Final Progress Report

Project Title: U.S. Integrated Ocean Observing System Implementation:
Southern California Coastal Ocean Observing System

Award number: NA16NOS0120022

Period of Activity: 06/01/2016 – 5/31/2022

Principal Investigator: Clarissa Anderson, UCSD - SCCOOS Executive Director

I. PROJECT SUMMARY

The Southern California Coastal Ocean Observing System (SCCOOS) is one of eleven regions that contributes 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 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 work plan is broken down into five subsystems that map to the Regional Coastal Ocean Observing System (RCOOS) requirements (1) Governance and Management Subsystem, (2) Ocean Observing Subsystem, (3) Modeling and Analysis Subsystem, and (4) Data Management and Cyberinfrastructure Subsystem, and (5) Stakeholder Engagement Subsystem. SCCOOS' priorities and objectives are aligned with the seven societal goals as outlined in the IOOS Summit Report. The focus themes, as designated by IOOS, highlight these priorities and are designed to improve safety, enhance the economy, and protect our environment.

1. Marine Operations: to advance integrated, customized products that are critical for safe and efficient navigation, search and rescue, and oil spill response.
2. Coastal Hazards: to provide accurate, validated inundation models and information with the long-term goal of improving coastal safety.
3. Ecosystems, Fisheries and Water Quality: to provide monitoring, tracking, and prediction tools for harmful algal blooms, outfall and storm water plumes, and surf zone contaminants.
4. Climate Variability and Change: to monitor ocean climate trends and environmental changes in the Southern California Bight by collecting physical, chemical, and biological data.

II. PROGRESS AND ACCOMPLISHMENTS

i. GOVERNANCE AND MANAGEMENT SUBSYSTEM

SCCOOS Regional Association Governance - UCSD

Task 1: Maintain a centralized program office that oversees SCCOOS operations and effectively coordinates with all partners to expand capacity.

Successes and Challenges: SCCOOS organization is represented by 1) a lean program office with internal data management based at Scripps Institution of Oceanography, and by 2) a regional consortium of institutions with 11 founding members and five signatories of memoranda of understanding (MOU). These MOUs are continually increasing in number as new partnerships are formalized. SCCOOS follows a set of by-laws voted in by the SCCOOS Board of Governors, a group whose charge is to advise SCCOOS vision and direction. The Executive Steering Committee prioritizes recommendations, reviews Expressions of Interest, meets to formulate scopes of work documented in the Work Plan, and advises the BOG on technical manners and strategic planning. SCCOOS

met annually with the BOG and ESC to enact the Operational Work Plan and Strategic Plan, expand the program through extramural projects, build capacity via international-toregional working groups (including IOOS Association governance), and interact with partner organizations via frequent travel and conference calls. SCCOOS works to meet our mission by regularly participating in funding opportunities. During the the award period SCCOOS was successful in 20 (38%) proposals receiving an additional $4,833,838 over the award period. See here for further details.

Status: On-going; continued funding from SCCOOS FY21-26 award

ii. OCEAN OBSERVING SUBSYSTEM

Focus Area 1: Marine Operations

California Surface Current Mapping Network - Cal Poly/UCSB/USC/UCSD

Task 1: Operate and maintain a network of short, medium, and long-range HF radar systems and deliver data streams to the National HFR Network. Task 2: Deliver surface current data and surface wind analyses to aid spill response, SAR real-time recovery, and post analysis trajectories. Task 3: Annually provide training to first responders of maritime incidents in the use of SCCOOS products.

Successes and Challenges: SCCOOS HFR PIs regularly serviced HF radar sites throughout the award period. SCCOOS additionally participated in training and science education to a broad range of stakeholders either by request or as opportunity arises, a list of relevant opportunities is available here. Many of the network's radar systems and ancillary equipment are old and require frequent maintenance procedures and repairs. In addition, the new sites have been acquired and existing sites upgraded to fill gaps in radar coverage. SCCOOS and CeNCOOS jointly operate about 62 radars at any given time and these comprise about 40% of the overall IOOS HFR network. SCCOOS and CeNCOOS operators estimate that $7.5 million is needed to fully recapitalize and bring the network back to its original specifications. Some funding for this recapitalization has been provided through small increases in IOOS core funding to "fill gaps" and the Bipartisan Infrastructure Bill in FY22.

