U.S. Integrated Ocean Observing System (IOOS) Implementation
Southern California Coastal Ocean Observing System (SCCOOS)
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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 capabilities to support short-term decision-making and long-term assessment by implementing and leveraging biological, chemical, and physical observations and models, many of which are available in near real-time. SCCOOS' priorities and objectives are aligned with the seven societal goals as outlined in the IOOS Summit Report. The focus themes, as designated by IOOS, highlight these priorities and are designed to improve safety, enhance the economy, and protect our environment.

- **Coastal Hazards:** to provide accurate, validated inundation models and information with the long-term goal of improving coastal safety.
- **Ecosystems and Climate:** to monitor ocean climate trends and environmental changes in the Southern California Bight by collecting physical, chemical, and biological data.
- **Marine Operations:** to advance integrated, customized products that are critical for safe and efficient navigation, search and rescue, and oil spill response.
- **Science Education and Communication:** to provide visualizations and resources for the public to learn, educate, and promote scientific research using data obtained from SCCOOS.
- **Water Quality:** to provide monitoring, tracking, and prediction tools for harmful algal blooms, outfall and storm water plumes, and surf zone contaminants.

2) PROGRESS AND ACCOMPLISHMENTS

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 actively participates in IOOS Data Management 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). SCCOOS leverages the Coastal Data Information Program (CDIP), the HF Radar National Network programs (HFRnet), the California Underwater Glider Network (CUGN), data from automated shore station sensors and manual measurements of physical, chemical and biological parameters related to ocean acidification. SCCOOS utilizes both THREDDS and ERDDAP to facilitate distribution of most of these datasets. SCCOOS also continues to implement QARTOD data quality control standards for all parameters for which QARTOD exists, including the recent chlorophyll fluorometry QARTOD manual. All data have associated ISO 19115 compliant metadata.

As a result of SCCOOS listservs 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 centers.
   a. Completion date: TBD - ongoing milestone

b. Status: On-Track

c. Successes: The principal investigator has added an oxygen sensor (SBE63) to the glider fleet. New procedures for *in situ* and lab calibration have been implemented. Real-time data are delivered to the ERDDAP, then to the national glider DAC, and then onto the GTS. Delayed mode, quality controlled data including temperature, salinity, depth-averaged velocity, time, latitude, longitude, where/depth and profile ID are available for download at spraydata.ucsd.edu.

There are three Spray underwater gliders off the coast of California at all times sending back data on temperature, salinity and ocean currents. These missions are funded through IOOS and the NOAA Climate Program Office/Ocean Observing and Monitoring Division. The data are assimilated into regional circulation forecasts. These models are used by a variety of end-users and are crucial to predicting circulation patterns relevant to fisheries and oil spill response. An alongshore glider line has been occupied continuously since January 2019. The Fill the Gaps funding will allow this line to be sustained for a year. In addition, following the winter PI meeting, a new glider page (http://sccoos.org/gliders/) was developed with background information and links to access the data.

2. Continue to develop, integrate, and enhance long-term time series products for distribution.
   a. Completion date: TBD - ongoing milestone
   b. Status: On-Track
   c. Successes: Lead Co-PI C. Anderson spearheaded the California HAB Bulletin that is hosted on the SCCOOS website (sccoos.org/california-hab-bulletin/). The CA HAB Bulletin synthesizes model output, near real-time observations, and public health alerts to provide a more complete picture of the regional variability in harmful algal blooms (HABs) to help managers and the public interpret the HAB seascape on a monthly basis. The bulletin is a synergistic collaboration between federal-state-academic-private groups actively engaged in contributing data or model output: SCCOOS and CeNCOOS California Harmful Algal Bloom Monitoring and Alert Program (HABMAP) monitoring data, monthly means and GIFs of California Harmful Algae Risk Mapping (C-HARM) predictions, California Department of Public Health (CDPH) Marine Biotoxin Quarantines and Health Advisories, CDPH percent composition of *Pseudo-nitzschia spp*. and *Alexandrium spp.*, and marine mammal and seabird strandings due to suspected domoic acid from The Marine Mammal Center (TMMC), the Marine Mammal Care Center – Los Angeles (MMCC-LA), Marine Animal Rescue (MAR), California Wildlife Center (CWC), the Pacific Marine Mammal Center (PMMC), and SeaWorld.

Coastal Hazards

1. Drivers of Primary Productivity of the Shelf and Nearshore Region
   a. Completion date: TBD
   b. Status: On-Track
   c. Successes: The work proposed here aims to demonstrate an observing approach for nutrient flux triggers of phytoplankton blooms in shelf and nearshore waters in Southern California, by carrying out a limited-time observational campaign in the San Diego region. The proposing team consists of PIs Kristen Davis, UCI, Andrew Lucas, UCSD, and Uwe Send, UCSD. The project leverages existing moorings (at two outfalls of San Diego Wastewater Treatment Plants (SD WWTP), and Uwe Send's Del Mar mooring), adds two new platforms, and seeks to:
      1. Provide temporally well-resolved measurements of cross- and alongshore fluctuations of in situ measured nitrate concentration on isopycnal surfaces.
      2. Assess biological response to measured nitrate fluctuations through in situ bulk parameters such as chlorophyll fluorescence and backscatter.
      3. Show proof-of-concept of the combination of traditional and profiling moorings in observing bloom initiation, persistence, and distribution.

