Reef Check

Citizen-science monitoring of rocky reefs and kelp forests: creating a baseline for California's south coast MPAs

Revised Plan of work

Field work

To describe the shallow rocky reef and kelp forest ecosystem feature for the baseline characterization we will estimate density, population size structure and community attributes (i.e. relative diversity, trophic structure, biological habitat) of key fish, invertebrate and algae species. We will build on and expand our existing monitoring system in Southern California to 40 annually surveyed reef sites in the SCSR region. All fieldwork will be performed by RCCA certified citizen scientist scuba divers under the oversight and assistance of RCCA staff. All data collection is done using counts and size estimation while scuba diving. No organisms are removed; therefore we do not need scientific collecting permits to perform this work.

Spatial sampling design
Central to our spatial sampling design in the SCSR is a balance between the replication of samples in and outside of individual MPAs and spatial coverage of all mainland bioregions as identified in the Draft Methods Used to Evaluate Marine Protected Area Proposals in the South Coast Study Region (California MLPA Master Plan Science Advisory Team 2009, October 26). We think one of the strengths of the RCCA program is our application of a standardized sampling protocol across a network of sites spanning the study region. We use a *stratified random permanent* sampling design, in which randomly located transects are sampled within fixed sites permanently located inside and outside of MPAs. These random transects are stratified within each site across fixed depth zones.

For the baseline monitoring project we propose to survey 40 sites in the SCSR over the period from July 2011 to November 2012. These sites will include currently monitored RCCA sites as well as new sites so as to expand our network to cover three of the five bioregions, as well as 16 of the new MPAs in the SCSR (Figure 3, revised Table 1). We are proposing a nested sampling design in which we will survey two sites (inside and reference site) at two MPAs of each management type (i.e. SMR, SMCA) in three bioregions of the SCSR (Figure 4). This will allow us to analyze data at several spatial scales (i.e. individual MPAs, within bioregions, across bioregions) and account for biogeographic variability in species inevitably present in a study region as large as the SCSR (Hamilton et al. 2010). We will apply this design to bioregions where multiple MPAs of each type were implemented with the exemption of the 'Eastern Islands' where Santa Barbara Island SMR is difficult to access (and well sampled by PISCO) and the 'Northern Mainland' where Pt. Conception SMR is difficult to access for volunteers. Within MPAs and reference sites we will sample at least one survey site (one cell in PISCO/CRANE terminology) and, to increase sampling at the individual MPA level, we will coordinate site (i.e. cell) selection within MPAs and reference sites with other groups sampling the same ecosystem feature (e.g., Caselle/Pondella; Anderson/Edward see: Partnerships and integrative approaches) so that both programs will complement each other and

data from respective sites (cells) can be used to supplement data collection. Based on a recent analysis the integration of each other's data, especially for the key species RCCA monitors and that were identified as potential focal species in the Long-term Monitoring Draft Metrics, is entirely feasible (Gillett et al. 2011). At several MPA locations (e.g., Laguna Beach SMR/SMCA complex) we will sample at higher spatial replication (i.e. multiple sites inside and outside of MPAs). These sites will be used for an analysis to evaluate the replication necessary at individual MPAs to establish MPA baseline information (see: *Analytical approaches*).

All sites will be surveyed using RCCA's unique statewide sampling protocol (see below). This approach makes us the only research group that will incorporate the study sites in the SCSR into a statewide monitoring network, which includes the CCSR and NCCSR, maintained by a single organization. Therefore, RCCA's dataset covers all three of the MLPA initiative's study regions in which MPAs have been implemented and allows for statewide comparisons and quantitative analysis of MPA function and effectiveness in the future.

Additionally, several of RCCA's sites are located in areas where they are accessible to large number of volunteers. The placement of these sites is not necessarily based on the spatial design proposed here for MPA baseline monitoring. Instead they are part of our outreach and education strategy. In order to target a large number of volunteers we have to have sites that are desirable diving locations and within reach of most of our volunteers (e.g., Catalina Island, Palos Verdes, Orange County). Many of the volunteers start out diving at these sites and once they have become familiar with our protocol they will continue to dive with us and survey harder to reach sites that take a larger time commitment. Without these 'easy access sites' we would not be able to build a successful team of volunteer divers.

