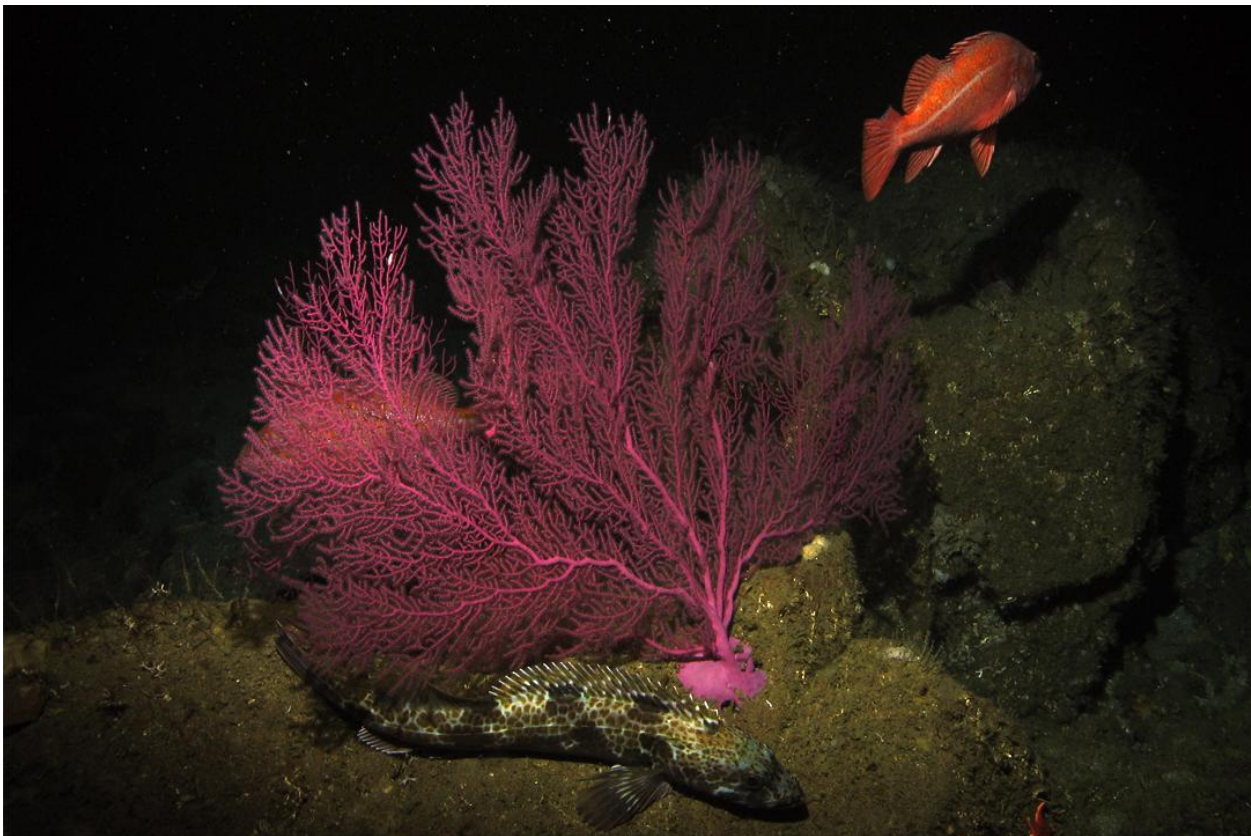

Cruise Report for 'Patterns in Deep-Sea Corals' 2017 Expedition: NOAA ship *Bell M. Shimada* SH-17-05



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Cruise Report for 'Patterns in Deep-Sea Corals' 2017 Expedition: NOAA ship *Bell M. Shimada* SH-17-05

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Background

In 2014, over 50% of the seafloor in the Channel Islands National Marine Sanctuary (CINMS) was adequately surveyed but poorly characterized. The waters surrounding this archipelago are home to several endangered species, large populations of commercially important species, and fragile ecosystem components such as deep-sea corals. Given the mandate to preserve and maintain this unique marine environment, natural resource managers require a detailed understanding of the distribution, abundance, and condition of the benthic habitats in the Sanctuary. NOAA Scientists from the National Center for Coastal Ocean Science (NCCOS) collaborated with CINMS office to survey and study these unexplored areas of the marine sanctuary. The Fisheries Survey Vessel (FSV) NOAA Ship *Bell M. Shimada* (Figure 1) provided a capable platform for NCCOS and CINMS.



Figure 1. NOAA Ship *Bell M. Shimada* at Pier 30/32 San Francisco, CA (April 2017).

NOAA conducted a Mapping Prioritization Workshop in 2015 which discussed cross-agency seafloor mapping data requirements for the region. A data gap analysis was conducted within CINMS boundaries and produced a map of the existing multibeam coverage which collaborators used to prioritize new data collection efforts (Figure 2). The results from the workshop were critical in guiding research expeditions in CINMS by NOAA and other partners.

NOAA continued ongoing work in CINMS between April 27th - May 12th, 2017 by acquiring fish, deep-sea coral and seafloor data using the *Shimada*'s ME70 and EK60 sonars, the Office of Coast Survey's REMUS- 600 Autonomous Underwater Vehicle (AUV), and the Remotely Operated Vehicle (ROV) Beagle from Marine Applied Research and Exploration

(MARE,) supported by the NOAA Office of Ocean Exploration and Research (OER). The course of work is outlined in table 1, and the participants from each organization are listed in table 2. The data collected included high definition still images and videos from the ROV transects, acoustic imagery from sonar, and biological samples of deep-sea corals. This new information helped build on the ecological baseline of the benthic habitats within CINMS and informed natural resource managers with valuable input for the next revision of the sanctuary’s management plan.

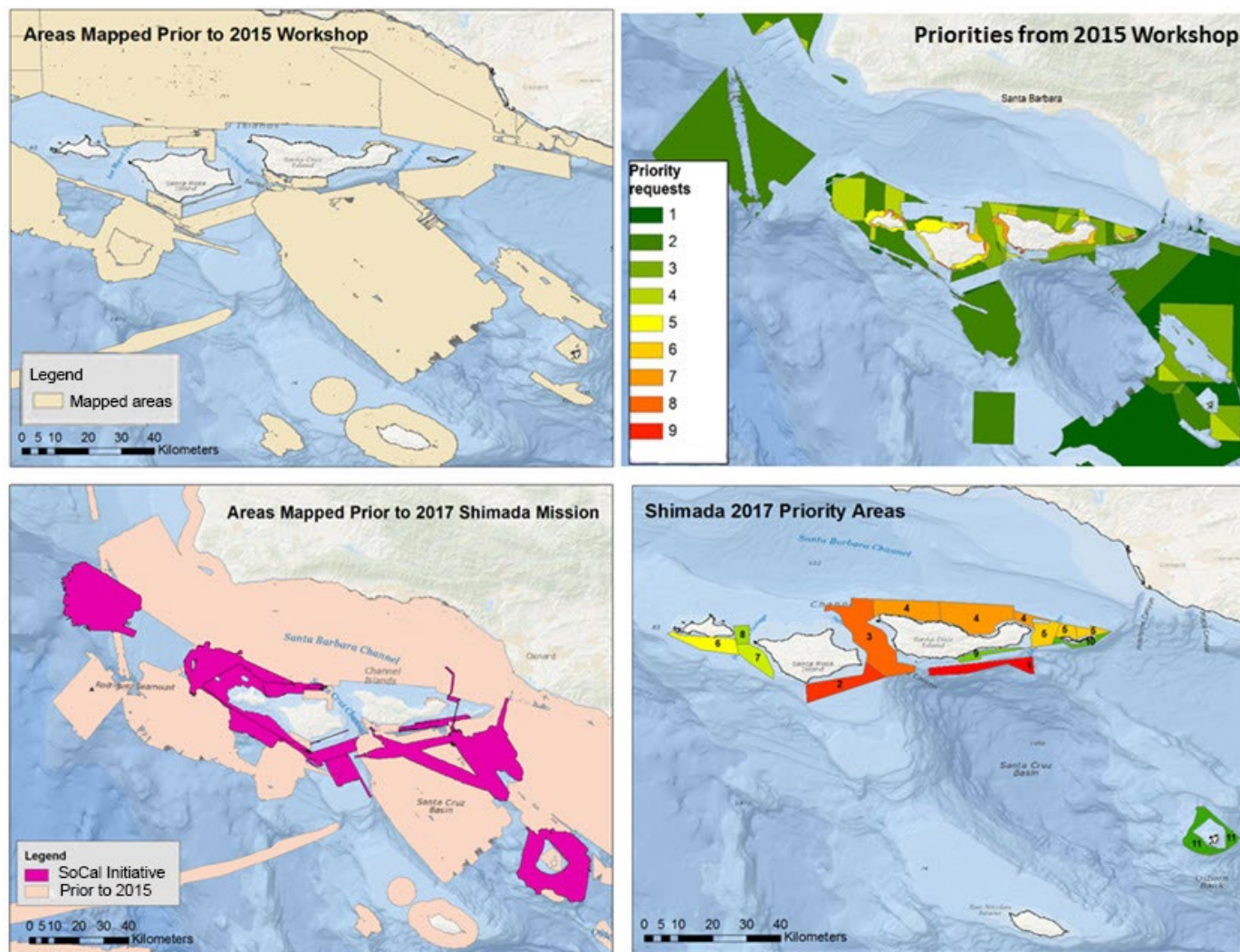


Figure 2. Priority mapping areas and available mapping data. Top left depicts the areas mapped prior to the 2015 Mapping Workshop. The top right panel shows the amount of overlap among agencies that resulted from the 2015 workshop. Red areas show high agency concordance in priority mapping locations. The lower left panel highlights more recent acquisition collected as part of the Southern California Seafloor Mapping Initiative. The lower right panel contains the SH-17-05 Priority Areas that guided acquisition on this mission; priority is denoted with a red, yellow, green color scale with red representing the highest priority.

Objectives

There were four primary objectives associated with this project:

1) To fill in existing mapping data gaps with high-resolution bathymetry using Multibeam Echo Sounders (MBES) from the *Shimada* (depths of 30 – 350m) and the REMUS 600 AUV (depths

to 400m). The AUV complements the vessel-acquired data with deeper water acquisition and provides highly resolved data over features of interest identified during the mission. 2) To simultaneously acquire water column data indicating the presence, relative abundance and distribution of fishes associated with various seafloor features utilizing the shipboard EK60 Split Beam Echo Sounder (SBES). 3) To explore, identify, characterize and assess fish and deep-sea coral communities using an ROV with a manipulator arm for biological sampling. 4) To capitalize on the opportunity to educate the local community about the Sanctuary's natural resources and the pressures they face.

The NOAA Office of Marine and Aviation Operations has designated this cruise as SH-17-05. This work built off of earlier notable benthic habitat mapping and research efforts in the CINMS conducted by the *EV Nautilus*, *RV Shearwater* and NOAA ships *Okeanos Explorer*, *Bell M. Shimada*, and *Reuben Lasker*, 2015- 2017 (Caldow et al., 2015; Etnoyer et al., 2017).

Methodology

ME70 Testing and Data Acquisition

A first order task was to verify installation parameters and the ME70 fishery multibeam sonar. Based on an assessment of the previous year's ME70 survey output, there remained some concern around dropouts in the GPS feed, vessel motion and noise interference, and instrument offsets. The science team arrived on the *Shimada* several days before the cruise to test the integration of the multibeam and positioning systems with the ship's survey and electronic technicians.

Prior to the cruise, the positioning antennas were relocated further forward on the mast to receive a full GPS constellation. The new offsets were recalibrated into the ME70 system by the Hydrographic Systems and Technology Branch of the Office of Coast Survey (OCS) under LCDR Samuel Greenaway (Greenaway and Devereaux, 2017). The science team implemented the ME70-Hypack integration for real-time bathymetry, efficient line planning, and better communication with the bridge. Other ME70 software configurations were reviewed by the science team with the ship's survey and electronics technicians to assess 1) the DGPS navigation integration with the POS MV 2) the vessel configuration, reference points, and lever arm offsets 3) the integration and calibration of the surface sound speed sensor 4) and the synchronization of ME70 computer with the ship's central time server. More information on the ME70 configurations used by the *Bell M. Shimada* and other NOAA Fisheries Survey Vessels can be found in the *Report from the Using Acoustic Multibeam Echosounder (ME70) Technologies for Habitat Mapping Workshop* (Marshak et al. 2018).

A patch test and a GPS Azimuth Measurement Subsystem (GAMS) calibration were conducted over known features and a flat area of seafloor in the San Francisco Bay to check the ME70 settings, system integration, and lever arm offsets before transiting to the CINMS. Navigation, timing, heave, pitch, roll, and yaw were all calibrated using the CARIS HIPS & SIPS 9.1 patch test module. In addition, sound velocity correction (SVC) tests to the ME70 data were conducted by comparing the real-time surface sound speed with eXpendable Bathymetric Thermographs (XBT) and Conductivity-Temperature-Density (CTD) casts of

the water column. The science team relied on the XBT's for more timely and accurate measurements of the sound speed profile during the cruise. During the MBES acquisition, in CINMS, XBT's were casted every four hours or as water conditions changed. Discharge of XBTs was covered by the Sanctuary Manager's Permit (CINMS-2014-001).

After the raw sonar data was collected by the ME70, the data had to be converted to a Generic Sonar File (.gsf) format so that the bathymetric and backscatter information could be processed using the CARIS HIPS & SIPS and workflow (Figure 1). The science team used a custom Matlab code developed by Dr. Tom Weber (University of New Hampshire/Center for Coastal and Ocean Mapping) to apply a beam configuration and extract the bottom detection information from the ME70. The .gsf's allow CARIS and other MBES processing software to generate bathymetric surfaces using the Combined Uncertainty and Bathymetric Estimator (CUBE) algorithm. After the .gsf files were created, tidal corrections, SVC, and total propagated uncertainty were applied, as well as further filtering and cleaning of acoustic noise. The final edited .gsf files were imported into Fledermaus Geocoder Toolbox (FMGT) to create a backscatter (intensity) surface, showing the acoustic signal return strength of the seafloor in decibels. With the depth and backscatter information of the seafloor, the science team was able to assess the substrate and the geomorphology for benthic habitat mapping and plan ROV dives for ground validation.

After the field mission, all ME70 data was submitted to the OCS External Source Data Team (ESD team) for Survey Acceptance Review. The MBES surfaces underwent a rigorous quality control assessment and final corrections to supersede existing survey data for nautical charts where it was necessary. Upon further review and additional cleaning, the SH-17-05 cruise data was designated as W00374 by ESD Team and is now archived and available at the National Centers for Environmental Information (NCEI).

EK60 Testing and Acquisition

The Simrad EK60 SBES was used to conduct fisheries acoustic sampling. The EK60 operated at five frequencies (18, 38, 70, 120, 200 kHz) simultaneously to detect different types of biota in the water column or off the bottom of the seafloor. The EK60 transducers were mounted on the *Shimada's* large retractable centerboard placed 7.5m below the sea surface. Pulse length was set to 512 μ s for all the frequencies. Pulse interval was defined automatically based on the depth range. The triggering and time synchronization with the ME70 was controlled by the Kongsberg K-Synch unit. A Data Processing Workflow for both the ME70 and EK60 was specifically developed for the NOAA FSV's by Marshak et. al 2018 (Figure 3). The EK60 was calibrated during the cruise using the standard tungsten-carbide sphere method. Noise was seen throughout the water column if the *Shimada's* Acoustic Doppler Current Profiler was running during survey operations was turned off while the EK60 and ME70 were logging. Water column and fisheries acoustics data were all processed onboard using the Echoview 8 software. Fisheries acoustic sampling was carried out primarily during night operations along with the ME70 survey.

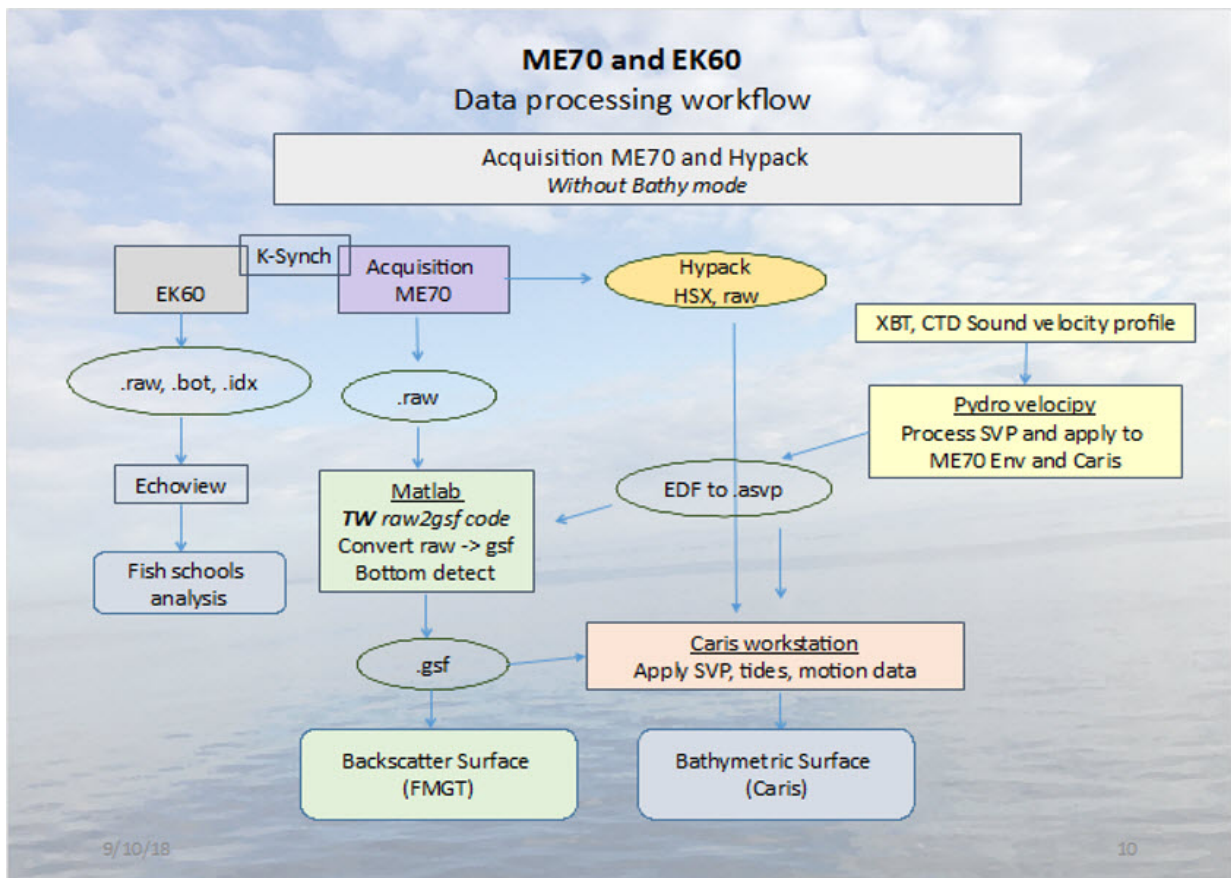


Figure 3. General data acquisition and processing workflow when using the ME70 to obtain seabed backscatter and bathymetry. Synchronized data acquisition (*k-synch*) using both the EK60 (.raw, .bot, .idx data formats) and ME70 (.raw data format) echosounders, with EK60 fish school data examined and analyzed using Simrad Echoview software. ME70 data are processed with Dr. Tom Weber’s Matlab code (*raw2gsf*) that converts ME70 .raw data to .gsf format to allow for bottom detection for input into CARIS (bathymetry) and FMGT (seabed backscatter). In this workflow, sound velocity profile, tides, and motion data are additionally applied.

REMUS-600 AUV Data Acquisition

The REMUS-600 AUV conducted multibeam sonar seafloor mapping surveys in priority areas designated by The science team using a Kongsberg EM-3002. The AUV targeted deeper areas outside of the ME70 instrumentation’s ability to provide high resolution data. The AUV was programmed to conduct overnight mapping missions at fixed altitude above the seafloor based on operating depth, coverage requirements, and desired data resolution. During missions the AUV was programmed to surface at regular intervals (1-2 hours) to update its GPS fix and broadcast its position and status to the shipboard console via Iridium satellite telephone.

The AUV was launched daily at 1500--1600 and recovered in the morning at 0800--0900. This maximized the time the AUV was on survey, while maintaining consistent launch and recovery times, and provided adequate time for post-mission activities, AUV charging, and mission planning. AUV mission plans included transect programming, launch and recovery locations, expected surfacing locations, and the duration of surface time were made available prior to launch to the ship’s and science crew.

The science team requested that an XBT be launched in the AUV's operating area prior to launch, which provided the AUV team with a sound velocity profile for the initial descent to survey altitude. The MBES data from AUV's Kongsberg EM 3002 was collected in the .ALL file format and processed using the CARIS HIPS and SIPS workflow. Final products from these efforts were submitted to NCEI after the data went through the Survey Acceptance Review by the ESD Team and can be found acquired via the NCEI bathymetry web portal at under survey W00374 at www.ngdc.noaa.gov/mgg/bathymetry/multibeam.html.

ROV Data Acquisition

The ROV *Beagle* is a 450 lbs ROV (560 lbs with manipulator skid), that is rated to 1100 meters. It is approximately 60 inches long by 32 inches wide and is equipped with both forward and down looking video cameras, as well as an HD digital still camera with an adjustable tilt. The three objectives of the ROV surveys were to: 1) ground-truth multibeam echosounder data in order to facilitate interpretation of topography and backscatter data; 2) identify fish assemblages associated with EK60 and ME70 water column returns; and 3) identify and characterize benthic communities including deep-sea coral and sponge environments. The science team anticipated 2-4 ROV dives per day, of 1-3 hours duration each dive. Deployment delays and equipment issues resulted in only 1-2 dives per day. Biological samples of corals were collected using the multi-function manipulator on the ROV. Location of ROV targets was determined daily based on a variety of factors including weather, sea -state, current location of the vessel, proximity to targets surveyed with multibeam during previous (e.g. EV *Nautilus*) and current missions. Protocols for launch and recovery of the ROV remained the same regardless of the objective for the specific dive. Variables that changed include time on station and distance the vessel moves during deployment.

ROV seafloor surveys

The ROV collected high-resolution still and video image data continuously from the initial visual contact with the seafloor to the final ascent. During each seafloor survey, the ROV transited at an altitude of <1 m off the bottom and a speed over ground of <0.5 knots. The ROV was equipped with the following equipment that collected continuous data throughout each dive: (1) a high-definition, forward-looking video camera, (2) a high-definition, forward-looking still camera that collected still images every 5 seconds, (3) parallel lasers projected 10 cm apart used to scale images collected by the video and still cameras, (4) an ultra-short baseline (USBL) sonar navigation system used to calculate the ROV's real-time position to an accuracy of 10 m every 1 second, and (5) a CTD environmental sensor, used to collect salinity, temperature, and depth.

