Citizen-scientist Monitoring of Rocky Reefs and Kelp Forests:
Creating a Baseline for California's North 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. RCCA's current species list includes almost all species in the respective taxonomic groups identified in the Draft Monitoring Metrics for the NCSR. The three species not currently on the list, quillback, yelloweye rockfish and dungeness crab, will be added. We will build on and expand our existing monitoring system in Northern California to at least 8 annually surveyed reef sites in the NCSR region. Additionally we will attempt to survey two sites located near Shelter Cove inside and out of the Big Flat SMCA. We will try to survey these sites because initial discussion with the local community indicated that there is intense local interest in conducting surveys here. But we will only be able to survey these sites if we can secure boat support from the local fishing and/or charter boat operators at little cost. 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 or handled; therefore we do not need scientific collecting permits to perform this work.

Spatial sampling design

We think one of the strengths of the RCCA program is our application of a standardized sampling protocol across a network of sites spanning not only the study region, but also the entire state's coastline. 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 characterization project we propose to survey sites in five MPAs and associated references sites mostly in Mendocino County over the period from July 2014 to November 2015. These sites will include currently monitored RCCA sites as well as new sites so as to expand our statewide network (Table 1). MPA and associated references sites will be selected to represent similar habitat and oceanographic features (i.e. depth, reef substrate, relief, swell exposure and direction) and transects in associated MPA and references sites will be placed in similar depths. At sites currently or historically exposed to intense red abalone exploitation we will place invertebrate transects shallow enough to survey the areas most impacted by abalone take (i.e. 3-5 meters). The rational for choosing these MPAs is based on achieving a representative sample of MPAs while considering the restraints of surveying remote locations in a region such as the NCSR with large stretches of inaccessible coastline given the funding allocated to this project. When using citizen scientist divers, sites have to be accessible within a reasonable travel time so that participants can reach them given the nature of their voluntary involvement in our program. Given these constrains in the NCSR region we have chosen a representative set of MPAs with substantial amounts of rocky reef habitat and within reasonable proximity to population centers in the NCSR. Within MPAs and reference sites we will sample at least one survey site (i.e. 18 fish and six invertebrate, UPC and algae transect; see below). To increase sampling at the individual MPA level, we will coordinate site (cell in PISCO terminology) selection within MPAs and reference sites with other groups sampling the same ecosystem feature (see: Partnerships and integrative approaches). In MPAs where both programs are sampling data from respective sites (cells)

can be used to supplement data collection and serve as sampling replicates inside MPAs and reference sites. This collaboration will increase data collection but is not critical to the success of the proposed project. The integration of Reef Check's citizen scientist collected data with academic monitoring is entirely feasible and has successfully been implemented in other study regions (Gillett et al. 2012, OST and CDFW 2013).

We will focus some sampling effort on the Cabrillo Point SMR/Caspar Urchin Closure area. This area has been closed for commercial sea urchin harvest independently of the MLPA process. There is intense interest in the effects of this closure on the sea urchin populations and the ecological community on the reefs in the Fort Bragg commercial fishing community as well as in the wider community in the Fort Bragg/Caspar area (Bill Lemos, personal communication). In this area we will sample sites inside the SMR, inside the urchin closure and in an area where commercial harvest is ongoing to begin to address the questions raised by local residents in several meetings during the proposal preparation period.

In addition to the above-described approach of sampling inside and out of MPAs, we will try to add sites in order to add to the overall characterization of the rocky reef and kelp forest ecosystem feature along the north coast where many areas have never been surveyed. This is especially true in the northern bioregion where we will focus this effort. These additional sites will be added as conditions and volunteer availability allows. These sites not only contribute to the overall characterization of the study region but they also serve as an outreach and education strategy. In order to target community volunteers, we have to have sites that are desirable diving locations and within reach of most of our volunteers (e.g., Van Damme). 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.

