Reef Check California Instruction Manual

A Guide to Monitoring California's Kelp Forests

TENTH EDITION

REEF CHECK CALIFORNIA

INSTRUCTION MANUAL

A Guide to Monitoring

California's Kelp Forests

Reef Check
CALIFORNIA

10th Edition

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This is the official instruction manual (10th Edition) for the Reef Check California Community Monitoring Program.

If you have any questions about training procedures or about the Reef Check California protocol, please contact Reef Check.

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Table 1: Commonly used acronyms.

Abbreviation	Definition
AAUS	American Academy of Underwater Sciences
BCD	Buoyancy Compensator Device
CDFW	California Department of Fish and Wildlife
CRANE	Cooperative Research and Assessment of Nearshore Ecosystems
DAN	Divers Alert Network
DO	Dissolved oxygen
EMBARC	Educational Marine Biological Adventures with Reef Check
ENSO	El Niño–Southern Oscillation
ESA	Endangered Species Act
FGC	(California) Fish and Game Code
GIS	Geographic Information System
GPS	Global Positioning System
MBARI	Monterey Bay Aquarium Research Institute
MLPA	Marine Life Protection Act
MPA	Marine Protected Area
NAUI	National Association of Underwater Instructors
NMFS	National Marine Fisheries Service (also known as NOAA Fisheries)
NOAA	National Oceanic and Atmospheric Administration
OA	Ocean Acidification
PISCO	Partnership of Interdisciplinary Studies of Coastal Oceans
QA/QC	Quality Assurance/Quality Control
RCCA	Reef Check California
RCF	Reef Check Foundation
RCVT	Reef Check Volunteer Tool
SC	Special Closure
SMB	Surface Marker Buoy
SMCA	State Marine Conservation Area
SMP	State Marine Park
SMR	State Marine Reserve
SMRMA	State Marine Recreational Management Area
UPC	Uniform Point Contact
YOY	Young-of-the-year

Chapter 1

Introduction

Welcome to Reef Check California! You are now on the path to becoming a citizen scientist. The Reef Check California (RCCA) training will help you to understand the dynamics of the marine environment that you have come to love and give you the skills to gather quality data that will be used in research, management, and conservation efforts across the state of California and beyond.

Beginning in the 1990s, citizen science has helped to transform how scientists and resource managers gather data to inform research and resource conservation in ways that go beyond the standard scientific data collection by academic groups and resource agencies. Citizen scientists provide the ability to collect more data over time and space (Thiel et al. 2014). By involving volunteer divers as citizen scientists, we can involve the public in the data collection process, and educate them about the ecology, oceanography, management, and conservation of the ecosystems that they encounter. Through our training, we can inform the public about current threats to these ecosystems, thereby promoting ideas of conservation for the areas we study and which we all live.

The kelp forests and rocky reefs of California's coast are home to a vast array of marine organisms that many Californians regularly enjoy, and many others depend upon for their livelihoods. Unfortunately, the rapid growth of California’s population and the resulting impacts of coastal development, pollution, and overfishing have placed increasing demands on our nearshore resources. Global issues such as climate change and resulting ocean warming and acidification add to the pressure put on our nearshore environment. Many species that were once abundant have virtually disappeared from our reefs.

Reef Check California is building a network of informed and involved citizens who support the sustainable use and conservation of the Golden State’s nearshore marine environment. To accomplish this, volunteers are trained as citizen scientists to survey nearshore reefs and collect data on the status of key indicator species. Reef Check California’s survey methodology has been specifically designed for you – the volunteer. By becoming a citizen scientist, you will be able to make a significant contribution to the research behind the conservation and management of California’s precious marine resources. This instruction manual provides all the information necessary for Reef Check California volunteers to carry out rocky reef monitoring using the standard Reef Check California survey protocol. In addition to this manual, there are a variety of training materials available including PowerPoint presentations, flashcards, and online identification tests that you will be introduced to during your course. Upon successful completion of the Reef Check California training course, participants will be eligible to contribute data to the Reef Check California database and can elect to receive a Specialty EcoDiver Certification Card (NAUI). Data will only be accepted from individuals who have successfully completed the full training course taught by a Reef Check California accredited instructor and have demonstrated proficiency in Reef Check California methods by completing the requisite examinations and field evaluations.

About Reef Check Foundation

Reef Check Foundation (RCF) was founded in 1996 to drive an inclusive process to save our oceans. It became a registered 501(c)(3) not for profit organization in California in 2001. Our mission is to empower people to save our reefs and oceans through education, research, and conservation. Our overarching goal is to work collaboratively on local, regional, national, and international levels to implement environmentally sound and socioeconomically sustainable solutions to improve management and conservation of ocean ecosystems.

Education: Our educational strategy is to create long-term, sustainable ocean conservation by empowering people—often from the most vulnerable communities—to think about the relationship between the ocean, science, and their own lives.

Research: In 1997, RCF implemented the first global survey of coral reefs by training divers as citizen scientists to collect high-quality data on the condition of those ecosystems. Since then, we've built a network of over 10,000 trained citizen scientists who have monitored coral reefs in over 100 countries and/or territories. All data are freely available online to universities, government agencies, and the public at our Global Reef Tracker database at data.reefcheck.org.

Conservation: Reef Check's research and experiential education programs provide a public service that sets it apart from other ocean conservation organizations. We provide data and work with communities, managers, and policy makers so that they can make informed decisions about the conservation of our resources. We believe that informed and educated stakeholders and publicly available data and analyses are key to sound, sustainable and science-based marine conservation.

For more information about Reef Check activities, including how you can participate in our tropical work, please visit our website reefcheck.org or email rcinfo@reefcheck.org.

By becoming part of RCCA, you are taking direct action to improve marine management and conservation!

Chapter 2

Reef Check California

The Reef Check California (RCCA) program has two primary goals: to produce data that can be used for the management and conservation of California's kelp forests and rocky reefs, and to involve the public in the scientific process to foster an educated public, supportive of science–based management and ocean stewardship. Towards these goals, RCCA trains scuba divers to become citizen scientists to collect scientific data using a standardized protocol. This allows us to study these kelp forest and rocky reef ecosystems over long periods of time and a large geographic scale. RCCA provides the data to the public, scientists, resource managers, and policymakers, so that they can make informed, science-based choices concerning the management and conservation of California's precious living marine resources. Since its beginning in 2006, the program has collected data from over 1,000 surveys at over 100 sites along the California coast. These data have been used by the California Department of Fish and Wildlife (CDFW), federal agencies, and researchers to understand, manage, and protect California's nearshore environment.

The Program in Context

Reef Check California's monitoring program has been designed in consultation with some of the foremost marine scientists in California and has been developed in the context of other monitoring programs. Begun in 1999, The Partnership of Interdisciplinary Studies of Coastal Oceans (PISCO) has a longstanding kelp forest monitoring program that predates the implementation of RCCA in 2005. Other programs using similar monitoring methods were the Cooperative Research and Assessment of Nearshore Ecosystems (CRANE), which monitored a large section of the California coast from Monterey to San Diego in 2004, and the kelp forest monitoring program conducted by the Channel Islands National Marine Sanctuary around the Northern Channel Islands, which is somewhat more limited in geographic scope but has been conducted since 1982 (Davis et al. 1997). While the geographic scope, temporal and spatial resolutions, and the number of species monitored varies among the different programs, they all have some characteristics in common. They have used trained scuba divers to count (and size) species along transects at sites that are visited repeatedly over time. RCCA was developed to complement existing monitoring programs by collecting data that is compatible with the data from these programs to gain a more in-depth understanding of California's rocky reefs and kelp forests, specifically with the goal of informing resource management.

The monitoring protocol designed for volunteer citizen scientists is largely based on the protocol developed by PISCO for its subtidal monitoring program. While using similar monitoring techniques as PISCO, the RCCA protocol is designed to be conducted by volunteers after a rigorous amount of training, by reducing the taxonomic resolution and by reducing some of the complexities of the diving tasks necessary for PISCO surveys. Several studies have shown that the data collected by RCCA volunteers are compatible with data collected by other programs (Caselle & Cabral 2018, Claisse et al. 2018, Gillett et al. 2012).

Beyond data collection, RCCA's citizen science approach, in which research methods are designed by scientists and volunteers collect data, involves the public in research used to inform marine management (Shirk et al. 2012). This collaborative effort ensures high data quality and scientific oversight while generating considerable public participation in an ongoing research project. RCCA creates a link between local stakeholders and the research community. For example, this collaboration allows the statewide Marine Protected Area (MPA) monitoring program to develop a local presence in the areas where RCCA volunteers live and work, use data collected by the stakeholders affected by the MPA regulations, and to generate an avenue for integrating local knowledge into the MPA management process.

> A note on the term "citizen science": The term "citizen science" emerged in the 1990s, right around the time Reef Check was founded, to describe research that included non-scientists in the study of the environment. Back then, we had to explain the term every time we used it. Now the term has become widespread, and there are many alternative labels in use now, ranging from "Public Participation in Scientific Research" to "civic science" or "community science". The term *citizen science* has recently been criticized, particularly in the United States, where "citizen" is sometimes narrowly defined to mean only legally recognized citizens of the country where the research is being conducted. We do not understand the term "citizen science" as exclusive or as defining someone by their citizenship or national origin. For us, it is an inclusive term that embraces all to participate in science regardless of their background. This use is in the spirit of the term "world citizen" as has been used by thinkers from Greek philosopher Diogenes in 400 B.C. to Albert Einstein in the 20th century. Therefore, we continue to refer to our work as citizen science while also recognizing other terms as equally valid and essentially describing the same approach to research.

California Marine Protected Areas

In 1999, the California Legislature voted and passed the Marine Life Protection Act (MLPA), which legally required the state of California to design, implement, and enforce a network of marine protected areas (MPAs) throughout the state. The intent of the network within state waters is to ensure ecosystem protection, sustain fisheries, and preserve cultural resources.

Following the passing of the MLPA, researchers and stakeholders spent the next 13 years working together to develop a network of MPAs. One of their goals was to create an MPA network that aligned with scientific guidelines, and targeted areas that represented the diverse array of habitats present along the California coast, such as kelp forests/rocky reefs, intertidal zones, seagrass beds, seamounts, and deep submarine canyons. In addition, effective implementation of the MLPA required that MPAs be large enough and spaced closely together to protect reproductive adults and facilitate the dispersal of their young into areas surrounding MPAs and from one MPA to another. Lastly, multiple MPAs needed to be present within coastal regions and within each habitat type to ensure replication of habitats and ensure protection should one MPA experience an environmental disaster.

After several years, the final installment of the MPA network in California was completed in the North Coast and included a total of 124 MPAs statewide, ultimately increasing the protection of California waters from 2.7% in 1999 to 16.1% in 2012. MPA regulations are strictly enforced by California Department of Fish and Wildlife Wardens and supported by citizens who regularly call the CAL-TIP hotline to report poachers.

MPAs in the state of California vary in their level of protection, and it is our responsibility as Reef Check divers and ocean-enthusiasts to be aware and abide by the laws present in each of the sites we dive. Below are examples of the types of protection associated with MPAs.

State Marine Reserve (SMR): This is simply a “no take” area, meaning that the possession, damage, or injury of any living, geologic or cultural resource is strictly prohibited. SMRs are depicted in red on CDFW maps, and currently constitute 8.76% of all Coastal State Waters.

State Marine Conservation Area (SMCA): This is an area where special restrictions apply (see CDFW regulations on their website) to the commercial and recreational take of marine resources. SMCAs are depicted in blue, and currently constitute 6.52% of all Coastal State Waters.

No-Take State Marine Conservation Area (No-Take SMCA): This area follows the same guidelines outlined by a SMCA, however, agencies are permitted to conduct incidental take and specified activities (example: infrastructure maintenance). No-Take SMCAs are depicted in purple, and currently constitute 0.64% of all Coastal State Waters.

State Marine Park (SMP): This is an area that does not allow commercial take but allows some recreational take. SMPs are depicted in yellow and constitute 0.12% of state waters.

State Marine Recreational Management Area (SMRMA): Areas where restrictions vary on the take of marine resources; for example, hunting waterfowl is permitted, but restrictions apply to the take of other marine life beneath the sea. SMRMAs are depicted in green, and currently constitute 0.08% of all Coastal State Waters.

Special Closure: These are areas where human access to ecologically important sites (such as marine mammal and seabird rookeries) are restricted or prohibited. Special Closures are often seasonal as they follow the annual cycle of marine organisms that utilize the beaches at certain times of the year. Special Closures are depicted in pink, and currently constitute 0.06% of all Coastal State Waters.

Your research efforts will focus on key indicator species. In lieu of performing a detailed ecological survey of every reef we encounter, we will be focusing on the abundance and size distribution of key species and whether they change over time. The techniques you are about to learn are extremely valuable because they can be mastered in a relatively short period of time and be employed by divers like yourself up and down the California coast. This means that you will play an invaluable role in providing data to government agencies such as the CDFW. RCCA data have been used by state and federal agencies for management and resource conservation. One of the most important uses of RCCA data have been the monitoring and evaluation of California's MPA network.

From the beginning, this program was developed with the goal of providing data for California's MPA network. The network was established along the California coast in four regional implementation processes beginning in Central California then moving to the North Central Coast Region followed by Southern California and finally, the North Coast. In each region, a baseline study followed the implementation of the MPAs. During the baseline studies, several monitoring programs would establish the ecological and socio-economic condition at the time when the MPAs were put in place in order to have a reference point to judge the effectiveness of the MPAs in the future. During the first baseline period in Central California, RCCA was just getting started, and the data collected inside and outside of the newly established MPAs in this region were integrated into the MPA baseline as this first study came to completion. In the subsequent regions, RCCA was more established by the time the MPA baseline studies were initiated, and the program was awarded contracts by the state to contribute to the establishment of the baseline conditions of the shallow rocky reef and kelp forest habitat (Freiwald & Neumann 2017, Freiwald & Wisniewski 2015, Freiwald & Wehrenberg 2013).

Following the completion of the network, RCCA has continued to monitor MPAs and their reference sites statewide, as part of California's long-term monitoring efforts. In fact, RCCA is the only citizen science program that has continuously monitored these areas along the entire coastline from the initial implementation of the MPAs in 2007 until now. The information collected during the baseline periods and the subsequent, ongoing long-term monitoring of the MPAs, will serve the state of California for years to come in evaluating and adaptively managing its MPA network to protect and conserve our marine ecosystems.

How to Participate in Reef Check California

The Reef Check California training course is designed to provide participants with the skills required to precisely monitor kelp forests and rocky reefs with the Reef Check California survey protocol. The training program also reviews safe diving practices, techniques of research diving, ecological sampling design, marine ecology, species identification, and discusses how monitoring helps achieve marine management needs. Training includes a combination of classroom (online or in person) and field sessions. Following successful completion of the training, all participants will be issued a Reef Check California Certification and will be eligible to obtain a Reef Check California EcoDiver Specialty Certification through NAUI. Data will only be accepted by divers who have met the minimum testing standards and received accreditation from Reef Check. No prior scientific training is required for participation. However, to be eligible to take this course, you must meet the following course prerequisites:

- Proof of Rescue dive certification
- Minimum of 30 logged lifetime dives
- Minimum of 15 logged dives in California or other temperate region with water temperature below 65°F
- Minimum of 6 dives within the last year
- Minimum age of 16 on the first day of class
- Completion of Reef Check California liability release

- Completion of NAUI liability release
- Completion of NAUI medical waiver
- Completed reading of this Reef Check California Instruction Manual
- Be able to pass swim tests conducted during RCCA training:
    - Swim 100 meters in less than 4 minutes
    - Tread water for 10 minutes, or 2 minutes without the use of hands

Recommended Dive Skills

- Comfortable swimming in and around kelp, both at depth and on the surface.
- Able to keep track of your buddy, your air, and your no-deco time while engaged in other tasks.
- Able to dive in a horizontal position within a foot off the bottom while maintaining proper buoyancy.

The Reef Check California protocol requires that divers successfully perform multiple tasks underwater. Tasks include: hovering motionless near the seafloor (often in an upside down or horizontal position); identifying and counting target organisms and writing these observations on datasheets using a dive slate; and counting "stipes" of kelp plants and recording them on your datasheet. These tasks often require extra concentration underwater and buoyancy control can easily be lost – even for experienced divers. This course is designed for experienced divers who have mastered buoyancy and safe diving practices and are comfortable with their equipment.

Liability

Participants in Reef Check are fully independent individuals who have chosen to follow the Reef Check California survey methodology by their own free will and are entirely responsible for their own safety. All participants must sign the liability waivers before taking part in this volunteer activity.

Reef Check California has been designed to minimize safety risks by limiting dives to a maximum depth of 60 feet (18 m). However, accidents can occur at any depth. Each participant is responsible for their personal safety and their decision to participate in any Reef Check activities.

Diving, boating and related activities present inherent substantial risks to participants, including risk of severe injury and death. Reef Check surveys may take place at a substantial distance from facilities providing medical treatment or rescue services. Every volunteer participant in Reef Check activities is expected to take full personal responsibility for their physical and mental health, insurance coverage, compliance with standard safety rules and every personal decision relating to said activities in which they engage. Only you can decide when and where you dive.

The Divers Alert Network (DAN) is a not-for-profit, worldwide organization developed to improve safety for all divers. DAN offers a low-cost annual insurance for divers to cover medical expenses incurred due to diving accidents experienced in the US and abroad. We highly encourage all of our trainees and volunteers to purchase this insurance to cover costs that are often not covered by personal health insurance. Learn more at dan.org.

California's Marine Environment

Marine Ecology Crash Course

Although science can seem a bit daunting at first, it can actually be a lot of fun! In fact, what you will be doing when employing the Reef Check California protocol is studying the relationship between living things and their environment. This is arguably the most enjoyable branch of the natural sciences, ecology. Understanding the complex relationships between individuals, populations, and their environment requires large amounts of data on many species over long time periods. These time series data are difficult and often expensive to collect, especially in the marine environment where direct observations are difficult to make unless you are scuba diving. These are the types of data you will be collecting as a citizen scientist with Reef Check California.

An ecosystem is the complex of all species and their environment. Our ecosystems of interest are the temperate rocky reefs and kelp forests along the California coast. Stop for a second to imagine all the inhabitants in a California kelp forest ecosystem. Sea lions, California Sheephead, rockfishes, urchins, sea otters and giant kelp may immediately come to mind. Physical processes such as ocean currents, water temperatures and convection of different water masses set the scene for the living communities on California's rocky reefs and kelp forests.

> *"When we try to pick out anything by itself, we find it hitched to everything else in the Universe."* -- John Muir

California's Currents

Unlike coral reefs, which generally only occur in warmer waters, kelp forests are only found in areas with colder, nutrient-rich seas. California's cold water comes primarily from the Gulf of Alaska (Figure 1). A current, known as the California Current, flows generally from north to south throughout the year, but its intensity varies with the season. This current follows the coastline of California during winter and spring. However, there are also times when California's nearshore waters flow northerly. This current, called the Davidson Current, occurs between November and February and is accompanied by southwest winds and warmer waters. Another important current known as the Southern California Countercurrent occurs in the Southern California Bight (the area between Punta Colonet in Baja California and Pt. Conception, California) and may be thought of as a very large-scale eddy in the California Current (Hickey, 1994).

These oceanographic processes lead to the development of two distinct kelp forest communities with warmer water species found in Southern California and colder water species found in Central and Northern California. The biogeographic boundary between these communities is located at Pt. Conception.

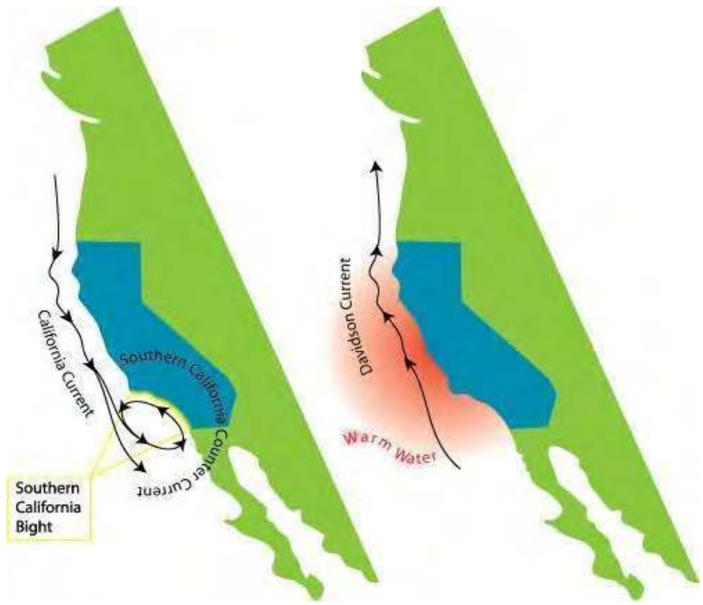


Figure 1: The currents along California's coast help explain the distribution of kelp forests throughout the state. The figure on the left shows the California Current as it moves down the coast and the Southern California Current in the Southern part of the state called the Southern California Bight. The figure on the right shows the direction of the Davidson Current, which can bring warm water along the coast of California in the winter months (Dave Makena Illustrations).

Upwelling

Kelp forests are not uniformly distributed along the California coast. They tend to consistently be found in some places but not in others. This pattern of kelp forest zonation is in large part explained by an oceanographic process known as upwelling. Upwelling occurs when surface waters are pushed away from the coast and are replaced by nutrient-rich cold water from deep ocean areas. In California, upwelling usually occurs as a result of prevailing northwesterly winds and the influence of the earth's rotation pulling surface waters offshore. This surface water is replaced by deeper, colder, and nutrient-rich water that rises to the surface as it replaces the water moved offshore (Figure 2). The closer the deep ocean comes to the shore, such as in the giant canyons along the coast or at points that jut out into deep waters, the more upwelling will occur. In California, the strongest upwelling of these colder waters usually occurs during the spring. Kelp forests thrive in these areas of strong upwelling because the upwelled waters are loaded with nutrients, most of which come from decaying organic matter on the ocean floor (Snyderman, 1998).

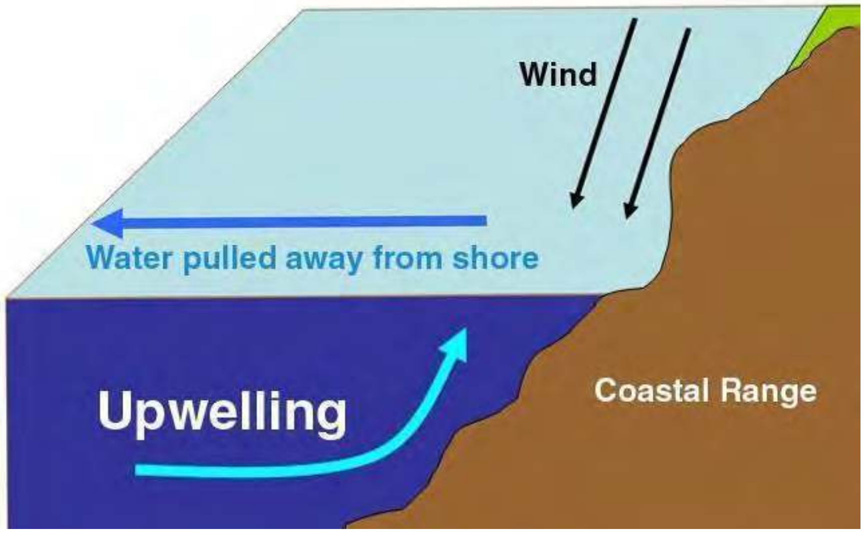


Figure 2: Offshore winds push surface waters away from shore and allow for deeper, nutrient-rich waters to rise to the surface in a process called upwelling (Dave Makena Illustrations).

Kelp Forest Ecology

Across all oceans, kelps grow on temperate rocky reefs creating three-dimensional structures known as kelp forests. Kelp forests are one of the most biodiverse and productive ecosystems in the world as they provide refuge, food, and habitat to fish, invertebrate, bird, and mammal species. In addition, kelp forests can sequester carbon from the atmosphere, create oxygen, dampen wave energy, and alter sedimentation flow, all of which have direct impacts to ecosystem function. Battered by waves and variations in light and temperature, kelp forests are robust ecosystems that can thrive in challenging conditions. Along the California coast, there are two main species of kelp that form forests as they grow from the seafloor to the ocean's surface: giant kelp and bull kelp. Giant kelp (*Macrocystis pyrifera*) is the main kelp species found in Southern and Central California and is a perennial species (meaning it can persist for several years). Bull kelp (*Nereocystis luetkeana*) is found in Central and Northern California. In Northern California, it is the predominant species of canopy forming kelp. Unlike giant kelp, bull kelp is annual (meaning adults live for about a year before reproducing and dying, leaving their spores to repopulate the kelp forest). These forests build the basis of complex ecological communities of fish, invertebrates, mammals and birds as well as many other algal species. For many species, the kelp not only creates the physical structure and habitat in which to live, but it also provides the basis of their food web by acting as the primary producer that, just like plants on land, turns sunlight into biomass. Primary consumers, or herbivores, feed on kelp or other algae and are in turn food for secondary consumers, or predators, which in turn are preyed upon by higher-level predators.

The complex ecological structure and food web dynamics, in which species play different functional roles by creating biomass as primary producers or making dead material available to the community as detritivores, by being prey or predators, provide stability to the community. When the same functions and roles are held by a diversity of species, ecological communities can become very stable against change because if one species is lost (e.g. due to overfishing or an environmental change) another species will take on that role and the system as a whole is preserved. This preservation of the system, in light of a perturbation or impact, is referred as ecological resistance. Another way kelp forest communities persist is called resilience. Resilience describes a community that returns to its original state after it has been changed due to some strong external factor. For example, kelp forests can be disturbed by strong storms, and large areas of kelp can be lost, but they are resilient to this and often grow back after such a disturbance. It may take some time, but typically the kelp beds, and their associated community, return to the same reefs even if most of the kelp was ripped out by huge waves during a storm. Sometimes, though, disturbance can be so strong, or several of them can occur at the same time, that both resistance and resilience are not enough, and the entire system changes to a different state. This is called an ecosystem phase shift, and the community created after this shift looks and functions very differently than the community that existed previously. This new community can in turn become resistant and/or resilient, making the reverse shift to kelp forest unlikely unless there is another strong disturbance.

Another important concept in ecology and conservation is that of ecosystem services. These are services that an ecosystem provides to humans. The 800 plus species that are supported by kelp forests are a thrill to experience, and many feel that this biological wealth is reason enough to conserve these habitats for their inherent value. However, there are also compelling economic reasons to protect these habitats. Rocky reefs and kelp forests, like all large ecosystems, provide us with a host of ecosystem services. These services include obvious benefits such as commercial fisheries; they also form the basis of many recreational fisheries that extract resources from this system and create substantial economic value directly and through associated business such as tourism and local commerce. Activities such as scuba diving, kayaking and other recreational activities are also supported by the kelp forest environment. These ecosystem services are referred to as non-consumptive uses and while they do not extract resources from the ecosystem, they may provide just as much or more value to society.

Ecosystem Services: The conditions and processes through which natural ecosystems, and the species that comprise them, sustain and fulfill human life. "Marine ecosystems provide a constellation of services: they produce food, receive and assimilate wastes, protect shorelines from storms, regulate the climate and atmosphere, generate tourism income, and provide recreational opportunities" (Palumbi et al. 2009).

Food web dynamics, resistance, resilience, and stable ecosystem states are some of the important processes that need to be considered when managing and conserving marine areas. Only through carefully designed studies and long-term monitoring can we understand these processes and ensure that management and conservation actions are ecologically sound and lead to the desired outcomes. In the next section, we are highlighting some of the processes and disturbances that we have observed during RCCA's long-term monitoring program and how kelp forests have changed over that time.

Ecosystem Changes and Long-term Monitoring

Despite the aesthetic and economic value of kelp forest habitats, they continue to be stressed by human pressures. The most immediate human pressures rocky reefs and kelp forests face are overfishing, pollution, and the impacts of global climate change such as rising water temperatures and ocean acidification. RCCA long-term monitoring has captured some of these trends, and below are some examples of types of ecosystem changes and impacts we can only understand if we have long-term monitoring data. These important findings are based on data collected by volunteers that have gone through the same training as you are about to begin.

Sea Star Wasting Disease and Urchin Barrens

In 2013, sea star wasting disease devastated sea star species along the entire west coast (Harvell et al. 2019, Hewson et al. 2014). Consequently, RCCA and others documented the coast-wide decimation of many sea star species. The abundance of sunflower sea stars (*Pycnopodia helianthoides*) and giant spined sea stars (*Pisaster giganteus*) decreased dramatically in 2013 and 2014, statewide. Sunflower sea stars, which can grow up to one meter in diameter and are voracious invertebrate predators on California's rocky reefs, have been all but absent from RCCA sites since 2014 (Figure 3). In fact, we have not seen any recovery of this once abundant predator. In 2020, Reef Check's data were used as part of a successful effort to have sunflower sea stars listed as Critically Endangered on the IUCN's Red List (Gravem et al.).

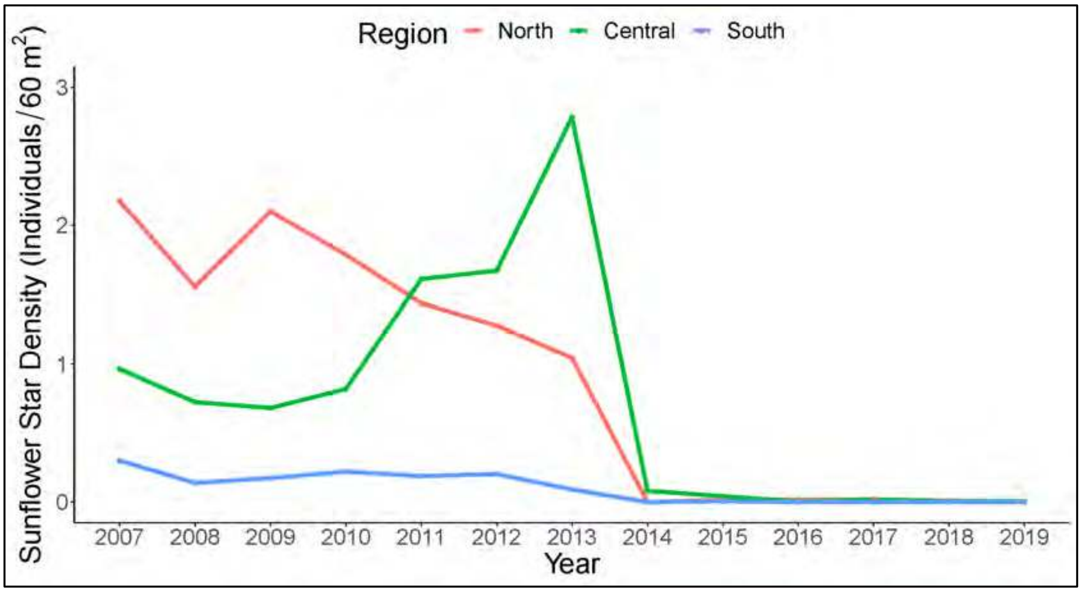


Figure 3: Density of sunflower sea stars observed during annual RCCA surveys by region.

In Northern California, where sunflower sea stars are the main predators of sea urchins, their decline had widespread consequences for the kelp forest ecosystem. At the same time as the sea stars were ravaged by disease, the canopy-forming bull kelp disappeared. It is likely that the unusually warm oceanographic conditions, referred to as the "Warm Blob", followed by an El Niño played a role in the decimation of the kelp (Leising et al. 2015, Peterson et al. 2015). Regardless of the cause, the resulting changes to the community were likely a result of this concurrence. The loss of canopy kelp and sea stars was followed by a sharp increase in purple urchin abundance (Figure 4). This increase in purple urchins led to the formation of urchin barrens. In many places, urchin densities are 100 times greater than they were before the loss of sunflower stars and kelp. This ecosystem change, or as ecologists often refer to it, regime shift, from kelp to urchins, had cascading effects throughout the rocky reef community.

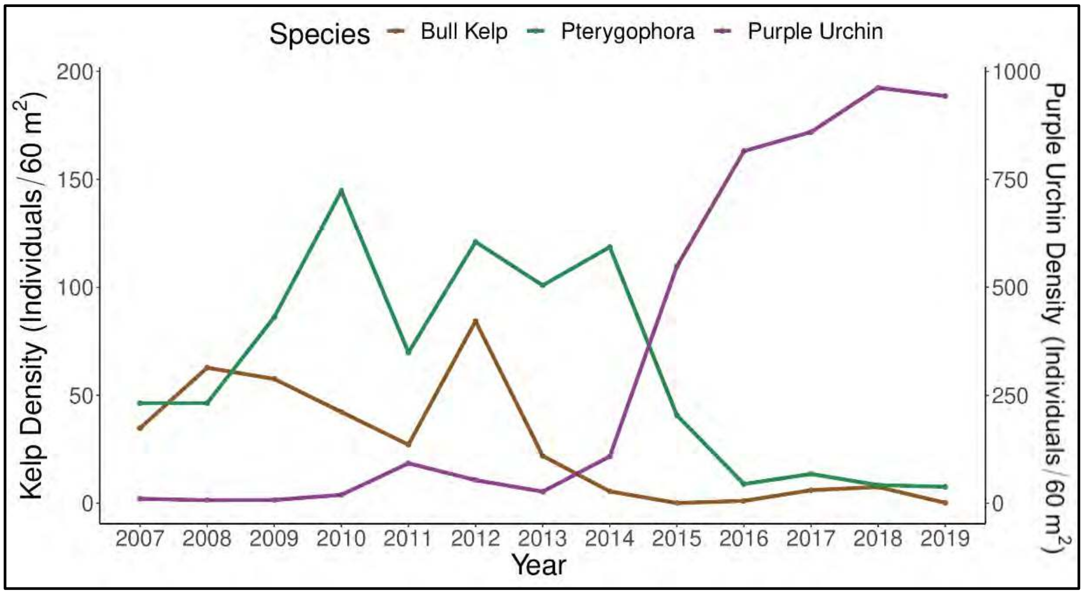


Figure 4: Changes in key kelp forest community species at RCCA sites in Sonoma and Mendocino Counties. While purple sea urchins have increased over 100-fold, kelps have all but disappeared at these sites.

Changes from kelp forests to urchin barrens have been observed in other locations around the world, but they have not been documented along the Northern California coast at this scale. Like urchins, abalone feed on kelp, and the loss of kelp has left the abalone population starving. In contrast to urchins, abalone cannot survive for long when their main food source is lost. Since the disappearance of the kelp and the emergence of urchin barrens, red abalone populations along the North Coast have declined to unprecedented levels (Figure 5). Where there used to be an abundance of abalone, we now see very few individuals, many of whom are showing signs of starvation.

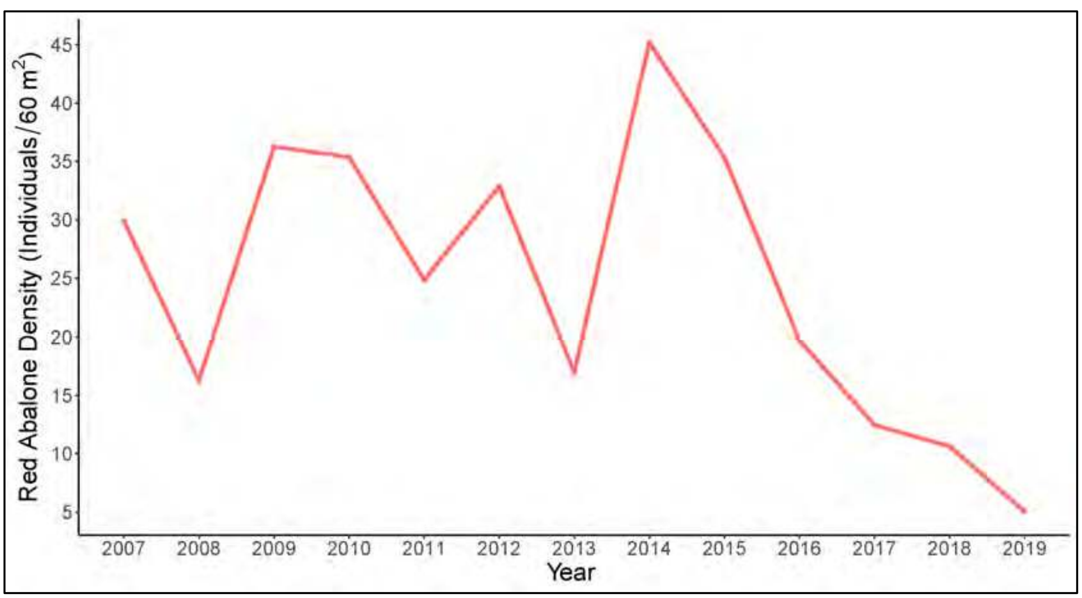


Figure 5: Red abalone densities at RCCA sites in Sonoma and Mendocino Counties.

Because of this decline, the California Fish and Game Commission (FGC) closed the recreational red abalone fishery to reduce additional pressure on the surviving populations. The goal of this drastic fisheries management decision is that the remaining healthy abalone will help the recovery of the population, so that the fishery can be reopened. Several abalone populations collapsed in other parts of the state, and due to a lack of data, management decisions to protect these populations were made too late. None of these abalone populations have recovered to levels seen in the past. Along the North Coast, RCCA volunteers documented the sequence of events and the resulting ecosystem changes. By collecting these data annually and documenting the species that were present, RCCA helped the FGC to make management decisions to conserve the remaining abalone populations in the hope to sustainably manage the last remaining abalone fishery in California.

Kelp Forest Restoration

Urchin barrens can persist for variable amounts of time (years to decades) but given the right conditions can undergo a "reverse shift" back to kelp forests in as little time as a single season. The phase shift from a kelp forest to an urchin barren and vice versa, is contingent on the biological composition of the ecosystem, as well as oceanographic conditions. To create favorable conditions in the ecological community for an urchin barren to shift back to a kelp forest, restoration efforts can manipulate the community by removing species, such as grazers that prevent kelp growth, or even enhance kelp recovery by seeding kelps through outplanting of individuals or by distributing spores on the reef.

Reef Check California is working to restore kelp forest ecosystems by removing urchins from several sites off our coast. Our methods involve removing urchins from predetermined restoration sites by working with recreational divers and/or commercial urchin fishermen. The objective is to reduce the urchin densities below a certain threshold, which will greatly decrease the grazing pressure exerted on juvenile kelps and hopefully lead to the regrowth of mature kelp forests. These restoration sites will serve as "kelp oases", hopefully allowing kelp to repopulate the surrounding areas, provide crucial habitats, and act as a spore bank. Long-term monitoring will be essential in observing the potential recovery of these restoration sites. We need to record whether urchins emigrate back into the sites, if juvenile kelps become established in cleared areas, and how the kelp forest community is responding to these restoration efforts.

Invasive Species and Range Expansions

Another environmental issue that can only be understood by collecting data over long time periods and large geographic scales is the spread of species from their native regions into new areas. These movements of species are referred to as *invasions* or *range expansions.*

Invasions happen through transport of species through the aquarium trade (individuals releasing fish, invertebrates, or algae into the water), or by transport in ballast water from boats or inadvertently carrying them on the hull of their boats.

Range expansions occur when species are able to extend their normal ranges through changing environmental conditions such as warming waters or changing currents due to global climate change. RCCA data have documented both invasions and range expansions of species in California's kelp forest ecosystem.

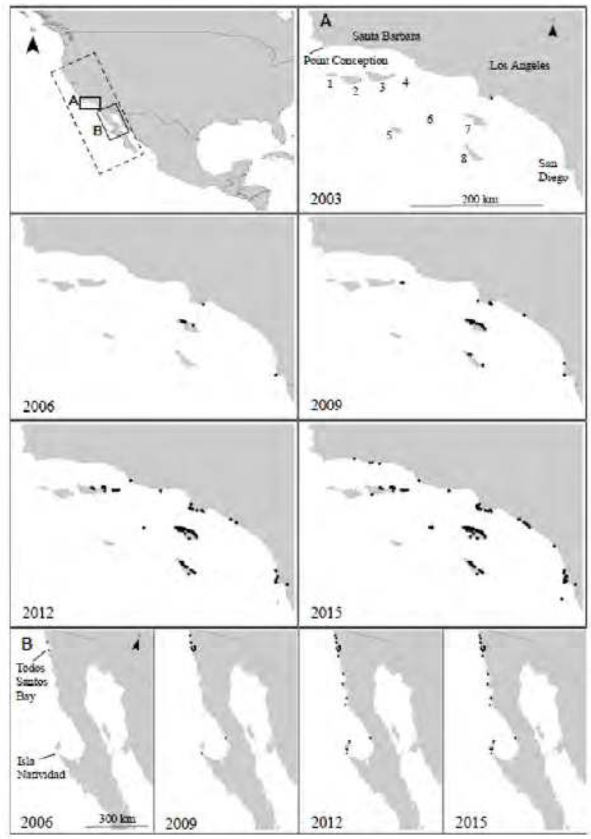


Figure 6: Spread of the invasive seaweed *Sargassum horneri*. Figure taken from Marks et al. 2016.