ROV transects

Multiple short transects, 5-15 min in duration were conducted during the ROV dives and roughly correspond to a survey distance of ~100-300 m. Transects were conducted over the predominant habitat types apparent from the available backscatter and bathymetry data. During each transect, the ROV cruised at a constant altitude (1 m) and speed (0.5 knots) off the bottom, with the video and still cameras maintaining a wide and fixed frame. Transect videos were then

annotated once ashore; coral and sponge taxa were identified to the lowest reliable taxonomic level and habitat was given a coarse level description (Hard, Soft, Mixed). This data was then submitted to the Deep Sea Coral Research and Technology Program's deep-sea coral database (deepseacoraldata.noaa.gov).

Specimen collections

Nine biological specimens were collected during seafloor surveys using the 5 function manipulator arm of the ROV. These specimens were collected to confirm species level identifications, and to facilitate the live culturing of target taxa for ongoing temperature tolerance studies. Once specimens were brought on deck, they were labeled, photographed and inventoried into a database with all relevant metadata. Once photographed and labeled, live specimens were placed in a 3.78 L plastic container with previously collected and chilled surface water, while preserved specimens were stored in non-denatured molecular grade 95% ethanol.

Permits

Sampling within the sanctuary was conducted under scientific research permit CINMS-2017-003 issued to Dr. Peter Etnoyer of NCCOS by CINMS. Prior to the expedition, the chief scientist Chris Caldwell completed an informal consultation with NOAA National Marine Fisheries Service under section 7 of the Endangered Species Act (ESA) to address impacts of cruise activities on ESA-listed species and critical habitat after which NMFS issued a letter of concurrence.

Funding

The expedition was funded by NOAA's Deep Sea Coral Research and Technology Program, Office of Ocean Exploration and Research (OER), OCS, NCCOS and Office of National Marine Sanctuaries (ONMS).

Expedition schedule

The expedition began on April 26, 2017 in San Francisco with the arrival of the science team to the NOAA Ship *Bell M. Shimada*. On April 27th, the *Shimada* left the pier and conducted patch tests and GAMS calibrations in the San Francisco Bay. After the tests were completed, the *Shimada* began to transit to the Channel Islands (33° 55' 11.7516" N, 119° 53' 8.0124" W) and arrived on April 29th at 20:30 GMT. Upon arrival, a final patch test took place over a feature detected from a previous CINMS cruise. After a patch test, mapping operations commenced in the Areas of Interest south of Santa Cruz and Santa Rosa Islands. High sea state and winds prevented the ROV and AUV from being deployed until the following morning. From April 30th to May 9th, the *Shimada* conducted 24 hour operations. The ship based acoustic and AUV survey was conducted at night and ROV operations were generally conducted during the day unless weather did not permit deployment. The *Shimada* collected mapping data in Priority areas 1, 2, and 3 while the ROV mostly dove over areas previously surveyed south of Santa Rosa and Santa Cruz island (Figure 2 and 4). All acoustic survey and ROV operations ended on May 9th and the transit back to San Francisco began on May 10th. Demobilization of the ROV and the science team concluded on May 11th.

Table 1. Schedule of Bell M Shimada expedition SH-17-05 that surveyed deep-sea coral ecosystems in the Channel Island National Marine Sanctuary.

Date (UTC)	Operations	Comment
4/26/2017	Mobilization	
4/27/2017	Depart San Francisco	
4/28/2017	Transit to Channel Islands	
4/29/2017	ME70, EK60	ROV and AUV operations cancelled due to high wind
4/30/2017	ME70, EK60, AUV, ROV	
5/1/2017	ME70, EK60, AUV, ROV	
5/2/2017	ME70, EK60, AUV, ROV	
5/3/2017	ME70, EK60, AUV, ROV	
5/4/2017	ME70, EK60, AUV, ROV	
5/5/2017	ME70, EK60, AUV, ROV	
5/6/2017	ME70, EK60	ROV and AUV activity cancelled due to high wind
5/7/2017	ME70, EK60, AUV, ROV	
5/8/2017	ME70, EK60, AUV, ROV	
5/9/2017	ME70, EK60, AUV, ROV	
5/10/2017	Transit	
5/11/2017	Demobilization	

Table 2. Participant list for OMAO cruise SH-17-05, April 27 – May 12, 2017. Participant affiliations include; Marine Applied Research and Exploration (MARE), Office of National Marine Sanctuary (ONMS), National Research Council (NRC), Office of Coastal Survey (OCS), National Centers for Coastal Ocean Science (NCCOS)

<u>Name (Last, First)</u>	<u>Title</u>	<u>Affiliation</u>	<u>Email</u>
<u>Botman, Rick</u>	<u>ROV Operator</u>	<u>MARE</u>	<u>Rick@maregroup.org</u>
<u>Caldow, Chris</u>	<u>Chief Scientist</u>	<u>ONMS</u>	<u>Chris.Caldow@noaa.gov</u>
<u>Campanella, Fabio</u>	<u>Post Doc – Fish acoustics</u>	<u>NRC</u>	<u>Fabio.Campanella@noaa.gov</u>
<u>Doroba, John</u>	<u>AUV Operations</u>	<u>OCS</u>	<u>John.Doroba@noaa.gov</u>
<u>Downs, Rob</u>	<u>AUV Project Manager</u>	<u>OCS</u>	<u>Rob.Downs@noaa.gov</u>
<u>Etnoyer, Peter</u>	<u>Coral Ecologist, ROV Lead</u>	<u>NCCOS</u>	<u>Peter.Etnoyer@noaa.gov</u>
<u>Freedman, Ryan</u>	<u>Data Manager</u>	<u>CINMS Contractor</u>	<u>Ryan.Freedman@noaa.gov</u>
<u>Holz, Steve</u>	<u>ROV Operator</u>	<u>MARE</u>	<u>Steve@maregroup.org</u>
<u>Husted, Rachel</u>	<u>GIS Analyst</u>	<u>NCCOS Contractor</u>	<u>Rachel.Husted@noaa.gov</u>
<u>Kinney, Juliet</u>	<u>Hydrographer-OCS (AUV Ops)</u>	<u>OCS</u>	<u>Juliet.Kinney@noaa.gov</u>
<u>Kracker, Laura</u>	<u>Geographer, MBES Lead</u>	<u>NCCOS</u>	<u>Laura.kracker@noaa.gov</u>
<u>Lauermann, Andy</u>	<u>ROV Operator</u>	<u>MARE</u>	<u>Andy@maregroup.org</u>
<u>Rosen, Dirk</u>	<u>ROV Operator</u>	<u>MARE</u>	<u>Dirk@maregroup.org</u>
<u>Sautter, Will</u>	<u>Physical Scientist</u>	<u>NCCOS Contractor</u>	<u>Will.Sautter@noaa.gov</u>
<u>Shuler, Andrew</u>	<u>Marine Biologist</u>	<u>NCCOS Contractor</u>	<u>Andrew.Shuler@noaa.gov</u>

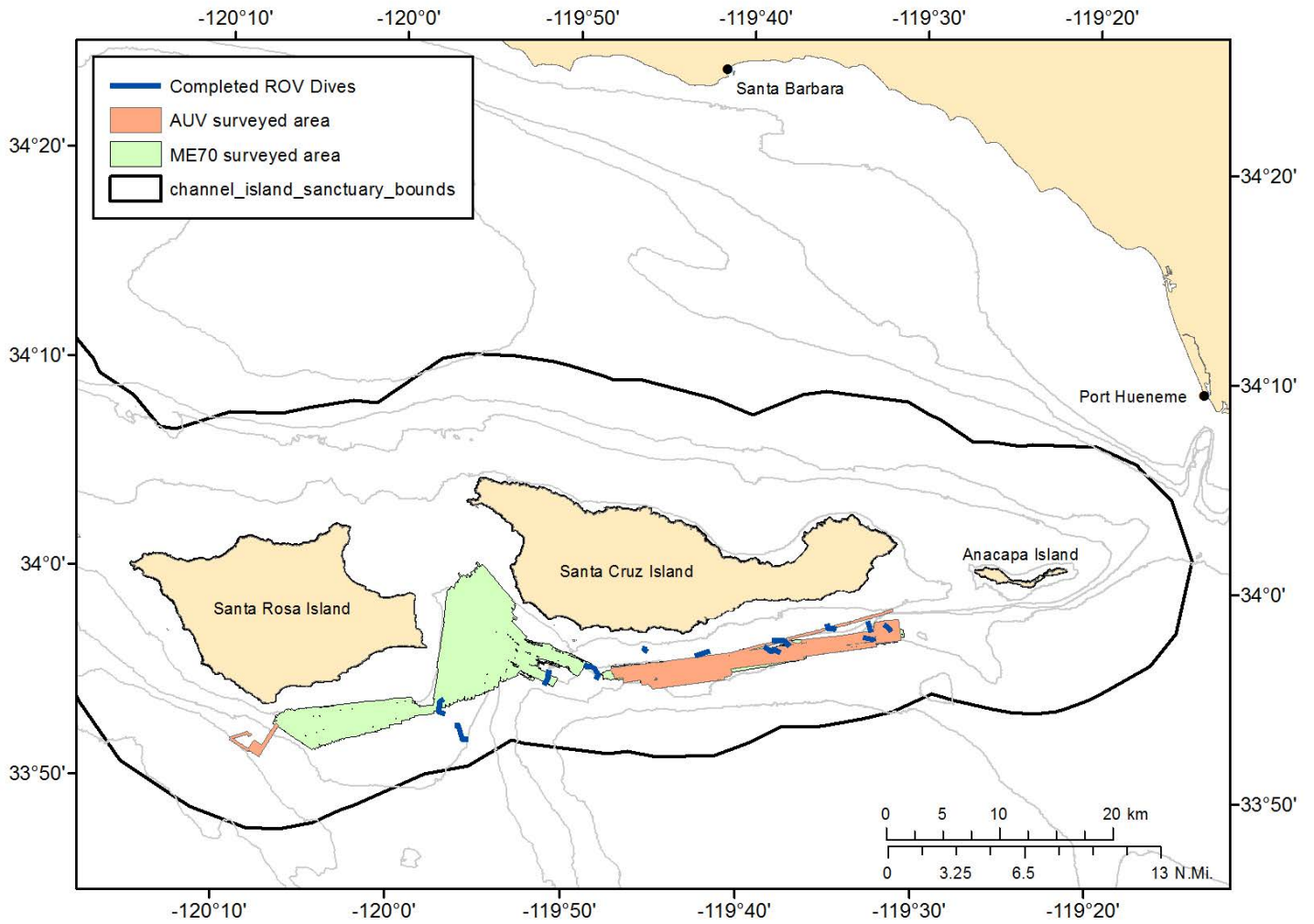


Figure 4. Map showing the operational area of the expedition aboard the NOAA Ship *Bell M. Shimada* (SH-17-05: April 26-May 11, 2017) that surveyed deep-sea coral ecosystems off the Channel Islands National Marine Sanctuary using ROV, AUV, ME70 and EK60 mapping surveys and XBT casts.

Narrative of cruise results

ME70 operations and data quality issues

Mapping operations lasted 12 hours each day for 11 days, which led to a total of 940.3 nautical miles of bottom surveyed (Figure 4). This included 343.2 nmi in priority area 1 (12.2 sq. nmi); 283.3 nmi in priority area 2 (13.7 sq. nmi); and 358.8 nmi (30.7 sq. nmi) in priority area 3. Mapping was initially hampered because a time offset in the ME70 and EK60 computers was causing them to ping at separately, resulting in a significant degree of signal interference. Once rectified the team began processing data from the ME70, still noticed a significant amount of noise, false bottom detections, and large areas where the data had dropped out. It was discovered that most of the noise artifacts were due to hardware failures in circuit cards of the ME70 computer after conducting several BIST tests. The ship's electronic technician was able to bypass the faulty cards and redirect the power supply to get all the ME70 systems to run properly.

In several areas, false bottom detections occurred in the MBES data above or below the actual seafloor. Possible environmental or biotic causes of this phenomenon included natural gas bubbles, plankton, or nekton in the water column which created a scattering surface which the CUBE algorithm perceived as the seafloor. The team also found that the default depth threshold of the beam configuration from the Matlab code was accidentally filtering the data from the multibeam surfaces during the file conversion. The code had to be readjusted to the depth range of each priority area, but it was also used to filter out the false bottom detections <15m deep from the sea surface or >15m deep from the seafloor.

EK60 operations

In addition to general surveying in conjunction with the ME70, five additional small-scale surveys were conducted over selected ROV dive sites in order to validate the acoustic data with the visual observations. The acoustic surveys on the ROV sites were repeated twice (day and night) to better understand the diel variability of fish distribution and behavior. In all, a total of 484.6 nmi were surveyed for the purposes of seafloor mapping, and 116 nmi were surveyed at the ROV sites.

A preliminary analysis of the data was completed aboard the ship using the software Echoview 8. That analysis showed the average fish backscatter for both the mapping area and the ROV sites during the day was estimated to be about 1 order of magnitude higher than at night. Fish normally aggregate in dense schools during the day and move close to the bottom during the night, reducing the catchability of the echosounder. The aggregations observed during the night presented a very scattered distribution sometimes associated with features at the bottom. Few dense aggregations were also observed at night. Priority 1 (south of Santa Cruz Island) and Priority 2 (south of Santa Rosa Island) were the areas with the highest fish backscatter detected. The schools of fish detected during the day presented large variability in terms of species and activity; this indicated a high complexity of the habitat and productivity of the system. Moreover, from this preliminary analysis it seems that high fish densities and school diversity were associated with areas with high coral abundance. Different shapes and packing density of the schools can be an indication of different size/age classes, species-specific behavior or feeding and spawning behavior. Further work is necessary to obtain additional information about the schools (e.g. 3D volume, true size of the school) and can be obtained by the ME70 water column data that were collected simultaneously with the EK60.

AUV operations

The AUV was deployed on seven overnight missions and one daytime mission. The usual launch time for an overnight mission was 1800, with recovery the following morning at 0800. All of the overnight missions were in the Priority 1 survey area (e.g. south of Santa Cruz Island). The daytime mission took place in the area south of Santa Rosa Island. The first three missions did not provide usable data due to configuration issues with the AUV. Following successful troubleshooting, which included installation of new vehicle control software from the manufacturer, four successful missions took place. The final daytime mission aborted early when a leak was detected in the AUV's oil-filled tail section. Despite ending early, some data was collected during this final daytime mission. In total the AUV collected 147 linear nautical miles (20 square nautical miles) of high resolution bathymetric data in water depths ranging from 30 fathoms (55 meters) to 300 fathoms (550 meters).

ROV operations

GPS synchronization issues and electronic failures compromised portions of the ROV operations during the first 5 days of the mission. Despite those challenges, successful dives were conducted each day. Once ROV operations began, only one day was lost to weather. The average bottom time of the ROV was 2 hr 50 minutes, which is low compared to other ROV cruises. Shorter than typical bottom times were primarily due to ROV equipment failures, long transit times, and competing mission objectives that prioritized the mapping objectives. The ROV team completed 15 dives over 9 days and surveyed ~10.5 nmi of seafloor (Table 3 and Figure 5).

The ROV collected nine coral samples from four different species of corals and 2 species of echinoderms. Date, time, latitude, longitude, and depth was recorded at the time of collection for each specimen (Table 4 and Figures 6-10). All samples collected were sent to NCCOS Charleston to conduct advanced morphological and genetic review and provide or confirm species level identifications. Of the samples collected, the most notable was a sample of an unidentified plexauridae that was observed multiple times during ROV dives. Morphological analysis of this sample revealed sclerites indicative of a species of *Placogorgia*. Given the unique nature of this specimen, a sample was sent to Meredith Everett (Northwest Fisheries Science Center) to be incorporated in a larger genetic evaluation of west coast octocoral taxa. Five colonies of *Adelogorgia phyllosclera* were collected, maintained aboard ship and shipped live to CCEHBR. The *Adelogorgia* samples served as back up test subjects for temperature threshold experiments that took place as part of a graduate student's thesis, in the Etnoyer lab in Charleston, SC. This work was published in the *Journal of Experimental Marine Biology and Ecology* (Gugliotti et al., 2019).

The ROV conducted a total of 47 transects approximately 15 minutes each in duration with each averaging 242 meters in length (Table 5). Analysis of these transects was originally completed by Jordan Penn from Millersville University as part of the Research Experience for Undergraduates (REU) program. Preliminary analysis revealed that habitat type was quite variable during transects. The intent of these transects was to evaluate coral densities over 100-300 meters of hard, soft, and mixed substrate. With the majority of transects being over mixed substrate it was decided to expand annotations beyond their designated time and reassign transects based on specific habitat types, to ensure an adequate pool of transects for comparison. Annotations were completed at a one second interval from on bottom to off bottom. The software R was used to identify and reassign 100 meter transects over like habitat. After reassigning transects the dataset was expanded to a 110 transects. The transect data is available in the DSCRTP deep-sea coral and sponge database.

Table 3. Summary information for the fifteen dives of the ROV *Beagle* conducted during expedition SH-17-05 to the Channel Islands National Marine Sanctuary.

Date (UTC)	Event ID	Locality	Site ID	On bottom latitude	On bottom longitude	Off bottom latitude	Off bottom longitude	Bottom time (h:min)	Specimens collected	Number of transects
2017/4/30	17-120A	South Santa Cruz	SoStCruz_02	33.96935	-119.58416	33.96785	-119.57668	2:10		5
2017/5/1	17-121A	South Santa Cruz	SoStCruz_03	33.96355	-119.54213	33.97215	-119.54523	1:15		3
2017/5/2	17-122A	South Santa Cruz	SoStCruz_05	33.95121	-119.62053	33.955133	-119.63736	2:03		4
2017/5/3	17-123A	Santa Cruz Canyon	SoStCruz_09	33.92041	-119.80318	33.937066	-119.81585	3:34		5
2017/5/3	17-123B*	South Santa Cruz	SoStCruz_08	33.94296	-119.75476	33.942966	-119.75476	0:10		0
2017/5/4	17-124A	South Santa Cruz	SoStCruz_01	33.94495	-119.69503	33.941533	-119.70956	1:47		4
2017/5/4	17-124B	Santa Cruz Canyon	SoStCruz_10	33.92786	-119.81063	33.9314	-119.8111	1:12	2 coral, 1 brittle stars	0
2017/5/5	17-125A	South Santa Cruz	SoStCruz_07	33.91483	-119.85316	33.926916	-119.84836	1:40		4
2017/5/5	17-125B	South Santa Cruz	SoStCruz_12	33.94548	-119.62848	33.950033	-119.6434	2:20		3
2017/5/7	17-127A	South Santa Cruz	SoStCruz_08	33.94825	-119.75748	33.942966	-119.75476	0:59		3
2017/5/7	17-127B	South Santa Cruz	SoStCruz_4A	33.95608	-119.53895	33.959616	-119.54986	1:53		4
2017/5/7	17-127C	South Santa Cruz	SoStCruz_4B	33.96443	-119.52301	33.96705	-119.52993	1:41		4
2017/5/8	17-128A	South Santa Rosa	SoStRosa_X1	33.88923	-119.94583	33.900418	-119.94931	2:50		5
2017/5/8	17-128B	South Santa Rosa	SoStRosa_X3	33.90349	-119.93713	33.875368	-119.93281	1:45	1 coral	3
2017/5/9	17-129A	Santa Cruz Canyon	SoStCruz_Sample1	33.93017	-119.80921	33.929952	-119.80912	0:26	6 corals, 1 asteroid	0

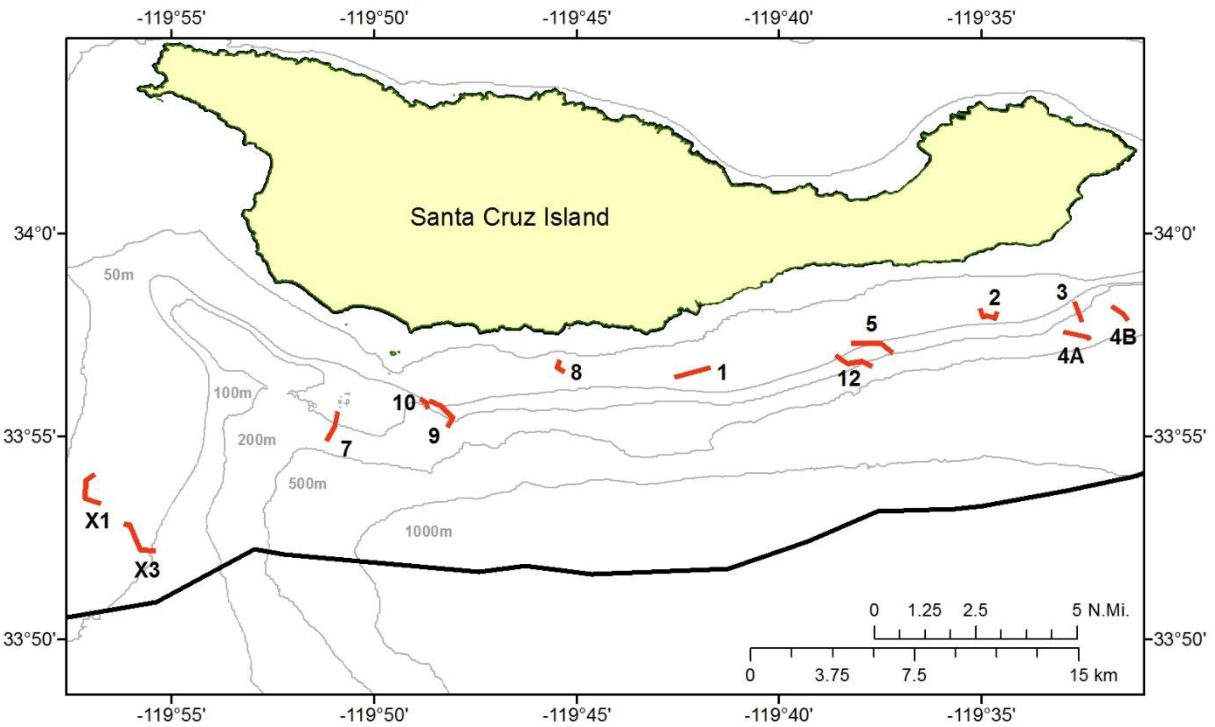
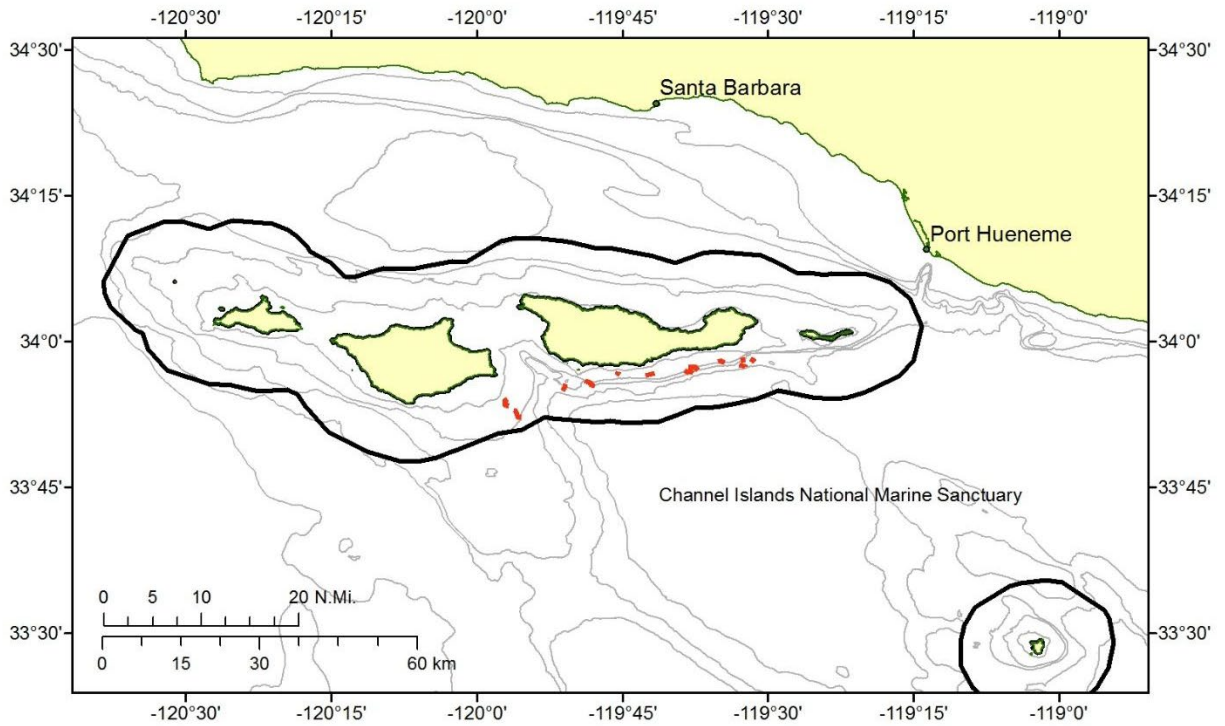


Figure 5. Maps showing (top) general area of ROV operations and (bottom) dive paths of all ROV dives conducted during SH-17-05 expedition to Channel Islands National Marine Sanctuary.

