MPA PROJECT SUMMARY

Institution: Occidental College and University of California, Santa Barbara

Title: South coast kelp and shallow rock ecosystems: baseline data collection and long-term trends using historical data.

Initiation Date: 1 July 2011
Completion Date: 30 June 2014

Co-Principal Investigator: Pondella, Daniel J.
Affiliation: Vantuna Research Group, Occidental College

Principal Investigator: Caselle, Jennifer
Affiliation: Marine Science Institute, University of California, Santa Barbara

Project Goals & Objectives:

The *overall goal* of the proposed study is to describe the ecological conditions of kelp and shallow rock ecosystems inside and outside of MPAs in the South Coast Study Region (SCSR) and to utilize these baseline surveys together with historical data to measure changes in conditions over both short and long time scales. The *specific objectives* of the proposed surveys and analyses are to: (1) produce a quantitative baseline characterization of the structure of kelp and shallow rock ecosystems in all MPAs in the SCSR, (2) provide quantitative comparisons inside and outside of MPAs, (3) develop easily interpretable ecosystem indicators for assessing the health and status of this ecosystem, (4) inform future monitoring methods while optimizing integration of existing long-term data sets with future monitoring data, and (5) integrate data from the proposed baseline survey with existing long-term data to describe the current trajectory of ecosystem trends.

Methodology:

Our approach to creating a baseline characterization of kelp and shallow (0 - 30m depth) ecosystems in the SCSR involves (1) new surveys of targeted elements of kelp forest and rocky reef ecosystems using SCUBA and (2) analysis of existing historical datasets on rocky reef communities. Our proposed sampling design and protocols are an extension of those being used in the Central and North Central Coast Study Regions, and in the Northern Channel Islands (NCI) MPAs. All accessible SCSR MPAs and military closures that include kelp and shallow rock habitat, and nearby non-reserve reference sites, will be sampled once per year in 2011 and 2012. Data are collected visually by teams of SCUBA divers who sample fishes, invertebrates and macroalgae following a *stratified random permanent* sampling design, stratified across depth zones. From these data we will calculate a variety of population (e.g., density, percent cover, size frequency distribution, biomass) and community-level (e.g., species composition, trophic guild biomass). Univariate and multivariate statistical analyses will then be conducted to compare metrics at varying spatial scales and regulatory designations across the SCSR.

The PIs of this study have developed and led multiple large scale kelp and rocky reef monitoring programs across the SCSR over the past 2 decades, including the long-term monitoring of the NCI MPAs. The synthesis of these programs provides an unrivaled volume of historical data, including surveys spanning the SCSR in 2004 and 2008, and time-series sites going back to as far as 1974. Combined with the new baseline surveys, these historical data will be used to describe the current trajectory of the various population and community metrics. Additionally, ecological indicators, which are becoming mainstream tools for assessing impacts of human disturbance and general environmental ‘quality’ or ‘health,’ will be developed in collaboration with the Southern California Coastal Water Research Project (SCCWRP).

Outcomes & Deliverables:

Our surveys inside and outside of the SCSR MPAs will provide a baseline characterization of the fish, invertebrates and macroalgae in the kelp and shallow rock ecosystem, addressing all of the Vital Signs and Key Attributes as designated for the SCSR with the exception of sea otters and predatory birds. Using new and historical data, we will provide a quantitative assessment of the current trajectory of ecosystem trends, indicators and individual species metrics at the time of implementation of the SCSR MPA network. Data products will include smaller scale ‘reef by reef’ and regional assessments. We will also work with SCCWRP to develop a rocky reef ecosystem indicator which can both inform user groups and allow informed management decisions. Syntheses across multiple ecosystem monitoring projects will also be developed as described in Blanchette and Caselle’s integrated proposal: “Integrative Assessment of baseline ecological and socioeconomic conditions and initial changes within the South Coast MPA region”.

Another critical output of this project will be informed recommendations on long-term monitoring of nearshore rocky reef and kelp habitats in the SCSR. There is a critical need to create a sustainable MLPA monitoring program that is efficient and cost-effective while scientifically robust. This proposal has been developed in collaboration with a separate proposal from Reef Check CA, a citizen science program dedicated to involving citizen divers in reef monitoring. As the state of California increasingly moves towards the use of data from citizen science groups for management purposes, comparison of results from both projects will facilitate better understanding and calibration of specific elements to optimize utility and cost of MPA monitoring using both methods.

Annual progress reports will be written and submitted at the conclusion of the first two 12-month periods following the start of this project. These reports will briefly describe progress towards project goals, timelines for work completed/remaining and updated financial information. In March of 2014 a final report will be delivered that will include: (1) a narrative accounting of our progress towards Baseline Program purposes and our project goals, (2) a financial report, (3) a technical report describing our methods, a baseline characterization, current status of ecological trends incorporating new and historical data and recommendations for future long-monitoring, and (4) an executive summary written to be appropriate for broad public release. Data and associated metadata will also be delivered as part of the completion of the project and will likely draw from previous database structures developed for the Central and North Central Study Region baseline surveys.

Justification:

Over the past decade, global and regional efforts to employ MPAs as tools for both marine conservation and fisheries management have escalated rapidly, however the effectiveness of *networks* of MPAs, such as those developed through California’s Marine Life Protection Act, in meeting the broad diversity of conservation objectives is yet to be determined. Kelp and shallow rock ecosystems are iconic features along the coast of California. They are among the most productive ecosystems in the world, with services that span commercial and recreational consumptive uses and a diverse array of non-consumptive services. They provide food, shelter, and habitat for a rich diversity of ecologically and economically important species, many of which support valuable commercial and recreational fisheries that target a diversity of fishes (e.g., sheephead, kelp bass, and rockfish) and invertebrates (e.g., sea urchins, spiny lobster). Over the last few decades there has been a general trend of declines in kelp forest biomass throughout southern California. While there remains a heated debate concerning the causes of that decline, both fishing effects and water quality are important drivers of ecosystem health that vary across the SCSR. Monitoring MPAs, which controls the effects of fishing while not affecting water quality *per se*, should allow more insight into the debate. For this reason, monitoring and assessment of kelp and nearshore rocky reefs throughout the entire SCSR (i.e. mainland sites adjacent to large human populations and island locations far from sources of pollution) is of particular importance.

South coast kelp and shallow rock ecosystems: baseline data collection and long-term trends using historical data

Project Leader(s) and Associated Staff

Dr. Dan Pondella (Co-PI): together with Caselle, Pondella will oversee all aspects of the kelp forest ecosystem baseline characterization as well as the development of an integrated data base, long-term monitoring recommendations, ecosystem indicators, synergies with other projects affiliated with this proposal, and report writing.

Dr. Jennifer Caselle (Co-PI): together with Pondella, Caselle will oversee all aspects of the kelp forest ecosystem baseline characterization as well as the development of an integrated data base, long-term monitoring recommendations, ecosystem indicators, synergies with other projects affiliated with this proposal, and report writing.

Dr. Jeremy Claisse (Postdoc) will support Dr. Pondella in all aspects of the project, with particular focus on design, analyses and report writing.

Project Goals and Objectives

The *overall goal* of the proposed study is to describe the ecological conditions of kelp and shallow rock ecosystems inside and outside of Marine Protected Areas (MPAs) in the South Coast Study Region (SCSR) of the Marine Life Protection Act (MLPA) and to utilize these baseline surveys together with historical data to measure changes in conditions over both short and long time scales.

The *specific objectives* of the proposed surveys and analyses are to:
(1) produce a quantitative baseline characterization of the structure of kelp and shallow rock ecosystems in all MPAs in the SCSR through SCUBA surveys utilizing techniques similar to those used in other MLPA regions,
(2) provide quantitative comparisons between kelp and shallow rock ecosystems inside the MPAs and associated reference areas outside MPAs,
(3) analytically explore these baseline characterizations and historical data including water quality metrics to develop easily interpretable ecosystem indicators for assessing the health and status of kelp and shallow rock habitats in southern California,
(4) inform future monitoring methods while optimizing integration of existing long-term data sets with future monitoring data,
(5) integrate data from the proposed baseline survey with existing long-term data to describe current trajectory of ecosystem trends.

