SOUTHERN CALIFORNIA COASTAL OCEAN OBSERVING SYSTEM

U.S. Integrated Ocean Observing System (IOOS) Implementation
Southern California Coastal Ocean Observing System (SCCOOS)
FY16-21 National Oceanographic Partnership Program Report:
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I. PERFORMANCE PROGRESS REPORTS

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

1. **Climate Variability and Change**: to 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 centers, and to continue to develop, integrate, and enhance long-term time series products for distribution.
2. **Coastal Hazards:** to provide accurate, validated inundation models and information about wave observations and run-up, total water levels, coastal erosion, and storm surge, with the long-term goal of improving coastal safety.
3. **Ecosystems, Fisheries, and Water Quality:** to monitor ocean climate trends and environmental changes in the Southern California Bight by collecting physical, chemical, and biological data and to provide monitoring, tracking, and prediction tools for harmful algal blooms, outfall and storm water plumes, and surf zone contaminants.
4. **Marine Operations:** to advance integrated, customized coastal products that are critical for safe and efficient navigation into ports and harbors, search and rescue missions, and oil spill response.
5. **Science Education and Communication:** to maintain a public, accessible website for data discovery and a portal that provides visualizations and resources for the public to learn, educate, and promote scientific research with SCCOOS data. A spreadsheet of SCCOOS education and outreach efforts can be found here, as well as a spreadsheet of stakeholders can be found here.

2) PROGRESS AND ACCOMPLISHMENTS

With advances in public health safety information to prevent the spread of COVID-19, many operations are now back online.

In December 2020, SCCOOS submitted a strong five-year proposal to NOAA IOOS which included 46 Principal Investigators from 20 institutions and 76 letters of support. SCCOOS endeavours to sustain and expand a regionally relevant system -- in close collaboration with CeNCOOS -- that monitors ecosystem dynamics, from physics to biogeochemistry to biology, and simultaneously serves the needs of existing and future stakeholders, from governmental agencies and the private sector, to leading national researchers. We proposed to maintain and grow our four thematic focus areas listed above, as they define our core capabilities.

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 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 catalogued in our RICE certification documentation that was renewed in April 2021. As a result of SCCOOS listservs (e.g., sccoos@sio.ucsd.edu, CA.HAB.Bulletin@sccoos.org) and social media streams (e.g., Facebook, Twitter), more ocean observing news items are now widely distributed throughout the Regional Associations, the IOOS program office, and the SCCOOS user community.

CLIMATE VARIABILITY AND CHANGE

1. 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.

a. Principal Investigator: Rudnick (UCSD); b. Completion date: TBD - ongoing milestone; c. Status: On-Track d. Successes and Challenges: 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. An achievement of the past year is the 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. The goal is 5 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 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 and in the CalCOFI State of the California Current article.

2. Continue to develop, integrate, and enhance long-term time series products for distribution.

a. Principal Investigator: Anderson (UCSD); b. Completion date: TBD - ongoing milestone; c. Status: On-Track d. Successes: Lead PI C. Anderson, Program Coordinator, Megan Medina, and Data Analyst, Ross Timmerman, published six CA HAB Bulletins during the performance period. Progress with the development of the CA Imaging FlowCytobot (IFCB) network includes virtual, three-day trainings with McLane Research Labs, Inc. for the teams at SIO, USC, SCCWRP, and MBARI. We have successfully deployed an IFCB on the Scripps Pier (on deck in a safe housing with water pumped from the water surface to the instrument). Per State requirements, we installed a sign at Scripps Pier informing the public of the project and its statewide breadth. A second IFCB was deployed subsurface on the Del Mar mooring three miles offshore. Data for both instruments have been successfully brought online in real-time, and we have stood up an instance of the WHOI Dashboard to display imagery on a SCOOS-Axiom URL. During a Del Mar mooring servicing hiatus, the Del Mar instrument was deployed at Scripps Pier for a set of calibration experiments comparing the two IFCBs. Dates have been scheduled in July for UCSB node training and deployment of IFCBs at Newport Beach Pier and Stearns Wharf. [CeNCOOS upcoming deployments: M1 Mooring and Trinidad Pier (or Hog Island Oyster Company)]. HABON funds have also allowed a dedicated staff member and plankton scientist (Dr. Kasia Kenitz) at SIO to focus on machine-learning methods for classifiers and organizing the CA IFCB team members to prepare for 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. 2021, in review). The data management and analysis work is being done in collaboration with WHOI, UCSC, CeNCOOS, and Axiom Data Science to ensure that we co-design and continually improve software in a community-development framework to ensure a HAB Data Assembly Center with maximum flexibility and access for IFCB practitioners in all regions.