Invasive Marine Algae, **Sargassum horneri***, Spreading in Southern California*

Native to the west coast of Japan and South Korea, the invasive marine alga, *Sargassum horneri*, was first detected in 2003 near Long Beach, California. Reef Check has been tracking this species since 2006, and the data collected by our citizen scientists were used to document the spread of this invasive species across Southern California and into Baja California, Mexico (Marks et al. 2015). The data showed that the expansion of *S. horneri* is characterized by isolated appearances of the seaweed at nearshore islands and locations along the mainland, followed by the steady expansion into surrounding areas (Figure 6).

The rapid spread of *S. horneri* is likely a combination of both natural dispersal and humans unintentionally transporting individuals. Due to rising ocean temperatures, researchers predict the further spread of *S. horneri* along the Baja coast and northward along the California coast. In response to the rapid spread of this invasive algae, RCCA has revised its monitoring protocol so that we are now recording the amount of *S. horneri* found at each site.

In 2020, an RCCA diver discovered an *S. horneri* individual in Monterey, California. This was the first documented sighting of *S. horneri* growing north of Pt. Conception. Reef Check notified the larger scientific and management communities, and the plant was removed (https://www.reefcheck.org/invasive-algae-sargassum-horneri-found-in-monterey/).

Crowned Sea Urchin Seen in Monterey Bay

In 2016, Reef Check California documented a crowned sea urchin, *Centrostephanus coronatus*, in the kelp forest at the breakwater in Monterey. This subtropical species has a reported distribution range from the Galapagos Islands in the south to the California Channel Islands in the north. In Southern California, they are present in much lower densities than other common sea urchin species but are increasing in abundance (Figure 7). This species has not been reported north of Pt. Conception and therefore this observation in Central California represents a range extension of over 300 km (Freiwald et al. 2016b).

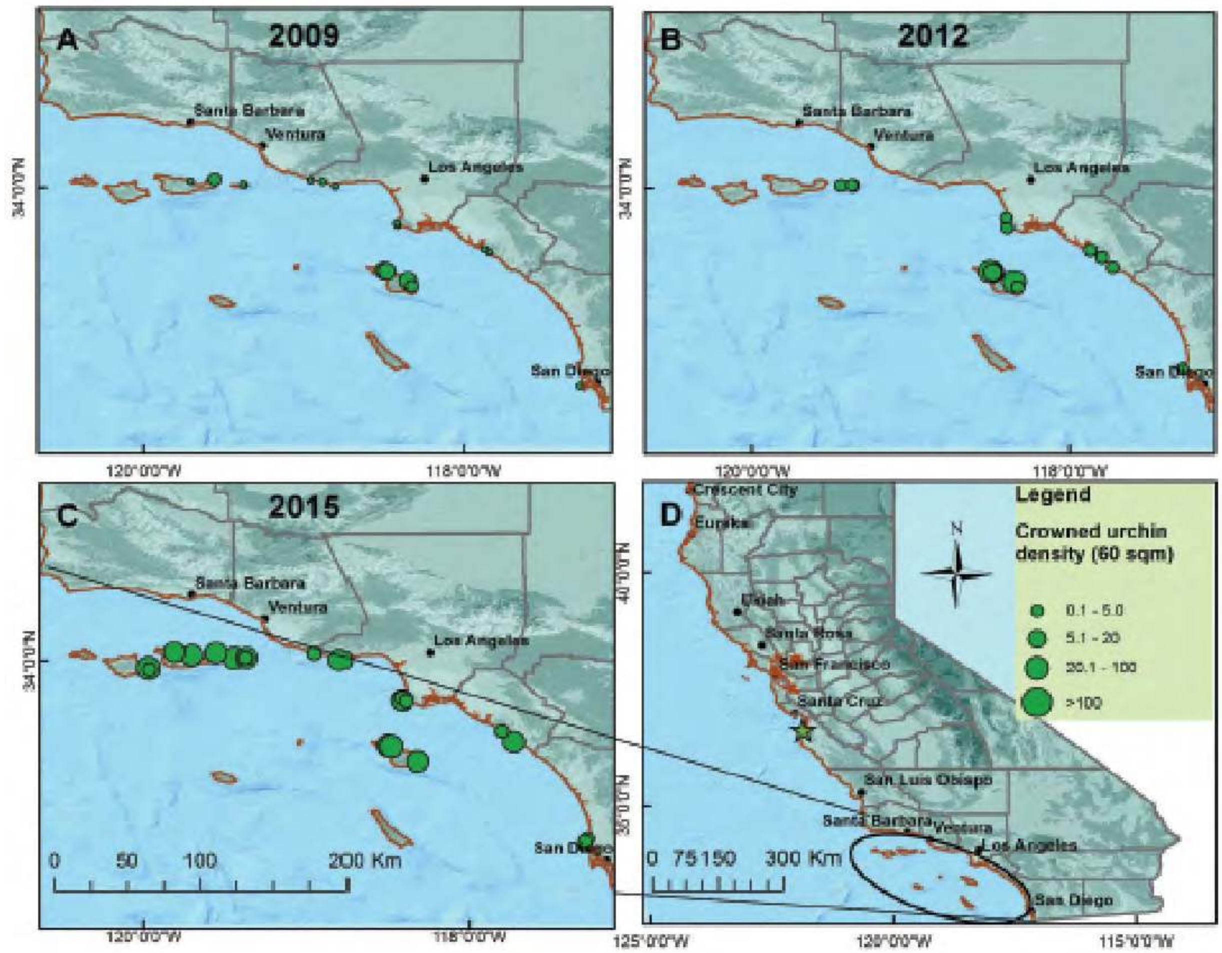


Figure 7: Crowned sea urchin population growth in Southern California (A-C) and observation of an individual over 300km north of historic distributions (D). Figure taken from Freiwald et al. 2016b.

Crowned urchins are one of RCCA's indicator species. Because RCCA's species list is consistent throughout the state, it lends itself to detecting range expansions such as these as divers look for species even outside of their reported historical ranges. In some cases, divers report species that we did not previously include on our species list because they were uncommon along the California Coast. These observations can lead to changes to our survey methods as we add new species in order to track their expanding ranges and the effects they may have on the kelp forest communities.

Rare Species Sightings in California

While Southern species have been observed in Central California from time to time, in recent years, these observations seem to have become much more common in the Monterey/Carmel Bay area. For example, an uncommon fish species was observed in Central California when RCCA divers saw a Finescale Triggerfish (*Balistes polylepis*) sleeping in the sand near a reef along the Monterey Peninsula. A member of the triggerfish family (Balistidae), which is mostly found on coral reefs, the Finescale Triggerfish has been found along the west coast of California (although it is rarely seen in Central California). This fish has recently become more common in Southern California where similar increases in its abundance have been observed after previous El Niño events. Therefore, RCCA has added this fish species to its species list and is now recording it if seen anywhere during a survey.

Another species that has become increasingly common in Southern California is the Largemouth Blenny (*Labrisomus xanti*). This species' historical range (from outer Baja Peninsula south to Southern Mexico) expanded northward into California, and it was first reported near La Jolla Cove, San Diego in 2015 (Love et al. 2016). Now they are common at Santa Catalina Island and are being seen throughout Southern California. RCCA has added Largemouth Blennies to its species list and is now documenting their densities and potential range expansion in Southern California and statewide.

In short, long-term monitoring is required to obtain an accurate picture of the state of California's rocky reef ecosystems and the ways in which they are changing. These ecosystems are affected by many factors, anthropogenic and natural, and only detailed studies over large geographic scales and long time periods will be able to document and help understand these changes to the rocky reef and kelp forest ecosystem. The data generated from Reef Check California surveys will paint a clearer picture of the state of the ecosystem and help detect trends that are emerging. This information will help determine what management and conservation actions should be taken and help evaluate the success, or failure, of management in the future.

Chapter 4

Scientific Survey Methods

The Intricacies of Data Collection

Scientific surveys are used to characterize the natural environment by making estimates of reality. A survey is a sample of a population or community that is done in a standardized fashion in order to describe the observed population or community in a scientific way. This could be done by counting every individual and every species in the ocean. This type of survey is called a census (e.g., the national census that is done every 10 years in the US). Obviously, this is unrealistic in the ocean and we must use another method to estimate the true nature of a population or community. This is done by taking samples. Samples are counts of parts of a population in order to say something about the entire population. The scientific survey method ensures that these samples are taken in a way that allows inferences about the population or community as a whole to be made - often using statistics.

Several factors influence how well we can make predictions about a population or community based on our samples. Some of these factors are addressed in detail below: variability, replication, and accuracy and precision.

Variability

Imagine if your RCCA team went out and counted the number of Kelp Bass observed along a 30 m x 2 m area of reef inside an MPA and another Reef Check team surveyed the same sized area outside the MPA. Would you expect the difference in the number of fishes counted inside and outside of the MPA to be enough to determine whether the MPA had an effect on Kelp Bass abundance? Consider all the factors: What if there were more fish inside the reserve to begin with? What if you happened to sample one of the sites just after a group of divers came through the area and scared away the fish or perhaps attracted fish with food? What if the two areas have different environmental conditions that are not related to the MPA at all? Before diving into the intricacies of the Reef Check California methodology, it is worth considering the potential causes of error in our sampling. Let’s consider the example of counting Kelp Bass once more, but just concentrate on the data collected within the MPA.

One factor we need to account for is temporal variability. That is a term for the fact that if we are sampling the exact same site, at different times, it is likely that we will get different counts of the same species because ecosystems are not static, and individuals move around. Another factor would be spatial variability. Just as the timing of your survey can influence your results, the location of the survey can have an influence as well. Your survey might be deployed in a location that causes you to swim through a large school of fish, or, alternately you may have positioned yourself so that the same school will swim right behind you.

Another cause of variability is observer error. Sometimes you will miss a few individuals, and other times you might count some that are outside of your survey areas (i.e. 30 m x 2 m area). In addition to mistakes, there is something called observer bias. Bias is when a certain observer always counts either more or fewer individuals than other observers. Most samplers are going to introduce a certain amount of biases into the overall data set.

Our goal in providing you with a rigorous training in Reef Check California methodology is to standardize the data collection procedure as much as possible. That will minimize the observer error and observer bias and reduce the variation between each survey. Furthermore, as you go through the standardized Reef Check California training, your data collecting technique will be calibrated to insure the least amount of error possible. This is an integral part of your training and will allow you to correct your biases.

Replication

At this point you may be asking, "Even if we do end up doing our best to account for the differences in spatial variability, temporal variability and sampling bias, isn't there still going to be too much variability in our data to say anything meaningful?" In a word, the answer is replication. In statistics, replication means having replicate observations of the same condition. Replication is essential because biological systems are inherently variable, and replication adds information about the reliability of the conclusions or estimates to be drawn from the data (Quinn & Keough, 2002). As you begin to learn the Reef Check California survey methods, you will see that we have incorporated numerous replicates to try to minimize the error in our estimates associated with spatial and temporal variability.

Precision vs. Accuracy

The goal of any sampling program is to be both precise and accurate. Although used synonymously in everyday speech, the two terms are technically quite different. Accuracy is the closeness of an estimated value to its true value; precision is the closeness of different replicates to each other (Sokal & Rohlf 2001) (Figure 8). For example, assume that the true number of Kelp Bass on a reef is 25. Your first day of training you perform three replicate surveys yielding counts of 10, 25, and 40, giving you a mean number (average) of 25 Kelp Bass. This would be a highly accurate sample, but one that is not precise. Now imagine that you go out one hour later, repeat the same surveys, and tally 39, 40, and 41 Kelp Bass, giving you a mean of 40. This sample would be precise because all your numbers are very similar, but not accurate, as the average of those numbers does not reflect the real number of Kelp Bass (25). Finally, imagine that you perform the same three surveys after your Reef Check California training and count 23, 25 and 27 Kelp Bass, yielding an average of 25. This estimate would be both accurate and precise.

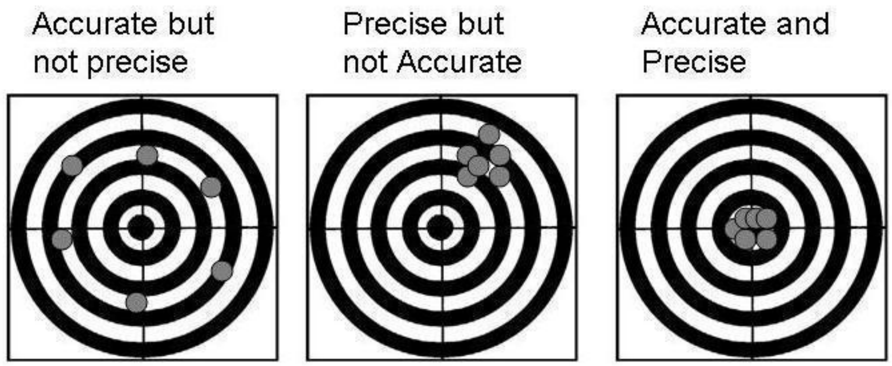


Figure 8: Example of precision and accuracy.

General Sampling Methods

Whether we are performing investigations ashore, at sea, or on the moon, the scientific method can be employed. Every study will be conducted with metrics. Metrics are systems or standards of measurement. These metrics are collected by sampling the population or community. Samples need to be taken in a standardized way and there are several common practices of taking samples and important metrics in ecology. Reef Check collects several different metrics to monitor kelp forest species and communities. Each of these require different methods. We collect density and percent cover data using transects, and size frequency and presence/absence data without the use of transects but employing measurement tools or estimation.

Density

Density is defined as the number of individuals of a species over an area. A transect is one way to sample the density of a population. A transect is a line or strip across a surface along which a survey is conducted. To sample density, all individuals must be counted along the transect over a predefined area and/or reef. That means the transect has to be of a defined length and width, basically demarcating a rectangular area of reef in which individuals are counted. This type of transect is referred to as a band transect and is one of the main ways in which RCCA counts species of fish, invertebrates and algae. Density can be used for all species for which it is easy to define an individual. While it may sound strange at first that there are species for which we cannot define individuals, there are many cases in the marine environment where it is impossible to identify them. For many sessile invertebrates or algae that form crusts on the rocky reef, it is impossible to define where one individual ends and where the next one begins. Later in this manual, we will often refer to band transects simply as transects. You will learn about fish, invertebrate, and algae transects; all of these are band transects.

Percent Cover

Estimation of percent cover is a way to measure species that occupy space on the rocky reef but for which it is difficult to identify individuals such as encrusting algae or sponges. Transects can be used to measure percent cover of these species. In contrast to density, percent cover is not measured over an area. Rather, it is a relative measure of how much space is occupied by one species compared to others. Therefore, it is expressed as a percentage of space occupied by a species or species grouping. To estimate percent cover, the data are collected at specific points along a transect and a certain number of points are sampled in order to generate a percentage of points that are occupied by a given species or feature of interest. Reef Check uses Uniform Point Contact (UPC) surveys along a transect to estimate percent cover of species, as well as of certain substrate types. UPC surveys are designed so that samples are recorded at uniformly spaced points along the transect.

For both density and percent cover estimates to be representative of the reef, it is important to deploy the transects that are used to generate these metrics in a thoughtful way. RCCA deploys random transects that are laid haphazardly (i.e., as close to random as possible) within predetermined depth zones at each site. This is called a randomly stratified sampling design. Random transects help to minimize bias by distributing transects over the sampling area. Another advantage is that the data from several randomly placed transects may provide a more representative picture of the whole reef area as opposed to fixed transects. This only holds true when enough transects are conducted to account for spatial variation on the reef, so that this variation can be distinguished from the temporal differences that are of interest. A key element to successfully implementing random transects is unbiased transect placement. Predefined compass headings and starting points can be used to help minimize bias of random transects. Deploying random transects in different depth zones (i.e. stratified) ensures that the entire reef (or most of it) is sampled. This helps to account for differences in the ecological community at different depths across a reef from the shore to the offshore edge.

Presence/absence

Presence/absence data are one of the simplest ways of describing species or communities but can be very important in some cases. It is what it sounds like: a record of a species being present or not. This metric is useful for rare species that might only be seen when swimming over a large area, but not often enough to be counted along narrow transects. RCCA uses this metric for rare or endangered species because the chance of seeing an individual is greater if we look for it everywhere rather than just along our transects. This is also a good metric for invasive species because even a single observation of an invasive species can be very important, as it might need immediate mitigation measures (i.e. removal).

Size Frequency

Size frequency data estimate the size distribution of individuals in a population. Rather than counting, this requires a record of the sizes of individuals. This can either be done by using a measuring device such as a caliper or tape meter, or by estimating sizes of individuals. If no measurement device is used, this is one of the most difficult tasks during RCCA surveys and requires a lot of practice. RCCA does size frequency surveys for several invertebrate species, such as sea urchins and red abalone, which can be measured. RCCA also collects size frequency data for fish for which the sizes need to be estimated. When enough individuals are sized, this method will provide a size distribution of individuals in the population. Size frequency surveys can be done along a transect or without a transect, and they can provide important information about a species. Often size is related to age, and age structures can be estimated based on size-age relationships. Certain patterns in size distributions can also be used to say much about the fishing pressure on exploited species, as fishing practices leave very discernable patterns in a population's size structure. For example, in many species that are in danger of being overfished, large size classes are missing, as large individuals are usually targeted by fisheries. Size structures of populations can also be used to estimate when recruitment (or birth) of individuals were great and in which years populations had recruitment failures. When size data are collected along transects, and in combination with density, the biomass of a population can be estimated based on the number of individuals and a weight to size relationship. Biomass per area is a very important metric in evaluating the effects of MPAs.

Bringing together the above metrics allows us to describe kelp forest communities, identify trends in their populations and make many inferences about their status, level of exploitation, and effectiveness of conservation. To do this, we combine these metrics, generate derived parameters, and use statistics to evaluate what we have observed using the survey methods that you are about to learn. In addition to these metrics, we also collect other data using video recordings and oceanographic sensors to generate a visual documentation of the ecosystem and to study environmental factors affecting it, respectively.

Video Recordings

RCCA is increasingly using video transects to document the reef community at sites that are surveyed. Video transects can be conducted in many different ways. They can be quantitative and be used to count individuals to estimate population densities when the area that is recorded along a video transect is well defined. Often lasers that point onto the reef and are a known distance apart are used to get accurate size estimates of the area surveyed and to estimate sizes of organisms recorded. The counting and size estimations are done after the survey is completed, and the video is replayed back on land. The benefit of this type of transect is a permanent record of the transects that can be reexamined in the future. But post-processing of video transects is very time intensive, and depending on the visibility and type of habitat, sometimes difficult to count or identify all targeted organisms within the transect area. Video transects can also be qualitative, meaning that they are not used to estimate densities or sizes of species, but they are used to document a general ‘picture’ of the reef community at the time of the survey. This approach can be very useful when unprecedented changes are detected long after a survey program was initiated. Because they produce a permanent record, we can go back and look at the video to see species that we might not have counted initially, but that we are interested in for some reason.

Sensors

Sensors are a way to monitor the underwater environment and can record an almost endless number of parameters. Typically, these are physical parameters such as: waves, tides, currents, or chemical parameters such as: temperature, salinity, dissolved oxygen, or pH. Other sensors record biological parameters such as chlorophyll concentrations or abundance of organisms. Sensors can be placed in the ocean, in situ, or be remote (i.e. satellites that are monitoring the ocean from space). They use electric, chemical, sound and light properties to collect information about the ocean environment. Compared to surveys, which are always a snapshot of an environment or a community, sensors have the benefit of being deployed over long time periods and recording continuous information, or information at very short time intervals. That way they can provide a very detailed picture of ongoing processes and changes to the ocean environment or populations. RCCA uses temperature, dissolved oxygen, and pH sensors to monitor the effects of climate change along the California coast. These sensors are installed permanently at survey sites and can be serviced by volunteers after they receive additional training beyond the RCCA monitoring protocol.

Scientific Integrity & Ethical Concerns

As mentioned earlier, the data you collect plays an integral part in informing marine management in California. It is imperative that it is collected in the most unbiased way possible. While it may be tempting to "fudge" the data in order to serve a personal agenda (no matter how noble), in the long run, it will only distort the decision-making process.

Be forewarned - marine sampling involves quite a lot of zeros. Even among experienced scientists, there is a temptation to record a species observed just outside the transect boundaries. As a Reef Check California diver, you must exercise restraint when confronted with such a situation. Remember, our goal is to minimize variability between individual samplers. Therefore, we must ensure everybody is using the exact same methodology. Zeros in your data are not a bad thing, but representative of the ocean environment. The long-term trends are much more important than a single survey. Organisms not falling within transect boundaries can be recorded in the comments section but must not be recorded in the data reporting fields.

In the remainder of this manual, you will learn the methods to scientifically sample the rocky reef and kelp forest environment using the Reef Check California survey protocol. Once you complete the training, you will be tested and will be allowed to contribute data to the RCCA dataset only for the types of transects that you have shown proficiency in. To maintain data submission eligibility, all divers must complete yearly recertification dive training as well as complete the online quizzes.

Chapter 5

Reef Check California Survey Methods

Many different types of data are collected during Reef Check California surveys.

Survey Overview

All Reef Check California surveys include:

- **Site Description** (1 per site). Anecdotal, observational, historical, geographical and other data should be recorded on the Site Description Form. These data are extremely important when we interpret correlations in Reef Check California 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 assures that data comparisons will be made between similar reef settings (see Conducting Reef Check California Surveys, Chapter 7).

- **Invertebrate Transects** (6 transects, 36 taxa). Divers search for and record target invertebrate species along six 30 m x 2 m transects. Target invertebrates are found only on the bottom.

- **Kelp Transects** (6 transects, 11 species). Divers count seven target kelp species (and one invasive algae *Sargassum horneri*) along six 30 m x 2 m transects and note four invasive algal species as present or absent anywhere on the site.

- **Uniform Point Contact Transects (UPC)** (6 transects). Divers characterize the substrate by sampling 30 points at 1 m intervals along the tape. At each point, divers contact the substrate and record three types of information: the reef substrate (e.g. sand or reef), what organism is living on the substrate, and the rugosity (variation of vertical relief) of the reef.

- **Fish Transects** (18 transects, 35 species). Divers search for and record the 35 target fish species observed along a transect 30 meters long, 2 meters wide and 2 meters high.

In total, there are 36 transects at each site: 6 core transects, each consisting of a fish, invertebrate, kelp and UPC along the same transect tape; and then 12 additional fish-only transects.

Supplemental data collected during some Reef Check California surveys:

- **Urchin Size Frequency** (1 per site). Divers measure the test diameter to the nearest centimeter of 100 to 300 urchins per species using calipers. This survey is not associated with a transect but should occur in the immediate vicinity of other transects. This survey is only done in areas of great urchin abundance.

- **Abalone Size Frequency** (1 per site). Divers measure maximum shell diameter to the nearest millimeter of red abalone using calipers on a roaming survey not necessarily associated with a transect. These surveys are only conducted north of the Golden Gate where there was a recent abalone fishery.

- **Video Transects** (Multiple per site). Divers collect video while conducting their fish transects. This video is archived for later analysis should the need arise.

- **Ongoing Temperature Monitoring** (Most sites). Temperature loggers have been deployed at the majority of RCCA sites. These loggers sit on the bottom year-round and record the water temperature every 15 minutes. Divers retrieve these loggers, and deploy new ones, every 6 to 12 months.

- **Ongoing pH Monitoring** (6 sites). At six sites, larger instrument arrays have been deployed to record additional oceanographic information including pH, dissolved oxygen, and salinity. These instruments need to be retrieved by divers roughly every three months so that their data can be downloaded, and the instruments can be calibrated.

Site Selection

Site selection is a critical factor in the success of your surveys. The ultimate goal of Reef Check California is to monitor rocky subtidal communities once per year along the entire mainland and island coasts. Initially, priority was given to monitoring sites inside and on the periphery of planned or existing MPAs and at sites recommended by CDFW. Monitoring sites will be selected based on a variety of factors including, but not limited to, logistics, accessibility and presence of volunteer teams. In addition to the criteria listed above, teams are encouraged to adopt their “favorite” dive site as a monitoring location.

For the purposes of Reef Check California, a site is defined as 250 linear meters of coastline unless distinguished by distinct geological features (e.g., a bay). When selecting sites, it is helpful to first map the area of interest. This will help identify the best places to deploy transects. Due to the importance of long-term monitoring, preference should be given to sites that teams anticipate they can revisit year after year.

With all site selection, however, it is important to remember that a survey is only a sample of the rocky reef environment. The site selected for the survey should be representative of the reef area of interest. For purposes of standardization, surveys of steep walls (drop-offs), pinnacles, and reefs predominantly located in caves or beneath overhangs should be avoided.

Most sites are targeted to be surveyed once per year, with some sites surveyed twice per year (in spring and fall). Ideally surveys are completed in one day of diving, though it is perfectly acceptable to spread the diving out over several days, as long as all transects are completed within a four-week time period to minimize temporal variation associated with that survey.

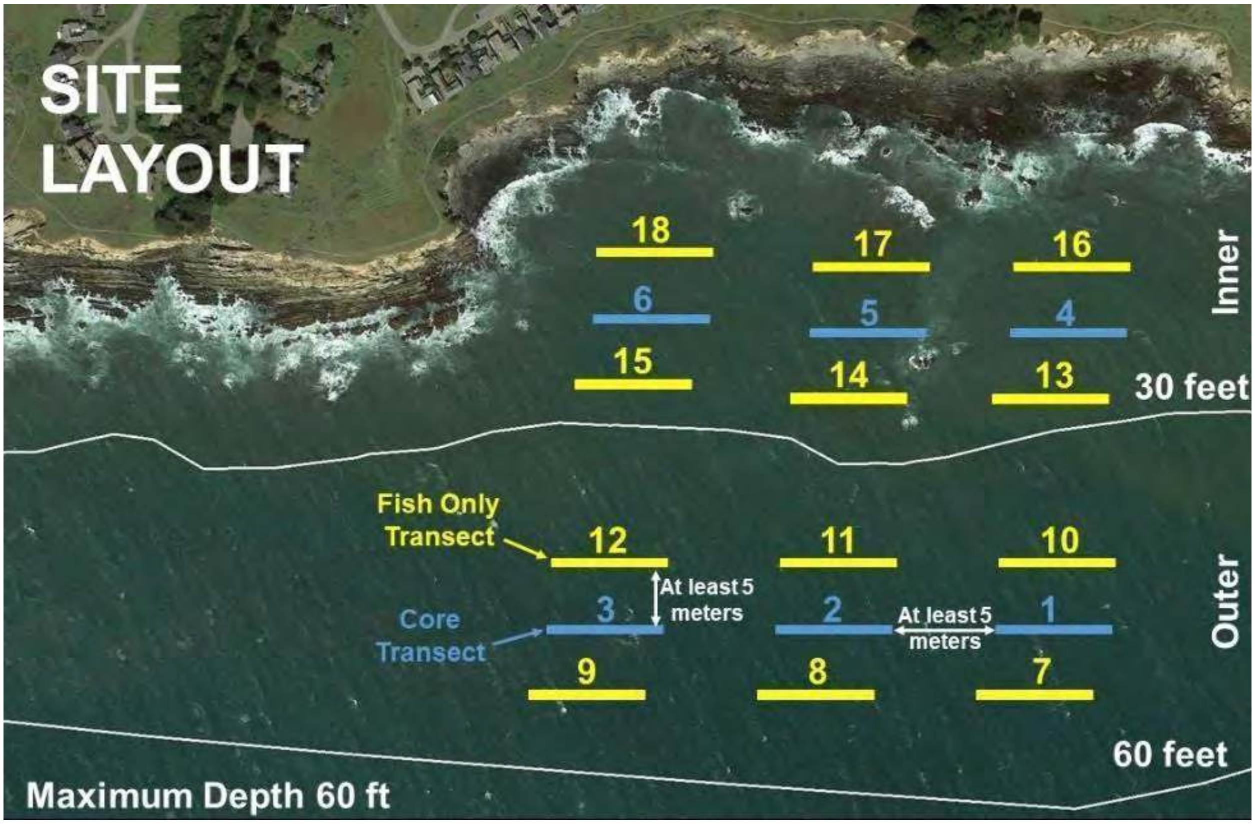


Figure 9: Diagram of transects over a rocky reef. All teams should aim to complete six core transects, which are marked in blue (3 in each zone), plus an additional twelve random fish-only transects, which are marked in yellow (6 in each zone). All transects are 30 meters in length.

Deploying the Transects

For a long-term monitoring program, it is critical that we use the same protocols to collect data from year to year. At each site, we collect data across 6 core and 12 fish-only transects (Figure 9). Half of these transects are located closer to the shoreline (inshore), while the other half are located offshore (usually in deeper water). Core transects are numbered 1 – 6 with the outer transects numbered first as 1 – 3 (deeper dive first) and the inshore core transects numbered 4 – 6. Fish-only transects shall be numbered 7 – 18 with the offshore fish only transects numbered 7 – 12 (deeper dive first) and the inshore fish only transects numbered 13 – 18. Due to logistics and safety, reef habitats deeper than 18 m (~60 feet) will not be sampled. Zones were created to help allocate samples across an entire site providing a representative sample.

Transects are deployed either by divers while simultaneously collecting fish data or by divers prior to collecting invert, kelp, and UPC data. Each transect should follow a predetermined compass heading at a designated depth based on the topography of the site and previous surveys. Relying on headings reduces bias that could occur from divers selecting their own course (for example, avoiding or heading towards large schools of fish).

Transects can be laid one after another on small reefs, however, the transect start and end points must be separated by a minimum of a 5 m gap. There should also be a minimum of 5 m spacing between transects (i.e., all transects should have spacing of 5 m on all sides). These 5 m gaps are necessary to ensure independence between samples (replicates).

Our mission is to survey rocky reefs, so it is important to keep the transect on the reef (rock or cobble substrates). The transect should stay predominantly on rocky substrate and not cover more than 10 continuous meters of sand. Additionally, because the distribution of organisms can vary significantly with depth, large pinnacles and drop-offs should be avoided. Each individual transect should be deployed at a somewhat constant depth, ideally, plus or minus 5 feet of the starting depth.

The predetermined compass heading can be altered or ignored to maintain a 5 m distance from other transects, to stay on rocky reef, or to avoid drastic changes in depth (Figure 10). In some situations, the transect may have to twist and turn along the reef to follow all the guidelines above. It may be necessary to wrap the transect tape around kelp stipes or hold the tape down with rocks to make the transect line as stationary as possible for the divers conducting other types of surveys on that transect. In some cases, it may not be possible to redirect the tape. Therefore, the transect will need to be terminated and redeployed at a better location.

Staying 5 m from other transects	>	Staying on reef	>	Staying in depth zone	>	Following compass heading

Figure 10: Order of importance of guidelines when laying a transect tape from greatest to least.

Minimum visibility

Reef Check California surveys require at least three meters (~10 feet) of visibility in order to identify, count and measure fish effectively. Divers may need to measure the visibility to determine if it meets this requirement. To perform a visibility check, one diver stays stationary while holding the free end of the tape in one hand and holds out their other hand (preferably wearing a black glove) away from their body with their fingers spread wide. The other diver takes the reel end of the tape and swims away until they can no longer make out the individual fingers on their buddy's hand. The visibility measurement is the furthest distance that each individual finger can be clearly made out. Water clarity can change at different depths and throughout the day. Therefore, it may be necessary to conduct a visibility check multiple times on a survey by each buddy team.

Core Transects

For each of the six core transects, four different types of data will be collected:

1. Fish (can be separate)
2. Invertebrate
3. Kelp
4. UPC

Generally, a fish transect is completed as the tape is deployed and all four transect types are conducted on the same line, but the fish transect can be collected separately for logistical or safety reasons. However, the other three transect types (kelp, invertebrate, and UPC) must be completed on the same line before the transect is finished. If all three transect types cannot be completed on a dive, for example if someone runs low on air, the dive team can leave the transect tape in place, send up a Surface Marker Buoy (SMB), and return to the transect tape on a subsequent dive to complete the data collection. Alternatively, they can scrap the core transect, roll up the tape and return later to repeat the data collection on another dive. It is important to discuss which approach should be taken if the dive needs to be ended before data collection is completed.

There are many acceptable ways for a buddy pair to allocate the tasks to complete a core transect. However, safety is the number one concern when conducting Reef Check surveys, so the allocation of tasks should be planned so that the divers always remain in contact with their buddy.

For example, in Figure 11, one diver conducts a fish transect while the other diver follows on the first pass, which generally takes about five minutes. Then they both turn around and while one diver conducts an invert transect, the other conducts a UPC transect. Both of these transects tend to take about the same amount of time (roughly 15 minutes) so pairing these two transect types makes it easier for divers to stay together. Finally, on the third pass, one diver collects kelp transect data while the other either just follows as a buddy or helps with counting kelp by counting some of the species of kelp.

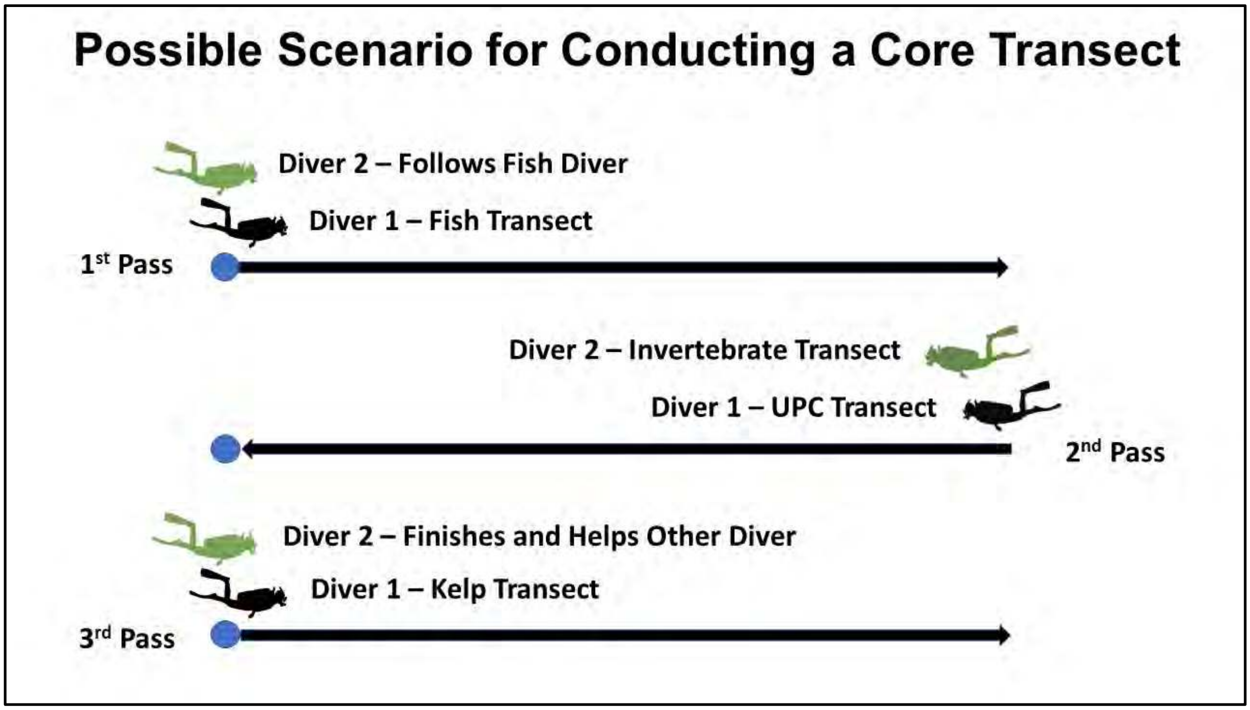


Figure 11: Example of a dive plan to complete a core transect where divers are always in close buddy contact.

There are many other ways to allocate tasks on RCCA dives, and there have been many creative solutions to completing the transects while maintaining good buddy contact, including dividing up some of the species on an invertebrate transect (like urchins) or dividing up a UPC with even and odd points (just make sure it all ends up on the same datasheet!). How you divide up the tasks will depend on both the proficiency of the dive team (how fast each diver is at conducting the different transect types) and variation of the survey site. A site in an urchin barren will require a different strategy then one in a lush kelp forest with several different species of abundant kelp. Keep in mind, no matter how you divide up the tasks, you will have to swim the line three times (or some other odd number) so that you end up on the far end to roll up the tape. Lastly, it is often necessary to alter your plan if the conditions in the water do not match what was predicted on the surface. A diver may need to pause, or even abandon, data collection to maintain contact with their buddy even if it results in the transect not being completed. Safety is always more important than data collection.

Invertebrate Transect

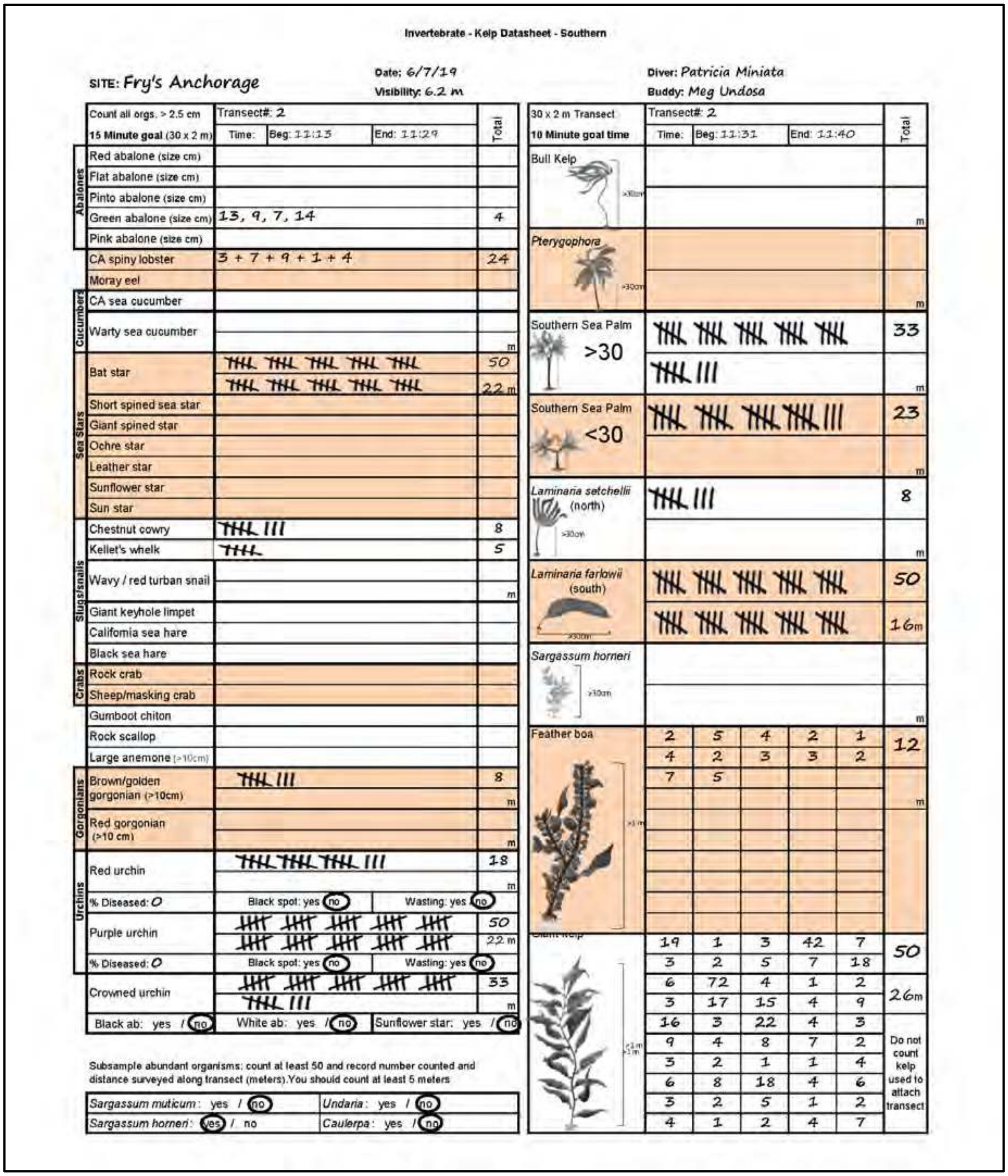
Individuals of the RCCA invertebrate species list are recorded along a two-meter-wide (one meter on either side of the transect line) and 30-meter-long transect. Therefore, the total survey area is 30 meters x 2 meters, equaling 60 square meters for each transect. Invertebrates are counted if any part of their body is in the survey area. It is key that divers are calibrated to these measurements so that everyone counts the same area. Starting and ending times should be recorded on the datasheet in the appropriate locations. There is no time limit for an invertebrate transect; however, they should be performed with a 15-minute goal in mind.