Status: On-going; continued funding from SCCOOS FY21-26 award

HF Radar Quality Control Development - UCSB

Task 1: Allow HF radar operators to quickly evaluate the consistency of radial currents measured by different radars through improving the core software toolbox on which the QA/QC comparison website is built.

Successes and Challenges: In 2020 the server on which the website and data management code was running reached the end of its life, preventing the website from running in real-time. In 2021, the team spent significant time building and installing a new server, which is now operational. The website and processing code are running on the new server. The team worked with an undergraduate Computer Science Student in converting the code to Javascript. The student implemented enhancements, based on suggestions by users. These include the ability for users to select a wide range of times scales for the comparisons, and the ability to interactively choose which particular location within the radial coverage to visualize the comparisons. The javascript-based web design now dynamically generates the plots and statistics, while the MATLAB code generates and maintains the comparison data that feed into the javascript. The improved code is live and viewable here. Another project the student completed was a URL to make the HFR data easier to visualize on mobile devices. A link to that URL is here.

Status: Completed in May 2022.

Focus Area 2: Climate Variability and Change

California Underwater Glider Network (CUGN) - UCSD

<u>Task 1</u>: Operate and maintain a network of gliders to collect measurements of temperature, salinity, chlorophyll, current velocity, dissolved oxygen, and acoustic backscatter; deliver data to the SCCOOS website and push to modeling and data archive centers.

<u>Successes and Challenges</u>: Real-time data are delivered to the NOAA Southwest Fisheries ERDDAP, then to the national glider DAC, and then onto the GTS. Delayed mode, quality controlled data are available for download at spraydata.ucsd.edu. In 2012, SeaBird changed the design of DO sensors, and in 2018, the Spray Glider lab tested a new oxygen sensor (SBE63). In 2020, the lab finished calibration of the complete dissolved oxygen data set using a combination of lab calibrations and comparisons with CalCOFI bottle data, available at spraydata.ucsd.edu. In January 2019, with IOOS Fill the Gaps funding, SCCOOS began supporting the alongshore line, which is now part of the five sustained lines using Spray underwater gliders off the coast of California. The lines follow the CalCOFI geometry, from south to north: line 90.0 (funded by NOAA GOMO), alongshore at station 60 (SCCOOS), line 80.0 (SCCOOS), line 66.7 (NOAA GOMO), and line 56.7 (CeNCOOS). The COVID-19 pandemic interrupted the observations, with all lines except for line 90.0 having a break. All lines are now up and functioning normally. More information on the California Glider Network can be found on the SCCOOS website. CUGN data are included in the California Current Integrated Ecosystem Assessment (IEA) and in the CalCOFI State of the California Current article.

<u>Status</u>: On-going; continued funding from SCCOOS FY21-26 award

Focus Area 3: Ecosystems, Fisheries, and Water Quality

HAB Monitoring Alert Program (HABMAP) - SIO/USC/UCLA/UCSB/CalPoly

<u>Task 1:</u> Sustain weekly sampling at five pier sites in the SCCOOS region for HAB species, particulate toxins, chlorophyll-a, temperature, salinity, & inorganic nutrients. Plankton classification, chlorophyll-a, temperature and salinity are reported weekly and data are submitted weekly to the SCCOOS database. Samples are shipped monthly to USC for domoic acid analysis. Samples are shipped quarterly to UCSB for nutrient analysis. <u>Task 2:</u> Sustain weekly SPATT sampling for dissolved DA toxins and shipped monthly to USC for analysis.

<u>Successes and Challenges</u>: Data are distributed via the California HABMAP listserv and are discoverable online via the SCCOOS ERDDAP server and CalOOS Joint Data Portal CalHABMAP dashboard. Information is also made available on the SCCOOS website and CalHABMAP website, developed in collaboration with UCSC (Kudela Lab). In 2018, the SCCOOS Data Manager worked with HABMAP PIs to standardize the reporting format to make the datasets Darwin Core-compliant for ingestion into ERDDAP and the OBIS database. In 2020, Solid Phase Adsorption Toxin Tracking (SPATT), a robust HAB toxin detection tool, was added at three of SCCOOS HAB piers (Scripps Pier, Newport Beach Pier, and Stearns Wharf) with IOOS Fill the Gaps funding. Interruptions to sample collection and processing occurred between 23 March 2020 and 31 May 2021, with the closing of several piers, university laboratories, and periodic shelter-in-place orders associated with the COVID-19 pandemic.

