North Central Coast MPA Baseline ROV Data Collection for Deep Benthic Rock and Soft-Bottom Ecosystem Characterization and Monitoring (20 -116 m)

Introduction

Ecosystem characterization and monitoring of both deep benthic rock and soft-bottom communities (20 m or shallower[1]- 116 m) will be undertaken by a unique partnership between Marine Applied Research and Exploration (MARE), California State University's Institute for Applied Marine Ecology (IfAME), and The Nature Conservancy's (TNC) California Coastal and Marine Program, with the additional participation of NOAA's Office of National Marine Sanctuaries (ONMS), Commercial Fishermen (Tim Maricich), and emeritus scientist and fish biologist, Bob Lea. Baseline data collection and analyses will occur over the first two of the three project years, focusing on priority metrics and species from the draft monitoring plan (CDFG 2009) identified in the RFP (CALOST 2009), as well as priority species identified in interviews with State and Federal marine managers who work in the study area. The third year will be focused on data synopsis and interpretation, including development of recommendations for future monitoring and integration of project data with other elements of the regional monitoring program

The partnership and approach proposed are uniquely positioned to address monitoring priorities in the region.

- The ROV proposed for use in this work is a perfect tool for this region and depth range and engages a new technology that was designed and built for the purpose of monitoring state marine resources through funding from OPC. The proposed depths are generally below the depth at which divers can operate safely, but well within the limits of the ROV. The camera configuration, which includes both forward and down-looking video and still cameras, provides comprehensive habitat coverage and high definition records for difficult species identifications.

- Each of the partners collaborating on this proposed work has prior experience in MPA monitoring and/or management. We can therefore leverage experience gained in the Channel Islands, Central California Coast MPAs, Florida Keys National Marine Sanctuary, and Stellwagen Bank National Marine Sanctuary in the conduct of this research. These partners have also had prior experience working as a team on a trawl impact research project underway in Morro Bay, California and habitat characterization within the Monterey Bay National Marine Sanctuary.

- This project leverages the expertise and resources of multiple regional institutions, including public and private, academic and non-governmental, coupling data processing and analysis with education and training of the next generation of scientists in California.

- The study design provides potential for data calibration with other technologies such as diver and manned submersible that have already been used extensively in other regions and depths in California waters.

- The study design focuses on MPAs specifically designed to support this kind of monitoring research (i.e. paired and adjacent SMR/SMCA combinations) with additional objectives focused on protection of exploited fish populations and their habitats. Video files collected provide a permanent record of baseline conditions that can be used for a variety of purposes in addition to baseline analyses such as public education or future reanalysis using refined techniques.

[1] We can dive the ROV in as shallow as 5m depth if there is no kelp and seas are calm for areas such as the Farallons.

General Approach

Our goal is to collect both structural and biological community data within four primary geographies that were selected to represent each of the three biogeographic regions identified in the North Central Coast Regional Profile (CMLPAI 2007) and an additional site requested by reviewers. All are heavily impacted areas expected to show changes related to MPA establishment. They are (listed from north to south) 1): Pt. Arena SMCA and SMR, 2) Bodega Head SMCA and SMR, 3) South Farallon Island SMCA and SMR, and 4) Montara SMR and Pillar Point SMCA (Figure 1).