Table 4. Inventory of specimens collected during expedition SH-17-05 to the Channel Islands National Marine Sanctuary.

Sample ID	Scientific Name	Date (UTC)	Time (UTC)	Locality	Latitude	Longitude	Depth (m)	Preservation	Specimen destination after cruise
SH-17-05-17124B-S01	Plexauridae	5/5/2017	0:10:05	Santa Cruz Canyon	33.93041	-119.81163	97	95% EtOH; vial and bag	NCCOS Charleston
SH-17-05-17124B-S01-A	Brittle Star	5/5/2017	0:10:05	Santa Cruz Canyon	33.93041	-119.81163	97	95% EtOH; vial	NCCOS Charleston
SH-17-05-17124B-S02	Plexauridae	5/5/2017	0:34:07	Santa Cruz Canyon	33.93049	-119.81165	90	95% EtOH; vial and bag	NCCOS Charleston
SH-17-05-17128B-S03	<i>Adelogorgia phyllosclera</i>	5/8/2017	23:49:15	South Santa Rosa	33.87483	-119.93281	93	Live	NCCOS Charleston
SH-17-05-17129A_S04	<i>Adelogorgia phyllosclera</i>	5/9/2017	17:15:45	Santa Cruz Canyon	33.93007	-119.80939	98	Live	NCCOS Charleston
SH-17-05-17129A_S05	<i>Adelogorgia phyllosclera</i>	5/9/2017	17:24:42	Santa Cruz Canyon	33.93021	-119.80912	98	Live	NCCOS Charleston
SH-17-05-17129A_S06	<i>Adelogorgia phyllosclera</i>	5/9/2017	17:28:30	Santa Cruz Canyon	33.93005	-119.80907	98	Live	NCCOS Charleston
SH-17-05-17129A_S07	<i>Adelogorgia phyllosclera</i>	5/9/2017	17:33:30	Santa Cruz Canyon	33.92996	-119.80906	98	Live	NCCOS Charleston
SH-17-05-17129A_S08	Primnoidea	5/9/2017	17:35:30	Santa Cruz Canyon	33.92996	-119.80906	98	95% EtOH; vial and bag	NCCOS Charleston
SH-17-05-17129A_S09	<i>Eugorgia rubens</i>	5/9/2017	17:35:30	Santa Cruz Canyon	33.92996	-119.80906	98	95% EtOH; vial and bag	NCCOS Charleston



Figure 6. *Plexauridae* (an unknown octocoral with white polyps), sample SH-17-05-17124B-S01 from 97 meters



Figure 7. *Plexauridae* (an unknown octocoral with white polyps), sample SH-17-05-17124B-S02 from 90 meters



Figure 8. *Adelogorgia phyllosclera*, live samples SH-17-05-17128B-S03 to SH-17-05-17129A-S07 from 93-98 meters.



Figure 9. *Primnoidae*, sample SH-17-05-17129A-S08 from 98 meters

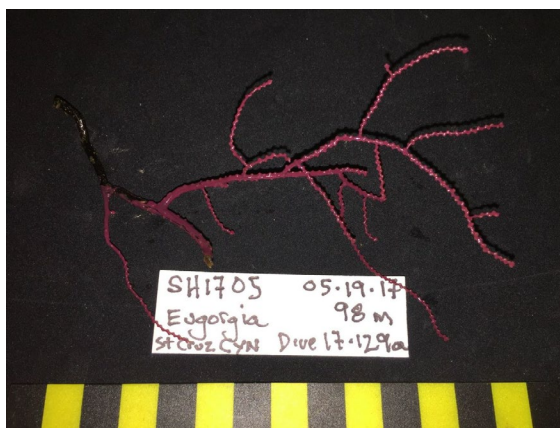


Figure 10. *Eugorgia rubens*, sample SH-17-05-17129A-S09 from 98 meters.

Table 5. Inventory of seafloor transect surveys conducted using the ROV *Beagle* during expedition SH-17-05 to the Channel Islands National Marine Sanctuary.

ROV Dive no.	Transect ID	Locality	Start time (UTC)	Start latitude	Start longitude	Start depth (m)	End time (UTC)	End latitude	End longitude	End depth (m)
39	17-120A-T01	South Santa Cruz	21:28:00	33.96913	-119.584	81	21:35:30	33.96798	-119.584	81
39	17-120A-T02	South Santa Cruz	21:43	33.96684	-119.583	86	21:49:36	33.96625	-119.583	86
39	17-120A-T03	South Santa Cruz	22:00:00	33.95158	-119.582	87	22:15:10	33.96608	-119.581	87
39	17-120A-T04	South Santa Cruz	22:20:40	33.96584	-119.58	87	22:35:46	33.9652	-119.578	88
39	17-120A-T05	South Santa Cruz	22:43:55	33.96555	-119.578	87	22:58:56	33.96776	-119.577	83
40	17-121A-T01	South Santa Cruz	16:52:40	33.96354	-119.542	250	17:10:40	33.96525	-119.542	251
40	17-121A-T02	South Santa Cruz	17:14:15	33.96569	-119.543	251	17:29:20	33.96809	-119.543	189
40	17-121A-T03	South Santa Cruz	17:41:05	33.96871	-119.543	184	17:55:22	33.97049	-119.544	139
41	17-122A-T01	South Santa Cruz	22:52:05	33.95208	-119.622	248	23:03:05	33.95398	-119.625	218
41	17-122A-T02	South Santa Cruz	23:20:19	33.95506	-119.626	191	23:35:10	33.95764	-119.629	149
41	17-122A-T03	South Santa Cruz	23:59:00	33.955	-119.626	148	0:10:10	33.95504	-119.629	146
42	17-122A-T01	Santa Cruz Canyon	16:40:26	33.9232	-119.802	NA	17:04:17	33.92448	-119.801	NA
42	17-123A-T02	Santa Cruz Canyon	17:12:00	33.92491	-119.802	222	17:28:00	33.92542	-119.802	170
42	17-123A-T03	Santa Cruz Canyon	17:51:00	33.92671	-119.803	147	18:19:30	33.92857	-119.804	100
42	17-123A-T04	Santa Cruz Canyon	19:01:00	33.92952	-119.806	98	19:14:37	33.9301	-119.808	94
44	17-124A-T01	South Santa Cruz	19:19:09	33.94485	-119.695	73	19:34:09	33.9442	-119.698	70
44	17-124A-T02	South Santa Cruz	19:40	33.94408	-119.698	71	19:55	33.94364	-119.7	73
44	17-124A-T03	South Santa Cruz	20:06	33.94326	-119.702	75	20:22	33.94272	-119.705	80
44	17-124A-T04	South Santa Cruz	20:27	33.94255	-119.705	80	20:42	33.94202	-119.708	83
46	17-125A-T01	South Santa Cruz	16:57:30	33.91494	-119.853	337	17:12:25	33.91715	-119.852	310
46	17-125A-T02	South Santa Cruz	17:29:01	33.91995	-119.85	253	17:44	33.92256	-119.849	206
46	17-125A-T03	South Santa Cruz	17:56:30	33.92478	-119.849	103	18:11:30	33.9283	-119.848	98
46	17-125A-T04	South Santa Cruz	18:26:55	33.92917	-119.848	92	18:28:16	33.93123	-119.847	92
47	17-125B-T01	South Santa Cruz	20:50:05	33.9459	-119.629	326	21:05:13	33.94667	-119.631	277
47	17-125B-T02	South Santa Cruz	21:26:30	33.94722	-119.633	222	21:43:23	33.94699	-119.635	225
47	17-125B-T03	South Santa Cruz	22:21:20	33.94716	-119.639	197	22:36:29	33.94876	-119.639	138
48	17-127A-T01	South Santa Cruz	15:27:02	33.94288	-119.838	86	15:42	33.9445	-119.757	73
48	17-127A-T02	South Santa Cruz	15:44:25	33.94465	-119.757	70	15:56	33.94515	-119.758	69
48	17-127A-T03	South Santa Cruz	16:01	33.94553	-119.758	66	16:16	33.94775	-119.758	63
49	17-127B-T01	South Santa Cruz	18:41:45	33.95634	-119.539	362	18:56:49	33.95738	-119.54	295
49	17-127B-T02	South Santa Cruz	19:01:15	33.95739	-119.54	283	19:17	33.95775	-119.542	245
49	17-127B-T03	South Santa Cruz	19:21:40	33.95813	-119.543	236	19:37:42	33.95857	-119.546	230
49	17-127B-T04	South Santa Cruz	19:55:49	33.95887	-119.546	230	20:10:45	33.95941	-119.548	230
50	17-127C-T01	South Santa Cruz	21:41:42	33.96507	-119.524	330	21:58:30	33.96643	-119.525	280
50	17-127C-T02	South Santa Cruz	22:18:15	33.96726	-119.526	240	22:34	33.96782	-119.527	218

ROV Dive no.	Transect ID	Locality	Start time (UTC)	Start latitude	Start longitude	Start depth (m)	End time (UTC)	End latitude	End longitude	End depth (m)
50	17-127C-T03	South Santa Cruz	22:35:15	33.96802	-119.527	215	22:38:20	33.96882	-119.526	206
50	17-127C-T04	South Santa Cruz	22:59:30	33.96903	-119.528	203	22:19:40	33.96994	-119.53	202
51	17-128A-T01	South Santa Rosa	16:59:30	33.88923	-119.946	83	17:08:44	33.88993	-119.949	84
51	17-128A-T02	South Santa Rosa	17:28:45	33.8902	-119.95	77	17:43:43	33.89107	-119.952	74
51	17-128A-T03	South Santa Rosa	18:29:30	33.89146	-119.952	73	18:46:30	33.89426	-119.952	73
51	17-128A-T04	South Santa Rosa	19:00:14	33.89537	-119.952	72	19:15:39	33.89752	-119.952	73
51	17-128A-T05	South Santa Rosa	19:28:14	33.89866	-119.952	72	19:43:30	33.89948	-119.934	74
52	17-128B-T01	South Santa Rosa	22:48:15	33.86961	-119.923	108	23:02:37	33.86988	-119.926	106
52	17-128B-T02	South Santa Rosa	23:09:00	33.86992	-119.93	99	23:23:51	33.87115	-119.93	96
52	17-128B-T03	South Santa Rosa	23:30:15	33.92235	-119.931	94	23:45:15	33.92461	-119.931	93

Outreach/Education

In prior years, this cruise has had a Teacher at Sea aboard to develop outreach and education products. This model has proven successful in the past, however a lack of berth space this year prevented a Teacher at Sea from sailing on this mission. Despite this, we were able to contribute to a blog and post the Mission Highlights on social media in near real-time. This included posts that had a large reach; one post in particular had over 20,000 views and over 1000 shares. Post cruise, CINMS education staff continued to use the images and video from the expedition to further develop outreach products and contribute to the Office of National Marine Sanctuary’s Media Library.

Acknowledgements

We thank the officers and crew of the NOAA Ship *Bell M Shimada*, and in particular Commanding Officer Paul Kunicki, who provided extraordinary support for all operations. Special thanks to the ROV pilots Dirk Rosen and Andy Lauermann, who exhibited superb skills in operating the ROV. We would also like to thank Dr. Juliet Kinney for troubleshooting issues with the ME70 hardware and software, and the hydrographic survey technicians and electronics technicians of the *Shimada* for their support in resolving those issues. Special thanks are also due to Fabio Campanella, Laura Kracker, and Rob Downs for their OMAO summaries and figures that served as the starting point for this document.

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Appendix I: Dive Summaries

This appendix identifies dives by the NOAA assigned dive number and the MARE dive number which is continuous across the multiple years of this survey project. NOAA dive numbers are formatted as year, Julian date, and a letter for dives occurring within the same day. Start and End coordinates, a depth range, and the approximate amount of on bottom time are also provided. The maps included for each dive show the ROV track over the best available bathymetry available at the time of the expedition, and are representative of the layers used to plan the dive. A written summary of the events of each dive were authored at the end of each day of operations and attempt to capture all of the significant events of the dive, highlight images are included to provide a representation of the habitat and taxa observed during the course of the dive.

Dive 17-120A (MARE 39)

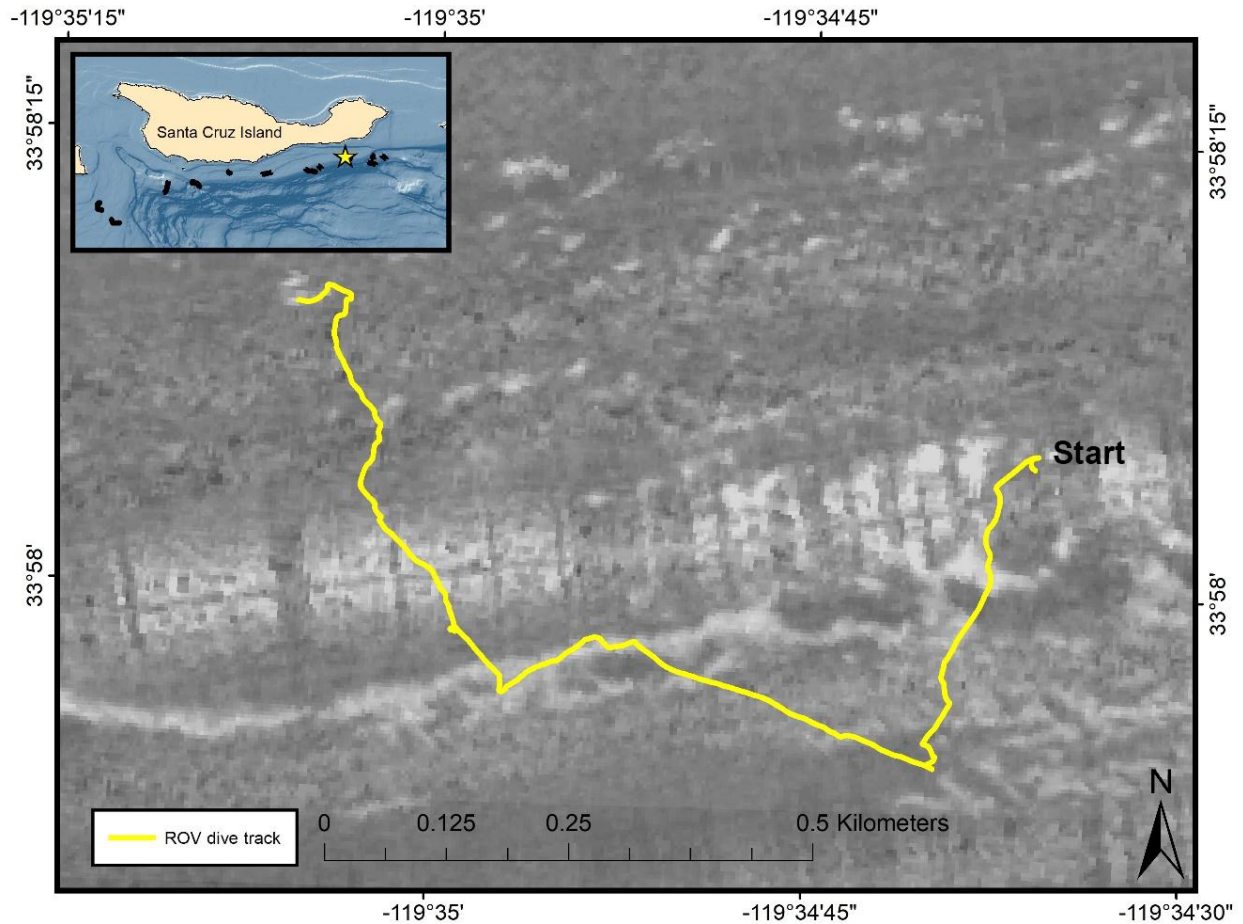
SCS Site ID: SoStCruz_02

Start Coordinate: 33.96935, -119.58417

End Coordinate: 33.96785, -119.57668

Depth Range: 80-89m

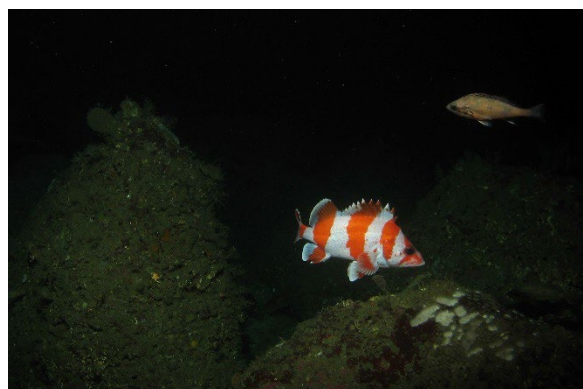
Bottom Time: 2 hours 10 minutes



Map caption: ROV dive path outlined in yellow over black and white backscatter data generated in 2016 aboard NOAA vessel Reuben Lasker.

Dive Summary:

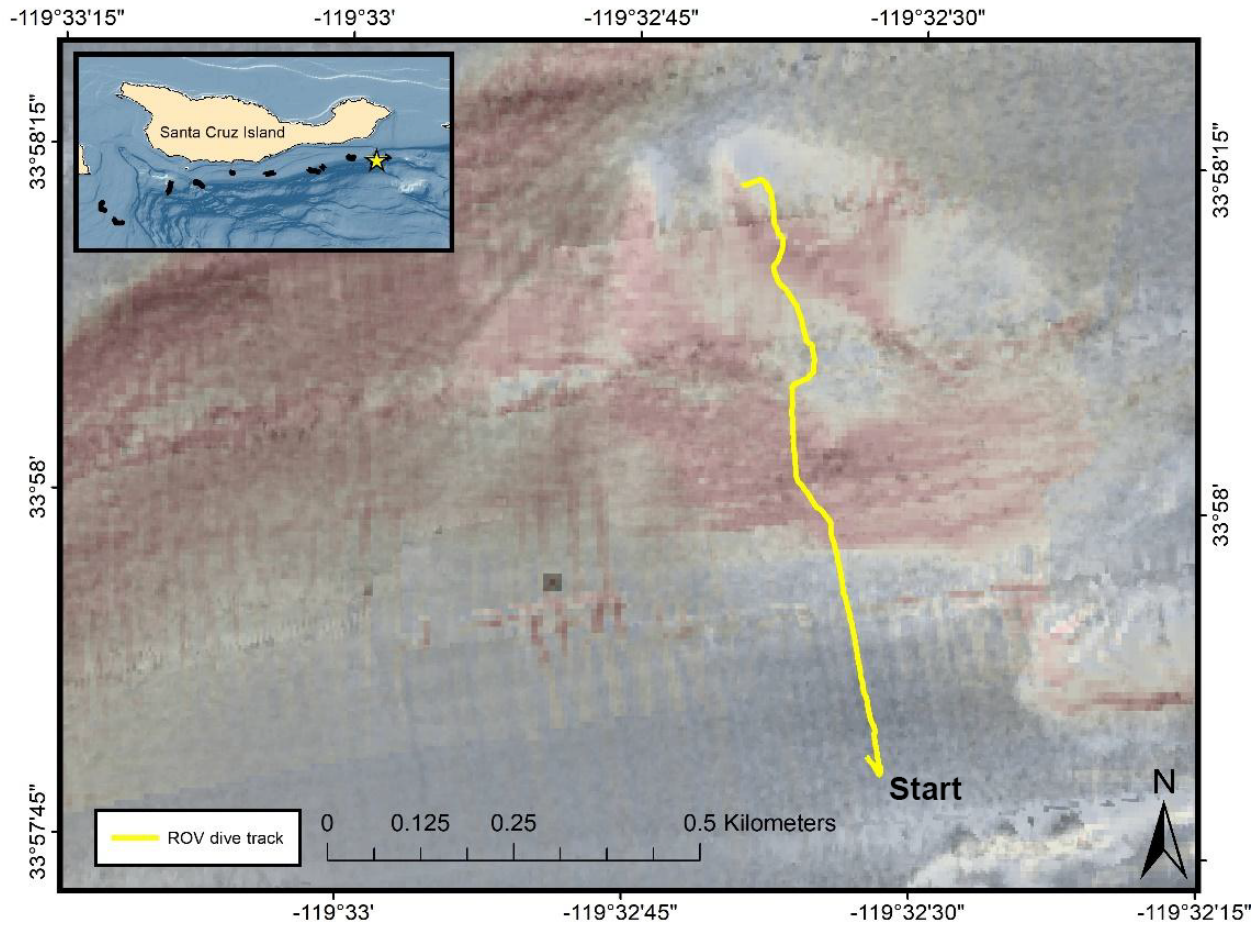
ROV arrived on bottom at 21:14:31 UTC and left bottom at 23:04:23 UTC on April 30 2017 (UTC). While on bottom five transects were conducted each lasting approximately 15 minutes in duration. No samples collections were attempted this dive. The key species observed during this deployment were sea pens and sea whips and small urchins while over soft sediment. Key species observed over rocky habitat were *Eugorgia rubens*, an unknown yellow gorgonian, and several species of sponges. Common fish species observed included; flag, copper, half-banded rockfish, and poachers. There were a few technical issues with the ROV during this deployment, such as a GPS time stoppage on the video that lasted approximately two minutes. In addition, this dive was conducted from the shallowest waypoint to the deepest waypoint at the request of the bridge crew. Typically, for the ease of ROV operations and adequate visibility of the seafloor, ROVs travel up slope.



