 2015-2016 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 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.
- SCCOOS received funding for IOOS’s ocean acidification marine sensor program. SCCOOS/SIO will operate a “Burkolator” 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. West Coast ocean acidification related data can be found at: <http://www.ipacoa.org/>
- SCCOOS ocean data inform classroom curriculum and informal education programs.

TRANSITIONS

Quality of Life

- Monitor Harmful Algal Blooms (HABs) at five pier stations by collecting weekly measurements of temperature, salinity, chlorophyll, nutrients, and toxic species; distribute data and expand HABs website to include Central and Northern California.
- *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 and Mark Brzezinski’s group at the Analytical Laboratory at the Marine Science Institute at the University of California, Santa Barbara test for primary inorganic nutrients for the 5 SCCOOS HAB monitoring sites.
- 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.
- 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. In addition to the display at the SCCOOS web site, we are also displaying some static ROMS images on our group web site. The ROMS nowcast page is: http://west.rssoffice.com/ca_roms?variable=curr. The ROMS forecast page is: http://west.rssoffice.com/ca_roms_forecast?variable=curr. ROMS validation images against three assimilated data sets are also displaying:
 - Satellite SST http://west.rssoffice.com/ca_roms_valid_other?variable=IRsst
 - HF radar http://west.rssoffice.com/ca_roms_valid_radar?variable=2
 - Gliders http://west.rssoffice.com/ca_roms_vaild_prof?variable=sscat
- 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 are being assessed for their amount of augmentation of net primary productivity in the surrounding shelf regions. Second, the roles of surf current instability and the ensuing surf-eddy turbulence under various wave and coastline shape influences are being assessed how far offshore their influences reach. This is being done using two tactics; 1) Exploit the surface wave -- current interaction and grid- nesting capabilities of ROMS to examine cross-shore exchange of materials in the shelf and surf zone. Sites near Pt. Conception, the northern Channel Islands, Santa Monica Bay, and the Newport region are the foci, and 2) Develop a coupled ROMS/biogeochemistry/ecosystem model to aid the evaluation of the effects of nutrient inputs on bloom formation and nutrient cycles, as well as variability and trends in hypoxia and acidification. The progress is posted [online](#).
- 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.
- 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 web site.
- Currently an HF radar quality assurance/quality control(QAQC) Development Project is underway with the goals to;
 - Provide real-time baseline comparisons of radial HF radar velocities;
 - Provide other real-time comparisons of radial HF radar velocities;
 - 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. A draft report is underway that aims to explain the HR Radar Quality Control tools that are being developed for quantifying and monitoring the quality of IOOS HF radar data.

- Operate, support and maintain network of one glider line to collect measurements of temperature, salinity, chlorophyll, current velocity and acoustic backscatter. Deliver data from 3 glider lines to SCCOOS website and push to modeling centers.
- The automated shore stations program operates and maintains 3 stations (Scripps Pier, Newport Pier and Santa Barbara Pier) and provide real-time continuous data at 1-4 minute intervals with limited interruptions. Real-time coastal measurements of temperature, salinity and fluorescence. The automated shore station data are one of the most requested data sets provided through SCCOOS. These data are used by the public and local state and research agencies to assess local conditions related to water quality, nearshore processes, population dynamics of coastal species and harmful algal blooms. Data collected at these stations includes temperature, salinity, fluorescence, and pressure. Calibration samples have been collected during cleaning and service dives, however incorporation of these data quality checks is not feasible at the current funding level
- 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 NMFS. This collaboration will help SIO, SWFSC, 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.
- SCCOOS is in collaboration with the Orange County Sanitation District (OCSD) to improve data quality at Newport Beach Pier Automated Shore Station. Real-time measurements of temperature, salinity and fluorescence provide current resources for evaluating coastal conditions of water quality and potential harmful algal blooms. Over the last year, data quality has improved by funding additional service dives to clean sensors and the purchase of new fluorimeters. OCSD is funding an upgrade with the sensors package at the Newport Pier to addressing the aging infrastructure. This project will ultimately provide a more reliable measurement of temperature, salinity, chlorophyll, pH and oxygen at the Newport Pier so that these data can be used as indicators of HABs, low pH or low oxygen events, and provide high quality data critical for evaluating ecosystem health and climate trends. The new sensors will also provide relevant data to evaluate potential transport of waters with elevated phytoplankton or low pH and oxygen toward shore and whether these are natural events or influenced by nutrients discharged by POTWs. The data supplement related water quality data products provided by SCCOOS including the Harmful Algal Bloom Monitoring Program and the Manual Shore Stations Program.

RELATED PROJECTS

- SCCOOS maintains and validates the pCO₂-DIC system (Burkolator). We are developing a system for 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.
- SCCOOS now has 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 leverages the California Data and Information program (CDIP) mission is to monitor and predict nearshore waves and shoreline change. The program has deployed over 130 wave stations, has archived over 100GB of wave data, and disseminates these data in near real time via the CDIP website, National Data Buoy Center, and the National Weather Service radio broadcasts. CDIP is primarily funded by the U.S. Army Corps of Engineers in support of planning and design of structures and beach nourishment projects and considers this funding their main contribution to the U.S. IOOS. This resource is accessed by over 6,000 sites daily by the Navy, Marines, Coast Guard, coastal planners and managers, maritime pilots, commercial fisherman, recreational boaters, and beach-goers.
- 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.
- SCCOOS leverages the Marine Mammal Center by displaying their marine mammal health map on the [SCCOOS site](#). The goal of this project is to develop a national marine mammal health tracking program that is web-based and readily accessible to scientists, managers and the general public. This will allow detection of spatial and temporal changes in marine mammal health that will enable early prioritization of management and conservation efforts to mitigate mortality and identify potential public health risks. In addition, this project will potentially contribute to the detection of climate change impacts on marine mammal health.
- SCCOOS visualizes [AIS ship tracking](#) by leveraging the Southern California Marine Exchange and NOAA Office of Coast Survey.
- SCCOOS visualizes [meteorological observations](#) by leveraging National Oceanic and Atmospheric Administration (NOAA) Research (Oceanic and Atmospheric Research) Earth System Research Laboratory (ESRL) Global Systems Division (GSD) developed the Meteorological Assimilation Data Ingest System (MADIS) to collect, integrate, quality control (QC), and distribute observations from NOAA and non-NOAA organizations.
- SCCOOS visualizes [satellite ocean data](#) by leveraging NASA jet propulsion laboratory.
- SCCOOS visualizes [modelled wind and rain](#) nowcasts and forecasts by leveraging The COAMPS® model is a product of NRL: The Naval Research Laboratory's Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS®). [COAMPS®](#) is produced by NRL Monterey and accessed through the [US Global Ocean Data Assimilation Experiment \(USGODAE\)](#).

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University of Southern California (USC)

REFERENCES

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

SUCCESS STORY FOR DISTRIBUTION

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.