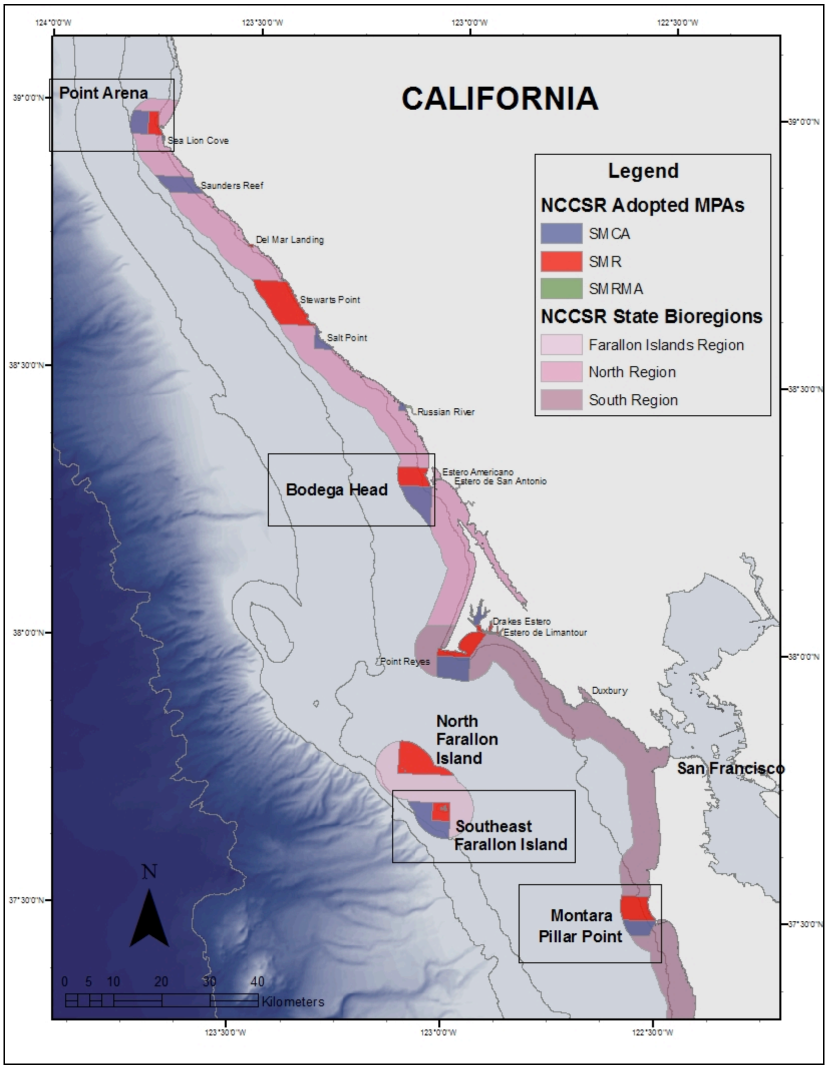

Figure 1. Map of NCC study area including four sites selected for sampling in this proposal.

We propose a nested BACI (before-after-control-impact) design to quantify potential effects of MPAs following designation across the NCC study area, including changes in community structure inside and out of MPAs, and potentially to relate those changes to revised patterns of exploitation adjacent to MPAs. A simple schematic depicting the nested design is provided in Figure 2. Each of the geographies selected has a range of habitats available at each 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 each level of protection and adjacent locations at comparable water depths. Five treatment sites will be sampled within each geography–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. We will target two (2) transects greater than 1 km in length within each of the five treatment sites in each geography and then sub-sample from those transects for quantitative analyses.

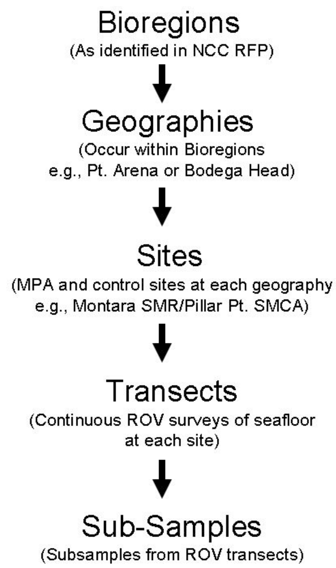

Figure 2. Overview of hierarchical sampling design.

In Project Year 1 we will conduct extensive sampling both inside and outside of MPAs, beginning in the south at Montara/Pillar Point, and then working our way north to South East Farallon Island, Bodega Head, and Pt. Arena, to characterize seafloor communities represented across the North Central Coast study region. A new remotely operated vehicle (ROV; owned by TNC, acquired through Ocean Protection Council funding, and operated by MARE in Richmond, CA) 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 draft monitoring plan (CDFG 2009) and RFP (CALOST 2009) and augmented based on interviews with managers of the State and Federal agencies charged with managing the marine environment in the study area. Transects will maximize continuous ROV dive time and encompass rocky and soft sediment substrates and the transitional areas between the two. 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 video analysis lab under the supervision of Dr. Lindholm.

