Reef Check California Monitoring Protocol 2009

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Preface

This document summarizes the Reef Check California Monitoring Protocol and the rationale for its development. This document was written as a scientific document to facilitate effective peer review. A detailed training course including training materials (i.e. slide presentations, training manual, and species ID flashcards) has been developed to make the program accessible to a broad audience. ONLY dive instructors that have been trained and certified as RCCA Instructors can teach and certify divers in the Reef Check California Monitoring Protocol. RCCA Instructors must meet the following requirements:

- Active leadership level certification (DM,AI, or higher) for at least 2 years from nationally recognized dive certification agency
- Current active Instructor level certification
- Have an active status AAUS affiliation with one year experience in underwater data collection

  or
- Have 2 years experience as an active Reef Check California surveyor.

1 Introduction

California's nearshore waters host a unique and valuable marine ecosystem, considered to be one of the most productive ocean areas in the world (CDFG 2001). This productivity, coupled with over 1000 miles of coastal scenic beauty, drives an ocean economy worth approximately $43 billion, the largest in the United States (Kildow and Colgan 2005). The rapid growth of California's human population, together with technological advances in fishing and increases in non-consumptive recreation, has placed growing demands on California's nearshore coastal marine resources.

Charged with protecting these resources, the California State Legislature passed the Marine Life Management Act (MLMA) in 1998 and the Marine Life Protection Act (MLPA) in 1999. The MLMA established a new legilative madate for managing marine fisheries that requires the conservation, sustainable use and restoration of California's living marine resources, including the conservation of healthy and diverse marine ecosystems (MLMA, Fish and Game Code § 7050, CDFG 2001, Geever and Dart 2003). The MLPA mandated the state design and manage an improved network of marine protected areas (MPAs) to protect marine life, habitats, ecosystems and natural heritage (California Fish and Game Code § 2850). Accurate and consistent data describing California's nearshore marine ecosystems are critical to the successful implementation of the MLMA and MLPA, yet the California Department of Fish and Game (CDFG) has expressed concern over the lack of adequate funding for long-term monitoring, addressing

the data needs for sustainable adaptive management and enforcement in new MPAs (Broddrick 2005).

There is a long history of marine monitoring in California and there are numerous ongoing monitoring efforts led by a combination of government, academic, private and non-profit institutions -- including those using volunteers (Burcham 2004, Reed et al. 2002, San Diego Oceans Foundation 2005, www.reef.org). The largest and most comprehensive scientific sampling effort in California's nearshore waters was carried out in 2004 by the Cooperative Research and Assessment of Nearshore Ecosystems (CRANE) led by the CDFG in combination with the Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO, www.piscoweb.org) and other partners. This sampling effort surveyed 88 sites between Monterey and San Diego including sites on all of the Channel Islands (Tenera Environmental 2006). Despite the scale of this project, no funding was provided for future data collection efforts (M. Bergen personal comm.). Consequently, there currently is no statewide standardized fishery independent monitoring program specifically designed to provide data for marine management such as stock assessments or to evaluate existing and newly implemented marine management measures like MPAs.

2 Background and Goals of the Reef Check California Monitoring Program

The primary objective of the Reef Check California (RCCA) monitoring program is to improve marine management in California by providing managers with the scientifically robust data needed to make sustainable management decisions. Currently, both State and Federal government agencies invest heavily in marine management efforts and are mandated by law to sustainably manage marine resources. However, without adequate long-term monitoring, it is extremely difficult to determine the efficacy of management actions and the lack of available applied science often leads to insufficient information for decision-makers (Baird *et al.* 2005). When changes in marine populations are detected, it is equally important to determine the scale of the change**.** To do this, it is necessary to use a standardized program over a large geographic area so that results can be compared among different areas.

The Reef Check Foundation has been using scientifically trained volunteer teams to monitor tropical marine systems for almost ten years. Faced with financial shortages, state and international governments have turned to community-based monitoring programs to help supplement other data collection efforts. Internationally, the Reef Check coral reef community-based monitoring program (Hodgson *et al*. 2004) is active in over 90 countries and territories and governments in many of these countries, including the Dominican Republic, the Philippines and China which are using this community-based monitoring program to help make management decisions and provide information about management results. In California, and across the nation, numerous volunteer water quality monitoring programs have been used to inform management and regulatory processes (Abramson et al. 2000, US EPA 1997). In addition to providing high quality data, a valuable by-product of including stakeholders directly in marine monitoring is the formation of an informed constituency supportive of science-based ocean management. This strategy provides a channel for key stakeholders (*e.g.*, recreational divers, fishermen,

ocean lovers) to communicate their intimate knowledge of local habitats to the regulatory process.