Rationale

Over the past decade, global and regional efforts to employ MPAs as tools for both marine conservation and fisheries management have escalated rapidly (Coleman et al. 2000; NRC 2001; Pomeroy et al. 2004; Sobel and Dalgren 2004). Although some global and regional syntheses of the effects of establishing MPAs have been conducted (Halpern 2003; Lester and Halpern 2008), most of the studies in those meta-analyses evaluated the effectiveness of a single or few, small MPAs. Though these studies demonstrate population and community-wide responses to the establishment of MPAs worldwide, the effectiveness of *networks* of MPAs, such as those developed through California's Marine Life Protection Act, in meeting the broad diversity of conservation objectives is yet to be determined.

Kelp and shallow rock ecosystems are iconic features along the coast of California with services that span commercial and recreational consumptive uses and a diverse array of non-consumptive services (e.g., tourism, diminishing coastal erosion). Kelp forests are among the most productive ecosystems in the world. Kelp beds and rocky reefs provide food, shelter, and habitat for a rich diversity of ecologically and economically important species, while drift kelp and dissolved organic matter from kelp provide an energetic resource to populations of species both within and around kelp beds (Duggins et al. 1989; Tegner and Dayton 2000; Graham et al. 2007). In southern California, kelp beds and rocky reefs support valuable commercial and recreational fisheries that target a diversity of fishes (e.g., sheephead, kelp bass, and rockfish) and invertebrates (e.g., sea urchins, spiny lobster). The red sea urchin fishery, for example, is one of the highest value fisheries in California, with about two-thirds of all landings caught within the Northern Channel Islands CINMS (CDFG 2006).

Over the last few decades there has been a general trend of declines in kelp forest biomass throughout southern California. To this day, there remains a heated debate concerning the causes of that decline and whether kelp forest loss is a result of overharvesting of predators on kelp grazers (e.g. CA sheephead, spiny lobster) or anthropogenic changes in water quality from historic sewage discharge into nearshore environments (Foster and Schiel 2010). There is also a significant stress on these nearshore systems due to sedimentation, associated turbidity, scour and reef burial (Pondella 2009; Pondella 2010). Fishing effects and water quality are important drivers of kelp forest ecosystem health and the relative importance will vary across the study region, which includes island locations far from sources of pollution and mainland sites adjacent to large human populations. Monitoring MPAs, which controls the effects of fishing while not affecting water quality *per se*, should allow more insight into the debate. For this reason, monitoring and assessment of kelp and nearshore rocky reefs throughout the entire SCSR (i.e. mainland and island sites) is of particular importance. To this end we have put together a scientific team that includes leading experts on water quality and nearshore reef ecology in the region.

Ecological indicators are becoming mainstream tools for assessing impacts of human disturbance and general environmental 'quality' (Donnelly et al. 2007). Indicators are useful when they condense composite biological information into single measures, which might be more understandable for the general public and for non-scientific users, such as decision makers involved in environmental management. As indicators are used for different purposes in ecology and conservation, many argue that their selection depends on the issue at stake (Failing 2003; Heink and Kowarik 2010), however, any good 'indicator' must ultimately be related to the phenomena of interest that the indicator reflects (Heink and Kowarik 2010). While specific indicators will depend on the management or ecological objective (Leonard et al. 2006) they should be:

(1) easy to measure (e.g. cost-effective, not too time consuming, readily observed),
(2) suitable for statistical analyses or 'robust' (e.g. low random variation among samples),
(3) sensitive to anthropogenic perturbations in a predictable way,
(4) applicable to a variety of temporal and spatial scales as well as habitats.

While some progress has been made in assessing the utility of indicators of ecosystem health for soft bottom and rocky intertidal habitats in Southern California, equivalent work has not been completed for important and biologically diverse kelp forest and subtidal rocky reef habitats.

The SCSR is one of the better-studied regions in California's MLPA process. Large spatial scale, time series and MPA assessments have been completed primarily by the VRG and PISCO. These studies include the current biogeographic surveys of reef fishes (Pondella

2000; Clark 2005; Pondella et al. 2005; Hamilton 2010), site surveys of MPAs and reference reefs (Craig and Pondella 2006; Froeschke 2006; Caselle 2011) and the longest time series studies in the bight (Stephens et al. 1994; Pondella et al. 2002; Pondella and Allen 2008). More recently, survey programs involving 'citizen scientists' have been implemented. A recent study of community structure and population abundance on rocky reefs compared results from our 'professional scientific' program with a 'citizen science' program, Reef Check California (RCCA). It examined the elements that overlapped between the two programs setting the stage for further collaboration (Gillett in review). In addition, no evaluation of the utility of the citizen science approach to assessing changes over time in MPAs has been undertaken. As the state of California increasingly moves towards the use of data from citizen science groups for management purposes, comparisons must be further developed to facilitate better understanding and calibration of specific elements to optimize utility and cost of MPA monitoring using both methods.

Partnerships

This proposal represents partnerships at several levels. First, the proposed work is a seamless integration between the two Co-PIs, Caselle and Pondella. Caselle has been the lead scientist on MPA monitoring for the Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO) since 1999, while Pondella is the Director of the Vantuna Research Group (VRG) since 1996 and an Associate Professor of Biology. Both PI's collaborated closely on the development and implementation of the Cooperative Assessment of Nearshore Ecosystems (CRANE '04) and the BIGHT '08 rocky reef monitoring programs. PISCO is a long-term ecosystem research and monitoring program established with the goals of understanding dynamics of the coastal ocean ecosystem along the U.S. west coast and sharing that knowledge so ocean managers and policy makers can make science based decisions regarding coastal and marine stewardship. In the SCSR, PISCO scientists work closely with the National Park Service Kelp Forest and Intertidal Monitoring programs, as well as MARINe (Multi Agency Rocky Intertidal Network). Dr. Caselle, in partnership with CDFG, NPS and CINMS was a lead scientist on the 5-year evaluation of the Channel Islands MPA network in 2008. The VRG has been studying nearshore SCSR rocky reefs since the mid-1960s. Dr. Pondella led the Bight '08 Rocky Reef Program and developed and oversees the Santa Monica Bay Restoration Commission's (SMBRC) Rocky Reef Monitoring Program that includes the rocky reefs from Malibu (Los Angeles/Ventura County Line) to Pt. Fermin, Palos Verdes. This collaborative effort features the ongoing collaboration of the SMBRC's marine research, Los Angeles County Sanitation District's (LACSD) research arm, and Santa Monica Baykeeper Kelp Restoration Program. Currently these four research programs are working collaboratively on kelp bed restoration projects and reef monitoring along the Malibu and Palos Verdes coastlines. Ongoing projects include kelp bed restoration and evaluation through the removal of urchin barrens; studies of rocky reef restoration to mitigate nearshore impacts due to elevated sedimentation; and abalone restoration. Much of this research is currently being funded by NOAA's Montrose Settlements Restoration Program (MSRP) on the Palos Verdes Shelf. The integration among these programs led to the successful inclusion of rocky reef studies in the Southern California Coastal Water Research Project's (SCCWRP) Bight Programs led by Ken Schiff which greatly enhances the resources needed to address water quality issues on small and large scales throughout the Southern California Bight. Featured in this extended partnership is the coordination and the biological evaluation of subtidal reefs in Areas of Special Biological Significance (ASBSs) through SCCWRPs Bight Program. SCCWRP will use its expertise to closely collaborate with the development of rocky reef and ecosystem health metrics, spearhead the integration of contextual water quality data with rocky reef metrics, and assist in improving GIS layers. Rocky reef research and monitoring will continue as a part of the ongoing Bight Programs and we propose to integrate this monitoring program with the Bight Program allowing maximum leverage of resources for both the short-term (i.e. the duration of this grant) and long-term.