Temporal sampling design

We will survey each site twice over the first two years of this project, once during the summer and fall months of 2011 and again within the same time frame in 2012. To insure that seasonal variability in community composition or population dynamics (e.g., recruitment of rockfishes, kelp density) is controlled for we will sample each site around the same time of year (i.e. in the same month) in both years (Thompson and Mapstone 2002). Whenever possible we will increase our temporal resolution by repeatedly sampling sites within one year. The third year will be used for data analysis and reporting as well as development of outreach materials based on the monitoring results.

RCCA sampling method

At each selected site we will conduct surveys according to the RCCA protocol (Shuman et al. 2011). RCCA surveys consist of eighteen 30m transects to monitor key species of fishes (35 species), invertebrates (32 species), algae (5 native, 4 invasive species) (Appendix 1). Because the distribution and abundance of fish, invertebrate and algae species are known to vary with depth and the cross-shore location within the kelp forest (i.e. offshore to onshore), it is necessary to assure that samples are stratified across these gradients. This is achieved by distributing an equal number of transects (n= 9 for fish, n=3 for invertebrates & algae) for sampling in two strata: an inshore (5 -12m) and an offshore (12-20m) area of the rocky reef (Figure 5).

Transects are divided into core transects (3 in each depth zone) and fish 'only' transects (6 in each zone) that are placed haphazardly but parallel to the depth gradient in each strata. Along the core

transects the fish, invertebrate and algae communities, as well as the physical habitat, is characterized. Response variables in this sampling design are density and size structure, in three size categories (< 15cm, 15-30 cm, >30 cm), of the 35 fish species; density of key invertebrates and algae species (Appendix 1). For giant kelp (*Macrocystis pyrifera*), number of plants and the number of stipes on individual plants are counted. Further, the reef substrate is characterized in four categories of reef (>1m), boulder (<1m), cobble (<0.1m) and sand as well as by a categorical estimate of the relief (4 categories: 0 – 10 cm, 11 cm – 1m, 1 – 2 m, and > 2). Fish are counted and sized from within a two by two meter volume above the seafloor along the transect (2m wide by 2m tall by 30m long). Key invertebrate and algae species are counted within a two meter band (2m by 30m swath) along the rocky reef seafloor. The physical substrate and proportional cover of species for which individuals are not readily distinguishable (e.g., colonial species, small macroalgae) is characterized using uniform point contact (UPC) survey methods. Taxonomic resolution (i.e. species, genus, family and higher) at which data are collected on UPC transects varies among taxa. To increase the sampling of fish they are sampled in the same way along six additional transects (fish only transects) in each zone.

Red and purple sea urchin size frequency data is collected at sites with high urchin abundance to get a representative sample of population's size frequency distribution (100 individuals/species). Divers measure urchins to the nearest centimeter in situ without removal of urchins (Shuman et al. 2011). This sampling is not associate with transects and urchins are measured in a random manner to assure an unbiased sample of the size frequency distribution.

Diver training and data quality assurance

RCCA's immersion learning training and ecosystem monitoring are the core of the program and effectively engage hundreds of California's citizen scientists in the marine management process. The program was designed with oversight from state resource managers and leading marine scientists and is formally recognized by the CDFG in a Memorandum of Understanding as a valuable tool for marine management and public engagement. RCCA's training course consists of a four-day immersion-learning curriculum. It includes: rigorous classroom work focused on reef ecology, conservation and MPA science and identification of 73 selected indicator species (both native and invasive); swimming pool sessions for learning underwater scientific data collection techniques; and field days for practice, testing and certification in RCCA's survey protocols. Through this training, volunteers acquire a thorough understanding of the value of a healthy native marine environment, an appreciation for the importance of monitoring and the tools to conduct scientific surveys. Divers who complete the course and pass certification levels sufficient to conduct surveys continue to increase their knowledge by actively participating in or leading underwater surveys along the California coast. Strict quality assurance and control procedures ensure that the data collected are of high quality and scientifically useful. These procedures include a one-day annual recertification (including written and field tests) of each diver by RCCA each year after initial certification. Further, divers discuss the data they collected with each other and RCCA staff after each dive and datasheets are proof read by fellow volunteers to insure accuracy of the data. This procedure has proven to be a very effective way of catching mistakes or unusual data early on when it can still be addressed. At this quality assurance step transects are redone if mistakes or data omissions (e.g., species misidentified or not counted) are noted. RCCA's online data entry system (NED) provides another layer of quality control. Automated data error checks are programmed into the database so that unusual data is flagged for examination by RCCA staff. Additionally, all data are reviewed by RCCA