The invertebrate transect is a thorough search of the ocean floor for RCCA indicator species, many of which can be small and/or cryptic. Buoyancy is key as invertebrate surveying is most easily performed when the diver adopts a slight face-down, feet-up position roughly 1-2 feet off the bottom. Flashlights are used to scan for invertebrates and look in cracks and crevices. All RCCA surveys are non-invasive, so it is also important not to move any rocks or organisms during a survey, thereby leaving the reef as you found it.

All invertebrates have a minimum size requirement of 2.5 cm (roughly an inch) except anemones and gorgonians. Anemones must be at least 10 cm tall or wide, while gorgonians must be at least 10 cm tall. All abalone are measured, and their maximum shell length is recorded to the nearest centimeter, except for red abalone surveyed north of San Francisco's Golden Gate Bridge which are recorded to the nearest millimeter. If you can't physically measure an abalone, record "X" on your datasheet for the appropriate species.

Due to their endangered status, white abalone, black abalone, and sunflower sea stars are recorded if they are observed anywhere during the survey (on or off transect). If you believe you see an individual of any of these three species, do as many of the following as possible: check for ID confirmation from your buddy; record whether or not it is on transect; take a photo if possible; and mark the location with an SMB (Surface Marker Buoy) so GPS coordinates can be taken from the surface.

At the end of each survey dive, all data should be examined for clarity, and the total for each invertebrate species should be placed in the box to the right of the line associated with each species. See Figure 12 for an example of how to record data on the invertebrate datasheet.



Invertebrate - Kelp Datasheet - Southern

SITE: Fry's Anchorage   Date: 6/7/19   Visibility: 6.2 m   Diver: Patricia Miniata   Buddy: Meg Undosa

Count all orgs. > 2.5 cm / 15 Minute goal (30 x 2 m)	Transect#: 2 — Time: Beg: 11:13 End: 11:29	Total
Red abalone (size cm)		
Flat abalone (size cm)		
Pinto abalone (size cm)		
Green abalone (size cm)	13, 9, 7, 14	4
Pink abalone (size cm)		
CA spiny lobster	3 + 7 + 9 + 1 + 4	24
Moray eel		
CA sea cucumber		
Warty sea cucumber		m
Bat star	卌 卌 卌 卌 卌 / 卌 卌 卌 卌 卌	50 / 22 m
Short spined sea star		
Giant spined star		
Ochre star		
Leather star		
Sunflower star		
Sun star		
Chestnut cowry	卌 III	8
Kellet's whelk	卌	5
Wavy / red turban snail		m
Giant keyhole limpet		
California sea hare		
Black sea hare		
Rock crab		
Sheep/masking crab		
Gumboot chiton		
Rock scallop		
Large anemone (>10cm)		
Brown/golden gorgonian (>10cm)	卌 III	8 / m
Red gorgonian (>10 cm)		m
Red urchin	卌 卌 卌 III	18 / m
% Diseased: 0	Black spot: yes / (no) — Wasting: yes / (no)	
Purple urchin	卌 卌 卌 卌 卌 / 卌 卌 卌 卌 卌	50 / 22 m
% Diseased: 0	Black spot: yes / (no) — Wasting: yes / (no)	
Crowned urchin	卌 卌 卌 卌 卌 / 卌 III	33 / m
Black ab: yes / (no)	White ab: yes / (no)	Sunflower star: yes / (no)

Subsample abundant organisms: count at least 50 and record number counted and distance surveyed along transect (meters).You should count at least 5 meters

Sargassum muticum: yes / (no)	*Undaria*: yes / (no)
Sargassum horneri: (yes) / no	*Caulerpa*: yes / (no)

30 x 2 m Transect / 10 Minute goal time	Transect#: 2 — Time: Beg: 11:31 End: 11:40					Total
Bull Kelp (>30cm)						m
Pterygophora (>30cm)						m
Southern Sea Palm >30	卌 卌 卌 卌 卌 / 卌 III					33 / m
Southern Sea Palm <30	卌 卌 卌 卌 III					23 / m
Laminaria setchellii (north) (>30cm)	卌 III					8 / m
Laminaria farlowii (south) (>30cm)	卌 卌 卌 卌 卌 / 卌 卌 卌 卌 卌					50 / 16m
Sargassum horneri (>10cm)						m
Feather boa (>1 m)	2	5	4	2	1	12
	4	2	3	3	2	
	7	5				m
Giant kelp (<1m / >1m)	19	1	3	42	7	50
	3	2	5	7	18	
	6	72	4	1	2	26m
	3	17	15	4	9	
	16	3	22	4	3	Do not count kelp used to attach transect
	9	4	8	7	2	
	3	2	1	1	4	
	6	8	18	4	6	
	3	2	5	1	2	
	4	1	2	4	7	

Figure 12: Example of invertebrate and kelp transect sheets (combo sheet). Note how all species are tallied and the totals written to the right of each transect. When species were subsampled, the number of organisms counted, and the distance traveled on the transect is also recorded to the right of each transect data table.

Kelp Transect

Reef Check kelp indicator species are counted along the same two-meter-wide and 30-meter-long transect used for the invertebrate survey. Starting and ending times should be recorded on the datasheet in the appropriate locations. There is no time limit for kelp transects, however, they should be done with a 10-minute goal in mind.

Kelp individuals are counted if any part of their holdfasts (the rootlike structures that attach the kelp to the reef) are in the transect area. Only kelp attached to the substrate are counted, drift kelp is not counted. Kelp plants that are used to fasten the transect tape at the start of the survey (see below) are not counted.

For giant kelp and feather boa kelp, the number of stipes ("stems") per individual holdfast is recorded. See Figure 12 for an example on how to record data on the kelp transect datasheet. Counting giant kelp and feather boa stipes should be done one meter off the bottom of the holdfast and can be easily accomplished by gathering up all stipes and running one's fingers through the kelp stipes counting as you go.

Most of the kelps have a minimum size of 30 cm. Giant kelp and feather boa must be at least one meter tall to count. Southern sea palm has two size categories, one for greater than 30 cm, and one for less than 30 cm, and are only counted if you can place your thumb between the "v" at the top of the stipe.

Four species of invasive algae are recorded as "present" or "absent" anywhere within the survey site (on or off transect) no matter what size they are. Special attention should be given to *Undaria* and Caulerpa, which can spread fast but can, potentially, be controlled if detected early enough. It is important that if you find one of these species, that you do not try to remove it yourself. These algae can sometimes be spread during removal and need to be handled by trained individuals.

Subsampling on Transect

In some situations, there are very large abundances of particular species. In these cases, rather than counting all of the individuals along the entire transect tape (which could be very time consuming), a smaller area can be counted as long as these two rules are followed:

1. At least 50 individuals **and** 5 meters are counted.
2. Both the number of individuals counted and the distance along the tape surveyed are recorded.

For example, if the fiftieth bat star was counted at the 10-meter mark on the transect, the diver could stop counting and record 50 as the total and 10 meters as the distance. However, if they were working backwards along the transect line (starting at 30 m and working towards the 0 m mark) and the fiftieth bat star was counted at the 10-meter mark, the distance would be 20 m instead of 10 m. It is always ok to count more than 50 individuals and it is very important that all individuals are counted in the area surveyed and recorded. For example, if there are 49 bat stars at 9 meters, and another 20 between 9 and 10 meters, it would be recorded as 69 bat stars at 10 meters.

Any of the kelp or invertebrates can be subsampled with a few exceptions. Abalone are never subsampled. Giant kelp and feather boa plants can be subsampled, but not stipes. A plant with 100 stipes is just one plant. All the stipes on each plant must be counted, and there must be at least 50 plants to be able to subsample. *Sargassum horrneri* can be subsampled at less than five meters, but at least 50 plants must be counted. Finally, subsampling applies only to kelp and inverts; fish are never subsampled.

Uniform Point Contact (UPC) Transect

The purpose of the Uniform Point Contact Survey (UPC) is to characterize the habitat in which the organisms we count during the other three transects live. Unlike the other three transects, in which we are searching areas for organisms, for the UPC transect we are going to look at 30 points (one at each meter mark) and record what is at that point. To do this, you will swim along the transect tape stopping at each meter mark, put your finger on the reef, and record what is at the exact spot you touch. When you put your finger on the reef, it is imperative that you don't look at where you are putting your finger down, because if you do so, you will bias the survey by selecting the point you touch. To prevent this, close your eyes or look away each time you put your finger down to select a point. At each point, three types of data are recorded:

Substrate: This describes the physical structure of the seafloor and is largely based on the size of the rocky material your point is on.

Cover: Describes the type of organism growing on the substrate at your point.

Relief: Describes the rugosity or vertical relief of the reef around your point.

For the three data categories above, the UPC datasheet provides 30 boxes, one for each meter mark along the 30-meter transect (Figure 22). For each category, there are several codes that specify what is seen at a point. You will record the category codes in the appropriate column on the datasheet. Upon completion of the dive, you will tally up the number of each of the codes in the totals area of the datasheet. Double check to ensure that your substrate, cover and relief categories each add up to 30. There's no time limit for a UPC transect, so no matter how long it takes to complete the survey, on each UPC transect you will end with 30 points of data for each of the three categories.

Substrate

Substrate is simply determined by the size of the object your point lands on, and is divided into the following broad categories:

S - Sand/Silt/Clay (< 0.5 cm)

C - Cobble (0.5 cm – 15 cm)

B - Boulder (> 15 cm – 1 m diameter)

R - Reef (> 1 m diameter)

O - Other (anthropogenic, etc.) any size

These categories are determined by measuring the widest dimension of the object directly under your finger at each point. For example, a rock that is half a meter wide, but 1.2 meters long is considered reef since its largest dimension is greater than a meter. Sometimes the above categories can be different than what we normally think of on land. The key is not to make subjective judgments and instead simply measure and categorize. For instance, a rock that's a little over 15 cm wide would not be thought of as a boulder on land, but for our purposes it's categorized as a boulder. Likewise, a large round rock just over a meter wide could be considered a boulder, but for our purposes it is reef. There are some cases when the substrate type may be ambiguous, such as a rock buried in sand where you are unable to see the entire rock. In these cases, you will have to do your best to make an unbiased assessment. The last category, "Other," is for anthropogenic objects like pipes, or shipwrecks that were put there by humans.

For the sand substrate category, many times (especially in Southern California) sand will come and go on the reef depending on wave action and storm events. Therefore, it is important that when your point lands on sand, that you dig your finger down into the sand at least knuckle deep to ensure that it is truly sand and not sand covering reef. If your finger does find reef, sweep the sand away to expose the reef before determining the cover category.

Table 2: Uniform point contact (UPC) cover categories.

N = None	
Algae	**B = Brown kelp holdfast** (holdfast of kelp on band transect)
	OB = Other Brown algae (including invasive algae and feather boa)
	G = Green algae
	R = Red algae
	E = Encrusting red algae
Coralline Algae	**AC = Articulated Coralline**
	CC = Crustose Coralline
Invertebrates	**SI = Sessile Invertebrate** (sponges, anemones, sandcastle worm etc.)
	MI = Mobile Invertebrate (sea stars, snails, urchins, cucumbers etc.)
SG = Seagrasses (including surfgrass and eelgrass)	

Cover

Cover is determined by recording what is directly under your finger at each point, and is divided into the following categories (Table 2):

None

Record "N" for none if there is nothing living on the substrate at your point. However, before you record "None", make sure nothing is there. In the ocean, rock is valuable real estate, so if your point falls on rock, there is generally something living there (even if it doesn't look like it at first). Sometimes a layer of brown detritus covers everything, so try waving your hand to blast water on it to see if there is something underneath. Take your flashlight out and look closely as the cover may be very small. A brown nondescript layer could be a small brown turf alga growing on the rock, so pinch it and tug to see if it's attached; if it is then you record it as "Other Brown algae" (see below). Unless you are on sand or the rock clearly looks clean, you should investigate thoroughly before recording it as “None”.

Algae

There are hundreds of species of algae that grow along our coast, with a vast range of morphologies. Fortunately, for the UPC transect, we do not have to learn all the different species, but instead we just divide them up into five categories based primarily on color. **Brown kelp holdfast (B)** is only the holdfast of one of six large kelps that we count on our kelp transect (bull kelp, giant kelp, Southern sea palm, *Pterygophora, Laminaria setchelli,* and *Laminaria farlowii).* All other brown algae should be recorded as **Other Brown (OB)** including feather boa kelp, *Sargassum muticum*, and *Sargassum horneri*. **Green algae (G)** are really green, like grass, and not greenish-brown (which would be categorized as Other Brown). **Red Algae (R)** has red pigment and sometimes appears purplish. **Encrusting Red Algae (E)** is red algae that grows like paint on a rock and is deep red or burgundy colored.

If the point falls upon any part of an alga (blade, stipe, holdfast), it should be recorded. This rule applies to all algae except for kelp. If the point falls on any part of the kelp species listed above, you move it aside and count what’s directly under it. Kelp is only counted as cover on the UPC transect if your point lands directly on the holdfast. Then you would record the cover as “B” (Brown Kelp Holdfast). Algae that is not attached to the substrate, or drift algae, should be moved when encountered to determine what is attached to the reef below. When long blades of algae are encountered on your point, it is important to determine if they are attached to the reef (accomplished by giving a gentle tug). If they are attached, they will be counted, and if they are not attached, they will not be counted. Low profile, fuzz-like growth that you cannot physically grab and remove from the substrate should be disregarded and you should record the dominant feature below it. If the fuzz-like growth is significant enough to grab a piece from the substrate and the color can be determined, record it in the appropriate category.

None

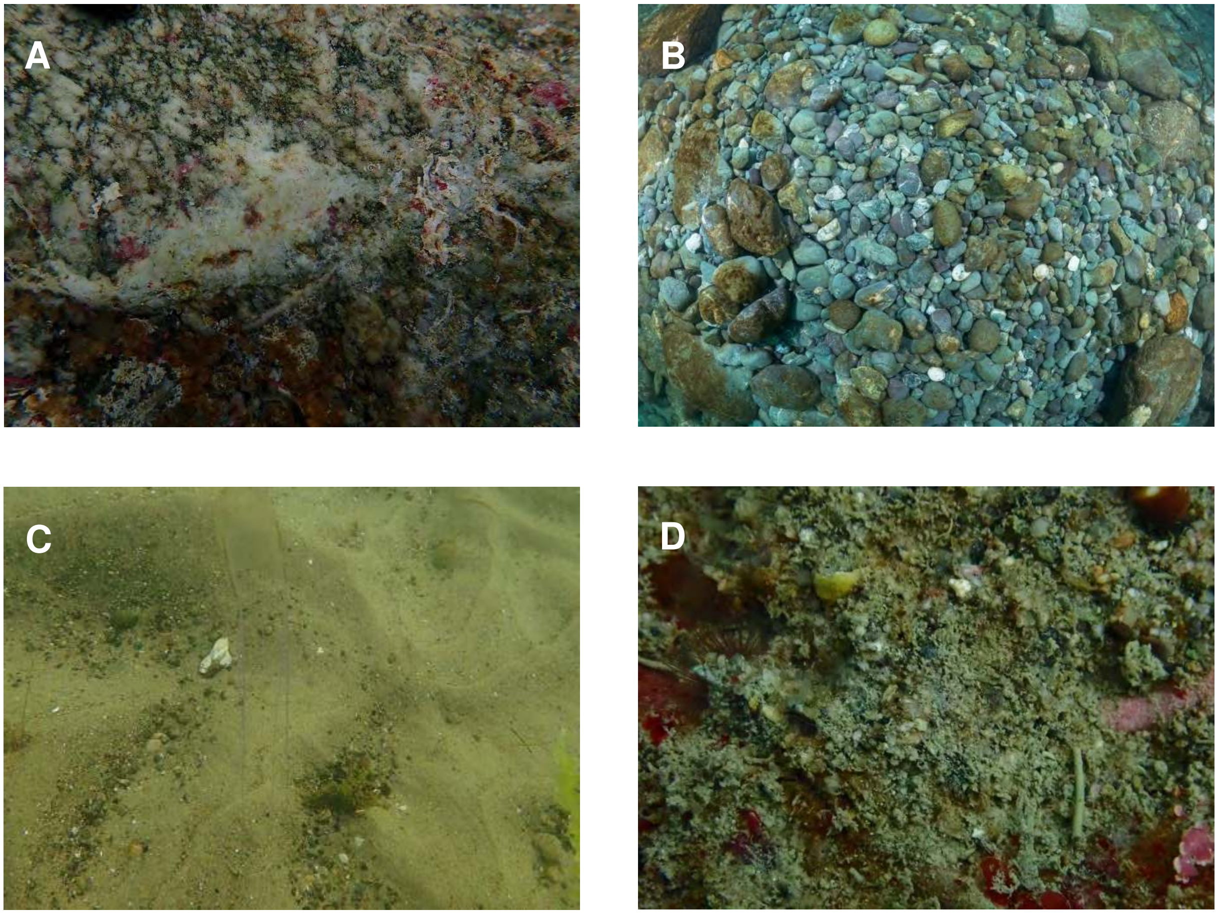


Figure 13: Examples of the UPC cover category "None": A) Bare rock (Selena McMillan); B) Bare rock/cobble (Kate Vylet); C) Sand (Selena McMillan); D) Brown fuzz (Selena McMillan). The brown fuzz in this photo would **not** be categorized as "None" but would need to be examined closely, and if attached, could be either algae or sessile invertebrates (e.g., hydroids, other brown algae, etc.).

Algae

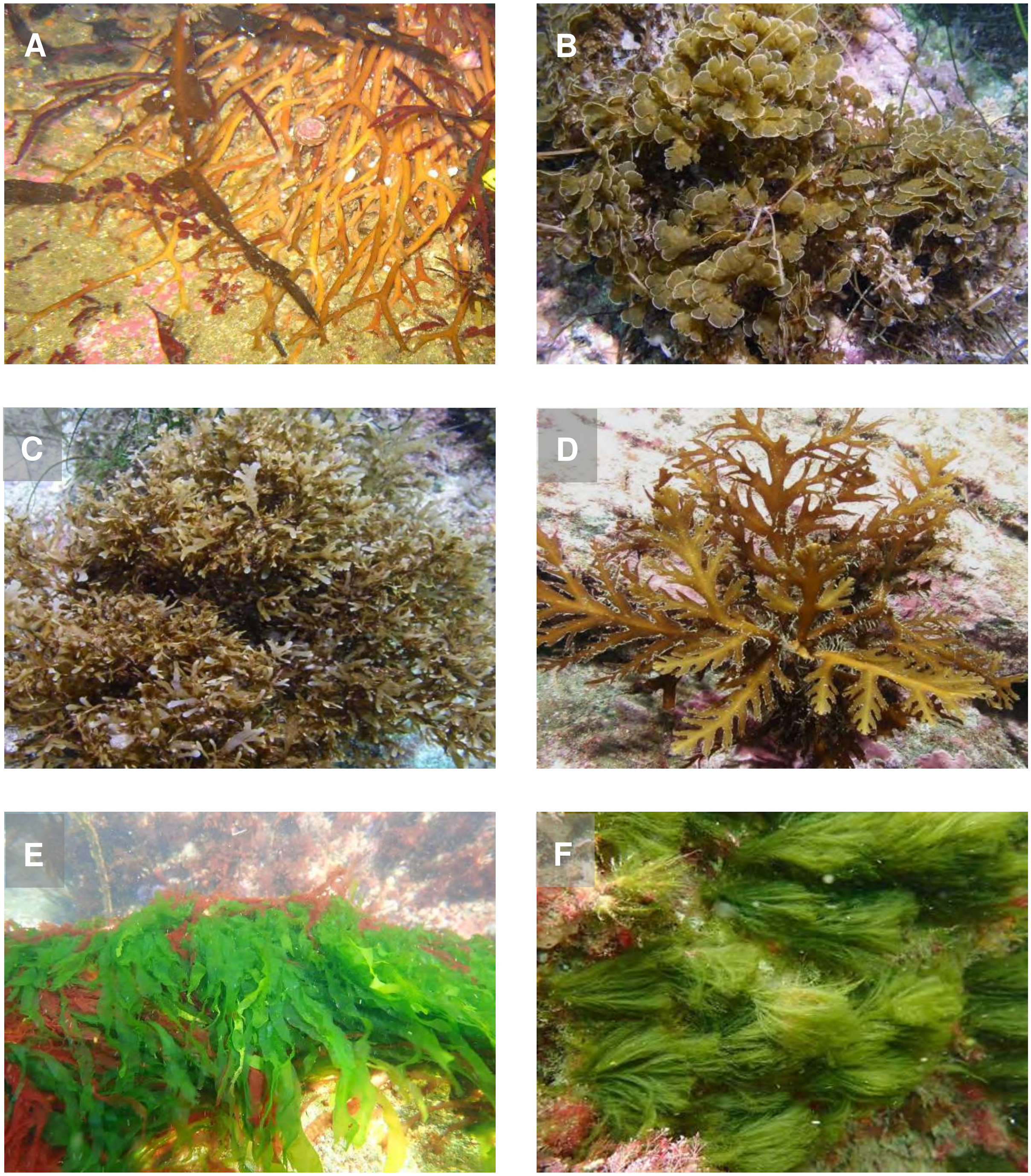


Figure 14: Examples of the Reef Check California UPC cover categories, Brown: A) Giant kelp holdfast; Other Brown: B); C); D); and Green: E); F) (All photos Selena McMillan).

Algae – continued

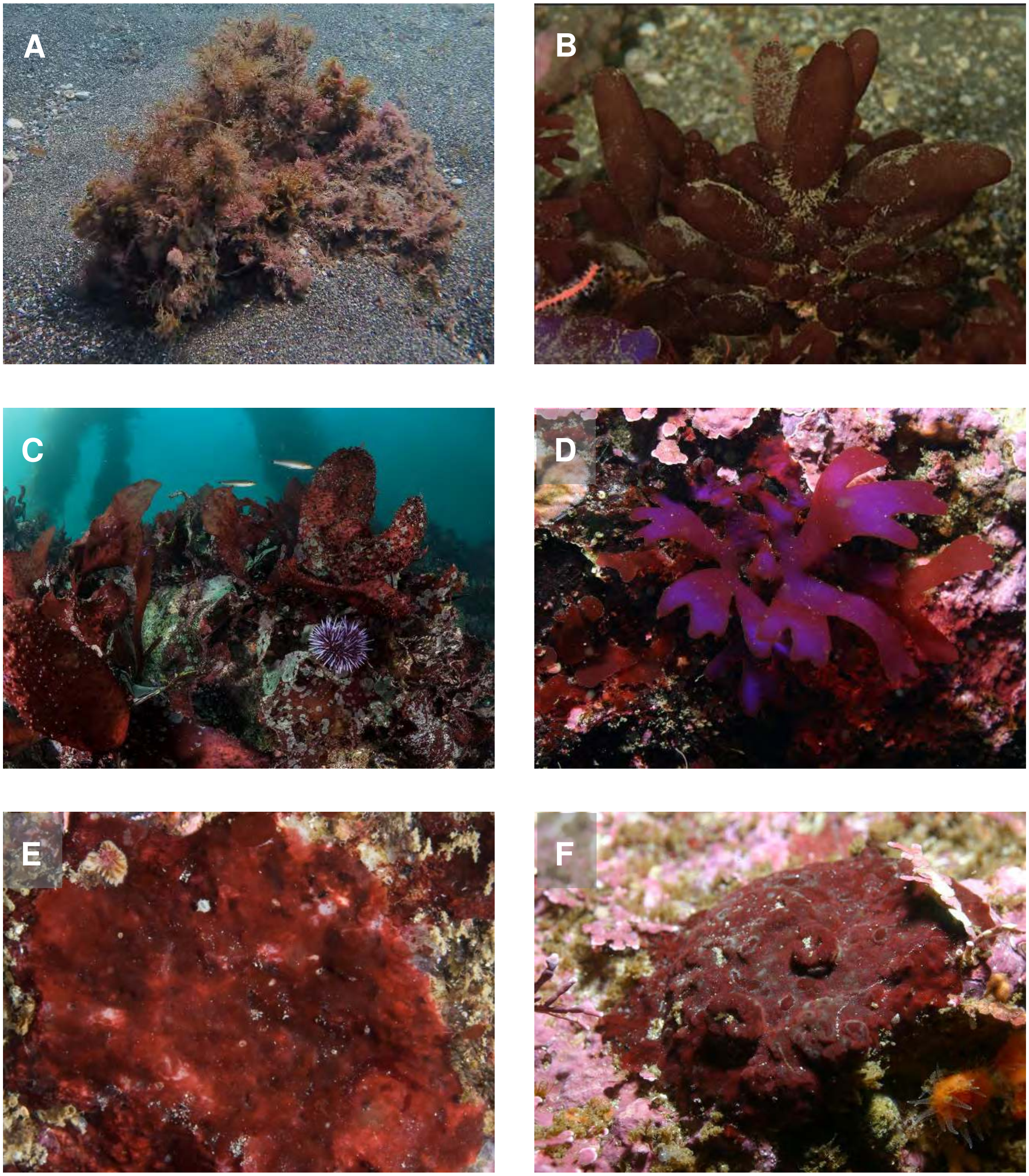


Figure 15: Examples of the Reef Check California UPC cover categories, Red: A) (Selena McMillan); B) (Phil Garner); C) (Kate Vylet); D) (Steve Lonhart); and Encrusting Red: E) (Kate Vylet); F) (Steve Lonhart).

Coralline Algae

Coralline algae can be distinguished from the other algae because they are pink, hard and crustier than the other algae. The two categories of coralline algae can be distinguished by their growth forms. **Articulated coralline algae (AC)** looks like little pink branching plants. They are crusty yet flexible due to softer sections between their harder, calcified sections. **Crustose coralline algae (CC)** looks like a pink lichen that has grown on the rock, or even like bubble gum that someone stuck onto a rock and flattened. Crustose coralline algae have a similar growth pattern as the encrusting red algae, both are common and they can even grow next to each other, but they can be easily distinguished as the former is pink while the latter will be a deep burgundy red.

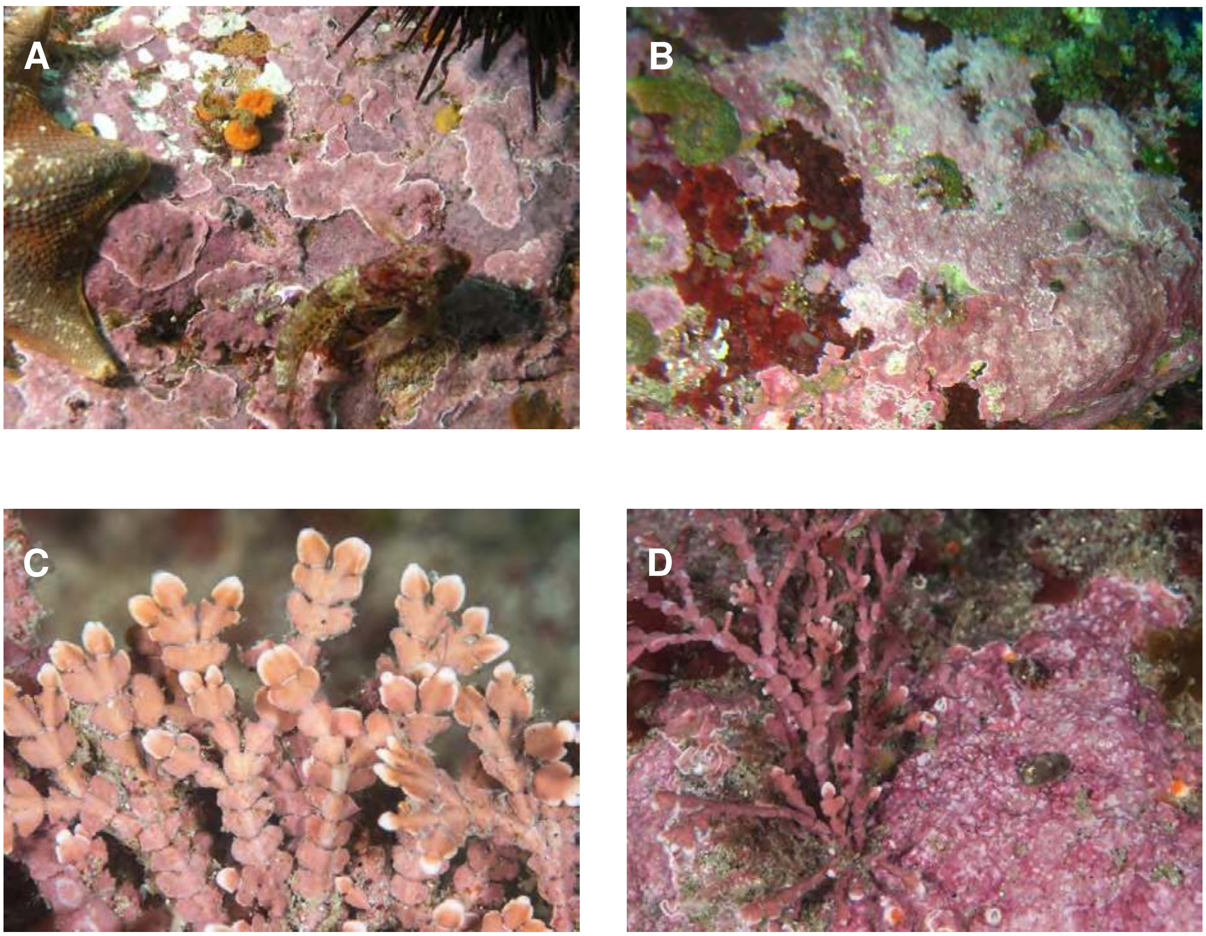


Figure 16: Examples of the Reef Check California UPC cover categories Crustose Coralline: A); B) crustose coralline algae intermixed with red encrusting algae; and Articulated Coralline: C); D) Articulated coralline algae growing next to crustose coralline algae (Kate Vylet).

Invertebrates

There is a vast number of invertebrates with a huge range of growth forms that live in our nearshore environment. We separate all these organisms into two categories: either **Mobile Invertebrates (MI)** for invertebrates that move around on the ocean floor, and **Sessile Invertebrates (SI)** for ones that are physically attached to the substrate. Mobile invertebrates tend to be things we are familiar with such as urchins, sea cucumbers, sea stars, abalone, and other organisms we count on the invertebrate transect. Sessile invertebrates are a huge category that includes organisms such as rock scallops, barnacles and anemones, as well as many others that are hard to distinguish or generally unfamiliar to most people like tunicates, sponges, hydroids, or bryozoans. If you don't know what something is, it's likely a sessile invertebrate.

Mobile Invertebrates

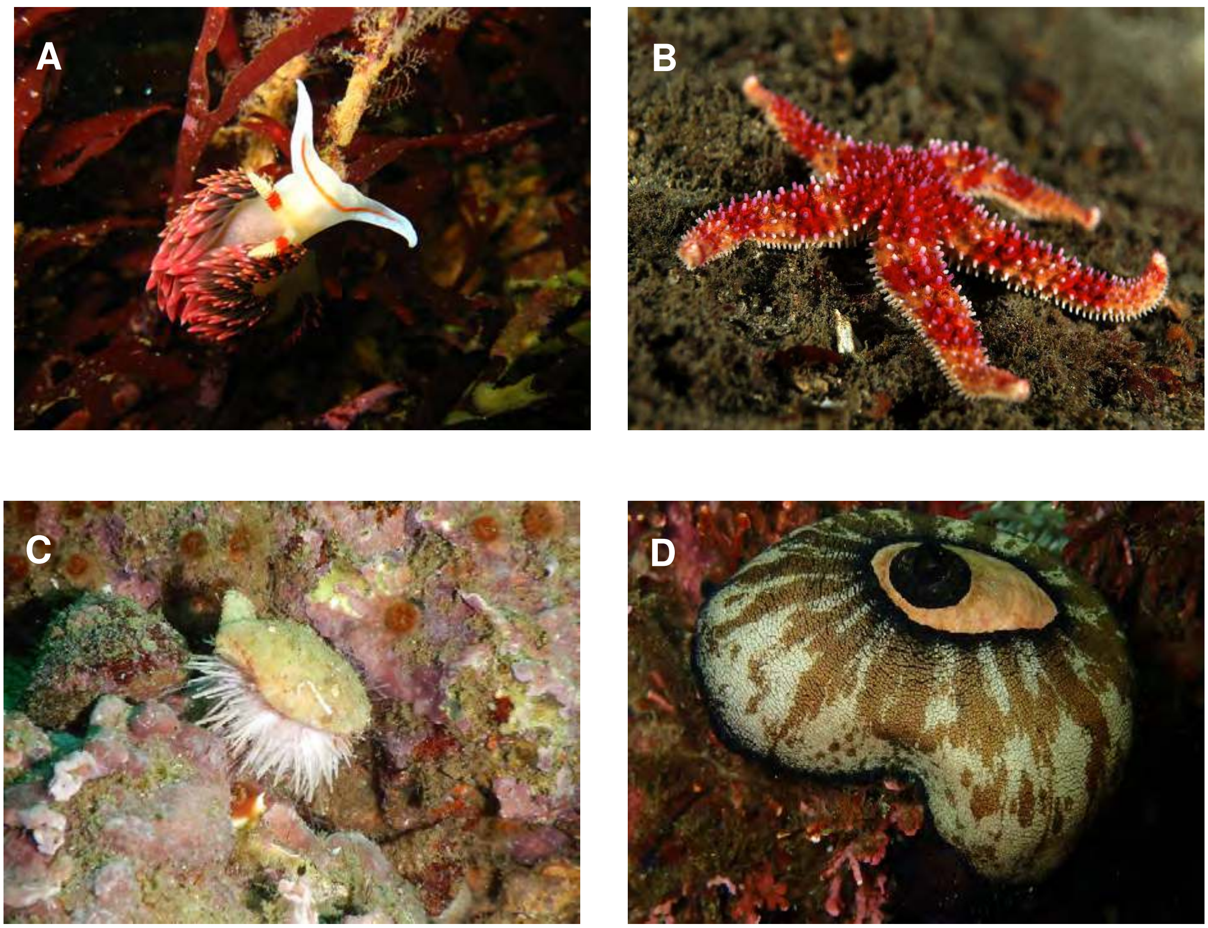


Figure 17: Examples of the mobile invertebrate UPC cover category A) Hilton's aeolid (Selena McMillan); B) Rainbow sea star (Phil Garner); C) White urchin (Selena McMillan); D) Keyhole limpet (Andrew Harmer).

Sessile Invertebrates

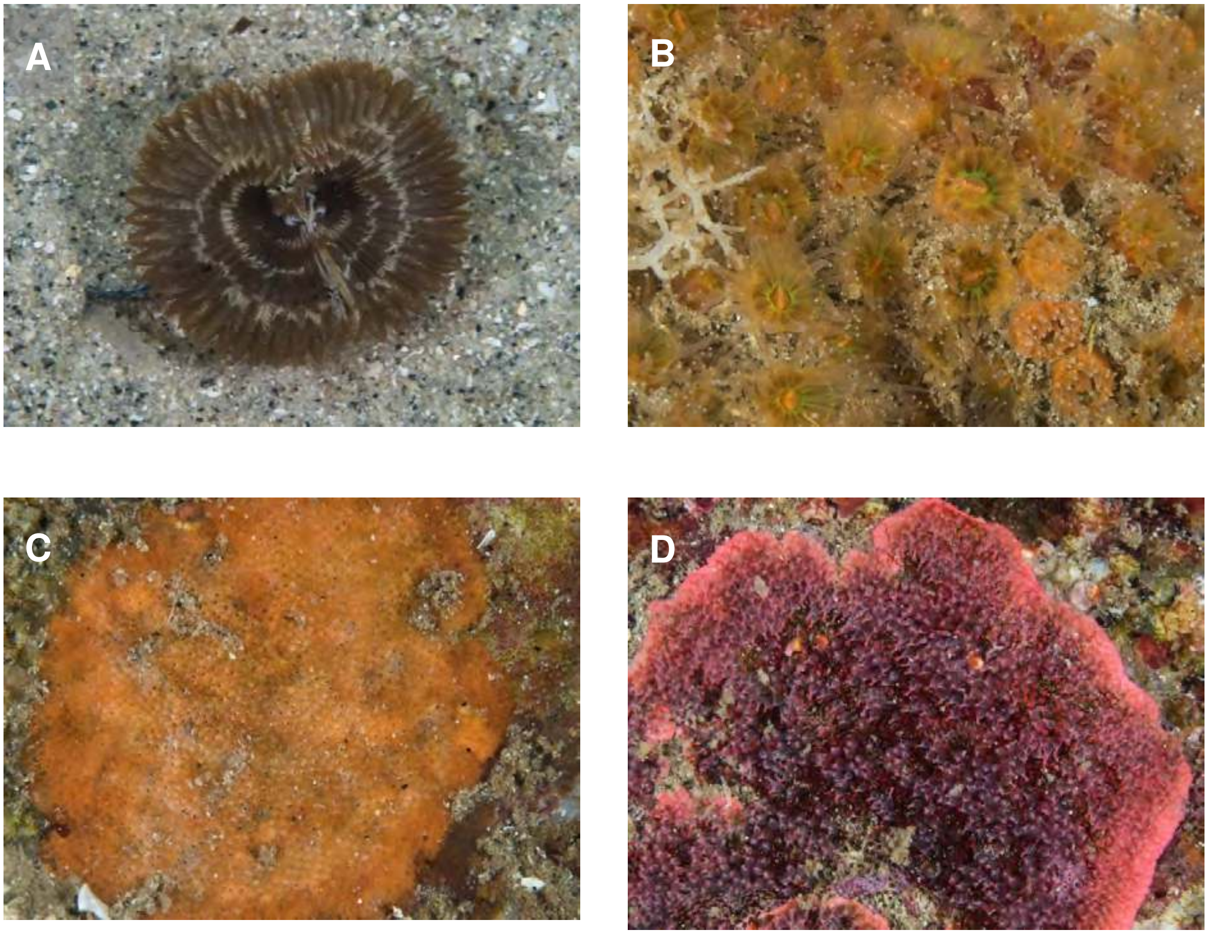


Figure 18: Examples of the sessile invertebrate UPC cover category: A) Tubeworm; B) Cup corals; C) Bryozoan; D) Bryozoan (Kate Vylet).

Seagrass

Seagrasses (SG) are actual vascular flowering plants and can be distinguished from marine algae by the presence of plant-like shape and structure similar to grasses on land.

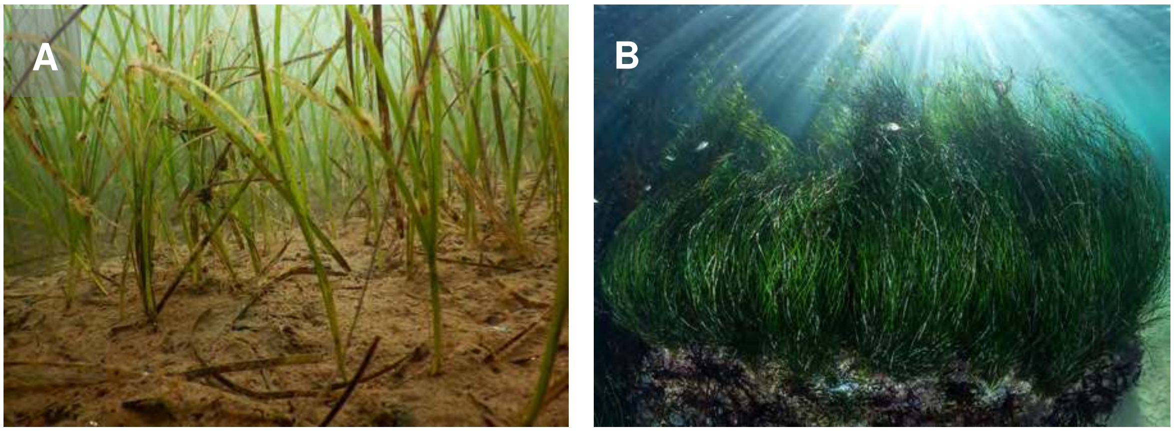


Figure 19: Examples of the Reef Check California UPC transect category, Seagrass: A) Eelgrass (Dudek); B) Seagrass (Kate Vylet)

Relief

Relief is a measurement of the amount of vertical variation there is in an area. Relief is sorted into the following four categories:

Category 0: 0 – 10 cm

Category 1: > 10 cm – 1 m

Category 2: > 1m – 2 m

Category 3: > 2 m

To determine relief, we expand out from our point on the reef by drawing an imaginary rectangular box that goes half a meter to either side of our point and half a meter forward (Figure 20), and then by determining the maximum vertical relief within that box. It is a two-step process, and to record relief accurately, you'll need to measure both the size of the box and the vertical relief within that box. The vertical relief is measured by the difference in height between the highest and the lowest point in the box (Figure 21).