Shallow subtidal monitoring has been identified as the highest priority activity by CDFG in the Channel Islands to monitor the newly enacted marine reserve network (CDFG 2004) and throughout the state. Effective implementation of the MLPA and MLMA requires that shallow subtidal monitoring be carried out along the entirety of California's coastline. Community-based programs have been identified as a valuable tool to help meet this need (CDFG 2005, MLMA §7056(h), §7059(a)(2), West Coast Governors' Agreement 2006, CA Ocean Protection Council 5-year Strategic Plan 2006)

The RCCA program provides data on the status of key indicator species living in the nearshore, shallow water ecosystems. By employing a relatively rapid survey protocol, leveraged with man hours from volunteer teams, it is possible to survey many sites each year. The monitoring results will fill geographic and temporal data gaps in existing broad-scale monitoring programs (such as PISCO) and supplement data collection efforts by geographically-focused programs such as the Kelp Forest Monitoring program in the Channel Islands National Park (Davis *et al*. 1997).

3 Monitoring Program Overview

The RCCA monitoring program has been designed to assess how key biotic and abiotic characteristics of coastal rocky reef communities change over time - including the abundance and relative age distribution of target species. This will permit the evaluation of population and community attributes at sites inside and outside of existing and proposed MPAs. It will also provide insight into and how different sites respond to newly imposed management measures. In addition, this monitoring will facilitate early diagnosis of abnormal changes and help identify their underlying causes. The RCCA protocol has been designed to determine the status and trends of key ecosystem features similar to the 'vital signs' monitoring in the Channel Islands National Park (Davis 2005).

RCCA protocol has been designed to match CRANE and PISCO methods as closely as possible. The sampling unit is identical to CRANE/PISCO methods, 30 x 2 m (x 2 m for fish). An RCCA site is 250 m of linear coastline while CRANE/PISCO sites are 500 m split into 2 areas of approximately 250 m. When compared to half, either the upcoast or downcoast area, of a CRANE/PISCO site RCCA has the same sample size for benthic surveys (n = 6) and a slightly higher replication, 18 instead of 12 transects, for fish surveys. When designing a monitoring protocol, it is important to match the scientific skills of the intended users with the scientific requirements of the program. By selecting a subset of key indicators and requiring rigorous training, testing, certification and annual recertification, the RCCA monitoring protocol has been specifically designed to suit the State's management needs at a level that can effectively utilize the vast resources of community-based divers. The RCCA protocol indicator species list is smaller overall than the PISCO/CRANE list in order to ensure the data quality of RCCA surveys while still providing key information needed to improve nearshore marine management in Califonia. All the RCCA indicator species are also surveyed by PISCO/CRANE.

A standard Reef Check California survey will include:
Site Description (1 per site), including anecdotal, observational, historical, geographical and other data of this sort. These data are extremely important when we interpret correlations in RCCA survey results. It is very important to describe the physical setting of the site and its position in relation to obvious human influences on the Site Description Form. This ensures that data comparisons will be made between similar reef settings. All sites are surveyed at least once per year with each region having at least one index site that is surveyed twice per year in the spring and fall.

- Fish Transect - (35 species, 18 transects surveyed in the spring and fall– 6 core transects and 12 fish only transects) Divers search for and record the 33 target fish species (some species are grouped) observed along a transect 30 meters long, 2 meters wide and 2 meters high.

- Invertebrate Transect - (30 species, 1 order (*Actiniaria* - anemones) 6 transects) Using the same six core transects as the fish transects, divers search for and record the target invertebrate species along the transect (30 x 2 m). Note that these transects do not have a height associated with them; all target invertebrates are found only on the bottom.

- Algae Transect - (8 species, 1 genus comprising several species, 6 transects) Target algae species within the 2 m band along the core transects, as well as invasive species that are noted as present or absent anywhere on the site.

- Substrate Uniform Point Contact (UPC) - (6 transects surveyed in spring and fall) The same core transects as the fish, invertebrate and algae transects are used, but this time, points are sampled at each 1 m interval along the tape. At each point, three types of information will be collected to determine reef substrate composition, organisms that are covering the reef and the rugosity (variation of vertical relief) of the reef.

- Urchin Size Frequency Survey - (1 per site in fall if density allow) This survey is not associated with the transect but occurs in the immediate vicinity of the core transects.

3.1 Site Selection, Sampling Frequency, and Replication

The ultimate goal of RCCA is to monitor rocky subtidal communities twice per year at regular intervals along the entire mainland and island coasts. Initially, priority has been given to monitoring sites inside and outside of planned or existing MPAs and at sites recommended by the CDFG. Monitoring sites are selected based on a variety of factors including, but not limited to, diver safety, logistic feasibility, accessibility and presence of community-based teams in the local area.

