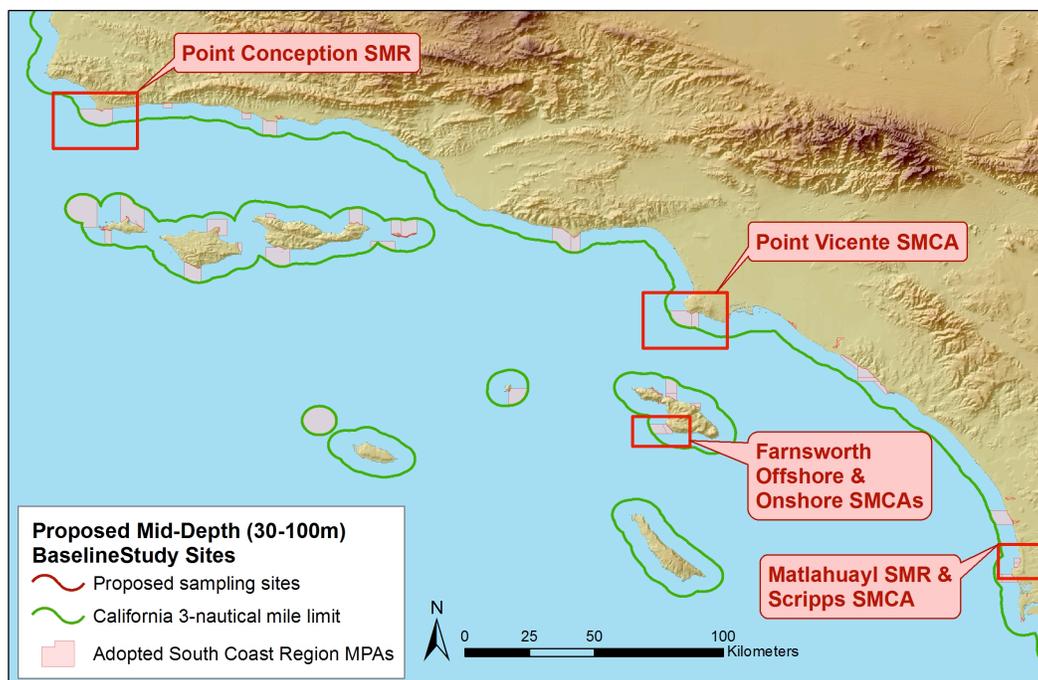


**Project Title:** Baseline Characterization and Monitoring of the MPAs along the South Coast: ROV Surveys of the Subtidal (20 – 500 m)

**REVISED Plan of Work:** (minimal changes to the work plan are highlighted in red)

### **Project Overview**

Our plan is to collect both structural and biological community data in the deeper subtidal across the full geographic extent of the South Coast Study Region. All are areas that experience high levels of human use, including fishing, and are ultimately expected to show changes related to MPA establishment. They are (listed from north to south) 1) Pt. Conception SMCA, 2) Pt. Vicente SMCA and Abalone Cove SMCA, 3) Farnsworth Bank SMCAs (offshore and onshore), and 4) San Diego-Scripps Coastal SMCA/Matlahuayl SMR (Figure 1).



**Figure 1.** Map of the South Coast Study Region including the four study sites selected for sampling in this proposal, highlighted in red. Inclusion of the Point Conception study site is dependent on supplemental funding. In Year 1 the PIs will attempt to raise funds. In Year 2 additional support will be required.

We propose a nested BACI (before-after-control-impact) design to quantify potential effects of MPAs following designation across the South Coast Study Region, including changes in community structure inside and out of MPAs, and potentially to relate those changes to revised patterns of exploitation adjacent to MPAs. Each of the selected sites has a range of habitats available from at least two of the three protection levels (SMR, SMCA, and no protection) so that we will be able to collect data for soft substrate, hard substrate, and transitional habitats under two or three levels of protection and adjacent locations at comparable water depths. Up to five treatments will be sampled within each study site (depending on the MPA configuration)— inside and outside the SMR, inside and outside the SMCA, and a site relatively distant from both but of similar bottom habitat composition that will be considered a control site. Transects will be positioned to traverse all three substrate types where possible. We will target two (2) transects greater than 1 km in length within each of the five treatments at each study site (with four treatments at Point Conception) and then sub-sample from those transects for quantitative analyses. Due to the paucity of hard bottom in the South Coast, once the 2km of site

transects have been collected, we plan to focus a few short transects on areas of hard bottom substrate identified in multi-beam and from discussions with stakeholders.

In Project Year 1 we will conduct extensive sampling both inside and outside of MPAs at each of the four sites. Two remotely operated vehicles (ROVs) will be used to collect photographic and videographic imagery. Characterization based on this imagery will include collection and analysis of data on 1) multi-scale topographic structure on the seafloor, 2) epifaunal macro-invertebrates (both sessile and mobile), and 3) associated fishes (including selected exploited and non-exploited species identified as priorities). The selection of species targeted for monitoring (Table 1) was developed from the RFP and augmented based on the experience of the PIs with similar surveys. Transects will maximize continuous ROV dive time and encompass rocky and soft sediment substrates and the transitional areas between the two at multiple water depths. Continuous imagery will be sub-sampled at a variety of spatial scales to determine the optimum sampling rate for each substrate and associated biological community. Data post-processing and analysis will be conducted by trained graduate and undergraduate students at IfAME's image analysis lab under the supervision of Dr. Lindholm.

In Project Year 2 we will re-survey three of the four core site transects from Year 1 to compare community composition, abundance and density of selected fish and invertebrate species and structural attributes of the seafloor with Year 1 data. **The inclusion of the Point Conception study site in Year 2 sampling will depend on the acquisition of supplemental financial support.**

Our efforts in Project Year 3 will focus entirely on data analysis, summarization, and visualization as well as integration of results with other baseline products produced by our collaborators under the Caselle/Blanchette proposal. For managers/policy-makers we will produce a comprehensive report describing the characterization of the seafloor communities inside and outside the MPAs across the South Coast Study Region and data for selected species, as well as providing recommendations for future monitoring. The report will first be provided as presentations to the respective agencies and to the California Fish and Game Commission, followed by a detailed report at the end of the project. Outreach to the scientific community will be conducted through the submission of one or more manuscripts to peer reviewed journals and the presentation of project results at regional and national scientific meetings. Outreach to the general public will be conducted through a variety of compelling data visualizations and imagery libraries made available via the web. Our experience in the North and Central Coast MPAs showed us that these localized cruises are also good opportunities for outreach, with Harbor Masters and concerned citizens. We will continue to meet and talk with locally interested parties when and where practical.