Dive took place South of Santa Cruz Island in depths ranging from 80 to 90 meters, using the ROV *Beagle* aboard NOAA vessel *Bell M. Shimada*. A) *Ptilosarcus gurneyi* in soft sediment habitat. B) Sea whip (Pennatulacea) in soft sediment. C) *Eugorgia rubens* on hard bottom habitat. D) Porifera on hard-bottom habitat with school of half banded rockfish in background. E) Flag and half banded rockfish over hard-bottom habitat. F) Copper rockfish over hard-bottom sediment.

Dive 17-121A (MARE 40):
Start Coordinate: 33.96355, -119.54213
Depth Range: 110 – 260 meters

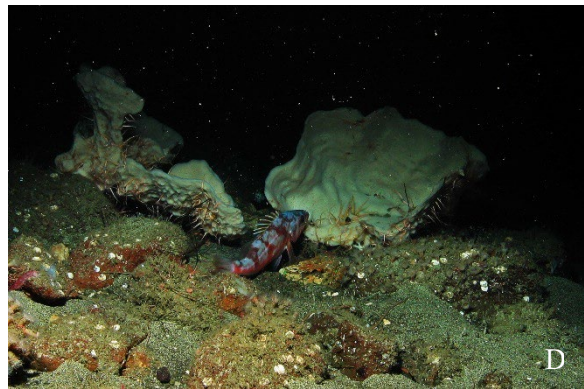
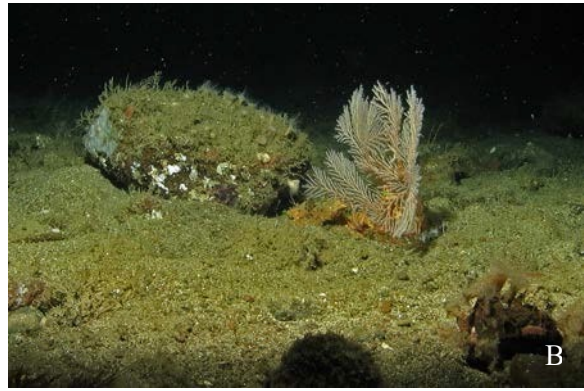
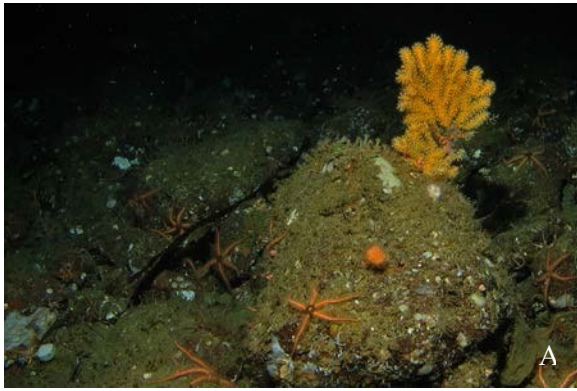
Site: SoStCruz_03
End Coordinate: 33.97215, -119.54523
Bottom Time: 1 hour 15 minutes



Map caption: ROV dive path outlined in yellow over three background layers. Those layers include backscatter data in transparent greyscale, slope transparent with red representing high slope, and a hill shade generated from bathymetry data generated in 2016 aboard NOAA vessel Reuben Lasker.

Dive Summary:

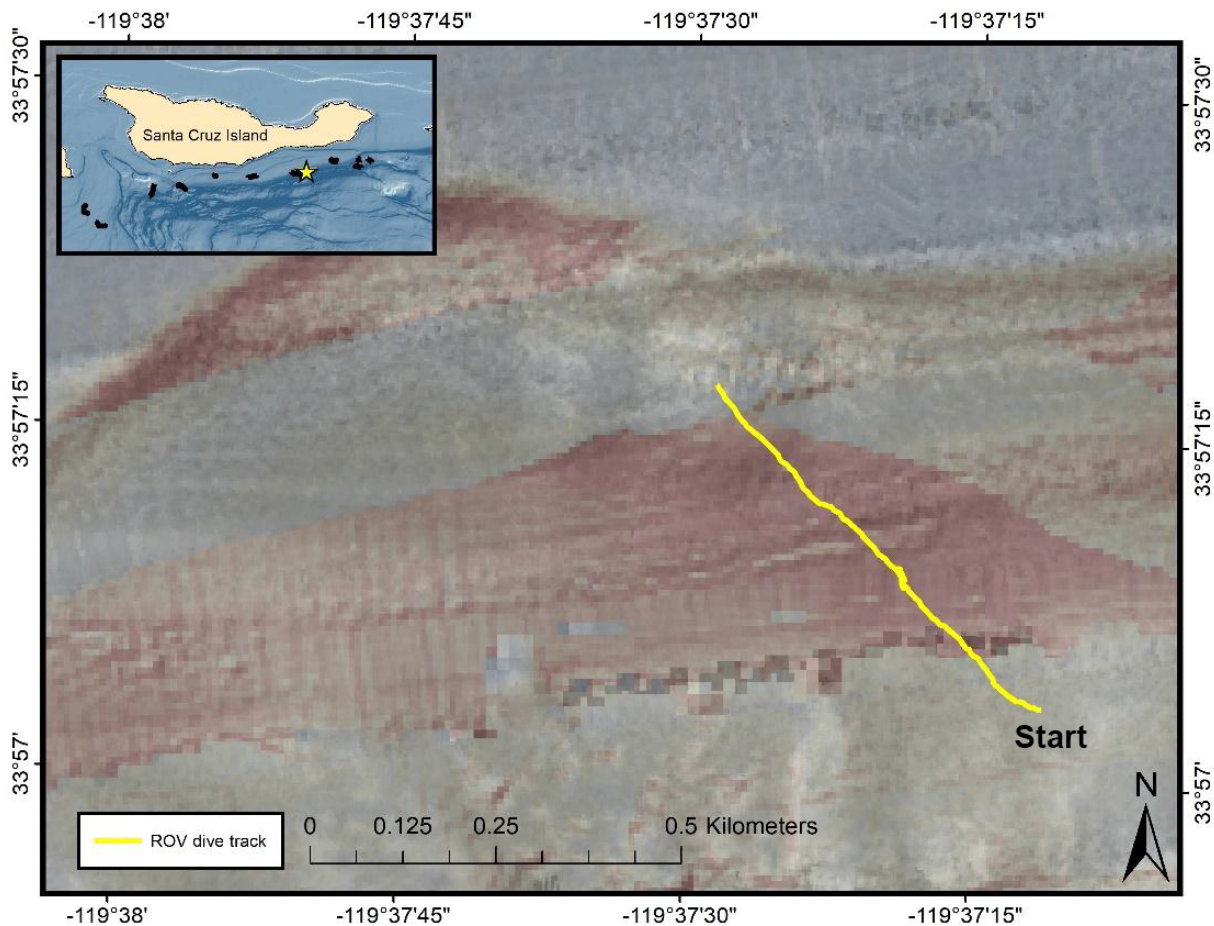
ROV arrived on bottom at 16:45:53 UTC and left bottom at 18:02:45 UTC on May 1 2017 (UTC). While on bottom three transects were conducted, each approximately 15 minutes in duration. No samples collections were attempted this dive. Key species observed during the dive included pink urchins, flatfish, poachers, and sea pens over soft bottom, and boot and vase sponges, as well as *Plumarella* and *Acanthogorgia* over rocky bottom. Fish species observed included copper, aurora, and green spotted rockfish. The dive was ended due to a flooded rectifier bottle on the ROV. The hand controller for the still camera also experienced intermittent outages though video was unaffected.



Dive took place South of Santa Cruz Island in depths ranging from 110 to 240 meters, using the ROV *Beagle* aboard NOAA vessel *Bell M. Shimada*. A) *Acanthogorgia sp.* with evidence of injury, on hard-bottom habitat. B) *Plumarella sp.* on hard-bottom habitat with thin veneer of coarse sediment. C) Crinoid and *Sebastes* utilizing *Porifera* as habitat. D) *Porifera* on hard-bottom habitat potentially providing structure for Mexican Rockfish. E) Injured sponge providing structure and shelter from squat lobster. F) Cowcod rockfish over hard-bottom sediment.

Dive 17-122A (MARE 41):
Start Coordinate: 33.95122, -119.62053
Depth Range 92-250m

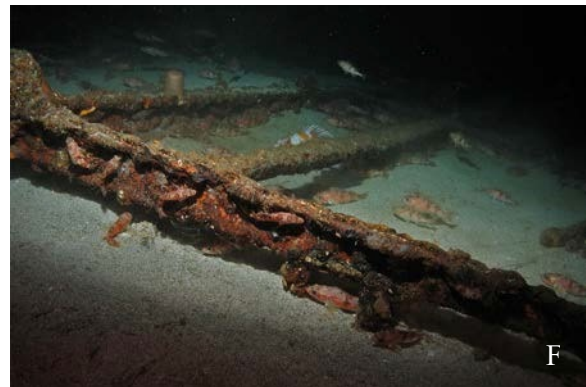
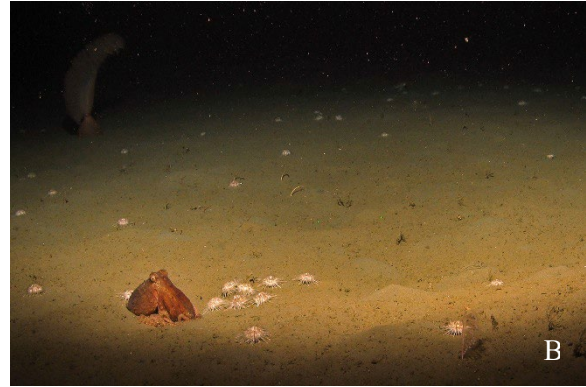
Site: SoStCruz_05
End Coordinate: 33.95513, -119.63737
Bottom Time: 2 hours 3minutes



Map caption: ROV dive path outlined in yellow over three background layers. Those layers include backscatter data in transparent greyscale, slope transparent with red representing high slope, and a hill shade generated from bathymetry data generated in 2016 aboard NOAA vessel Reuben Lasker.

Dive Summary:

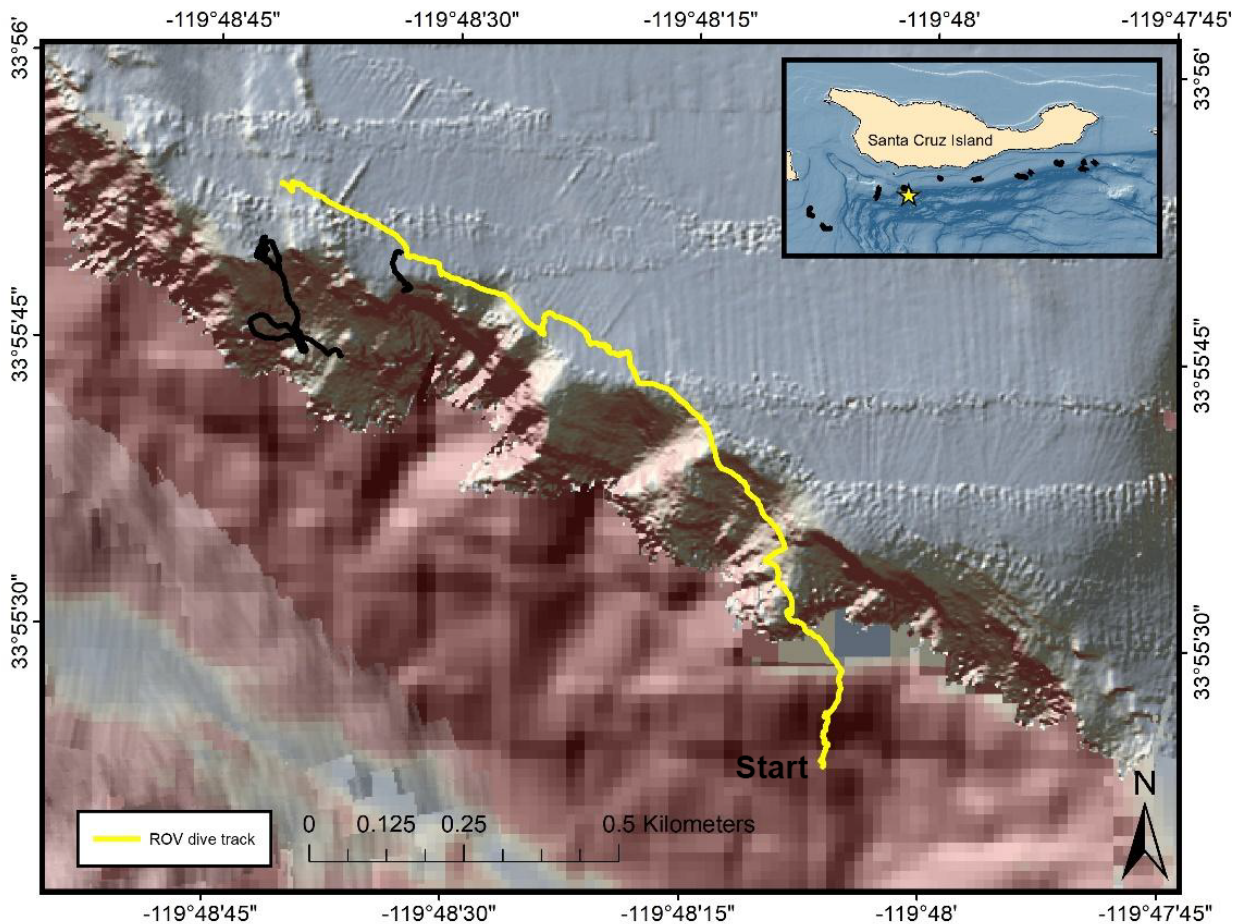
ROV arrived on bottom at 22:47:35 UTC on May 2 2017 (UTC) and left bottom at 00:50:58 UTC on May 3 2017 (UTC). Bottom was 50 meters deeper than predicted. While, on bottom 4 transects were conducted each were approximately 15 minutes in duration. No samples collections were attempted this dive. The skeletal remains of what was likely multiple elephant seals were observed at the end of the dive. Key species observed during the dive included urchins, *Dromalea*, California king crab, flatfish, and a few small octopus. The entirety of the dive was over soft bottom with a few rock outcrops. At the end of the dive wreckage from a barge or ship was found surrounded by large aggregations of rockfish. Tracking on the ROV failed after the third transect and the ROV was operated by dead reckoning. The camera hand controller issues experienced during the previous dive continued during this dive.



Dive took place South of Santa Cruz Island in depths ranging from 85 to 250 meters, using the ROV *Beagle* aboard NOAA vessel *Bell M. Shimada*. A) King crab and urchin on fine sediment soft-bottom habitat. B) Small octopus and urchins on soft-sediment habitat with *Ptilosarcus gurneyi* in background. C) Ratfish and anemone on coarse sediment soft-bottom habitat. D) *Crinoids* and anemone on line or cable possibly from fishing efforts, with associated lingcod. E) Anemone and large school of various *Sebastes* on sunken debris from possible ship or barge in soft sediment. F) Large school of various *Sebastes* on sunken debris from possible ship or barge in soft sediment.

Dive 17-123A (MARE 42):
Start Coordinates: 33.92042, -119.80318
Depth Range 88-350

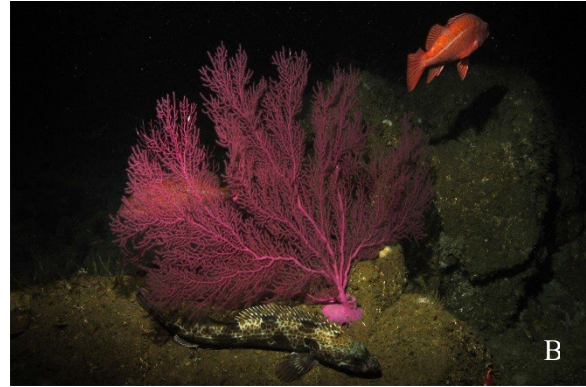
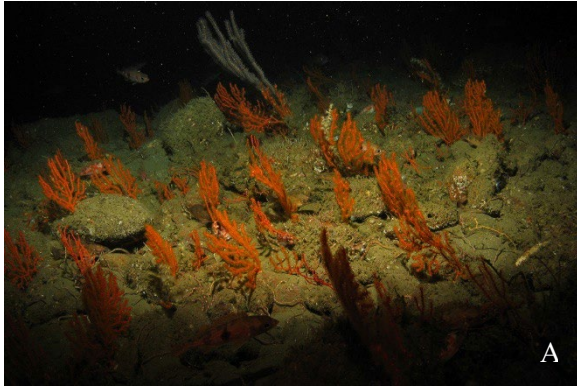
Site: SoStCruz_09
End Coordinates: 33.93707, -119.81585
Bottom Time: 3 hours 34 minutes



Map caption: ROV dive path outlined in yellow over three background layers. Those layers include backscatter data in transparent greyscale, slope transparent with red representing high slope, and a hill shade generated from bathymetry data generated in 2016 aboard NOAA vessel Reuben Lasker and Okeanos explorer in 2011.

Dive Summary:

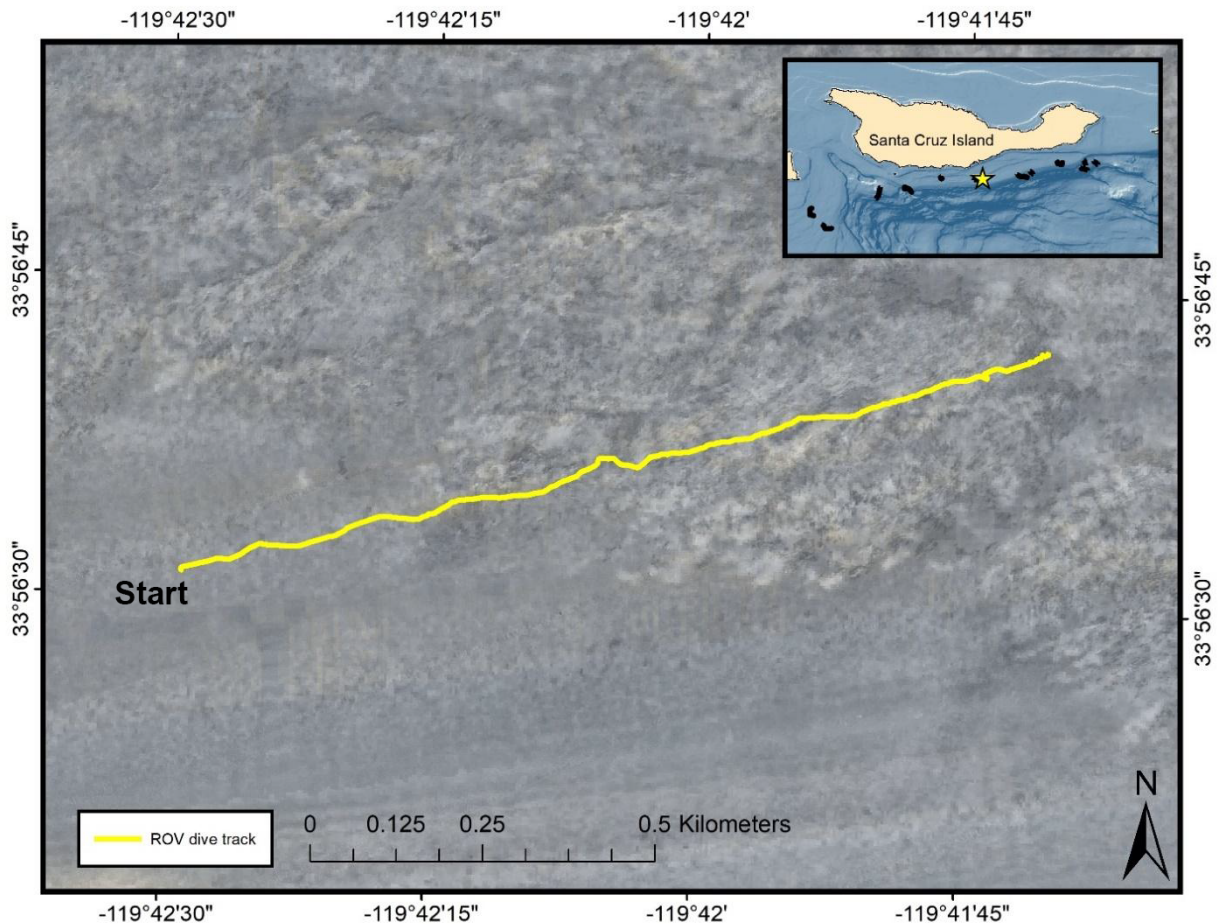
The ROV arrived on bottom at 16:08:49 UTC and left bottom 20:08:52 UTC on May 3 2017 UTC. While on bottom 4 transects were conducted each approximately 15 minutes in duration. The ROV experienced fewer technical issues though there was a short video outage after the fourth transect. Key species observed included various sponges, *Swiftia* and *Acanthogorgia* on the canyon rise, with large dense aggregations of *Adelogorgia* at the rim. The aggregations of *Adelogorgia* were intermixed with occasional occurrences of *Plumarella*, *Eugorgia*, and an unknown *plexaurid* with white polyps. A large variety of rockfish species were observed, including large schools of vermilion and half banded and square spot. Of special note was *Lophelia* was spotted at 172 meters, and detached Sargassum was observed at 150 meters. The habitat observed was all hard bottom.