4. Connect and contrast these natural drivers of bloom initiation via inorganic nutrients with anthropogenic organic nutrient inputs from effluent discharge at local outfalls by using the combination of nitrate and chromophoric dissolved organic material (CDOM) sensors.

This is a one-year demonstration project. The PI's received the funds in September 2019 and are preparing to deploy the DTS system in 2020.

2. Shoreline inundation forecast, validation, and dissemination of warnings to select city managers.
   a. Completion date: TBD - ongoing milestone
   b. Status: On-Track
   c. Successes: Emails are sent to the City of Encinitas when the Cardiff flood index shows potential flooding events three days in advance.

   Imperial Beach flooding forecasts have been made available to city officials and the public via the SIO Center for Climate Change Impacts and Adaption (CCCIA) Resilient Futures project (https://climateadapt.ucsd.edu/imperialbeach/forecast/). Accurate forecasts this past January 2019 were instrumental in alerting Imperial Beach city officials to expected flooding several days earlier than traditional models had predicted (https://www.sandiegouniontribune.com/news/environment/sd-me-imperial-beach-scripps-flooding-20190117-story.html).

3. Expand development and integration of inundation website.
   a. Completion date: TBD - ongoing milestone
   b. Status: On-Track
   c. Successes: Surveys of sand levels on beaches and storm inundation monitoring at select locations have been used to validate and refine coastal data and forecast models of erosion and flooding. Accurate inundation levels can potentially be used to manage and protect beaches, real estate, and highways. Initial flood forecasts were based on the tide, wave height, and wave period. The resulting water level predictions are generally lower than those from previous models, but are expected to be more representative of the actual water levels observed at the coast. The CDIP Cardiff website water levels were updated to include mild and moderate flood thresholds (http://sccoos.org/data/flooding-storm-surge-models/#a).

   As part of its Resilient Futures project, the SIO Center for Climate Change Impacts and Adaption (CCCIA) has teamed with the Imperial Beach community with support from the David C. Copley Foundation and SCCOOS to upgrade the city's flood alert capabilities and to develop tools to better prepare stakeholders for sea-level rise. The dedicated observing network and modeling system will provide the information needed for accurate, early flood warnings for vulnerable locations throughout the city, as well as the baseline information needed to develop and evaluate future sea-level rise adaptation strategies. The Imperial Beach website has been developed on the SCCOOS website (http://sccoos.org/imperial-beach-flood-forecasts/) for presentation of historical, current, and forecast conditions.

   Comprehensive field observations at Imperial Beach from an energetic storm, including wave buoy and current meter measurements of the incident wave conditions, and LiDAR and pressure sensor measurements of runup were obtained this past 18-21 January 2019 and have been used to validate and improve wave and water level forecasts, nowcasts, and hindcasts. Updated water level forecasts now incorporate current beach profiles and an improved runup parameterization. (https://climateadapt.ucsd.edu/imperialbeach/forecast/).

   Observations of offshore incident wave conditions and resulting runup and overtopping will continue at Imperial Beach through the 2019-2020 winter season. Results will be used to further test, calibrate, and improve models to predict flooding and inundation.

A prototype Cardiff Coastal Hazard Website analogous to the Imperial Beach website was developed and HTML code for the site was passed to SCCOOS in July. SCCOOS then converted the HTML to develop the new Beach Erosion and Inundation page (http://sccoos.org/beach-erosion-inundation/) that includes Imperial and Cardiff Beach historical, current and forecast conditions. Updated water level forecasts based on the improved runup parameterization developed at Imperial Beach are being tested at Cardiff. Work to standardize and improve the online portal for public access to the coastal hazard model products will continue.

4. Develop model for Huntington and Imperial Beach inundation sites
   a. Completion date: TBD – ongoing milestone
   b. Status: On-Track
   c. Successes: In order to provide the public and beach managers with an assessment of how various processes combine to cause coastal flooding, total water level for extreme historic events at Imperial Beach have been deconstructed to quantify relative contributions from tides, nontidal residual sea level, and wave runup. Examples of these extreme water level products are available at the Imperial Beach CCCIA Resilient Futures website (http://resilientib.ucsd.edu/pastevents.html). The website continues to be populated with products and updated based on city managers feedback on website content.

   At Cardiff the relative contributions to the total water level from the tide, nontidal residual sea level, and wave runup for extreme historic events have also been determined and will be available from the coastal hazard website. This information is being used to develop extreme water level statistics and return periods specific to this location. Historic beach profiles and widths have also been formatted for the Cardiff Coastal Hazard website.

   A template based on the Imperial Beach and Cardiff Coastal Hazard websites has been developed and will be used to expand to other coastal sites in the region.