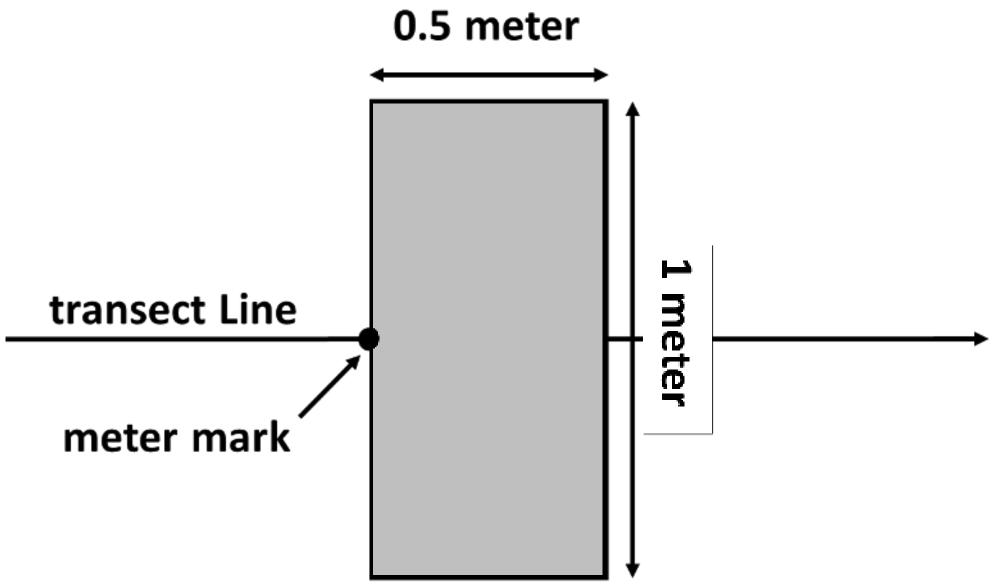


Figure 20: Top view. Physical relief is measured as the greatest vertical relief within a rectangular box one-meter wide and half a meter forward from your point.

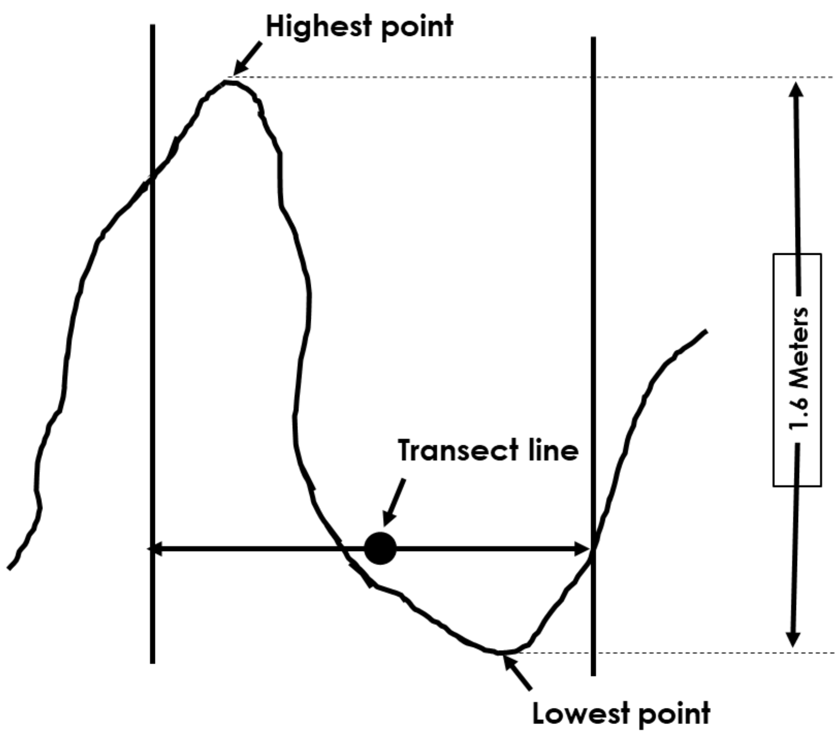
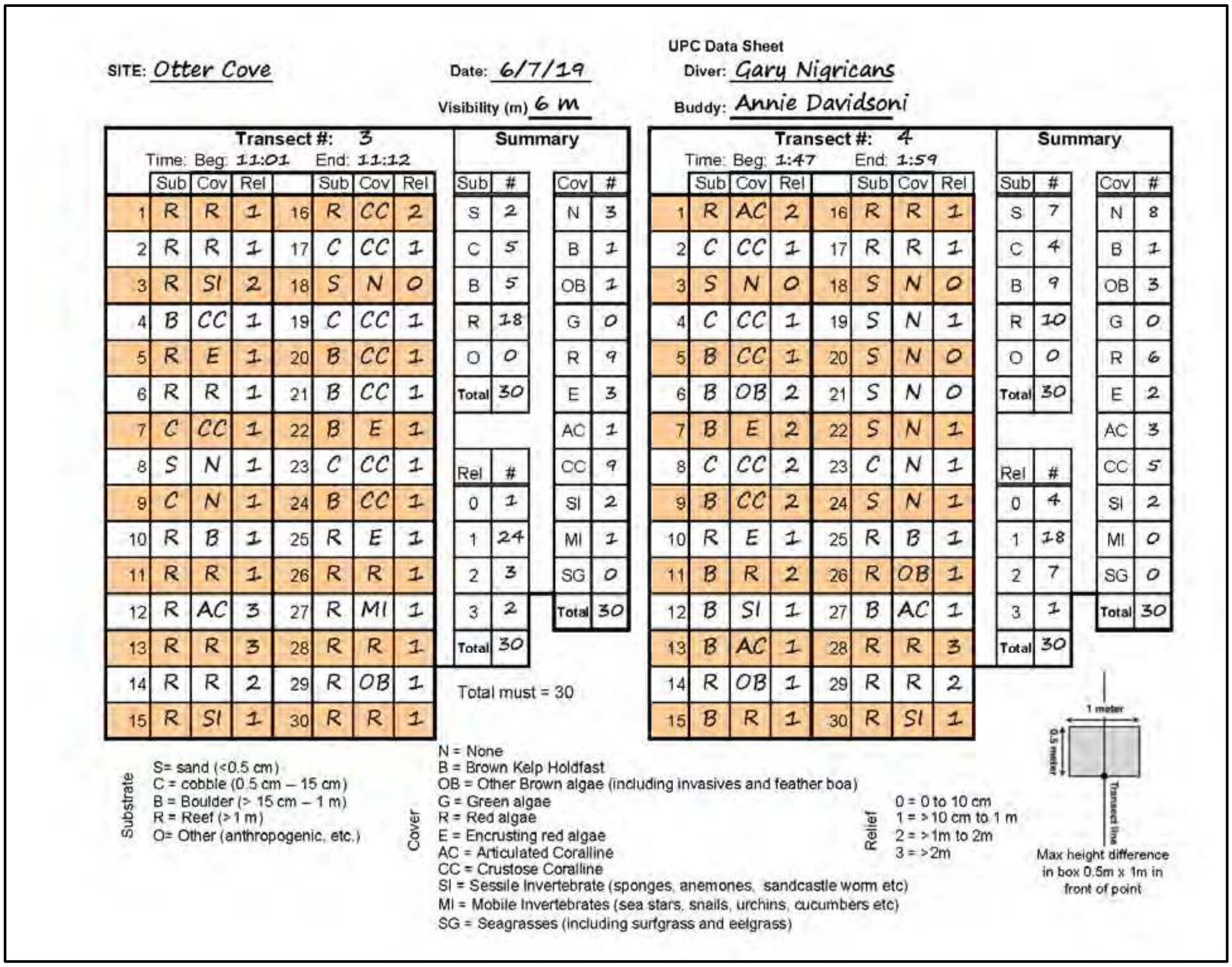


Figure 21: Cross section of an estimate of relief. Maximum vertical relief is 1.6 meters, so the point would be a category 2.



UPC Data Sheet

SITE: Otter Cove   Date: 6/7/19   Visibility (m) 6 m

Diver: Gary Nigricans   Buddy: Annie Davidsoni

Transect #: 3   Time: Beg: 11:01   End: 11:12

	Sub	Cov	Rel		Sub	Cov	Rel
1	R	R	1	16	R	CC	2
2	R	R	1	17	C	CC	1
3	R	SI	2	18	S	N	0
4	B	CC	1	19	C	CC	1
5	R	E	1	20	B	CC	1
6	R	R	1	21	B	CC	1
7	C	CC	1	22	B	E	1
8	S	N	1	23	C	CC	1
9	C	N	1	24	B	CC	1
10	R	B	1	25	R	E	1
11	R	R	1	26	R	R	1
12	R	AC	3	27	R	MI	1
13	R	R	3	28	R	R	1
14	R	R	2	29	R	OB	1
15	R	SI	1	30	R	R	1

Summary

Sub	#
S	2
C	5
B	5
R	18
O	0
Total	30

Rel	#
0	1
1	24
2	3
3	2
Total	30

Cov	#
N	3
B	1
OB	1
G	0
R	9
E	3
AC	1
CC	9
SI	2
MI	1
SG	0
Total	30

Total must = 30

Transect #: 4   Time: Beg: 1:47   End: 1:59

	Sub	Cov	Rel		Sub	Cov	Rel
1	R	AC	2	16	R	R	1
2	C	CC	1	17	R	R	1
3	S	N	0	18	S	N	0
4	C	CC	1	19	S	N	1
5	B	CC	1	20	S	N	0
6	B	OB	2	21	S	N	0
7	B	E	2	22	S	N	1
8	C	CC	2	23	C	N	1
9	B	CC	2	24	S	N	1
10	R	E	1	25	R	B	1
11	B	R	2	26	R	OB	1
12	B	SI	1	27	B	AC	1
13	B	AC	1	28	R	R	3
14	R	OB	1	29	R	R	2
15	B	R	1	30	R	SI	1

Summary

Sub	#
S	7
C	4
B	9
R	10
O	0
Total	30

Rel	#
0	4
1	18
2	7
3	1
Total	30

Cov	#
N	8
B	1
OB	3
G	0
R	6
E	2
AC	3
CC	5
SI	2
MI	0
SG	0
Total	30

Substrate
S= sand (<0.5 cm)
C = cobble (0.5 cm – 15 cm)
B = Boulder (> 15 cm – 1 m)
R = Reef (>1 m)
O= Other (anthropogenic, etc.)

Cover
N = None
B = Brown Kelp Holdfast
OB = Other Brown algae (including invasives and feather boa)
G = Green algae
R = Red algae
E = Encrusting red algae
AC = Articulated Coralline
CC = Crustose Coralline
SI = Sessile Invertebrate (sponges, anemones, sandcastle worm etc)
MI = Mobile Invertebrates (sea stars, snails, urchins, cucumbers etc)
SG = Seagrasses (including surfgrass and eelgrass)

Relief
0 = 0 to 10 cm
1 = >10 cm to 1 m
2 = >1m to 2m
3 = >2m

Figure 22: Example of RCCA Uniform Point Contact (UPC) Datasheet. Note that each category is counted, and totals are placed in the corresponding tables to the right of the main data collection table. All categories for each UPC transect type (i.e. substrate, cover, and relief) must add up to 30 (i.e. 30-meter marks equal 30 data points).

Fish Transect

Fish are surveyed along a 30 m transect in an area 2 m across the transect tape and 2 m off the bottom (30 m x 2 m x 2 m). Imagine this transect like a 30 m long 2 m by 2 m rectangular atrium where your job is to identify, size and count all of the RCCA key fish species inside this volume of water (Figure 23).

Fish transects are always conducted while deploying the tape so that fish are not scared away from, or attracted to, the divers. This means that fish divers must identify, count and size fish while laying the transect tape in accordance with all the guidelines in the Deploying the Tape section above. It is important that other divers do not occupy the space the fish diver is going to survey as this can also attract or scare away fish.

Before starting a fish transect, divers should get ready by attaching their transect tape to their data board so that the tape rolls out easily, taking their flashlight out so that it is ready to use, and recording their start time and depth on their datasheet. Once that is all set, they should secure the end of the transect tape, double check their heading, and then look up to take their first "snapshot".

The "snapshot" technique is used to count, identify and size fish in a manageable and consistent way by only counting fish that are within the survey window at a moment in time. Divers look up and count, identify, and size all the fish that are in the volume of water 2 m wide, 2 m high and roughly 3 m forward (the actual distance forward varies depending on visibility and/or abundance of fish). Once they have captured all the fish that were there at that moment, they are done with that volume of water, and additional fish that swim into that section are ignored. Otherwise, they could potentially be there all day, as fish continually swim into that area potentially attracted to the diver or even swimming circles around them! If divers encounter a large school of fish, they need to maintain their "snapshot" and only count fish that are in the 2 m by 2 m window at that moment.

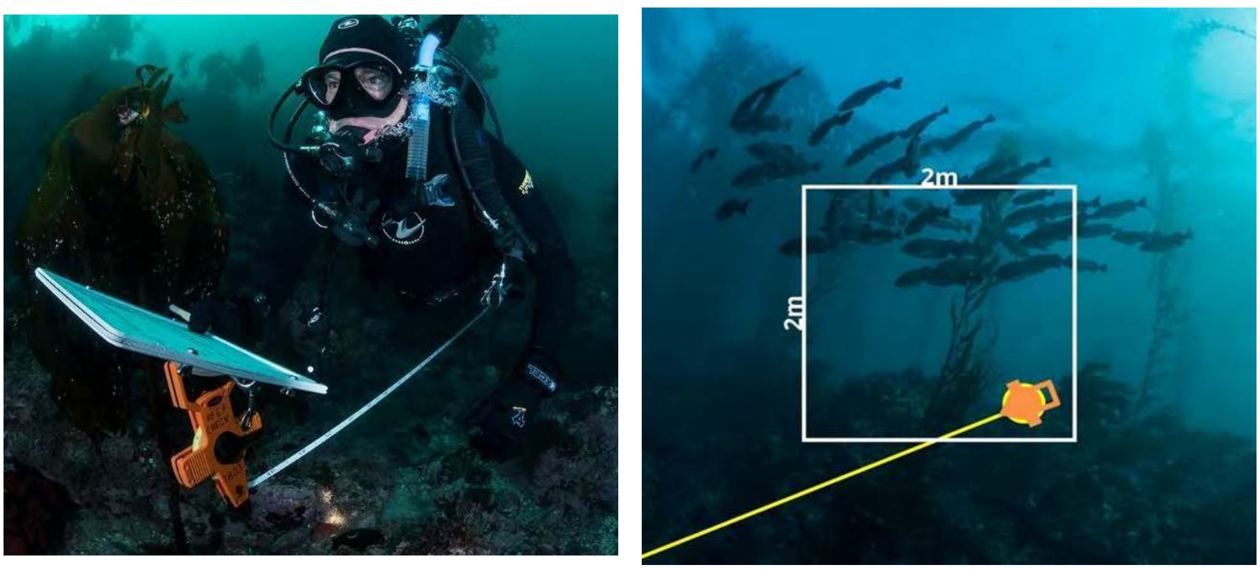


Figure 23: Example of a fish diver conducting a fish transect and taking a "snapshot" (left), and an image of what the fish transect imaginary "window" would look like to the fish diver. The fish diver would identify, count and size all the fish in that 2m x 2m window ahead to the next landmark (which is the giant kelp individual in this example). Photos by Kate Vylet.

After recording all the fish that were observed in that first "snapshot", divers then swim forward while looking down, scanning the bottom for benthic fish tucked away in the substrate. It may be necessary to use flashlights to look for fish in holes by turning on the light, looking in the hole, and turning the light off again before recording any fish found. Flashlights can be powerful attractors of fish, so they should be turned off during fish transects except for when looking in holes, to not bias the count. Once the area has been scanned and any fish observed have been recorded, the diver looks up and takes another "snapshot" and repeats the process. It's helpful to use landmarks (like a rock, kelp plant, bright orange sponge, etc.) to identify the far end of the “snapshot”. Moving in bounds likes this breaks the transect up into manageable sections.

When conducting a fish transect, divers should swim at a slow sculling pace, alternating between looking up to count fish in the water column and looking down and in holes for fish on the bottom. Fish transects should take 5 - 10 minutes, with simple flat habitats with few or no fish being quicker than highly complex habitats with lots of fish. It is important to keep moving forward and not get bogged down with fish attracted to our presence. Never count fish that come from behind or individuals that are seen on subsequent transects (i.e. invert or algae transects) that may seem like you have “missed” during the fish transect.

RCCA divers do the fish survey as a buddy team. However, only the diver deploying the transect will be conducting the fish survey count. The diver that is not deploying the transect tape will stay well behind the bubble stream of the first diver and out of that diver’s field of vision while maintaining close enough contact to assist in an emergency. The buddy can spend this time practicing fish survey skills like sizing and identification.

Sizing Fish

For the purposes of Reef Check California, we will be measuring total length, which is simply the length of a fish from the mouth to the tip of the tail (Figure 24).

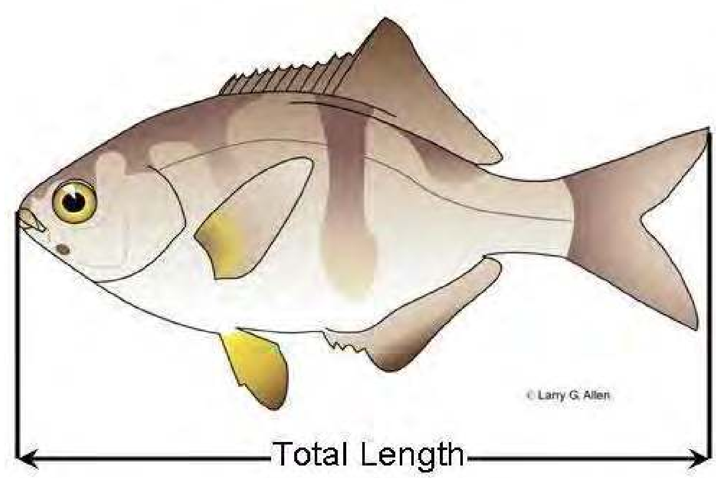


Figure 24: Total length of fish, in this case a Pile Perch, is measured from mouth to tip of tail (Illustration © Larry G. Allen).

During an RCCA fish transect, divers size fish to the nearest centimeter. Estimating sizes of moving fish underwater requires practice and is one of the more difficult aspects of RCCA surveys. That said, with adequate practice, all divers can be trained to make accurate size estimates. The goal is to estimate the size of each individual fish to within 10%. In the case of large schools, it is ok to “bracket” by recording the largest and smallest size and the number of individuals in the group. For example, if a school of 20 Blue Rockfish is present and the largest fish is 25 cm and the smallest is 23 cm, you would record: 20 Blue Rockfish at 23-25 cm (for details on how to record this on the datasheet, see section: Recording Fish Transect Data). Size brackets should be as small as possible even if it requires breaking a school up into several groups.

Estimating size underwater is complicated by the magnifying effect of water. This phenomenon, known as Snell's Law of Refraction, is caused by the refraction of light moving from one medium (water) to another (air inside your mask), and the differing speed of light in the varying media. As a rule, objects appear 33% larger and 25% closer. Therefore, though practicing on dry land can be a helpful first step, especially to get acquainted with the metric system, it is critical to practice sizing underwater to be able to make accurate size measurements. There are several other factors that can make estimating size difficult.

Factors that contribute to an underestimation of fish size:

- Low light
- Poor visibility
- Dull body color
- Objects in foreground
- Deep-bodied or “fat” fish. Pay special attention to species with abnormal proportions of length to height (e.g., Rubberlip Seaperch, Black Perch, etc.).

Conversely, there are several specific factors that lead to an overestimation of fish size:

- Bright light
- Good visibility
- Bright body color (e.g., Garibaldi, Sheephead, etc.)
- Objects in background
- Skinny or elongate fish. Pay special attention to species with abnormal proportions of length to height (e.g., Lingcod, Señorita, etc.).

Aids to sizing

Fortunately, there are several tricks that can be used to improve sizing estimates. The most straightforward is to hold a data board with centimeter marks on it, or even the span of your hand or outstretched fingers, up to the fish, provided the fish is willing to be measured. If a fish is sitting on a rock, make note of the features on the rock at the head and tail of the fish (i.e. some algae or invertebrate), then measure the distance between the features when the fish swims away.

In other cases, fish will be moving around, and their sizes will have to be estimated without using the above techniques. Therefore, it’s important to calibrate size estimates by practicing on non-moving objects or organisms (e.g., rocks, kelp, sea cucumbers, etc.). To practice, pick an object, estimate its size, then approach it and measure it with your slate or a piece of transect tape. Note if your estimate was below or above the actual size. Adjust your estimation, pick a new object, and repeat this process. RCCA fish divers must practice size estimation every year before they survey and then throughout the year to insure accuracy.

Recording Fish Transect Data

When counting and sizing fish on transect, it is important to record and tally data in a standardized way. Codes for each species can be found in the column on the right of the datasheet (Figure 25 & Figure 26). These codes are essentially abbreviations used to streamline the data collection process, requiring just a few letters instead of complete words to note each species. For each fish seen, record the code in the grey box, then the size in parenthesis, followed by the number observed at that size. For instance, if you see two, 23 cm, blue rockfish (code = BLU), you would record it as:

BLU (23) 2

If another 23 cm blue rockfish was observed further down the transect, it could be added to the previous notation with a comma:

BLU (23) 2,1

When bracketing large schools (see above), put the range in the parenthesis and number afterwards:

BLU (23-25) 20

If you see only one fish of a particular size, it is ok to forgo with the parenthesis:

BLU 23

There are several columns on the datasheet for recording individual species during a fish transect. If you find more species than available columns on a transect, you can split a column by drawing a horizontal line (Figure 25).

After the dive, total the number of individuals of each species and record them in the "transect total" column on the far right of the datasheet. Make sure the species codes are correct, ensure all sizes and numbers are legible and clear, and then give the datasheet to another team member to be reviewed for clarity. Discuss any observations that seem uncommon or unusual to you or your team member. After all issues have been discussed and resolved, have the reviewer write their name in the 'Field QA' space at the top of the datasheet. This field quality assurance (QA) is essential to ensuring that data will be entered correctly later.

Fishing Gear and Trash Observations

To record the amount of marine debris and lost or active fishing gear in the kelp forest, we count any fishing gear and debris that falls within our 2-meter transect on all fish transects (18 transects). If any part of the gear or trash is within your swath (i.e. the edge of a lobster trap or a piece of monofilament line), it will be recorded. Fishing gear that is attached to fish that are observed on transect (e.g. hook in mouth, trailing line, etc.) will also be recorded. Fishing gear and other objects will be broken down into four categories:

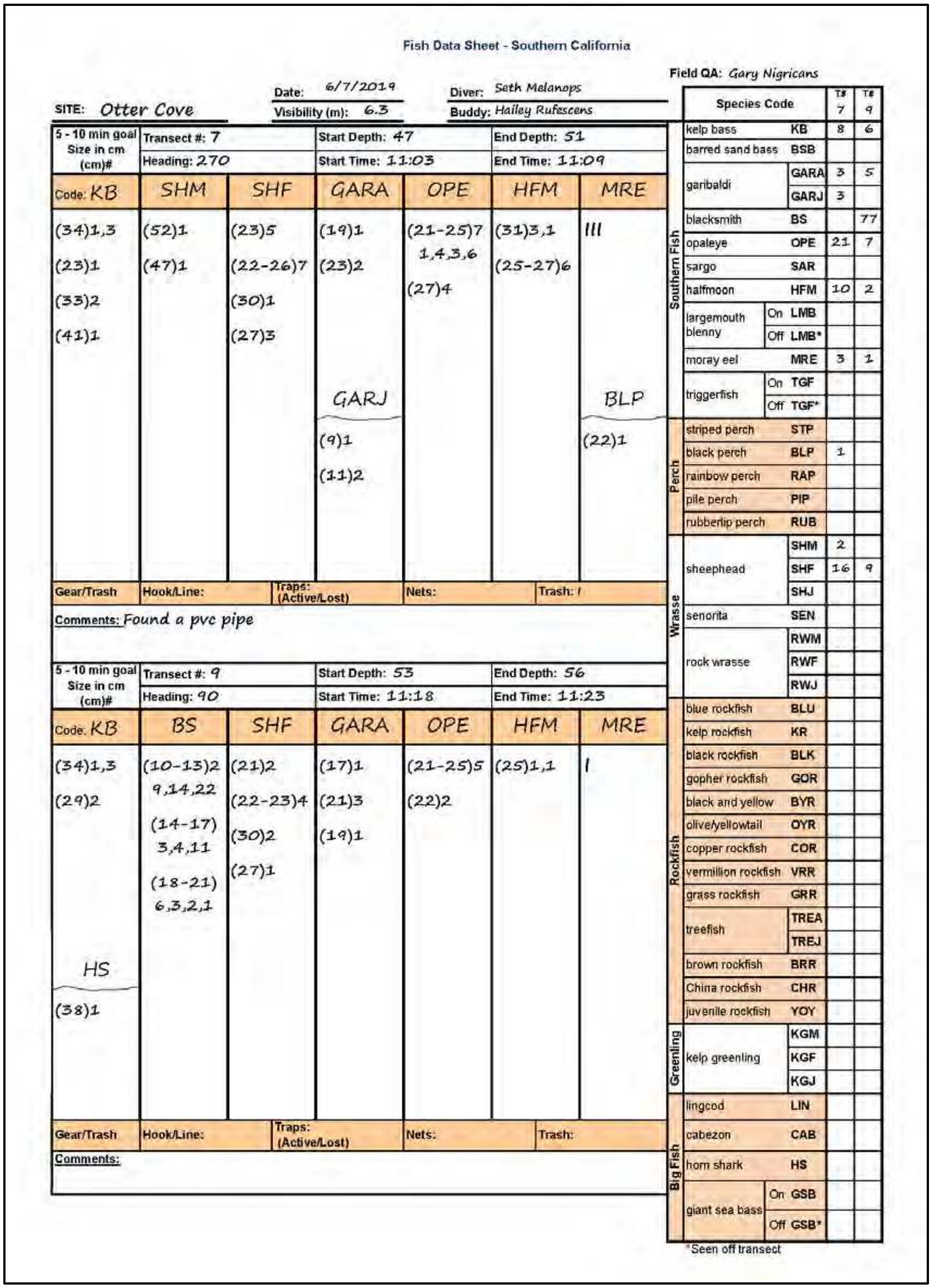
Hook and line (recreational fishing tackle) - includes hooks, lures, bobbers, sinkers, fishing rods and fishing line, etc. This category also encompasses boat anchors, anchor line, and spearfishing gear including spears, tips and guns. If gear is counted, it should be recorded in the comments section what type of gear was found.

Traps - includes both abandoned (recorded as 'lost') and active (recorded as 'active') traps. Broken and deteriorated traps (i.e., parts of traps) will also be counted. Lobster hoop nets will fall into this category since they serve the same purpose as a trap.

Nets - includes full nets or pieces of net material.

Trash - includes anything man made that was lost or tossed into the ocean and that doesn't fall into one of the fishing gear categories. This includes plastics, bottles, cans, metal, ropes, etc. If trash is recorded, it should be noted in the comments section what type of trash was observed.

Each item from the above categories that is encountered on a fish transect will be recorded on the fish datasheet as a tick mark in its respective category (Figure 25 & Figure 26). After the dive, once you have tallied your fish counts, you can tally and circle the total number of each fishing gear and trash observation.



Fish Data Sheet - Southern California

SITE: Otter Cove | Date: 6/7/2019 | Visibility (m): 6.3 | Diver: Seth Melanops | Buddy: Hailey Rufescens | Field QA: Gary Nigricans

5 - 10 min goal Size in cm (cm)#	Transect #: 7		Start Depth: 47		End Depth: 51	
	Heading: 270		Start Time: 11:03		End Time: 11:09	
Code: KB	SHM	SHF	GARA	OPE	HFM	MRE
(34)1,3	(52)1	(23)5	(19)1	(21-25)7 1,4,3,6	(31)3,1	III
(23)1	(47)1	(22-26)7	(23)2	(27)4	(25-27)6	
(33)2		(30)1				
(41)1		(27)3				
			GARJ			BLP
			(9)1			(22)1
			(11)2			
Gear/Trash	Hook/Line:	Traps: (Active/Lost)		Nets:	Trash: I	

Comments: Found a pvc pipe

5 - 10 min goal Size in cm (cm)#	Transect #: 9		Start Depth: 53		End Depth: 56	
	Heading: 90		Start Time: 11:18		End Time: 11:23	
Code: KB	BS	SHF	GARA	OPE	HFM	MRE
(34)1,3	(10-13)2 9,14,22	(21)2	(17)1	(21-25)5	(25)1,1	I
(29)2	(14-17) 3,4,11	(22-23)4	(21)3	(22)2		
	(18-21) 6,3,2,1	(30)2	(19)1			
		(27)1				
HS						
(38)1						
Gear/Trash	Hook/Line:	Traps: (Active/Lost)		Nets:	Trash:	

Comments:

Group	Species		Code	T# 7	T# 9
Southern Fish	kelp bass		KB	8	6
	barred sand bass		BSB		
	garibaldi		GARA	3	5
			GARJ	3	
	blacksmith		BS		77
	opaleye		OPE	21	7
	sargo		SAR		
	halfmoon		HFM	10	2
	largemouth blenny	On	LMB		
		Off	LMB*		
	moray eel		MRE	3	1
	triggerfish	On	TGF		
		Off	TGF*		
Perch	striped perch		STP		
	black perch		BLP	1	
	rainbow perch		RAP		
	pile perch		PIP		
	rubberlip perch		RUB		
Wrasse	sheephead		SHM	2	
			SHF	16	9
			SHJ		
	senorita		SEN		
	rock wrasse		RWM		
			RWF		
			RWJ		
Rockfish	blue rockfish		BLU		
	kelp rockfish		KR		
	black rockfish		BLK		
	gopher rockfish		GOR		
	black and yellow		BYR		
	olive/yellowtail		OYR		
	copper rockfish		COR		
	vermillion rockfish		VRR		
	grass rockfish		GRR		
	treefish		TREA		
			TREJ		
	brown rockfish		BRR		
	China rockfish		CHR		
	juvenile rockfish		YOY		
Greenling	kelp greenling		KGM		
			KGF		
			KGJ		
Big Fish	lingcod		LIN		
	cabezon		CAB		
	horn shark		HS		
	giant sea bass	On	GSB		
		Off	GSB*		

*Seen off transect

Figure 25: Example of a Southern California RCCA Fish Transect Datasheet. Note that all fish are tallied for each transect (there are two transects on this datasheet example) and the totals are placed in the table to the right of the sheet to aid in quality control.

Fish Data Sheet - North/Central

Site: Otter Cove Date: 6/7/19 Diver: Mack Purifera Field QA: Garu Niaricans

5-10 min target time | Size in cm (cm)# | Visibility (m): 5.7 | Buddy: Meg Undosa

Transect #: 6	Heading: 270	Transect #: 15	Heading: 90
Beg Depth: 25	End Depth: 22	Beg Depth: 25	End Depth: 27
Beg Time: 1:43	End Time: 1:48	Beg Time: 2:11	End Time: 2:17

BLU	23,19,(17-19)5	BLU	26,21,30,19,13
KR	25,29	KR	(17-22)7,1
STP	19	KR	24,27,33
BYR	22	COR	34
YOY	3,5,7,11	YOY	9,5,3
BLK	(24)5,1	BLK	27
LIN	57	CAB	43
BLP	12	SEN	(13-17)16
BLU	17,23,21		
			Plastic bag

Hook/line:	Traps(A/L):	Nets:	Trash:	Hook/line:	Traps(A/L):	Nets:	Trash: 1

Transect #: 18	Heading: 270	Transect #:	Heading:
Beg Depth: 21	End Depth: 22	Beg Depth:	End Depth:
Beg Time: 2:18	End Time: 2:23	Beg Time:	End Time:

PIP	23,24,25		
KR	30		
KGM	44		
YOY	34		

Hook/line:	Traps(A/L):	Nets:	Trash:	Hook/line:	Traps(A/L):	Nets:	Trash:

Don't size YOYs or moray eels * note if see on or off transect

Group	Species	Code	T# 6	T# 15	T# 18	T#
Rockfish	blue rockfish	BLU	10	5		
	kelp rockfish	KR	2	11	1	
	black rockfish	BLK	6	1		
	gopher rockfish	GOR				
	black & yellow	BYR	1			
	olive/yellowtail	OYR				
	copper rockfish	COR		1		
	vermilion	VRR				
	grass rockfish	GRR				
	treefish	TREJ				
		TREA				
	brown rockfish	BRR				
	China rockfish	CHR				
	YOY rockfish	YOY	26	17	34	
Perch	striped perch	STP	1			
	black perch	BLP	1			
	rainbow perch	RAP				
	pile perch	PIP				
	rubberlip perch	RUB				
Greenling	kelp greenling	KGM			1	
		KGF				
		KGJ				
Wrasse	sheephead	SHM				
		SHF				
		SHJ				
	senorita	SEN		16		
	rock wrasse	RWM				
		RWF				
Southern Fish	kelp bass	KB				
	barred sand bass	BSB				
	garibaldi	GARJ				
		GARA				
	blacksmith	BS				
	opaleye	OPE				
	sargo	SAR				
	halfmoon	HFM				
	largemouth blenny	LMB				
	moray eel	MRE				
	triggerfish	TGF				
Big Fish	lingcod	LIN	1			
	cabezon	CAB		1		
	horn shark	HS				
	giant sea bass	GSB*				

Figure 26: Example of a Northern and Central California RCCA Fish Transect Datasheet. Note that all fish are tallied for each transect (there are four transects on this datasheet example) and the totals are placed in the table to the right of the sheet to aid in quality control.

Urchin Size Frequency Survey

Urchin Size Frequency surveys are conducted when surveying in areas with high abundances of urchin (e.g. barrens). Calipers are used to measure the **test** size of 100 to 300 individual urchins of each abundant urchin species. These surveys are "roving surveys" not associated with a transect and can be done anywhere at the site. The goal is to obtain a representative sample of the urchins at the site, so it is important to not just count those that are of a particular size. To measure an urchin, wiggle the arms of the calipers through the spines until they press up against the test, and record the size in centimeters. Their sizes are recorded in centimeter bins. For example, an individual that is between three and four centimeters is recorded as 3 cm.

You need to ensure you measure all of the first 100 urchins you encounter. If you begin an urchin survey but are not able to measure 100 urchins of each species by the end of the dive, the data are still useful and should be turned into the data captain/dive team leader.

Northern California Red Abalone Size Frequency Survey

North of the San Francisco Golden Gate Bridge, Reef Check conducts Red Abalone Size Frequency Surveys. These occur on transects during monitoring surveys and as part of separate roving surveys that are conducted independently. The maximum shell diameter of red abalone is measured to the nearest millimeter using specially designed calipers. The "roving" size frequency surveys are similar to the urchin size frequency surveys above, where the diver swims over the reef and measures all red abalone that are encountered. The goal is to collect over 250 size measurements at each site. These surveys are performed at regular RCCA monitoring sites and additional sites along the North Coast in Sonoma and Mendocino Counties. These surveys can be performed by single buddy teams without the presence of an organized RCCA survey team and provides a good opportunity to get in the water and collect data at times when no surveys are scheduled.

If you are taking this course in Northern California, you will practice this survey method; otherwise, it is described in a separate manual and will not be difficult to learn after you have completed this course (Freiwald et al. 2016a).

Climate Change Monitoring

Since 2017, RCCA has been monitoring temperature, dissolved oxygen concentrations, and the ocean's pH at sites along the California coast. Changes in these oceanographic parameters can be used to measure the impacts of climate change on the ocean environment such as rising ocean temperatures, increasing acidification of the water, and more frequent occurrence of low oxygen zones along the coast (Wernberg et al. 2016, Breitburg et al. 2018, Hodgson et al. 2018). They are measured by sensors that are permanently installed on the rocky reefs in areas where we conduct our surveys. Temperature sensors are installed at most of the RCCA monitoring sites, and oxygen and pH sensors, which are larger and more complex, are installed at two sites in each of the Southern, Central, and Northern California regions. These sensors are serviced at regular intervals throughout the year. Volunteers can get involved in the servicing of these sensors and take on the responsibility for maintaining some of these oceanographic monitoring sites after receiving additional training.

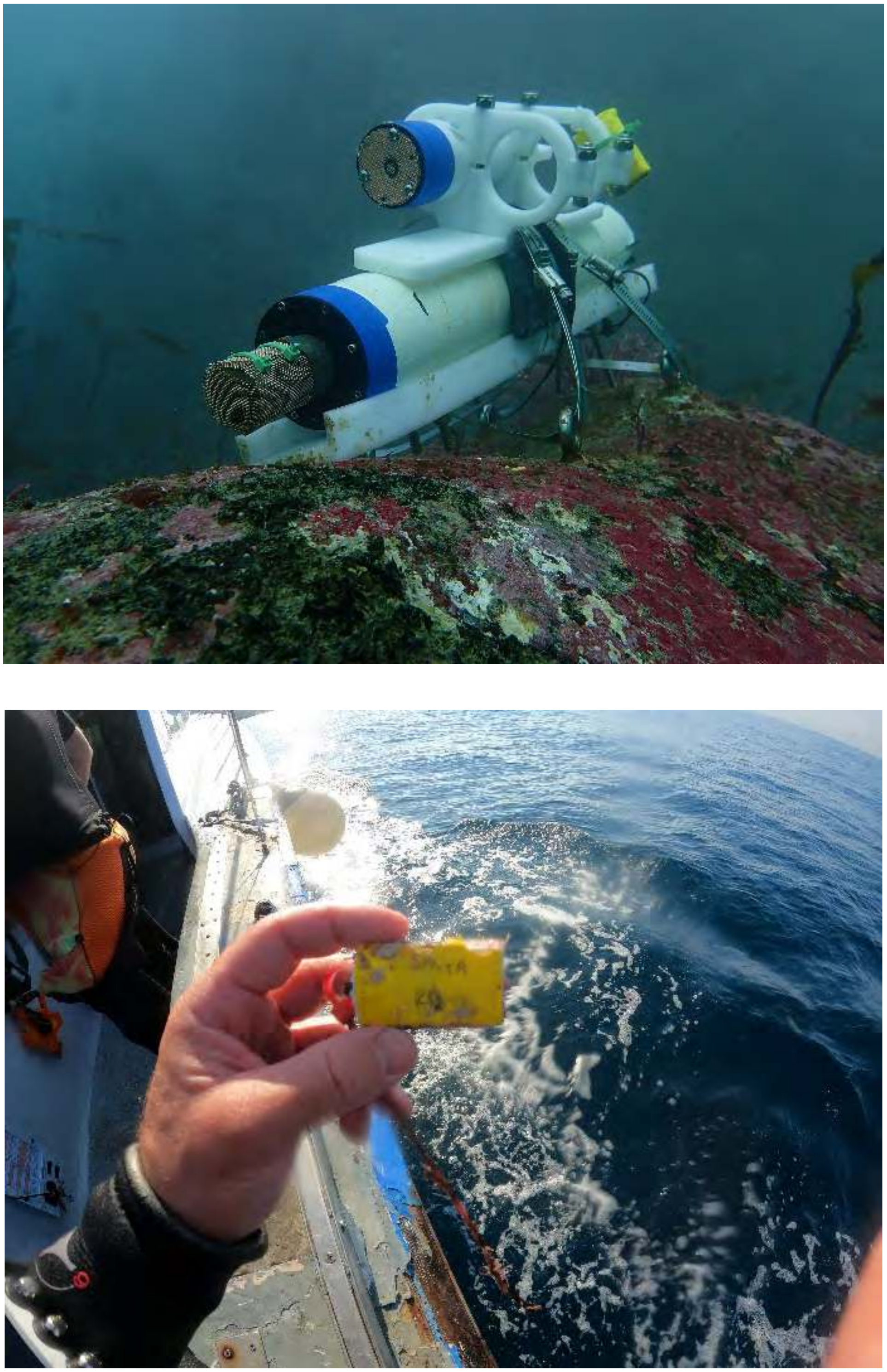


Figure 27: RCCA oceanographic sensors. Top: A deployed unit that collects data on pH, O_2, and temperature of the water. Bottom: A recovered temperature logger (HOBO).

Chapter 6

Reef Check California Key Species

The Reef Check California protocol was designed to assess the health of rocky reefs and kelp forests and is quite different from many other monitoring protocols. Before selecting the species list, a thorough literature review was conducted to determine which species are monitored by the numerous existing sampling programs and the criteria the groups used to select their target species (Burcham 2004; Airame & Ugoretz 2008; Carr et al. 2003; Schroder et al. 2002; Davis et al. 1997). RCCA focuses on the abundance of local marine organisms that not only best reflect the condition of the ecosystem but are easily recognizable. The species list was compiled using the following criteria:

- Ease of identification
- Species 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
- Ecologically important species

For example, the Garibaldi was selected because it is commonly observed in Southern California and is a species of special interest or concern due to its protected status and designation as California's state marine fish. The red urchin, on the other hand, was selected because it is a commercially fished species and is an ecologically important species. Cryptic species are not typically included because they cannot be surveyed adequately by visual techniques alone (Allen et al. 2006).