Dive took place at Santa Cruz Canyon in depths ranging from 80 to 350 meters, using the ROV *Beagle* aboard NOAA vessel *Bell M. Shimada*. A) High density aggregation of *Adelogorgia phylosclera* and a single unknown white *Plexauridae* on hard-bottom habitat. B) Large *Eugorgia rubens* being utilized by lingcod and vermillion rockfish over hard-bottom habitat. C) Two white *Plexaurids* co-occurring with *Adelogorgia phylosclera*. D) School of vermillion rockfish over hard-bottom habitat. E) Giant octopus traversing through an aggregation of *Adelogorgia phylosclera* and *Eugorgia rubens*. F) Sixgill shark on high relief rock wall.

Dive 17-124A (MARE 44):
Start Coordinate: 33.94495,-119.69503
Depth Range: 73-84m

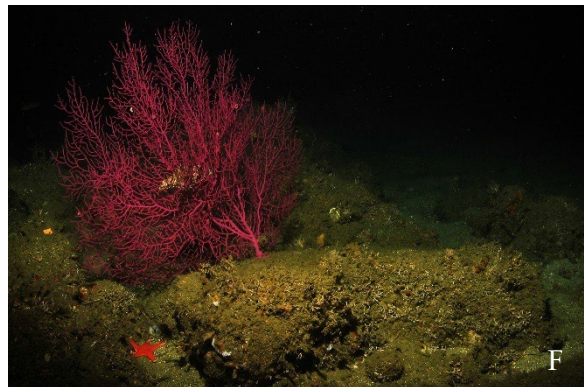
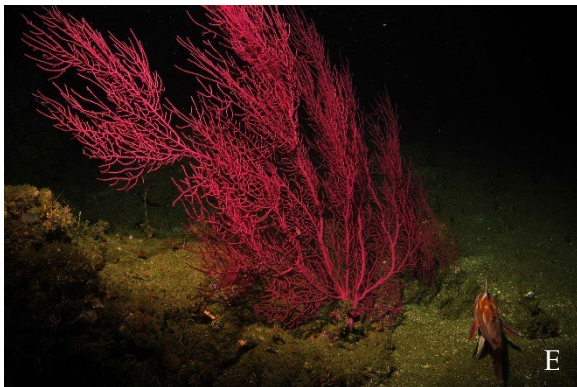
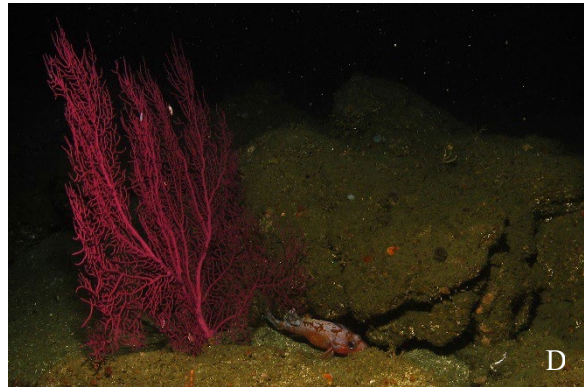
Site: SoStCruz_01
End Coordinate: 33.94153, -119.70957
Bottom Time: 1 hour 47 minutes



Map caption: ROV dive path outlined in yellow over two background layers. Those layers include backscatter data in transparent greyscale, and a hill shade generated from bathymetry data generated in 2016 aboard NOAA vessel Reuben Lasker.

Dive Summary:

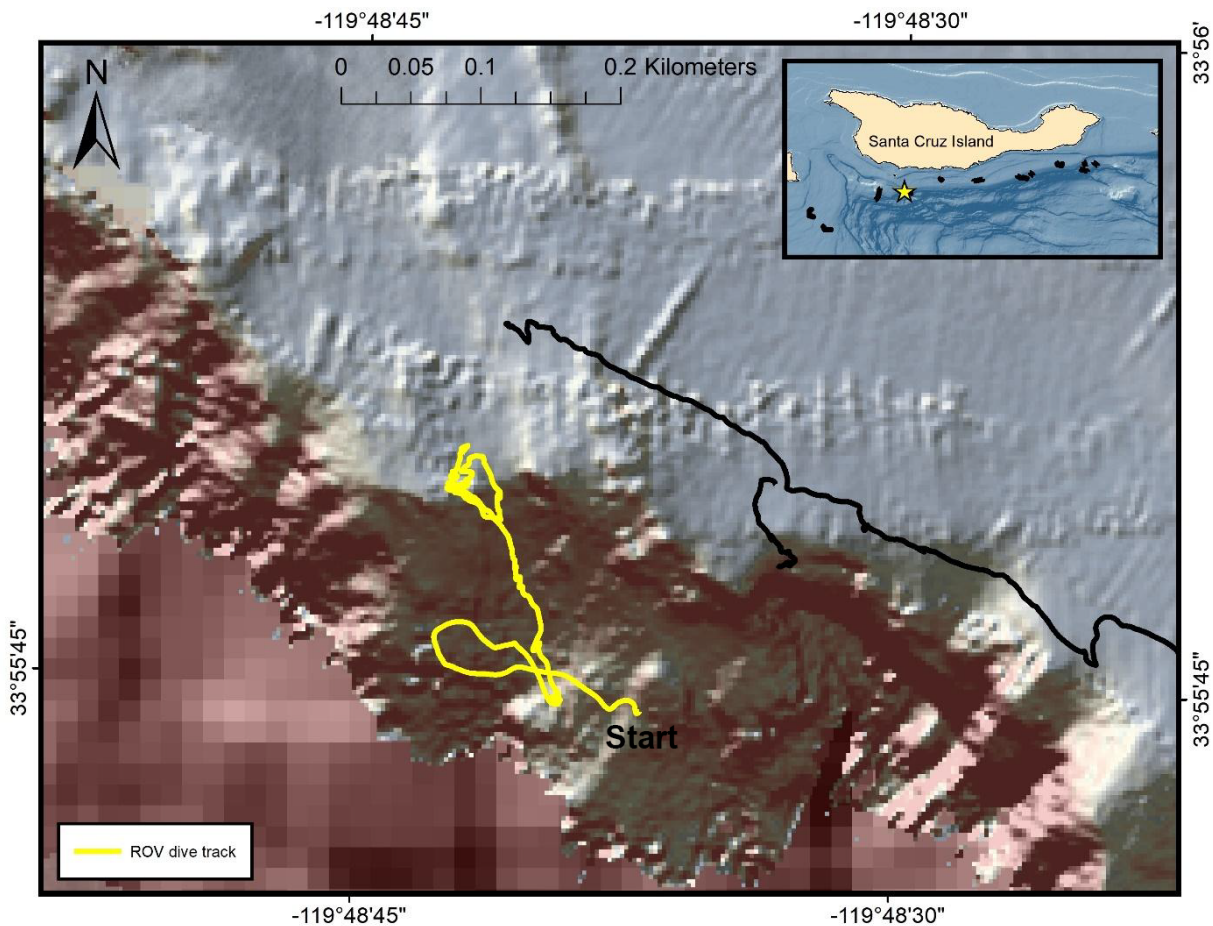
The ROV reached bottom at 19:05:00 UTC and left bottom 20:52:00 UTC on May 4 2017 UTC, while on bottom four transects took place. Habitat was predominantly rocks and boulders with many large *Eugorgia* colonies, there were a few instances of possible *Lophelia*. Fish species observed during this dive included vermilion, starry, blue, and copper rockfish. Yellow gobies, California scorpionfish, and ocean whitefish were also present. There were no technical issues during the course of this dive.



Dive took place south of Santa Cruz Island in depths ranging from 70 to 80 meters, using the ROV *Beagle* aboard NOAA vessel *Bell M. Shimada*. A) Starry rockfish over mixed bottom. B) Copper rockfish over mixed bottom type habitat. C) Large *Eugorgia rubens* possibly being utilized by starry rockfish. D) Large *Eugorgia rubens* possibly being utilized by Mexican rockfish. E) Large *Eugorgia rubens* possibly being utilized by copper rockfish. F) Large *Eugorgia rubens* possibly being utilized by California scorpionfish.

Dive 17-124B (MARE 45):
Start Coordinate: 33.92787, -119.81063
Depth Range: 90-168m

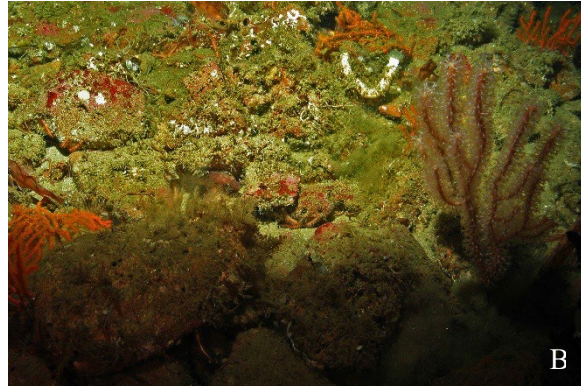
Site: SoStCruz_10
End Coordinate: 33.93140, -119.81110
Bottom Time: 1 hour 12 minutes



Map caption: ROV dive path outlined in yellow over three background layers. Those layers include backscatter data in transparent greyscale, slope transparent with red representing high slope, and a hill shade generated from bathymetry data generated in 2016 aboard NOAA vessel Reuben Lasker and Okeanos Explorer in 2011.

Dive Summary:

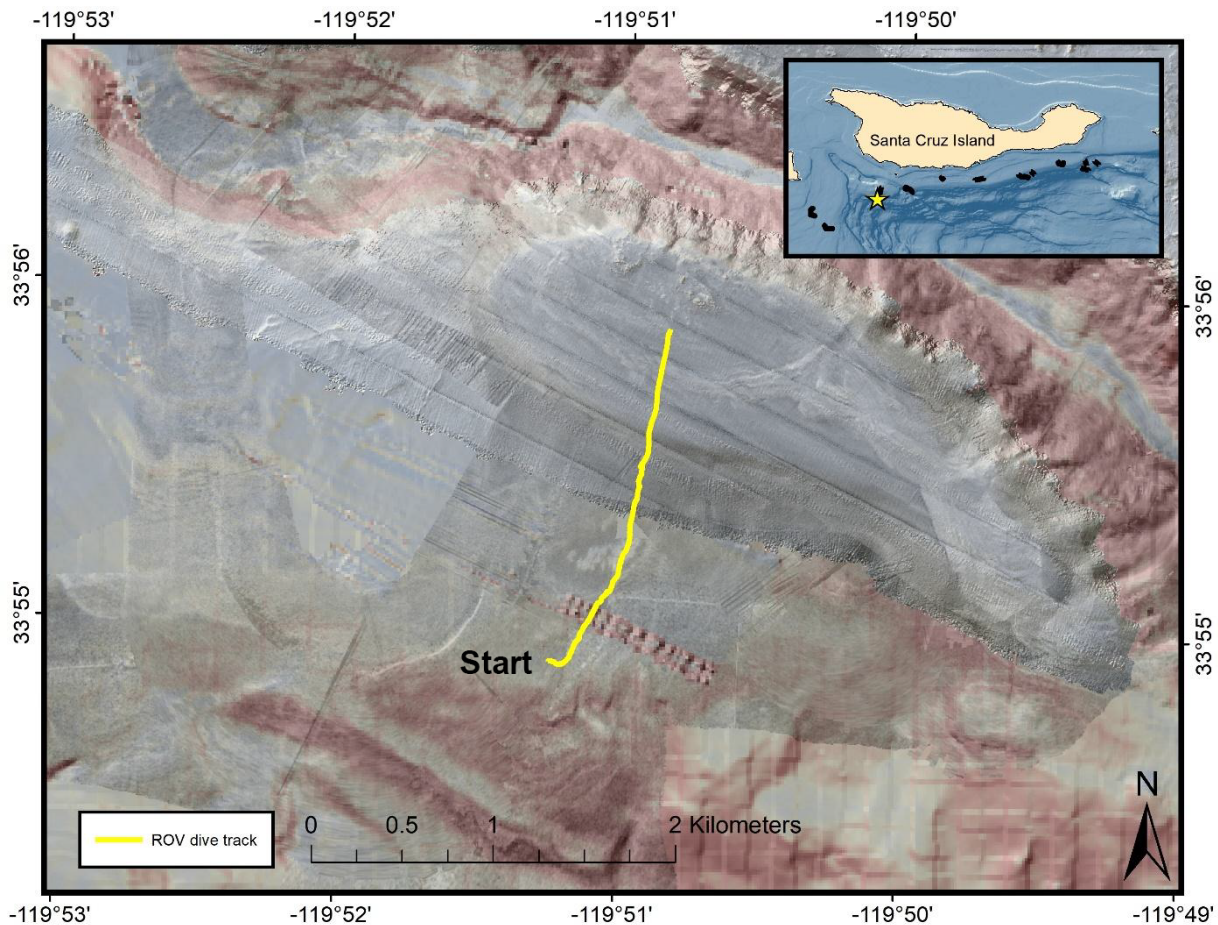
The ROV first reached bottom at 23:25:30 on May 4 2017. The vessel failed to hold position and drug the ROV. Vessel and ROV returned to planned dive path and acquired bottom again at 23:43:40. During this process the clump weight may have struck bottom. No transects were attempted on this dive, since sample collection was the priority objective. Three colonies of an unknown gorgonian with white polyps were targeted for collection. The first sample fell into a crevice and could not be retrieved; two subsequent samples were both successful. The still image camera on the ROV was only available intermittently; however, the dive was fully documented on video.



Dive took place in Santa Cruz canyon in depths ranging from 80 to 250 meters, using the ROV *Beagle* aboard NOAA vessel *Bell M. Shimada*. A) Starry rockfish near unknown white plexaurid targeted for collection B) Unknown plexaurid targeted for collection.

Dive 17-125A (MARE 46)
Start Coordinate: 33.91483, -119.85317
Depth Range 92-337m

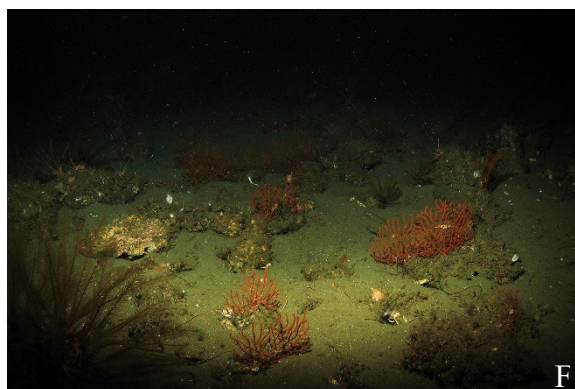
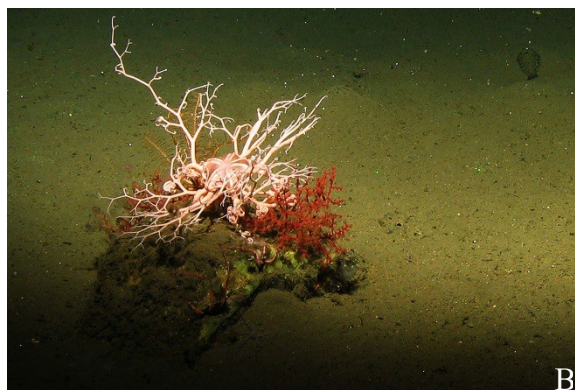
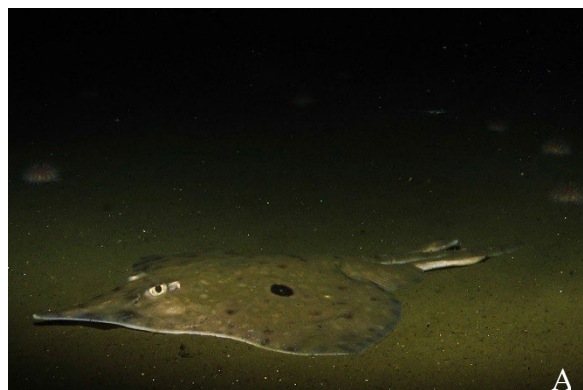
Site: SoStCruz_07
End Coordinate: 33.92692, -119.84837
Bottom time 1 hour 40 minutes



Map caption: ROV dive path outlined in yellow over three background layers. Those layers include backscatter data in transparent greyscale, slope transparent with red representing high slope, and a hill shade generated from bathymetry data generated aboard NOAA vessel Reuben Lasker (2016), NOAA vessel Okeanos Explorer (2011) and EV Nautilus (2016).

Dive Summary:

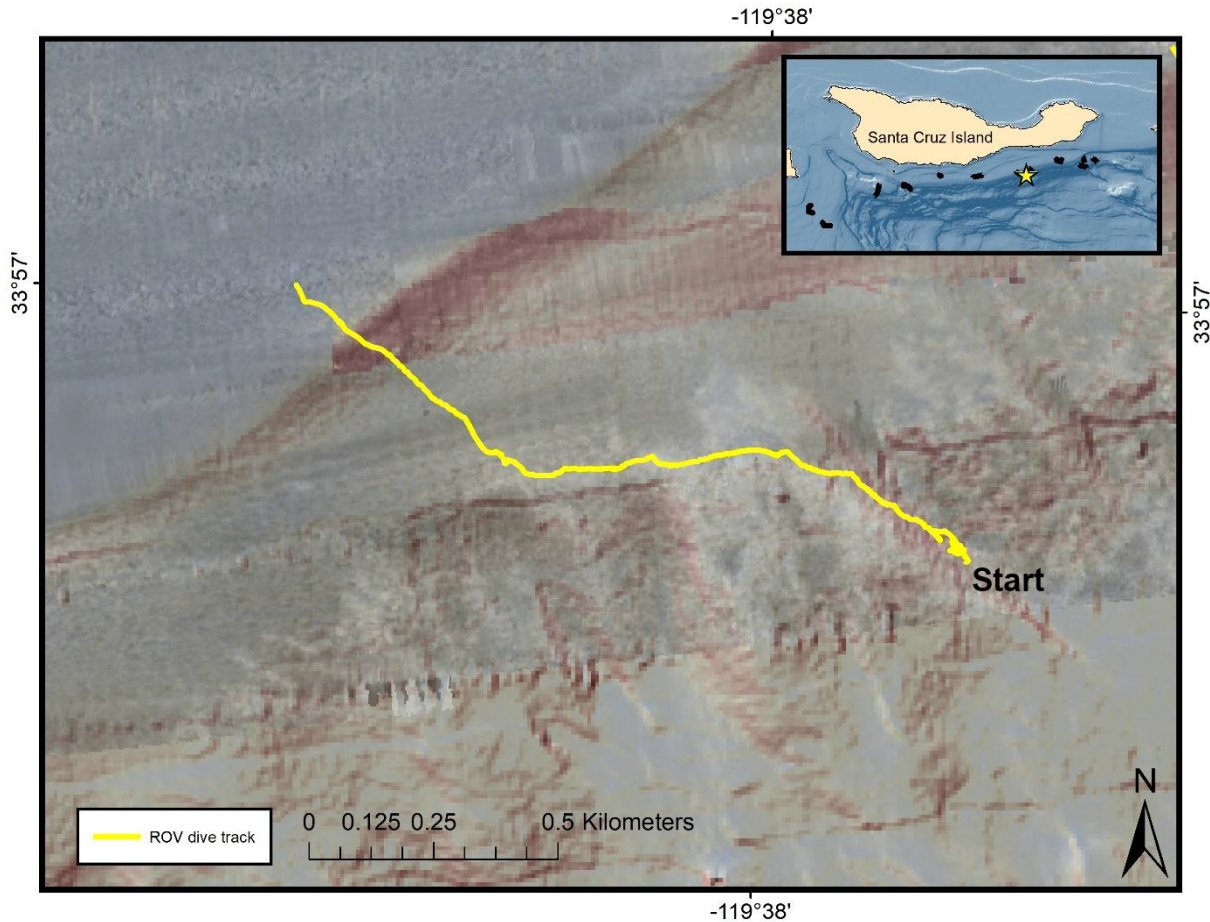
The ROV reached bottom at 16:51:09 UTC and remained on bottom until 18:29:10 UTC on May 5 2017 UTC. During this dive 4 transects were conducted that lasted approximately 15 minutes. ROV speed was increased during these transects given the sand habitat. Only a few small rock outcrops were observed during this dive, the hard bottom signature from the back scatter and the potential ridge identified in the slope model were never observed. Key species observed were primarily sea pens in the soft sediment, with *Adelogorgia* and *Eugorgia* present on the few rock outcrops encountered. Ratfish, skates, and halfbanded rockfish were the common fish species observed.



Dive took place south of Santa Cruz Island in depths ranging from 92 to 337 meters, using the ROV *Beagle* aboard NOAA vessel *Bell M. Shimada*. A) Skate over soft bottom. B) *Adelogorgia phyllosclera* and basket star on small rock surrounded by soft bottom. C) Urchin aggregations on soft bottom. D) Spot prawn, urchins, unidentified fish species, with single sea pen. E) California king crabs and basket star on mixed bottom habitat. F) *Adelogorgia phyllosclera* aggregation surrounded by crinoids.