The benefits of this partnership are:

- A long history of close collaboration among the PIs and partners
- The ability to efficiently collect baseline information at the scale of the entire Southern California Bight
- Joint training of divers to ensure identical protocols
- Joint data management and analysis
- Joint access to historical datasets from PISCO, VRG, SMBRC, LACSD and SCCWRP.
- Unparalleled reef and water quality expertise
- Extraordinary opportunity for cost leveraging
- No startup costs or lag time as these programs are ongoing

Our proposed work is also in close partnership with Reef Check CA (RCCA), a citizen science program dedicated to involving citizen divers in reef monitoring. RCCA is relatively new organization and as such, developed survey protocols in close collaboration with PISCO and VRG. RCCA protocols, while less taxonomically diverse than ours, were specifically designed and modeled after our survey methodology allowing these techniques to 'nest' in our methods (Gillett 2010; Gillett in review). Both PIs have worked closely with RCCA in the past and are designing a survey plan (e.g., site locations, survey timing) for the SCSR MPA baseline together. The benefits of this collaboration are:

- Reef Check can fill in spatial 'gaps' in our survey plan
- Calibration analyses have been completed

This proposal is part of a larger collaborative network of proposals including all ecosystem indicators and an integrated proposal (Caselle and Blanchette "Integrative Assessment of baseline ecological and socioeconomic conditions and initial changes within the South Coast MLPA region") to ensure synthetic analyses among all groups. It will also provide an excellent opportunity to overlay these data products with vessel use patterns discerned in the Ford proposal "Aerial Surveys of the Southern California Coast to Describe Vessel Distribution, Type and Activity". Of the ecosystem features monitored in our group, we will begin syntheses with two in particular, rocky intertidal and deep rock. From the start of the project, we will co-locate sites to the extent possible, allowing a unique look at the structure of rock reef communities from the intertidal, through the nearshore subtidal and into the deep rock areas. We have also worked closely with Todd Anderson, and his proposal "South Coast MPA Baseline Program: Characterization of the Kelp and Shallow Rock Ecosystem in San Diego and Orange Counties" is rooted in our long-term collaborations beginning with CRANE and extending into Bight '08.

Approach to be Used (Plan of Work)

Overview

Our approach to creating a baseline characterization of kelp and shallow (0 - 30m depth) ecosystems in the MLPA South Coast Study Region (SCSR) involves (1) new surveys of targeted elements of kelp forest and rocky reef ecosystems using SCUBA and (2) analysis of existing historical datasets on rocky reef communities.

Sampling will address all kelp and shallow rock ecosystem Vital Signs (Ecosystem Feature Checkup) and Key Attributes (Ecosystem Feature Assessment) as designated by the

Monitoring Enterprise (ME) in the Monitoring Plan for the South Coast MPA Baseline Program with the exception sea otters and predatory birds (See Appendix 1). Our proposed sampling design and protocols are a geographic extension of comparable design and protocols that are being used to generate baseline characterizations of kelp and shallow rock ecosystems in the Central Coast Study Region (CCSR) and the North Central Coast Study Region (NCCSR). Further, the study design and protocols were also employed in the network of MPAs in the Northern Channel Islands (NCI), which were implemented in 2003 and now form part of the SCSR. Results from these methods were incorporated into the successful five-year data review of the NCI MPAs (Airamé and Ugoretz 2008; Hamilton et al. 2010). We propose to maintain similarities in the design and protocols to maintain standardization across the Study Regions until necessary changes in design or sampling protocols are identified.

Spatial and temporal sampling design

Central to our overall sampling design is the underlying analytical model that defines all aspects of both the spatial and temporal components of the sampling approach. The sampling design involves a tradeoff in sample allocation between temporal and spatial samples. We believe, especially for a baseline characterization, that spatial coverage is far more informative in describing the distribution of key attributes of the ecosystem. Each location will be sampled once in each year (2011 and 2012) and individual MPAs and their associated reference sites will be sampled as closely as possible in time in order to avoid confounding these direct comparisons with temporal effects.

Large scale spatial sampling design - Our spatial sampling design is characterized as a *stratified random permanent* sampling design, in which randomly located transects are sampled within fixed sites permanently located inside and outside of MPAs and military closures. These random transects are stratified within each site across fixed depth zones. We propose to sample all accessible SCSR MPAs that include kelp and shallow rock habitat and nearby non-reserve reference sites (Figure A, Table A). Some MPAs, such as Richardson's Rock, are generally not accessible due to typically inclement conditions. Unlike the other MLPA regions (particularly the North Central Study Region) we have preexisting sampling sites in most MPAs and reference areas. Thus, in selecting locations for this baseline among a broad range of potential survey sites, we will balance the need to choose sites with a large amount of historical data with (1) choosing MPA and reference sites that are as comparable as possible in community structure, reef geomorphology (e.g., substratum type, relief, reef slope) and oceanic conditions, and (2) locating reference areas as close as possible to nearby MPAs, but outside of a 0.5 km buffer zone to prevent the potential effects of regulatory treatments within the MPA from influencing density estimates at a nearby reference site (i.e., "spillover effects"). Site selection criteria are explained in a later section. We have used our best professional judgment to propose a sampling design representing all MPAs and reference reefs as shown in Figure A.

Within-site spatial sampling design – Within each site, all sampling of fishes, invertebrates and macroalgae is conducted along 30 m transects. Because the distribution and abundance of fish, invertebrate and algae species are known to vary with depth and the cross-shore location within the 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 benthic transects (n= 12; each benthic transect is accompanied by a midwater and canopy transect) for fish sampling and (n= 6) for benthic invertebrates, algae, seagrasses and reef characteristics (relief, substrate, cover) at each for rocky reefs that span these depth ranges (Figure B). For rocky reefs that do not span these depths, the cross-shore distance is divided into four equal strata and transects are distributed equally among the strata. In addition, beginning with the Bight '08 Rocky Reef Program, we have added a deep strata (20-30 m) for reefs that extend into this zone. This depth strata is particularly important at a subset of reefs (e.g. Palos Verdes, East End of San Clemente Island, Begg Rock etc.) and allows us to increase our knowledge of key vital signs. For instance, there is a much greater diversity and abundance of rockfishes below 20 m.   In the deep depth zone, 4 fish transects and 2 benthic transects are completed.