## ***Experimental Design***

### *Site Selection*

The four study sites in this project (Figure 1) were selected to represent the full latitudinal extent of the South Coast Study Region, ranging across the mainland from Pt. Conception to South La Jolla and including an off-shore island site. The study sites are (from north to south): 1) Pt. Conception SMCA 2) Pt. Vicente SMCA and Abalone Cove SMCA, 3) Farnsworth Bank SMCAs, and 4) San Diego-Scripps Coastal SMCA/Matlahuayl SMR. Additionally, the four sites were selected to represent a cross-section of three ecosystems prioritized for monitoring in the RFP, including Mid-depth Rock Ecosystems (30-100 m), Soft-Bottom Subtidal Ecosystems (0-100 m), and Deep Ecosystems (> 100 m) including Canyons. Each of the selected sites has a range of habitats available at each of the three protection levels so that we will be able to collect data for soft bottom, hard substrate, and transitional benthic habitats under each level of protection at comparable water depths. At the one canyon site in San Diego, we plan to dive the ROV to 400+ meters to better understand how the canyon biota vary with depth. All transects will be positioned to traverse all three substrate types (with a focus on hard-bottom in the areas in which it occurs) and will be identified following thorough GIS analyses of multibeam data.

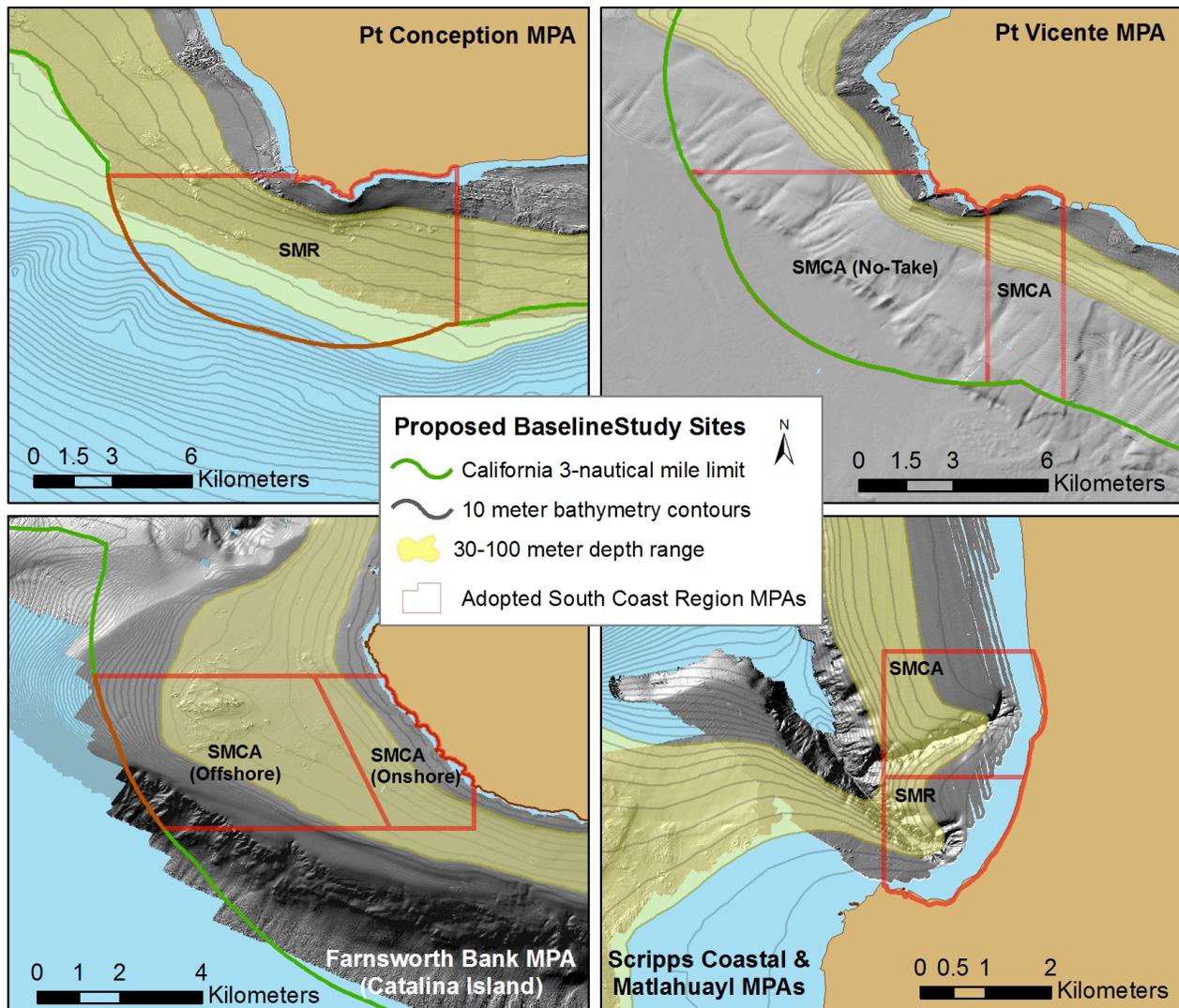
In Year 1 we will target 2 km transects within each of five separate treatments at each site, inside and outside the SMR, inside and outside the SMCA, and a site relatively distant from both but of similar bottom habitat composition (Figure 2). Sampling will begin in the north at Pt. Conception and will proceed south, culminating with San Diego-Scripps Coastal SMCA/Matlahuayl SMR. **The prioritization of sampling effort in Year 2 will derive from our accomplishments in Year 1, from preliminary analyses of the resultant data, and will be dependent on the acquisition of supplemental financial support.**

### ***ROV Operations***

We propose to use the state-of-the-art 1,000 meter rated Vector L4 ROV (owned by TNC and acquired through a grant from the OPC to support monitoring of marine resources), for video and still photographic sample collection because it builds on OPC's investment in this technology and provides data with efficiency and economy of collection along with the Phantom S2+2 (owned and operated by MARE). The Vector L4 is equipped with five geo-referenced cameras (forward video and digital still, downward video and digital still, and rear facing), and associated lights, scaling lasers and strobe. The 300 meter rated Phantom S2+2 has similar cameras and lighting, and ranging altimeter configuration as the Vector L4 [ but does not have sonar, CTD or DO]. The depth range and diversity of the study area, as well as the desire to cover both hard and soft bottom habitats and the transitional area between the two, fit the depth and versatile performance capabilities of these vehicles. The ROV controllability, neutral buoyancy and navigational sensors allow us to fly straight line transects and closely follow the terrain. By applying best practices from multiple institutions we will collect data that is compatible and complementary to existing deepwater databases of the North Central and Central Coast MPA networks.