Dive 17-125B (MARE 47)
Start Coordinate: 33.94548, -119.62848
Depth Range: 197-337m

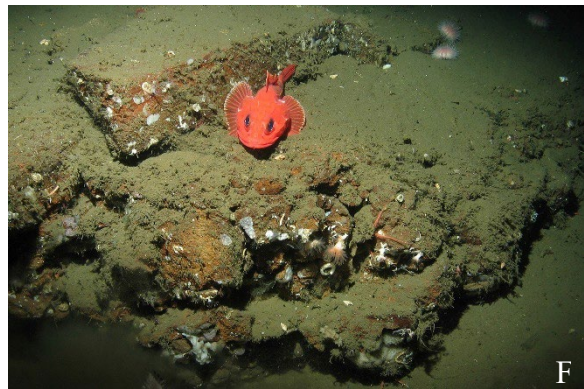
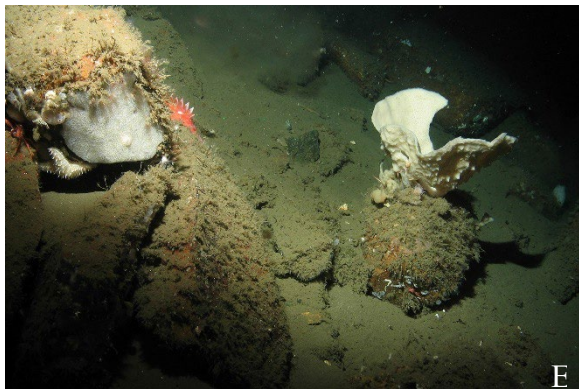
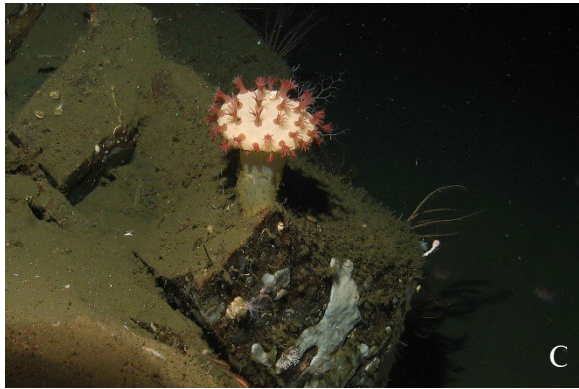
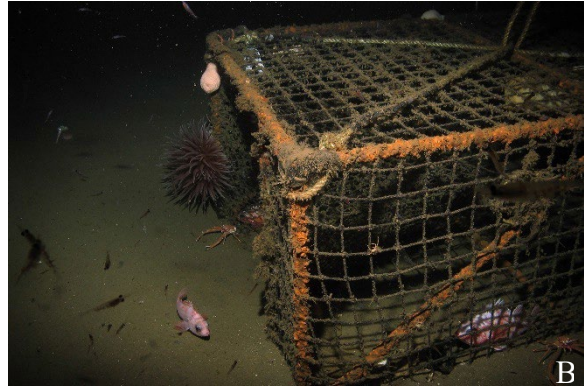
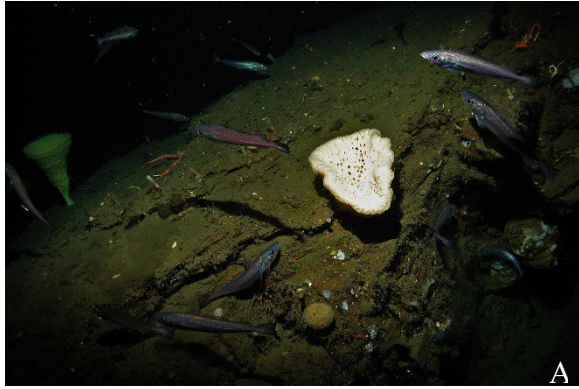
Site: SoStCruz_12
End Coordinate: 33.95003, -119.64340
Bottom Time: 2 hours 20 minutes



Map caption: ROV dive path outlined in yellow over three background layers. Those layers include backscatter data in transparent greyscale, slope transparent with red representing high slope, and a hill shade generated from bathymetry data generated in 2016 aboard NOAA vessel Reuben Lasker.

Dive Summary:

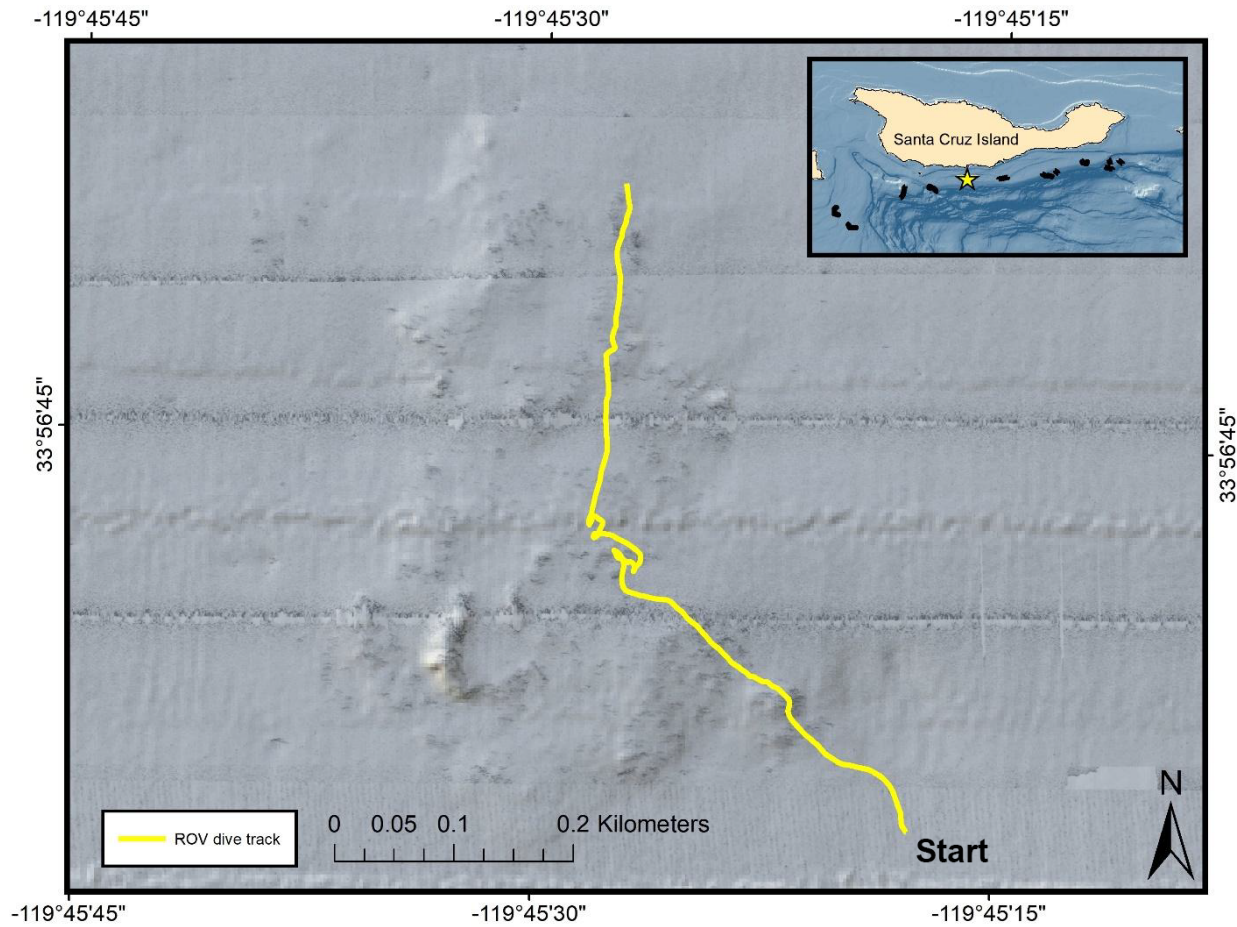
ROV reached bottom at 20:29:55 UTC and remained on bottom until 22:40:00 UTC on May 5 2017 UTC. During the descent, the ROV encountered a large school of Tomcod at 300 meters that continued until the seafloor was reached (337m). Upon arrival on bottom the ROV encountered derelict fishing gear and had to leave bottom to avoid becoming entangled in the associated line floating in the water column above the gear. The lateral thruster of the ROV was out, but did not impede operations. Three transects were conducted each approximately 15 minutes in length. Key species observed included a variety of sponges and anemones attached to rock features covered in a veneer of sediment.



Dive took place south of Santa Cruz Island in depths ranging from 197 to 337 meters, using the ROV *Beagle* aboard NOAA vessel *Bell M. Shimada*. A) Various sponges surrounded by school of Tomcod. B) Derelict crab trap with pom pom anemone and rockfish. C) *Anthomastus* sp. (mushroom coral) on sedimented rock feature. D) Anemones on sedimented rock feature. E) Sponges on rock outcrop. F) Thornyhead on sediment covered rock feature.

Dive 17-127A (MARE 48)
Start Coordinate: 33.94825, -119.75748
Depth Range: 63-86m

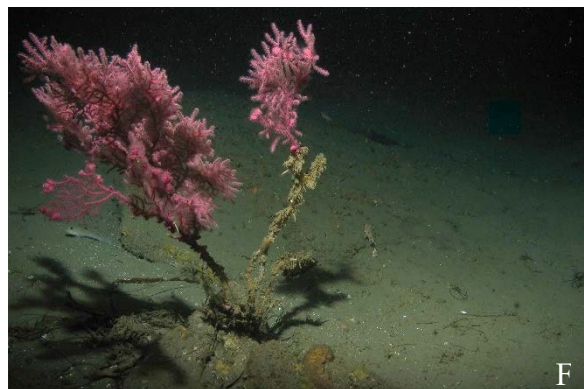
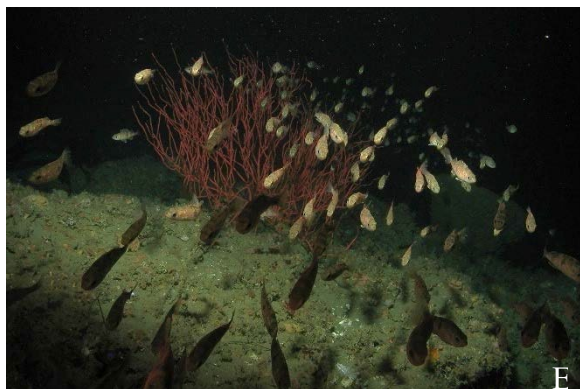
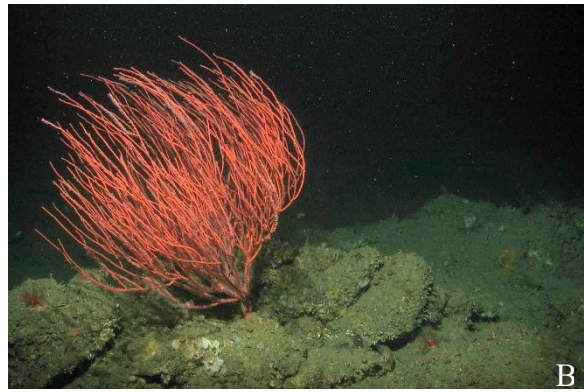
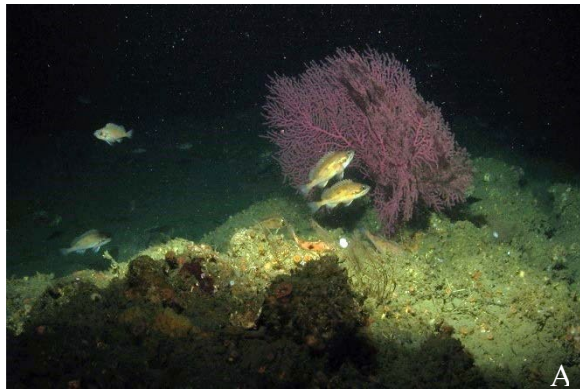
Site: SoStCruz_08
End Coordinate: 33.94297, -119.75477
Bottom Time: 59 minutes



Map caption: ROV dive path outlined in yellow over three background layers. Those layers include side scan data in transparent greyscale, slope transparent with red representing high slope, and a hill shade generated from bathymetry data generated in 2016 aboard NOAA vessel Reuben Lasker.

Dive Summary:

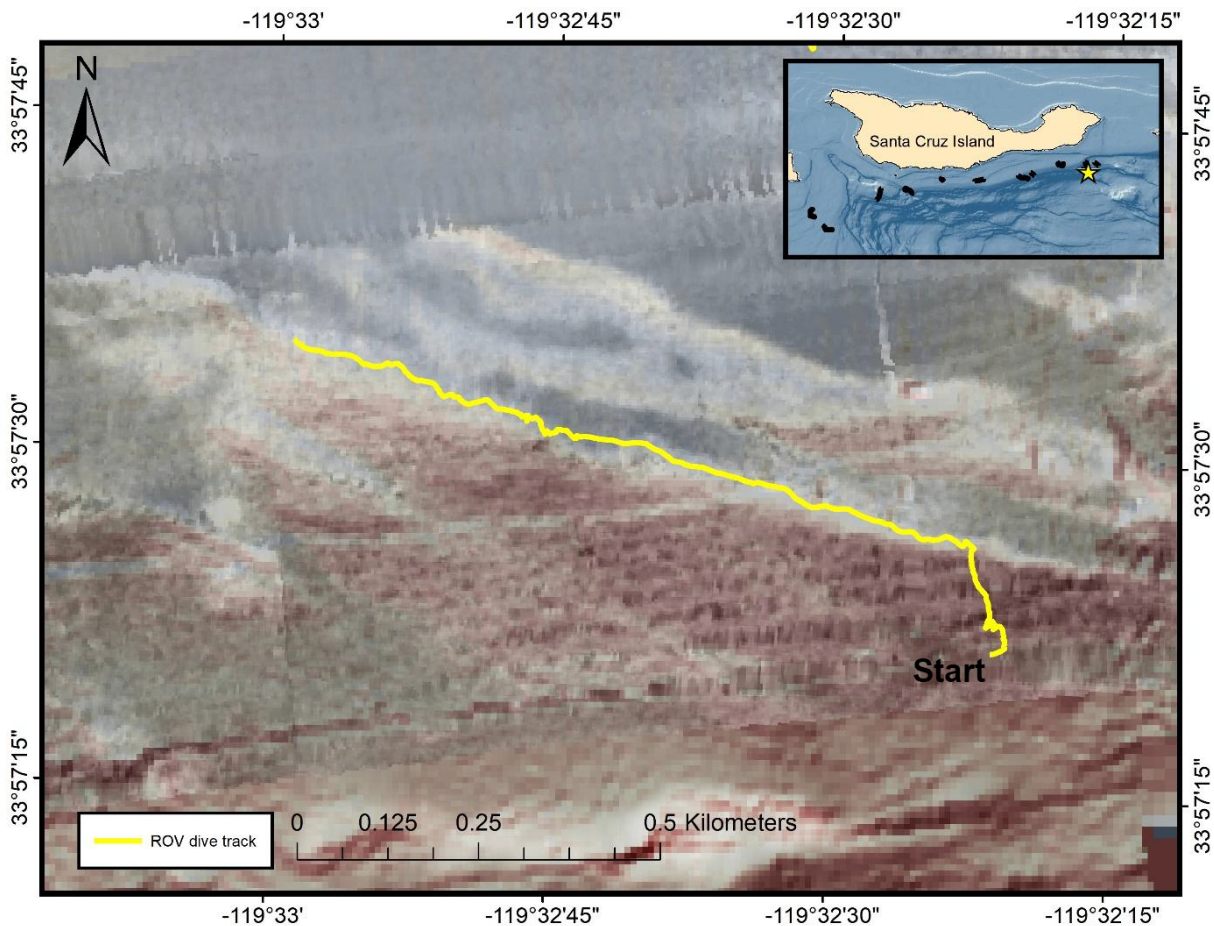
ROV reached bottom at 15:21:35 UTC and remained on bottom until 16:20:00 UTC on May 7 2017 UTC. During this dive 3 transects were conducted each approximately 15 minutes long. The second transect had multiple pulls off bottom and is likely not useful for analysis. There were no technical issues with the ROV. Rocks and boulders over soft sediment was the common habitat type observed, which both *Eugorgia* and *Leptogorgia* had colonized. There was also a potential *Lophelia* aggregation. Fish species observed included flag, copper, vermillion, blue, and half-banded rockfish. As well as lingcod, ocean whitefish, flatfish, and perch.



Dive took place south of Santa Cruz Island in depths ranging from 63 to 86 meters, using the ROV *Beagle* aboard NOAA vessel *Bell M. Shimada*. A) Pair of Rockfish associated with *Eugorgia rubens*. B) *Leptogorgia chilensis* on rock formation. C) Copper rockfish on rock feature with sponge and other associates. D) Lingcod on rock feature with kelp debris. E) School of half banded rockfish passing through a *Leptogorgia chilensis* colony. F) A severely damaged *Eugorgia rubens*.

Dive 17-127B (MARE 49)
Start Coordinate: 33.95608,-119.53895
Depth Range 233-378 m

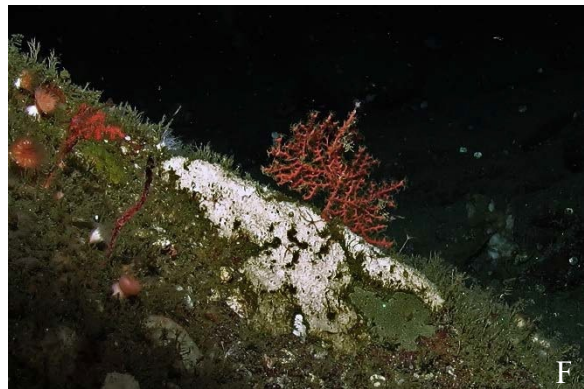
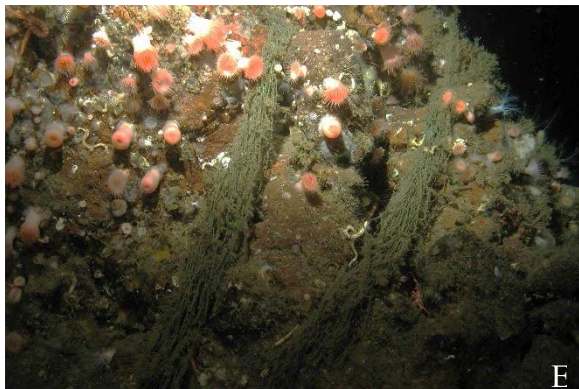
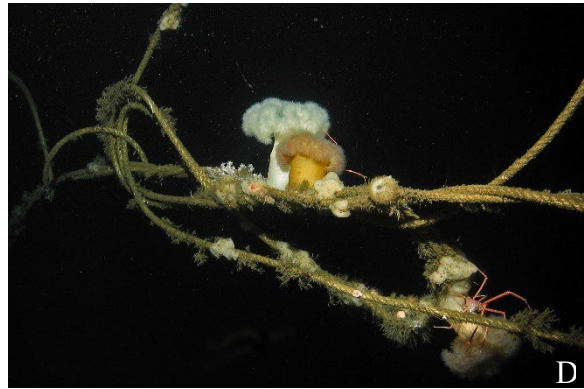
Site: SoStCruz_4A
End Coordinate: 33.95962, -119.54987
Bottom Time: 1 hour 53 minutes



Map caption: ROV dive path outlined in yellow over three background layers. Those layers include backscatter data in transparent greyscale, slope transparent with red representing high slope, and a hill shade generated from bathymetry data generated in 2016 aboard NOAA vessel Reuben Lasker.

Dive Summary:

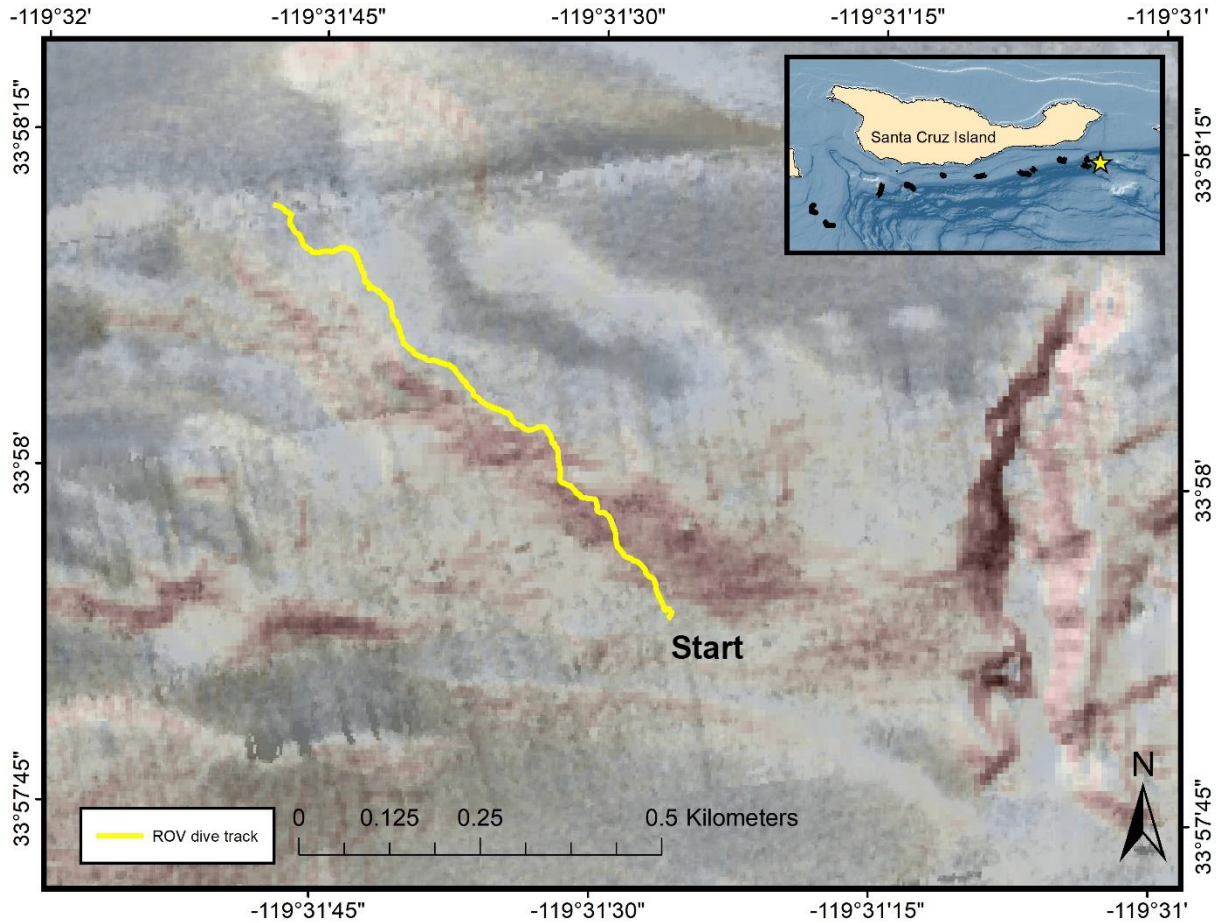
The ROV reached bottom at 18:26:05 UTC and remained on bottom until 20:19:43 UTC on May 7 2017 UTC. Shortly after reaching the proposed dive path and starting the first transect a series of equipment failures required the transect to be aborted. After troubleshooting the issue the dive continued; four transects were conducted with no additional issues. This dive documented multiple instances of debris, this included beer bottles and plastic cups, as well as abandoned lines and snagged nets. The rock features provided habitat for *Acanthogorgia*, *Paragorgia*, and *Antipatharia*. However, most notable was a large area of *Lophelia* skeletons that had fallen from the rocks it likely used to colonize forming rubble fields below the once associate rock. Fish species were plentiful in the area and included; tomcod, cowcod, thornyheads, and hagfish.



Dive took place south of Santa Cruz Island in depths ranging from 233 to 378 meters, using the ROV *Beagle* aboard NOAA vessel *Bell M. Shimada*. A) Various sponges and anemones on boulder. B) Skate swimming past rocks and crinoids. C) Evidence of human impacts. D) Derelict fishing gear overgrown by anemones and sponges on sedimented. E) Fishing net entangled on rock with anemones and *Desmophylum*. F) *Swiftia* and encrusting sponge on hardbottom habitat.