Table 1. Species, features and metrics proposed for collection at proposed NCC ROV Baseline sites with input from management agencies. Importance to individual agency or plan is indicated by an X.

Taxa		Metric	Vital Sign	Monitoring Plan	CDFG NFMP	CDFG	Cordell Bank	NMFS
Deep Rock Ecosystems (30-116 m)								
Community								
	Multiple species	Species diversity						
	Multiple species	Species richness						
	Dominant habitat (50% coverage)	Composition and relief						
	Subdominant habitat (20% coverage)	Composition and relief						
Biogenic habitat								
	Biogenic habitat composition	Height and complexity						
	Microhabitat composition	Relative height and complexity						
	Structure-forming	Density and cover		X				
	Encrusting Invertebrates	Cover		X				
Sessile Invertebrates								
	Metridium spp.	Bed cover		X				
	Hydrocoral	Density		X				
Mobile Invertebrates								
	Dungeness crab (*Cancer magister*)	Abundance, density	X	X				
	Sheep (spider) crabs (*Loxorhynchus grandis*	Density		X				
	Box crabs (*Lopholithodes foraminatus*)	Density		X				
Fishes								
	Bocaccio (*Sebastes paucispinis*)	Density and size structure		X			X	X
	Yelloweye (*Sebastes ruberrimus*)	Density and size structure		X				X
	Vermilion (*Sebastes miniatus*)	Density and size structure		X	X	X	X	
	Lingcod (*Ophiodon elongatus*)	Density and size structure	X	X		X		
	Dwarf rockfish: Halfbanded *S.*	Total abundance	X	X			X	X
	Gopher rockfish (*Sebastes carnatus*)	Density and size structure		X	X	X		
	China rockfish (*Sebastes nebulosus*)	Density and size structure		X	X	X		
	Ratfish (*Hydrolagus colliei*)	Density and size structure					X	
	Rosy rockfish (Sebastes rosaceus)	Density and size structure					X	
	Black rockfish (*Sebastes melanops*)	Abundance and freq. of occurrence			X	X		X
	Blue rockfish (*Sebastes mystinus*)	Abundance			X	X		X
	Brown rockfish (*S. auriculatus*)	Abundance and size structure			X	X		
	Cabezon (*Scorpaenichthys marmoratus*)	Abundance and size structure			X	X		
	Copper rockfish (*S. caurinus*)	Abundance and size structure			X	X		
	Kelp greenling (*Hexagrammos*	Abundance and size structure			X	X		
Soft-bottom (20-116 m)								
Community								
	Multiple species	Species diversity						
	Multiple species	Species richness						
	Dominant habitat (50% coverage)	Composition and relief						
	Subdominant habitat (20% coverage)	Composition and relief						
Biogenic habitat								
	Multiple species	Total cover and diversity		X				
	Biogenic mounds and depressions	Density and relative abundance						
	Biogenic habitat composition	Height and complexity						
	Microhabitat composition	Relative height and complexity						
Benthic invertebrate predators								
	Dungeness crab (*Cancer magister*)	Density and size structure	X	X				
	Box crabs (*Lopholithodes foraminatus*)	Density and size structure						
	Sea star (multiple species: *Rathbunaster /*	Abundance and size structu	X	X				
Demersal fish predators								
	California halibut (*Paralichthys*	Density and size structure	X	X				
	Starry flounder (*Platichthys stellatus*)	Density and size structure	X	X				
	Pacific sanddab (*Citharichthys sordidus*)	Density and size structure		X		X		
	Other flatfish	Density and size structure	X					
	Lingcod (*Ophiodon elongatus*)	Density and size structure				X		

In Project Year 2 we will re-survey the 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 prioritization of Year 2 sampling effort will be based on the sampling completed in Year 1 and will be determined at a meeting with the MPA Monitoring Enterprise prior to the beginning of the field season. Continuous videographic and still photographic imagery will be collected using the ROV and will be sub-sampled post-hoc based on statistical analysis of year 1 data. An interim report summarizing observations of the targeted species will be presented to managers.

Our efforts in Project Year 3 will focus entirely on data analysis and summarization, and integration of results with other baseline products. For managers/policy-makers we will produce a comprehensive report describing the characterization of the seafloor communities inside and outside the MPAs across the NCC 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.