<u>Status</u>: On-going; continued funding from SCCOOS FY21-26 award

SCCOOS Automated shore stations (SASS) - UCSD/CSUN/UCSB

<u>Task 1</u>: Operate & maintain four SCCOOS Automated Shore Stations (SASS; Scripps Pier, Newport Pier, Santa Monica Pier, and Stearns Wharf) with continuous data service at a four-minute ingestion frequency, with routine (monthly) sensor cleaning and maintenance. Standard station parameters are temperature, salinity, depth, and chlorophyll fluorescence.

<u>Successes and Challenges</u>: SASS data are one of the most requested data sets provided by SCCOOS. These data are used by both the public and local-to-state managers to assess conditions related to water quality, nearshore processes, population dynamics of coastal species and HABs, and ecosystem health and long-term climate trends.

SIO obtained an exception to work during the ongoing COVID-19 campus closure to maintain the SASS stations at Scripps Pier, Newport Beach Pier, and Santa Monica Pier. Data were collected at all sites throughout the closure and captured the massive *L. polyedra* "red tide" bloom (19 March - 18 May 2020). However, COVID-19 restrictions and shelter-in-place orders kept the UCSB team from servicing the Stearns Wharf pier station from February through June 2020. Due to the long break in cleaning and maintenance at this site, the sensors (CTD and fluorometer) and cables were damaged due to excessive biofouling and were replaced at significant expense; the Stearns Wharf pier station was back online by 1 July 2020. The Stearns Wharf Pier station has been supplemented by funds through the University of California, Santa Barbara to support maintenance and cleaning dives in collaboration with the Santa Barbara Long-Term Ecological Research Project. This is an important and leveraged partnership.

Supplemental funding for the Newport Beach Pier SASS has been renewed by the Orange County Sanitation District for the July 2020 - June 2022 period with the option for renewal of up to four years through 2024. This funding supports the collection of oxygen and pH measurements alongside the standard automated shore station observations. New pH sensors (SeaBird SeaFET) were purchased by OCSD and deployed on 17 December 2020. Challenges for this station include outages due to old infrastructure and power-related issues that have been temporarily resolved with patches, however additional investment in infrastructure will be required for long-term observations at this site.

The Santa Monica Pier shore station was decommissioned at the beginning of this award period and then reinstated with City of LA Sanitation/Hyperion Water Reclamation Plant, The Bay Foundation, and The Los Angeles Waterkeeper funding through December 2019. However, since January 2020, SIO maintained this station without funding, and PIs worked to keep this site online at the expense of other goals for this project. Note: With the new FY 21-26 funding cycle, we prioritized SCCOOS resources to support a new PI at Cal State Northridge.

All stations were equipped with engineering controls to improve real-time measurements from underwater sensors; however most of these systems are not working as originally planned due to the low-budget supplies and parts purchased to show proof-of-concept for this plan. New funding in 2021 along with contributions from an undergraduate research student will help get these systems working again. Date and stations when air-blaster was installed: SB 2/26/18, SIO 1/25/2019, SM 6/27/2019 and NB 2/13/2020. The SASS program also continues to provide "hands-on" training and learning for graduates and undergraduates at UCSD by providing tours to learn about ocean observations and climate change, use of SASS data in classes, and complementary datasets for student projects. SIO and UCSD classes include SIO221, SIO210, SIO101, SIO87, and MAE3.

<u>Status</u>: On-going; continued funding from SCCOOS FY21-26 award

CalCOFI Nearshore Stations - UCSD

<u>Task 1</u>: Support monitoring for nine nearshore California Cooperative Oceanic Fisheries Investigations (CalCOFI) stations.

<u>Successes and Challenges:</u> Since 2004, SCCOOS has funded nine nearshore stations in addition to CalCOFI's standard 66 stations. SCCOOS links to data that are measured in the nearshore region of southern California as part of CalCOFI - California Current Ecosystem Long Term Ecological Research (CCE-LTER) program. These parameters include temperature, salinity, zooplankton, phytoplankton, fish eggs and invertebrate larvae. CalCOFI data, resources, and reports are posted on the CalCOFI website. More information on SCCOOS-CalCOFI background, observations, data access and publications can be found on the SCCOOS website.