Fish, invertebrate, algae and substrate data are collected along haphazardly placed transects at fixed sites. Three replicate 30 meter transects are surveyed in each of two zones (offshore and inshore reef). Due to field logistics and safety, reef habitats deeper

then 18 meters (~60') will not be sampled. Restrictive depth categorization will be avoided due to the diverse bathymetrey of California's rocky reefs and logistical feasibility of sampling along fixed depth intervals (Schroeder *et al*. 2002, J. Caselle Personal Comm.). Sites will be stratified into offshore and inshore zones which will be based on distance from shore. A RCCA site is 250 m of linear coast in length and approximatley 250 m in width (inshore to offshore). Selected index sites will be sampled twice per year - once in spring/early summer and again in late summer/early fall. All other sites will be sampled during the late summer/early fall period.

Due to the variability inherent when surveying fish, teams are required to complete 12 additional fish surveys (6 each within offshore and inshore zones) at each site during each sampling period. The fish surveys can be spread over several days as long as the duration does not exceed 4 weeks during each sampling period.

Random transects shall be allocated by zone/stratum (offshore reef and inshore reef) and should be targeted for replication levels of 18 transects for fish (9 at each zone), 6 transects for invertebrates (3 at each zone) and 6 transects for substrate (3 at each zone). Random transects should not be placed in areas where they cover greater than 10 m of continuos sand or where the depth varies by 4 m above or below the starting depth.

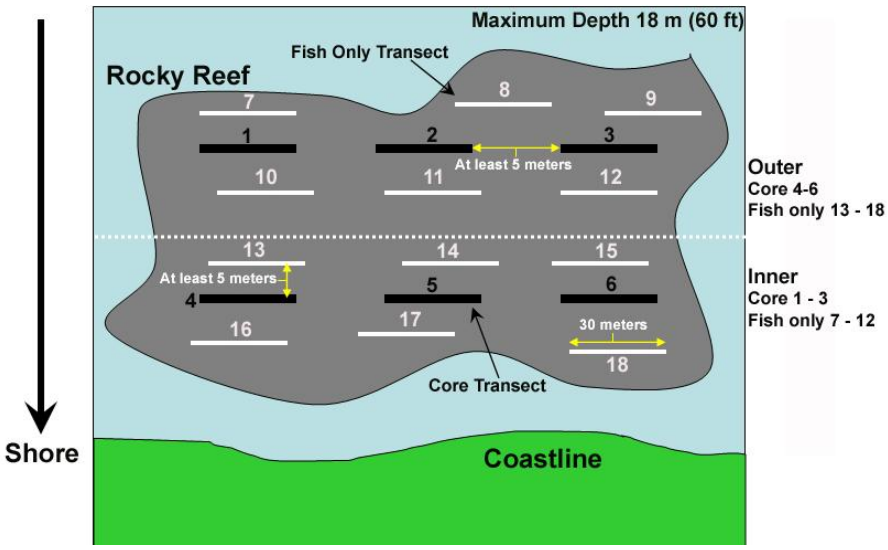

Figure 1. Hypothetical layout of transects at an RCCA site. Dark bolded lines indicate core transects (#1 – 6) and light lines indicate fish only transects (#7 -18).

Where logistics and resources permit, some teams may adopt permanent transects. Permanent transects will be installed with assistance from Reef Check staff after approval from appropriate agencies. Subsequently, community-based teams (dive clubs, etc.) will be encouraged to take 'ownership' of specific transects, thereby encouraging regular monitoring of each site.

3.2 Target Species

Due to specific goals of the RCCA program, a set of target species was identified to be monitored. A thorough literature review was performed to determine a base list of species currently monitored and the rationale used to select the target species by the various existing sampling programs (Burcham 2004, CDFG 2004, Carr *et al*. 2003, Davis et al. 1997). In addition, the REEF volunteer database (www.reef.org) was examined to ascertain the relative frequency of species encountered by recreational divers in the Monterey/Carmel region (J. Wolfe, personal comm). The RCCA shallow subtidal species list was then compiled based on the following criteria:

- Ease of identification
- Commonly observed by divers in shallow subtidal rocky reef habitat
- Species of special interest or concern (*i.e*., protected species, species known to be endangered, overfished and/or seriously depleted)
- Species commonly targeted by recreational and commercial fishing activities or included in the Nearshore Fishery Management Plan (http://www.dfg.ca.gov/marine/nfmp/)
- Ecologically important species

Following extensive field testing, the draft species list was revised and the final RCCA species lists were created containing 30 species and 1 order of invertebrates, 35 fish species and 8 species and 1 genus of algae (Tables 1 – 3). As noted in Tables 2 and 3, size estimates are made of all abalones, and fishes are recorded in size classes and differentiated as juveniles, males and females where appropriate. Size classes were chosen to distinguish between approximate life stages of target species (*e.g*., sexually mature). Only juvenile blue rockfish (*Sebastes mystinus*) will be identified to species level; all other juvenile rockfish they will be lumped into the "Unknown rockfish" category in the appropriate size category.