Project Goals and Objectives

Our project objectives address ecological components of the Baseline Program goals as stated in the RFP and contribute to the nearshore community structure and monitoring plan evaluation components. All are directed toward using ROV technology to provide videographic and still photographic imagery of seafloor habitat structure and associated biological communities in the NCC study region to develop a basis for tracking status and changes in deep subtidal communities over time.

GOAL 1: Baseline Characterization and Monitoring Recommendations

Task 1: Review and summarize available historical information on deep subtidal communities within each of the biogeographic regions represented in North Central Coast MPAs. Evaluate in the context of the North Central Coast Regional Profile (CMALPO 2007) and the National Marine Sanctuaries Biogeographic Assessment of North/Central California (NCCOS 2003). Analyze benthic habitat distribution within each proposed site and identify transect locations for data collection.

Task 2: Collect videographic and still photographic imagery in deep subtidal (20-116 meters) soft and hard bottom habitats inside and out of the Montara SMR/Pillar Point SMCA , , South East Farallon Island SMR and SMCA, Bodega Head SMR and SMCA and Pt Arena SMR and SMCA to provide a permanent record of seafloor communities occurring there at MPA implementation. Sampling will include imagery of 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 (Table 1)).

Task 3: Provide a summary description and assessment of ecological conditions inside and outside SMRs and SMCAs and comparable sites distant from both as initial data for future comparison with condition and trends over long-term monitoring timeframes. The description will include benthic ecosystem structure, processes, habitat characteristics and species assemblages in the context of the key attributes, indicators and focal species defined by the monitoring framework and local State and Federal marine managers.

Task 4: Evaluate the draft long-term monitoring plan species and ecological indicators for deep subtidal communities and develop recommendations for implementation and modification. Recommend a set of indicators, technology and methods to assess long-term status and trends for subtidal ecosystems surveyed.

Task 5: Work with other investigators to integrate data, findings and recommendations across ecosystem features.

GOAL 2: Assessment of Initial Ecological Changes

Task 6: Collect second year of videographic and still photographic sample imagery from the same treatment sites sampled in Year 1.

Task 7: Describe any ecological changes to deep benthic community composition and structure in sites sampled. Identify data elements considered sensitive and rapid to respond to MPA implementation. Describe changes observed and provide potential explanations, specifically whether they can be attributed to MPA establishment.

Study Framework

Site Selection

The primary geographies selected represent each of three biogeographic regions identified in the North Central Coast Regional Profile (CMLPAI 2007) and are all heavily impacted areas expected to show changes related to MPA establishment. They are 1), Montara SMR and Pillar Point SMCA 2) South Farallon Island SMCA and SMR, 3) Bodega Head SMCA and SMR, and 4) Pt Arena SMCA and SMR (Figure 1). Each proposed geography is perfect for ROV operations because depths targeted are below safe human diving depths without using specialty techniques but in the shallower operating depths of the ROV. Further, some of these areas are not safe for diving. In addition, the ROV is agile and easily navigable across a range of habitats with varying topography and species targeted have all been observed by the vehicle in previous work. Each of the geographies selected 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. All transects will be positioned to traverse all three substrate types 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 within each geography, inside and outside the SMR, inside and outside the SMCA, and a site relatively distant from both but of similar bottom habitat composition. Sampling will begin in the south at Montara and Pillar Point and will proceed north, culminating with Pt. Arena if time and weather permits.

In Year 2 we will convene a meeting with staff from the MPA Monitoring Enterprise to evaluate the sampling completed in Year 1. The prioritization of sampling effort in Year 2 will be based on that evaluation.

Vector L4 ROV Operations

We propose to use the state-of-the-art Vector L4 ROV (owned by TNC and acquired through a grant from the state 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. Additionally, the depth range and topography 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 strong and versatile performance capabilities of this vehicle. The ROV controllability, neutral buoyancy and navigational sensors allow us to fly straight line transects and closely hug rugose terrain, an advantage over other technologies that fly around instead of over uplifted mounds and pinnacles. The camera configuration, consisting of both forward facing and downward video and high resolution still photography provide maximum areal coverage and archival documentation for future uses. ROV video is collected straight ahead - in front of and below the ROV as it is flown in a straight line less than 1 meter off the bottom. Additional equipment on the ROV such as sonar and lasers for sizing organisms and maintaining altitude and an in situ temperature sensor allow a broad range of data collection capabilities. By applying best practices from multiple institutions we will collect data that is compatible and complementary to existing databases. If awarded, we would willingly overlap transects with other technologies (i.e. manned submersible) for calibration purposes.