Reef Check California does not have separate key species lists for different geographic regions in California. Although we recognize the distinct biological breaks along California's coast and associated different ecological communities, separate species lists would limit the ability of the monitoring program to detect geographic range shifts in target species. In addition, a single species list permits volunteers trained in any part of California to participate in surveys along the entire coast.

Invertebrate Species

Most invertebrates are relatively sedentary (they don't move very much), allowing for careful examination of their features. Some invertebrates will be camouflaged, and thus difficult to see, which means that you must know what you are looking for to sample well. The following section will introduce you to all the key invertebrate species that we identify, count, and sometimes measure, but we encourage you to use the supplemental materials given to you prior to your training to become familiar with these organisms.

Table 3: Species and rationale of Reef Check California indicator invertebrate species.

Common Name	**Scientific Name**	**Rationale**
Red Abalone*	*Haliotis rufescens*	E, SI
Flat Abalone	*Haliotis walallensis*	E, SI
Pinto/Threaded Abalone	*Haliotis kamtschatkana*	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, EI
CA Sea Cucumber	*Parastichopus californicus*	E, EI
Warty Sea Cucumber	*Parastichopus parvimensis*	E, EI
Bat Star	*Patiria miniata*	EI, SI
Leather Star	*Dermasterias imbricata*	EI, SI
Short-Spined Star	*Pisaster brevispinus*	EI, SI

Common Name	**Scientific Name**	**Rationale**
Giant-Spined Star	*Pisaster giganteus*	EI, SI
Ochre Star	*Pisaster ochraceus*	EI, SI
Sunflower Sea Star†	*Pycnopodia helianthoides*	EI, SI
Sun Star	*Solaster* spp	EI, SI
Chestnut Cowrie	*Neobernaya spadicea*	E
Kellet's Whelk	*Kelletia kelletii*	E, EI
Rock Crab	*Cancer productus, Metacarcinus anthonyi, Romaleon antennarius*	E, EI
Sheep and Masking Crabs	*Loxorhynchus grandis, L. crispatus*	E
Wavy and Red Turban Snails	*Megastraea undosa, Pomaulax gibberosus*	C, E
Giant Keyhole Limpet	*Megathura crenulata*	E
Gumboot Chiton	*Cryptochiton stelleri*	C, EI
Rock Scallop	*Crassedoma gigantea*	E
CA Sea Hare	*Aplysia californica*	EI
Black Sea Hare	*Aplysia vaccaria*	EI
Red Urchin	*Mesocentrotus franciscanus*	E, EI
Purple Urchin	*Strongylocentrotus purpuratus*	C, EI
Crowned Urchin	*Centrostephanus coronatus*	C, SI

Common Name	Scientific Name	Rationale
CA Golden and Brown Gorgonians**	*Muricea californica, M. fruticosa*	C
Red Gorgonians**	*Lophogorgia chilensis*	C
Large Anemones**	Order Actinaria	C

† Recorded if identified anywhere on site (on or off transect)
* Size estimated to nearest centimeter south of San Francisco and to the nearest millimeter to the North
** To be recorded, anemones must be 10 cm or larger (height or width) and gorgonians must be 10 cm or greater in height
C = commonly observed, **E** = species exploited by recreational and commercial fishing,
EI = ecologically important species (important to trophic food web), **SI** = species of interest or concern (protected, endangered, overfished, etc.)

Mollusks

The phylum Mollusca includes many organisms including snails, slugs, mussels, and octopuses. They have a soft, unsegmented body with most having an external calcareous shell.

- **Snails**

Marine snails, like land snails, come in all shapes, sizes and colors. Some have shells on the outside, some on the inside and some do not have shells at all. We sample six species of abalone and four other snail species on our invertebrate transect.

- **Abalone**

Abalone are marine snails that occur throughout the world, but most are found in colder, temperate oceans. For all the abalone species, we will be referring to their epipodium, respiratory pores, and tentacles. The epipodium is the frilly tissue that can be seen when the abalone lifts its shell up. Respiratory pores are the holes on the top of the shell that the abalone uses for respiration, excretion, and reproduction. The number, size, and structure of these holes can sometimes be used to help identify an abalone to species. The tentacles are the pointed "stalks" sticking out of the respiratory pores and the epipodium of the abalone.

- **Red Abalone (*Haliotis rufescens*)**

Red abalone are the world's largest abalone and are found in subtidal rocky reefs from Oregon to Baja California (Leet 2001). Their shell is brick red when they are feeding on red algae, and they can reach a size of 31 cm (12.3 in). They have a grey to black epipodium and black tentacles. The commercial fishery for red abalone closed in 1997, with recreational fishing allowed north of San Francisco until that fishery closed in 2018 (CDFW 2018).

- **Flat Abalone (*Haliotis walallensis*)**

Flat abalone (*Haliotis walallensis*) are found in subtidal rocky reefs from the Oregon Coast to Monterey Bay, California. They have a very flat shell and the epipodium usually sticks out from the shell and lies flat against the substrate. The epipodium is mottled yellow and dark brown and is covered in little bumps. The tentacles are dark brown to greenish. This species is not currently considered as a species of concern, but more information needs to be collected to determine if it should be added to the list (NOAA 2009).

- **Pinto Abalone (*Haliotis kamtschatkana*)**

Pinto abalone are found on subtidal rocky reefs from Alaska to Baja California. They have a colorful shell, golden to yellowish brown tentacles, and light brown epipodium with a pebbly appearance. Pinto abalone were identified as a species of concern by NOAA Fisheries in 2006. Ongoing efforts are being made in Washington State to outplant juveniles of this species to aid in the recovery of their population (Neuman et al. 2018). A recent scientific paper has concluded, through morphological study and genetic testing, that the threaded abalone (*Haliotis kamtschatkana assimilis*) is actually the same species as the pinto abalone, although their shells can be different shapes and colors (Owen and Rafferty 2017).

- **Green Abalone (*Haliotis cracherodii*)**

Green abalone are found on subtidal rocky reefs from Pt. Conception to Magdalena Bay, Baja California. These abalone usually have several open and several closed respiratory pores. They have a frilly epipodium that is mottled cream and brown with olive green tentacles. This species was identified as a species of concern by NOAA Fisheries in 2004 and efforts are being made to increase the population through aquaculture and outplanting strategies in Southern California (NOAA 2009). A fishery still remains in Mexico and is regulated by local cooperatives (NOAA 2009).

- **Pink Abalone (*Haliotis corrugata*)**

Pink abalone can be found in the subtidal from Pt. Conception to Baja California. They have a very round, corrugated shell with tall, volcano-like respiratory pores. The epipodium is “lacy” and black and white in color with very long, black tentacles. This abalone was determined to be a species of concern in 2004 (NOAA 2009).

- **Black Abalone (*Haliotis cracherodii*)**

Black abalone can be found in the intertidal and subtidal from Oregon to Baja California. It has a smooth black shell with black epipodium and black tentacles. This abalone used to be extremely abundant along the Pacific Coast but was designated as endangered by the National Marine Fisheries Service in 2009 (VanBlaricom et al. 2009). Because of this status, we identify, measure, and record this species if seen anywhere on site.

- **White Abalone (*Haliotis sorenseni*)**

White abalone are found on subtidal rocky reefs between Pt. Conception and Baja California. They have an oval shell which is beige in color. White abalone have a mottled orange-tan epipodium with light colored, tan tentacles.

White abalone were the first marine invertebrates listed as endangered under the Endangered Species Act in 2001 (NOAA 2018). The number of white abalone in 1999 was found to be 0.1% of the estimated original population (Hobday & Tegner 2000). Today, captive breeding programs and outplants are being used to try and increase their numbers. Therefore, we identify, measure, and count any white abalone individuals we see anywhere on site.

Mollusks – Abalone

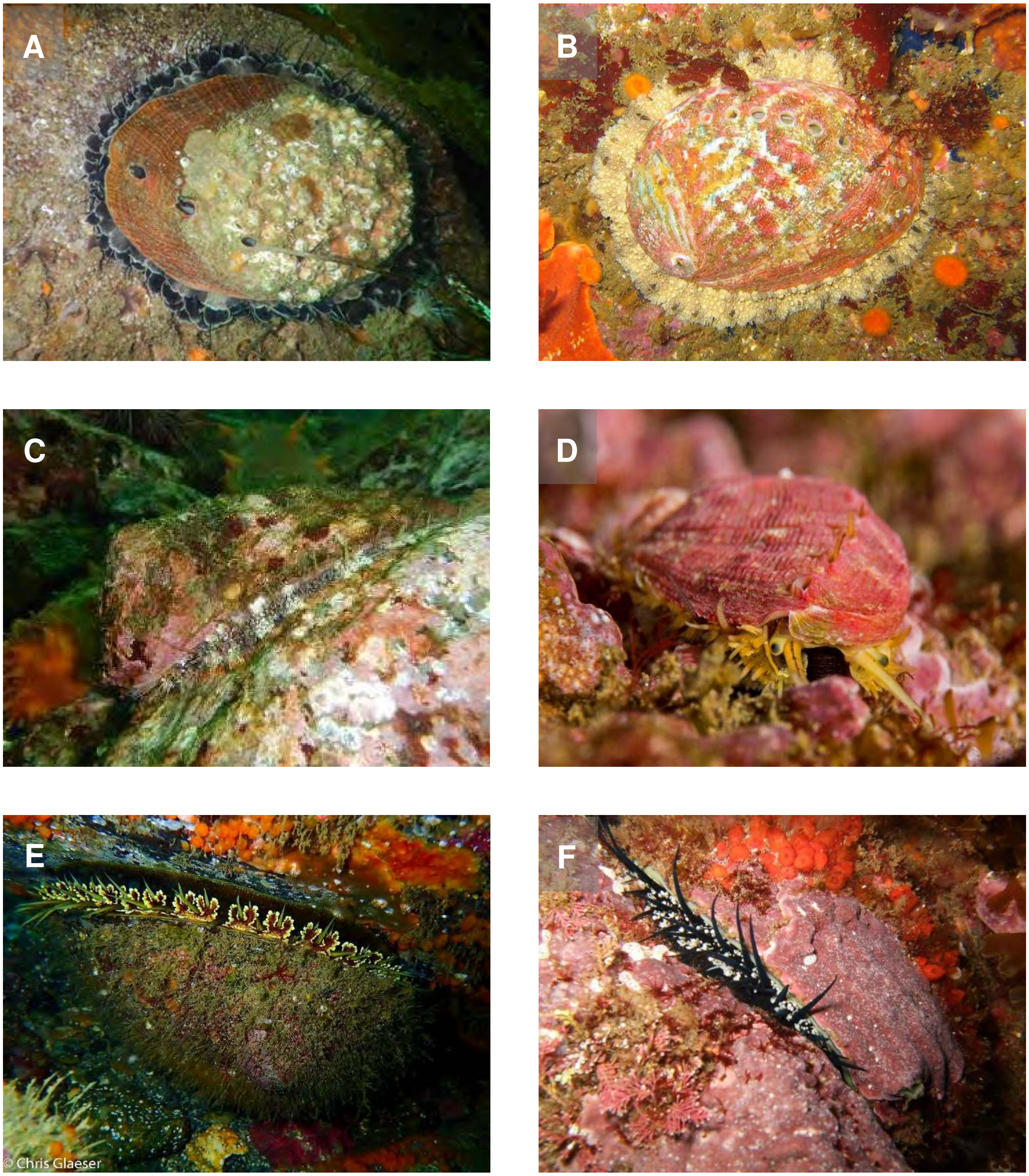


Figure 28: Examples of RCCA abalone species: A) Red abalone (Selena McMillan); B) Flat abalone (OSP); C) Pinto abalone (Jan Freiwald); D) Threaded abalone (Doug Klug); E) Green abalone (Chris Glaeser); F) Pink abalone (Brianne Emhiser).

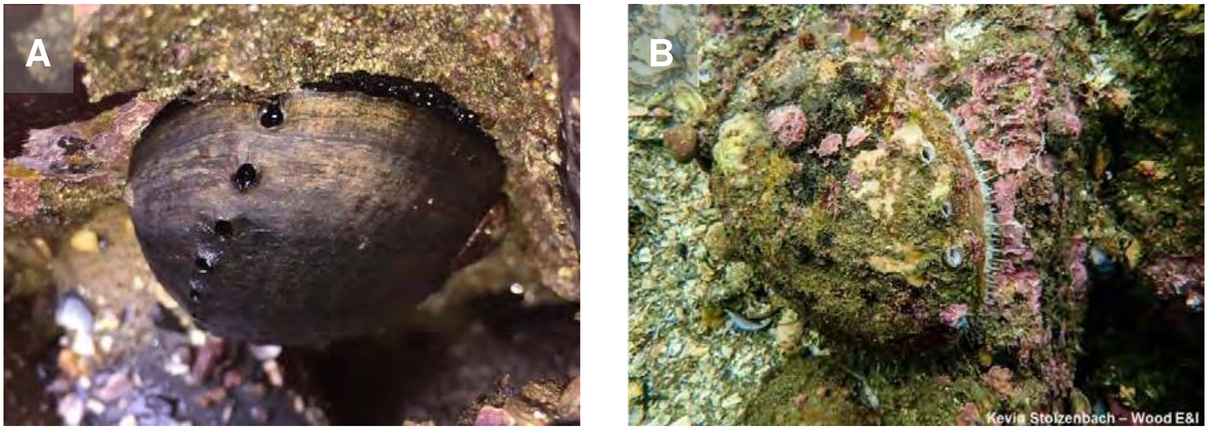


Figure 29: RCCA abalone species (continued): A) Black abalone (Andrew Harmer); B) White abalone (Kevin Stolzenbach). We record these two species if observed anywhere on site.

- **Other Snails**

    - **Kellet's Whelk (*Kelletia kelletii*)**

The Kellet's whelk is one of the largest snails, other than abalone, living along the California coast. It can be found from Monterey Bay to Baja California. The shell of this species has a purplish hue and is distinctive with its spiral appearance. The foot (body) of the Kellet's whelk is a bright orange to yellow with black stripes and white spots. They are carnivores and scavengers that will gather together to mate, leaving small, white finger-nail sized egg cases that are often found in abundance between June and September. A fishery for these snails does exist, although little information is known about the commercial or recreational catch of this species.

    - **Wavy/Red Turban Snails (*Megastraea undosa; Pomaulax gibberosus*)**

Wavy and red turban snails are found subtidally from Alaska to Baja California and are large snails with a conical shell. They are harvested by divers, but at this time, there is no threat to their population.

    - **Chestnut Cowrie (*Neobernaya spadicea*)**

Chestnut cowries are typically found subtidally from Pt. Conception to Baja California and are known for their strikingly shiny shell. They have a light, tan-colored mantle that can extend over their shell. Although these invertebrates seem easy to locate because of their brilliant shell, they typically hide in crevices and behind urchins. When their mantle is covering their shell, they can become very cryptic and hard to find.

- **Giant Keyhole Limpet (*Megathura crenulata*)**

The giant keyhole limpet is the one of the largest limpets found in the world's oceans. It lives on rocky reefs from Central California to Baja California. Its mantle covers its shell and can be many colors ranging from solid black to a mottled brown and cream to a striped pattern. This gastropod has blue blood that is used to treat a variety of human illnesses and conditions (Harris & Markl 1999). Their shells are often found on the beach or reefs and have the characteristic hole in the middle – hence the name.

- **California Sea Hare (*Aplysia californica*)**

The California sea hare can be found from Northern California to Northwestern Mexico. This marine gastropod has two appendages on top of its head that look like bunny ears, hence the name "hare". It ranges in color from a mottled cream/white and brown to purple to pink, depending on the type of algae they consume. This species can weigh up to 7 kg (15 lb) and can reach lengths of up to 75 cm (30 in), although they are usually only half this size. The California sea hare, when threatened, can expel a cloud of purple ink, which is derived from their red algal diet (Derby et al. 2007).

- **Black Sea Hare (*Aplysia vaccaria*)**

The black sea hare is found between Monterey Bay, California and the Gulf of Mexico and is the largest of its kind. The biggest specimen found to date measured 99 cm (36 in) and weighed 14 kg (31 lb) (Behrens 1980). It is black and has a smooth "skin" that can sometimes be covered in debris or sand. This black sea hare does not produce ink and prefers a diet of kelp or brown algae. This species is frequently found in a large group of several mating individuals. An estimate of their numbers can be recorded as removing any individuals for an accurate count would be considered rude.

- **Other mollusks**

We also sample two other species of mollusks, including the largest chiton found in the world's oceans.

- **Rock Scallop (*Crassedoma gigantea*)**

The rock scallop can be found in rocky reefs located from Alaska to Magdalena Bay, Baja California. This species is extremely cryptic, but when their shells are open, a flashlight will reflect their many eyes looking out from their orange (female) or grey (male) mantle. Most scallops across the world's oceans live in sandy substrate, but the rock scallop secures itself on rocky substrate and can recruit to empty scallop shells. Due to the patchy distribution of their population, CDFW determined that rock scallops are not eligible as a commercial fishery, but recreational collection of this species continues to be a popular sport among divers.

- **Gumboot Chiton (*Cryptochiton stelleri*)**

The gumboot chiton is the largest chiton found in the world's oceans and can be found from Alaska to the Northern Channel Islands. It is very large (up to 33 cm or 13 in) with reddish-brown leathery "skin". The foot, or bottom of the chiton, is usually yellow in color. It has eight internal plates, which you may have found on the beach and thought, "that looks like a butterfly". You can find this invertebrate cruising about on the reef or hiding under rock ledges.

Mollusks – Other Snails

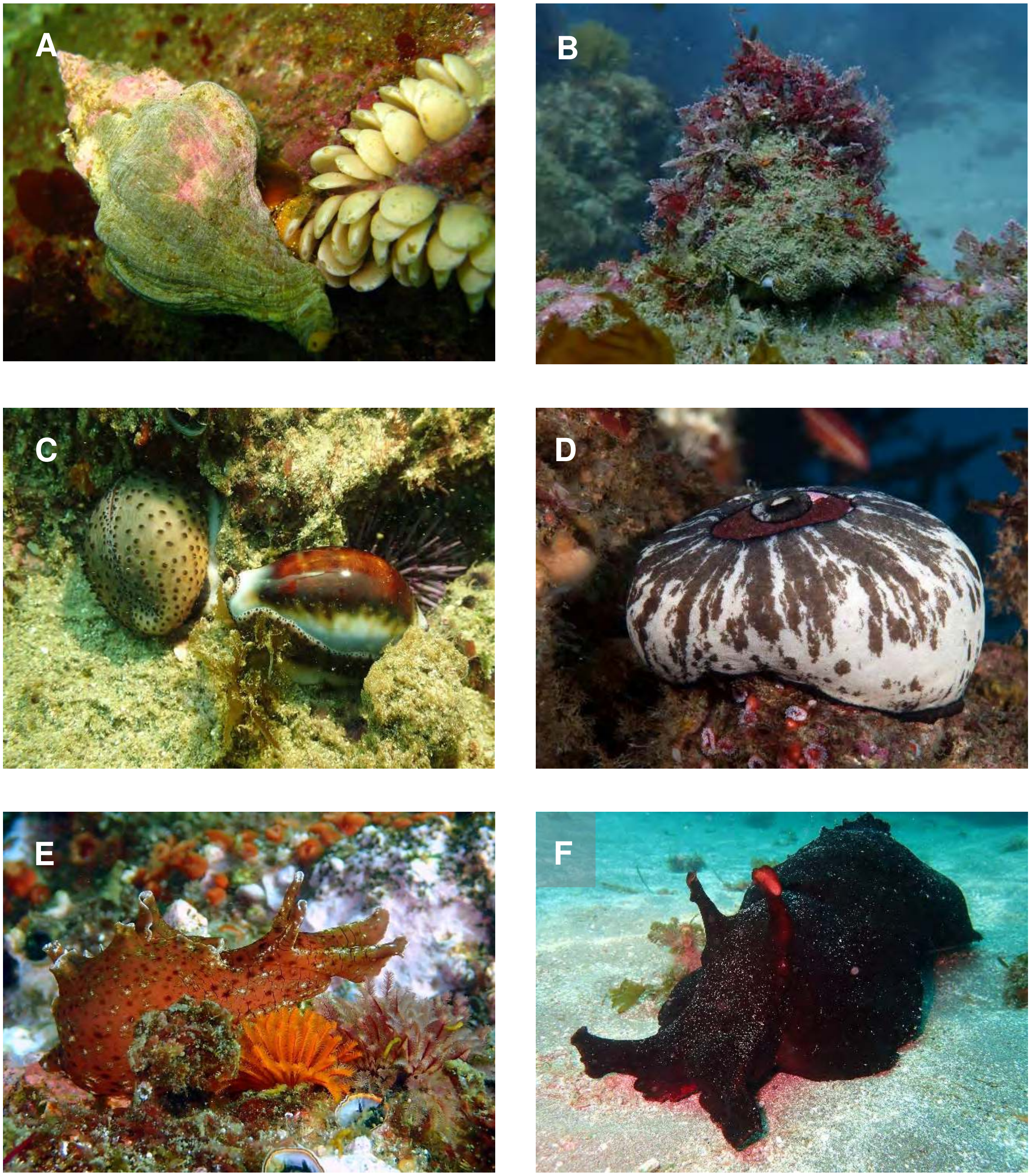


Figure 30: Examples of RCCA's other snail species: A) Kellet's whelk laying eggs (Selena McMillan); B) Wavy/Red turban snail (Selena McMillan); C) Chestnut cowrie (one with spotted mantle and one with shell exposed) (Andrew Harmer); D) Giant keyhole limpet (Phil Garner); E) California sea hare (Susy Horowitz); F) Black sea hare (Janis Vasquez).

Other Mollusks

Figure 31: RCCA's other mollusk species: A) Rock scallop (Selena McMillan); B) Gumboot chiton (Kate Vylet).

Echinoderms

The phylum Echinodermata includes sea stars, urchins, sand dollars, sea cucumbers, and sea lilies. These animals have radial symmetry and are found at most depths, including the intertidal, throughout the world's oceans.

- **Sea Urchins**

Sea urchins are usually round, spiny animals that are found in all oceans and depth zones. There are about 950 species worldwide. They have hard shells or tests and they use their tube feet and spines to crawl across the seafloor. They can be herbivorous but sometimes consume dead animals, sessile or slow-moving invertebrates, and biofilm. Their predators include sea otters, sea stars, and some species of fish. We sample three species of urchins in our surveys.

- **Red Urchin (*Mesocentrotus franciscanus*)**

Red urchins are found on subtidal rocky reefs from Alaska to Baja California. This species can be purple to red to almost black in color and has a large, robust test with spines as long as the test is wide. The red urchin is larger than the purple urchin but tends to be less abundant. The gonads of this species were a target export for the Asian market. A large commercial fishery began in the 1970s and reached its peak in the early 1990s. The population subsequently crashed, and the fishery died out. However, the red urchin is still harvested at lower rates today.

- **Purple Urchin (*Strongylocentrotus purpuratus*)**

Purple urchins are found intertidally and subtidally from Alaska to Mexico and sometimes leave round depressions in the rock where they scrape out a hole for themselves, using their teeth and spines. They are light to bright purple in color, and their test can be as large as 100 mm (4 in) in diameter, although they are usually around 50 mm (2 in). They have dense, short spines (relative to the size of their test) and feed on algae and sessile invertebrates.

- **Crowned Urchin (*Centrostephanus coronatus*)**

Although the historical range of the crowned urchin was recorded as the Northern Channel Islands to the Galapagos Islands, this urchin was considered rare in California. However, over the last 10 years, the population of crowned urchins has increased, and individuals have been spotted as far north as Monterey Bay (Freiwald et al, 2015). These urchins are found in the rocky subtidal and venture out to forage at night, traveling only a meter (3 ft), before returning home prior to sunrise. They are completely black and have iridescent blue circles located at the base of their spines, which will seem to glow in the light of your flashlight. The test of the crowned urchin is small, but the spines are very long. This allows this species to squeeze into small holes and crevices.

Note: Flashlights should be used to verify urchin species. Red urchins (*Mesocentrotus franciscanus*) may appear black, but with a flashlight, will be red, while crowned urchins (*Centrostephanus coronatus*) are black and have a bright blue ring at the base of each spine.

- **Sea Stars**

Sea stars (sometimes referred to as starfish) are star-shaped and occur in all the oceans and at all depths. There are about 1,500 species of sea stars that occur from the tropics to the earth's poles. They usually have a central disc and five arms, though some species can have lots of arms. They are opportunistic feeders and consume many types of algae and marine animals, dead and alive. In California, we have over 40 species of sea stars, but luckily for you, we only record five of those.

- **Bat Star (*Patiria miniata*)**

Found from Alaska to Baja California, bat stars are the most abundant and colorful of the sea stars that we record. These stars are the typical star-shape with “wings" or webbing between each of their five arms (although some individuals can have more or fewer). They can be almost any color and can also be a combination of two or three colors (see Figure 33A). They are sometimes confused with the red sea star (*Mediaster aequalis*) which does not have the webbing between the arms and the broad range of color morphology that is typical of the bat star. These stars are omnivorous and scavengers.

- **Leather Star (*Dermasterias imbricata*)**

Just like its name, the leather star has skin that feels like leather or, well, skin. Leather stars are typically bluish-gray in color and have a distinct, reticulated pattern of red or orange. These sea stars can be confused with bat stars; however, unlike leather stars, bat stars have rough skin and lack the visible madreporite (the white dot found on the front side of the leather star) that is used to filter in water to echinoderms. The leather star is also unique as it uses a special defense against its predators by excreting a chemical that smells like garlic.

- **Giant Spined Star (*Pisaster giganteus*)**

The giant spined star is found on subtidal rocky reefs from British Columbia to Baja California. This species has five arms with large white spines or knobs that are surrounded by a bluish ring. These large sea stars can be a light rust to blue in color and are carnivorous, preying on a variety of invertebrate species.

- **Short Spined Sea Star (*Pisaster brevispinus*)**

The short spined sea star is found subtidally from Alaska to San Diego, California. It is usually light pink (can sometimes look grey or white in low light conditions) and has five arms with very short spines. This species can be found on rocky substrate or in the sand and is an active predator of other invertebrates.

- **Ochre Sea Star (*Pisaster ochraceus*)**

Sometimes confused with the giant spined star, the ochre star can be found in the intertidal and subtidal from Alaska to Baja California. This star is considered a keystone species within the rocky intertidal and can often be observed clinging tightly to rocks amongst beds of mussels (a main prey species of the ochre star). They also eat snails, barnacles, clams, limpets, chitons and many other invertebrate organisms they come across. Predators of the ochre sea star include seagulls and sea otters.

- **Sunflower Sea Star (*Pycnopodia helianthoides*)**

The sunflower sea star is the largest of all sea stars and was typically found between Alaska and Carmel Bay, California but can be observed all the way to Baja California. They have 15-26 arms and can be many colors but are usually purple with fluffy white tufts above hard, spikey white spines. They are carnivorous with their main diet consisting of urchins and bivalves. They have become very rare after their populations were severely reduced by the sea star wasting disease of 2013 and the following years (Winningham et al. 2018). RCCA now records these if found anywhere on site.

- **Sun Star (*Solaster* spp)**

The sun star is a common name that applies to several stars of the genus *Solaster*. Most of these species are uncommon in California with many only observed north of Monterey Bay. Like the sunflower sea star, these sea stars have many arms and come in many colors but have a “cleaner” appearance (they do not have the fluffy white tufts that sunflower sea stars exhibit). The sun stars are carnivores that prey on other stars and urchins.

Echinoderms – Urchins

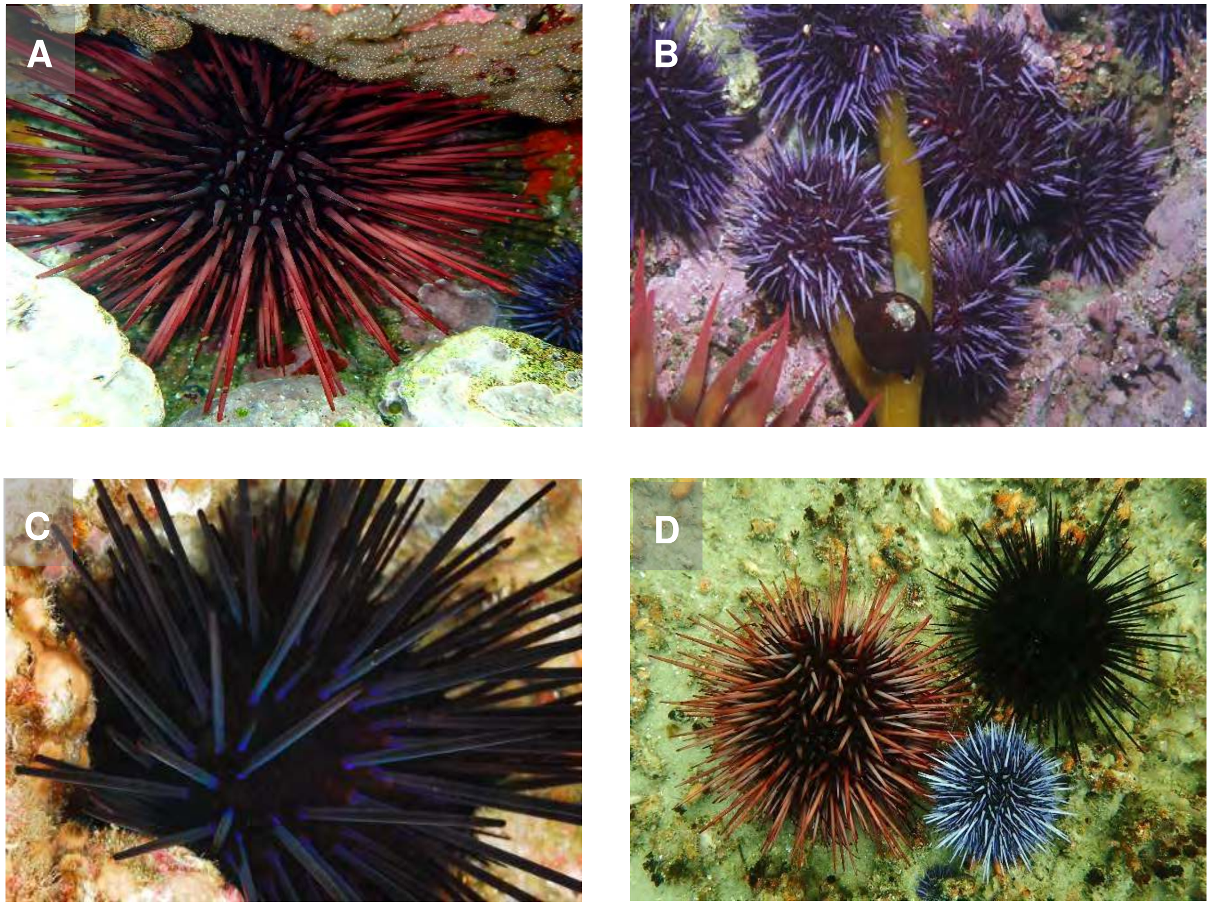


Figure 32: RCCA urchin species: A) Red urchin (Selena McMillan); B) Purple urchins (Steve Lonhart); C) Crowned urchin (Derek Tarr); D) Red urchin (left), Crowned urchin (top right), Purple urchin (bottom right) (Zack Gold).

Echinoderms – Sea Stars

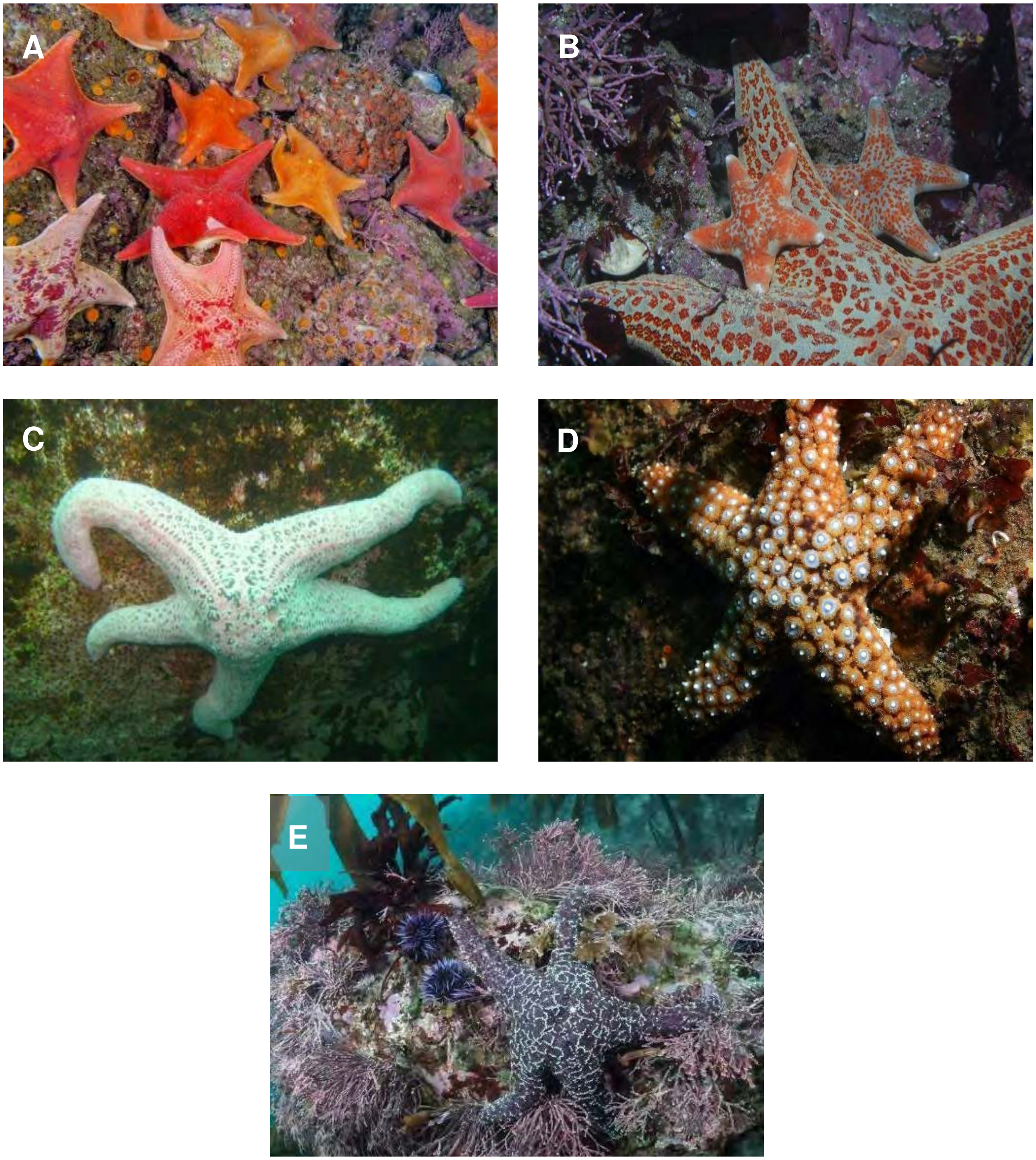


Figure 33: RCCA sea star species: A) Bat stars (Jon Anderson); B) Leather stars (Steve Lonhart); C) Short spined star (David Horwich); D) Giant spined star (Chad King); E) Ochre star (Kate Vylet).

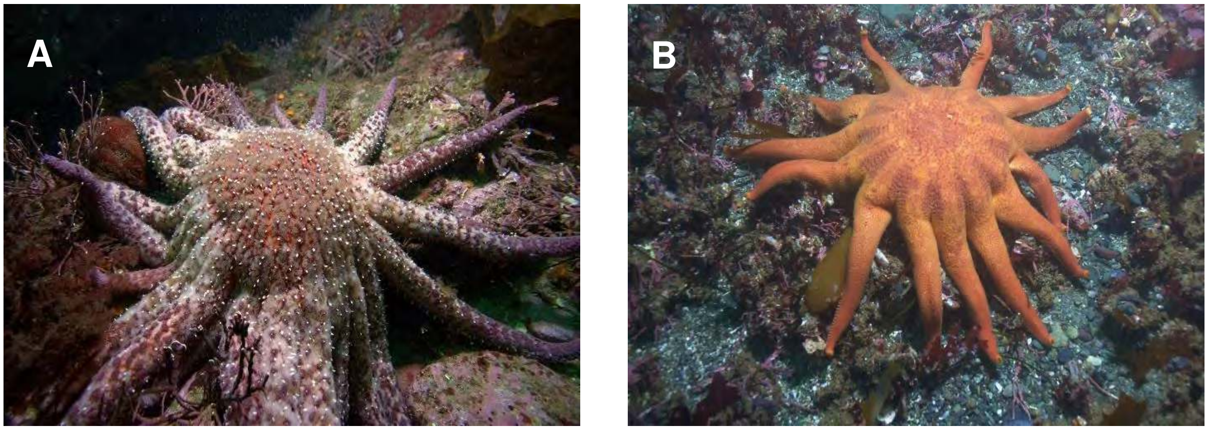


Figure 34: RCCA sea star species (continued): A) Sunflower star, recorded if seen anywhere on site (Chad King); B) Sun star (Chad King).

- **Sea Cucumbers**

Sea cucumbers are a large group of echinoderms (over 1700 species) that typically have elongate bodies covered in leathery skin. These animals live in many types of ocean environments worldwide and, as detritivores (animals that break down organic matter), are extremely important to their marine ecosystems. Some species of sea cucumbers are capable of ejecting part or all of their internal organs in times of stress or in response to a potential threat. Several species of sea cucumbers, including the two California sea cucumbers that we count, are harvested, dried and sold to Asian markets for human consumption.

  - **Warty sea cucumber (*Parastichopus parvimensis*)**

The warty sea cucumber is found in coastal waters from Monterey Bay, California to Baja California. It is orange to brown in color and has a few large and many small “warts” or protrusions on its body that are tipped with a black “whisker”. A commercial fishery for the warty sea cucumber has existed since the 1980s, but a recent increase in foreign interest in this species has caused a decline in their overall abundance. The CDFW is in the process of developing future management strategies for the warty sea cucumber population. These new management strategies might include the use of RCCA data.

  - **California sea cucumber (*Parastichopus californicus*)**

The California sea cucumber can be seen on rocky reefs from Alaska to Baja California but are less frequently observed south of Pt. Conception. This species is a light tan to red in color and can sometimes have large blotches of dark color on its body. The California sea cucumber has large conical, thorn-like protrusions on its body. These “thorns” are soft and flimsy in texture and are not tipped with a black “whisker” like the warty sea cucumber (see above). This cucumber is also part of a commercial fishery, but more data are needed to determine the effects of fishing on this species.

Crustaceans

Crustaceans are Arthropods, and are related to insects, arachnids and myriapods. These animals are all bilaterally symmetrical and have exoskeletons, segmented bodies and paired appendages. Crustaceans form a subphylum that contains over 67,000 species and includes animals such as crabs, lobsters, crayfish, shrimp, krill and barnacles. We sample three species of crustaceans on our invert transects.

- **Spiny Lobster**

Spiny lobster all belong to the family Palinuridae and can be found in areas such as the Bahamas, New Zealand, Australia, the west coast of North America, Ireland, and South Africa. This family contains about 60 species and, unlike their cousins, the family Nephropidae, they do not have large claws. In California, we only have one species of Palinuridae, the California spiny lobster.

  - **California Spiny Lobster (*Panulirus interruptus*)**

The California spiny lobster is easily identified, as it is the only lobster species on our coast. Typically found from Morro Bay, California to the Gulf of Tehuantepec, Mexico, this clawless lobster is reddish-brown in color with two long antennae that poke out from under rocks and crevices. It is carnivorous and feeds on urchins, clams, mussels and worms, and is food for Sheephead, Giant Sea Bass, Cabezon, sharks, and humans. The California lobster is a target for both commercial and recreational fisheries in California (regulated by CDFW) and an important commercial fishery for Mexico.

- **Crabs**
  - **Sheep Crab (*Megastraea undosa*) and Masking Crab (*Pomaulax gibberosus*)**

In some cases, collecting information on marine organisms is important even when they are difficult to tell apart. This is the case for the sheep and masking crabs. These crabs look very similar to each other and are therefore counted in one category. The sheep crab is a type of decorator crab, which attaches materials to its body for camouflage. It can be found from Northern California to Baja California from the intertidal to 183 m (600 ft). The masking crab is pear-shaped with the widest part towards the rear of the body. It is greyish-brown in color with short brown hairs all over its body and white at the tips of its appendages.