Piloting for both vehicles is assisted by auto heading, auto depth and vertical ranging altimeter to maintain a straight course ( $\pm 1$  degree) and altitude above substrate ( $\pm 0.3$ m) with minimal corrections. In addition, cruise control helps the pilot maintain a constant forward velocity. A Blueview multi-beam sonar provides a real time wide area view to 15m. ROV tracking yields distance and visual area surveyed. A Trackpoint III ® acoustic positioning system is used to reference the ROV position relative to the ship's GPS position. The resulting ROV GPS coordinates are logged into Hypack® navigational software. Hypack also records GPS time, ROV heading, depth, speed and altitude, CTD and DO data, forward looking camera tilt angle, and forward looking camera distance to seafloor and associated viewing screen width. Area surveyed is calculated by multiplying distance traveled by viewing screen width.

One color video camera is positioned forward and angled approximately 30° below horizontal and the other pointing straight downwards. The two-camera system provides a near continuous view forward and downward. The camera images are well illuminated by two highly efficient dimmable Nuytco 200 Watt HMI lights and two dimmable 250 watt Deep Sea Power and Light tungsten halogen lights. Paired 15 mW red lasers for image scaling are centered about forward and down cameras. They paint 2 red dots 10cm apart in their respective viewing areas. Digital video for both the forward and down facing cameras is captured on digital video cassettes using SONY® DSR 45s and on DVD by Pioneer DVR 550h recorders. The two digital still cameras are co-positioned with forward and downward video cameras to make use of forward and downward facing red lasers for scaling purposes. In addition to capturing biological and habitat observations, the forward video captures redundant onscreen overlay recordings of GPS time code, depth, heading, range to bottom, screen width and temperature.



**Figure 2.** Maps of each of the four sample sites including MPA boundaries, depth strata for each ecosystem type, and multibeam bathymetry (where available). **The inclusion of Pt. Conception in Year 2 is dependent on additional financial support.**

### **Data Collection & Sampling Strategy**

Field sampling will be preceded by a thorough review of existing publications and data related to subtidal communities within the study area to inform our evaluation of baseline condition in relation to historical records. This review will include in-depth geospatial analyses of existing multibeam, biogeographic and physical habitat data to identify locations within each site where habitat conditions can be duplicated most closely while maximizing ROV bottom time for efficient and thorough imagery collection. All geospatial analyses will be conducted at the Spatial Information Analysis and Visualization (SIVA) Center at CSU Monterey Bay (<http://seafloor.csUMB.edu/siva/siva-home.shtml>).

In Year 1 we will target a minimum of 38 km of transects per year with the expectation of surveying much more as time and weather allow. **In Year 2 the total area sampled will depend on additional funding.** Videographic and still photographic imagery will be collected continuously along transects of greater than 1 km. These transects will encompass both sedimentary and hard substrate environments, as well as the transitional areas between the two environments that will allow multi-scale sub-sampling post hoc. The ROV will be “flown” at an altitude of approximately 0.5 m above the seafloor

**Table 1.** Organisms, features and metrics proposed for collection at proposed South Coast ROV Baseline sites based on PI experience using ROVs to collect similar data in the study region and elsewhere.

		Metric
<b>Subtidal Rocky Ecosystems (20-500 m)</b>		
<b>Community</b>		
	Multiple species	Species diversity
	Multiple species	Species richness
	Dominant habitat (50% coverage)	Composition and relief
	Subdominant habitat (20% coverage)	Composition and relief
<b>Biogenic habitat</b>		
	Biogenic habitat composition	Height and complexity
	Microhabitat composition	Relative height and complexity
	Structure-forming	Density and cover
	Encrusting Invertebrates	Cover
<b>Fishes</b>		
	Rockfishes ( <i>Sebastes spp.</i> )	Density and size structure (subject to occurrence in ROV imagery)
	Perches (Embiotocidae)	Density and size structure (subject to occurrence in ROV imagery)
	Basses ( <i>Paralabrax spp.</i> )	Density and size structure (subject to occurrence in ROV imagery)
	Other Fishes – including lingcod, giant sea bass, scorpionfish, cabezon.	Density and size structure (subject to occurrence in ROV imagery)
<b>Invertebrates</b>		
	Abalone ( <i>Haliotis spp.</i> )	Density and size structure (subject to occurrence in ROV imagery)
	Crabs	Density and size structure (subject to occurrence in ROV imagery)
	Urchins	Density and size structure (subject to occurrence in ROV imagery)
	Other invertebrates	Density and size structure (subject to occurrence in ROV imagery)
<b>Soft-bottom (20-500 m)</b>		
<b>Community</b>		
	Multiple species	Species diversity
	Multiple species	Species richness
	Dominant habitat (50% coverage)	Composition and relief
	Subdominant habitat (20% coverage)	Composition and relief
<b>Biogenic habitat</b>		
	Multiple species	Total cover and diversity
	Biogenic mounds and depressions	Density and relative abundance
	Biogenic habitat composition	Height and complexity
	Microhabitat composition	Relative height and complexity
<b>Fishes</b>		
	Rockfishes ( <i>Sebastes spp.</i> )	Density and size structure (subject to occurrence in ROV imagery)
	Flatfishes (Paralichthyidae and Pleuronectidae)	Density and size structure (subject to occurrence in ROV imagery)
	Other Fishes	Density and size structure (subject to occurrence in ROV imagery)
<b>Invertebrates</b>		
	Shrimp	Density and size structure (subject to occurrence in ROV imagery)
	Crabs	Density and size structure (subject to occurrence in ROV imagery)
	Other invertebrates	Density and size structure (subject to occurrence in ROV imagery)

at a speed of 0.5-1.0 knots to facilitate the highest resolution possible for videographic and photographic imagery. We will collect both forward looking and downward still photographic and videographic imagery of 1) topographic and micro-topographic structure<sup>1</sup> on the seafloor, 2) epifaunal macro-invertebrates (both sessile and mobile), and 3) associated fishes (including selected exploited and non-exploited species identified by the RFP and monitoring workshops (Table 1). We will use a combination of best practices for data compilation and analysis derived from a comprehensive review of existing visual observation research programs that we recently concluded, including programs at CDFG, NMFS, WSU, UCSB, MBARI and NURC. These techniques will include both live and post-processing techniques and will focus primarily on area-based community analyses rather than individual species. Comprehensive, frame by frame video data compilation, recording all structural and biological elements resolvable, combined with still photo techniques for higher resolution microhabitat characteristics and species identification, will provide a complete geo-referenced database of habitat features and organisms suitable for a broad range of subsequent analyses.