COASTAL HAZARDS

1. Shoreline inundation forecast, validation, and dissemination of warnings to select city managers.

a. Principal Investigator: Merrifield/Fedderson (UCSD); b. Completion date: TBD - ongoing milestone; c. Status: On-Track d. 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 of flood occurrence, particularly at Huntington Beach.

2. Expand development and integration of inundation website.

a. Principal Investigator: Merrifield/Fedderson, UCSD; b. Completion date: TBD - ongoing milestone; c. Status: On-Track d. Successes and Challenges: 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.

3. Develop model for Huntington, Imperial Beach, and Malibu inundation sites
a. Principal Investigator: Merrifield/Fedderson (UCSD); b. Completion date: TBD – ongoing milestone; c. Status: On-Track d. Successes and Challenges: We have completed a study that demonstrates how to improve Imperial Beach flood forecasts based on remote sensing of the nearshore to estimate surf zone width. The information is used to account for otherwise unresolved offshore bathymetry. In collaboration with CA State Parks, new field data were collected at Malibu to expand the runup forecast model. Field data collection was limited and delayed due to COVID-19. We are scouting sites for live stream videos for remote inundation validation at the Imperial Beach, Huntington Beach and Malibu sites, and continue to document flood events via in-person validation to improve flood threshold estimates. This information feeds into our new probabilistic assessment of minor and moderate flood risk.

ECOSYSTEMS, FISHERIES, AND WATER QUALITY
1. Monitor Harmful Algal Blooms (HABs) at five pier stations by collecting weekly measurements of temperature, salinity, chlorophyll, nutrients, toxins, and potentially harmful phytoplankton species. Provide data online and distribute via the California HABMAP listserv.
a. Principal Investigators: Washburn/Brzezinski (UCSB), Caron (USC), Walter/Pasulka (Cal Poly), Shipe (UCLA), Carter/Anderson/McGowan (UCSD); b. Completion date: TBD - ongoing milestone; c. Status: On-Track d. Successes and Challenges: Weekly measurements of temperature, salinity, chlorophyll, particulate domoic acid, macronutrients, and potentially harmful phytoplankton taxa are distributed via the California HABMAP listserv and are discoverable online via the SCCOOS ERDDAP server. 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. Details for each station follow:

- Cal Poly Pier/Cal Poly: Cal Poly obtained an exemption to continue weekly sampling at the Cal Poly Pier during COVID-19 closures. PIs Walter and Pasulka advised a senior thesis project (current undergraduate assistant,Nicholas Soares) comparing phytoplankton community composition from the Cal Poly Pier with a separate sampling site, funded by an internal grant, in Morro Bay. Training has been underway for a new undergraduate sampling assistant (Elysa Romanini) to take over full-time duties this spring/summer. PIs Walter and Pasulka, along with former undergraduate student Alex Barth and Senior Research Scientist Ian Robbins, published a paper in *Marine Ecology Progress Series* (Barth et al., 2020) describing seasonal and interannual phytoplankton variability from a decade of HAB measurements made at this site.
- Stearns Wharf/UCSB: As with other groups, Stearns Wharf pier sampling and sample processing were suspended after 16 March 2020 due to COVID-19 safety restrictions. Weekly sampling and sample processing restarted on 13 July 2020 and have continued unabated through the present time (21 June 2021). Fabrication of a SPATT bag deployment system (for passive collection of a full suite of harmful algal toxins) restarted in August 2020 with weekly SPATT bag deployment commencing on 17 November 2020 and continuing through the present.
- Santa Monica Pier/UCLA: Santa Monica Pier access was restricted over long holiday weekends in late December 2020 and mid January 2021 due to COVID-19 pandemic conditions. Samples were acquired a day later than scheduled during those periods. Weekly sampling has since resumed; samples have been partially processed at a remote/home location, and full analyses occur every other week at the university laboratory.
- Newport Beach Pier/USC: As with other pier sampling efforts, sampling at Newport Beach was shutdown beginning in mid-March 2020 due to COVID-19. The pier itself was closed to the public for some time, and USC policy curtailed all sampling at the pier and sample processing in the lab through 15 June 2020. On-campus research activities were restarted at USC the week of June 15th, and sampling at the Newport Beach pier restarted on June 22nd. Weekly sampling at the pier has continued unabated through the present time (31 May 2021). Two manuscripts were recently

published that were, in part or entirely, a result of samples and data collected at Newport Beach Pier: Busch et al., 2019 and Smith et al., 2019.