<u>Status</u>: Complete. NOAA SWFSC and SIO are now funding the nine nearshore stations as part of CalCOFI's core sampling stations. This was a successful transition to operations from SCCOOS to CalCOFI, freeing funds for new collaborative directions in the next funding cycle.

CalCOFI- Distribution and abundance of marine birds in the Southern California Bight and adjacent waters - Farallon Institute

Task 1: Collect seabird & marine mammal distribution and abundance data on winter, spring, and summer CalCOFI cruises and spring/summer NMFS RREAS (rockfish recruitment survey) and deliver annual reports to SCCOOS for incorporation into CCIEA and NMS reports.

Successes and Challenges: Since 2012, SCCOOS has published survey reports and maps of seabird and marine mammal species distribution and abundance on the SCCOOS website. In 2021, Sydemans lab at the Farallon Institute collaborated with NOAA's Environmental Research Division to post the seabird and marine mammal dataset on ERDDAP; data are also available on the CalOOS Data Portal.

Status: On-going; continued funding from SCCOOS FY21-26 award.

OAH Monitoring - UCSD (non-core)

Task 1) SeapHOx mini-mooring operations at Carlsbad Aquafarm. Successes and Challenges: From 2019-2021, SCCOOS funded the Martz lab to operate a real-time mini-mooring with SeapHOx in the Agua Hedionda Lagoon (AHL), within 10m of the Carlsbad Aquafarm growing area. During 2020, the mooring operated successfully, sending real-time data to SCCOOS. Data are served on the SCCOOS ERDDAP, and time series plots of the real-time data are available on the SCCOOS website. The SeapHOx successfully delivered data for four months (Jan - Apr 2020), at which time the cellular modem battery died on 7 April 2020. A battery replacement was scheduled, but, due to the COVID-19 shutdown, maintenance was delayed. On 15 June 2020, the system was recovered and then redeployed in July 2020. The data downloaded captured the low dissolved oxygen and pH levels in AHL during the massive "red tide" event in March-May 2020, specifically anoxic levels for nine days in May in the lagoon, which likely contributed to the 80% die off of Carlsbad Aquafarm crop! The mooring was recovered in Spring 2021 and overhauled. Bresnahan et al., 2020 was published in *Results in Engineering* on Equipping smart coasts with marine water quality IoT sensors, and the 2020 low oxygen data are currently contributing to two student-led manuscripts.

Status: On-going; continued funding for task 2 from SCCOOS FY21-26 award.

National HAB Observing Network: CA IFCB Network - UCSD (non-core)

Task 1: Operate and maintain a network of nine operational Imaging FlowCytobots (IFCBs) to identify HAB species in real-time at critical land-based and offshore locations throughout California. The full network now comprises 12 IFCBs, several of which are currently dedicated to science projects, e.g. ECOHAB.

Successes and Challenges: The California Imaging FlowCytobot (IFCB) Network is a highly leveraged network with funding from NOAA PCMHAB, NOAA MERHAB, NOAA ECOHAB, CA OPC, and in 2020 from NOAA IOOS and NCCOS, as an NHABON pilot project, to operate and maintain nine IFCBs deployed at piers and offshore moorings and on ships of opportunity to monitor for offshore bloom dynamics. In 2020, we successfully deployed an IFCB at Scripps Pier, Del Mar Mooring, Newport Beach Pier, and Stearns Wharf. Data from the instruments have been brought online in real-time via an Axiom-supported Dashboard to display imagery on a SCOOS-Axiom URL and CalOOS Data Portal (PCMHAB funding). SCCOOS Research Scientist, Dr. Kasia Kenitz, has applied machine-learning image annotation to validate the performance of the classifiers on data from the Del Mar Mooring IFCB. Dr. Kenitz is organizing the CA IFCB team members to develop a coordinated and standardized approach to annotating IFCB imagery for training classifiers. A manuscript describing this community effort was recently submitted to *Frontiers in Marine Science-Methods* (Kenitz et al. 2022, in review). Although the instruments have great potential for a real-time HAB alert system, we've discovered that the IFCB instruments are prone to clogging due to southern California rich sediments nearshore, and their have been some growing pains as the technicians learn how to troubleshoot the instrument, in part due to hosting virtual trainings during the COVID pandemic.