We will identify all fauna to the lowest possible taxonomic level, estimate sizes and document habitat and microhabitat features and associations across a gradient of benthic habitats in each depth zone. Both soft and hard bottom habitats will be sampled, as well as transition areas between the two, to provide a comprehensive geo-referenced database for subtidal community composition. Producing archived video and still photographic records with comprehensive data compilation will allow evaluation of all community components to identify those which will be most appropriate for long-term monitoring to achieve the goals identified by the MPA Monitoring Enterprise. Though we will focus on community indices and metrics, individual species, taxa, functional category or assemblage analyses can be drawn from such a database as well, providing wide applicability and valuable data for other management agencies. Year 3 will be devoted to finalizing data compilation from video records, analyses, report preparation and visualization development.

### Post-processing

The collection of continuous imagery will allow us to subsample that imagery at a variety of spatial scales depending on the spatial extent of the substrate types and the associated seafloor communities at each study site. It is possible, based on similar data collected by the PIs and others (e.g., Lindholm et al. 2004; Bergen et al. 2005) to specify *a priori* a sampling strategy that involves sub-samples of the larger transects in 300 m or smaller increments based on species and habitat accumulation curves plotted in both soft sediment and rocky subtidal communities. As such, ROV transects will be configured to include a target of six (with a minimum of three) sub-samples per habitat type in each treatment site per sampling year, subject to weather and other factors. However, the collection of continuous data will not constrain us to any particular sub-sampling unit. Rather, power analyses of Year 1 data will allow us to more accurately determine *a posteriori* the optimum length of the sub-samples necessary to evaluate site differences and adjust subsequent sampling to maximize the power of data collected. Further, it is likely, based on our experience to date in central California, that sub-sampling units will vary by taxonomic groups and sediment types.

### **Fish and Epifaunal Macro-Invertebrates**

All geo-referenced photographic records will be reviewed during post-processing. Each video transect will be treated as a series of non-overlapping video frames (or quadrats; Auster et al. 1991, Lindholm et al. 2004) with contents recorded comprehensively (frame-by-frame data collection). Organism sizes and counts are derived from the videotape either through sampling at specified time intervals or continuously as individuals occur. Within each transect, *all* megafaunal individuals visible in down-looking cameras and between the forward projecting lasers and lower edge of the field of view in forward video, will be identified to the lowest taxon possible, measured (fish total length is visually estimated to 5-cm size classes when desired), counted and

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<sup>1</sup> Topography refers to both the physical substratum (e.g., sand waves, rock, cobble), any associated structure-forming taxa (e.g., corals, algae, anemones, sponges, brachiopods), and any biogenically built structure (e.g., mounds and depressions). In addition to the organisms that form them, microhabitats are critical for a variety of fish species at different life history stages (Auster et al. 1991).

recorded. Paired lasers projected into the cameras' field of view are used as reference to gauge organism size and to establish an upper limit for the data collection field.

Area surveyed will be calculated from track line width for forward cameras, view field area for downward cameras, and distance travelled for each transect. Track line width on the forward camera is determined from a ranging sonar fixed below and parallel to the camera between the two forward-facing red lasers spaced 100 mm apart. To achieve a transect width of approximately 2 m, the pilot flies the vehicle at 0.6 to 0.8 m altitude off the bottom, using the ranging sonar to maintain the distance from the camera to the substrate (at the screen horizontal midpoint) between 1.5 and 1.75 m. Maintaining downward video and still camera height of approximately 0.75 m off the seafloor will provide covered an area of approximately 0.13 m<sup>2</sup> and 0.40 m<sup>2</sup> respectively.

Coverage of encrusting and structure-forming invertebrates will be estimated by overlaying each image with a 10 cm grid. Video records will be annotated continuously with macrofauna counts or coverages (for a list of target organisms and metrics see Table 1), sizes and associations in a database structure that will allow geo-referencing and maximum flexibility for subsequent analyses. Abundances will be calculated as number per square area surveyed. Forward digital still photographs will be used to verify species identifications where high resolution of species characters is required.

### ***Seafloor Microhabitats***

Seafloor habitat characteristics will be determined and recorded comprehensively for all substrate types including physical substrata (such as boulders and sand waves), biogenic structure (such as erect seaweeds, sponges or anemones), and structures of biogenic origin (such as depressions and mounds in soft sediment formed by mobile fishes and invertebrates). Both quantitative and semi-quantitative multi-scale approaches will be used to evaluate benthic habitat composition and characteristics. Habitat characteristics within each transect (intermediate scale) will be categorized and delineated from the videotape during post-processing using definitions from Greene et al. (1999). Substratum composition (rocks [outcrop], boulder [ $>25$  cm], cobble [64–256 mm], sand, and mud) will be categorized by using the dominant (primary  $\geq 50\%$ ) and subdominant (secondary  $\geq 20\%$ ) percentages of substratum cover. Habitat relief is also recorded and is categorized as flat ( $0-5^\circ$ ), low ( $5-30^\circ$ ), moderate ( $30^\circ-60^\circ$ ) or high ( $>60^\circ$ ) (Tissot et al. 2006, Anderson et al. 2007). Additional characteristics that will be included for soft-sediment habitats include bioturbated ( $>50\%$  of surface area hummocky with burrows and animal tracks), sand waves ( $>60$  cm), sand ripples (10-60 cm), subtle wave-ripple ( $<10$  cm), and shell hash.

Other characteristics of interest that will be recorded include animal tracks, drift kelp, biogenic burrows and mounds or features of interest such as fishing gear, tracks, or habitat interfaces. Habitat patches can be identified and sizes estimated from videotape records as well (Tissot et al. 2006). Data on the density and relative abundance of common microhabitats will be derived from still images using a classification system based on abiotic and biotic seafloor features that fishes have been shown to use for cover (Auster et al. 1991, Auster et al. 1995, Lindholm et al. 2004). Density will be calculated as the number of features in each category per area surveyed. Imagery from the down-looking video camera will be used to characterize the density and relative abundance of rare microhabitats (i.e. biogenic depressions and biogenic mounds).