  - **Rock Crab**

Like the sheep crab and the masking crab category, the rock crab category contains three species of crab that look very similar to each other: the red crab (*Cancer productus*), the yellow crab (*Metacarcinus anthonyi*), and the Pacific rock crab (*Romaleon antennarius*). The red crab is the largest of the rock crab category and can be found from Alaska to Baja California. Mostly found south of San Pedro, yellow crab has a range that extends from Northern California to Baja California. Finally, the Pacific rock crab is found between San Francisco and Baja California. These crabs all have the typical cancer crab shape (like a Dungeness crab) and are brown to red in color. These crabs are all part of the recreational and commercial rock crab fishery which is managed by the CDFW.

Cnidarians

Cnidarians are a group of mostly marine animals that include jellyfish, corals, hydroids and anemones. There are over 11,000 species of cnidarians and they have two basic body forms: swimming medusa (think sea jellies) and sessile polyps.

- **Gorgonians**

Gorgonians are also known as sea fans or sea whips and include over 500 species found throughout the world's oceans. They are sessile colonial cnidarians that can create structures of various colors, shapes and sizes. These organisms are filter feeders and collect plankton and detritus from the water around them. For our invertebrate surveys, we collect data on three species of gorgonians in two categories. All gorgonians must be at least 10 cm tall to be counted during invertebrate surveys.

  - **California Golden Gorgonian (*Muricea californica*) and Brown Gorgonian (*Muricea fruticose*)**

California golden and brown gorgonians are found south of Pt. Conception and are very hard to distinguish (especially when their polyps are not exposed). Therefore, we record these two species in one category. These gorgonians have a flat, two-dimensional appearance (like a fan) and can grow as high as 90 cm (3 ft). The branches are reddish-brown to red in color. The polyps of the California golden gorgonian vary in color from white to bright yellow to orange, while the brown gorgonian polyps are usually white.

  - **Red Gorgonian (*Lophogorgia chilensis*)**

Red gorgonians are also found south of Pt. Conception and unlike the California golden and brown gorgonians, this species is more bush-like than fan-like in its structure with its red branches growing out like fingers. The polyps on the red gorgonian are white, and it can also grow to heights of 90 cm (3 ft).

- **Anemones (Order Actinaria)**

Anemones are carnivorous marine animals that come in a variety of shapes, sizes and colors. They are usually sessile, securing themselves to the sea floor. They are typically solitary and have an oral disc that is surrounded by a ring of tentacles that can be retracted into the body cavity.

  - **Large Anemones (several species)**

We record several species of anemones in this category, but they all must be larger than 10 cm tall and/or 10 cm wide. Although tube-dwelling anemones are closely related to these anemones, they are not included in this category.

Echinoderms – Sea Cucumbers

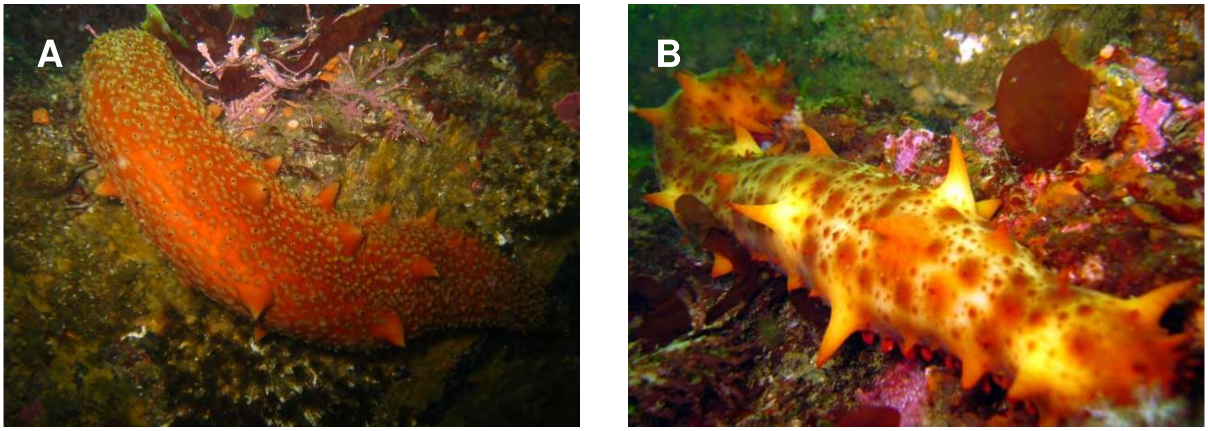


Figure 35: RCCA sea cucumber species: A) Warty sea cucumber (David Horwich); B) California sea cucumber (Dana Murray).

Crustaceans – Lobster and Crabs

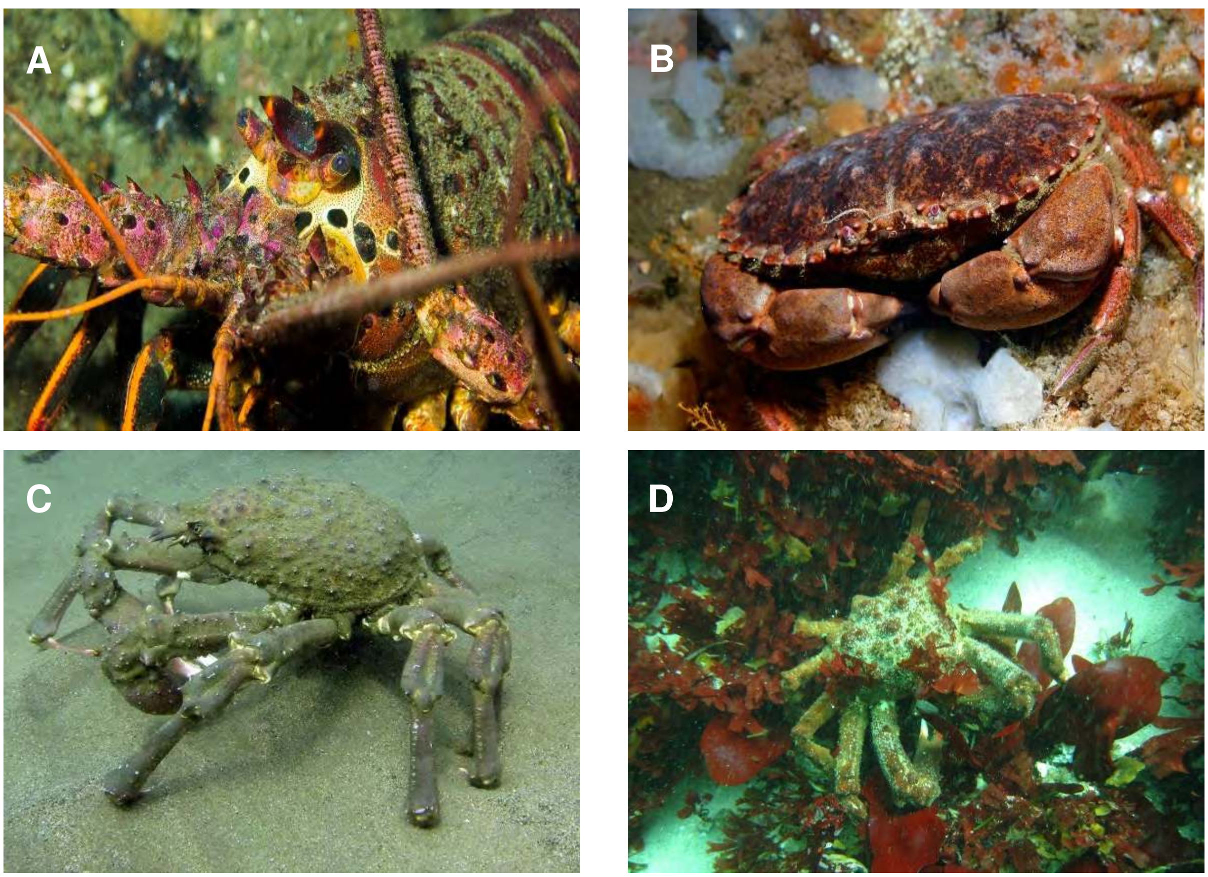


Figure 36: RCCA crustacean species: A) California spiny lobster (Tom O'Leary): B) Rock crab (Steve Lonhart): C) Sheep crab (J. Williams); D) Masking crab (David Horwich).

Cnidarians

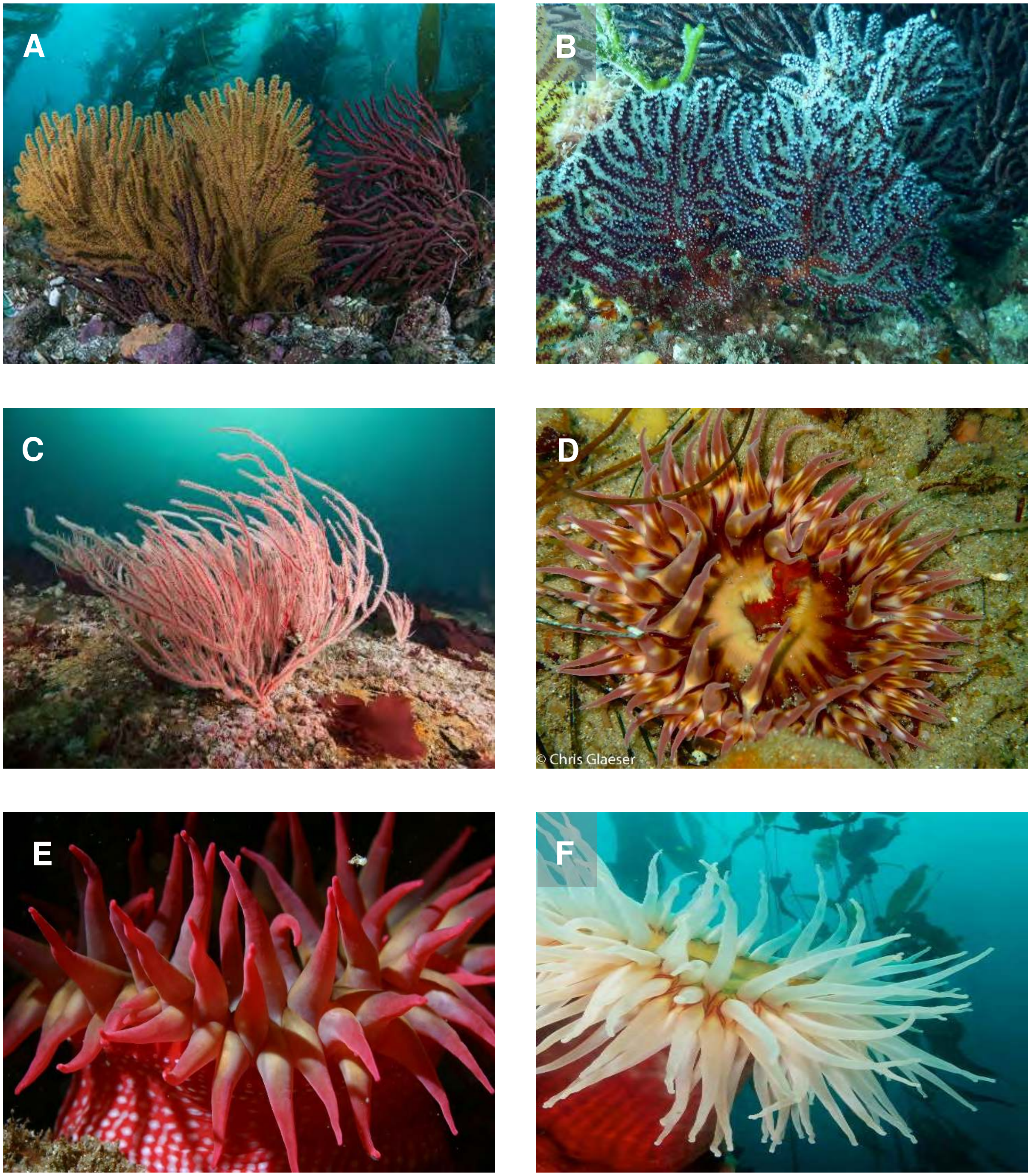


Figure 37: RCCA cnidarian species: A) Golden gorgonian (Kate Vylet); B) Brown gorgonian (Avrey Parsons-Field); C) Red gorgonian (Phil Garner); Examples of large anemones: D) Sand rose anemone (Chris Glaeser); E) White-spotted rose anemone (Chad King); F) Fish-eating anemone (Pete Naylor).

Kelp Species

Kelp is the common name for several large species of brown algae found across the world's oceans and can be a primary habitat and food source for many marine species. Sometimes called seaweed, these species of brown marine algae belong to a type or order called Laminariales. This order of algae is typically found in temperate and arctic regions, including both the Atlantic and Pacific oceans. The main target of our kelp transects are species of Laminariales, however there are a few species of marine algae that we also include in our kelp transect, such as invasive species.

Table 4: Key algal species recorded on the Reef Check California kelp transect.

Common Name	Scientific Name	Rationale
Giant kelp*	*Macrocystis pyrifera*	C, E, EI
Southern sea palm**	*Eklonia arborea*	C, EI
Pterygophora**	*Pterygophora californica*	C, EI
Bull kelp**	*Nereocystis luetkeana*	C, EI
Feather boa kelp*	*Egregia menziesii*	C, EI
Laminaria setchellii**	*Laminaria setchellii*	C, EI
Laminaria farlowii***	*Laminaria farlowii*	C, EI
Sargassum**†	*Sargassum horneri*	C, EI, I
Sargassum†	*Sargassum muticum*	C, EI, I
Undaria†	*Undaria pinnatifida*	EI, I
Caulerpa†	*Caulerpa taxifolia*	EI, I

* Number of stipes greater than 1 meter per holdfast are recorded
** Must be taller than 30 cm to be recorded
***Blade must be longer 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

Kelp (Laminariales)

- **Giant Kelp (*Macrocystis pyrifera*)**

Although we think of this amazing kelp as a California habitat, it is also found in the temperate seas of South America, South Africa, Australia, and New Zealand. Giant kelp can grow up to a meter (about 3 ft) per day, and the fronds can reach lengths of over 45 meters (150 ft) long. This species is perennial, meaning an individual can live for many years and have multiple reproductive events in a lifetime. Reproduction occurs on blades just above the holdfast. The giant kelp forests that this species creates can offer protection for young fish, habitat and food for a multitude of species and oxygen to the subtidal and terrestrial environment. Each giant kelp individual creates a root-like structure, called a holdfast, that grabs onto the rocky reef and grows stipes (stems) upwards, seeking the sun from above. Depending on resources and oceanographic conditions, giant kelp individuals can vary in the number of stipes they have, ranging from one to over 500 stipes. Stipes have leaf-like structures called blades that take in nutrients from the water and sunlight for photosynthesis. At the base of each of these blades, you can find a gas-filled structure called a pneumatocyst. These incredible structures allow this huge underwater "tree" to grow from the bottom of the ocean to the water's surface above, thus creating the three-dimensional underwater structure that you imagine when you think of "kelp forests". In the past, giant kelp was collected and burned for soda-ash, which was used in the production of several household products. Currently, it is still harvested for alginate, the main carbohydrate in giant kelp. Alginate is used to make food and household products "smoother", like toothpaste, ice cream, jelly, shampoo/conditioner and salad dressing. It is also harvested in several places to feed abalone in an increasing number of abalone farms (mariculture) along the coast.

During the kelp transects, all giant kelp individuals are counted if any part of their holdfast is within the transect area (2 m x 30 m) and if at least one of their stipes is one meter tall. For each giant kelp individual you record, every stipe that is above one meter must be counted, with the total of those stipes recorded in a box that represents one giant kelp individual on your datasheet. For each individual, write the number of stipes counted in each box. If you fill all 50 boxes on your datasheet, you can subsample and record the distance you traveled along your transect. (See subsampling).

- **Bull Kelp (*Nereocystis luetkeana*)**

Bull kelp can be found from Alaska to San Luis Obispo County in California either exclusively, or in conjunction with giant kelp. Like giant kelp, bull kelp can grow from the bottom of the reef to the surface of the ocean. However, unlike giant kelp, bull kelp has one stipe growing from its holdfast with one large pneumatocyst (air bladder) at the top of the stipe. The singular stipe allows this species of algae to proliferate in rough waters with less risk of entanglement and getting ripped off the seafloor. The single gas-filled pneumatocyst produces two sets of blades that can grow up to 10 meters long and will photosynthesize and produce reproductive spores at the surface. This kelp is annual, meaning it grows from juvenile to adult for one year and then dies after releasing its spores. Bull kelp must be at least 30 cm long from the base of the stipe to the top of the pneumatocyst to be counted.

- ***Laminaria setchellii***

Laminaria setchellii can be found from Alaska to Baja California, however, it is mainly found north of Pt. Conception. It has a single smooth stipe growing from its holdfast with a large blade that tends to tear into several distinct parts (which may look like a palm with fingers). During surveys, divers often find *Laminaria setchelli* mixed in with beds of *Pterygophora californica*, so be sure to be aware of this when subsampling one or both algae. This alga needs to be at least 30 cm from holdfast to the base of the blade to be counted.

- ***Laminaria farlowii***

Laminaria farlowii is found mainly in Southern California but has been observed from Baja California to British Columbia. In 2015, divers began reporting beds of *Laminaria farlowii* in Monterey Bay and Carmel Bay, suggesting a possible range expansion for this species of kelp. It has a very short stipe coming out from its holdfast and has a very large corrugated blade growing from the stipe. Large individuals have been observed to blanket and shade large areas of the reef. The blade can be over a meter in length, but to count it for Reef Check, the blade and stipe combined need to be at least 30 cm long.

- **Pterygophora (*Pterygophora californica*)**

Pterygophora can be found from Alaska to Baja California and is perennial, living for many years. This kelp has one sturdy, woody stipe growing from its holdfast. The top of the stipe flattens and ends in one long blade. Each side of the flattened area has several blades growing out from it (like wings). This species of kelp has been known to exceed 2 meters in height; however, we count this alga if it is larger than 30 cm from the holdfast to the base of the flattened area where the blades begin.

- **Southern Sea Palm (*Eklonia arborea*)**

The Southern sea palm is a species of Laminaria that can be found from British Columbia to Baja California. They are very similar to Pterygophora but have a split or fork at the top of their stipe instead of a long blade. Therefore, their blades hang out to either side of the split like the pom-poms of a cheerleader (Southern sea palm-pom). Studies have shown that the stipes of this species can grow very large in some regions but remain very small in others (Matson & Edwards 2017). Southern sea palms grow up the same way as many other kelps with one little stipe and a little blade. These kelps only look different from each other after they mature. Therefore, we count all Southern sea palms once they have developed the split at the top of their stipe. Once you are able to place your thumb between the two sides of the split of each of the “branches”, you can count it as either less than 30 cm (<30) or larger than 30 cm (>30) from the holdfast to the split or “v” of the stipe.

- **Feather Boa Kelp (*Egregia menziesii*)**

Feather boa kelp occurs from Alaska to Baja California and is typically found from the intertidal to shallow subtidal. However, in certain areas of California, this kelp grows deeper, either growing with giant kelp or even creating its own kelp forest habitat. Just like with giant kelp, every stipe that is above one meter must be counted, with the total of the stipes being recorded in a box that represents one feather boa individual on your datasheet. If you reach 50 feather boa individuals, you can subsample and record the distance you traveled on your transect. (See subsampling).

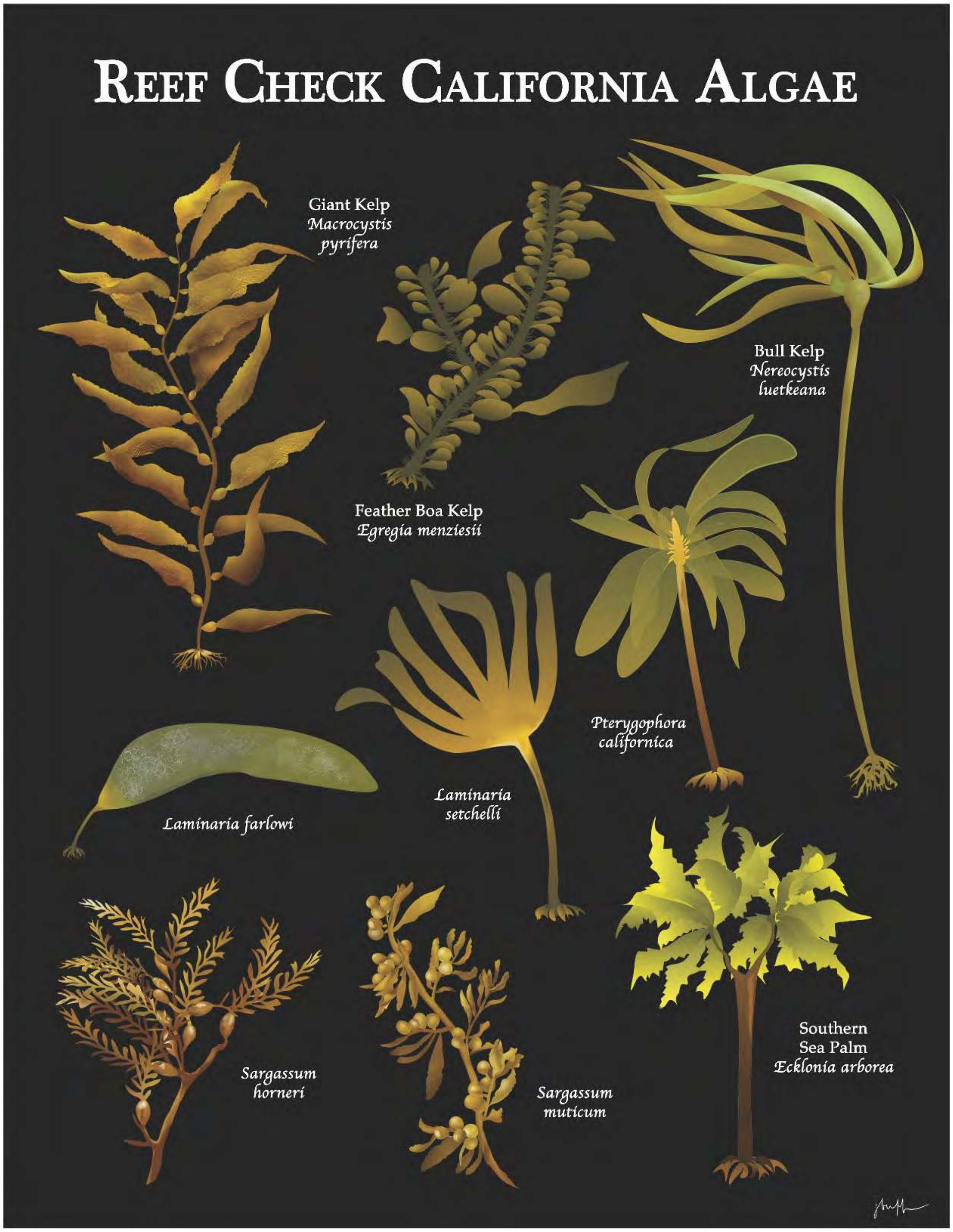


Figure 38: RCCA algal species recorded on the Kelp Transect. Illustration by Jann Griffiths.

Invasive Species

The algal species listed below are all invasive species, which means they are not native and have entered the California marine environment by human influences via boats and/or the aquarium industry. These algal species have proven to be detrimental to many other areas that they have invaded and are considered a threat to the health and stability of our California reef system.

- ***Sargassum horneri***

Sargassum horneri was first identified at Long Beach Harbor in 2003. It is native to Japan, Korea and China, but most likely arrived on a commercial vessel coming from Japan. This alga has been nicknamed the "devil weed" as it has spread throughout Southern California, from the Northern Channel Islands to Guadalupe Island, Mexico. This alga is golden brown to greenish brown in color and has a small, woody stipe with several fronds branching out and up from the stipe. These fronds can grow over five meters long and have flattened, fern-like blades that grow in a zig-zag pattern; they can often be mistaken for *Stephanocystis osmundacea*. These blades have little oblong (chilli-pepper shaped) pneumatocysts (air bladders) that grow as a part of the blade.

Like the other invasive species that we sample, Reef Check originally only noted if it was present or absent at each site, but with *Sargassum horneri'*s proliferation and expansion, we began counting all individuals of this species that are 30 cm or larger. Remember, we still mark on the Kelp Transect Data Sheet if this species is seen anywhere on site at any size.

- ***Sargassum muticum***

The invasive species *Sargassum muticum* appeared in Southern California in the 1950s and 1960s, and like *Sargassum horneri*, it is native to several Asian countries in the Western Pacific and most likely arrived from Japan. It can be found from Alaska to Mexico, where it has spread rapidly along coastlines and has become a major component of algal communities (Engelen et al. 2015). This alga is similar in color to *Sargassum horneri* and typically grows to about 1-3 m high but can be as tall as 6-10 m (Fofonoff et al. 2019). There is one stipe that grows from the holdfast, but the stipe can branch, making the alga look bushy. On each stipe are small, elongate blades coming out in all directions (like an artificial Christmas tree) and among these blades growing closely to the stipe are many small round air bladders (like Christmas ornaments). We do not count this species, but note if found anywhere on site at any size (including juveniles).

- **Undaria *(Undaria pinnatifida)***

Undaria, or wakame, can be found in its native Western Pacific from Russia to several Asian countries including Japan, Korea and China. However, this kelp has become a major invader to the west coast of North America (from Northern California to Mexico), Europe, Argentina, New Zealand and Australia (Fofonoff et al. 2019). This species usually grows between 1-2 m high but can get as large as 3 m. Each individual is made up of a holdfast, one stipe and a large blade that has a prominent mid-rib. The blade can be drawn into many lobes that are greenish-brown in color, while the mid-rib is noticeably lighter in color. Another major feature of this invasive kelp is its reproductive structure. When mature, this species creates a large, ruffled, football-shaped structure on the stipe, above the holdfast (Figure 39).

A program to control *Undaria* through hand removal by divers in the Monterey Bay National Marine Sanctuary began in 2010. The goal of this effort is to slow the spread of *Undaria* and protect native kelp communities. Evidence for negative impacts in California is currently unclear

(Thornber et al. 2004, Anderson 2006, Schaffelke et al. 2006). Therefore, we must note if *Undaria* is found anywhere on site at any size. Any individual of this species needs to be photographed, and the CDFW should be notified of its location.

- **Caulerpa *(Caulerpa toxifolia)***

Native to Queensland, Australia, *Caulerpa* or "killer seaweed" has wreaked havoc in areas such as the Mediterranean, where it covered the sea floor in several areas. A beautiful green algal species, it is a popular aquarium alga and it is thought that the invasion of this species came from aquariums. It is bright green and, unlike all of the other algae we sample, this species does not have a holdfast but has horizontal stolons (like a vine growing on a wall) that grab the seafloor and can extend as far as 1 m. Feather-like "blades" grow from the stolon and can reach lengths of up to 50 cm. Since its introduction to California in 2000 and subsequent eradication in 2002, all sales of *Caulerpa* have been banned statewide (Fofonoff et al. 2019). Like *Undaria*, any individual of this species must be photographed, and the location reported to CDFW.

Invasive Species

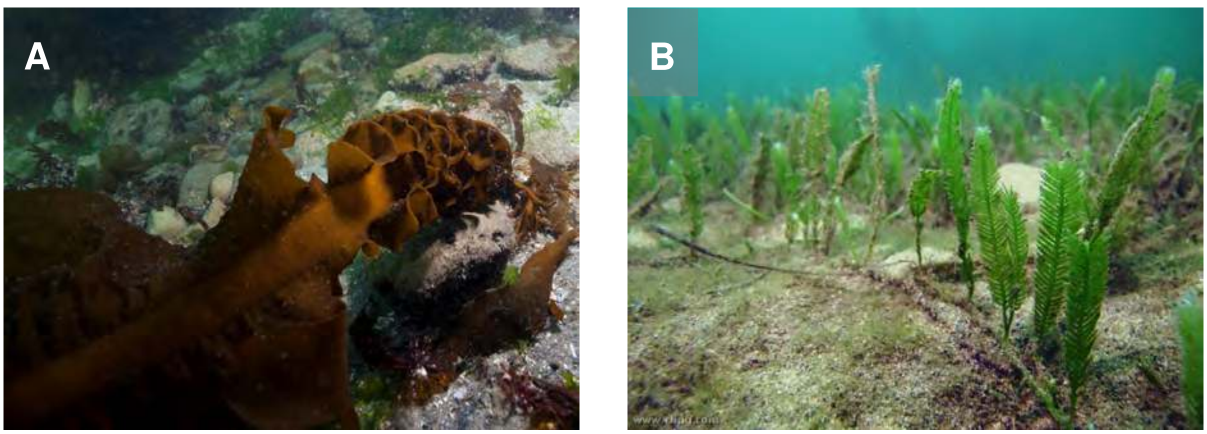


Figure 39: Two of the four invasive species noted on or off the RCCA Kelp Transect: A) *Undaria pinnatifida* (Chad King); B) *Caulerpa taxifolia* (Richard Ling).

Fish Species

While the prospect of learning the 35 fish species listed in Table 5 may appear daunting, you will be surprised that, with a bit of practice, you will soon be a fish identification expert! Underwater fish identification will be eased by considering the following factors: habitat, behavior, size, shape, color and markings.

- **Habitat** - Is the species swimming in the mid-water or hiding under or on a rock? At what depth did you see it?

- **Behavior** - Is the fish schooling or is it alone? Does it immediately swim away when it sees you?

- **Size and shape** - There are several areas on which to focus: the body, mouth, fin shape, color and markings.

- **Body** - Does the fish have a heavy body and large lips? If so, it is probably a rockfish or a sea bass. Does it look eel-like (like a moray eel) or have an elongated body? If so, it is probably a Kelp Greenling or Lingcod.

- **Mouth** - By looking at the mouth type and shape, you can often determine the food source (i.e. Señorita vs Sheephead).

- **Fin shape** - Examine the tail and dorsal fins of the species of interest. Are they rounded, straight, forked or joined?

- **Color** - Remember that color varies dramatically and is influenced by conditions, especially light levels. The most reliable places to look for colors are the fins. The Vermilion Rockfish, for example, has dark edges on its fins. It is important to remember that for some species there can be significant variation between males and females (e.g., Kelp Greenling, Rock Wrasse, Sheephead, etc.) and between different life phases – juvenile and adult (e.g., Sheephead, Garibaldi, rockfish, etc.).

- **Markings** - Generally more distinctive than colors, markings are the bedrock of any ecologist's fish identification skill set. Pay special attention to stripes (horizontal), bars (vertical) or bands for identifying Seaperch and Sargo. For identifying Yellowtail Rockfish, Olive Rockfish and juvenile Garibaldi, on the other hand, it is best to look for spots or blotches. Finally, fine lines or speckles along the body are important to consider when identifying fish such as Striped Seaperch or Blacksmith.

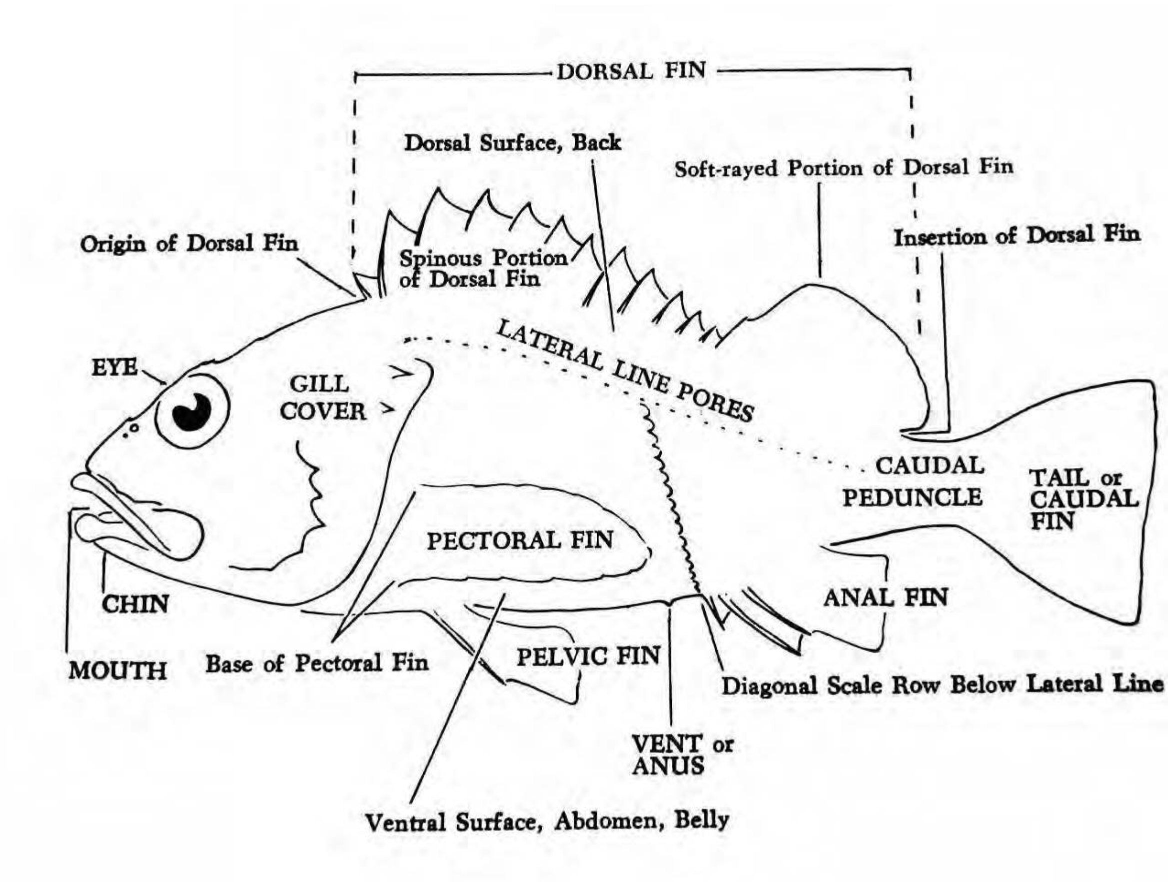


Figure 40: Diagram showing several key features of a fish (Miller and Lea 1972).

Table 5: Resource conservation species and rationale of RCCA indicator fish species.

Common Name	**Scientific Name**	**Rationale**
Blue Rockfish*	*Sebastes mystinus*	E
Black Rockfish*	*Sebastes melanops*	E
Olive Rockfish*	*Sebastes serranoides*	E
Kelp Rockfish*	*Sebastes atrovirens*	E
Grass Rockfish*	*Sebastes rastrelliger*	E
Brown Rockfish*	*Sebastes auriculatus*	E
Black and Yellow Rockfish*	*Sebastes chrysomelas*	E
Gopher Rockfish*	*Sebastes carnatus*	E
Copper Rockfish*	*Sebastes caurinus*	E
Vermilion Rockfish	*Sebastes miniatus*	E
China Rockfish*	*Sebastes nebulosus*	E
Treefish*	*Sebastes serriceps*	E
Kelp Greenling*	*Hexagrammos decagrammus*	E
Lingcod	*Ophiodon elongatus*	E, SI
Cabezon*	*Scorpaenichthys marmoratus*	E
Black Perch	*Embiotoca jacksoni*	C, E
Striped Seaperch	*Embiotoca lateralis*	C, E
Rainbow Seaperch	*Hypsurus caryi*	C, E
Pile Perch	*Rhacochilus vacca*	C, E

Common Name	Scientific Name	Rationale
Rubberlip Seaperch	*Rhacochilus toxotes*	C, E
Señorita	*Oxyjulis californica*	C
CA Sheephead*	*Semicossyphus pulcher*	C, E, EI
Rock Wrasse	*Halichoeres semicinctus*	C
Blacksmith	*Chromis punctipinnis*	C
Garibaldi	*Hypsypops rubicundus*	C, SI
Kelp Bass	*Paralabrax clathratus*	C, E
Barred Sand Bass	*Paralabrax nebulifer*	E
Opaleye	*Girella nigricans*	C, E
Halfmoon	*Medialuna californiensis*	C
Sargo	*Anisotremus davidsoni*	C
Giant Sea Bass†	*Stereolepis gigas*	SI
Finescale Triggerfish	*Balistes polylepis*	SI
Horn Shark	*Heterodontus francisci*	EI, E
California Moray	*Gymnothorax mordax*	EI
Largemouth Blenny	*Labrisomus xanti*	SI

* Fin fishes included in the Nearshore Fishery Management Plan (www.dfg.ca.gov/mrd/nfmp/)
† 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 (important to trophic food web), **SI** = species of interest or concern (protected, endangered, overfished, etc.)

Here we will present each fish group in an order that represents those species found from the north to the south of California. More information can be found in the flashcards provided to you in your training packet. We will talk about each one of these fish species and offer you tricks to tell them apart during your classroom training.

Rockfish (Genus Sebastes)

This genus of fish has over 72 species that are found in the Northeastern Pacific. Rockfish can be found from the intertidal zone to thousands of meters below the ocean's surface. The genus name, *Sebastes*, actually means "magnificent" in Greek and they truly are that!

- **Blue Rockfish (*Sebastes mystinus*)**

Mystinus is the species name for the Blue Rockfish and is derived from the Greek word for "priest". This dark colored rockfish is blue-black to grey-blue in color and have two dark stripes that run down from the eye to the cheek, making them look as if they are crying or "blue". They can grow to lengths of over 50 cm and can be solitary or school with many other fish of the same species, as well as Black Rockfish (which are commonly mistaken for Blue Rockfish). They occur from Alaska to Northern Baja and are a common sight in the Central and North coast kelp forests. They mature (meaning they can reproduce) at around 4-5 years of age and can live over 40 years. Blue Rockfish are a very large part of the commercial live-fish fishery and are regularly taken by recreational anglers. Fewer and fewer large individuals of this species are caught in commercial or recreational fishing efforts.

- **Black Rockfish (*Sebastes melanops*)**

The species name for the Black Rockfish is formed from two Greek words that mean "black face". These fish are found from Alaska to Huntington Beach, California, but for our purposes are mainly found in Northern and Central California. Like the Blue Rockfish, this species can be found alone near the bottom or schooling with other Black Rockfish and Blue Rockfish. These fish are mottled grey-black but have a white clearing across their sides, which looks as though someone swiped their thumb across their sides, wiping away the dark coloring. They have a few light colored "spots" near their dorsal fins and have a large mouth. They can reach a length of over 60 cm and weigh as much as 5 kg (11 lb). They mature between 6-8 years of age and can live to be about 50 years old. Black Rockfish are an important part of the live-fish fishery in California and are a huge part of Oregon's recreational fishery with about 50% of landings being Black Rockfish. In California, however, most of the Black Rockfish recreational catch are immature (less than 6 years old and non-reproductive).

- **Olive Rockfish (*Sebastes serranoides*)**

The Olive Rockfish can be found from Oregon to Baja California but are more commonly found in California from Cape Mendocino to Santa Barbara. *Serranoides* is the species name for Olive Rockfish and is a combination of both the Latin and Greek languages and translates to "resembling a bass". These fish are streamlined with a dark brown to dark green-brown back with light brown to green brown on the sides. They have a series of light blotches on their back, like the ones found on the Black Rockfish. They can reach a length of over 60 cm, mature between 3-8 years of age and can live to be at least 30 years old. Olive Rockfish are usually found in the water column, resting on the bottom or hovering over high relief rocks. This species is a minor part of the commercial fishery but is frequently landed by recreational anglers.

- **Kelp Rockfish (*Sebastes atrovirens*)**

Atrovirens means "black and green" in Latin, which may lend to the many color morphs observed in the Kelp Rockfish species. Sometimes called sugar bass or dumb bass, these fish are usually mottled tan or kelp-colored, but they can sometimes be white, brown, green, black-brown, or even a reddish coloration. No matter what color they are, they all have very large eyes in comparison to their head and are often found "hanging out" in the kelp or mid-water, but can also be found on the bottom or in crevices. They also have very large pectoral fins and can reach a length of 40 cm. Kelp Rockfish can be found from Northern California to Central Baja California and are most commonly observed in the shallow subtidal to depths of 18-24 m. These fish mature at about 5-6 years old and can live over 20 years. Like the Black and Blue Rockfishes, Kelp Rockfish are an important part of the commercial live-fish fishery and are regularly caught by recreational fishermen.

- **Grass Rockfish (*Sebastes rastrelliger*)**

The species name of the Grass Rockfish, *rastrelliger*, is Latin for "I bear a small rake" which refers to the small gill rakers (bony, tooth-like projections found in the gill). This fish is found from Oregon to Baja California and often live in waters shallower than any other Rockfish species discussed here. Grass Rockfish are the bulldogs of rockfish, having big heads, heavy bodies and are typically found on the bottom. They can be dark green to olive green to almost black in color and are covered by many black blotches and spots. They live to be about 20 years old and mature around 4-5 years of age. These fish are hardy and are sought by the live-fish commercial fishery in Oregon and California. They are also fished by recreational anglers.