SCCOOS has been working with the manufacturers at McLane Labs, Inc. to resolve the issues. The first in-person technician training workshop is slated for January 2023.

Status: On-going; continued funding from SCCOOS FY21-26 award.

Dynamics Driving Nutrient Delivery to the Shelf - UCSD/UCD (non-core)

Task 1: Deploy a SUNA-V2 optical nitrate sensor and a suite of other biophysical sensors on the Wire Walker profiling platform off of San Diego, CA.

Successes and Challenges: This one-year demonstration project successfully integrated a SUNA V2 optical nitrate sensor onto the Wire Walker profiler platform outfitted with physical and optical sensors. The Wirewalker mooring was deployed at 50 m depth and a "mini-mooring" at 25 m depth on a line between the Del Mar mooring (100 m isobath) and the coastline for the period of November 2021 through January 2021. This represents one of the first long-term profiling deployments of directly measured nitrate in the coastal ocean, complemented by fixed depth nitrate sensors on the Del Mar mooring (100m) and mini-mooring (25 m). Key outcomes of the research during the performance period include: (1) successful demonstration of the SUNA V2 integration on the Wire Walker, (2) the collection of high-frequency profiles (approximately every 11 min) of physical data and nitrate concentrations during the harmful algal bloom (*L. polyedra*) event, and (3) collection of supporting data from Del Mar mooring, including images from the Imaging Flow Cytobot (IFCB). Preliminary analyses of these novel observations indicate that optical attenuation by strongly swimming dinoflagellates (*L. polyedra*) can significantly influence the upper ocean heat budget, suggesting that biological feedbacks can be of first-order importance to the physical structure of the upper ocean. A second, prolonged deployment began on 13-Nov 2020, and included 1) the installation of a SUNA sensor of the Del Mar Mooring, 2) the deployment of a "mini-mooring" at the 20 m isobath inshore of the Del Mar mooring, with velocity, temperature/salinity, and SUNA sensor, and the deployment of the SUNA-equipped Wirewalker on the 50 m isobath, between the Del Mar mooring and the Mini-mooring. The SUNA V2 on the Wirewalker failed in January 2021 and was recovered and returned to Seabird for repairs. The Del Mar SUNA and the mini-mooring were recovered in March 2021. Challenges: Most of the challenges in the program derived from COVID-related delays.

Status: Completed; the demonstration project completed in May 2021.

Focus Area 4: Coastal Hazards

Shoreline Inundation Forecast and Validation - UCSD

Task 1: Support & expand the California Coastal Flood Network, adding a new southern California site to the threshold validation/evaluation process each year. Task 2: Shoreline inundation forecast, validation, and dissemination of warnings to select city managers. Task 3: Expand development and integration of inundation website. Task 4: Develop models for Huntington, Imperial Beach, and Malibu inundation sites

Successes and Challenges: Cardiff and Imperial Beach flooding forecasts are linked on the SCCOOS website for city officials and the public. We have developed a detailed error analysis and a probabilistic assessment to be included with the website forecasts, as described in a manuscript published June 2021 in *Natural Hazards*. Advanced flood models have been developed for Coronado and Huntington Beach, with additional flood reports needed to finalize flood thresholds. COVID-19 has posed a challenge for collecting data on flood occurrence, particularly at Huntington Beach. A website for Imperial Beach is available at CCCIA and linked on the SCCOOS website and includes products showcasing historic trends, latest observations, and the flood forecast. Historic products include a compilation of past events, a record of historic beach width, and a beach-profiles viewer for identified flooding sites. Latest observations include wave height predictions for Imperial Beach and an elevation map of the beach

based on the latest LiDAR survey. Beach products, including the beach width plot, beach profiles viewer, and LiDAR elevation map, have been improved to automatically update with the latest sand level surveys. The Imperial Beach site serves as a template to expand to other coastal sites. A website for Cardiff Beach is also on the CPG website, linked via the SCCOOS website and includes historic products as well as a flood forecast. The forecast has been specifically developed for Cardiff Beach and is in the process of being evaluated and improved. Other products include a beach-profiles viewer and record of past flooding events. Websites for Huntington Beach and Coronado are currently live with a beach-profiles viewer and a flood forecast based on the improved runup parameterization developed at Imperial Beach. The Malibu site is in development, using a less site-specific runup model on recently collected bathymetric data. We will continue to develop these sites as well as evaluate and improve the forecasts with observations.