staff and erroneous data are removed before data are submitted into the final database.

Over the last three years we have maintained a volunteer base of about 220 active divers statewide (Figure 1). Every year we have increased our diver retention and now have a body of experienced citizen scientists who have surveyed many of the proposed sites in southern California for several years. This long-term retention of volunteers guaranties consistency in data collection and quality and the years of service of many volunteers are comparable to those by undergraduate student or technicians in academic monitoring programs. In 2011, we will already have conducted most of our trainings and recertifications in the SCSR by the proposed start date of the project. We expect to have 80 experienced and new divers ready to survey by July. In 2012, we will conduct six trainings for new volunteers and five recertifications for current citizen scientists to recruit and retrained divers for the second survey season of the baseline monitoring project. In addition, we are also cultivating volunteer leaders from within our volunteers to take charge and conduct surveys at sites that they are familiar with without staff being present at each survey. With many of our volunteers having five years of experience, this will greatly increase our effectiveness in surveying and at the same time reduce staff time in the field and therefore, generate a substantial cost saving.

Analytical approaches

Univariate and multivariate statistical analyses will be conducted to compare species abundances, guild abundances (e.g., trophic guilds) and community structure among MPAs and reference sites across the study region. Estimates of the density of fish, invertebrate of algae species at site, across an entire bioregion or regulatory level (e.g., SMR, SMCA), as well as inside and outside of all MPAs within the network can be used to generate a multivariate description of species assemblages at each of these spatial scales. The same can be done for functional groups (e.g., detritivores, planktivores, primary producers) for description of the initial states of these community attributes among regulatory treatments and comparisons of how they change relative to one another over time. The inclusion of historical data in this analysis will greatly enhance our ability to detect initial changes in the population or community structure if they occur over the first two years of monitoring (Underwood 1991, Osenberg et al. 2006).

These analyses will be extended to explore how individual species or species complexes may function as indicators of composition, stability and functional processes within kelp forest ecosystems. The strength of potential system indicators (univariate or multivariate) will be explored by testing their correlation with various attributes of the system (e.g., the kelp density vs. species diversity). These analyses will be performed on the key species monitored by RCCA and then, in an integrative and collaborative extension of this work, we will compare these results to data from the Caselle/Pondella group. This group is monitoring a more extensive list of species and we will be able to identify commonalities and differences in the dataset and use this comparison to identify key species (either from RCCAs species list, the draft long-term monitoring metrics, or others) that have the potential to be used as indicators for long-term MPA monitoring in the SCSR. These analytical approaches will include the historical data from RCCA's current monitoring sites. The inclusion of these data and time series and trend analysis will enhance the possibility to detect initial changes in size structure, population or community parameters over the first two years of the existence of the MPAs. The analytical frameworks for these analyses will be similar to those used in the NCCSR baseline monitoring and therefore we will have developed these approaches by the time data collection in the SCSR will be completed. We will work closely with our collaborators at UCSC

(NCCSR), UCSB and Occidental College to develop these analytical approaches and integrate dataset as much as necessary to leverage expertise, reduce redundancy in effort and streamline the analysis aspect of this project.