All sites will be surveyed using RCCA's unique statewide sampling protocol (see below). This approach makes us the only research group that will sample across the entire state using a standardized sampling protocol and incorporate the study sites in the NCSR into a statewide monitoring network, maintained by a single organization. Therefore, RCCA's dataset covers all of the MLPA initiative's study regions and allows for statewide comparisons and quantitative analysis of MPA function and effectiveness in the future.

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 2014 and again within the same time frame in 2015. 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, Prindle et al. in press). 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 the implementation of long-term monitoring at the same sites monitored in the first two years. We will again reach out, educate and train divers to continue the monitoring beyond the initial baseline if additional funding can be secured (no funding is requested for this activity).

RCCA sampling method

At each selected site we will conduct surveys according to the RCCA protocol (Freiwald et al. 2013b). RCCA surveys consist of eighteen 30m transects to monitor key species of fishes (35 species),

invertebrates (32 species), and 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 cross-shore location within the kelp forest (i.e. offshore to onshore), samples are stratified across these gradients. This is achieved by distributing total of 18 fish and 6 invertebrate, algae and UPC transects in equal numbers of transects (n= 9 for fish, n=3 for invertebrates & algae) for sampling in two strata: an inshore (3 -12m) and an offshore (12-20m) area of the rocky reef (Figure 4).

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 contours in each strata. Along the core transects the fish, invertebrate and algae communities, as well as the physical habitat, are sampled. Response variables in this sampling design are density and size structure of the 35 fish species, density of key invertebrates (abalone are sizes to nearest cm), and algae species (Appendix 1). For giant kelp (*Macrocystis pyrifera*) the 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 to the nearest centimeter 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) of data 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 (Figure 4).

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 the removal of urchins (Freiwald et al. 2013b). This sampling is not associated 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 form 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 CDFW in a Memorandum of Understanding as a valuable tool for marine management and public engagement (http://reefcheck.org/PDFs/RC_DFG_MOU.pdf). 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 underwater surveys. Only divers who completed the required training and testing in each transect type and have demonstrated proficiency in data collection activities are allowed to contribute data for the transect types they are certified for. This tiered approach allows volunteers to collect data for certain taxa once they complete testing for those transect types and enables volunteers with differing abilities to participate in the

program without adversely affecting data quality. Strict quality assurance and control procedures ensure that the collected data 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 staff each year after initial certification. Further, divers discuss the data they collected with each other and RCCA staff after each dive, and datasheets are proofread 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 (e.g., species size ranges, regional distributions) are programmed into the database so that unusual data is flagged for examination by RCCA staff. Additionally, all data are reviewed by RCCA staff marine scientists 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 250 active divers statewide. Every year we have increased our diver retention and now have a body of experienced citizen scientists who have surveyed many of RCCA's sites 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 2014, we will conduct most of our trainings and recertifications in the NCSR between May and July. We expect to have 20 experienced and new divers ready to survey by July. To achieve this we will hold two trainings and one recertification for divers in the NCSR. These will be held in coordination with the HSU scientific diver program and as community trainings in the Fort Bragg area. In 2015, we will conduct two trainings for new volunteers and one recertification 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. 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

Ecosystem feature characterization

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 and algae species at sites inside and outside of MPAs within the network, can be used to generate a multivariate description of species assemblages at the time of MPA implementation. The same can be done for functional groups (e.g., detritivores, planktivores, primary producers) for description of the initial states of these community attributes 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). By 2016, when these analyses will be performed we will have completed similar analyses for the baseline monitoring in the NCCSR and SCSR. This will insure consistency and efficiency in the analytical treatment of the survey data and allow for the integration across study regions as well as with collaborators in the NCSR and other regions.