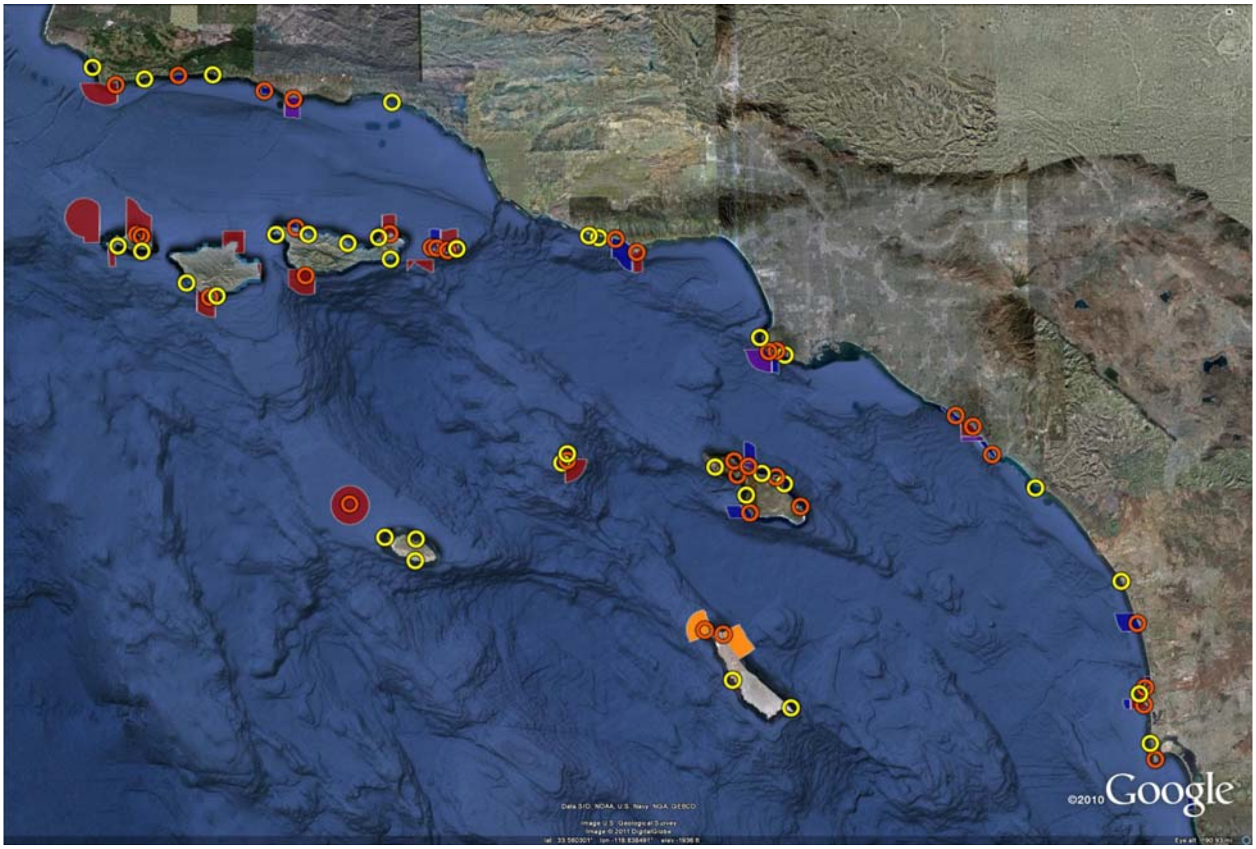


Figure A. Proposed kelp and shallow rock sampling sites in the South Coast Study Region. MPAs and military closures are shown as solid polygons. Orange circles are inside closed areas and yellow circles are reference sites.

Table A. Proposed kelp and shallow rock sampling sites in the South Coast Study Region. MPA sites are highlighted in orange.

Site	Latitude	Longitude	Site	Latitude	Longitude
1 Jalama	34.48916667	-120.4957	35 Arch Point	33.48753333	-119.0275833
2 Cojo	34.44321667	-120.4223333	36 County Line	34.04301667	-118.9522167
3 Tyler Bight	34.0273	-120.41175	37 Leo Carrillo	34.03761667	-118.9219833
4 Cuyler	34.05705	-120.3526	38 El Matador	34.03328333	-118.8701667
5 Harris Point Reserve	34.05255	-120.33865	39 Point Dume	33.99853333	-118.8056333
6 Crook Point	34.01385	-120.3373333	40 Target Rock	33.03119139	-118.6155973
7 Bullito	34.45816667	-120.3315667	41 Iron Bound	33.44798429	-118.5760709
8 Kashtayit	34.46664451	-120.2249149	42 Reflector Reef	33.01953289	-118.5601407
9 Cluster Point	33.93166667	-120.1974167	43 Eel Point	32.90154427	-118.5339763
10 South Point	33.89441667	-120.1252	44 Indian Rock	33.4625894	-118.517552
11 Arroyo Quemado	34.4675	-120.1171667	45 Cat Harbor	33.42616418	-118.5088772
12 Johnsons Lee South	33.89756667	-120.1032167	46 Sentinel Rock	33.37489168	-118.4822902
13 Naples	34.42463333	-119.9553167	47 Blue Cavern	33.44854322	-118.4740738
14 Forney	34.05455	-119.91925	48 China Point	33.32928397	-118.472218
15 IV Reef	34.40295	-119.8645167	49 Rippers	33.42942558	-118.4334083
16 Painted Cave	34.0719	-119.85755	50 Rocky Point	33.77527383	-118.4315767
17 Gull Island	33.94816667	-119.82795	51 Pt Vicente	33.73912152	-118.4051467
18 Hazards	34.05438333	-119.81935	52 Long Point	33.41973761	-118.3900787
19 Pelican	34.03065	-119.69665	53 Abalone Cove	33.7401875	-118.3819897
20 Begg Rock	33.36444121	-119.6957942	54 Hen Rock	33.40191789	-118.3654323
21 Coche	34.04493333	-119.6014	55 Lil Flower	32.82731375	-118.3574865
22 West End	33.27841978	-119.5886158	56 Bunker Point	33.72940773	-118.3557429
23 Cavern Point	34.05428333	-119.5668667	57 Lovers Cove	33.34292185	-118.3169398
24 Yellowbanks	33.9893	-119.5649333	58 Crystal Cove	33.56503561	-117.834789
25 Horseshoe Reef	34.39173333	-119.5577	59 Laguna Beach	33.53595238	-117.7827477
26 Dutch Harbor	33.21828613	-119.4964181	60 Dana Point	33.46429484	-117.7253685
27 Alpha Foul	33.27356814	-119.4933996	61 San Mateo Kelp	33.37567753	-117.59422
28 West Isle West	34.01755	-119.4379167	62 Carlsbad	33.1293834	-117.336828
29 West Isle East	34.01625	-119.42175	63 Swami's	33.0195326	-117.290465
30 Middle Isle	34.00988333	-119.3883333	64 La Jolla	32.83779058	-117.2888241
31 East Isle	34.01703333	-119.3611333	65 South La Jolla	32.80889296	-117.2759268
32 Lighthouse Reef	34.01371667	-119.36	66 Matlahuayl	32.85306625	-117.2712433
33 Cat Canyon	33.46441667	-119.0440833	67 Point Loma	32.70870844	-117.2591993
34 Southeast Sealion	33.47061667	-119.0281167	68 Cabrillo National Monument	32.66697726	-117.2446158

Figure B. Locations of inner, middle, outer and deep depth strata are shown with respect to a typical mainland kelp bed shown as dark brown in the satellite image. Within each depth strata 4 fish transects, and 2 transects for benthic invertebrates, algae, seagrasses and reef characteristics (relief, substrate, cover) are completed.

Temporal sampling design – Kelp and rocky reef ecosystems will be surveyed once per year for two consecutive years (2011 and 2012). Within each sampling site, the stratified randomly located transect samples produce an estimate of the mean of the response variable (e.g., density of species X) at each sampling event and, over time, allows an estimate of the temporal trajectory of the mean of that response variable within each of the sites inside and outside of an MPA. Having initially selected each of the sites randomly (in most cases, many years ago), we envision that each site would be repeatedly sampled over time (i.e. as part of subsequent monitoring programs). The mean trajectories of response variables estimated from the sites are assumed to be representative of all potential sites in the MPA because they were initially randomly selected. Two types of analyses can be used to statistically assess changes through time inside and outside of MPAs: (1) the trajectories of species abundance or size can be compared directly between reserve and reference pairs or (2) the magnitude of difference in response variables between the reserve and reference pair can measured over time. These analytical models are more clearly explained in the *Analyses* section below. The power of this random, permanent sampling design is that it minimizes spatial variability as a source of variation in samples over time, yet generates independent estimates of the state of the response variables at each cell in each consecutive time interval (deGruijter and terBraak 1990; Van der Meer 1997).

Sampling protocols

Data collection - All of the data used to estimate biological variables are collected visually by teams of SCUBA divers that access sample sites from research vessels. In general, fish surveys are conducted separately from benthic invertebrate and macroalgae surveys because of differences in the time required for sampling and to minimize SCUBA effects on fish observations such as the attraction of various species (Stephens 2006). Fish survey teams consist of two or four divers (2 buddy pair) depending upon reef topography (i.e. reefs with less slope necessitate two teams due to limitations of bottom time and distance between sampling strata). Benthic survey teams consist of two teams of two divers (swath, UPC; see Section "Response variables"). The coordination of multiple dive teams will enable the entirety of the SCSR region to be sampled within a similar timeframe (i.e. summer-fall). Surveys are restricted to days that have not experienced recent (within 1-2 days) large swell events and with underwater horizontal visibility of no less than 3 m.