RCCA data management and dissemination

Data collected by RCCA divers are captured within RCCA's online Nearshore Ecosystem Database (NED), a public, interactive portal for data management and retrieval (http://ned.reefcheck.org). NED's design review team consisted of representatives from the California Department of Fish and Game, the Ocean Protection Council, the Ocean Science Trust, the State Coastal Conservancy and the University of California. This team was chosen to ensure the database would be compatible with the needs of State resource managers and scientific researchers. The result is an online system that displays near real-time data in comprehensible, manageable, spatially explicit and engaging formats. Unlike proprietary datasets, RCCA data are easily accessed and utilized by a variety of end users including resource managers, policymakers, stakeholders, teachers, scientists and the general public. Features include interactive mapping and data entry portals, multiple quality checks and controls, detailed information on RCCA's indicator species and a downloadable database. At the same time, NED is RCCA's data entry and QA/QC tool. Online data entry masks enable volunteers to enter data from anywhere but their entry is controlled by automated data checks, an outlier flagging system and a final control of all data by RCCA staff. In addition to the publically available data portal, RCCA data is now kept and made available in data formats and associated metadata in Ecological Metadata Language (EML) and according to the MPA Monitoring Enterprises metadata standards. NED is linked to other monitoring and educational databases, clearinghouses and research programs such as the Northern California National Marine Sanctuaries Integrated Monitoring Network (SIMON) and the Central and Northern California Ocean Observing Systems (CeNCOOS) and MLPA Initiative's map-based online decision support tool (Marine Map). All data collected for this project will be integrated into RCCA's statewide dataset and all data will be provided at the end of the project in the required format.

Community Outreach and Education

RCCA also focuses on public education as a strategy for improving marine management. The key public message is "sound ocean stewardship based on science". RCCA's training and monitoring system automatically fosters a sense of responsibility for participants many of who are leaders and opinion makers in their local communities (over 50% of volunteers have Masters, PhD or professional degrees). It also provides an avenue for active individual stewardship and education about marine management and MPAs (Figure 6). As a secondary effect, the friends, families, colleagues or students of RCCA volunteers are often inspired to learn more about marine life and issues at local and global levels and to take action in a variety of ways beyond RCCA's immediate scope. General public education and conservation are also furthered through the program's web forum (http://forum.reefcheck.org), public presentations, community events and publications such as its biennial report (Shuman et al. 2008) and a soon-to-be-published 5-year report. In addition, RCCA's volunteers and the general public are encouraged to make their voices heard in management and decision-making processes. As a result of these activities, RCCA is developing a cadre of ocean enthusiasts that are knowledgeable about marine environments, directly engage in monitoring, have a scientifically based stewardship ethic and are making a tangible difference in their local communities and in marine conservation.

We will use the first year of the proposed project to reach out to new ocean user groups by capitalizing on the publicity that the implementation of the MPAs will inevitably generate in southern California. Specific activities will include: researching and participating in local speakers circuits; strengthened collaborations with institutional and business partners to further general public education and media reach; and public presentations and media events. This approach was very successful in the NCCSR where we will be holding our first trainings in Fort Bragg after receiving interest from previous MLPA stakeholder group members and the general diving community. One year after the start of the monitoring in this region, we have been approached by the commercial urchin fisherman of northern California to conduct a specialized training (hookah divers) for their community. We are aiming to replicate this success in outreach and community involvement in the SCSR. In the second year we will train new divers and hold additional outreach events at dive clubs, public venues such as our partner Aquaria and engage with educational facilities (e.g., Catalina Island Marine Institute, Emerald Bay Boy Scout Camp and Dana Point Ocean Institute) to reach a wide audience. During the development of the final reports and recommendations, in the third year, we will work with our collaborators and the MPA Monitoring Enterprise to develop not only scientific reports but also to make this information readily available for the general public. We will use our online Nearshore Ecological Database (NED) and other outreach tools for this effort. Further, we will again reach out, educate and train divers and continue the monitoring if additional funding can be secured (no funding is requested for this activity).