Dive 17-127C (MARE 50)
Start Coordinate: 33.96443, -119.52302
Depth range: 199-334 m

Site: SoStCruz_4B
End Coordinate: 33.96705, -119.52993
Bottom Time: 1 hour 41 minutes



Map caption: ROV dive path outlined in yellow over three background layers. Those layers include backscatter data in transparent greyscale, slope transparent with red representing high slope, and a hill shade generated from bathymetry data generated in 2016 aboard NOAA vessel Reuben Lasker.

Dive Summary:

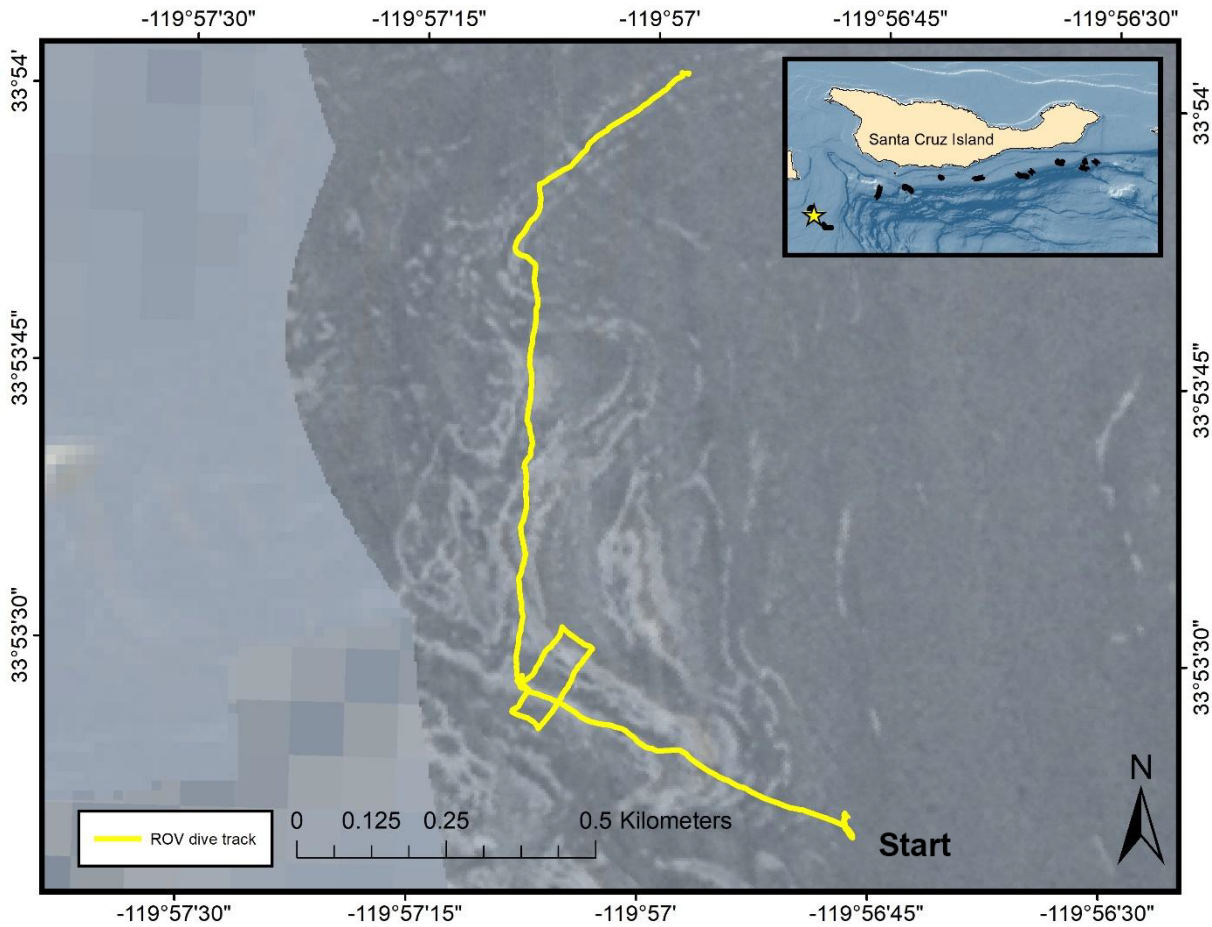
The ROV reached bottom at 21:39:00 UTC and remained on bottom until 23:20:52 UTC on May 7 2017 UTC. The ROV conducted 4 transects each approximately 15 minutes in duration. There were software issues with the video interface resulting in several segmented video files, however there were few technical issues with the ROV. Key species noted this dive were an abundance of black corals, in addition to *Acanthogorgia* and vase sponges.



Dive took place south of Santa Cruz Island in depths ranging from 199 to 334 meters, using the ROV *Beagle* aboard NOAA vessel *Bell M. Shimada*. A) Unknown sponge potentially undocumented in the area. B) Urchins feeding on kelp debris. C) Sponge being utilized by crinoids and small California king crab. D) *Antipatharia* with overgrowth being utilized by at rockfish. E) Series of sponges with associated *crinoid* and bank rockfish. F) *Antipatharia* with associated basket star and catshark egg case.

Dive 17-128A (MARE 51)
Start Coordinate: 33.88923, -119.94583
Depth Range: 72-84m

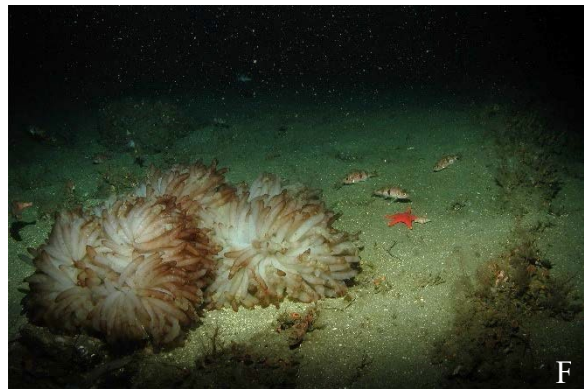
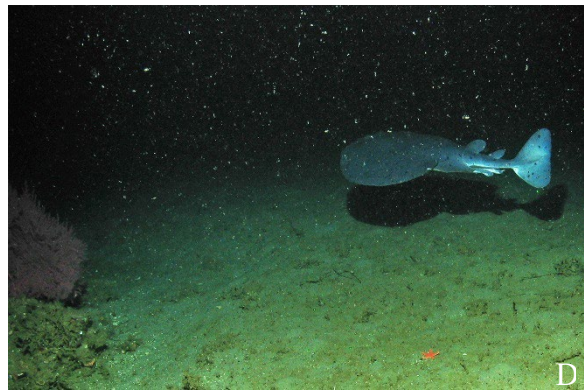
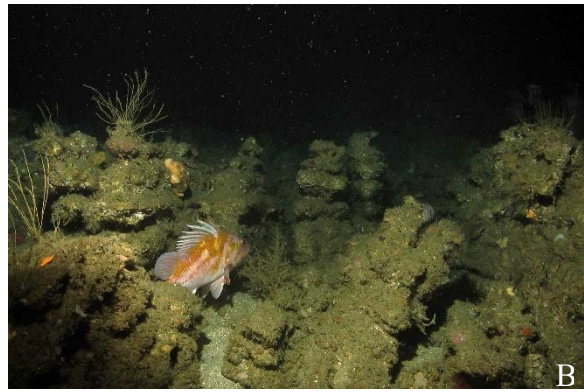
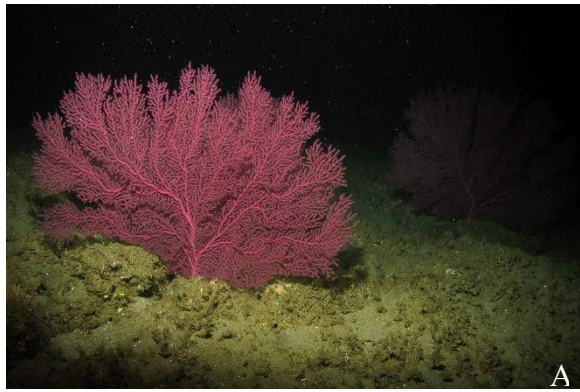
Site: SoStRosa_X1
End Coordinate: 33.90041, -119.94931
Bottom Time: 2 hours 50 minutes



Map caption: ROV dive path outlined in yellow over backscatter data generated by EV Nautilus in 2016.

Dive Summary:

ROV reached bottom at 16:59:30 UTC and remained on bottom until 19:49:12 UTC. 5 transects were conducted 4 of which were 15 minutes in length, the third transect was 30 minutes long and created a square search grid. This change in protocol was implemented because the backscatter appeared to have a 40 meter offset. Key species included sea pens in the soft sediment, but dense *Eugorgia*, as well as *Adelogorgia* and *Leptogorgia* in rockier habitat. Fish observed were mostly half banded rockfish, however there was one yellow eye rockfish observed during this dive.



Dive took place south of Santa Rosa Island in depths ranging from 72 to 84 meters, using the ROV *Beagle* aboard NOAA vessel *Bell M. Shimada*. A) Large *Eugorgia rubens* on hardbottom habitat. B) Copper rockfish among unusual rock formation. C) *Siphonophore* floating over soft sediment habitat. D) Torpedo ray over soft sediment habitat. E) Hermit crab utilizing *Eugorgia rubens*. F) Squid eggs on soft sediment.

Dive: 17-128B (MARE 52)

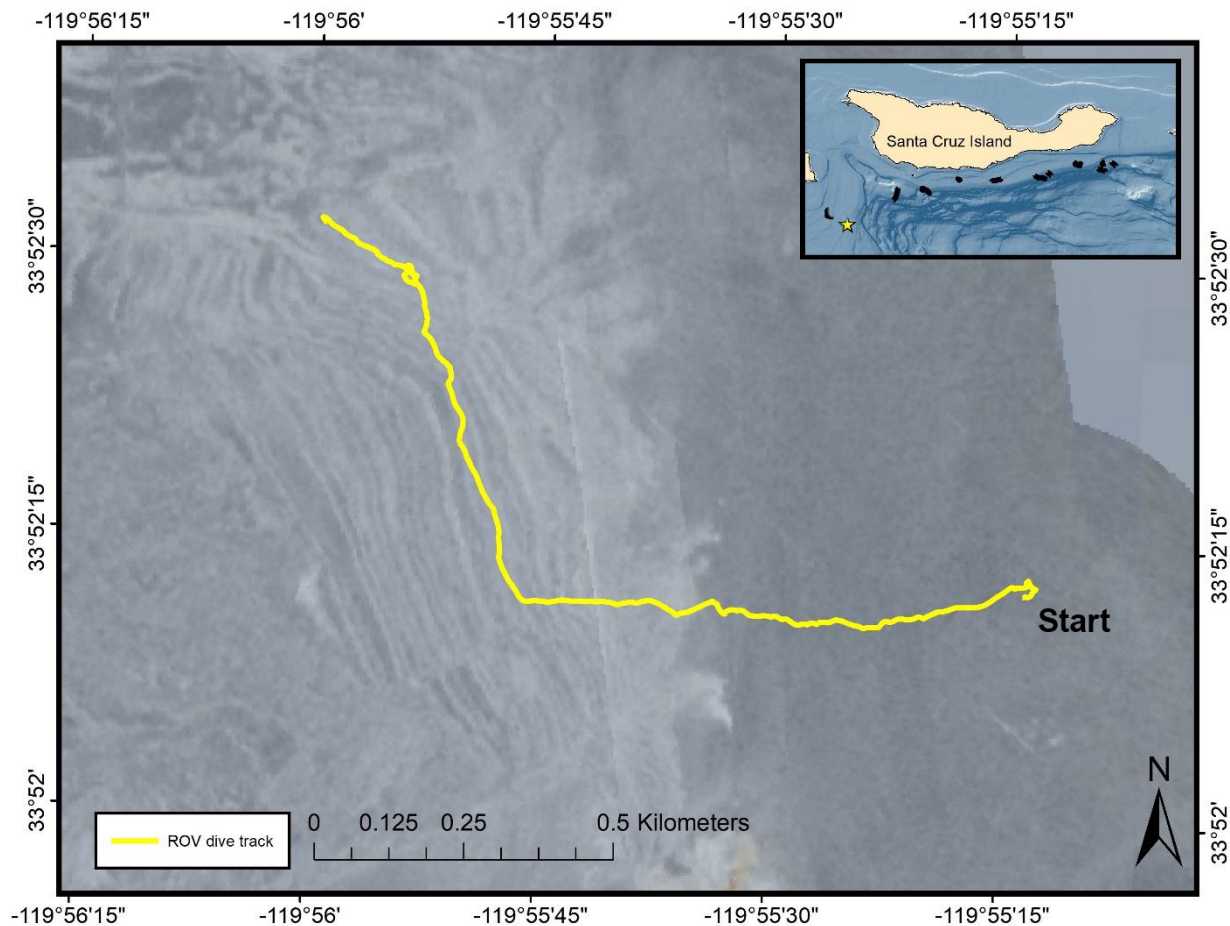
Start Coordinates: 33.90349, -119.93713

Depth Range: 90-108m

Site: SoStRosa_X3

End Coordinates: 33.87536, -119.93281

Bottom Time: 1 hour 45 minutes



Map caption: ROV dive path outlined in yellow over backscatter data generated by EV Nautilus in 2016.

Dive Summary:

The ROV arrived on bottom at 22:30:24 May 8 2016 UTC and departed bottom at 00:13:35 May 9 2017 UTC. Vessel struggled to maintain proximity to desired start location during deployment, landed almost 300 meters from intended start point. Once on bottom the ROV ran 3 transects until it reached hard bottom habitat and then began looking for *Adelogorgia* to collect. The most dominant species observed during this dive was Crinoids. The density of crinoids made locating *Adelogorgia* difficult. In addition to *Adelogorgia*, *Eugorgia* was also observed but in low density. Fish species observed included cowcod, copper rockfish, lingcod, and flag rockfish. The dive ended after the successful collect of an *Adelogorgia* colony, which was kept alive aboard the vessel.



Dive took place south of Santa Rosa Island in depths ranging from 90 to 108 meters, using the ROV *Beagle* aboard NOAA vessel *Bell M. Shimada*. A) Copper rockfish and cowcod on hardbottom feature surrounded by crinoids. B) Flag rockfish on sediment covered hardbottom feature with numerous crinoids. C) Cowcod utilizing hardbottom feature, surrounded by crinoids. D) *Adelogorgia* and retracted anemones on sediment covered rock feature. E) Crinoids on uplifted rock feature. F) Fishing debris snagged in rock feature.

Dive 17-129A (MARE 53)

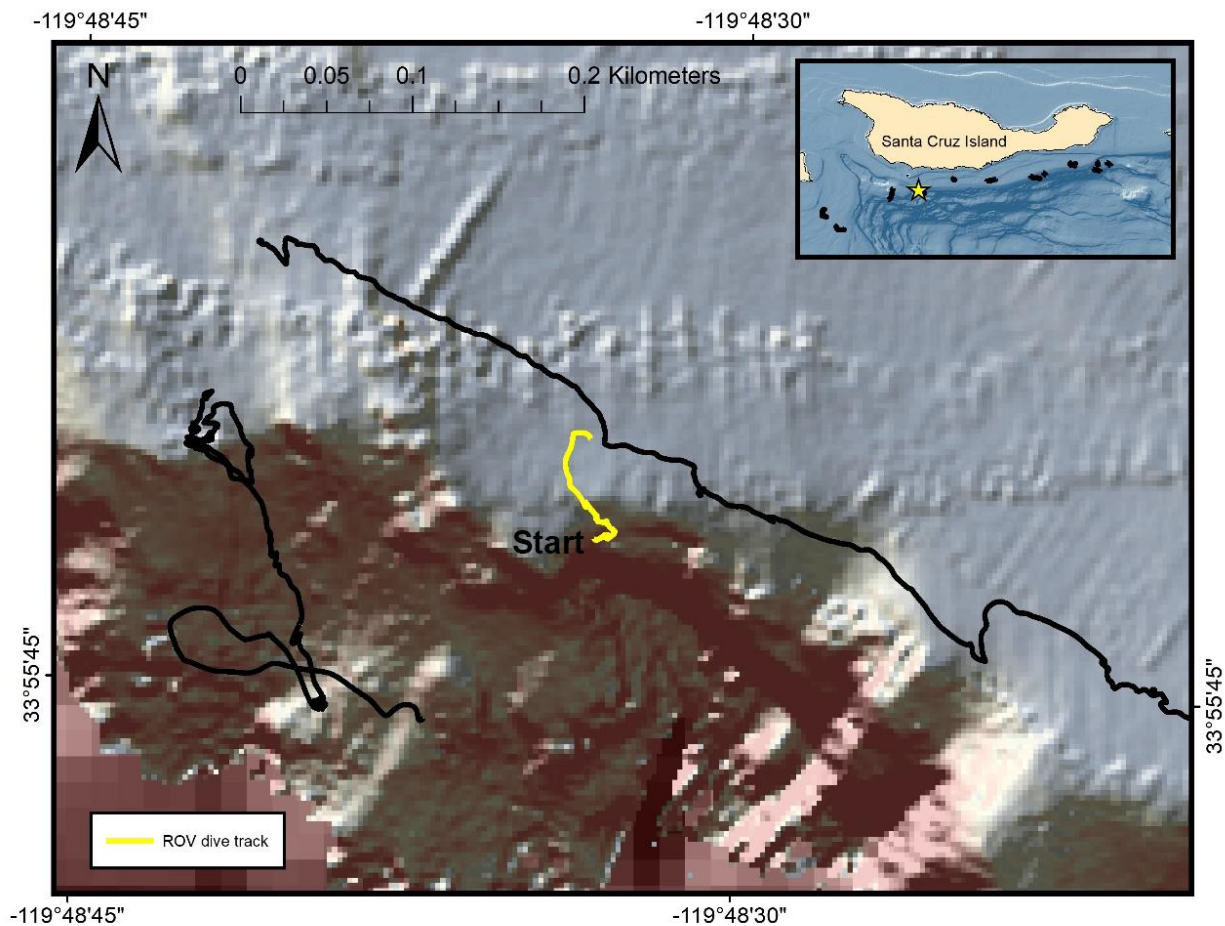
Start Coordinate: 33.93017, -119.80921

Depth Range: 90-100m

Site: SoStCruz_Sample1

End Coordinate: 33.92995, -119.80912

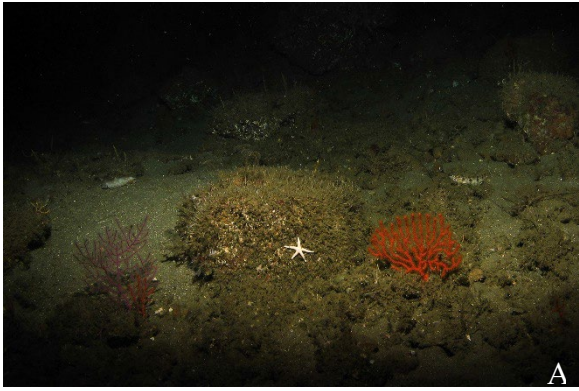
Bottom Time: 26 minutes



Map caption: ROV dive path outlined in yellow over three background layers. Those layers include backscatter data in transparent greyscale, slope transparent with red representing high slope, and a hill shade generated from bathymetry data generated in 2016 aboard NOAA vessel Reuben Lasker.

Dive Summary:

The ROV reached bottom at 17:10:00 UTC on May 9 2017 UTC. The dive took place along a previous dive track on the Canyon Ridge in the depth zone ideal for *Adelogorgia*. Once on bottom the digital still camera routinely crashed and had to be restarted making digital stills hard to acquire. No transects were conducted as the mission of this dive was solely to collect samples. Six samples were successfully collected in 26 minutes, after which the ROV was retrieved without incident.



Dive took place south of Santa Cruz Island in depths ranging from 90 to 100 meters, using the ROV *Beagle* aboard NOAA vessel *Bell M. Shimada*. A) *Adelogorgia* targeted for collection B) Multiple *Adelogorgia* with one suffering from a yellow zooanxthid overgrowth.

Appendix II: Mapping Products

This Appendix provides an illustration of each of the major mapping products that were created as a result of this survey. This includes products from the ME70, EK60, and AUV.