- **Brown Rockfish (*Sebastes auriculatus*)**

Brown Rockfish, also commonly known as "Bolina", have the species name *auriculatus,* which translates to "eared" in Latin. Although the name Bolina pays tribute to Bolinas Bay, CA where this fish was first harvested in substantial abundance, Brown Rockfish have a large range within the Eastern Pacific, ranging from Northern Gulf of Alaska to Southern Baja California. Brown Rockfish can reach a maximum size of 56 cm and live at least 34 years. Brown typically display dark brown, maroon, or black mottling (spots or blotchy patterns). Unlike the Copper or Grass Rockfish, Brown Rockfish display a dark blotch on the rear of the gill cover. Brown Rockfish are important to the recreational fishery and is sought by the commercial fisheries of Central and Southern Baja California.

- **Black and Yellow Rockfish (*Sebastes chrysomelas*)**

The species name *chrysomelas* means "gold and black" in Greek and perfectly describes the Black and Yellow Rockfish. These fish are found from Oregon to Baja and are rare north of Sonoma County and south of Pt. Conception. This fish species is very similar to the Gopher Rockfish (below) with the patterns on their body being almost identical. However, their coloration can be much different, with the Black and Yellow Rockfish having a yellow body with dark olive to black pattern on top. Both Gopher and Black and Yellow Rockfishes have three or more white patches found on their back that extend to the tips of their dorsal fin. However, Black and Yellow Rockfish live in shallow water (below 18 m), where Gophers tend to be found deeper than 12 m and up to 80 m. Black and Yellow Rockfish are usually less than 25 cm in length and may live to be up to 30 years old. Because of their brilliant coloration, this species is important to the live-fish commercial fishery and are often caught by anglers and spear fishermen.

- **Gopher Rockfish (*Sebastes carnatus*)**

Gopher Rockfish have the species name *carnatus,* which means "flesh-colored" in Latin. These fish are found from Oregon to Baja California, but are uncommon north of Sonoma County, and, unlike the Black and Yellow Rockfish, can be found south of Pt. Conception. Gophers can reach a length of over 40 cm, mature between 3-7 years of age, and can live for 30 years. They have a flesh to white colored body with an olive brown to reddish brown pattern on top, and as stated above have the same pattern as Black and Yellow Rockfish. Genetically, these two species are similar, but differences in their color morphology and depth ranges allow them to remain two separate species. Like Black and Yellow Rockfish, Gophers are sought by commercial and recreational fisheries.

- **Copper Rockfish (*Sebastes caurinus*)**

The species name *caurinus* comes from the Latin *caurus*, which means "northwest wind" referring to the first specimen harvested in Sitka, Alaska; the northwest corner of North America. Copper Rockfish range from the Gulf of Alaska to Central Baja California. They are among one of the most frequently seen rockfish by divers in Central and Northern California waters; however, except for the Channel Islands and the Santa Barbara Channel, their abundances are quite low south of Pt. Conception. Copper Rockfish can reach a maximum length of 66 cm and reach 50 years of age. Copper Rockfish can display a wide variety of colorations, which is why they are often confused for Canary or Gopher Rockfish. Distinctive features for Copper Rockfish include a white/pink clearing of the lateral line that begins at the tail and typically stops halfway through the fish. In addition, most individuals have a white belly and fins. Copper Rockfish have varying home ranges based on the amount of relief in a given outcrop; home range is smaller when relief is high (<10 m^2), and home range is larger when relief is low (up to 4,000 m^2).

- **Vermilion Rockfish (*Sebastes miniatus*)**

The species name for the Vermilion Rockfish, *miniatus*, is Latin for vermilion and refers to the bright red color that these fish can exhibit. They can be found from Alaska to Baja California and are most common between 50 m to 150 m. They can live to be over 60 years old and mature between 5-9 years of age. They are usually red to orange in color but can be brown, dark yellow, and dark reddish black. They tend to have a prominent white marking along their lateral line that goes from their tail to midway along their body. The Vermilion Rockfish is a great prize for both recreational and commercial fisheries.

- **China Rockfish (*Sebastes nebulosus*)**

China Rockfish have the species name *nebulosus,* which means "clouded" in Latin. This name refers to the beautiful dark blue or black body color and delightful yellow speckles on the head and body. In addition, there is typically a pronounced yellow stripe that runs from the dorsal fin and connects to the lateral line, making the shape of a "Nike swoosh". China Rockfish can live to at least 79 years old and reach a maximum size of 45 cm. Sexual maturity in males and females is reached at about 30 cm. China Rockfish are a typically solitary species that find refuge in cracks or caves, and prey on a variety of small benthic organisms. China Rockfish are commonly found from the Gulf of Alaska to Redondo Beach and San Nicholas Island in Southern California, with greater abundances north of Pt. Conception. Historically, the beautiful colorations of China Rockfish have made them a very commercially viable species. They are still highly sought after and sold live in Asian markets with most of the live-fish commercial harvesting occurring from Alaska to San Francisco.

- **Treefish (*Sebastes serriceps*)**

The species name of the Treefish, *serriceps,* means "saw head" in Latin, which refers to an enlarged head spine. The Treefish has many distinguishing features, including black or dark olive body bars extending across its entire body, two black bars extending at an angle from the eye towards the pectoral fin, sometimes red or pink lips, and pronounced head spines. This species of rockfish can live to at least 23 years old and reach a maximum size of 41 cm. Treefish are often observed in protected habitats with high structural complexity. Although they are shy and often escape to safety in the presence of divers, they can also be territorial and display their dorsal spines when threatened. In fact, it has been observed that during confrontations for territory, one fish will bite the jaw of another fish and shake it ferociously. Additionally, some have observed one fish momentarily swallowing the head of another fish! Treefish are commonly caught by recreational anglers on shallow rocks from Pt. Conception to Ensenada.

- **Juveniles - YOY**

In addition to the rockfish species listed above, RCCA also counts "young-of-the-year" (YOY) rockfishes (Figure 43). Another name for these newly hatched rockfishes is "recruits." Rockfishes have pelagic larvae that are released from the females in the kelp forest and then drift offshore on the ocean currents until they eventually return to nearshore waters and "recruit" back to the kelp forest to grow into adults. The timing of the release of larvae and the duration of their pelagic stage varies by species. Generally, juveniles are released in the early spring to fall and are in the pelagic stage from 1- 6 months depending on the species (Love et al. 2002). It is difficult for even the most highly trained scientists to differentiate YOY rockfish species when they are < 10 cm. As an RCCA certified diver, you will be asked to identify small individuals that clearly have a rockfish body shape but with coloration and/or markings that differ from adults and record them as YOY on your datasheet. Even if you can identify YOYs to species, do not record them under the respective species but as YOYs on your datasheet.

Rockfish

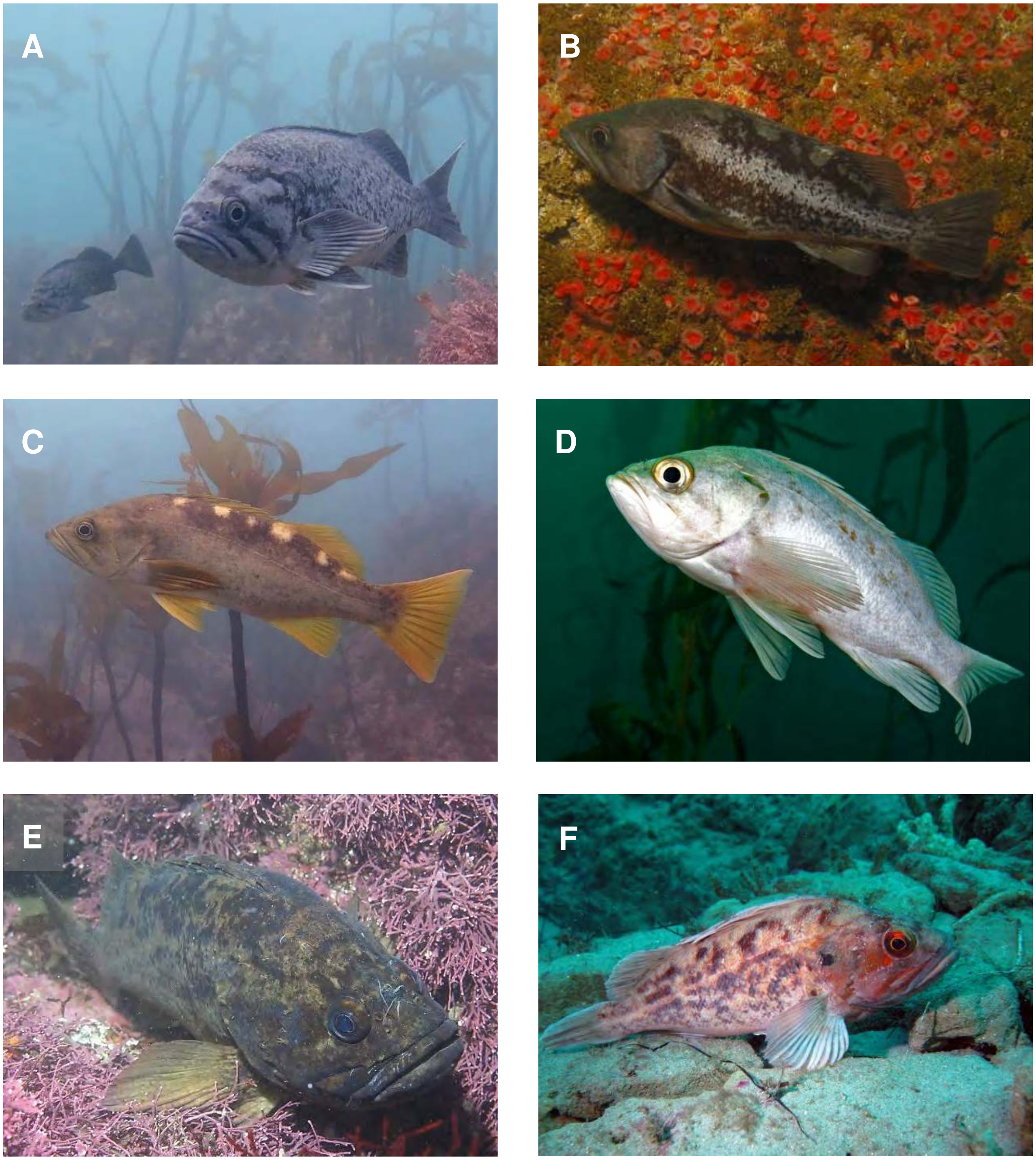


Figure 41: RCCA rockfish species: A) Blue Rockfish (Selena McMillan); B) Black Rockfish (Brian Hackett); C) Olive Rockfish (Selena McMillan); D) Kelp Rockfish (Phil Garner); E) Grass Rockfish (Steve Lonhart); F) Brown Rockfish (Herb Gruenhagen).

Rockfish – continued

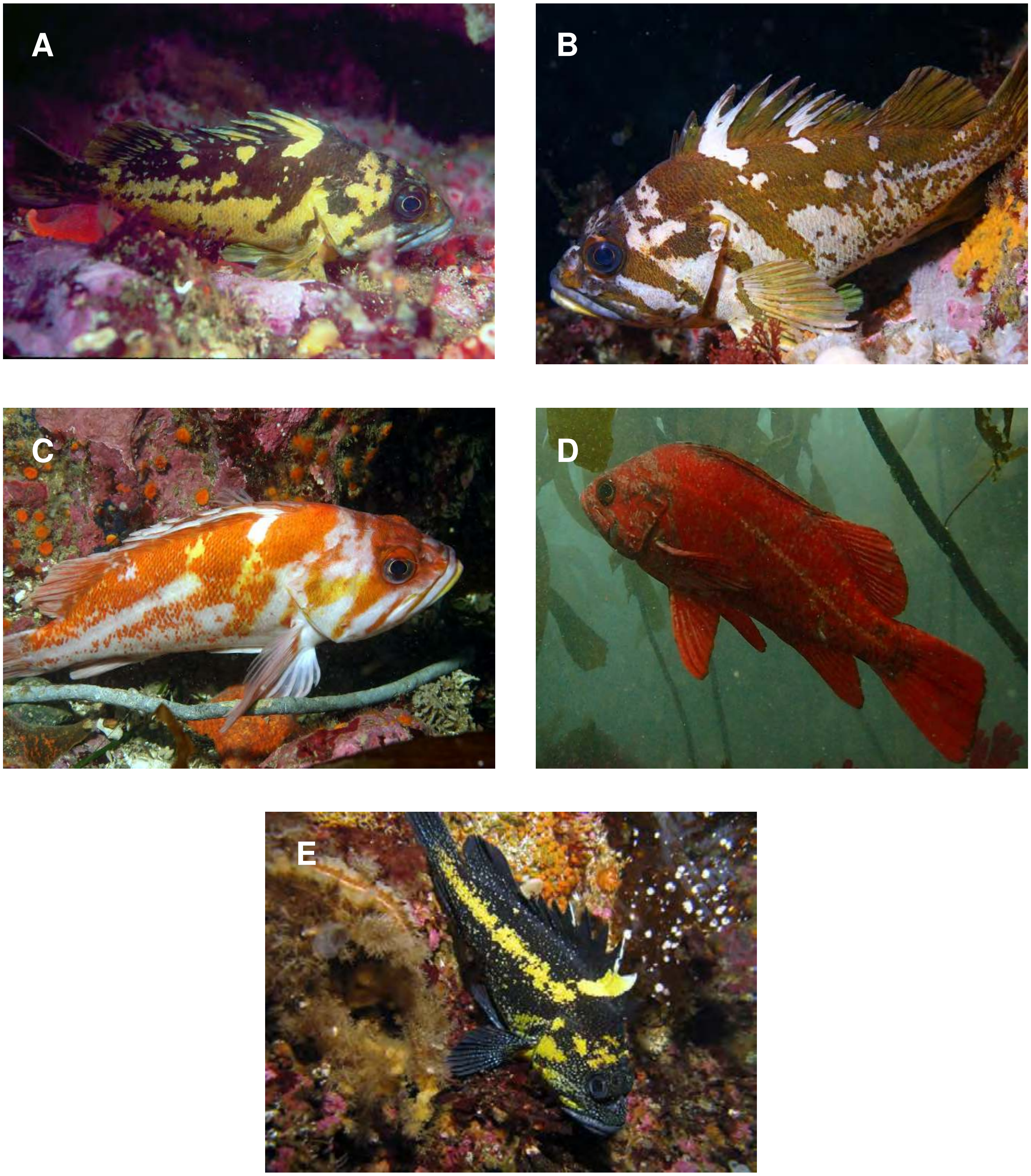


Figure 42: RCCA rockfish species (continued): A) Black and Yellow Rockfish (Herb Gruenhagen); B) Gopher Rockfish (Steve Lonhart): C) Copper Rockfish (Chad King); D) Vermilion Rockfish (Andrew Harmer); E) China Rockfish (Janna Nichols).

Rockfish – continued

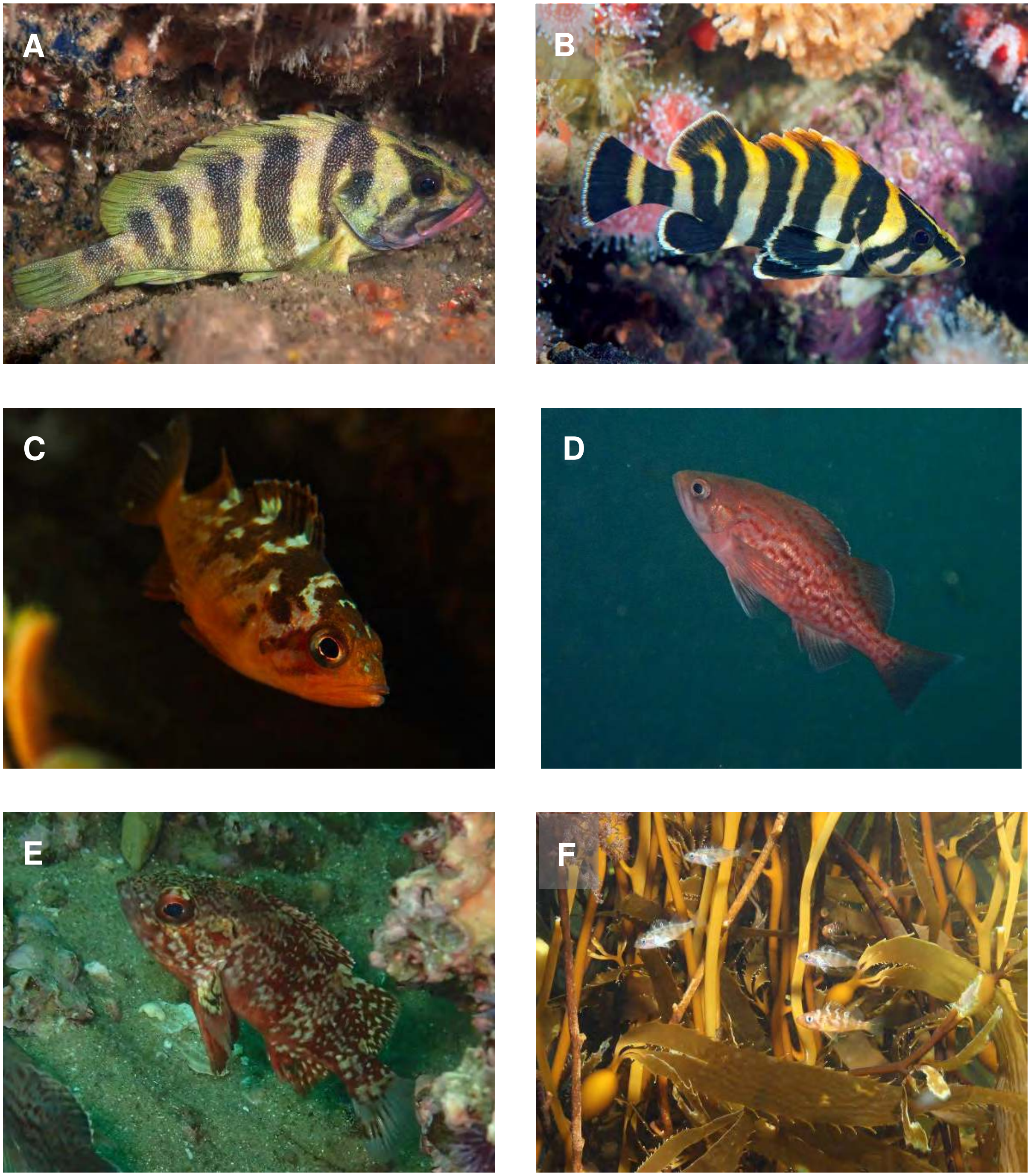


Figure 43: RCCA rockfish species (continued): A) Adult Treefish (Phil Garner); B) Juvenile Treefish (Phil Garner); Figures C-F are examples of young-of-year rockfishes: C) Kelp/Gopher/Black and Yellow/Copper (KGB complex) Rockfish juvenile (Dan Schwartz); D) Blue Rockfish juvenile (Chris Honeyman); E) Vermilion Rockfish juvenile (Chris Honeyman); F) KGB juveniles (Chad King).

Greenling (Family Hexagrammidae)

Greenlings are a part of the North Pacific family called Hexagrammidae with 13 species, nine of which are found on our coast. They live in temperate water and are not closely related to each other, with the Lingcod being the most distinct of all of the fishes found in this family.

- **Kelp Greenling (*Hexagrammos decagrammus*)**

Kelp Greenling are elongated and compressed fish with a conical head and small mouth. They exhibit sexual dimorphism in their coloration that makes males and females easily distinguishable, so we count them separately by sex. Females are uniformly speckled with reddish-brownish spots on a blue-gray background and usually have yellow-orange fins. Males are grayish, brownish, or reddish with bright blue blotches surrounded by brown-red spots on the front half of the body. They also have small cirri, or skin flaps, above the eyes, which are noticeable if observed closely. Kelp Greenling can be found between La Jolla, California and the Aleutian Islands, Alaska, but primarily north of Pt. Conception. They grow up to 53 cm in length and live up to 18 years of age. They are fished by anglers along rocky shores and jetties in Central and Northern California.

- **Lingcod (*Ophiodon elongatus*)**

Lingcod are large fish with an elongate, tapered body. They have a long conical head fitted with a big mouth and many large, sharp teeth; the lower jaw extends past the upper. Their coloration ranges from grayish and brownish to bluish and greenish with brown or copper blotches and spots throughout. Their belly is paler than the rest of the body. Lingcod are found between Pt. San Carlos, Baja California, and Kodiak Island, Alaska but primarily north of Pt. Conception. They can reach monstrous sizes, up to 152 cm in length, and live up to 20 years, maturing at 2-3 years or 50-76 cm long. They are associated with bottom habitat, rocky reefs and kelp beds, rarely seen free-swimming in the water column. Lingcod are popular among anglers and are considered a prize catch.

Sculpins (Family Cottidae)

Over 275 species of sculpins (both freshwater and marine) make up the family Cottidae and are found all over the world. There are 92 species found on our coast, however, we only sample one. This diverse group of fish species can all create sounds using muscle attached to their skull and come in all shapes, sizes and colors.

- **Cabezon (*Scorpaenichthys marmoratus*)**

Cabezon have an elongate but stout body and broad, blunt head topped with “fluffy” cirri above the mouth and eyes. Their common name translates to “big head” in Spanish, owing to their bulky head shape. They are one of the largest sculpins and are the only member of their genus. Their coloration varies, ranging between brownish, greenish, and reddish, with dark mottling throughout. Cabezon are found between Pt. Abreojos, Baja California to Sitka, Alaska and are associated with bottom habitat, rocky reefs and kelp beds, often camouflaging into the reef. They can reach up to 99 cm in length and live for up to 14 years, maturing at 2-2.5 years or 30-41 cm long. Cabezon are a popular catch among rocky shore anglers, although their eggs are toxic.

Greenling

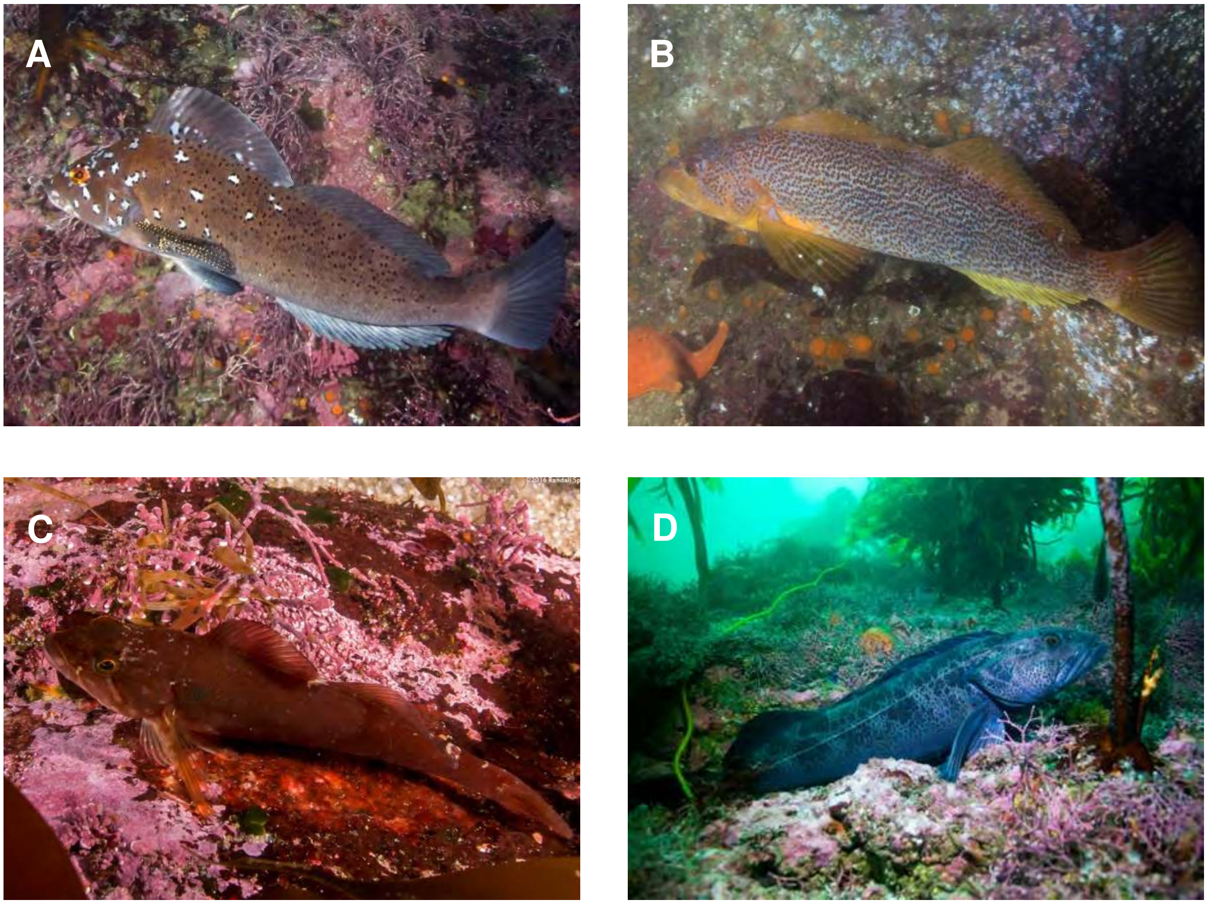


Figure 44: RCCA Greenling species: A) Kelp Greenling (male) (Randall Spangler); B) Kelp Greenling (female) (Randall Spangler); C) Kelp Greenling (juvenile) (Randall Spangler); D) Lingcod (Chad King).

Sculpin

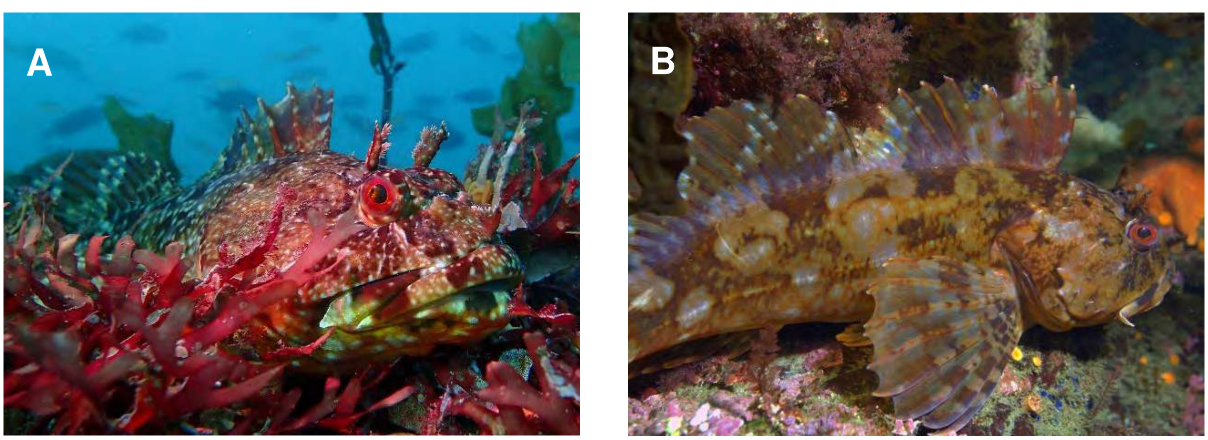


Figure 45: RCCA Sculpin species: A) Cabezon (Selena McMillan) B) Cabezon (Chad King).

Seaperch

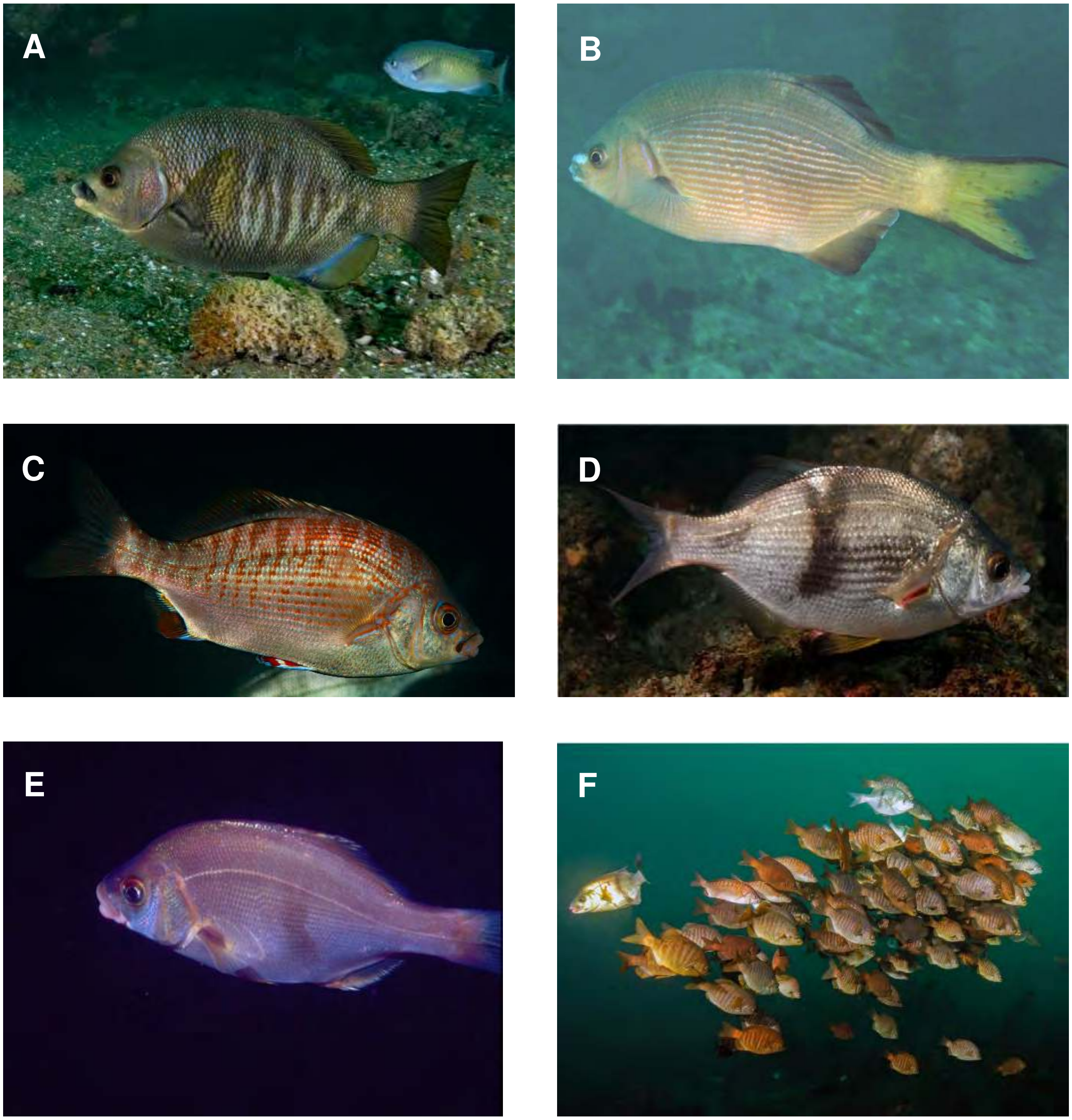


Figure 46: RCCA Seaperch species: A) Black Perch (Phil Garner); B) Striped Seaperch (Dan Gotshall); C) Rainbow Perch (Phil Garner); D) Pile Perch (Phil Garner); E) Rubberlip Seaperch (Herb Gruenhagen); F) School of Seaperch (Phil Garner).

Seaperch (Family Embiotocidae)

Sometimes called Surfperch or Perch, Seaperch are part of the family Embiotocidae, which include 23 species worldwide, 18 of which are found along our coast. They are typically found in near-shore, temperate marine waters. Unlike the other fish that we sample, Seaperch have live young and during the summer, you can see schools of miniature Seaperch swimming around looking very much like a tiny version of their parents.

- **Black Perch (*Embiotoca jacksoni*)**

Black Perch have an oval-shaped body that is laterally compressed. They are usually brownish or reddish but are likely capable of changing color to better match their environment. They often have large, dark bars across their body and yellowish lips with a dark “mustache” above the upper lip, along with a bluish line at the base of the anal fin. Black Perch are specifically distinguished from other perches by a patch of large scales between the pectoral and pelvic fin, which is noticeable if observed closely. They range between Pt. Abreojos, Baja California and Fort Bragg, California and grow up to 38 cm long. They are caught by anglers and spear fishermen.

- **Striped Seaperch (*Embiotoca lateralis*)**

Striped Seaperch have a deep oval-shaped body that is laterally compressed. They are silvery orange with about 15 thin, bright blue stripes below the lateral line. Their head is also dotted with bright blue spots and stripes and they usually have black blotches on their fins. Striped Seaperch range from Pt. Cabras, Baja California to Port Wrangell, Alaska and grow up to 38 cm long. They are usually found over rocky reef, kelp beds, or sand near rock.

- **Rainbow Seaperch (*Hypsurus caryi*)**

Rainbow Seaperch have an elongate oval-shaped body that is laterally compressed and a notably flat belly. They are brightly colored with red and blue stripes along the sides, reddish-brownish bars running down the back, and often red and blue marks on the face and fins, all against a silvery background. They also have a distinct black spot on both the dorsal and anal fin. Rainbow Seaperch are found between Rio Santo Tomas, Baja California and Cape Mendocino. They prefer rocky reef and edges of kelp forest over sand and grow up to 30 cm long.

- **Pile Perch (*Rhacochilus vacca*)**

Pile Perch have a deep oval-shaped body that is laterally compressed. Their dorsal fin is notably tall and pointed and caudal fin deeply forked. They are silvery or dusky with a thick dark bar that fades with age but is usually still visible in adults, along with some darker blotching on the back and sides. The pelvic fins are also often yellowish. Pile Perch range from Guadalupe Island, Baja California to Port Wrangell, Alaska and are usually found along rocky reef, kelp forests, pilings, and other underwater structures, as well as over sand near rock. They grow up to 44 cm and live to at least 10 years.

- **Rubberlip Seaperch (*Rhacochilus toxotes*)**

Rubberlip Seaperch have a deep oval-shaped body that is laterally compressed. Their mouth is distinctly thick-lipped and either pale or pink. They are silvery or brassy with a thick dark bar that is prominent in juveniles but usually very faded in adults. They range between Thurloe Head, Baja California and Russian Gulch State Beach, California and are usually found along rocky reefs and kelp forests as well as bays and harbors. Rubberlip Seaperch are the largest ocean perch and grow up to 47 cm in length. They are fished recreationally from skiffs, piers, and shore.

Wrasses (Family Labridae)

- **Señorita (*Oxyjulis californica*)**

The genus name of the Señorita, *Oxyjulis*, is Greek for “sharp”. They have an elongated, cigar-shaped body covered with large scales. Their coloration is yellowish to brown, usually a bit darker dorsally and a bit paler ventrally with a large black spot at the base of their caudal fin. They can be found from Salt Point in Northern California to Bahia Magdalena in Baja California and can also be found in the Gulf of California. Señoritas can grow up to 25 cm but are mature at 11 cm and live to about 7 years. You can often find them cleaning the parasites and dead tissues from the bodies of other fish or buried in the sand at night.

- **California Sheephead (*Semicossyphus pulcher*)**

The name “Sheephead” was occasionally used early on but did not really come into play until the early 20th century. Prior to this, they were mostly called “redfish” or “fat head” and nowadays, recreational anglers sometimes refer to them as “goats”, but regardless of all the nicknames they’ve acquired over the years, their species name *pulcher* is Latin for “beautiful”. All California Sheephead begin their lives as females and some transition to males as they grow larger. When they are juveniles, they are red-orange in color characterized with at least one white stripe running from their eye to the base of their tail with large black spots on their fins and at the base of their tail. Adult females have a pink to reddish coloration with a white chin and dog-like teeth. Sheephead males have a distinct color-blocking pattern of a black head and tail separated by a red band in the middle and a very prominent bump on their forehead. California Sheephead can be found from Monterey Bay to Baja California. They are most common south of Pt. Conception. They are relatively slow growing, but can grow up to 91 cm, weigh up to 40 lb and live to at least 53 years of age. The females that transition into males usually do so in their eighth year of life when they reach up to 30-36 cm (12-14 in). The adults can be found deeper than 86 m (281 ft) but are most commonly found between 3-61 m (10-200 ft).

- **Rock Wrasse (*Halichoeres semicinctus*)**

All Rock Wrasses begin life as females. When they are juveniles, they have two white stripes, one just below their dorsal fin and one that runs laterally along the midline of their bodies. They are also characterized by having two dark spots on their dorsal fin. The second phase in their life history is called the initial phase, in which they are females that are green to orange with dark, circular scales on their backs. Mid-phase individuals are males that have similar coloration as females, but they have a distinguishing dark bar or “hairy armpits” behind their pectoral fin. Rock Wrasse can be found from Central California to the Gulf of California but are more common toward the south. They range from tide pools and surface water up to 79 m (259 ft). They can grow up to 38 cm and usually live for at least 14 years. The females usually mature in their second year at 13-15 cm and transition to males at about 5 years of age.

Wrasses

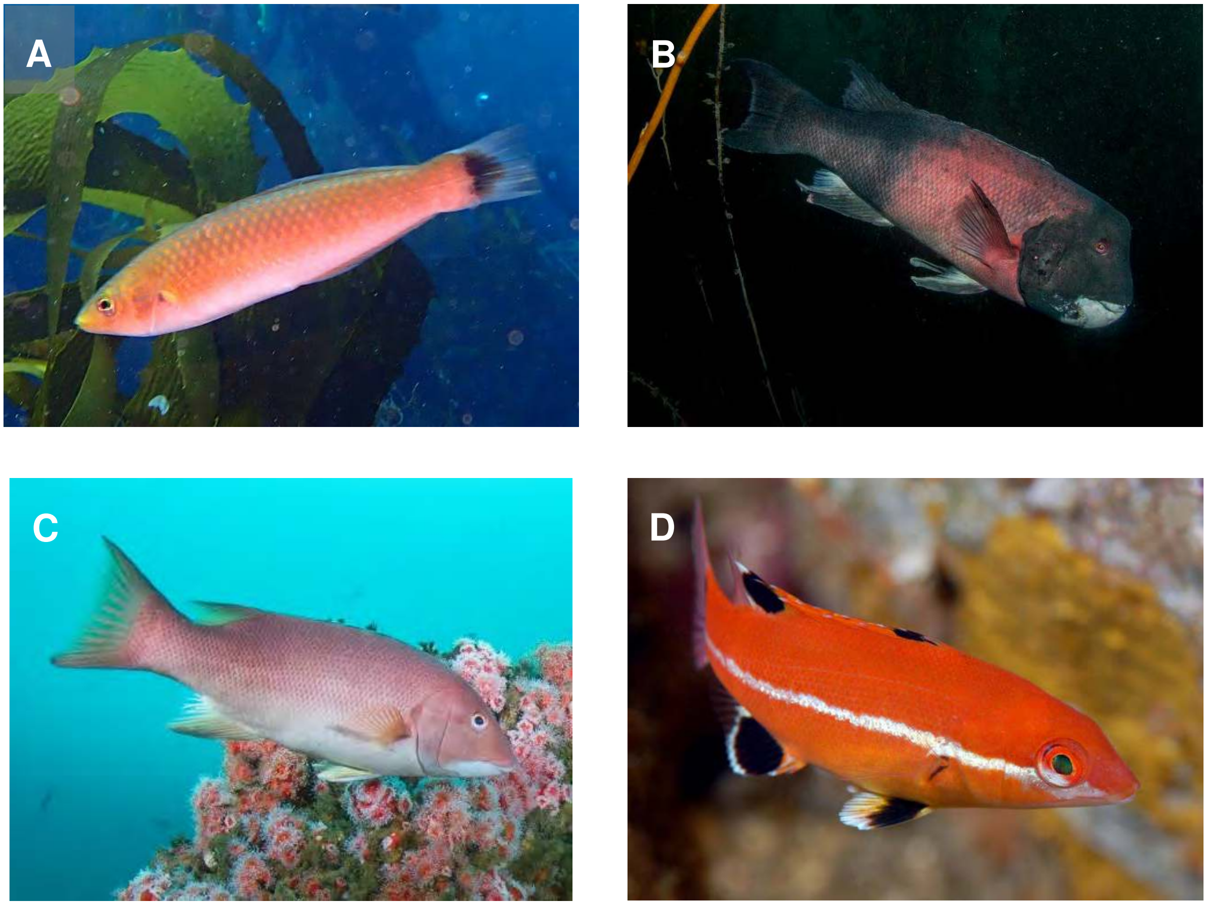


Figure 47: RCCA Wrasse species: A) Señorita (Selena McMillan); B) California Sheephead - male (Zack Gold); C) California Sheephead - female (Elizabeth Sullivan); D) California Sheephead - juvenile (Kevin Lee).