Training - Our proposed subtidal surveys are designed to rigorously sample rocky reef communities. Consequently divers must be well trained in species identification and survey techniques. We will ensure that all divers are competent in the survey techniques by providing intensive training and evaluation prior to the survey period. While many of our staff have been conducting these surveys for the past several years, all divers are trained in one to two weeks in an intensive classroom and field training course. Details on the scope of the training program are available at: http://www.piscoweb.org/research/community/subtidal/protocols

Ecosystem elements (response variables)

Elements of kelp forest ecosystems that will be targeted for sampling include (1) those species identified by the Monitoring Enterprise (ME) as potential kelp and shallow rock ecosystem focal species/indicators (Appendix I), (2) species that were identified as "likely to benefit" in the SCSR MPA design process (these are primarily fished species), (3) any additional species and environmental variables that have been identified in the literature as indicators of ecosystem structure (e.g., collective abundances of grazers, planktivores, detritivores, primary and secondary carnivores) and functional processes (e.g., algal abundance as a reflection of primary production, drift kelp cover that fuels a key detritivore trophic pathway) and (4) any other species that have been part of our previous historical monitoring in the South coast region.

Relative and absolute species abundance - Many of the overarching questions and recommended variables identified in the Baseline Monitoring Plan for the SCSR require estimates of relative and absolute species abundance. Most often, relative abundance is measured as relative differences in species density (number of individuals per unit reef area). Density estimates can often be translated into relative and absolute abundance estimates if the area of the habitat (e.g., shallow rocky reef or kelp forest) is known (i.e. abundance = density * area). Absolute abundance can be useful for estimates of larval production attributed to populations within MPAs and for stock size estimates.

Population density – Diver surveys estimate the density (individuals per unit area) and size distribution of all conspicuous species of fishes. All fishes are identified to species. Fish counts in 2 m wide X 2 m tall X 30 m long transects along the bottom and mid-water are combined to generate density estimates per 240m^3 volumes or represented per 60 m^2 of reef area. Counts of large benthic invertebrates and kelps generate density estimates per 60 m^2 of reef area.

Population cover – Proportional cover of species for which individuals are not readily distinguishable (e.g., colonial invertebrate species, small macroalgae) is estimated by point contact estimates distributed at 1 m intervals along the length of each 30 m-long transect (30 points per 30 m transect). Taxonomic resolution (i.e. species, genus, family, and higher) at which data are collected varies among taxa (Appendix I). For example, the red algae are difficult to identify and are therefore categorized into six morphological categories: encrusting red, turf and four categories of foliose species (bushy, branching, leafy, lacy). These morphologies are likely to provide habitat for different invertebrate assemblages. Thus, diversity of these algal categories could potentially be used as a proxy for invertebrate diversity among sites.

Fish size frequency distributions - Divers are trained to estimate fish total lengths (TL) of all species recorded to the nearest 1 cm for fish lengths ranging from 1 to 15 cm and to the nearest 5 cm interval for fishes greater than 15 cm. These length estimates are compiled to generate length frequency distributions. Because length-weight and length-fecundity relationships exist for many of the reef fishes monitored in our protocols, we can translate size frequency distributions into local estimates of biomass and potential larval production. Size frequency distributions can be compared with both univariate F tests and with multivariate analyses (in which each size class defines a variate) and are among the first metrics to show change in protected areas.

Invertebrate size frequency distributions - One diver in each group of benthic samplers will be allocated to collecting size frequency estimates of targeted invertebrate species. The species targeted for size frequency estimates include all abalone species, red and purple sea urchins, California Spiny Lobster. In addition to these species, for which we have previously collected size frequency information, there are three other invertebrates that will be included as part of this baseline monitoring plan. These include Kellet's Whelk (*Kelletia kelletii*), the Wavy Turban Snail (*Megastraea undosa*), and several species of rock crab in the genus *Cancer*. Kellet's whelk is the subject of a very rapidly expanding fishery in which takes place almost completely in the SCSR (CDFG 2010). Landings data from 1993 to 2006 increased almost 40 fold from 4590 pounds in 1993 to 191,177 pounds in 2006. The Wavy Turban Snail is harvested in Baja California and parts of Southern California and this now small commercial fishery has the potential for rapid growth (CDFG 2001). Virtually no size structure information exists currently. Invertebrate size frequency sampling will be closely coordinated with and complemented by additional sampling of these species by RCCA. In addition, we will provide density and distribution information for Giant Keyhole Limpet (*Megathura crenulata*), which is an emerging fishery due to the potential biomedical applications.

Physical environmental variables - Key environmental factors known to influence the distribution and abundance of fishes, invertebrates and macroalgae include geomorphological features of the rocky reef habitat and qualities of the seawater overlying the rocky reefs. Divers record percent cover of substratum type (sand, cobble, bedrock, boulder) and vertical relief in 4 categories (0 – 10 cm, 11 cm – 1m, 1 – 2 m, and > 2) along each benthic transect using the same uniform point contact method used to estimate cover of invertebrates and algae. These data allow quantitative comparison of habitats in MPAs to reference areas as well as examination of species-habitat relationships. Larger scale features (e.g., rock type, reef slope, exposure to oceanic swells, strength of upwelling) are gleaned from geologic and bathymetric charts and models we have used based on regional swell buoys and CDIP models.

Justification for new surveys in the Northern Channel Islands - We propose here to sample throughout the Southern CA bight including the Northern Channel Islands (NCI) (Santa Barbara, Anacapa, Santa Cruz, Santa Rosa and San Miguel). While we acknowledge the large amount of previous sampling at the NCI (primarily by PISCO and NPS), we feel that to create a true 'baseline' snapshot in *highly annually variable* ecosystems such as temperate reefs, sampling must occur contemporaneously with the rest of the 'baseline'. Including the NCI in this monitoring plan is both cost-effective and scientifically valid. First, new sampling in the NCI will be highly leveraged as PISCO will contribute the majority of sampling in 2011 as match. As well, sampling the NCI is highly efficient due to our knowledge of the conditions and the sites. Second, sampling through 2012 will provide a continuous time series for the mandatory 10-year evaluation of the NCI MPAs (implemented in 2003, reviewed in 2008 and likely again in 2013). This will be the first region to undergo a 10-year evaluation and the results of that evaluation are likely to influence decisions on the future of the remaining MLPA reserve networks as well as inform future monitoring plans in the SCSR. Lastly, the south coast MLPA process, more than any other region of the MLPA, designed a *network* of MPAs, using circulation models and guidelines regarding both size and spacing of individual closed areas. The NCI and the southern islands are critically important to Bight-wide connectivity patterns (Watson et al. 2010). For example, ocean circulation modeling with particle tracking shows that sites throughout the NCI are strong destinations for larvae from the mainland (Figure C). This means that the effects of increased production generated by organisms in mainland coast MPAs are likely to be seen on reefs at the Channel Islands. California leads the world in moving from single MPAs to systematically designed networks of protected areas for both conservation and fisheries benefits. While the proposed baseline surveys, alone, will not allow a 'test' of network connectivity, only with continued monitoring and a <u>complete</u> baseline, will that goal will be achievable.