Ecosystems, Fisheries, and Water Quality

1. Monitor Harmful Algal Blooms (HABs) at five pier stations by collecting weekly measurements of temperature, salinity, chlorophyll, nutrients and potentially harmful phytoplankton species. Provide data online and distribute via the California HABMAP listserv.
   a. Completion date: TBD - ongoing milestone
   b. Status: On-Track
   c. Successes: SCCOOS Program Coordinator, Megan Hepner, developed a new HABs page on the SCCOOS WordPress website and. interactive Shiny app that includes observations from the seven Harmful Algal Bloom Monitoring Alert Program (HABMAP) stations, including Central and Northern California (CeNCOOS) stations. Data manager, Vicky Rowley, also worked closely with personnel at UCSC to rebuild the HABMAP site to complement and be maximally compatible with the new SCCOOS HAB website. SCCOOS and CeNCOOS HABMAP PI's met in September to standardize the sampling protocols and reporting format to be ingested in ERRDAP. Vicky is working with the SBC-MBON program and CeNCOOS to convert files to Darwin Core formats. HABMAP PI's also discussed the protocol for sampling with Solid Phase Adsorption Toxin Tracking (SPATT), a robust HAB toxin detection tool, at four of SCCOOS HAB piers. SPATT has been deployed at Santa Cruz Wharf since 2012 and with IOOS Fill the Gap Funds SPATT will be deployed at Scripps Pier, Newport Pier, and Stearns Wharf in 2020. Training staff on SPATT deployment is expected to begin January 2020.

   Weekly reports of HAB species and related water quality measurements are provided to the California HAB Monitoring and Alert Program (HABMAP) and the California Department of Public Health (CDPH). *Pseudo-nitzschia* blooms that produce domoic acid are being monitored as part of ongoing

observations. The Caron lab at the University of Southern California (USC) is responsible for the analysis of domoic acid from the seven HABMAP monitoring sites, and the Brzezinski lab at the University of California, Santa Barbara is responsible for organizing the macronutrient analysis (NO_3, NO2, PO4, $Si(OH)_4$) with the UCSB Marine Science Institute Analytical Laboratory. The SCCOOS HAB program contributes to the statewide HABMAP program initiated by NOAA, the California Ocean Science Trust, and the Southern California Coastal Water Research Project (SCCWRP). The HABMAP program generates a baseline time series of HABs, nutrients, and water quality to monitor ocean conditions in the very near shore zone. These measurements are used to validate the California-Harmful Algae Risk Mapping (C-HARM) forecast model system for short-term warnings. They also increase our knowledge of the sign, frequency, and magnitude of variation of temperature, salinity, density, nutrients and pollutants.

2. Continue to collect California Cooperative Oceanic Fisheries Investigations (CalCOFI) observations and measurements.
   a. Completion date: TBD - ongoing milestone
   b. Status: On-Track
   c. Successes: 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 online (https://calcofi.org/). In addition, following the winter PI meeting we developed a new SCCOOS CalCOFI page (http://sccoos.org/calcofi/) with background information and links to access the data.

3. Conduct shipboard observations with CalCOFI and NMFS Rockfish Recruitment and Ecosystem Assessment Survey (RREAS); count seabirds; post data reports and data online.
   a. Completion date: TBD - ongoing milestone
   b. Status: On-Track
   c. Successes: Physical and ecological ocean patterns and processes constitute valuable information for Coastal and Marine Spatial Planning, Marine Protected Area monitoring, and monitoring climate effects on marine ecosystems. Under the auspices of SCCOOS, the California Current Ecosystem Long Term Ecological Research (CCE-LTER) program, and in conjunction with the CalCOFI and NMFS Rockfish Recruitment and Ecosystem Assessment Survey (RREAS), the distribution and abundance of seabirds and marine mammals during two seasons (spring RREAS, and summer CalCOFI) were studied. Survey data reports, including time series plots of species density, are published on the SCCOOS website (http://sccoos.org/seabirds/). The main finding from spring and summer 2019 was a continuing general increase in seabird species with warm-water affinities.

4. Publish survey reports and maps of seabird species distribution and abundance on SCCOOS web site.
   a. Completion date: TBD - ongoing milestone
   b. Status: On-Track
   c. Successes: Survey reports and maps of species distribution and abundance are published on SCCOOS website (sccoos.org/seabirds/).

5. Display the 3-km ROMS ocean forecasting system for real-time operations statewide.
   a. Completion date: TBD - ongoing milestone
   b. Status: On-Track
   c. Successes: 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. In addition to the display at the SCCOOS web site, we are also displaying some static ROMS images (e.g., nowcasts, forecasts and validations) on a group website (http://west.rssoffice.com/).

6. Validate the 3-km CA ROMS output against non-assimilated observations.
   a. Completion date: TBD - ongoing milestone
   b. Status: On-Track
   c. Successes: On a daily basis, we are making on the order of 20 ensemble model forecasts in order to quantify errors. Six hourly nowcasts and 72-hour forecast files are available via OPeNDAP/THREDDS. Three validation products have been developed and are being tested on the PI's website (http://west.rssoffice.com/ca_roms_valid_other?variable=IRsst). On a daily basis, there are on the order of 100,000 satellite SST pixels that are assimilated into ROMS. The RMS difference between the ROMS nowcast and the original satellite SST data is slightly less than 1ºC comparable to the 0.5ºC - 1ºC errors specified for the satellite retrieved SST data. In addition to the assimilated data sets, the ROMS nowcast has been validating against a number of non-assimilated data sets. The results are summarized in Chao et al., 2017.
   d. Challenges: Aging servers continue to be a problem in sustaining this quasi-operational model. This model should be rehosted on production hardware hosted in a production level facility such as the Scripps Institution of Oceanography (SIO) data center.