Site	MPA	Location	Bioregion
IV Reef	Campus Point SMCA	SMCA IN	North Mainland
Naples ref	Campus Pt /Naples	SMCA OUT	North Mainland
Naples Reef	Naples SMCA	SMCA IN	North Mainland
Lechuza	Point Dume SMCA	SMCA IN	North Mainland
Leo Carillo North	Point Dume SMCA	SMCA OUT	North Mainland
Paradise Point	Point Dume SMR	SMR IN	North Mainland
Big Rock	Point Dume SMR	SMR OUT	North Mainland
Refugio State Beach	MPA removed		North Mainland
Hawthorne Reef	Point Vicente SMCA	SMCA IN	South mainland
Christmas Tree Cove	Point Vicente SMCA	SMCA OUT	South mainland
120 Reef	Abalone cove SMCA	SMCA IN	South mainland
Abalone Cove	Abalone cove SMCA	SMCA IN	South mainland
White Point	Abalone cove SMCA	SMCA OUT	South mainland
Little Corona Del Mar	Crystal cove SMCA	SMR OUT	South mainland
Crystal Cove	Crystal cove SMCA	SMR OUT	South mainland
Seal Rock	Laguna Beach SMR	SMR IN	South mainland
Divers Cove	Laguna Beach SMR	SMR IN	South mainland
Shaws Cove	Laguna Beach SMR	SMR IN	South mainland
Heisler Park	Laguna Beach SMR	SMR IN	South mainland
Salt Creek	Dana Point SMCA	SMR OUT	South mainland
Swami's	Swami SMCA	SMCA IN	South mainland
Swami's out	Swami SMCA	SMCA OUT	South mainland
La Jolla Cove	Matlahuayl SMR	SMR IN	South mainland
La Jolla ref	Matlahuayl/La Jolla	SMR OUT	South mainland
La Jolla south	South La Jolla SMR	SMR IN	South mainland
North Hill Street	South La Jolla SMR	SMR OUT	South mainland
Broomtail Reef	South La Jolla SMR		South mainland
Malaga Cove			South mainland
Pier 400			South mainland
LA Breakwater			South mainland
Lion Head (doc cove)	Arrow Pt Lion SMCA	SMCA IN	East Islands
Lion Head	Arrow Pt Lion SMCA	SMCA OUT	East Islands
WIES Intake Pipes	Blue cavern SMCA	SMCA IN	East Islands
Bird Rock	Blue cavern SMCA	SMCA IN	East Islands
Ship Rock	Blue cavern SMCA	SMCA OUT	East Islands
Isthmus Reef	Blue cavern SMCA	SMCA OUT	East Islands
Long Point West	Long Point SMR	SMR IN	East Islands
Torqua	Long Point SMR	SMR OUT	East Islands
Casino Point	Casino point SMCA		East Islands
Petters Kelp Reef			East Islands

Table 1. RCCA study sites with the respective MPAs, site designation as either inside MPA or as reference site (Location) and Bioregion. Some sites do not have a designation. These are existing sites that are far from MPAs but will be sampled for continuity in the dataset and to provide data from outside of MPAs as reference data for the SCSR.

Freiwald/Hodgson Reef Check California
SCSR MPA baseline monitoring Milestone chart

TASKS AND MILESTONES	2011					2012												2013												2014					
Budget years	**year 1**																	**year 2**												**year 3**					
	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J
Hire SCSR Volunteer Coordinator (X) & period of employment (-)	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-												
Train SCSR Volunteer Coordinator	x	x																																	
Purchase supplies for training and survey season	x						x	x	x																										
Outreach & presentations by SCSR VC (recruit volunteers for trainings)								x	x	x																									
RCCA Community Trainings & recertifications								x	x	x																									
Assist with academic and institutional classes		x	x					x	x	x				x	x																				
Conduct RCCA SCSR surveys	x	x	x	x						x	x	x	x	x	x	x																			
Data entry and QA/QC			x	x	x										x	x	x																		
Develop report queries and distribute data						x	x	x										x	x	x															
coordinate with collaborators and through integrative framework		x	x															x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Data analysis & Final report																								x	x	x	x	x	x	x	x	x	x	x	x
Deliver data w/corresponding metadata and reports																																			x