Status: On-going; continued funding from SCCOOS FY21-26 award.

iii. MODELING AND ANALYSIS SUBSYSTEM

ROMS - High Resolution Shelf and Nearshore Physics - UCLA

Task 1: Support nearshore ROMS development for improved physics of direct relevance to water quality managers and SCCOOS partners; SCCOOS supports a project page with annual updates of model output/visualizations of nearshore physics developments

Successes and Challenges: Fine-scale simulations with a research-level, high-resolution ROMS are being analyzed in hindcast mode at UC Los Angeles to examine two circulation phenomena in particular. First, pollution effluent dispersal throughout the Southern California Bight is being assessed for augmentation of net primary productivity in the surrounding shelf regions with ancillary consequences for subsurface oxygen and carbon. Second, shelf submesoscale currents and surf-zone turbulence under various surface gravity wave and coastline shape influences are being assessed to determine their roles in along- and cross-shore transports of material concentrations, biological and otherwise. This is being done using the surface wave-current interaction theory 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 primary locales of interest. In parallel, we are developing a coupled ROMS/biogeochemistry/ecosystem model (ROMS-BEC) that we hope to use in the future 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 both published and periodically published online.

Status: On-going; continued funding from SCCOOS FY21-26 award

ROMS - 3 km Statewide Operational model - UCLA/Seatrac

Task 1: Support & serve real-time, data-assimilative ROMS predictions to SCCOOS & CeNCOOS end-users; models are run on SCCOOS servers and output is provided hourly to daily to the SCCOOS portal. Task 2: Validate the 3-km CA ROMS output against non-assimilated observations.

Successes and Challenges: 3-km California ROMS model with data assimilation and real-time forecasting capabilities has 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. The ROMS model is displayed in near-real time on the SCCOOS website - ROMS page. Additionally, Six hourly nowcasts and 72-hour forecast files are available on SCCOOS THREDDS servers. The validation results have been published in Chao et al., 2018. Over the years, we have developed a number of validation products. On a daily basis, we are comparing the ROMS nowcast against satellite SST, glider measured profiles of temperature and salinity and HF radar derived surface current.

Status: Completed; as of October 2022, SCCOOS no longer supports the CA ROMS 3KM model and has transitioned to serving the operational NOAA WCOFS instance of ROMS at 4-km resolution.

CDIP Long Beach Wave Buoy Model Validation - UCSD

Task 1: Maintain and expand integrated, customized products with multi-layer views of observations, nowcasts, and forecasts. Collaborate with the Port of Long Beach to maximize the benefit of SCCOOS observations.

Successes and Challenges: SCCOOS received $10K in pass-through funding to CDIP to help maintain the LA/LB wave buoy. 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. The link to this display is available [here](#). As previously mentioned, SCCOOS and CDIP staff participate and present at monthly to quarterly Ports of LA/LB Harbor Safety Committee Meetings. CDIP installed an AIS antenna in San Diego, which increases the range of visibility of ship traffic to the Marine Exchange of Southern California.

Status: On-going; continued funding from SCCOOS FY21-26 award.

iv. DATA MANAGEMENT AND CYBERINFRASTRUCTURE SUBSYSTEM

SCCOOS DMAC Activities - UCSD

Task 1: Support ongoing maintenance, operation, and development of SCCOOS cyberinfrastructure to sustain long-term data stewardship for our partners and stakeholders. Task 2: Promote data standardization, automation, discovery, and public access. Task 3: Strengthen data stewardship within the SCCOOS consortium to improve data quality, access, attribution, exchange, delivery, and storage and. Task 4: Support the functionality of national data assembly centers through leadership in observation and product delivery, quality control methods, and capacity building.