- Scripps Pier/SIO: SIO obtained an exception to continue weekly sampling throughout the UCSD campus closure. Efforts to minimize time on campus from 18 March 2020 through 30 November 2020 included freezing chlorophyll samples for subsequent analysis and deferring cell counts. Since the campus closure, Scripps Pier data have not been uploaded to the SCCOOS ERDDAP server due to limited personnel and time on campus. These will be uploaded as soon as feasible and an NCE was approved to fulfill these objectives. Deployment of SPATT was planned for March 2020 and was delayed due to COVID-19 campus restrictions. The SPATT rig was deployed 18 June 2020, and weekly samples are currently being collected for analysis of dissolved algal toxins in the environment. A long term collaboration with Kerri Danil at NOAA/SWFSC and other marine mammal researchers led to an 18 year synthesis paper by Danil et al., 2021, published in *Harmful Algae* on algal toxins and cetacean exposure for southern California. This research utilized weekly cell counts and domoic acid concentrations since 2008. Collaborations with Jules Jaffe, Peter Franks, Andrew Barton, and staff scientist, Kasia Kenitz, utilizing the Scripps Pier Plankton Camera and weekly cell counts led to the following paper by Kenitz et al., 2020 published in *Limnology and Oceanography*. Collaboration with Carl Carrano at San Diego State University and graduate student Kuyoko Yarimizu contributed to an investigation on the role of bacteria in iron and bloom dynamics. This research utilized weekly chlorophyll and cell counts and led to the publication by Yarimizu et al., 2019 published in *BioMetals*. Collaboration with Jeff Bowan, Jens Műhle, and postdoctoral researcher, Jesse Wilson, led to the following paper by Wilson et al., 2020 on trace gases and eukaryotic plankton at Scripps Pier.

Data Manager, Vicky Rowley, upgraded, standardized, and automated the weekly acquisition and distribution of HAB data from eight collection sites and transformed the data to make them available via the SCCOOS ERDDAP server. We are working to ingest HABMAP data collected from Bodega Pier soon, completing the ingestion of all HABMAP sites with service via ERDDAP. HABMAP information, products, and data are available on the SCCOOS HABMAP page and the jointly operated UCSC- and SCCOOS- HABMAP site. In addition, a Darwin-Core standardized version of these data are now served on ERDDAP to facilitate their submission to global biological data repositories such as MBON and OBIS thanks to Matt Howard Memorial supplemental funding from IOOS. This EML to ERDDAP to OBIS workflow will be fully automated by an NSF Environmental Data Initiative (EDI) intern working at SCCOOS during summer of 2021.

2. Continue to collect California Cooperative Oceanic Fisheries Investigations (CalCOFI) observations and measurements.
a. Principal Investigator: Goericke (UCSD); b. Completion date: TBD - ongoing milestone; c. Status: On-Track d. Successes and Challenges: 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. CalCOFI completed two cruises during this progress period, Jan 15, 2021 to February 5, 2021 and May 4, 2021 to May 15, 2021 and covered all SCCOOS stations.

3. Conduct shipboard observations with CalCOFI and NMFS Rockfish Recruitment and Ecosystem Assessment Survey (RREAS); count seabirds; post data reports and data online.
a. Principal Investigator: Sydeman (Farallon Institute); b. Completion date: TBD - ongoing milestone; c. Status: On-Track d. Successes and Challenges: The summer (July, 2020) CalCOFI was cancelled due to COVID concerns, but we participated in the winter (January 2021), and spring (April, June 2021) RREAS surveys. We have continued to emphasize DMAC during this period of uncertain fieldwork, and, in particular, are working to implement new statistically derived data products to be shared with the IOOS community. One of these newly derived products will include a dataset of time series of 20 species' densities by season for the period May 1987-present. Also, working with NOAA's Environmental Research Division we posted the seabird dataset on the ERDDAP (data access portal) for the benefit of the marine science community. Finally, we are working with collaborators from NMFS, Chapman University, and others on a manuscript investigating the effects of climate change and fisheries on range shifts of seabirds from the subtropics into the California Current. This investigation focuses on several species whose distributions have shifted from the Mexican Pacific and Gulf of California into the Southern California Bight.

4. Publish survey reports and maps of seabird and marine mammal species distribution and abundance on the SCCOOS website.
a. Principal Investigator: Sydeman (Farallon Institute); b. Completion date: TBD - ongoing milestone; c. Status: On-Track d. Successes and Challenges: Survey reports and maps of species distribution and abundance are published on SCCOOS website - Seabird and Marine Mammal page.

5. Display the 3-km ROMS ocean forecasting system for real-time operations statewide.
a. Principal Investigator: Chao (UCLA); b. Completion date: TBD - ongoing milestone; c. Status: On-Track d. 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. In July 2020, we replaced the aging computers used to run this quasi-operational model. With assistance from essential on-site personnel we were able to install the new ROMS hardware at Scripps Institution of Oceanography. The model is now running on enterprise-level server hardware at SIO and the data are now available on the SCCOOS ERDDAP and THREDDS servers.