   The ROMS model is displayed in near-real time on the SCCOOS website (http://sccoos.org/roms-model-output/). In 2020, Rowley and Hepner plan to redesign the ROMS webpage to, making it consistent with other SCCOOS technology pages thereby increasing user visibility.

7. Develop a coupled ROMS/biogeochemical model to aid the evaluation of the effects of nutrient inputs on bloom formation and nutrient cycles.
   a. Completion date: TBD - ongoing milestone
   b. Status: On-Track
   c. Successes: 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 across-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 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 and UCLA. SCCOOS funds contribute to general model development and system maintenance.

8. Continue automated sampling at four shore stations to measure temperature, pressure, salinity, chlorophyll, as well as O2 and pH at one station.
   a. Completion date: TBD - ongoing milestone
   b. Status: On-Track

c. Successes: Thanks to funding from the City of LA/Hyperion Water Reclamation Plant, The Bay Foundation, and The Los Angeles Waterkeeper, the decommissioned Santa Monica Pier shore station came back online on the 16th of October (sccoos.org/data/autoss/). This site is now being serviced by The Bay Foundation and the Los Angeles Waterkeeper. Also, funding by Orange County Sanitation District has allowed for continued collections of oxygen and pH data at the Newport Beach Pier location.

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 4-minute intervals with limited interruptions. Automated shore station data are one of the most requested data sets provided through SCCOOS. These data are used by both the public and local state and research agencies to assess local conditions related to water quality, nearshore processes, population dynamics of coastal species and HABs.

9. Burke-o-lator (BoL) and ACDC field deployment at Carlsbad Aquarium and Catalina Sea Ranch
   a. Completion date: TBD – ongoing milestone
   b. Status: On-Track
   c. Successes: The ACDC unit was deployed alongside a SeapHOx on a small mooring located in the Agua Hedionda Lagoon within ~10 m of the Carlsbad Aquafarm oyster platforms. The SeapHOx was configured to send real-time data, which were integrated into the SCCOOS and ERDDAP data server (http://erddap.sccoos.org/erddap/). Vicky Rowley, Megan Hepner and Phil Bresnahan developed a Shiny app (https://sccoos.shinyapps.io/AHL_Observations/) to display the SeapHOx data on the new Ocean Acidification monitoring page (http://sccoos.org/ocean-acidification/). The SeapHOx successfully delivered data for four months (late Aug to Dec) and will be recovered (along with the internally-logging ACDC) in Dec 2019, with a redeployment planned for Jan 2020. The Burkeolator was recovered and shipped to Tommy Moore at the Northwest Indian Fisheries Commission.

Marine Operations

1. Annually provide training to first responders of maritime incidents in the use of SCCOOS products.
   a. Completion date: TBD - ongoing milestone
   b. Status: On-Track
   c. Successes: SCCOOS participates in training and science education to a broad range of stakeholders either by request or as opportunity arises.

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. Completion date: TBD - ongoing milestone
   b. Status: On-Track
   c. Successes: The live feed of HF radar data is available on the national HFR network for oil and hazardous spill response in the Environmental Response Management Application® (ERMA) map viewer for the southwest region as well as at SCCOOS High-Frequency Radar page (http://sccoos.org/high-frequency-radar/).

   The radar on Santa Catalina Island (SCCI) is still off line. There is an ongoing issue with power as well as damaged transmit/receive cables on the island, which will need to be replaced. The radar at Torrance Beach (SCTB) had to be temporarily removed so the roof on the lifeguard building where it is located could be replaced. Finally, the upgraded radar from Dockweiler Beach (SCDB) was finally delivered. However, when making arrangements to install the upgraded antenna, mount etc., USC was asked about permits. USC is trying to sort out with the LA County Lifeguards which permits are required. This permit may affect the reinstall at SCTB as well.

Cal Poly's nine HF radar sites were calibrated on their yearly schedule and updated to SeaSonde version 8 software and OSX 10.13. Diablo Canyon's solar batteries were all recharged and maintained to maximize their lifespan. The receive antenna at Diablo Canyon LR site was replaced due to a damaged component and will be sent in for repair. A receive cable at Diablo Canyon's SR site was chewed through and needed to be replaced. The receive antenna was replaced at Point San Luis and will be returned for repair. The GPS antenna was replaced at Fallback 22 on Vandenberg Airforce base. Power was restored to Point Arguello LR and SR. The LR site is operational and the SR site hardware was moved to Point Conception to allow for the combine antenna upgrade at that site. The front panel board and ethernet power controller was replaced at Point Conception. All other Cal Poly sites were maintained in a manner that maximizes their uptime and lifespan. We received the combined TX/RX antenna to install at Point Conception, but we are currently waiting for the RX/TX chassis to be upgraded to proceed with the install. Ongoing student research is investigating circulation under various upwelling wind forcing regimes around San Luis Obispo Bay.