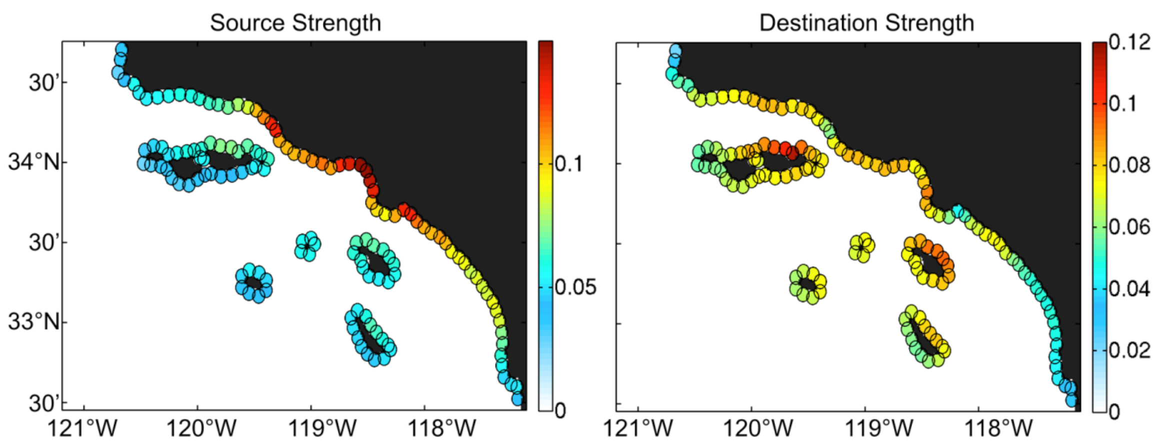


Figure C. Potential source strength (left) and destination strength (right) for kelp bass larvae. The color of a particular site reflects its relative source or destination strength. The model assumes uniform larval production; PLD = 25-33 d; Spawning from April to November.

Site Selection

We will use our existing data sets (see Existing Data Analysis Section below) to determine the benthic habitats based upon relief, substrate, exposure, and biogeographic region inside and outside of each MPA. Based upon our 2008 survey data we have determined that there are 6 reef types in the SCSR [pinnacles, wall reefs (typical but not limited to the islands), high relief, middle relief, low relief and cobble]. Within the four primary SCSR biogeographic regions (cold temperate versus warm temperate and islands versus mainland) we propose to express benthic reef characteristic in two-dimensional space using non-metric multidimensional scaling. Reefs that are significantly similar in structure will be proposed as reference sites for the MPAs. Using these statistical outputs experts in the region will choose reference sites that are (1) as comparable as possible in community structure, reef geomorphology (substratum type and relief and reef slope) and oceanic conditions, and (2) locating reference areas as close as possible to nearby MPAs, but outside of a 0.5 km buffer zone to prevent the potential effects of regulatory treatments within the MPA from influencing density estimates at a nearby reference site (i.e., "spillover effects") (3) using historical sites within MPAs and reference areas where available. It may be possible to use a reference site for more than one MPA if the habitat is comparable. Without completing these analyses we propose that the sampling design is approximated in Figure A.

Outcomes and Deliverables

Species-level data from our surveys will be combined with additional information (e.g., published size-fecundity relationships, habitat maps) to generate additional population metrics (e.g., size/age structure, biomass, larval production) and community-level metrics (e.g., species composition, relative abundance and richness, trophic guild abundance and biomass) and ecosystem-wide variables (abundance and spatial configuration of habitat-forming organisms, such as giant kelp and other algae).

Univariate and multivariate statistical analyses will then be conducted to compare species abundances, guild abundances (e.g., trophic guilds) and community structure among MPAs and reference sites across SCSR. Estimates of the density of fish, invertebrate of algae species at an individual site across an entire regulatory level (e.g., SMR, SMCA), or 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, predators) 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 (see Hamilton et al. 2010). 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 density of giant kelp vs. fish species diversity). Databases (including metadata catalogues) will be developed in accordance with the structure of the database developed for the integrated baseline study and will likely draw from previous structures developed for the CCSR and NCCSR baseline surveys.

Existing data analysis

The synthesis of these programs provides an unrivaled spatial and temporal scale pre-reserve implementation rocky reef study. Since 1974, hundreds of biogeographic and time series sites have been surveyed covering nearly every reef in the Southern California Bight (Figures D and E) (Pondella et al. 2002; Clark 2005; Pondella et al. 2005; Hamilton 2010). These data sets and programs were used to inform site selection and methodology for the original CRANE 2004 program that sampled reefs from central California throughout the entire SCSR (Tenera Environmental 2006). From an applied management standpoint, the 2004 biological data (e.g. density, biomass, richness) was used to inform the MLPA SCSR design process. A good example is the use of this bight wide data set as an input to connectivity modeling (Watson 2010). The 2004 data were then used in an adaptive management context to structure the stratified random sampling strategy conducted for the Bight ’08 rocky reef program (Stevens 1999). Sites were randomly selected using the biogeographic regions determined from the 2004 surveys. We propose to continue this adaptive strategy by synthesizing the biogeographic and time series studies with 2004 and 2008 regional surveys into a single database that can provide any of a variety of spatial and temporal outputs (Figure F).

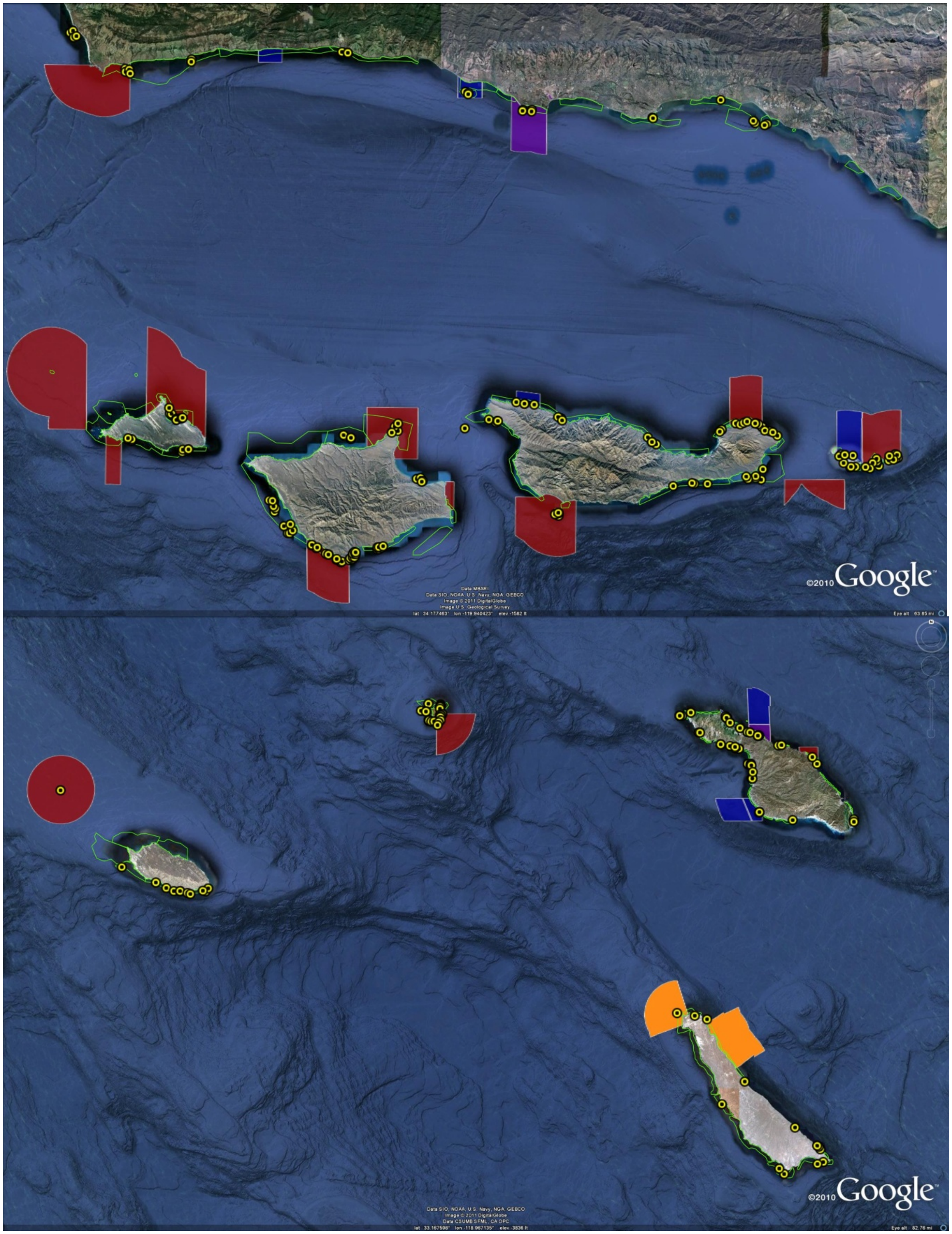


Figure D. Previously surveyed study sites (yellow) in the Santa Barbara Channel and Northern Channel Islands (above) and southern Channel Islands (below); SMRs (red), SMCAs (blue and purple), military closures (orange) and mapped natural reef (<30 m depth) areas (green).