6. Validate the 3-km CA ROMS output against non-assimilated observations.
a. Principal Investigator: Chao (UCLA); b. Completion date: TBD - ongoing milestone; c. Status: On-Track d. Successes and Challenges: 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. As the new SCCOOS 3-km ROMS is developed, we plan to display these real-time model validation results on that web page. Operational impacts due to COVID-19: Minimum to none. Most of our work is being performed remotely, so there has been little impact on our 3-km ROMS modeling effort.

7. ROMS High-Resolution Shelf and Nearshore model developed to aid the evaluation of the effects of nutrient inputs on bloom formation and nutrient cycles.
a. Principal Investigator: McWilliams (UCLA); b. Completion date: TBD - ongoing milestone; c. Status: On-Track d. 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. Funding for much of this work is provided by various extramural grants from the California Ocean Protection Council, NOAA, and UCLA. SCCOOS funds contribute to general model development and system maintenance but do not currently support additional product dissemination or development.

8. Continue automated shore sampling at four stations to measure temperature, pressure, salinity, chlorophyll, as well as DO and pH at Newport Beach Pier and pH at Scripps Pier.
a. Principal Investigators: Carter/Giddings/Anderson/Terrill (UCSD); b. Completion date: TBD - ongoing milestone; c. Status: On-Track d. Successes and Challenges: The automated shore stations program operates and maintains four stations (Scripps Pier, Newport Pier, Santa Monica Pier, and Stearns Wharf) and provides real-time, continuous data at four-minute intervals with limited interruptions. Automated shore station 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 Automated Shore Station (SASS) 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 2021 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 in years past and then reinstated with City of LA funding. However, funding from the City of LA Sanitation/Hyperion Water Reclamation Plant, The Bay Foundation, and The Los Angeles Waterkeeper for the Santa Monica Pier shore station ended on 31 July 2019 and has not been renewed at this time. Due to COVID-19 and possible city and state budgetary challenges, this funding may not be renewed in the future. Since December 2019, SIO has maintained this station without funding and PIs are working to keep this site online at the expense of other goals for this project; in the FY21-26 funding cycle, we expect to fund a PI at Cal State Northridge to assist with maintaining the Santa Monica Pier shore station.

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 helpget 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 data sets for student projects. SIO and UCSD classes include SIO221, SIO210, SIO101, SIO87, and MAE3.

9. SeapHOx mini-mooring operations at Carlsbad Aquafarm (CAF)
a. Principal Investigator: Martz (UCSD); b. Completion date: TBD – ongoing milestone; c. Status: On-track d. Successes and Challenges: Since 2019, the Martz lab has operated 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 currently 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 ed 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. As of June 2021, the sensor package is awaiting further shoreside tank tests before the next deployment. 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.

10. Drivers of Primary Productivity of the Shelf and Nearshore Region
a. Principal Investigators: Davis (UCI), Lucas/ Send (UCSD); b. Completion date: 1 May 2021; c. Status: Completed d. Successes and Challenges: This was originally a one-year project to demonstrate an observing approach for nutrient flux triggers of phytoplankton blooms in shelf and nearshore waters in Southern California, that was extended into this fiscal year due to COVID-related delays. **Successes:** The successes during the project period include: (1) integration of a SUNA V2 optical nitrate sensor onto the Wire Walker profiler platform that also was equipped with physical, optical, (2)

deployment and maintenance of the Wirewalker mooring near Uwe Send's Del Mar mooring (100 m isobath) for 22 days in late April and May 2020, and 3) deployment of both a Wirewalker mooring at 50 m depth and a "mini-mooring" in 25 m depth on a line between the Del Mar mooring 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). The observations are still being analyzed by SIO PhD student Bofu Zheng, but show promise in the proposed goal of the program: the assessment of the drivers of nitrate changes on isopycnals, and the corresponding phytoplankton response. The inclusion of subsurface irriadance measurements (included at no cost to the program by PI Lucas) highlighted the co-limitation of the observed phytoplankton concentration by both light and nitrate, allowing, along with the other physical measurements, a reasonably complete picture of the interplay of physical and biogeochemical processes in controlling primary productivity. **Challenges:** Most of the challenges in the program derived from COVID-related delays. Work on the initial integration of the SUNA V2 was delayed by a month because PI Davis was unable to recover a SUNA V2 from a field experiment in Panama due to COVID-19 related travel restrictions. As a work-around solution, a SUNA V2 was borrowed from a colleague (Dr. Erika McPhee-Shaw) allowing work to continue. 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.