### ***Analytical Methods***

The study is planned as a simple BACI design to compare MPA treatment areas within each of four study sites over two years of data collection to test for rapidly responding conditions in MPAs. Our underlying null hypotheses that will be used for statistical analysis within each site are:

#### Year 1

H<sub>0</sub> (1): There are no differences in the relative abundance of seafloor microhabitats among an SMR, SMCA, areas immediately adjacent to each and a control area.

H<sub>0</sub> (2): There are no differences in faunal indices such as abundance, density and microhabitat associations among an SMR, SMCA, areas immediately adjacent to each and a control area.

H<sub>0</sub> (3): There are no differences in community indices (diversity, similarity, species richness) among an SMR, SMCA, areas immediately adjacent to each and a control area.

## Year 2

H<sub>0</sub> (1): There are no differences in the relative abundance of seafloor microhabitats between year 1 and year 2 within an SMR, SMCA, areas immediately adjacent to each and a control area.

H<sub>0</sub> (2): There are no differences in faunal indices such as abundance, density and microhabitat associations between year 1 and year 2 within an SMR, SMCA, areas immediately adjacent to each and a control area.

H<sub>0</sub> (3): There are no differences in community indices (diversity, similarity, species richness) between year 1 and year 2 within an SMR, SMCA, areas immediately adjacent to each and a control area.

Multiple measures will be used to compare sub-sampled data in SMR (inside and adjacent), SMCA (inside and adjacent) and control sites to test for differences between epifaunal communities in year 1 (before) and to track the trajectories of communities at each location over time (after-control-impact). Species richness (S) will be calculated as the total number of species per transect for each site. The Shannon-Weaver index (H') will be used to calculate diversity (Pielou 1966, Krebs 1999). This index incorporates both numbers of species and their proportional abundance as an estimate of diversity. Community comparison of species composition and relative abundance between and among the sites will be measured using the Bray-Curtis Similarity Index (Wolda 1981, Krebs 1999).

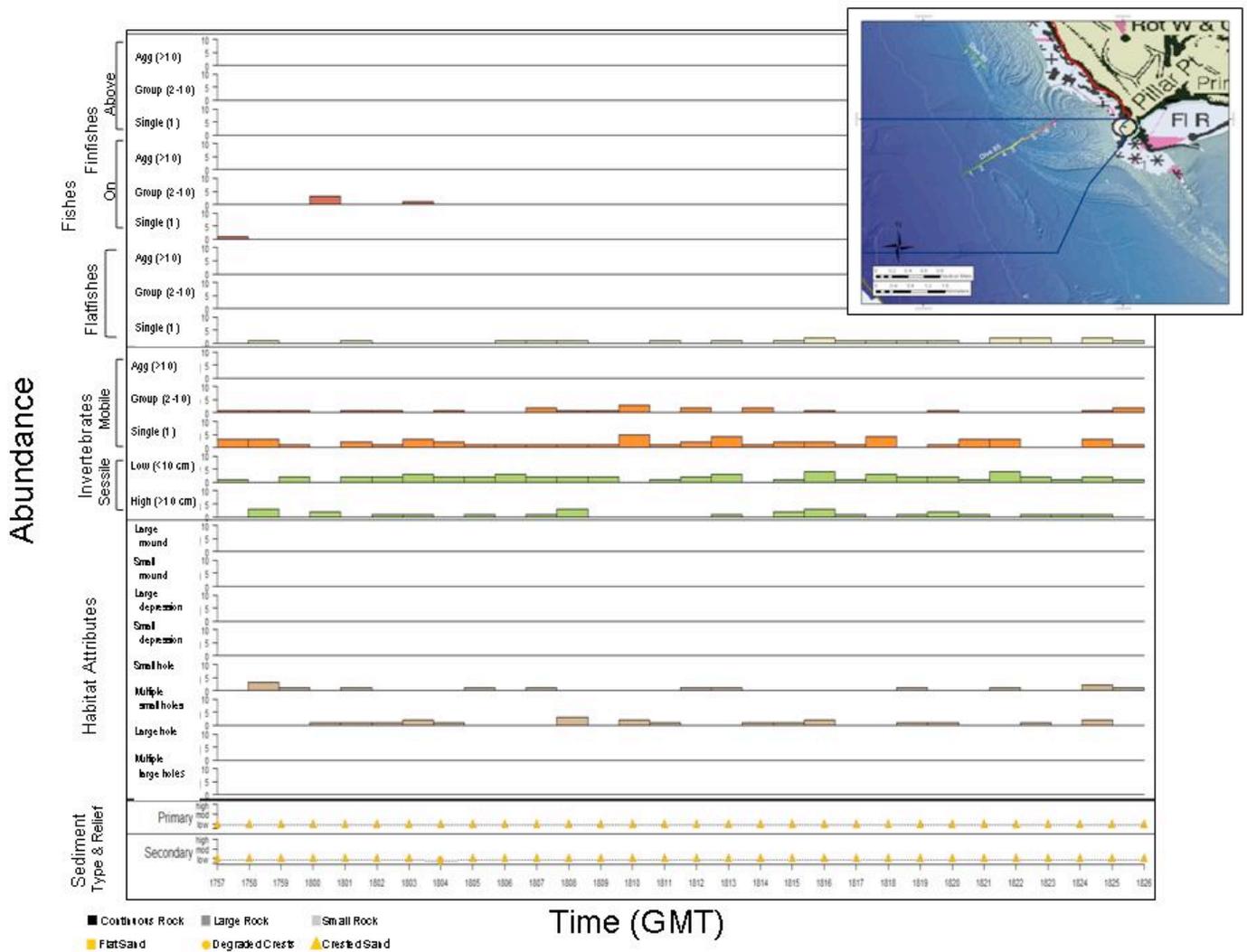
To examine multivariate associations among fish species abundances, macro-invertebrate species abundances, and seafloor characteristics, community analyses such as multiple comparisons, principal components analyses, dominance plots, and clustering analysis will be used. These techniques can be used to extract series of interrelations between two or more related data sets, either by location or by time period. Differences between treatments, or within treatments but between years, will be tested statistically using ANOVA or ANCOVA and identified using SIMPER. (Stein et al. 1992, Starmans et al. 1999, Yoklavich et al. 2000 & 2002, Spencer et al 2005, Stoner et al. 2007, Tissot et al. 2006 & 2007). Mixed effects modeling techniques will be used to test for relationships among species and/or physical structure and to quantify any effect of spatial autocorrelation on those relationships (Zuur et al. 2009).