RCCA does not have separate target species lists for distinct geographic regions in California. Although we recognize the distinct biogeographical breaks along the California coast and the associated composition of species, separate species lists would limit the ability of the monitoring program to detect subtle shifts in target species' geographic ranges. In addition, a single species list will permit volunteers trained in any part of the state to participate in surveys along the entire coast.

Table 1. Reef Check California seaweed species.

Common Name	Latin Name	Rationale
giant kelp*	*Macrocystis pyrifera*	C, E, EI
Southern sea palm**	*Eisenia arborea*	C, EI
elkhorn kelp**	*Pterygophora californica*	C, EI
bull kelp**	*Nereocystis luetkeana*	C, EI
laminaria**	*Laminaria spp.*	EI
sargassum†	*Sargassum muticum*	I, EI
sargassum†	*Sargassum filicinum*	I, EI
undaria†	*Undaria pinnatifida*	I, EI
caulerpa†	*Caulerpa taxifolia*	I, EI

* Number of stipes greater than 1 meter per holdfast are recorded
** Must be taller than 30 cm to be recorded
† Recorded if identified anywhere on site (on or off transect)
C = commonly observed, **E** = species exploited by recreational and commercial fishing, **EI** = ecologically important species (as food or habitat for the community), **SI** = species of interest or concern (protected, endangered, overfished, etc.), **I** = invasive

Table 2. Species and rationale of Reef Check California indicator invertebrate species.

Common Name	Latin Name	Rationale
red abalone*	*Haliotis rufescens*	E, SI
pinto abalone*	*Haliotis kamtschatkana*	E, SI
flat abalone*	*Haliotis walallensis*	E, SI
black abalone*	*Haliotis cracherodii*	E, SI
green abalone*	*Haliotis fulgens*	E, SI
pink abalone*	*Haliotis corrugata*	E, SI
white abalone*†	*Haliotis sorenseni*	E, SI
CA spiny lobster	*Panulirus interruptus*	E
CA sea cucumber	*Parastichopus californicus*	E
warty sea cucumber	*Parastichopus parvimensis*	E
bat star	*Patiria miniata*	EI
short spined star	*Pisaster brevispinus*	EI
giant spined star	*Pisaster giganteus*	EI
sunflower star	*Pycnopodia helianthoides, Solaster spp.*	EI
chestnut cowry	*Cypraea spadicea*	E
Kellet's whelk	*Kelletia kelletii*	E
rock crab	*Cancer spp.*	E
sheep and masking crabs	*Loxorhynchus grandis, L. crispatus*	E
wavy and red turban snails	*Lithopoma undosum, L. gibberosum*	E
giant keyhole limpet	*Megathura crenulata*	E
gumboot chiton	*Cryptochiton stelleri*	C, EI
rock scallop	*Crassedoma giganteum*	E
red urchin	*Strongylocentrotus franciscanus*	E, EI
purple urchin	*Strongylocentrotus purpuratus*	EI
crowned urchin	*Centrostephanus coronatus*	C
CA golden and brown gorgonians**	*Muricea californica, M. fruticosa*	C
red gorgonians**	*Lophogorgia chilensis*	C
large anemones**	Order Actiniaria	C

* Size estimated to nearest centimeter
** To be recorded, anemones must be 10 cm or larger (height or width); gorgonians must be 10 cm or greater in height
† Recorded if identified anywhere on site (on or off transect)
All organisms must be greater than 2.5 cm to be counted

C = commonly observed, **E** = species exploited by recreational and commercial fishing, **EI** = ecologically important species (trophically important species), **SI** = species of interest or concern (protected, endangered, overfished, etc.)