MARINE OPERATIONS

1. Annually provide training to first responders of maritime incidents in the use of SCCOOS products.

a. Principal Investigators: Walter (Cal Poly), Washburn (UCSB), Heidelberg (USC), and Terrill (UCSD) b. Completion date: TBD - ongoing milestone; c. Status: On-Track d. Successes and Challenges: SCCOOS participates in training and science education to a broad range of stakeholders either by request or as opportunity arises. Dr. Angelica Rodriguez presented on behalf of SCCOOS, CDIP and CCCIA on 3 June 2020 at the Ports of Los Angeles and Long Beach/ Harbor Safety Committee Meeting. Dr. Rodriguez spoke on issues surrounding ports and sea level rise, inundation and data/model products that support maritime transport. The new Captain of the Port, Captain Ore, was impressed by the presentation and sea level rise research in the region. We want to emphasize thatSCCOOS and CDIP staff regularly attend both the Port of San Diego and LA/LB Harbor Safety Committee Meetings. SCCOOS and CORDC staff attend and present at the routine US Coast Guard Area Committee Meetings, informing teams of USCG and CA OSPR staff about the HFR data products and their use in SAROPS and GNOME model systems. The spring meeting was cancelled due to COVID-19, but a virtual meeting was held in July 2020.

2. Operate and maintain a network of short, medium, and long-range HF radar systems and deliver data streams to the National HFR Network.

a. Principal Investigators: Walter (Cal Poly), Washburn (UCSB), Heidelberg (USC), and Terrill (UCSD); b. Completion date: TBD - ongoing milestone; c. Status: On-Track d. Successes and Challenges:

- Cal Poly: Cal Poly maintained an exemption to continue accessing field sites during COVID-19, although some on-campus work has been limited by in-person restrictions. Additionally, accessing field sites has been limited to a single researcher per vehicle. Diablo Canyon's solar batteries were all recharged and maintained to maximize their lifespan. The Diablo Canyon SR site has been intermittently losing power and we are sending the unit into CODAR and hope to have it operational again by July. The Point San Luis site (LUIS) received a new TX power supply. A new computer was installed at ESTR. We completed a frequency test at Fallback 22, on Vandenberg Air Force base, which involved installing a dome antenna and running the site at 16 MHz for 24 hours. We replaced the TX antenna after returning the site to its original broadcast frequency following the frequency test. An ethernet power controller and computer were replaced at PTC1. ARG1 was brought back online after RX repairs at CODAR and a new GPS antenna

was installed. AGL1 needed a new AC unit, and all four locks were replaced on the enclosure. All other Cal Poly sites were maintained in a manner that maximizes their uptime and lifespan. Ongoing student research using HF-Radar data has been focused on circulation patterns and upwelling jet formation near San Luis Obispo Bay under various wind-driven upwelling regimes. One student submitted their senior thesis in December 2020 looking at seasonal and conditionally averaged upwelling circulation patterns, and this work was submitted to *Continental Shelf Research* in February for peer-review. Another student will be completing their senior thesis in June 2020, looking at upwelling circulation spin-up and particle tracking in and around SLO Bay. Moreover, several students have been contributing to a public information display that will be installed at the Point San Luis site later in the summer. Outside of COVID-19 related restrictions and challenges, we have been working to get our new combined antenna up at PTC1, where we have had to go through environmental and cultural permitting. We anticipate we will have approval for this in the next month or so.

- UCSB: A continuing challenge since mid-March 2020 has been the ramp-down of research at UCSB due to the COVID-19 pandemic. This situation has improved over the last six months as COVID-19 restrictions have lessened in Santa Barbara county. Another major factor is that all lab personnel have now been vaccinated and are beyond the one-month period since the second vaccine dose. This has eased UCSB's restrictions, and carpooling by technicians is now permitted to reach remote HFR field sites. We are now able to have three people in the lab subject to mandatory mask wearing and social distancing. HFR sites at Navy installations remain inaccessible, and these include Pt. Mugu (PTM), San Nicolas Island (SNI1), and Santa Cruz Island (SCI1). We have not been able to communicate with our contacts at these sites despite repeated attempts. COVID-19 restrictions may be the cause of the lack of communication. We continue to use the Automated Identification System (AIS) and ships of opportunity to make APMs at these sites. We have resumed drone-based APM's, and team member, Eduardo Romero, has made four during this reporting period (twice at SSD1; once each at COP1 and RFG1).

  We are still awaiting delivery of new batteries that will be installed at the Mandalay site (MGS). The batteries have been on-order for many weeks due to supply chain issues. As previously reported, technicians David Salazar and Eduardo Romero continue to perform maintenance procedures on the aging trailer to protect it from the local marine environment and extend its life. We have continued our collaboration with the Channel Islands National Marine Sanctuary (CINMS), the National Park Service, and the Anthropocene Institute to establish a new radar site on Anacapa Island. A recent development has been the writing of a proposal describing the solar power system for the M2 radar for CINMS, and the HF radar for SCCOOS on the island. Washburn and Brian Emery participated in writing the proposal.