Geospatial analyses will be used to determine the influence of the benthic landscape or physical parameter distribution on spatial patterns of species distribution to elucidate what parameters are important. This approach is based on analyses using GIS software, linking the geological, physical and biological components of the ecosystem. The geological component is generated through production of benthic habitat maps. GIS map layers generated from spatially explicit physical data measurements produced by other researchers will be integrated with biological density, diversity, cover or occurrence data collected from video and the two combined using GIS analyses. This approach has seen limited application to date but offers powerful analysis capabilities for future work (Nasby-Lucas et al. 2002, Iampietro et al. 2005 & 2008, Lundsten et al. 2009).

## **Rapid Assessments**

Initial site and imagery evaluations will be conducted using a semi-quantitative “rapid assessment” technique developed by the PIs while working in the North Central Coast Study Region. The technique involves reviewing the down-video records and recording gross habitat and organismal metrics frame-by-frame during the first 20 seconds of each minute using a programmable keyboard. The resulting Taxonomic Distribution and Abundance Plots (TDAPs; Figure 3) illustrate frequency distributions for each metric across habitat

characteristics along a transect. These data will allow the MPA Monitoring Enterprise a first look at taxonomic distribution and frequency of occurrence prior to detailed data collection and analyses.



**Figure 3.** Example of Taxonomic Distribution and Abundance Plot (TDAP) depicting rapid assessment of community characteristics and habitat attributes within an MPA.

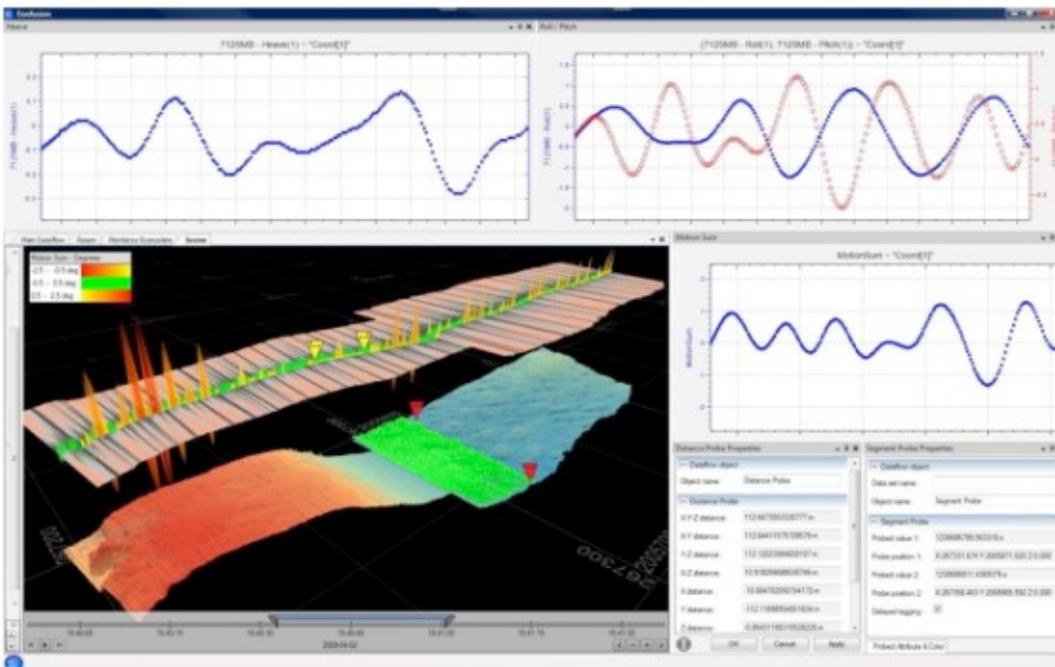
### Data Syntheses and Integration Across Projects

The collection of baseline and monitoring data represent only part of the larger importance of this type of project. Indeed, given the extensive and robust involvement of a diverse array of stakeholders in the MLPA effort in general, and in the South Coast Study Region in particular, the transparent dissemination of project imagery and results to wider (non-scientific) audiences is absolutely critical. In this regard, we are excited to be part of the larger, integrated proposal “Integrative Assessment of baseline ecological and socioeconomic conditions and initial changes within the South Coast MPA region” submitted by Jen Caselle and Carol Blanchette. The larger collaboration creates opportunities for synthetic analyses and data integration (described below) that would not be possible within any single project. That said, we recognize that funding decisions may result in only a sub-set of our collaborators receiving support. Below we describe several categories of synthetic products and highlight which are stand-alone as part of this proposal and which are linked to other proposals.

**NOTE:** We are not requesting any additional support for these activities. They will either be part of the activities of the personnel supported by the grant, or will leverage personnel and equipment from other on-going projects.

### Visualization of Project Data Across Habitats, MPA Boundaries, and Geographic Locations

1) Ecosystem Visualization: The Spatial Information Analysis and Visualization (SIVA) Center at CSU Monterey Bay (<http://seafloor.csUMB.edu/siva/siva-home.shtml>) specializes in the visualization and characterization of subtidal communities and ecosystems. Products combine animation techniques with real-world data and video to produce visualizations of ecosystem characteristics and organismal interactions. The core idea is to render the water column transparent such that interested audiences can experience directly the content ecosystem described entirely by rich inter-disciplinary datasets (Watson and Rahman 2003). This concept has been extended to several visualizations of marine ecosystems that are now deployed in visitor centers associated with marine protected areas in California, populated by data sets produced by collaborating labs at CSUMB and elsewhere. These MPA visualizations are primarily designed to support interpretation and policy awareness. Recent SIVA efforts include the use of the EonFusion software (<http://www.eonfusion.com/home>), an off-the-shelf product designed to facilitate the analysis and visualization of spatial data.