Successes and Challenges: SCCOOS continues to achieve its milestones by providing access to high-quality, integrated data and supporting regional user needs while complying with national standards and protocols for sharing and archiving data. SCCOOS leverages the [Coastal Data Information Program](#) (CDIP), the [HF Radar Network](#) (HFRnet), the [California Underwater Glider Network (CUGN)](#), and the Center for Climate Change Impacts and Adaptation (CCCIA). SCCOOS actively participates in IOOS DMAC efforts, such as the use of the UCAR community program Thematic Real-Time Environmental Distributed Data Services (THREDDS) and the NOAA NMFS Environmental Research Division's Data Access Program (ERDDAP) to facilitate distribution of most of our datasets ([SCCOOS Data Access and Services webpage](#)). SCCOOS actively participated in the IOOS Biological Data Standards Workshop in Seattle in 2019. SCCOOS also continues to implement QARTOD data quality control standards for all parameters for which QARTOD exists.. All data have associated ISO 19115-compliant and CF metadata and are well cataloged in our [RICE certification documentation](#) that was renewed in April 2021.

Status: On-going; continued funding from SCCOOS FY21-26 award.

Data Management and Cyberinfrastructure - Axiom Data Science

Task 1: Enable and support SCCOOS Cyberinfrastructure and development of a new Statewide Data Portal. Task 2: Ingest and maintain SCCOOS-operated and Non-SCCOOS Data Assets, including sensors, Gliders, HF Radar, models, biological, and historical legacy time series. Task 3: Implement real-time sensor data quality control system and. Task 4: Support the creation of data-driven products and applications.

SOUTHERN CALIFORNIA
**COASTAL OCEAN
OBSERVING SYSTEM**

Successes and Challenges: In June 2021, SCCOOS contracted with Axiom Data Science as our lead data manager. Axiom maintains ongoing continuous performance of the SCCOOS data system following IOOS DMAC guidelines. Axiom developed a new integrated coastal and ocean observing data portal that unifies data streams across the California coast from CeNCOOS and SCCOOS regions. The CalOOS data portal is available online at https://data.caloos.org/. Additionally, Axiom initiated a new data center build out in August 2021 to increase data storage and compute resources for system optimization. A new service was developed on the Axiom infrastructure to calibrate chlorophyll, O2, and pH data that are being collected by SCCOOS Shore Stations prior to their ingestion by packrat. The code reads raw data files, calibrates parameters using a library, and then continuously writes out new files for ingestion and visualization into the CalOOS data portal.

Status: On-going; continued funding from SCCOOS FY21-26 award.

IOOS OTT Biology - UCSD (non-core)

Task 1: Continue to iterate on the standards used when applying Darwin Core standards to HAB data for SCCOOS and CeNCOOS. Task 2: Host standardized data sets on the ERDDAP server and communicate regularly with OBIS data managers to ensure transfer of those data from ERDDAP to OBIS.

Successes and Challenges: The IOOS Ocean Technology and Transfer Matt Howard Memorial project was granted to ensure that SCCOOS stewards biological data sets to broader distribution databases such as ERDDAP and OBIS. In 2020, SCCOOS successfully applied Darwin Core-compliant standards to the CalHABMAP phytoplankton data and is serving the data on ERDDAP. From there, OBIS is pulling these data in their global database.

Status: Completed in June 2021.

IOOS OTT Acoustic Tollgate Pilot Project - UCSD (non-core)

Task 1: Fathom Bank mooring recovered and re-deployed. Task 2: Del Mar mooring recovered and re-deployed. Task 3: Data recovered from the moorings and the WBAT data processed and preliminary results available.

Successes and Challenges: In the summer of 2016, a pilot project was implemented as part of SCCOOS for initial testing of novel wide-band technology (WBAT) which NMFS, the West Coast Fisheries Centers, and Scripps Institution of Oceanography believe will be able to provide mooring-based assessments of fish abundance and migration – a concept here called acoustic tollgates. The pilot project was co-funded by IOOS, NMFS, SIO, and SWFSC, and allowed initial deployment of a second mooring offshore of San Diego (43 Fathom Bank, short FTFB) which forms a pair with the existing Del Mar mooring, and it allowed equipping both moorings with a basic WBAT transceiver and single transducer.

Status: Completed in June 2018.

IOOS OTT Tollgate Data Management - UCSD (non-core)

Task 1: SCCOOS will ingest and serve temperature and salinity data from Fathom Bank mooring and Del Mar mooring. Task 2: Deliver ADCP currents and oxygen QA/QC data to SCCOOS DMAC.

Successes and Challenges: The SCCOOS DMAC team worked with Dr. Send's group to ingest, analyze, visualize and archive the data from the Del Mar and Fathom Bank moorings and worked to ensure the data were compliant with the IOOS standards.