  As part of a NSF-funded project, Emery led a field experiment using drifters released along the arc of a range cell to compare drifter-based and HFR-based radial currents. Carter Ohlmann and Salazar deployed drifters along the range cell from a research launch. The experiment went well and more experiments will be conducted to capture a variety of radial flow patterns. Results from the experiments will inform bearing-error estimates and may assist in the assimilation of radial currents into models such as WCOFS. The field experiment was conducted offshore of SSD1 using a newly modified co-located 13.5 MHz SeaSonde. This radar was installed by Romero. A second receiver and receiver antenna were also installed to enable experimentation with what we hope will function as a six-channel system.

  Challenges: As reported previously, many of UCSB's radar systems and ancillary equipment are old and require frequent maintenance procedures and repairs. Romero and Salazar continue to perform these maintenance procedures to minimize downtime. Another continuing challenge is acquiring new sites and upgrading existing sites to fill gaps in radar coverage. We are investigating a possible site at Hollister Ranch. For example, assuming we can get permission, we are considering replacing the 13 MHz medium-range SeaSonde on Santa Cruz Island (SCI1) with a 5 MHz long-range system. This would expand total vector coverage since it would overlap extensively with the new UCSD site on San Clemente Island (SDSN).
- USC: The university has maintained strict COVID-19 protocols which have severely limited the ability to access field sites and work in close proximity to one another. While the state and county restrictions are easing, the university is continuing to maintain the more limiting policies even with members of the labs having been vaccinated; these restrictions should soon lighten to the point where working closely will be permitted. In January, a wave tore one of the doors on the HF radar cabinet housed at Newport Beach Pier (also affecting SASS operations at this pier). The HF radar electronics including the transmit and receive chassis were damaged by saltwater intrusion and have been sent to the manufacturer for repair. The door has since been modified to increase the ability to handle this type of occurrence in the future, and the communications link restored to provide access to the shore station. The new antenna

and upgraded electronics for the site at Santa Catalina Island (SCCI) were delivered and will be installed once access to the island is restored. The HF radar site was to be reinstalled, however, due to the tightening of COVID-19, restrictions, this has been put on hold until these restrictions are lifted.

- UCSD/SIO: HF sites maintained by SIO continue to be in a good operational state, but, as the network ages, some major repairs were required to extend their lifespan and, in some cases, restore operation. Following COVID-19 response protocol and research ramp up initiative after the ramp down initial effort, UCSD identified the HF Radar sensor network (HFRNet) as an essential and critical activity in support of national and domestic operations. Applications include U.S. Coast Guard response to search and rescue and domestic oil spill response. Safety protocols were established with personal protective equipment (PPE), enhanced cleaning, and appropriate social distancing allowing the University to respond to site maintenance in most areas.

  A new standard range CODAR was installed along the Camp Pendleton coast in late May. This site had been in planning for over six years and included many logistical hurdles, mostly stemming from placing gear on a US Navy facility inside a US Marine Corps base. COVID-19 related delays totaled over 12 months, and included delays due to a change in command during that time which required us to resocialize the project with the new command. Additional testing was required by the facility to make sure our equipment did not interfere with newly acquired gear at the facility. The site fills in the gap of 1km and 2km RTV between San Diego and Newport Beach. Once the Newport Beach site is operational, there will be continuous 2km RTV observations along the entirety of the Southern California Bight.

  Existing sites are still being maintained, albeit not at the same pace as previous years due to COVID-19 restrictions. Some highlights include: 1) Replacement of electrical infrastructure at the Border Field CODAR site. An older transformer had malfunctioned and was replaced with a new unit, and general wiring was improved. 2) Replacement of a burnt out tuning coil on the Scripps Long-range Transmit antenna.

  Challenges: SCCOOS operators continue to identify possibilities for funding recapitalization of network hardware. *Many of the oldest HFR systems in the IOOS network are located in California*. SCCOOS and CeNCOOS jointly operate about 60 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. This funding could be spread over multiple years. Operators are identifying high-priority repairs using IOOS "fill the gaps" funding, which will keep the network operating in the near term.

3. 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.
a. Principal Investigators: Anderson (UCSD) Behrens (UCSD/CDIP); b. Completion date: TBD - ongoing milestone; c. Status: On-Track d. 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.