Challenges: Efforts continued to identify possibilities for funding from the state of California. 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. California RAs conducted a study of the California portion of the HF radar network to determine needs for maintaining the existing network within operational requirements of NOAA, USCG, the Bureau of Ocean Management, State Agencies, County Sanitation Districts and Public Works, private companies and non-governmental organizations. Results of this study have motivated the efforts by SCCOOS and CeNCOOS to acquire state funding for recapitalizing aging hardware infrastructure of the network. Over 10% of the California network have reached the normal service life of equipment of 20 years, and 65% of the network's sites have been in service over 10 years. The network requires hardening of its existing infrastructure as evidenced by the damage to the NIC1 site from the Woolsey wildfire. Regional climate assessments suggest that wildfire threats will increase into the future. SCCOOS and CeNCOOS operators estimate that $7.5 million is needed to fully recapitalize and bring the network back to its original specifications.

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. Completion date: TBD - ongoing milestone
   b. Status: On-Track
   c. Successes: 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.

4. Deliver surface current data and surface wind analyses to aid spill response, SAR real-time recovery, and post analysis trajectories.
   a. Completion date: TBD - ongoing milestone
   b. Status: On-Track
   c. Successes: Surface current measurements and surface wind analyses are integrated into the General NOAA Operational Modeling Environment (GNOME) for oil spill trajectory analysis. Customized and expanded interactive map displays of wave and surface currents with multi-layered views of observations, nowcasts, and forecasts were developed for Naval Air Systems Command (NAVAIR), at Point Mugu. Progress continued on incorporating HFR sites within the IOOS network into a new QA/QC system. All HFR sites with over-water baselines or coastline sites suitable for producing "synthetic radials" were identified. These developments will be used to improve QA/QC procedures throughout the IOOS network. Implementation of surface currents measured by the SCCOOS HF radar network

are now accessible by U.S. Coast Guard for search and rescue (SAR) applications using their Environmental Data Server.

5. Provide HF Radar Quality Control Development.
   a. Completion date: TBD - ongoing milestone
   b. Status: On-Track
   c. Successes: 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. Code improvements to the toolbox were tested on data sets that we have developed for objectively evaluating the performance of different HF radar processing techniques. These techniques include alternate methods for direction-finding methods and signal detection. A goal of this analysis is to see if alternate direction-finding methods are superior to the commonly used MUSIC algorithm.

   In addition to the code development, a plan was formulated, based on user feedback, to improve web site usability and make the website more interactive, with user-changeable date ranges in the viewing window and the ability to download data appearing in the viewing window.

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 (served via the PODACC), high frequency (HF) radar surface current mapping, and data-assimilative ocean modeling. The projects described in this report represent the multi-disciplinary and collaborative efforts of the research teams that contribute data and information to SCCOOS.

4) PERSONNEL AND ORGANIZATION STRUCTURE

Extramural funding from the Ocean Protection Council to work with CeNCOOS on MPA data and model synthesis will fund a new postdoctoral fellow, Florybeth La Valle, to start work at SCCOOS and California Sea Grant in February 2020. SCCOOS and CA Sea Grant will cost share the fellow for a maximum of two years support.

5) BUDGET ANALYSIS

FY 2019, SCCOOS base funds remained the same from FY18 ($1,285,183). Directed Fill the Gaps Observations went towards gliders ($150,000), HF radar operations and maintenance ($150,000), Harmful Algal Bloom (HAB) and toxin monitoring ($75,000) and SCCOOS data management ($75,000). The Matt Howard Memorial funding ($15,000) was directed to advance biological observations by creating new data management schemes for applying “Darwin Core” standards to SCCOOS (and CeNCOOS) HABMAP data and serving them on the ERDDAP for eventual ingestion by the global Ocean Biogeographic Information System (OBIS) database.

FY19 funding has provided a valuable investment in important assets and will strengthen regional partnerships and national program planning. SCCOOS will continue providing its core observations and

expand data products when possible within budget constraints. SCCOOS is also committed to contributing to larger ocean observing efforts regionally, nationally, and internationally.

USC, Cal Poly, and UCSB have low expenditure rates in their HF Radar funds. If we do not receive increased spending, we may need to request a no-cost extension after Year 5.

II. PERFORMANCE PROGRESS REPORT ADDENDUM

1) Education and Outreach
   a. SCCOOS has updated the Education and Outreach Inventory. SCCOOS has also updated our internal spreadsheet of all meetings, workshops, conferences, summits, and webinars attended by SCCOOS staff. You can view the spreadsheet here.

2) Data Management, Products, and Services
   a. Open Data Sharing
   SCCOOS continues to have the ability to achieve its milestones by providing access to high-quality integrated data and support regional user needs while complying with the standards and protocols for sharing and archiving data that are developed nationally. SCCOOS actively participates in IOOS Data Management efforts, primarily ERDDAP, but also the Thematic Real-Time Environmental Distributed Data Services (THREDDS). By leveraging the Coastal Data Information Program (CDIP) and the HF Radar National Network programs, SCCOOS targets THREDDS and ERDDAP distribution for wave, surface currents and shore station data. SCCOOS also continues to implement QARTOD data quality control standards. Wave and surface current data have associated XML and FDGC compliant metadata. SCCOOS has completed a standards-based foundation for DMAC capabilities by converting HF radar and shore station formats into NetCDF, THREDDS and ERDDAP.