Ecosystem condition

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 (i.e. ecosystem condition). 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). We will use these analyses to identify key species, either from RCCA's species list or the draft long-term monitoring metrics that have the potential to be used as indicators for long-term MPA monitoring in the NCSR. The analytical frameworks for these analyses of ecosystem condition will be similar to those that will have been developed by baseline monitoring collaborations in the other MLPA regions by the time data collection in the NCSR will be completed. We will work closely with our collaborators in all study regions at UCSC, UCSB, Occidental College, SCCWRP and HSU to develop these analytical approaches and integrate datasets 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 initial design review team consisted of representatives from the California Department of Fish and Wildlife, 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. Currently the web-portal portion of the NED system is under revision to be updated according to newer web technology and to increase its usefulness for data dissemination to the public. The result will be 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 will include a Google Earth based interactive mapping and data retrieval portal, multiple quality checks and controls, detailed information on RCCA's indicator species, and a downloadable database. At the same time NED serves as 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 systems 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) 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). 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 formats.

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 fosters a sense of responsibility for participants, many of whom 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. Currently, we are working with Resource Media, a nonprofit organization focused on smart communications strategies for the environment, to develop a speakers' bureau consisting of Reef Check volunteers. This bureau will be in place at the beginning of the baseline monitoring in the NCSR and will facilitate RCCA's outreach and community involvement strategies in the region. 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 reports (e.g., (Freiwald et al. 2013a). 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 has sparked a growing movement 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 MPA baseline monitoring will inevitably generate in northern California. We already began this process by participating in the community meetings that were organized by the MPA Monitoring Enterprise in coordination with the RFP for the baseline monitoring in the NCSR. This has already led to several partnerships with community members and groups (see below). 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.

We are aiming to replicate our success with respect to outreach regarding the baseline monitoring in the other regions. 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 have done this successfully during the 5-year review of the central coast MPAs in collaboration with Resource Media and the MPA Monitoring Enterprise through several newspaper articles, blog posts and radio interviews. We will use our re-designed online Nearshore Ecological Database (NED) and Speakers Bureau for this effort.

Partnerships and integrative approaches

RCCA will collaborate and integrate our baseline monitoring and analytical approaches with several groups proposing to participate in the baseline monitoring project. For these partnerships we will take two different approaches depending on the nature of the proposed work of collaborators. We will collaborate with groups monitoring the same ecosystem feature (e.g., Mulligan/Tyburczy; Craig/Roggers-Bennett) as well as groups monitoring other ecosystem features (e.g., rocky intertidal, deep reef, sea birds and socioeconomics). All of these collaborations will enrich the analysis of our data and will leverage funding through collaborative field work but are not critical to the success of our monitoring proposal which will focus on leveraging the effort of community volunteers to carry out the baseline monitoring of the shallow reef and kelp forest ecosystems in the NCSR.

We will collaborate closely with Drs. Sean Craig and Laura Rogers-Bennett who are submitting a proposal titled: *Baseline Monitoring and Characterization of Nearshore Rocky Reefs/Kelp Forests of Marine Protected Areas in Northern California*. We will coordinate site selection towards two goals: 1) Supplementation of sampling; and 2) Integrative analysis of results. (1) Both groups will supplement each other's sampling efforts to increase sampling. This will lead to greatest spatial coverage and, at the same time, reduce duplication of efforts by leveraging existing resources (boats, training facilities) and utilizing volunteer citizen scientists for much of the sampling. (2) The second goal of this collaboration will be to demonstrate that datasets from both programs are compatible and integrate them to assess ecosystem condition (Gillett et al., 2011). This will provide us with the opportunity to compare different measures of community composition (i.e. different species lists) to evaluate their effectiveness in meeting the goals put forward in the Draft North Coast Monitoring Metrics. RCCA and the HSU subtidal team will also collaborate in the diver training. Over the past six years of RCCA monitoring in the north

coast region we have trained all of HSU's scientific divers in the RCCA survey methods and we will continue this in cooperation with the HSU scientific diving group. Because HSU's monitoring protocols are very similar to RCCA's (HSU will be using a modified PISCO protocol) it will generate substantial cost and time-savings to training all of HSU scientific divers in Reef Check protocols. RCCA's new north coast regional manager will coordinate the fieldwork and integration of efforts among the teams. This tight integration through shared divers will allow for a very flexible approach to this collaboration and cost sharing opportunities (e.g., shared boat time, travel, dive teams).