Table 3. Species, measurement criteria, and rationale of Reef Check California indicator fish

Common Name	Latin Name	Measured Specifics (cm)	Rationale
blacksmith	*Chromis punctipinnis*	<15, 15-30, >30	C
Opaleye	*Girella nigricans*	<15, 15-30, >30	C, E
Garibaldi	*Hypsypops rubicundus*	Juv, adult, <15, 15-30, >30	C, SI
Sargo	*Anisotremus davidsoni*	<15, 15-30, >30	C
black perch	*Embiotoca jacksoni*	<15, 15-30, >30	C,E
striped seaperch	*Embiotoca lateralis*	<15, 15-30, >30	C, E
rubberlip seaperch	*Rhacochilus toxotes*	<15, 15-30, >30	C, E
pile perch	*Rhacochilus vacca*	<15, 15-30, >30	C, E
rainbow seaperch	*Hypsurus caryi*	<15, 15-30, >30	C, E
CA sheephead*	*Semicossyphus pulcher*	Juv, female, male, <15, 15-30, >30	C, E, EI
rock wrasse	*Halichoeres semicinctus*	Juv, female, male, <15, 15-30, >30	C
Senorita	*Oxyjulis californica*	<15, 15-30, >30	C
kelp bass	*Paralabrax clathratus*	<15, 15-30, >30	C, E
barred sand bass	*Paralabrax nebulifer*	<15, 15-30, >30	E
cabezon*	*Scorpaenichthys marmoratus*	<30, 30-50, >50	E
Lingcod	*Ophiodon elongatus*	<30, 30-50, >50	E, SI
giant sea bass	*Stereolepis gigas*	None	SI
kelp greenling*	*Hexagrammos decagrammus*	Male, female, <15, 15-30, >30	E
rock greenling*	*Hexagrammos lagocephalus*	<15, 15-30, >30	E
horn shark	*Heterodontus francisci*	<30, 30-50, >50	EI, E
kelp rockfish*	*Sebastes atrovirens/*	<15, 15-30, >30	E
grass rockfish*	*Sebastes rastrelliger*	<15, 15-30, >30	E
brown rockfish*	*Sebastes auriculatus*	<15, 15-30, >30	E
gopher rockfish*	*Sebastes carnatus*	<15, 15-30, >30	E
black and yellow*	*Sebastes chrysomelas*	<15, 15-30, >30	E
China rockfish*	*Sebastes nebulosus*	<15, 15-30, >30	E
yellowtail rockfish & olive rockfish*	*Sebastes flavidus / Sebastes serranoides*	<15, 15-30, >30	E
copper rockfish*	*Sebastes caurinus*	<15, 15-30, >30	E
vermilion rockfish and canary rockfish	*Sebastes miniatus / Sebastes pinniger*	<15, 15-30, >30	E
black rockfish*	*Sebastes melanops*	<15, 15-30, >30	E
blue rockfish*	*Sebastes mystinus*	<15, 15-30, >30	E
Bocaccio	*Sebastes paucispinis*	<30, 30-50, >50	E, SI
treefish*	*Sebastes serriceps*	Juvenile, Adult, <15, 15-30, >30	E

* Fin fishes included in the Nearshore Fishery Management Plan (www.dfg.ca.gov/mrd/nfmp/)
C = commonly observed, E = species exploited by recreational and commercial fishing, EI = ecologically important species (trophically important species), SI = species of interest or concern (protected, endangered, overfished, etc.)

3.3 Uniform Point Contact (UPC) Benthos Sampling

Invertebrates and algae attached directly to the substrate are sampled at 30 uniformly spaced points at every meter along each 30 meter transect line (no epiphytes, epizooids or highly mobile organisms are be sampled). Three types of information are collected at each point: 1) substrate type, 2) type of dominant organism covering the bottom at point and 3) substrate relief category. Substrate type will be recorded as:

- Sand/Silt/Clay (< 0.5 cm)
- Cobble (0.5 cm – 15 cm)
- Boulder (> 15 cm – 1 m diameter)
- Bedrock (> 1 m diameter)
- Other (intact empty shell, metal, other man-made material etc.)

Bottom cover will be determined by recording what is directly under each 1 m point along the transect line. Eight categories will be used to record what percentage of the bottom is occupied by certain individuals.

- None
- Brown algae - Any type of the four canopy or sub-canopy forming kelps or one kelp group that are surveyed on the transect (giant kelp, bull kelp, *Pterygophora californica*, southern sea palm and *Laminaria* spp.)
- Other Brown Algae - Any other types of brown algae (e.g. *Cystoseira* spp., *Egregia spp.)* Also including invasives such as *Sargassum spp.* and *Undaria pinnatifida)*
- Green Algae (including the invasive *Caluerpa taxifolia*)
- Red Algae (all non-coralline red species)
- Articulated coralline algae
- Crustose coralline
- Sessile Invertebrate - Includes all sessile and mobile invertebrates that cannot be easily moved by the force of water from one's hand wave back-and-forth over organism (includes sponges, anemones, bryozoans, gorgonians, urchins, etc.)