4. Deliver surface current data to aid spill response, SAR real-time recovery, and post analysis trajectories.
a. Principal Investigators: Walter (Cal Poly), Washburn (UCSB), Heidelberg (USC), and Terrill (UCSD); b. Completion date: TBD - ongoing milestone; c. Status: On-Track d. Successes and Challenges: SCCOOS and CeNCOOS HF radar participants have hosted collaborative outreach discussions to foster informative exchanges with users/stakeholders of the HF Radar derived surface currents and radial vectors. Recent meetings included topics such as: forecasting and modeling availability in the U.S. Coast Guard SAROPS application with Dr. Cristina Forbes; initiatives in coastal modeling assimilation with Dr. Chris Edwards (UCSC) and Marine Protected Area research with CeNCOOS- and SCCOOS-supported fellows; and data availability, limitations, and opportunities for the U.S. Olympic sailing team as they plan for 2028 Olympics in Long Beach, CA. Near real-time surface current measurements continue to be available for integration into common operating systems via NOAA National Data Buoy Center (NDBC) and the Coastal Observing Research and Development Center (CORDC) at Scripps. These data allow for harvesting, redistribution, and visualization. NOAA CoastWatch has integrated the data sets into their ERDDAP server allowing alternate access for data downloads and visualization in multiple formats - example of the West Coast 6km data here. Data are also archived with NDBC's National Centers for Environmental Information (NCEI).

5. Provide HF Radar Quality Control Development.
a. Principal Investigator: Washburn (UCSB); b. Completion date: TBD - ongoing milestone; c. Status: On-Track d. Successes and Challenges: A primary goal of this project is to allow HF radar operators to quickly evaluate the consistency of radial currents measured by different radars. Work during the most recent reporting period was focused on improving the core software toolbox on which the QA/QC comparison website is built. The code calculates two types of radials for QA/QC evaluation: (1) over-water baseline radials from two radars and (2) synthetic radials formed by two radars for comparison with radial currents from a third radar. This approach provides critical tests on the consistency of radial currents measured by different radars. Toolbox improvements will also enable us to more easily operate and maintain the code base while simplifying the incorporation of new sites for the QA/QC website comparisons.

During the previous reporting period we described a significant challenge that prevented the website from operating in real time: the server on which the website and data management code was running reached the end of its life, and building a replacement required significant time, but has now been installed. The new server is now operational and the website and processing code are running on the new server. We are working with a talented undergraduate Computer Science Student in converting the code to Javascript. This student is making excellent progress as described in our weekly lab meetings. The student is implementing 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. While still a work in progress, the improved code is live and viewable at https://hfradar.msi.ucsb.edu/comparisons/. 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.

3) SCOPE OF WORK
SCCOOS operates as a system of partnerships and projects that are facilitated by technical and programmatic staff. Organized by the five 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 (that are now served via the JPL PODAAC), high frequency (HF) radar surface current mapping, and data-assimilative ocean modeling. The projects described in this report represent the highly leveraged, multi-disciplinary, and collaborative efforts of the research teams that contribute data and information to SCCOOS.

4) PERSONNEL AND ORGANIZATION STRUCTURE
SCCOOS governance organization chart can be found on the SCCOOS website - People page as well as a list of governing members and Principal Investigators. Data Manager, Vicky Rowley, leftSCCOOS on 5-May. SCCOOS is contracting with Axiom Data Science (ADS) as of 1 June 2021 for six months, with the option to renew as part of our FY21-26 descope process. Working with ADS will allow us to cost share the operation and maintenance of common core DMAC components with CeNCOOS and leverage Axiom Cyberinfrastructure, as well as create a statewide data portal. We plan to hire a part-time data manager at the SCCOOS program office to help fill in DMAC gaps and liaise with our PIs, ADS, and IOOS PO.

5) BUDGET ANALYSIS
We funded Axiom $80,000 for a six-month contract (1 June 2021 - 31 December 2021) to assume many of our data management needs. We submitted No Cost Extensions to support the SCCOOS program office, educational and outreach supplies, workshops, DMAC activities, and computer and office supplies.

II. PERFORMANCE PROGRESS REPORT ADDENDUM

Not required for performance period December 1, 2020 to May 31, 2021.

III ENVIRONMENTAL COMPLIANCE

1) **First Responder Training**
IOOS/NOAA determined this project has a categorical exclusion, and their statement is as follows:
The aforementioned project will not result in any changes to the human environment. As defined in Section 6.03c3(d), Administrative r Routine Program Functions, of NAO 216-6, this project involves conference room and/or classroom training activities that hold no potential for significant environmental impacts. As such, they should be categorically excluded from the need to prepare an Environmental Assessment or an Environmental Impact Statement.