   - SCCOOS has released ERDDAP service for its existing data sets, including adding the ability to select temporal or geographic subsets of data.
   - SCCOOS has leveraged CDIP wave data that are disseminated to the NDBC for ingestion into WMO GTS
   - SCCOOS has developed a Data Management Plan describing the current status of SCCOOS data streams and future goals for data quality assurance, quality control, dissemination, distribution, and archiving.
   - In addition to the Data Management Plan, SCCOOS has developed more detailed descriptions of various data streams and products in the form of Sensor Plans.
   - Sensor Plans follow a NOAA Data Sharing Template.
   - Sensor Plans have been developed for Gliders, Automated Shore Stations, CalCOFI Cruises, CDIP, HFR, HABs, Manual Shore Stations, Satellite Imagery, AIS and the Burkeolator.
   - Observations are collected from a variety of platforms in a variety of ways, each of which has its own level of data processing maturity. SCCOOS accepts data from both automated and manual systems via SFTP, HTTP, serial over internet, Webforms, email and Google Drive. Observations are stored in flat files, databases and NetCDF files, all of which are available on the SCCOOS website.

   b. Data Management Planning and Coordination
   Ongoing program-level participation in data management planning and coordination activities are:
   - Rowley attended the IOOS DMAC meeting in Silver Spring, MD on April 29 – May 3, 2019.
   - Rowley attended the SBC MBON Annual meeting in Santa Barbara, CA on May 30, 2019.
   - Anderson and Rowley organized and attended the California HABMAP PI meeting in Costa Mesa, CA on September 12, 2019.

- Rowley attended the IOOS DMAC Code Spring in Ann Arbor, MI on October 7-11, 2019.
- Rowley attended the Regional Data Sharing Workshop in Charleston, SC on November 20-22, 2019.
- Vicky Rowley collaborates regularly with our project scientists on data management tasks that provide high quality data and products while sustaining existing infrastructure, improving data quality control and coordinating efforts with our partners. Most recently, this has involved making observations of pH, O2 and HABs data available via our ERDDAP server. We have also begun making automatically updated, interactive visualization of select data available on our SCCOOS website using R Shiny.
- Rowley participated in the "Standardizing Marine Biological Data Working Group."
- Anderson participates in the Joint Planning DMAC work groups.
- Thomas is a QARTOD steering team member, and Anderson contributed to the chlorophyll QARTOD manual.
- Rowley collaborates with the West Coast RA Data Managers to ensure that our west coast wide ocean observing efforts are coordinated.

c. Provision of Data to the Global Telecommunication System (GTS)'

	WMO GTS	THREDDS	ERDDAP	SOS	IOOS Catalog (DAC)	Web Page	Primary Funder	Operated	Maintained (QC, Archive)
Automated Shore Stations		x	X	x	x	x	SCCOOS	SCCOOS	SCCOOS
Burkolator		x	x	x		x	SCCOOS	SCCOOS	SCCOOS
Gliders	x	x	x		x	x	NOAA/SCCOOS	NOAA/SCCOO	NOAA/SCCOOS
Harmful Algae Blooms						x	SCCOOS	SCCOOS	SCCOOS
High Frequency Radar	x	x		x	x	x	SCCOOS	SCCOOS	SCCOOS
State & Federally Leveraged									
Automated Information System						x	USCG	USCG	USCG
CalCOFI			x			x	NOAA/State of CA/NSF	NOAA/State of CA/NSF	NOAA/State of CA/NSF
CDIP Wave Data	x	x		x	x	x	USACE	CDIP	CDIP
Satellite Data						x	NASA/JPL	NASA/JPL	NASA/JPL

Table 1: Table indicates which communication; web services and access options are available for SCCOOS distributed data.