Non-fixed algae (kelp fronds) shall be moved when encountered to determine what is below. Mobile invertebrate (urchins, sea cucumbers and seastars, etc.) will only be moved if the force of water from one's hand wave back-and-forth over organism is sufficient to dislodge the organism, otherwise these species will be categorized as "Sessile Invertebrate". The goal is to characterize the dominant feature under the point. Even if there are multiple layers beneath the point, simply determine what is the dominant cover type under the point is and record that datum.

Rugosity will be estimated by determining the greatest amount of vertical relief that exists within a 1 meter wide section across the tape and 0.5 meter section along that tape in front of the survey diver.

Four categories will be used to record vertical relief estimates:

- 0 – 10 cm
- >10 cm – 1 m
- >1 m – 2 m
- > 2 m

3.4 Invertebrate Transect

The invertebrate transect is adapted from the PISCO/CRANE protocol described in Carr *et al.* (2003) and is based on a 30 m long by 2 m wide transect. The purpose of the invertebrate transect is to estimate the density of conspicuous, solitary and mobile invertebrates. Individual invertebrates are counted along the entire 30 m x 2 m transect. Flashlights are used to search cracks and crevices thoroughly. Understory algae are pushed aside during the search for indicator organisms. No organisms shall be moved during sampling. Species recorded within the swath are listed in Table 2. Any indicator organism greater than 2.5 cm with any part of its body within 1 m of either side of the transect line shall be counted. Individuals less than 2.5 cm are not counted. A maximum of 50 individuals of each species shall be recorded along each 30 x 2 m transect. If 50 individuals of a given species are recorded, counting of that species will cease and the distance along the transect recorded on the datasheet. Gorgonians and large anemone must be > 10 cm in width or height to be counted and if any part of species falls within the 2 m band of the transect it is counted.

The swath sampling will be performed only by those divers who have demonstrated proficiency in invertebrate species identification, transect methodology and have passed the invertebrate sampling identification and field tests.

3.5 Algae Transect

The seaweed (macro algae) transect uses the same 30 x 2 m transect as the invertebrate transect. The purpose of the algae transect is to measure the density of conspicuous macro algae. Individuals must be present on the transect and meet the minimum size requirements to be recorded as present on the transect. Giant kelp taller than 1 meter whose holdfast falls within the 2 meter swath will be recorded as well as the number of stipes at 1 meter above the substrate per individual holdfast. In cases where stipes from multiple holdfasts are intertwined and cannot easily be determined how many individuals are part of the group of stipes, surveyors simply count the total number of stipes and record that number. All other species must be a minimum of 30 cm to be recorded. To determine the height of Southern sea palm surveyors place their thumb in the juncture at the top of the stipe and measure from the bottom of the holdfast to the bottom of their thumb. To determine the height of *Pterygophora spp.* it is measured from the bottom of the holdfast the top of the stipe. To determine the height of *Laminaria spp.* it is measured from the holdfast out on to the blade to the maximum length of the entire individual. If the transect tape is secured to an individual algae at the start or end of the tape, **neither** of those plants should be included in the algae survey count.

Four invasive species of algae (*Undaria pinnatifida, Caulerpa taxifolia, Sargassum Muticum, S. filicinum*) will also be recorded but not counted. These species need not be present on the transect and are recorded on the datasheet as either present (Yes) or absent (No) anywhere in the survey site.

The algae transect will only be performed by divers who have demonstrated a proficiency in species identification and sampling methodology and have passed the algae sampling identification and field tests.

3.6 Fish Sampling

The purpose of the fish transects is to provide an estimate of fish density, relative size distribution/age structure and gender (if applicable). Fish transect sampling will sample only conspicuous species that are found within a 30 x 2 x 2 m transect. Divers will be trained to swim at a constant speed (~3 – 6 m min^{-1}) and count fish that occur in the survey zone directly in front of them to control for variable visibility conditions. Fish will be sized according to pre-determined bins (< 15, 15 – 30, 15 – 50, > 30 and > 50 cm) to generate an estimate of the size structure of the sampled population (Table 3). Divers will look in cracks and crevices. Flashlights will be only used when necessary to make a positive identification of a fish and then immediately turned off to prevent additional fish from being attracted into the transect area. Only those fish observed during the first pass of a fish transect will be recorded – if a fish is missed on the fish transect but is observed on the return pass on the invertebrate survey, it will not be counted. A comments section will be included in all data sheets for off transect sightings of rare or interesting species. Unlike CRANE/PISCO fish surveys, only a bottom transect will be sampled and no midwater survey will be conducted.