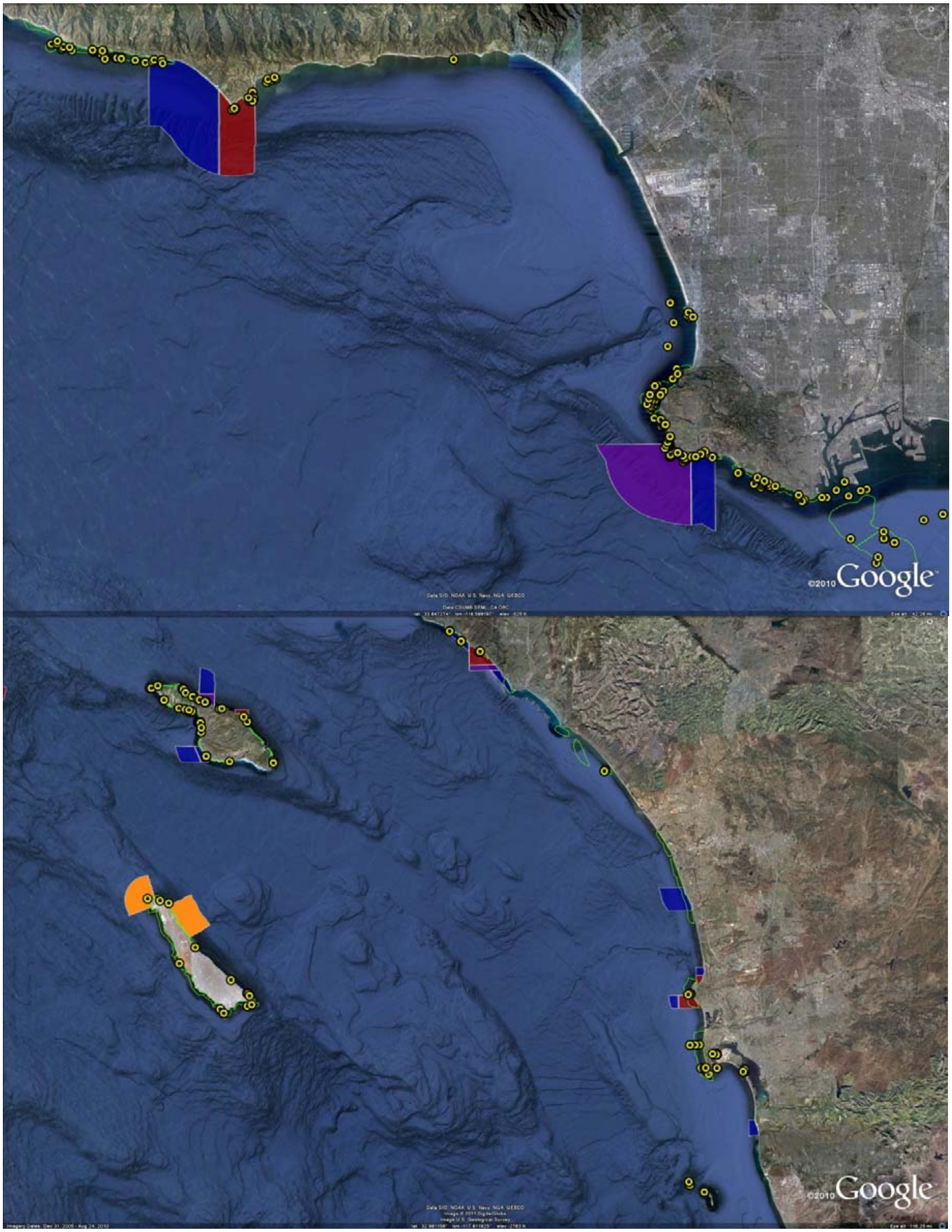


Figure E. Previously surveyed study sites (yellow) in Santa Monica Bay (Malibu to Horseshoe Kelp) (above) and Orange and San Diego County (above); SMRs (red), SMCAs (blue and purple), military closures (orange) and mapped natural reef (<30 m depth) areas (green).

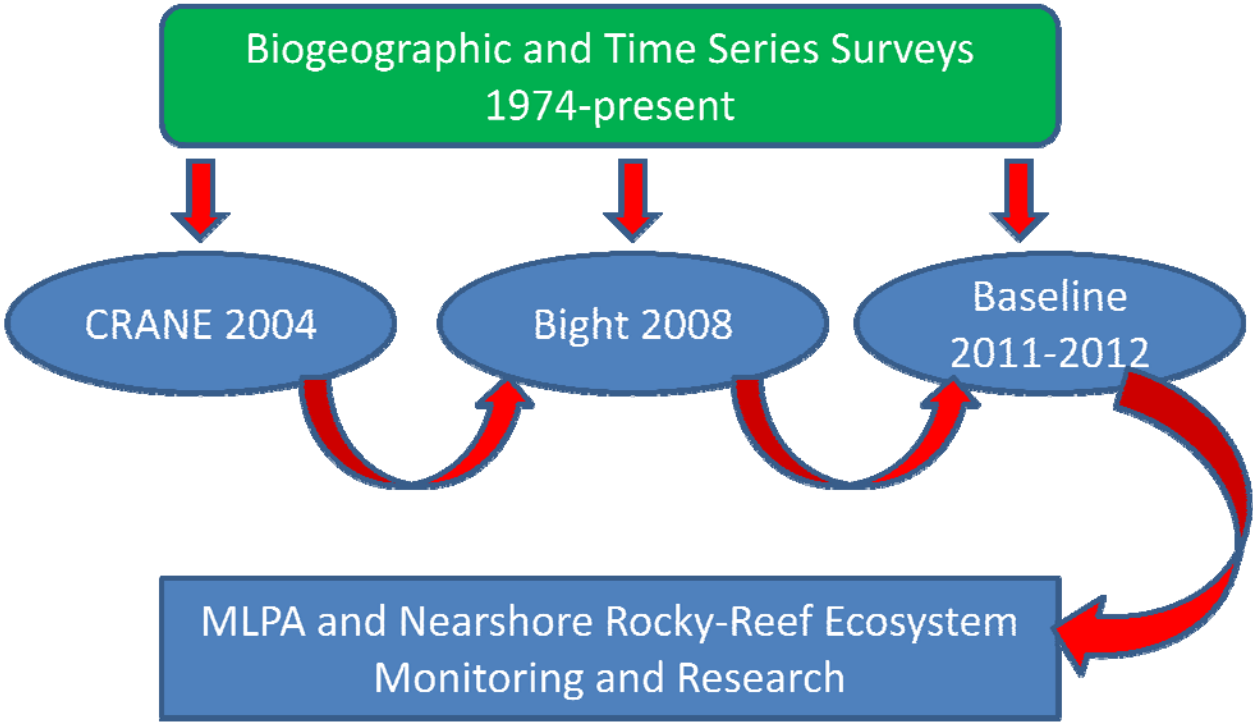


Figure F. An information management network showing past and proposed information products.