Remotely Operated Vehicle Equipment

The Vector L4 ROV is Deep Ocean Engineering's latest model. A state-of-the-art ROV, it has been proven to 385 meters, returning video and still images of exceptional resolution and quality. The images have enabled difficult rockfish species identifications and a clear view of small organisms such as three centimeter polychaete worms.

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 strobes. Piloting is assisted by auto heading, auto depth and vertical ranging altimeter to maintain a straight course (± 1 degree) and altitude above substrate (± 0.3m) 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, water temperature, 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^o 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 15mW red lasers for image scaling are centered about forward and down cameras. They paint 2 red dots 12cm 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 DVR550h 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.

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 years 1 and 2 we will target 20 days of sampling each year. 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 (Figure 3). The ROV will be "flown" at an altitude of approximately 0.5 m above the seafloor 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[2] on the seafloor, 2) epifaunal macro-invertebrates (both sessile and mobile), and 3) associated fishes (including selected exploited

[2] 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).

and non-exploited species identified by the draft monitoring plan (CDFG 2008) and management agencies (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 select habitat and microhabitat features and associations across a gradient of benthic habitats from 20 to 116 meters, and shallower depending upon conditions. 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 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.

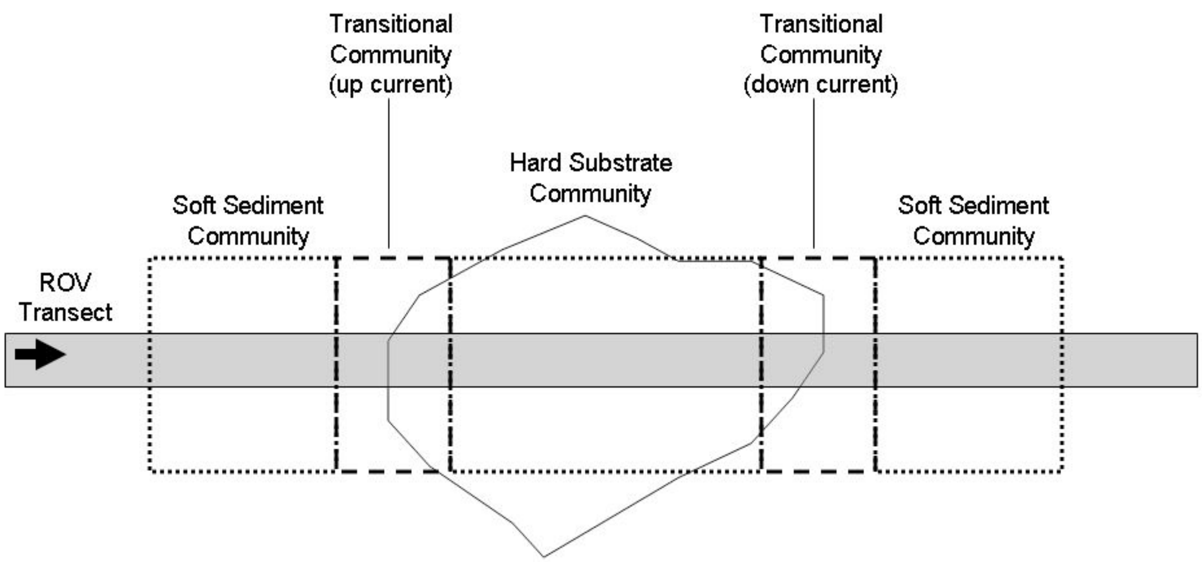

Figure 3. Idealized schematic depicting a continuous ROV transect that encompasses both hard and soft sediment communities as well as the transitional areas between the two communities (up- and down-current). Characteristics of each community will be quantified based on sub-sampling at intervals to-be-determined following analysis of Year 1 data.