RCCA divers will swim the fish survey as a buddy team. However, **ONLY** the diver laying out the transect (primary) will be conducting the fish survey count. The diver that is not laying out the transect tape (secondary) shall be responsible for:

- Staying well behind the bubble stream of the first diver and out of that diver's field of vision
- Maintaining close enough contact to assist in an emergency
- Evaluating the survey technique (e.g. speed, is the diver looking in all crevices as well as surveying the midwater, direction, etc.)

The secondary diver is a crucial part of the quality control program for Reef Check and should make notes on their data board to give feedback to the primary diver on the surface when reviewing the datasheets after the dive.

Fish sampling will have a greater level of replication (12 additional transects) than the other surveys. This is because the 6 core transects assess a relatively small area of habitat (120 m^3 for each transect) limiting the likelihood of gathering data on rare or patchily distributed species. There is a significant level of inherent variability associated with fish surveys in general and monitoring programs that use multiple surveyors (Willams et al. 2006, Thompson and Mapstone 2002, Connell et al. 1998, Samiolys 1991). The high number of replicate transects in a relatively small area was adopted to help to mitigate for these sources of inherent variability.

Divers will also record but not count the presence/absence of giant black sea bass (*Stereolepis gigas*). This species need not be present on the transect and is recorded on the datasheet as either present (Yes) or absent (No) anywhere in the survey site.

Fish sampling will only be performed by divers who have demonstrated a proficiency in species identification, sampling methods and have passed the fish sampling identification and field tests.

3.7 Urchin Size Frequency Survey

Urchin sizing will be performed once per year in sites with sufficient urchin densities to obtain 100 individuals of both purple and/or red urchin species (*S. purpuratus, S. franciscanus*) during the duration of one dive in the study area by two teams of divers. Urchin sizing is not restricted to the transect area, but should be performed in close proximity to the transect location. Urchin test size, not spine width, will be measured to the nearest centimeter. Unlike urchin counting along the invertebrate transect, individuals can be moved for sizing to ensure an accurate representation of urchins from the population is measured. It is very important that all individual urchins are represented in proportion to their abundance so care must be given to size all urchins in a given area and divers will size the first 100 urchin they encounter. Crowned urchins (*Centrostephanus coronatus*) will not be measured.

4 Diver Training

To ensure the protocol is consistently applied by multiple divers over time, a comprehensive diver training and testing program is maintained. While anyone may participate in RCCA training programs, only divers with an established record of diving and who have completed the training and demonstrated proficiency in survey methods and species identification will be certified.

Diver requirements include:

- minimum of 30 logged lifetime dives, 15 of which must be in temperate waters below 68° F
- minimum of 6 dives within previous 12 months
- Completion of written and field tests on safety, buoyancy, survey methods, invertebrate and fish taxonomy, substrate sampling, fish sizing and quality assurance

Data will only be accepted from RCCA certified divers who complete the required training and testing and have demonstrated proficiency in data collection activities. A tiered approach will enable volunteers with differing abilities to participate in the program without adversely affecting sampling accuracy and precision. Training materials, activities and duration are based on current scientific (Syms and Caselle 2003) and voluteer training programs (Hill 2005). Training courses consist of classroom training focusing on general ecology of target species, species identification, biological sampling

theory and specific sampling techniques. One pool dive is required to ensure proficiency with sampling methods and diving competency. A minimum of 6 training dives in the field (or equivalent experience) and successful completion of a proficiency exam is required to attain certification at each level. A one-day annual training recertification is required of all divers to maintain their accreditation to submit data.

5 Scientific Review and Field Testing

A panel of scientific, agency and recreational diving experts was convened in 2005 to review the draft protocol to ensure the sampling design, methods and species lists were scientifically sound and appropriate for volunteers. Extensive field testing was employed to evaluate the feasibility of the monitoring program and assess the ability of community-based divers to implement the protocol in a variety of different locations and conditions. Field testing occurred in Monterey, San Luis Obispo, Santa Cruz Island, Santa Barbara, Palos Verdes and Santa Catalina Island and employed over 20 divers encompassing a range of diving and research abilities. In addition to protocol modifications, field testing was used to help evaluate what level of training and testing is required of community-based divers. Following field testing and scientific review, the program was reevaluated to determine how best to be implemented in its final form.

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6 References

Abramson, M., D. Gregorio, and M. Witter (2000). The Malibu Creek Watershed Stream Team Pilot Project: Shattering the Myths of Volunteer Monitoring. Prepared for the State Coastal Conservancy by Heal the Bay, California.
http://www.healthebay.org/streamteam/volmon.pdf

Baird, B., L. Atkins, A. Mace, and C. Potter (2005). California Ocean and Coastal Information, Research, and Outreach Strategy. Adopted by: The California Ocean Protection Council, September 23, 2005. State of California Resources Agency.
http://resources.ca.gov/copc/InfoResOut_Strategy_final.pdf

Brodderick, L. R. (2005). Memorandum to R. R. Treanor, May 13.
http://www.dfg.ca.gov/mrd/mlpa/pdfs/dfgrec_mpf0505_memo.pdf

Burcham, D. (2004). Catalina Conservancy Divers Key Species Monitoring Project Protocols Handbook. Santa Catalina Island Conservancy, Avalon, California.