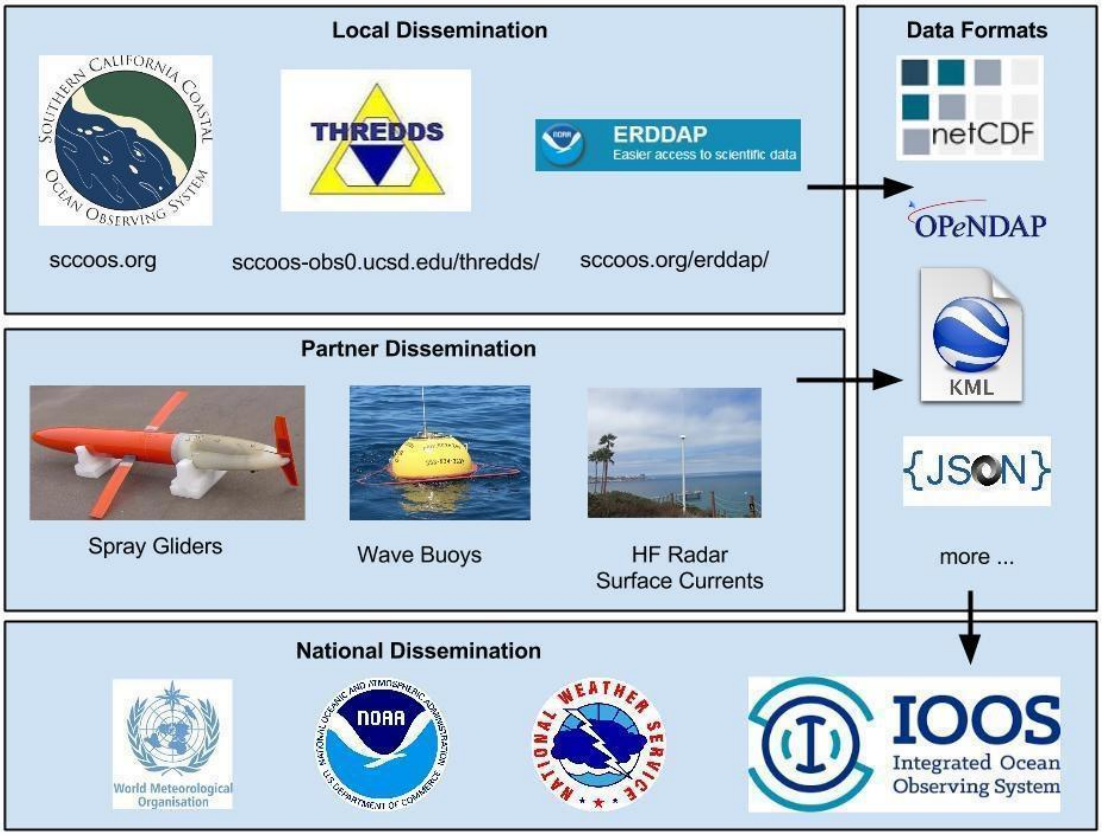
- SCCOOS has leveraged CDIP wave data that are disseminated to the NDBC for ingestion into WMO GTS (See Table 1).
- The HFR, glider, and CDIP wave observations are all transmitted to the National Data Buoy Center for inclusion on the World Meteorological Service Global Telecommunication Service.

d. Data Access Services

See Table 1 above for a breakdown of how SCCOOS data can be accessed. SCCOOS adheres to the NOAA Data Sharing Procedural Directive. All real-time and near real-time data managed by SCCOOS are freely available through open services, without delay or restriction. Avenues for accessing the data include the SCCOOS website: sccoos.org. SCCOOS does not restrict access to any data it collects or serves.

- SCCOOS targets THREDDS and ERDDAP distribution for wave, surface currents, shore station data and most recently the Burkeolator. This will soon include ACDC data, although without real-time capacity.

- SCCOOS has completed a standards-based foundation for DMAC capabilities by converting glider, HF radar, shore station, Burkeolator, and (soon) HAB/nutrient data formats into NetCDF, THREDDS and ERDDAP.
- All SCCOOS data are publicly available through the SCCOOS website. SCCOOS actively participates in on-going efforts to standardize data distribution through the use of web services such as the Sensor Observation Service and the Open-Source Project for a Network Data Access Protocol (OPeNDAP)/THREDDS.
- As an operational Data Assembly Center, SCCOOS aggregates and manages the integration and distribution of ocean data and products. Serving as a federal repository for physical and bio-chemical datasets, the Data Assembly Center provides data ingest, analysis, quality control, discovery, access services, visualization and archive. Observational information is made available in a variety of data formats to ensure that products are useful and easy to access, while preserving the necessary detail to support the scientific and educational communities.



Picture 1. Real-time and near real-time data managed by SCCOOS are freely available through open services, without delay or restriction.

e. Catalog Registration

HFR, gliders, Automated Shore Station and CDIP wave buoys are registered in the IOOS Service Registry. Registration of datasets and services with IOOS provides basic monitoring of service availability and response time.

f. Common Data Formats

- All SCCOOS data are publicly available through the SCCOOS website. The HFR, glider, and CDIP wave observations are all transmitted to the National Data Buoy Center for inclusion on

the World Meteorological Service Global Telecommunication Service. SCCOOS actively participates in on-going efforts to standardize data distribution through the use of web services such as the Sensor Observation Service and the Open-Source Project for a Network Data Access Protocol (OPeNDAP)/THREDDS.

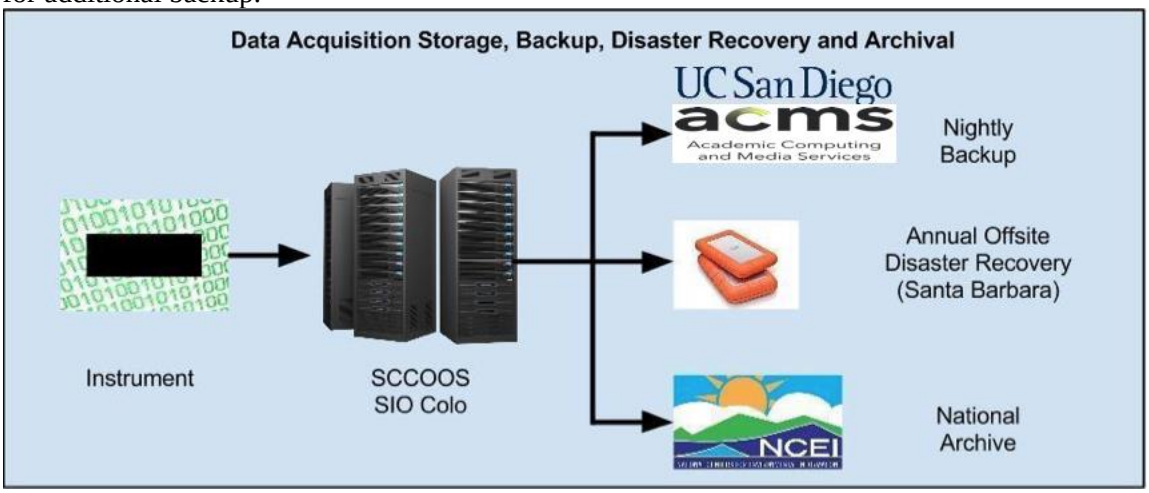
- SCCOOS participates with IOOS partners in a highly distributed system of interoperable components.
- SCCOOS is participating in the Standardizing Marine Biological Data Working Group to help develop standards for representing biological data collected from the marine environment.
- Collaboration with international programs such as OceanSITES and the Joint Commission of Oceans and Meteorology (JCOMM) are on-going instructive for CF compliancy and data handling issues.
- SCCOOS will make its HABs data available Darwin Core format via ERDDAP