Project Deliverables

Data and associated metadata collected during this project will be delivered to DFW, OPC, Sea Grant and OST as part of the completion of the project. To make data available it will be uploaded to OceanSpaces.org with the appropriate metadata as Reef Check has done in other baseline monitoring regions. Further, Reef Check will provide two annual progress reports during the duration of the project and a final technical report at the completion of the project. The final report will include a characterization of the study region and report on the data collected at monitoring sites inside and out of MPAs in the NCSR. The finding will be summarized in an Executive Summary of the final report.

Figures

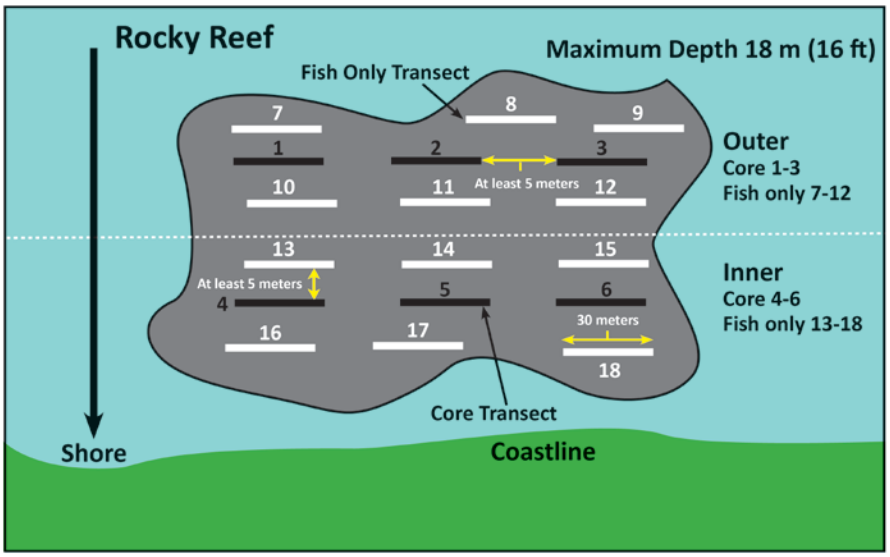

Figure 4. Diagram of RCCA's sampling scheme at a site. RCCA samples six core transects that include fish, invertebrate, algae and UPC transects, (black, 3 in each zone), plus an additional 12 fish only transects, (white, 6 in each zone). All transects are 30 meters in length and are placed haphazardly along depth contours.

Tables

Table 1 Revised RCCA monitoring sites

Site	MPA/Ref	Designation	County
*Big Flat**	*Big Flat SMCA*	*SMCA*	*Humboldt*
*Shelter Cove**	*Big Flat SMCA ref*	*SMCA ref*	*Humboldt*
Westport KOA	Ten Mile SMR ref	SMR ref	Mendocino
Pacific Star	Ten Mile SMR	SMR	Mendocino
Caspar	Pt Cabrillo SMR ref/ urchin closure ref	SMR ref/ urchin closure ref	Mendocino
Caspar urchin closure	Pt Cabrillo SMR ref	SMR ref /inside Urchin closure	Mendocino
Pt Cabrillo	Pt Cabrillo SMR	SMR	Mendocino
Russian Gulch	Russian Gulch SMCA	SCMA/ SMR ref	Mendocino
Mendocino Headlands		outside	Mendocino
Portuguese Beach		outside	Mendocino
Van Damme	Van Damme SMCA	outside SMCA	Mendocino

*Sites in Italics will be attempted to be surveyed but their successful completion depends on the availability of a local charter boat at low costs.