California Department of Fish and Game (2001). California's Living Marine Resources: A Status Report. W.S. Leet, C. M. Dewees, R. Klingbeil, E. J. Larson. (Eds). The Resources Agency, California.
http://www.dfg.ca.gov/mrd/status/

California Department of Fish and Game (2004). Channel Islands Marine Protected Areas Monitoring Plan.
http://www.dfg.ca.gov/mrd/channel_islands/monitoringplan0204.pdf

California Department of Fish and Game (2008). Master Plan for Marine Protected Areas. California Marine Life Protection Act Initiative.
http://www.dfg.ca.gov/mlpa/masterplan.asp

The California Ocean Protection Council Five-Year Strategic Plan (2006)
http://www.resources.ca.gov/copc/strategic_plan.html

Carr, M., C. Syms, and J. Caselle (2003). CRANE: Cooperative Research and Assessment of Nearshore Ecosystems. Nearshore Reef Monitoring Network Protocol Proposal.

Connell, S.D., M.A. Samoilys, M.P. Lincoln Smith, and J. Leqata. (1998) Comparisons of abundance of coral reef effort surveys vs visual census. Aus J. of Eco 23:579-586.

Davis, G. E. (2005). National Park Stewardship and 'vital signs' monitoring: a case study from Channel Islands National Park, California. *Aquatic Conservation: Marine and Freshwater Ecosystems*. 15: 71-89.

Davis, G. E., D. J. Kushner, J. M. Mondragon, J. E. Mondragon, D. Lerma, and D. V. Richards (1997). Kelp Forest Monitoring Handbook. Volume 1: Sampling Protocol Channel Islands National Park. National Park Service. Ventura, California.

Geever, J., and S. Dart (2003). Owner/Operator Manual for California's Marine Life Protection Act. Surfrider Foundation.

Hill, J. (2005). Reef Check Australia Survey Assist Course. Reef Check Australia, Townsville, Australia.

Hodgson, G., W. Kiene, J. Mihaly, J. Liebeler, C. Shuman, and L. Maun (2004).
Reef Check Instruction Manual: A Guide to Reef Check Coral Reef Monitoring
Published by Reef Check, Institute of the Environment, University of California at Los Angeles.

Kildow, J., and C. S. Colgan (2005). California's Ocean Economy. Report to the Resources Agency, State of California. National Ocean Economics Program. http://resources.ca.gov/press_documents/CA_Ocean_Econ_Report.pdf

Reed, B., C. Collier, J. Altstatt, N. Caruso, and K. Lewand (2002). Regional Kelp Restoration Project-Restoration & Monitoring Protocol. California Coastkeeper Alliance.

Samoilys, M.A. (1991). Review of the underwater visual census method developed by DPI/ACIAR project: visual assessment of reef fish stocks. Conference and Workshopr Series QC92006. Department of Primary Industrries, Brisbane.

San Diego Oceans Foundation (2005). Artificial Reef Monitoring Project Volunteer Diver Protocol.

Schroeder, D., D. Pondella, and M. Love (2002). On designing a survey program for the Nearshore Fishery Management Plan: The Modified PISCO Protocol.

Syms, C. and J. Caselle (2003). PISCO Annual Subtidal Survey Training Plan. University of California Santa Barbara and Santa Cruz.

Thompson, A.A. and B.D. Mapstone. (2002) Intra- versus inter-annual variation in counts of reef fishes and interpretations of long-term monitoring studies. Mar Ecol Prog Ser 232:247-257

Tenera Environmental. (2006). Compilation and Analysis of CIAP Nearshre Survey Data. http://www.dfg.ca.gov/marine/fir/sss.asp#crane

United States Environmental Protection Agency (1997). Volunteer Stream Monitoring A Methods Manual. Office of Wetlands, Oceans, and Watersheds. EPA 841-B-97-003. Washington, DC.

West Coast Governors Agreement. (2007). http://westcoastoceans.gov/docs/WCOceanAgreementp6.pdf

Williams, I.D., W.J. Walsh, B.N. Tissot, and L.E. Hallacher. (2006) Impact of observers' experience level on counts of fishes in underwater sureveys. Mar Ecol Prog Ser 310: 185-191.