<u>*Post-processing*</u>

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 in the study area. It is possible, based on similar data collected by the PIs and others (e.g., Lindholm et al. 2004; Bergen et al. 2006) 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 (within each of the four geographies) 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 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 110 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 0.42 m^2.

Data will be entered directly into a database by GPS time code. 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 species 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 seawhips, 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°), low (5−30°), moderate (30°-60°) or high (>60°) (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), shell hash and rock wall.

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). Data will be produced from the still photographs using a series of 50 randomly distributed dots overlaid on each photograph. The microhabitat feature under each dot will be counted and apportioned to a particular microhabitat type. Unique random patterns will be used for each photograph from each transect. The percent relative abundance of a given microhabitat will be calculated as the number of each habitat type divided by the total number of occurrences for all microhabitats for that transect. 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 five treatment areas within each of four MPA clusters 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 geography are:

Year 1

H_O (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_O (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_O (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_O (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_O (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_O (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, tying together 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. 2008).

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.
b. Summary final report- including species richness, diversity, community analysis, abundance and benthic habitat maps and summary analyses as define above.
c. Raw data and metadata delivered to DFG and the MPA Monitoring Enterprise.
d. Recommendations for technology (ies), methods, sites and species for future monitoring assessments.
e. If both ROV and Delta Sub proposals are awarded, we would work together to provide calibration results.
f. Presentation of results and lessons learned to managers.
g. Peer-reviewed publications.

Collaborative Research Partners

- **Marine Applied Research and Exploration (MARE):** Dirk Rosen, President, is an expert on ROV technology and operations. He will lead cruise planning and operations of the ROV system and associated technology. He has participated in MPA monitoring data collection in both the Channel Islands since 2003 and Central Coast MPAs.
- **California State University Monterey Bay (CSUMB)**: Dr. James Lindholm, Rote Professor of Marine Science and Policy, is an expert in ROV and camera sled operations and has conducted similar studies in both hard and soft-bottom habitats in the Florida Keys, Stellwagen Bank and the Central California Coast. He will lead the scientific design and all post-processing analyses. Donna Kline is experienced in marine research and ROV operations and will assist with oversight of field operations and data collection and will conduct and supervise analyses of videographic and still photographic data.
- **The Nature Conservancy (TNC)**: Dr. Mary Gleason, lead marine scientist for The Nature Conservancy's California Coastal and Marine Program, will be be involved as a research advisor and TNC has agreed to the use of the TNC-ROV, operated by MARE, for this project. As the lead planner for the MLPA Initiative's North Central Coast MPA planning process, she has been closely involved in the design and rationale for MPAs established in the region and in the development of monitoring efforts in state MPAs.
- **Commercial fishermen**: We will collaborate with fishermen who can provide vessel time for ROV operations. Specifically, Tim Maricich, who has provided operational support for other projects using the Vector L4 aboard F/V DONNA KATHLEEN will be the primary contract vessel in support of at sea operations.

- **Dr. Bob Lea (CDFG retired)**: Dr. Bob Lea is a retired CDFG Biologist and an expert on California fishes. He will provide consulation for fish identifications.
- **NOAA's Office of National Marine Sanctuaries (ONMS)**: ONMS will provide a towed camera sled (designed, built and maintained by the principles of MARE, owned by the ONMS and operated by IfAME) to augment data collection and provide a backup platform for the ROV.

Timeline for North Central Coast MPA Baseline ROV Data Collection & Processing

Tasks	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
	1-15	16-31	1-15	16-28	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	16-30	1-15	16-31	1-15	16-30	1-15	16-31
Year 1																								
Literature review, collect historical data from trawl surveys and previous video surveys from Cordell Bank and Farallones.																								
Cruise preparation and planning																								
Year 1 Cruise																								
Post cruise data compilation																								
Year 2																								
Year 1 Status Report																								
Continue Year 1 data compilation and analysis																								
Meet with MPA Monitoring Enterprise to prioritize Year 2 sites and order of survey																								
Cruise preparation and planning																								
Year 2 Cruise																								
Post cruise data compilation																								
Year 3																								
Year 2 Status Report																								
Continue Year 2 data compilation and analysis																								
Final report preparation																								
Submission December 31																								