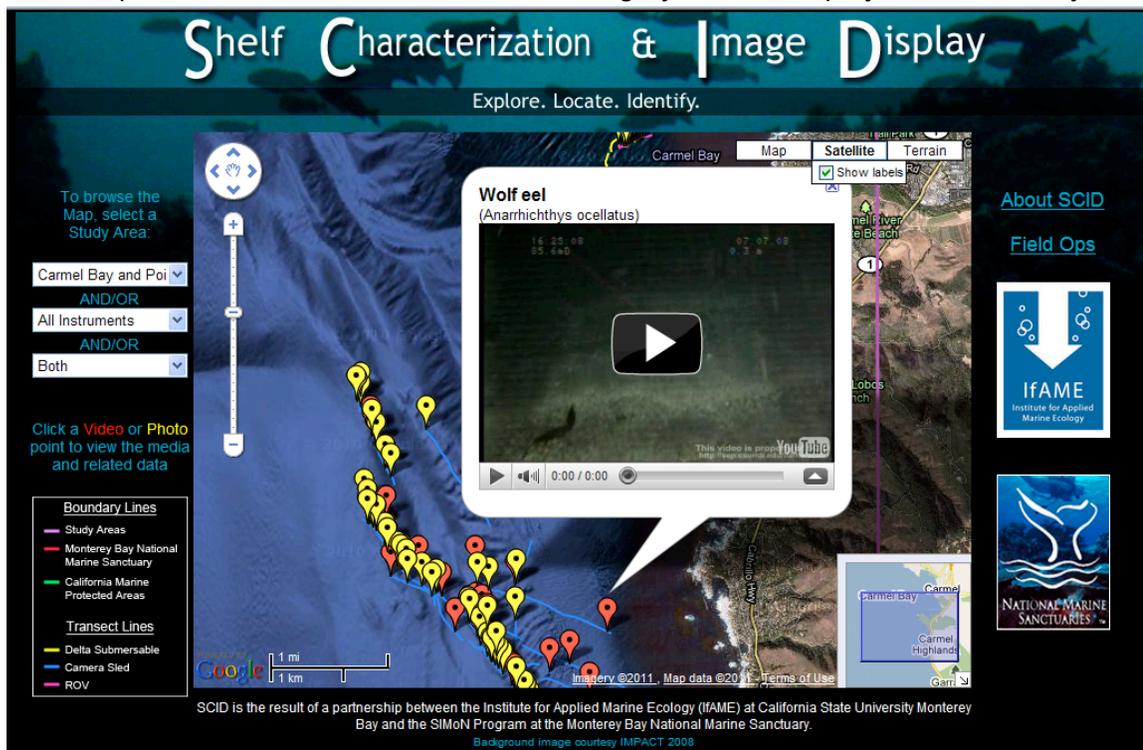
**Figure 4.** Sample output from EonFusion software depicting variation in a response variable relative to a 3-D image of the seafloor.

*ROV-Specific:* Imagery and data collected by the ROV are perfectly suited for visualization in EonFusion. Further, given our landscape approach to sampling, EonFusion will help extract patterns in the distribution of organisms and habitat attributes relative to seafloor topography over a variety of sediment types. For example, we will visualize a transect in its entirety from the base of La Jolla Canyon up into the Matlahuayl SMR, crossing a variety of relevant faunal breaks and characterizing biological communities at different depths. Other environmental data collected by the ROV, such as temperature and DO, can be ‘fused’ with video and multibeam data to provide images that capture multiple dimensions of ecosystem processes in the surveyed areas.

*Integration:* EonFusion will also provide an ideal vehicle for integrating data across projects. Using the La Jolla Canyon example again, we will be able to link ROV data (deep) to SCUBA data (shallow) to intertidal data (dry) for a comprehensive “mega transect” across the MPA. Conducting similar analyses at each of our four sites (all of which will have both SCUBA and intertidal sampling) will provide an extraordinary picture of biological community structure for use in outreach, education, and for scoping future monitoring efforts and research questions.

## 2) Shelf Characterization and Image Display (SCID) and On-Line Image Library

Another key iteration of our on-going efforts to render the water column transparent is the Shelf Characterization and Image Display website (<http://sep.csumb.edu/ifame/scid/>). In its current manifestation SCID 2.0 is a vehicle for the distribution of imagery (both still photographs and videography) on the deep subtidal of the continental shelf. The utility of SCID is predicated on the notions that 1) few people, often including policy makers and managers, understand what the systems they are managing actually look like, and that 2) easy accessibility to imagery will consequently enhance discourse and potentially improve management. We propose to add imagery from the South Coast Study Region to SCID and to provide that link to any associated/interested group or agency. The primary source of this imagery will be the ROV, however, we are open to the inclusion of sub-surface imagery from other projects should they collect such imagery.



**Figure 5.** Screen grab of SCID website depicting ROV transects off Pt. Lobos, CA. Yellow bubbles represent still photos and red bubbles represent video clips (as pictured).

## 3) Calibration with Other Data Collection Methodologies

The collection of similar or related data sets, using different technologies/approaches, at the same or adjacent sites, presents the opportunity to refine our understanding of how best to approach monitoring in marine systems. We will be collecting, within our broader collaborative, data on the abundance, size distribution, and

density of fishes and key invertebrates using ROVs, SCUBA, and hook-and-line. Further, each technology will offer insight into the community composition present at each of the sampled sites.

Based on the latest iteration of project planning for each site, it appears that the Pt. Vicente SMCA will serve as the best opportunity to compare the three approaches. The SMCA will be sampled by our project with an ROV (up to approximately 20 m), SCUBA by the REEF Check California team (down to 30 m), and hook and line by the collaborative fisheries research team (down to 40 m). Working with our collaborators from other projects, we hope to apply a similar analytical approach to what is currently being undertaken in the Central Coast Study Region in advance of next year's 5-year review.

### ***Deliverables***

All data and analyses produced from this work will be fully integrated with other baseline data products where possible. In addition, specific products will include:

- a. Annual project reports- including rapid assessment of community composition and habitat attributes depicted in Taxonomic Distribution and Abundance Plots for each ROV transect.
- b. Summary final report- including species richness, diversity, community analysis, abundance, benthic habitat maps, and summary analyses as defined above.
- c. Web-based visualizations of project data, including integration with other projects.
- d. Raw data and metadata delivered to DFG and the MPA Monitoring Enterprise.
- e. Recommendations for technology (ies), methods, sites and species for future monitoring assessments.
- f. Presentation of results and lessons learned to managers.
- g. Publications submitted to peer-reviewed journals.