Status: Completed in June 2018.

v. STAKEHOLDER ENGAGEMENT SUBSYSTEM

SCCOOS Outreach and Education - UCSD

Task 1: Develop regionally relevant, user-driven analysis, decision-support, and visualization products and tools to address historic and emerging stakeholder requirements in the SCCOOS region. Task 2: Engage stakeholders to gather customer feedback and refine requirements for SCCOOS products and services.

Successes and Challenges: While SCCOOS is at the forefront of implementing ocean technology, observing, and interpreting data, an underpinning of the organization is stakeholder requirements that inform data and product

delivery in an iterative process. In essence, products, tools, customized dashboards, and applications are optimized for the users using the expertise of SCCOOS to apply the latest science and technology. A full list of products developed by SCCOOS is listed in section V. Product Delivery. Additionally, SCCOOS engages regularly with our stakeholders through regularly planned meetings including our Joint Strategic Advisory Committee (JSAC), a formal partnership with CeNCOOS, that is composed of federal, state, and regional agencies, non-profits, and industry users. We meet with the JSAC annually to provide feedback on extant and emerging projects and products.

Status: On-going; continued funding from SCCOOS FY21-26 award

III. PUBLICATIONS

i. Publications and Reports

A detailed spreadsheet of SCCOOS related publications can be found here. During SCCOOS FY16-21 award, SCCOOS data were referenced in 177 publications and technical reports.

ii. Notable Presentations:

A detailed spreadsheet of SCCOOS presentations can be found here. During the five-year FY16-21 award SCCOOS program office gave over #168 presentations, tours, and exhibit booths. Presentations from 2016 to 2018 were not as well documented.

IV. EDUCATION, MEDIA ENGAGEMENT, AND OUTREACH MATERIALS

A record of SCCOOS media engagement and outreach materials can be found here under the 'Media' tab.

V. PRODUCT DELIVERY

SCCOOS continues to develop, integrate, and enhance long-term time series products for distribution. Below is a list of SCCOOS products and linked URLs with more information. *in collaboration with CeNCOOS.*

1. Automated Shore Station Dashboard
2. California HAB Bulletin
3. California HABMAP Dashboard*
4. California Harmful Algae Risk Mapping (C-HARM)
5. California IFCB Network Dashboard*
6. California Marine Protected Area Dashboard*
7. California Ocean Observing System (CalOOS) Data Portal*
8. California Operational 4DVAR ROMS 3km + Drop-a-Drifter*
9. California ROMS*
10. California Underwater Glider Network Dashboard*
11. CalCOFI Data Visualization tool (beta) + Infographics for IEA
    Assessment/Sanctuaries*
12. Coastal Modeling
13. Flooding and Storm Surge Models
14. HF Radar Hourly Surface Currents Map*
15. Imperial Beach and Cardiff Beach Flood Forecasts
16. Multivariate Ocean Climate Indicator*
17. Naval Air Systems Command (NAVAIR) Dashboard (pw protected for NAVAIR only)
18. Seabirds on the CalCOFI/CCE-LTER Survey
19. SoCal Index
20. Statewide Kelp Canopy Area/Biomass Dynamics*
21. Tijuana River Plume Tracker
22. West Coast Ocean Forecast System, searchable Nowcasts & Forecast

VI. CERTIFICATION UPDATES

- Changes in our Program Office staff and Governing Members during the award period can be found here.

VII. BUDGET SUMMARY

- A high-level budget summary of our FY16-21 award can be found here. The table below is a breakdown of our budget each year based on base/core funding, directed funding from IOOS, fill the gaps funding, and special projects which were one-time funding opportunities.

	FY16/17	FY17/18	FY18/19	FY19/20	FY20/21
Core/Base	$1,275,976	$1,280,641	$1,275,183	$1,274,508	$1,275,183
Directed	$951,622	$951,622	$961,622	$962,297	$961,622
Fill the Gaps	$0	$0	$375,000	$459,600	$541,000
Special Projects	$190,500	$297,578	$108,000	$98,675	$234,500
Total	$2,418,098	$2,529,841	$2,719,805	$2,795,080	$3,012,305

VIII. SUCCESS STORIES

- A spreadsheet of notable success stories during the award period is available here.

<center>End Report</center>