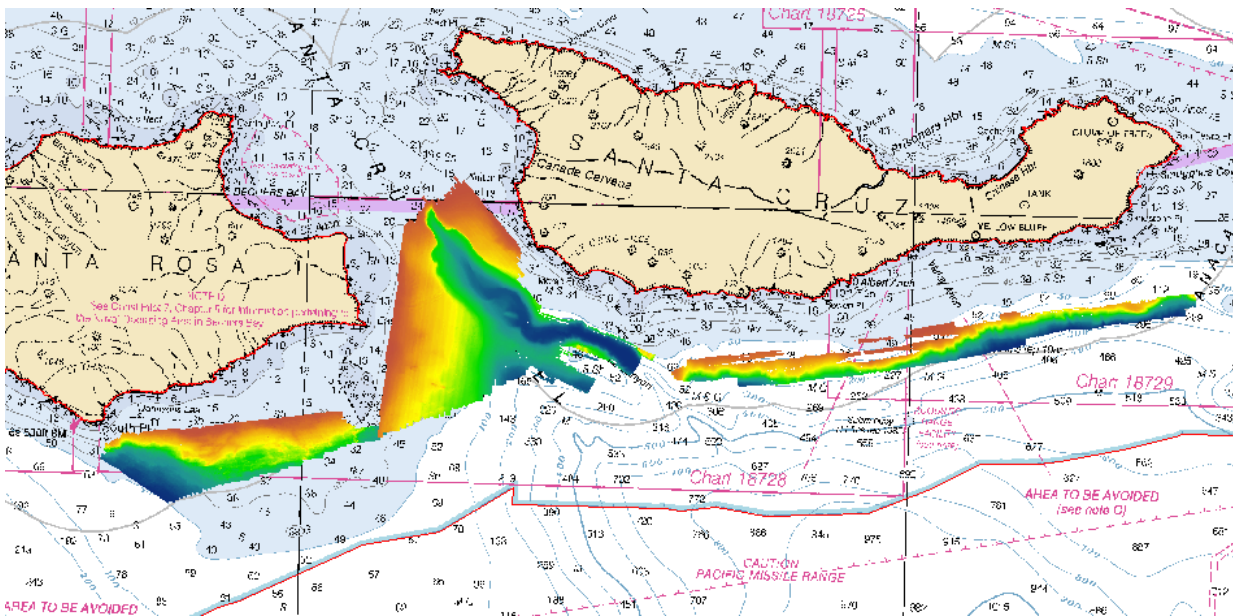


Figure A. ME70 bathymetry acquisition across Priority Areas 1, 2, and 3. The color gradient represents the same depths across products from each area

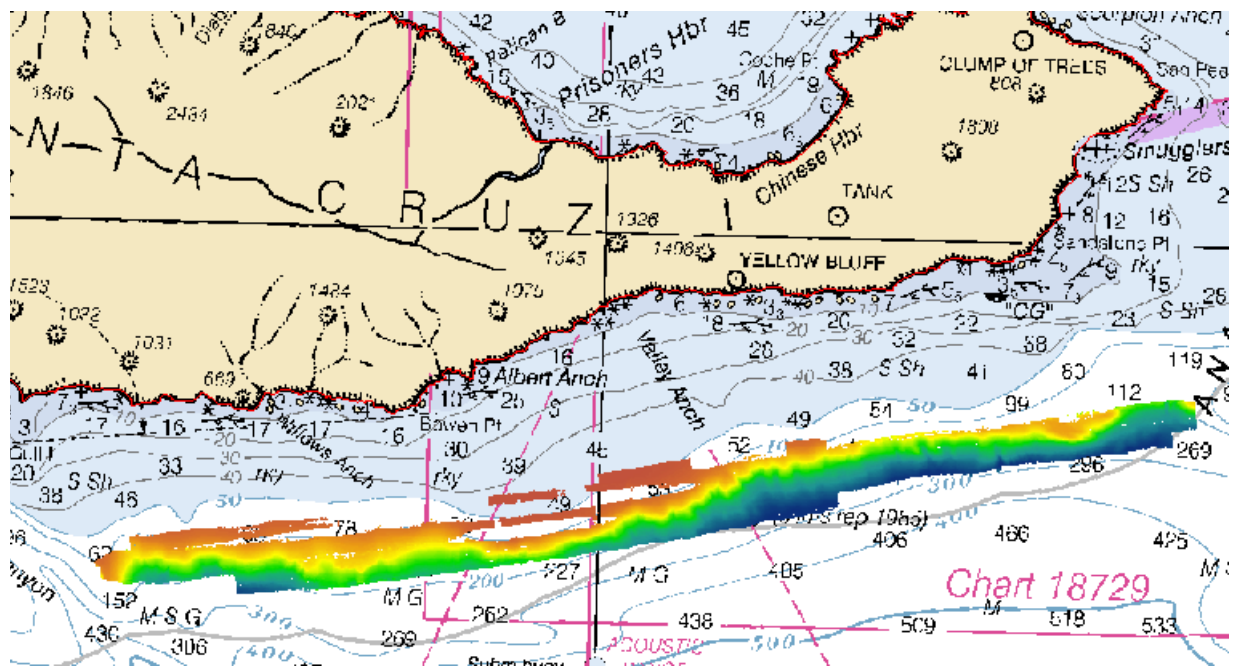


Figure B. ME70 bathymetry acquisition in Priority Area 1.

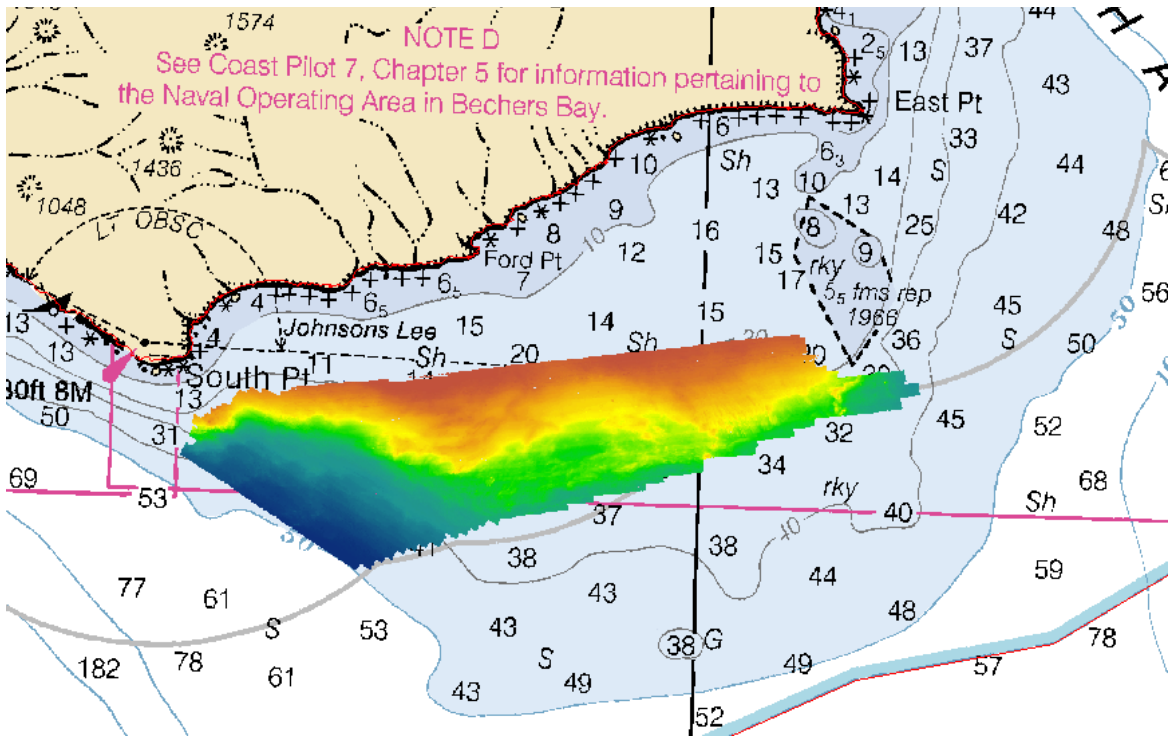


Figure C. ME70 bathymetry acquisition in Priority Area 2.

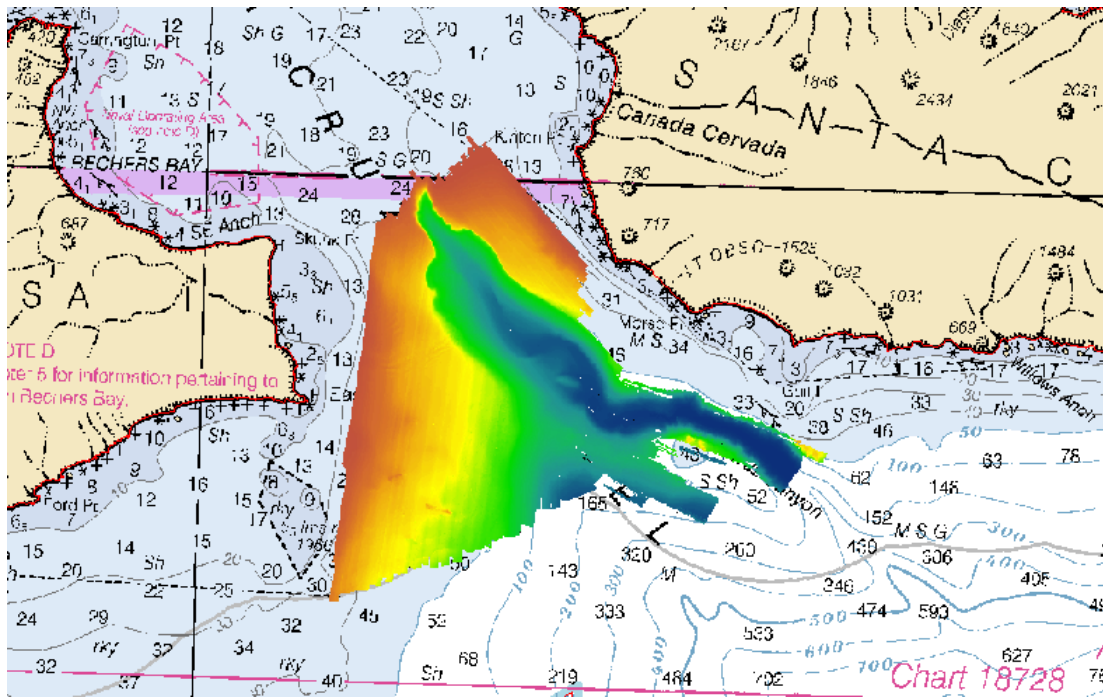


Figure D. ME70 bathymetry acquisition in Priority Area 3.

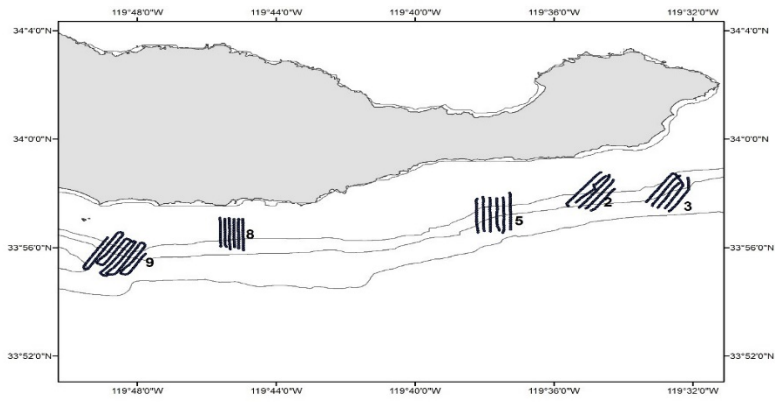


Figure E. Transects of fish acoustic surveys carried out over 5 ROV sites.

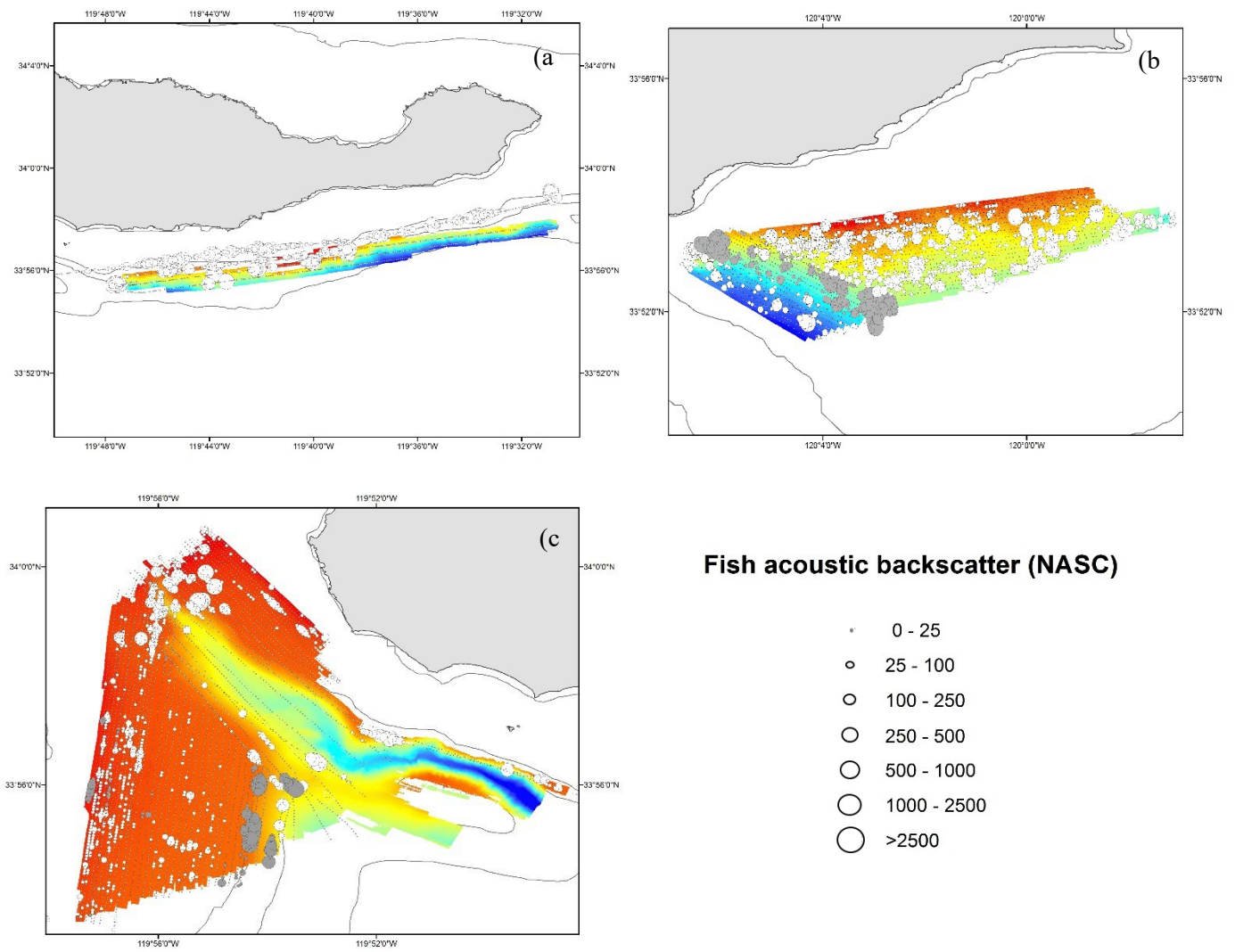


Figure F. Distribution maps of the fish backscatter in priority areas 1 (a), 2 (b) and 3 (c).

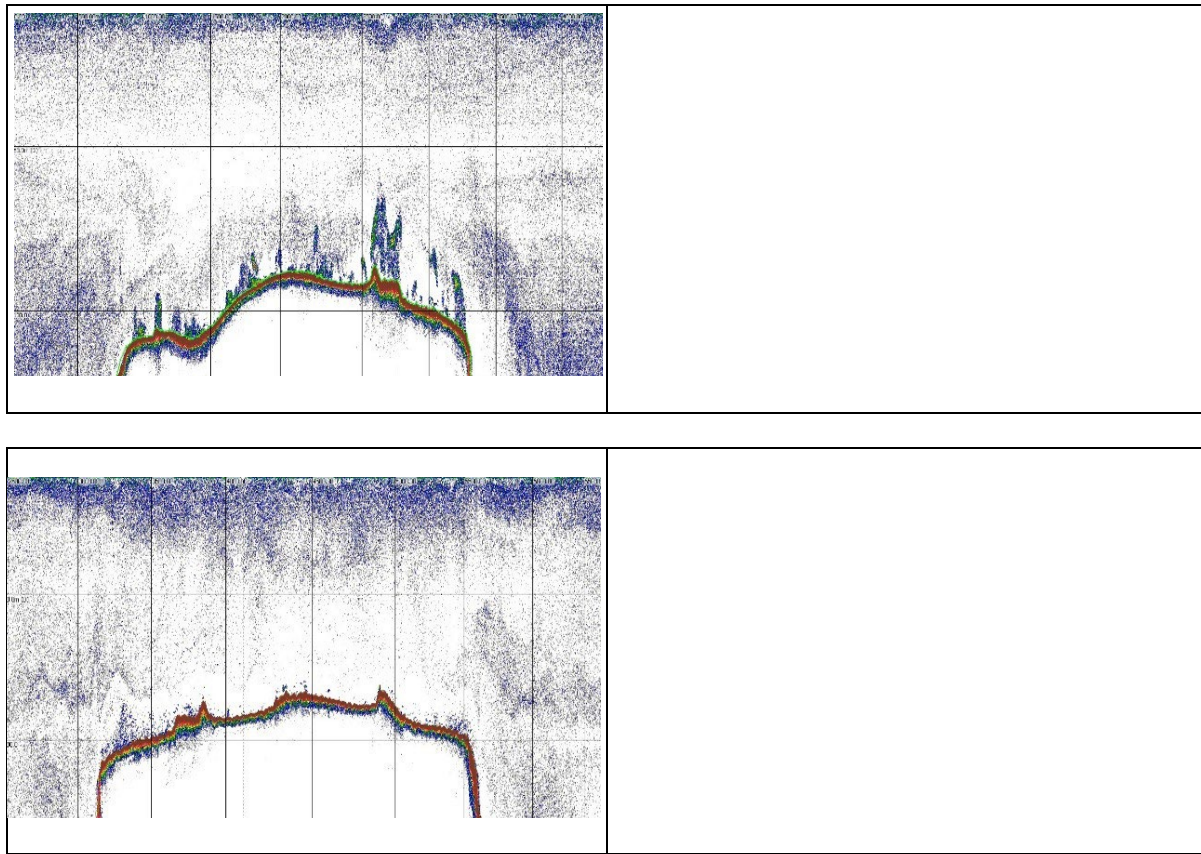


Figure G. Echograms of the same transect (site 9) and detail of a high relief area sampled at night (top) and day (bottom).

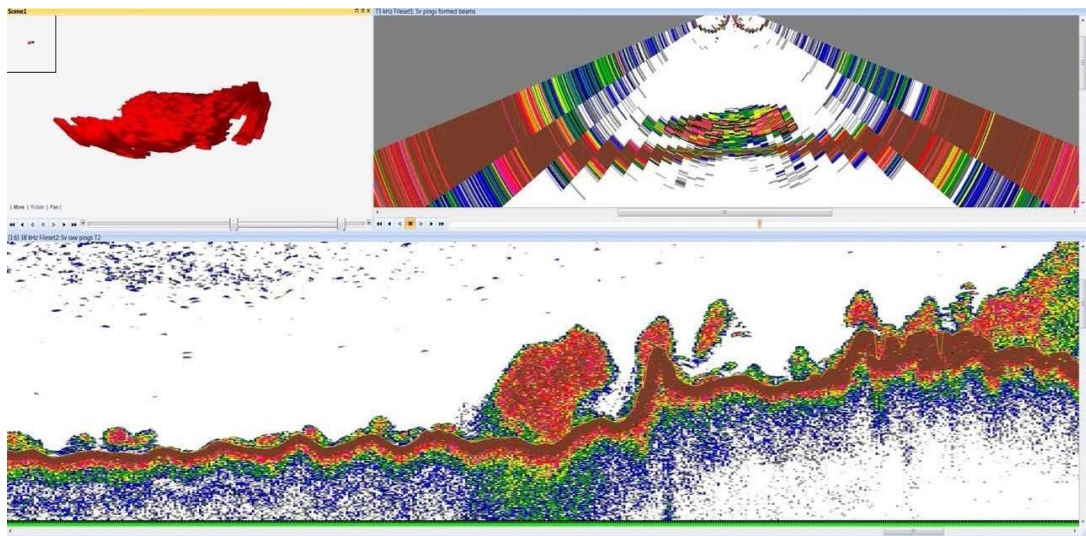


Figure H. ME70 and EK60 data analyzed using Echoview.

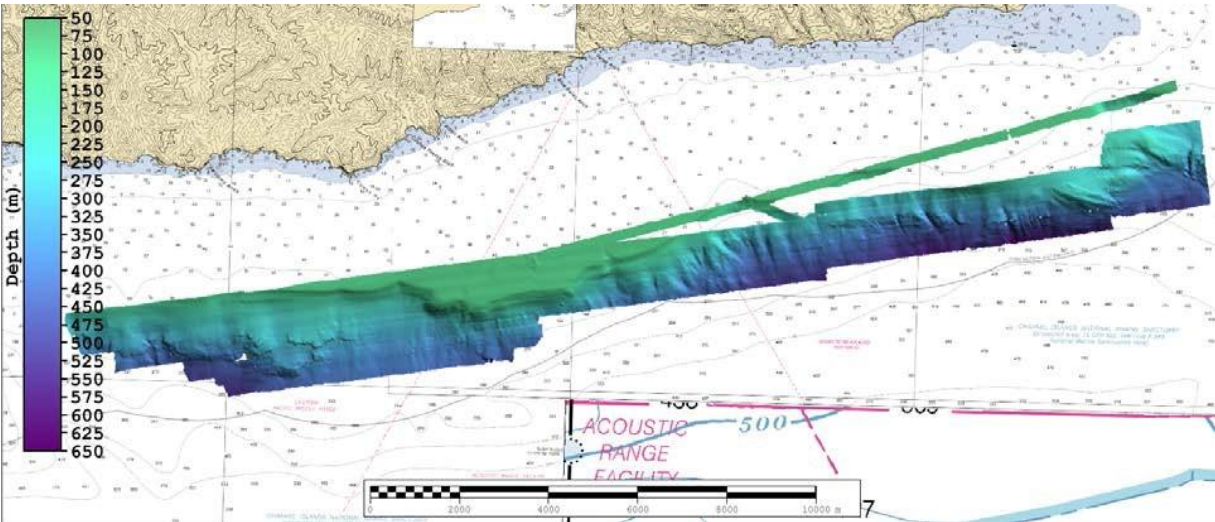


Figure I. AUV Multibeam Survey Coverage of Priority 1 area south of Santa Cruz Island

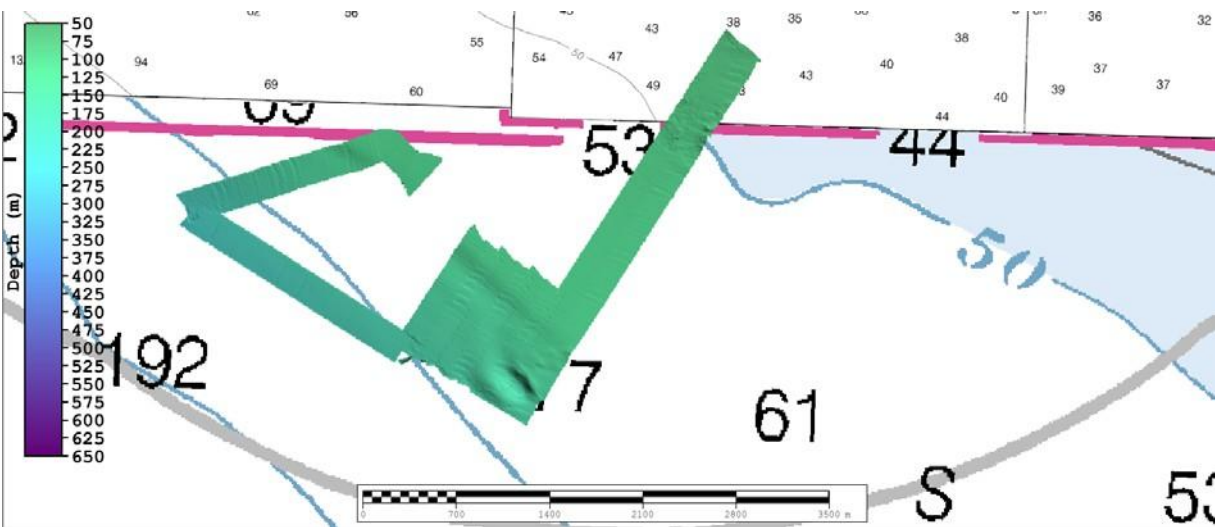


Figure J. AUV Multibeam Survey Coverage area south of Santa Rosa Island

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