## References Cited

- Anderson, T.J. and M.M. Yoklavich. 2007. Multiscale habitat associations of deepwater demersal central California. *Fish. Bull.* 105:168–179.
- Auster, P.J., R.J. Malatesta, S.C. LaRosa, R.A. Cooper, and L.L. Stewart. 1991. Microhabitat utilization by megafaunal assemblage at a low relief outer continental shelf site – Middle Atlantic Bight, USA. *J. Atl Fish Sci* 11:59-69.
- Auster, P.J., R.J. Malatesta, and S.C. LaRosa. 1995. Patterns of microhabitat utilization by mobile invertebrates on the southern New England (USA) continental shelf and slope. *Mar. Ecol. Prog. Ser.* 127:77-85
- Bergen, M., S. Holtz, K.A. Karpov, A. Laueremann, M. Prall, C. Pattison, and D. Rosen. 2005. Quality monitoring of Channel Islands Marine Protected Areas using a remotely operated vehicle – A cooperative study with the Department of Fish and Game, Channel Islands National Marine Sanctuary, and Marine Applied Research and Exploration. Department of Fish and Game. Cruise Report 05-S-1. February 2006.
- Greene, H.G., M.M. Yoklavich, R.M. Starr, V.M. O'Connell, W.W. Wakefield, D.E. Sullivan, J.E. M. and G.M. Cailliet. 1999. A classification scheme for deep seafloor habitats. *Oceanologica Acta* 22:1-12.
- Iampietro, P.J., R.G. Kvitek, E. Morris. 2005. Recent advances in automated genus-specific marine habitat mapping enabled by high-resolution multibeam bathymetry. *Mar. Tech. Soc. J.* 39(3):83-93. *Marine Mapping Enabled by High-resolution Multibeam Bathymetry.* *Mar. Tech. Soc.* 39(3):83-93.
- Iampietro, P.J., M.A. Young, R.G. Kvitek. (2008). Multivariate prediction of Rockfish habitat Suitability at Cordell Bank National Marine Sanctuary and Del Monte Shalebeds, California, USA. *Marine Geology* 31(4): 359-71.
- Krebs, C.J. 1999. *Ecological Methodology, 2<sup>nd</sup> Edition.* Addison Wesley Longman, Inc., Reading, MA.
- Lindholm, J., P. Auster, and P. Valentine. 2004. Role of a large marine protected area for conserving landscape attributes of sand habitats on Georges Bank (NW Atlantic). *Mar. Ecol. Prog. Ser.*, 269: 1-12.
- Lundsten, L.J., J.P. Barry, G. Cailliet, D.A. Clague, A.P. DeVogelaere, and J.B. Geller. 2009. Benthic invertebrate communities on three seamounts off southern and central California, USA. *Mar. Ecol. Prog. Ser.* 374:23-32.
- Nasby-Lucas, N., S.G. Merle, B.W. Embley, B.N. Tissot, M.A. Hixon, and D.J. Wright. 2002. Integrating submersible transect data and high-resolution multibeam sonar imagery for a habitat-based groundfish assessment of Heceta Bank, Oregon. *Fish. Bull.* 100:739-751.
- Pielou, E.C. 1966. Species-diversity and pattern-diversity in the study of ecological succession. *J. Biol.*, 10: 370-383.
- Spencer, M.L., A.W. Stoner, C.J. Ryer, J.E. Munk. 2005. A towed camera sled for estimating abundance of juvenile flatfishes and habitat characteristics: Comparison with beam trawls and divers. *Est. Coas. Sci.* 64:497-503.
- Starmans, A, J. Gutt, and W.E. Arntz. 1999. Mega-epibenthic communities in Arctic and Antarctic waters. *Mar. Biol.* 135:269-280.
- Stein, D.L., B.N. Tissot, M.A. Hixon and W. Barss. 1992. Fish-habitat associations on a deep reef of the Oregon continental shelf. *Fish. Bull.* 90:540-551.

- Stoner, A.W., M.L. Spencer, C.H. Ryer. 2007. Flatfish-habitat associations in Alaska nursery grounds: Use of continuous video records for multi-scale spatial analysis. *J. Sea. Res.* 57:137-150.
- Tissot, B.M., M.M. Yoklavich, M.S. Love, K. York, and M. Amend. 2006. Benthic invertebrates that form habitat on deep banks off southern California, with special reference to deep sea coral. *Fish. Bull.* 104:167-181.
- Tissot, B.M.M.A. Hixon, and D.L. Stein. 2007. Habitat-based submersible assessment of macro-invertebrate and groundfish assemblages at Heceta Bank, Oregon, from 1988 to 1990. *J. Exp. Mar. Biol. Ecol.* 352:50-64.
- Watson, F.G.R. & Rahman, J.M., 2003. Tarsier: a practical software framework for model development, testing and deployment. *Environmental Modelling and Software*, 19:245-260.
- Wolda, H. 1981. Similarity Indices, Sample size, and diversity. *Oecologia*, 50: 296-302.
- Yoklavich, M.M., H.G. Greene, G.M. Cailliet, D.E. Sullivan, R.N. Lea, and M.S. Love. 2000. Habitat association of deep-water rockfishes in a submarine canyon: an example of a natural refuge. *Fish. Bull.* 98:625-641.
- Yoklavich, M.M., G.M. Cailliet, R.N. Lea, H.G. Greene, R. Starr, J. de Marignac, J. Field. 2002. Deepwater habitat and fish resources associated with Big Creek marine ecological reserve. *CalCOFI RPT.* 43:120-140.
- Zuur, A.F., E.N. Ieno, N.J. Walker, A.A. Saveliev, and G.M. Smith. 2009. *Mixed effects models and extensions in ecology with R.* Springer Science and Business Media, LLC., 233 Spring Street, New York, NY 10013, USA. 574 pp.



Tasks	Jul		Aug		Sep		Oct		Nov		Dec		Jan		Feb		Mar		Apr		May		Jun	
	1-15	16-31	1-15	16-31	1-15	16-30	1-15	16-31	1-15	16-30	1-15	16-31	1-15	16-31	1-15	16-28	1-15	16-31	1-15	16-30	1-15	16-31	1-15	16-30
<b>Year 1</b>																								
Literature review, collect historical data from a variety of sources across the study region		█	█	█	█																			
Cruise preparation and planning			█	█	█																			
Year 1 Cruise							█	█	█	█	█													
Post cruise data compilation											█	█	█	█	█	█	█	█	█	█	█	█	█	█
<b>Year 2</b>																								
Year 1 Status Report	█																							
Continue Year 1 data compilation and analysis	█	█	█	█	█																			
Cruise preparation and planning			█	█	█																			
Year 2 Cruise							█	█	█	█	█													
Post cruise data compilation											█	█	█	█	█	█	█	█	█	█	█	█	█	█
<b>Year 3</b>																								
Year 2 Status Report	█																							
Continue Year 2 data compilation and analysis	█	█	█	█	█																			
Data Integration and Synthesis			█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█
Final Report Submitted	█																							