First, we propose to analyze these integrative data sets to determine the preexisting condition of the Draft Vital Signs and Indicators/Focal species (Appendix I). The contribution of the various Indicator/Focal species in developing assessment tools for Key Attributes will be completed. We will determine how measured reef characteristics vary across the entire Southern California Bight. These data products will have a variety of applications. First, information on these focused reef attributes will be used to determine appropriate site selection (described above) for the MPAs, military closures and reference areas. The resulting maps of fine-scale distributional data will have important use in coastal marine spatial planning efforts. Lastly, these fine scale spatial layers will greatly enhance modeling outputs for this system. For instance, in the connectivity analyses (Figure C), production estimates were created from fish abundance and body size data from the CRANE 2004 surveys. There were significant stretches of coastline without survey data and as such, data gaps were estimated using spatial averaging techniques. A clearer understanding of the spatial distribution of density and biomass of ecosystem features will strengthen future modeling outputs and enhance our understanding of connectivity. Greater resolution and understanding of spatial variation among reef characteristics will lead to a more informed integration among the various interests in this habitat and connected habitats. Finally, this proposed program will enable us to make recommendations based upon the best scientific information on how to best proceed with long-term monitoring of these ecosystem metrics and features.

One critical output of this program will be informed recommendations on long-term monitoring of MPAs in nearshore rocky reef and kelp habitats. There is a critical need to create a sustainable MLPA monitoring program that is efficient and cost-effective while scientifically robust. We propose to inform this optimization process by determining the precision necessary for tracking the vital signs or key attributes in this ecosystem feature (Smith 2011). We are also well poised to determine sets of 'core' sites that would be the most efficient to sample in ongoing monitoring. Our goal is to determine which sites are representative and will, as a subset, track an ecosystem feature. As a first cut, a set of 'core' sites would need to represent the various biogeographic regions already delineated in the SCSR. They would also need to be spatially distributed allowing for sensitivity to faunal shifts and explanatory of environmental perturbations. Establishing a core long-term monitoring program is essential because it will structure the partnerships enabling focused regional process studies and collaborations. For instance, a core set of monitoring sites augmented by RCCA sites can enhance spatial coverage.

Regional Assessments

Regional assessments of ecosystem features are key data products that enable tractable metrics to be readily interpretable to stakeholders and managers. They are critical outputs that can both inform user groups and allow informed management decisions. Such data products should include overall ecosystem health and smaller scale 'reef by reef' assessments enabling overlays with both macro- and micro-scale patterns obtained from other data sources. In Southern California and elsewhere, there has been much success in developing such metrics for marine habitats. These have focused primarily on soft bottom and estuarine ecosystems (Weisberg 1997; Borja 2000; Smith 2001). In southern California a fish guild metric was developed for all subtidal marine habitats (Bond et al. 1999). While this metric has shown value in tracking and comparing reef by reef performance (Pondella 2009), it has not yet been expanded to assess an entire ecosystem feature. Recently there has been progress towards developing such a metric for rocky intertidal habitats, and that work is ongoing. We propose to utilize the previous CRANE 2004 and Bight '08 rocky reef programs to begin to develop a regional assessment tool for nearshore rocky reefs. The two previous regional surveys will then serve as benchmarks for the data products generated from the current proposal contextualizing these surveys and allowing a trend assessment. This effort will be assisted by our collaboration with SCCWRP.

Reporting

The third and final year of the project will not include fieldwork and will focus on analyses and the generation of summary reports and outreach material. Databases and the results of analyses for baseline characterization and indicators will be incorporated into the final report. Data deliverables, identified in the previous sections, will be provided using ecological metadata Language (EML). We will work with partner organizations (e.g., National Marine Sanctuary) to develop printed material summarizing the baseline surveys, and we will develop pages on the PISCO (http://www.piscoweb.org/topics/marine-protected-areas) and VRG web sites that describe the surveys, their results and their role in informing decision makers. We will develop recommendations based on the strengths and limitations (scientifically and financially) of these programs to develop a set of recommendations future monitoring and evaluation studies. We intend to use these data products in any synthesis studies including other project studying other ecosystem features based on the language from the separate integrated proposals.

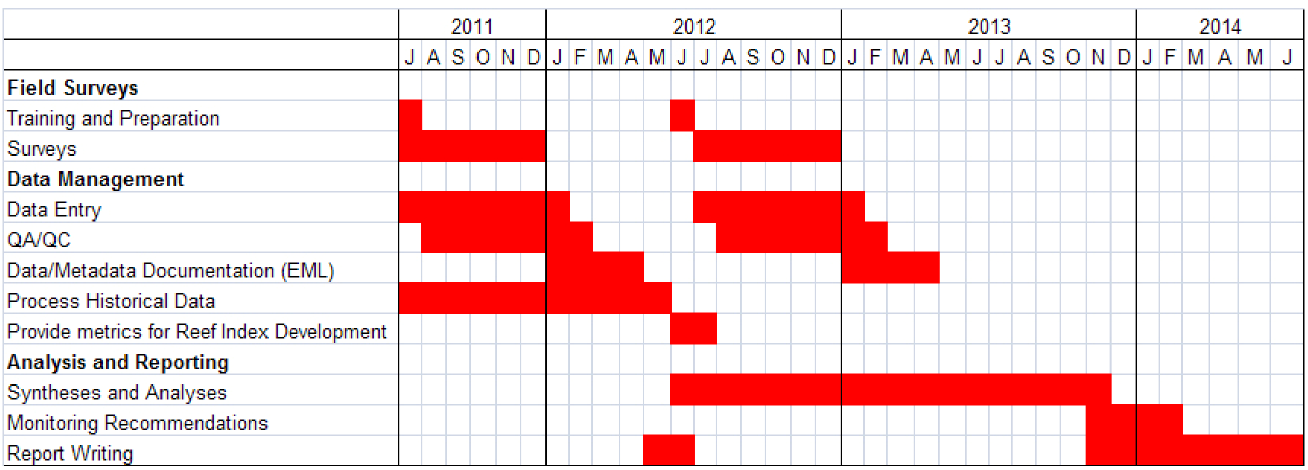
Annual progress reports will be written and submitted at the conclusion of the first two 12-month periods following start of this project. These reports will briefly describe progress towards project goals, timelines for work completed/remaining and updated financial information. In March of 2014 a final report will be delivered to California Sea Grant. The final report will include:

1. A narrative accounting of our progress towards Baseline Program purposes and our project goals.
2. A financial report showing budgeted and actual costs and variances.

3. A technical report describing the baseline characterization and the current trajectory of ecosystem trends based on a synthesis of existing data with those data collected for the baseline program. It will include a description of methods, data summaries, analyses and interpretation to describe, assess and understand implementation conditions. It will also include MPA and reference site characterizations, a regional assessment and recommendations for future long-monitoring and evaluation studies of kelp and shallow rock ecosystems in this SCSR.
4. An executive summary written to be appropriate for broad public release, summarizing methods, key findings and conclusions in 1-2 pages of text and, if needed, an additional 1-2 pages of figures.

Data and associated metadata will be delivered to DFG, OPC and the Monitoring Enterprise as part of the completion of the project. Data and metadata will include spreadsheets of raw sampling data and maps of sampling locations formatted as previously described.

Milestones Chart – *July 2011 to June 2014*



Project Permits and Permissions

The UCSB group currently has all the necessary permits from both the CDFG and the CINMS to conduct sampling in all existing MPAs north of Palos Verdes (including all Northern Channel Islands). We also have permits to conduct sampling in the "as yet to be designated MLPA reserves and conservation areas from Pt. Conception to Palos Verdes". We have provided the exact locations to CDFG to modify our permits. The VRG, LACSD, SMBRC and SMBK groups have current scientific collecting permits and they will be amended to include MPAs after review of CDFG.