g. Metadata Standards

SCCOOS is regularly in accordance with manufacturer guidance or industry best practice for calibrating, validating, operating, and maintaining equipment owned and/or operated by SCCOOS. Publicly available data are quality controlled at minimum with the following QARTOD required tests: 1) timing, 2) syntax, 3) location, 4) range, 5) climatology. SCCOOS maintains an active role in the ongoing effort to develop and apply QC standards throughout the IOOS Regions, including working to apply newly developed QC standards for pH. Highly leveraged programs such as CDIP wave data, HFR network, CalCOFI cruise data, and glider programs manage their own quality control which are compliant with the federal repository data management standards.

h. Storage and Archiving

SCCOOS stores observational data on its servers, which are located in the Scripps Institution of Oceanography (SIO) data center. SCCOOS operates two enterprise servers running the Redhat Operating System. Each server has dual 18 core Xeon Processors, 128 GB of RAM. Data are stored on a 24 Terabyte JBOD/NAS attached to these servers. Information necessary to re-establish the servers and the data themselves are backed-up nightly to offsite at the San Diego Supercomputer Center (SDSC). The SCCOOS website is backed up weekly, and in the event of a catastrophic failure of the website hardware, it could be restored from backup within hours. Annual disaster and recovery hard drives are sent to the University of California Santa Barbara for additional backup.



Picture 2. Data acquisition, storage, disaster recovery and archival.

There are only two existing datasets that are not archived at NCEI at this time:

- HABs, will be archived by June 2020 at NCEI
- HABs will be submitted in Darwin Core format for inclusion in MBON and OBIS databased by March 2020.

Presently, Automated Shore Station data, CDIP's wave data, HFR data, HAB/nutrient, Burkeolator and glider data are all archived at NCEI. Certain datasets that are registered with the IOOS Service Registry contain FGDC and ISO 19115-2 metadata are available through ERDDAP and THREDDS.

i. Ontologies, Vocabularies, Common Identifiers

Observations are collected from a variety of platforms in a variety of ways, each of which has its own level of data processing maturity. SCCOOS accepts data from both automated and manual systems via SFTP, HTTP, serial over internet, Webforms, email and Google Drive. Observations are stored in flat files, databases and NetCDF files, all of which are available via the SCCOOS website. Before making these data publicly available, every possible effort is made to convert the information provided into standard ontologies such as Darwin Core, and to use standardized vocabularies, including CF, NERC, etc.

j. Consideration for Long-Term Operations

SCCOOS Data Management and Communications goals are to develop and maintain the following capabilities:

- Deploy the information system components (including infrastructure and relevant personnel) for full life-cycle management of observations including product creation, public delivery, system documentation, and curation.
- Deliver accurate and timely ocean observations and model outputs to a range of consumers including government, academic, private sector users, and the general public utilizing standardization and specifications common across all providers.
- Establish a robust data exchange that is responsive to a wide breadth of customer requirements and user feedback, assuring the data handling flexibility to accommodate decision-support requirements.

SCCOOS will continue to provide timely access to high-quality integrated data and support regional user needs while complying with the national standards and protocols for sharing and archiving data following the "Guidance for Implementation of the Integrated Ocean Observing System (IOOS) Data Management and Communications Subsystem." SCCOOS will also continue to integrate a broad suite of observations in the form of raw data and products. Collaboration with partner RAs to advance stakeholder access to cross-regional data services as defined by commonalities in specified user requirements, is on-going through IOOS Data Management and Communications including workshops and webinars. SCCOOS is well poised to improve ingestion with a level of quality control based on Quality Assurance of Real Time Oceanographic Data (QARTOD) parameters, standardize the web services for all parameters, submit to National Centers for Environmental Information (NCEI) for archive, and enhance data visualization. In order to better support Long-Term operations, over the past year SCCOOS has modernized, automated and improved much of its underlying infrastructure. This is allowing more data to be ingested, processed, archived and disseminated with less human intervention. Additional desired outcomes are described on pages 18-30 of the Strategic Operational Plan.

3) Observing Assets

a. The RA asset inventory can be found on the SCCOOS website under Documents.
b. HF Radar Asset Inventory
c. HF Radar Staffing Inventory
d. Glider Days Inventory

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.