2) **Gliders**
IOOS/NOAA determined this project has No Significant Impact, and their statement is as follows:
It has been determined that this proposed activity is described in the Final U.S. IOOS Programmatic Environmental Assessment, dated June 2016. The action is covered by the analysis within the U.S. JOOS Program PEA and the signed U.S. IOOS Finding of No Significant Impact. The project and its potential impact may be limited through terms or conditions placed on receipt of NOAA funds. The action requires no further environmental review.

3) **Shore Stations**
IOOS/NOAA determined this project has No Significant Impact, and their statement is as follows:
It has been determined that this proposed activity is described in the Final U.S. IOOS Programmatic Environmental Assessment, dated June 2016. The action is covered by the analysis within the U.S. JOOS Program PEA and the signed U.S. IOOS Finding of No Significant Impact. The project and its potential impact may be limited through terms or conditions placed on receipt of NOAA funds. The action requires no further environmental review.

4) **Vessel Sampling – CalCOFI**
IOOS/NOAA determined this project has No Significant Impact, and their statement is as follows:
It has been determined that this proposed activity is described in the Final U.S. IOOS Programmatic Environmental Assessment, dated June 2016. The action is covered by the analysis within the U.S. JOOS Program PEA and the signed U.S. IOOS Finding of No Significant Impact. The project and its potential impact may be limited through terms or conditions placed on receipt of NOAA funds. The action requires no further environmental review.

5) **Mooring**
IOOS/NOAA determined this project has No Significant Impact, and their statement is as follows:
It has been determined that this proposed activity is described in the Final U.S. IOOS Programmatic Environmental Assessment, dated June 2016. The action is covered by the analysis within the U.S. JOOS Program PEA and the signed U.S. IOOS Finding of No Significant Impact. The project and its potential impact may be limited through terms or conditions placed on receipt of NOAA funds. The action requires no further environmental review.

The project and its potential impact may be limited through the following terms or conditions placed on receipt of NOAA funds:

- A permit is in place to allow the mooring to reside in its location: 1) Aid to navigation application; 2) Aid to navigation addendum; and 3) FCC Experiment License valid until 2017. The applicant must provide copies of these permits to the I OOS Office for the EC File of Record prior to undertaking the Del Mar Mooring Activities under the subject award.
- SCCOOS has implemented the Essential Fish Habitat Conservation Recommendations provided by NMFS on July 7, 2014 to avoid, minimize, or offset effects of this activity.

David Gassier, 9500 Gilman Drive, 0230, La Jolla, CA 92093-0230

United States of America
FEDERAL COMMUNICATIONS COMMISSION
EXPERIMENTAL
RADIO STATION CONSTRUCTION PERMIT
AND LICENSE

EXPERIMENTAL	WI2XAA
(Nature of Service)	(Call Sign)
XR FX	0539-EX-PL-2015
(Class of Station)	(File Number)

NAME Scripps Institution Of Oceanography

Subject to the provisions of the Communications Act of 1934, subsequent acts, and treaties, and all regulations heretofore or hereafter made by this Commission, and further subject to the conditions and requirements set forth in this license, the licensee hereof is hereby authorized to use and operate the radio transmitting facilities hereinafter described for radio communications in accordance with the program of experimentation described by the licensee in its application for license.

Operation: In accordance with Sec. 5.3(d) of the Commission's Rules

Station Locations

(1) Santa Barbara Channel, within 32 km, PC - NL 34-18-31; WL 120-48-15
(2) Pacific Ocean,, within 32 km, PC - NL 33-31-41; WL 122-30-15
(3) Pacific Ocean, within 32 km, PC - NL 32-55-48; WL 117-18-57

Frequency Information

Santa Barbara Channel, within 32 km, PC - NL 34-18-31; WL 120-48-15

Frequency	Station Class	Emission Designator	Authorized Power	Frequency Tolerance (+/-)
161.975-162.025 MHz	FX	25K0F1D	12.5 W (ERP)	0.00015 %

Pacific Ocean,, within 32 km, PC - NL 33-31-41; WL 122-30-15

Frequency	Station Class	Emission Designator	Authorized Power	Frequency Tolerance (+/-)
161.975-162.025 MHz	FX	25K0F1D	12.5 W (ERP)	0.00015 %

This authorization effective November 09, 2017 and will expire 3:00 A.M. EST November 01, 2019

FEDERAL COMMUNICATIONS COMMISSION

Frequency Information

Pacific Ocean, within 32 km, PC - NL 32-55-48; WL 117-18-57

Frequency	Station Class	Emission Designator	Authorized Power	Frequency Tolerance (+/-)
161.975-162.025 MHz	FX	25K0F1D	12.5 W (ERP)	0.00015 %

Special Conditions:

(1) The occupied bandwidth of the emission shall not extend beyond the band limits set forth above.