Wrasses - continued

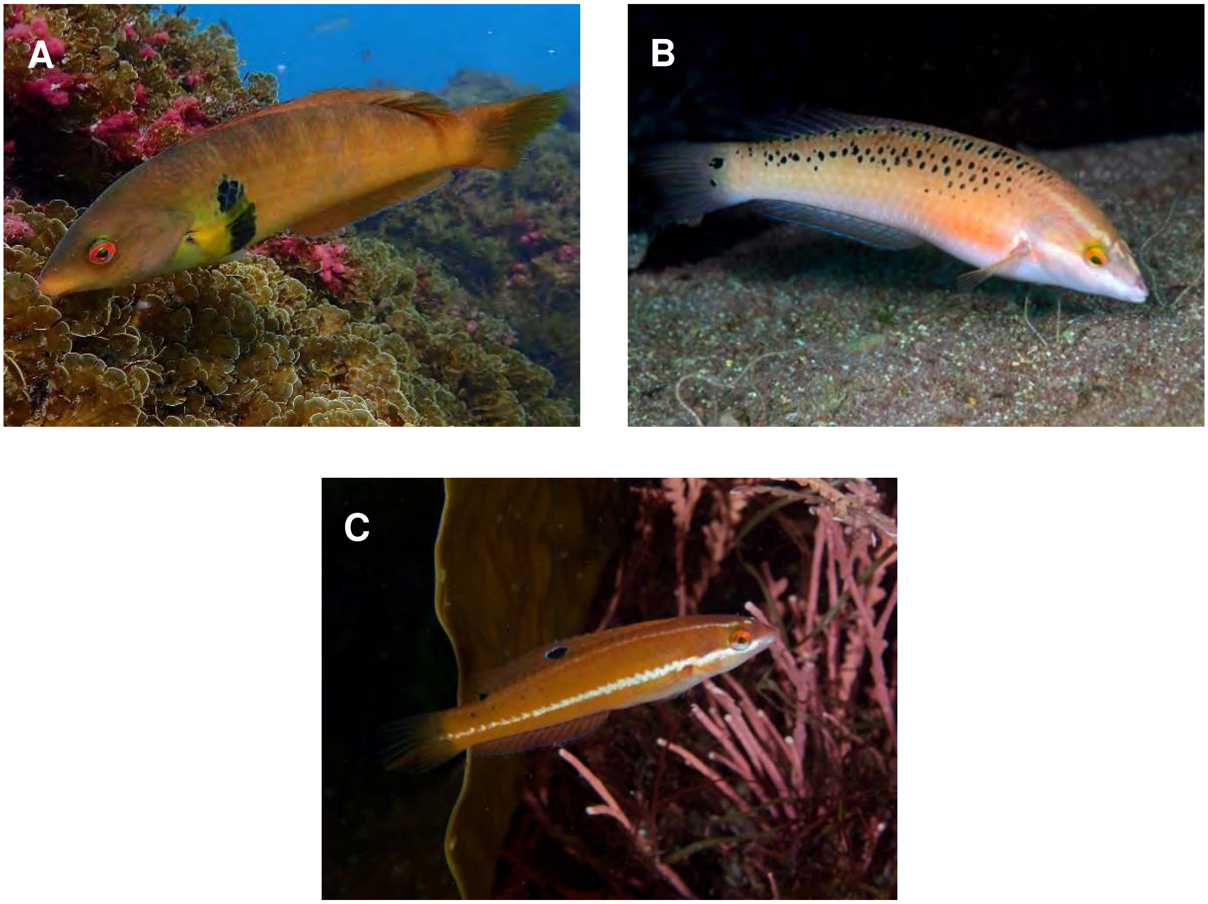


Figure 48: RCCA wrasses (continued): A) Rock Wrasse - male (Selena McMillan); B) Rock Wrasse - female; C) Rock Wrasse – juvenile.

***Sea Basses (Family Serranidae*)**

Serranids are found throughout the world in tropical and temperate waters. The family Serranidae represents about 250 species of sea bass with seven species found along the west coast of the United States.

- **Barred Sand Bass (*Paralabrax nebulifer*)**

The Barred Sand Bass can grow to a length of over 65 cm and can live to be around 24 years old, maturing at around 2-5 years of age. Their species name, *nebulifer*, is Latin in origin and means “I bear clouds”. They are large, greenish-grey, elongate fish with distinctive dusky bars located along the sides of their bodies. The Barred Sand Bass typically have freckles on their faces and can have brown, yellow and silver blotches on their bodies. They are usually found on the bottom in areas with lots of sand. Like Kelp Bass, commercial sale of these species was banned in 1953 in California, but they remain an important recreational fishery in Southern California.

- **Kelp Bass (*Paralabrax clathratus*)**

Kelp Bass are one of the most important nearshore recreational species in Southern California waters. Most fishermen call the Kelp Bass “calico bass.” Their species name *clathratus* is Latin for “latticed”, which refers to their distinguishing checkerboard pattern. They are olive-brown with alternating white blotches on their back and sides and are paler ventrally. The breeding and older males have orange chins. They can be found in the Columbia River to Baja California and are rare north of Pt. Conception ranging from shallow subtidal depths to 61 m (200 ft). They can grow up to 72 cm, weigh up to 15 lb and live for at least 33 years. Kelp Bass usually become sexually mature at 27 cm. They eat algae and a wide range of invertebrates such as crustaceans, mussels, clams, squid, octopus, and sea hares, while larger kelp bass switch to fishes. Some of their predators include angel sharks, Giant Sea Bass, bottlenose dolphins and California sea lions.

Seabass

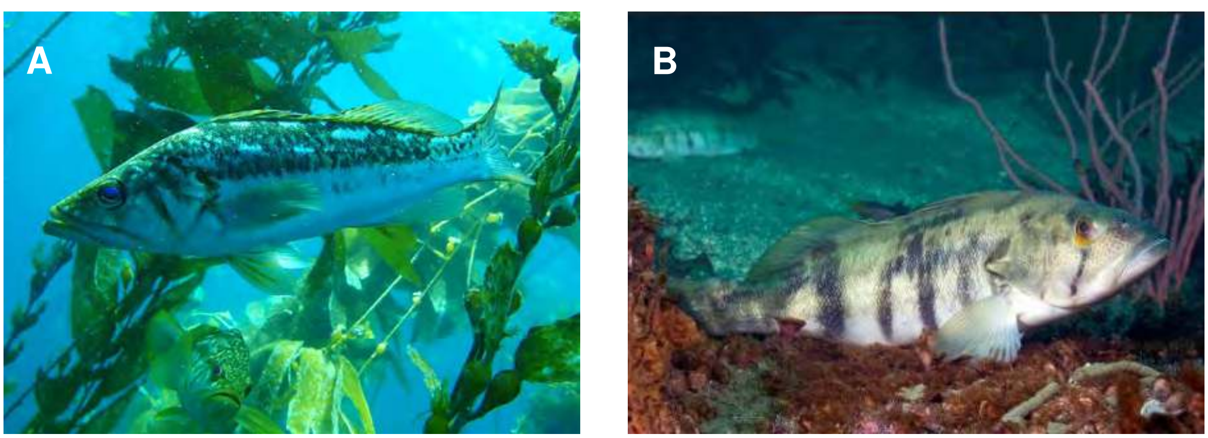


Figure 49: RCCA Seabasses: A) Kelp Bass (Selena McMillan); B) Barred Sand Bass (Phil Garner).

Damselfish

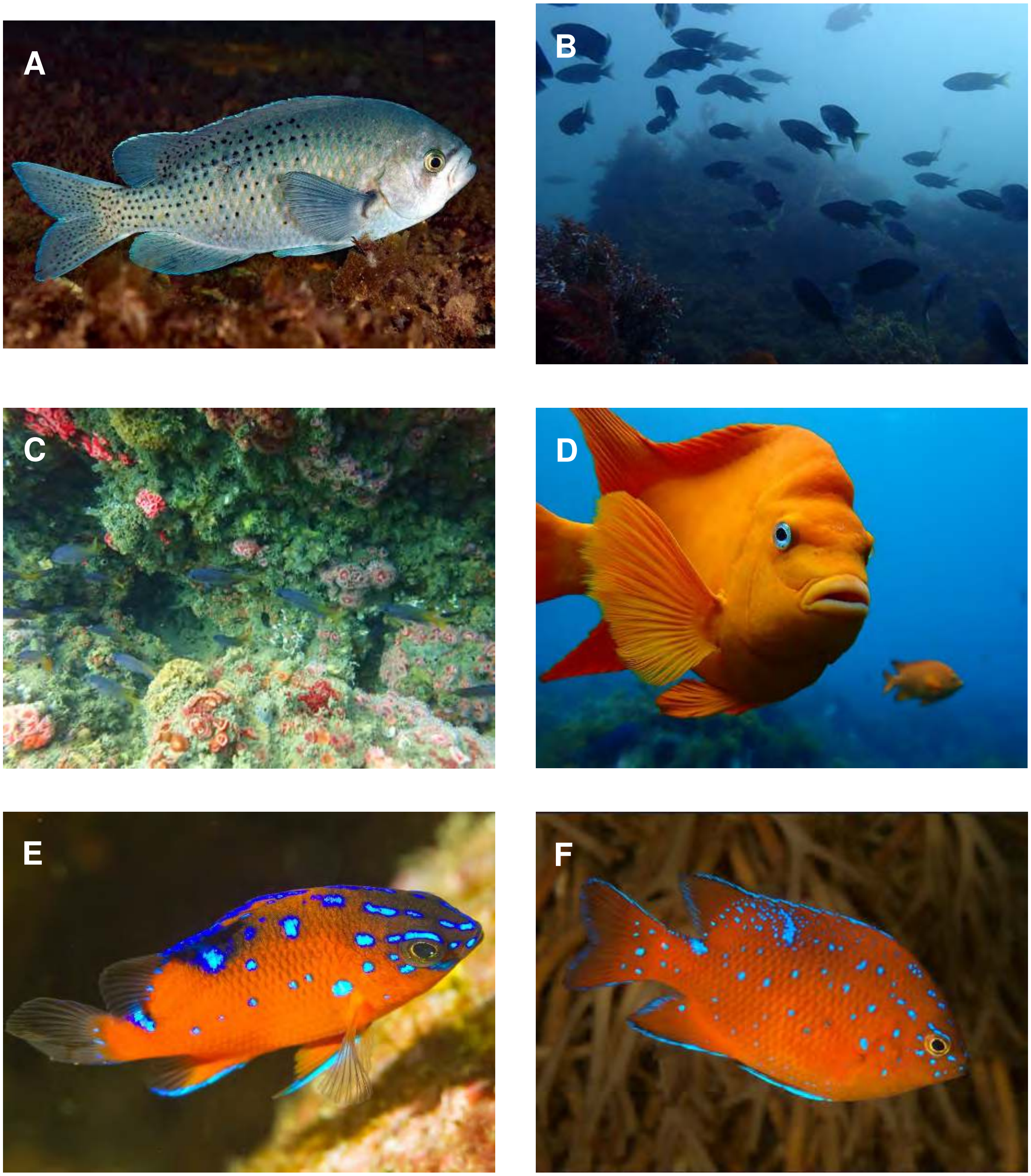


Figure 50: RCCA Damselfishes: A) Blacksmith (Phil Garner); B) School of Blacksmith (Selena McMillan); C) Juvenile Blacksmith (Selena McMillan); D) Garibaldi – adult (Selena McMillan); E) Garibaldi – juvenile (early stage; Tom O'Leary); F) Garibaldi – juvenile (later stage; Phil Garner).

Damselfishes (Family Pomacentridae)

The family of fishes included in Pomacentridae are mostly tropical and are found throughout the world's oceans. There are over 350 species and we have five species that live in California (mainly in the south). Most damselfish pairs have nests where they lay their eggs and either the female or male guards them until they hatch.

- **Blacksmith (*Chromis punctipinnis*)**

The species name for the Blacksmith, *punctipinnis*, is Latin for "spot" and "fin" referring to the small black spots on their scales. These fish have been observed from Monterey Bay to Baja California but are most commonly found south of Pt. Conception. This fish species can live for at least 7 years, with a maximum length of around 30 cm, and mature at around 2 years old. They can often be seen schooling in large numbers but can also be found in cracks and crevices. Blacksmiths are perch-shaped, grey-blue or grey with black spots towards their tails. Young Blacksmiths are bicolored and look like a tropical fish, with blue-grey towards their head and a beautiful orange color towards the tail. These fish are not a part of any commercial fishery but are caught frequently by recreational fishermen.

- **Garibaldi (*Hypsypops rubicundus*)**

The Garibaldi is California's famous state fish. The image of this fish adorns lots of magazines, billboards, t-shirts and even once adorned Reef Check California's logo. The genus name for this species is *Hypsypops*, which is Greek for "high", "below" and "eye" which refers to its large forehead. The species name, *rubicundus*, is simply Latin for "red". Adults are bright orange and can reach a length of over 35 cm. They can be seen from Monterey Bay to the Gulf of California (Southern Baja), but are mostly found south of Pt. Conception. Garibaldi can be fiercely territorial, especially the males when they are guarding their nest of unhatched eggs. They can often approach a diver directly, emitting a thumping sound by grinding their jaw together to protect their territory or nest. Juveniles of the species are orange, like the adults, but have brilliant (almost neon) blue spots and edging to their fins. For this species, we do distinguish between adults and juveniles. These fish are considered juvenile until all of their blue coloring has been replaced by orange. Any trace of blue should lead you to count them as juvenile, no matter the size of the fish. In California, it is illegal to fish Garibaldi, but in Mexico, there are both artisanal (think local markets) and recreational fisheries in place.

Sea Chubs (Family Kyphosidae)

Mainly found in the Atlantic, Pacific and Indian Oceans, Sea Chubs are nearshore fish species that live in both temperate and tropical marine waters. There are at least 45 species that exist worldwide with five species that occur in California. Mostly herbivores, several species have been found to have hindgut fermentation like horses or deer, where bacteria help in the digestion of their mainly algal diet (Mountfort et al. 2002; Knudsen & Clements 2016).

- **Opaleye (*Girella nigricans*)**

Sometimes called “button bass”, probably because of the prominent white spot on their back, Opaleye can be observed from Oregon to Cabo San Lucas to the Gulf of California but are commonly found between Central California and Baja California. They often school with Halfmoons (see below) and can be seen in large schools in kelp forests, over rocky reefs and in surfgrass and estuarine ecosystems. This species is typically large, grey, oval, perch-shaped fish with beautiful blue eyes and a white to yellow spot (or two or three) on their back. They can live to be at least 10 years old but mature at around 2-3 years of age. They are mainly herbivorous (eating algae) but also snack on small invertebrates. There is no commercial fishery interest for this species, however, they are sometimes caught by recreational and spear fishermen.

- **Halfmoon (*Medialuna californiensis*)**

The genus name for Halfmoon, *Medialuna*, means “Halfmoon" in Spanish, which refers to the shape of this species’ tail. Halfmoons can grow to be over 48 cm and can be found from British Columbia to the Gulf of California in Baja. They are oval but elongated and are grey-blue in color and have small, faint black bars on their sides. Halfmoons can mature at 8 years old and are mainly herbivorous but do consume many different types of invertebrates. In the 19^{th} century, these fish made up a large portion of a commercial fishery, but now are mostly caught by recreational fishermen.

Grunts (Family Haemulidae)

The grunts (Family Haemulidae) are found throughout the world in marine and freshwater, tropical and subtropical ecosystems. There are more than 145 species with five of those species found in Southern California.

- **Sargo (*Anisotremus davidsoni*)**

Sargo have been observed from Santa Cruz, California to Southern Baja California, but they are usually found south of Santa Monica, California. These fish can grow to 60 cm and live to be over 25 years old. They mature at about 2-3 years and are typically found in large schools, swimming in kelp forests or over rocky reefs. These fish are deep bodied, perch-shaped and have a vertical dark colored bar located in the middle of their body. They are silvery to dusky grey in color but often have shimmery, golden flecks on the scales along their back. Sargos are commonly sold in Mexican fish markets, but in California, they are only a recreational fish catch.

Sea Chubs

Figure 51: RCCA Sea Chubs: A) Opaleye (D. Ross Robertson); B) Halfmoon (Selena McMillan).

Grunt

Figure 52: RCCA Grunt species: A) Sargo (Nick Fash); B) School of Sargo (Selena McMillan).

Wreckfish

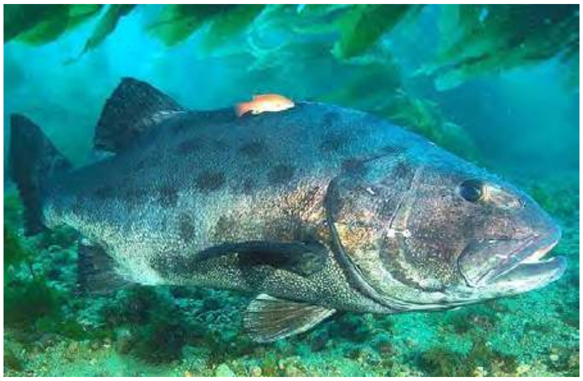


Figure 53: RCCA Wreckfish species: A) Giant Black Sea Bass (Linda Blanchard).

Triggerfish

Figure 54: Finescale Triggerfish (Patrick Webster).

Horn Shark

Figure 55: Horn Shark (Phil Garner).

Wreckfishes (Family Polyprionidae)

The wreckfishes are a small group (Family Polyprionidae) that have only about five species including the Atlantic Wreckfish, the Hapuka (found in Chile, Australia, New Zealand, South America and South Africa) and our own Giant Sea Bass. These species are typically deep-water fish that hang out around reefs, the ocean bottom or shipwrecks.

- **Giant Sea Bass (*Stereolepis gigas*)**

Although not bass, the common name for this fish species is the Giant Sea Bass; the genus name, *Stereolepis*, means "firm" and "scale" in Greek and the species name, *gigas*, is Latin for "giant". Commonly called "black sea bass", these fish can reach a length of over 225 cm (or over 7 feet long). Historically, they could be found from Humboldt Bay, California to Southern Mexico. Presently, they can be observed south of Pt. Conception and can live to be over 75 years of age. They mature at around 13-15 years old and are elongate fish with silvery, grey or brown bodies having black spots or blotches covering their bodies. These spots are like human fingerprints and can be used to identify individuals, similar to the patterns found on cheetahs. This species was fished heavily in the 19th century into the 20th century, depleting the population considerably. Currently, the Giant Sea Bass is illegal to take in California waters; however, commercial fishermen can retain one of these fish per trip. These fish are still legal for recreational fishermen to catch in Mexico.

Triggerfishes (Family Balistidae)

The Family Balistidae (or Triggerfishes) are found in subtropical and tropical waters throughout the world. There are about 40 species in total, but only three have been observed in Southern California, in particular, the Finescale Triggerfish.

- **Finescale Triggerfish (*Balistes polylepis*)**

The genus name of the Finescale Triggerfish, *Balistes*, is derived from the Latin word "ballista" that refers to a weapon that shoots arrows. These fish are aptly named because they can lock and unlock their dorsal spines. Their species name, *polylepis*, is Greek for "many scales". The Finescale Triggerfish can reach lengths of up to 80 cm and can be found from Alaska to Chile. These fish are very different from many of the California species you encounter. They are deep-bodied, thin, and have a very prominent dorsal fin. They have a small mouth that contains lots of incisor-looking teeth. These fish were common off Southern California during the 1982-1983 El Niño but are rare north of Baja California. However, during the recent warmer waters in California, divers have observed several of this species in Southern California and one resident individual at the Breakwater in Monterey, California. Therefore, we have included it on our key fish species list to record the Finescale Triggerfish's occurrences and distribution over time.

Horn Sharks (Family Heterodontidae)

The horn (or bullhead) sharks are classified as the Family Heterodontidae, which in Greek means "different teeth". This family has about nine species that are primarily found in the Indo-Pacific. However, two species of this family are found on the Pacific Coast, with *Heterodontus francisci* found to the north and *H. mexicanus* to the south.

- **Horn Shark (*Heterodontus francisci*)**

The Horn Shark is found from San Francisco (hence the species name, *francisci*) to the Gulf of California, Baja. This species can grow to about a meter long, but researchers are unsure of how long they can live. They have a lovely brown and tan pattern across their body with dark brown spots throughout. They have distinguished "eyebrows" or ridges over their eyes and distinctive spines or "horns" located in front of each dorsal fin. The Horn Shark also produces a unique egg case that is shaped in a spiral and can be found shoved into cracks and crevices on the rocky reef. These sharks are nocturnal, so they are usually found hiding in holes and caves deep within the reef.

Moray Eels (Family Muraenidae)

Moray Eels are found in warm-temperate and tropical marine waters throughout the world. There are over 185 species but only one is commonly found in Southern California waters.

- **California Moray (*Gymnothorax mordax*)**

The California Moray is found from Pt. Conception, California to Southern Baja and can reach a length of about 150 cm (5 ft) long. The genus name, *Gymnothorax*, is Greek for "naked thorax" and the species name *mordax* is Latin for "prone to bite". It is thought by researchers that the individuals of this species living in California do not reproduce, but that larvae drift up from Baja and settle here. They live in cracks and crevices within the rocky reefs and are a mottled orange to brown to dark green in color. They have very sharp teeth but are not typically aggressive. We only count this species and do not attempt to size them.

Blennies (Family Labrisomidae)

The family Labrisomidae represents a group of blenny species that are typically stocky and elongate and are usually found in the tropical waters of the Atlantic and Pacific oceans. They tend to have cirri (or whisker like growths) on their heads and hide in crevices when threatened.

- **Largemouth Blenny (*Labrisomus xanti*)**

The Largemouth Blenny was first documented in California waters in July 2015 at La Jolla Shores in San Diego. This species of blenny is endemic to Mexico, as it is observed from Central to Southern Baja, and throughout the Sea of Cortez. It is suspected that the Largemouth Blenny made its way to Southern California waters during the 2014 warm water anomaly and persisted during the 2015-2016 El Niño events (Love et al. 2016). The Largemouth Blenny is easily recognizable, as it has a conspicuous "blenny" shape that is elongated with a continuous-looking dorsal spine. The mouth is large, and not only includes one row of teeth on the top and bottom jaws, but also on the roof of the mouth! All individuals display a bright blue semicircle beneath the eye and have smooth-looking small scales. The Largemouth Blenny body color is wonderful; however, it varies depending on sex and reproductive status. Females and non-breeding males are greenish-brown in coloration with about eight dark bars along their sides. Breeding males have been observed to have bright red or orange coloration with small blue speckling in lieu of the greenish brown body coloration and black barring. The Largemouth Blenny is one of the smallest fishes counted during Reef Check surveys (most individuals between 10-14 cm) and are usually found on the bottom or in cracks and crevices.

Moray Eel

Figure 56: California Moray Eels (Phil Garner).

Blenny

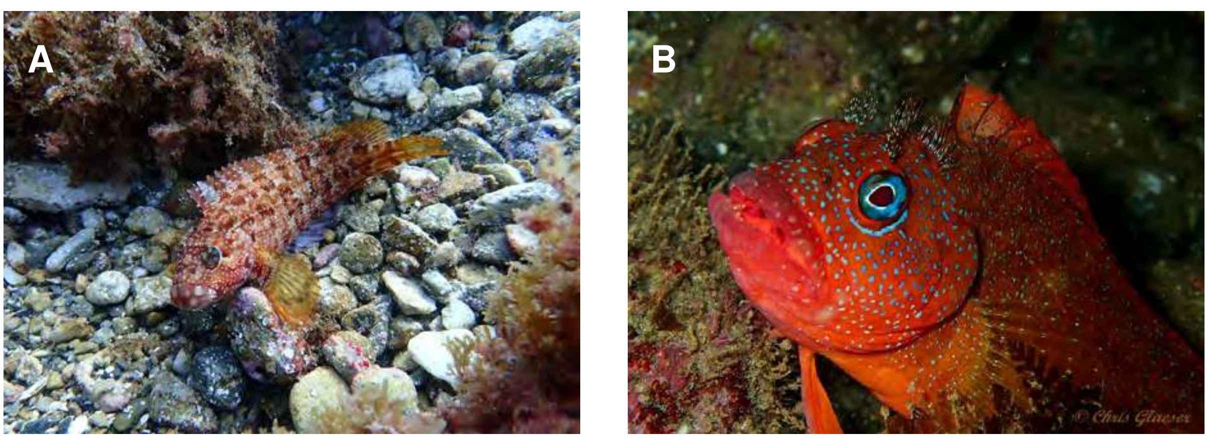


Figure 57: A) Largemouth Blenny (Selena McMillan); B) Largemouth Blenny – male during mating season (Chris Glaeser).

Further Reading

In addition to the species descriptions found above and in the supplemental training materials, we recommend investing in a quality fish identification guide. Some of our favorites include:

Allen, L. G., Pondella, D. J., & Horn, M. H. (Eds.). (2006). *The ecology of marine fishes: California and adjacent waters*. University of California Press.

Butler, J. L., Love, M. S., & Laidig, T. E. (2012). *A guide to the Rockfishes, thornyheads, and scorpionfishes of the northeast Pacific*. University of California Press.

Eschmeyer, W. N., & Herald, E. S. (1999). *A field guide to Pacific coast fishes: North America*. Houghton Mifflin Harcourt.

Humann, P. (1996). *Coastal fish identification: California to Alaska*. New World Publications Incorporated.

Love, M. S., Yoklavich, M., & Thorsteinson, L. K. (2002). *The Rockfishes of the northeast Pacific*. University of California Press.

Love, M. S. (1991). *Probably more than you want to know about the fishes of the Pacific coast*. Really Big Press.

Love, M. S. (2011). *Certainly more than you want to know about the fishes of the Pacific Coast: a postmodern experience*. Really Big Press.

Chapter 7

Conducting Reef Check California Surveys

The Reef Check Volunteer Tool

Once you are certified as a Reef Check California diver, you can take part in surveys throughout California. The RCCA social media groups and website are the primary tools for you to connect with your fellow divers and find links to upcoming trainings. Additionally, the Reef Check Volunteer Tool (RCVT) (calendar.reefcheck.org/) has been designed to allow you to sign up for surveys and find information about specific dive days. It is divided into three calendars: North, Central and South. These allow you to quickly focus on upcoming events in a specific region. During your course, you will be directed to register for the RCVT. Once registered, you can modify your profile settings, add emergency contact information, and view all the surveys scheduled for the current year.

Data Captain

RCCA staff does NOT need to be present for you to conduct a survey, though someone must oversee the survey and data collection. When a survey is being proposed and posted on the RCVT, it is essential to designate a team leader, also known as the Data Captain. This individual will coordinate with the regional RCCA staff and is responsible for:

- Logistics (e.g., checking weather conditions, parking permits, setting times, etc.)
- Making sure the team has enough blank datasheets to complete a survey
- Team survey assignments, including transect locations
- Collection and review of datasheets after each dive
- Ensuring all data are entered into the online database and the original datasheets are submitted to the Regional Manager

Data Captains usually have at least one year of RCCA survey experience before moving into this role. Volunteers are highly encouraged to participate in all aspects of the monitoring process, and becoming a Data Captain is a goal of many of our volunteers. There are numerous planning resources available for the Data Captain that can be obtained by contacting your regional RCCA staff. Please let your Regional Manager know if you are interested in leading surveys in your area and they will teach you all that you need to know to become an RCCA Data Captain.

The following sections describe the datasheets, equipment, organization, and other details you will need to know to conduct an RCCA survey.

Site Logistics

When surveying a site, it is necessary to decide what mode of diving works best for that area. For instance, when surveying a site within the Monterey Bay, you must determine whether the dive site is accessible by land and a shore dive can be done safely. However, in some cases, a boat dive may be necessary or preferred. Both kinds of diving offer their own set of considerations for the RCCA Regional Staff or Data Captain leading the dive. The following sections will address the logistics of performing either a shore dive or a boat dive to survey RCCA sites.

Shore Dives

Shore dives can be fun, inexpensive ways to conduct Reef Check surveys. In some areas (like Sonoma), this is the best way to access the survey sites, and you can always plan for a picnic or barbeque or even a camp out to make the day even better. There are, however, many things to consider when organizing a shore dive; some of which are listed below.

- Shore access – As a dive leader, you must make sure that the access to the shore is safe and legally accessible. As a Reef Check diver, you do not want to break any laws or cross private property. Also, steep cliff access, or dangerous, rocky beaches may prove too difficult for some volunteers to traverse. Know the limit of your volunteers and/or make sure you describe all the potential hazards for that particular site in your survey post on the RCVT.
- Parking – At several of our RCCA sites we access from the shore, parking can be difficult (especially on a beautiful, sunny, weekend day!). For this reason, we tend to schedule dives in those areas early, to minimize the distance to the shore access point. Sometimes the only parking available is metered parking and it will be necessary to plan ahead of time to grab enough quarters to feed the machine. All of these details need to be determined and that information included on the RCVT post.
- Noise – Be aware that some beach access points are in neighborhoods and snuggled in between houses. Keep your voices down and try to minimize any noise at these sites. We do try to let people know what we are doing for the ocean in a good way. A reputation for being the loud, rude dive group is not an image we would like to project.
- Trash – You have probably heard the phrase, “pack it in, pack it out”. This is exactly what we will do as RCCA divers. In fact, picking up any trash you see along the shore is an excellent way of practicing ocean conservation.
- Weather/Swell – For shore dives, it is particularly important to pay close attention to the swell forecast. Beach entry can prove tricky when the surf is up. When looking at the forecast, pay close attention to the direction, height, and period of the swell. The location of your shore access determines what swell will affect your entry point. For example, the Malibu shoreline runs east to west with the ocean to the south. Therefore, a south swell will hit the beaches there straight on and cause the greatest surf. The period of the swell is the amount of time between each wave and is measured in seconds. The period can determine how much water will be involved in those waves hitting the shore. Short periods mean that little time passes between each wave; therefore, not much water moves with

each wave. Long periods usually indicate a lot of water moving between and with each wave. Therefore, a forecast with long periods can mean a great day on the water for a surfer but a difficult entry for a scuba diver. The wave height is the distance between the top and bottom of a wave (crest and trough). The greater the wave height and the longer the period, the larger the swell.

- Beach entry – As waves move into shallow water, they get slower and bigger before they break at the shore. Waves usually break in sets. The time between these sets can vary between a few minutes to half an hour, and the number of waves in the set can be random. Therefore, it is very important to watch the surf at the dive site for at least 10 minutes before suiting up for the entry. When entering the water, make sure all of your gear is secure and you have a plan for donning your fins. Timing is key, so make sure you are entering the water between the wave sets, minimizing the chance of getting caught in the surf. The key thing to remember when getting through the surf zone (the area in the water where the waves are breaking), is to make it all the way through to the other side of the surf zone before making adjustments to your equipment. You do not want to be caught on the inside of this area when a wave set comes.
- Beach exit – Like the entry, you want to time your exit between the wave sets. Secure all of your gear and get through the surf zone as quickly as possible. If you do find yourself caught in a set, it is never a bad idea to do the beach crawl. Just make sure to crawl all the way up the beach past the surf zone (i.e. high and dry).

Boat Dives

Boat dives can also be fun and can be easier to do for some volunteers who find shore diving too strenuous. We use all types of boats to survey our sites. Some boats are full service, large dive boats that we hire for a day and sometimes overnight trips. We also use small boats, where divers are shuttled back and forth from the shore to the site between dives. Boats are necessary to access some of our sites, but they can also allow a dive team to complete more than one site in a day. There are many things to think about when organizing a boat trip, many of which are listed below and will need to be considered when creating a post for the RCVT or participating in a boat dive.

- Costs – Boat trips can be costly for the RCCA program, so we do ask for a donation from our participating divers to help with the associated boat costs. However, no one will be turned away if they want to participate in the survey. Every little bit helps, including all your valuable volunteer hours.
- Tanks – Every boat is different, so it is essential to know whether the boat requires divers to have their own tanks or if you can use the boat’s. Sometimes, it is also necessary to bring more than one tank.
- Food allergies/preferences – Some of the boats we hire make meals for the volunteers between dives. This can be a wonderful treat for most, but if you have a food allergy, you could be sadly watching all of your dive buddies enjoy a warm meal while you go hungry. Therefore, the dive leaders need to determine if anyone has any food preferences/allergies before the trip and let the boat staff know ahead of time. If you do have an allergy, make sure you let the dive leader know before the trip and the boat staff know when you board the boat.

- Paperwork – Most boats have waivers that they require all passengers and divers to sign when boarding the boat, so you must make time for this. They usually require that all divers show their certification card and sometimes their Diver's Alert Network (DAN) insurance card. Be prepared and bring both to the boat.
- Weather/swell – The same conditions discussed in the shore dive section also pertain to boat dives. However, wind is also a factor for boat dives. High wind can cause choppy seas and lead to an uncomfortable and sometimes hazardous boat ride to your dive site. Additionally, short wave periods may be good for shore dives, but may make a boat ride extremely choppy, leading to seasickness or a very slow ride to the survey site. If you are chartering a recreational dive boat, it will be necessary to work closely with the boat captain to ensure a successful day on the water.

Before You Jump in the Water

Prepare all Necessary Equipment

Prepare and distribute all equipment used during a Reef Check survey as follows:

Site Map: GPS or map to verify the position of the survey site and locations of transects.

Meter Tapes: you need at least one 30 m fiberglass measuring tape with a hand crank per buddy team (bringing two is a good practice as backup). We also recommend that you wrap a piece of stiff wire around the free end to secure it to kelp or rocks and add small pieces of colored electrical tape around the transect tape at each meter mark to make the points easier to find during the UPC surveys (Figure 58).

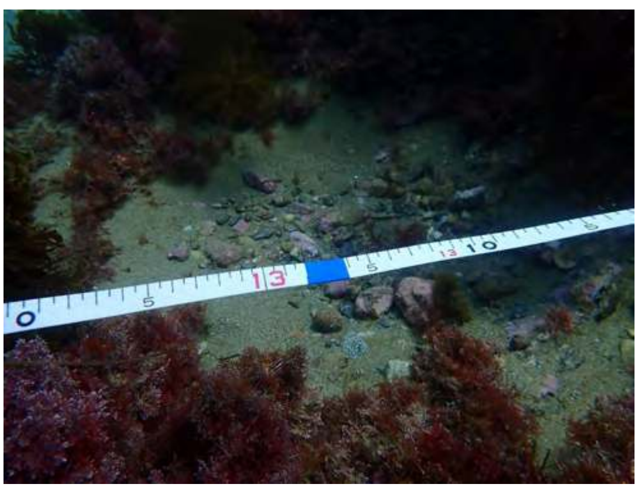


Figure 58: Transect tape with colored electrical tape placed to help indicate each meter mark.

Slates/Underwater Paper: We require that teams use pre-printed underwater paper and the sandwich-type PVC slates. All RCCA volunteers will receive a dive slate during training that they can prepare for data collection by adding ruler marks (in cm), a compass, and clips for attachment to meter tapes and their BCD. Bringing a spare slate and extra datasheets to a survey is highly recommended.

Pencils: To record data on underwater paper, we recommend using graphite, golf or plastic pencils.

Permanent markers: It is a great idea to have permanent markers available for labeling slates and equipment.

Buoys: We sometimes use buoys to mark the beginning and end of the transect line (safety sausages work best). These markers can also be used during a survey to mark rare finds like white/black abalone or invasive species.

Emergency gear: First aid kits, O2 kits, emergency procedures for a particular area and a list of emergency contacts for all divers participating in the survey are all highly recommended.

Care and Maintenance of Research Equipment: Research equipment is no different than the rest of your gear. Before each dive, be sure it is in working order and rinse it off with fresh water after every dive.

Prepare Datasheets

Prepare all the datasheets prior to the survey. Datasheets should be allocated prior to the dive, and every member should have a datasheet to complete his or her portion of the survey and enter the header information such as site, date and their assigned transects on the sheet.

Site Description Form

It is important to complete the Site Description Form prior to beginning the survey. Record the names of the team leader/data captain and team members as well as the date and site name on the site description sheet prior to getting into the water. This will help keep divers organized and serve as a roll call sheet of all divers in the water.

The data entered on the Site Description Form helps put the survey data into context – it is therefore essential in helping us interpret what we see underwater. The Site Description Form (Figure 59) should be started before the survey begins and completed immediately following the dives on the first day of the survey.

Record the location of your site on the Site Description Form using the following methods:

- Global Positioning System (GPS) – preferred
- Maps or nautical charts
- GIS software such as Google Earth (earth.google.com). Google Maps can also generate lat/long coordinates.

Basic Information

Site Name: The full name of the site should be recorded here as well as the city, county, and/or island where the site is located.

Date: Record the date you started the first transect and the date the final transect was completed. Each survey should be completed within a **four-week** time span from the first to the last transect.

Weather: Indicate the general weather conditions that prevailed over the sampling period. If the surveys were conducted over multiple days, record the weather condition that was most representative of average conditions.

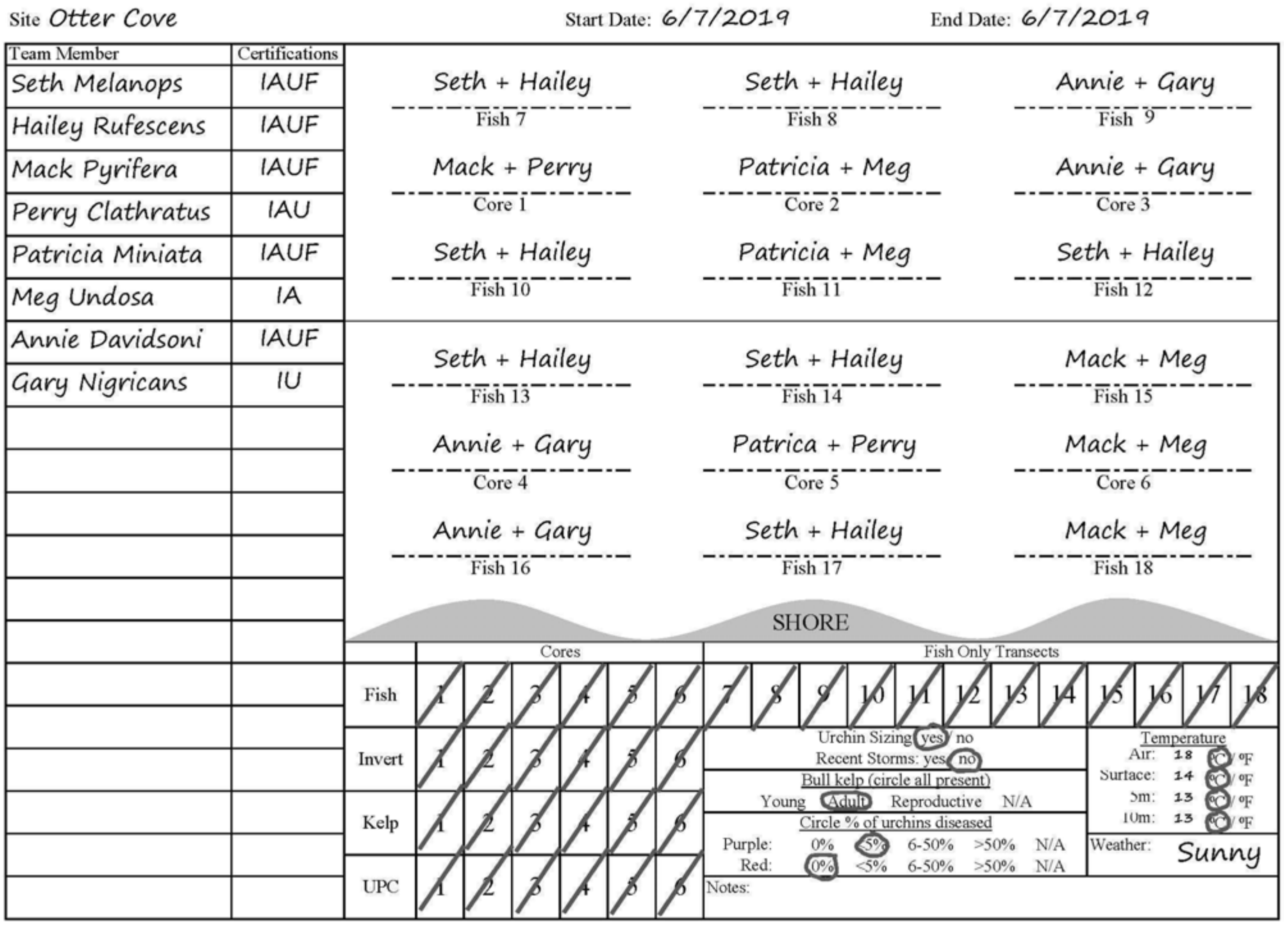
Temperature: Temperature is an important component of any survey. Please record the temperature on the surface and in the water during each survey. Record the 10 m temperature at the end of the first transect at that depth and record the 5 m temperature at the end of the safety stop. If the surveys were conducted over multiple days, use a representative water temperature for the survey period (e.g. an average).

Exposure and Storms: When analyzing data, it is important for us to ensure we are comparing reefs of similar types to each other. As you can imagine, highly exposed reefs are likely to exhibit different physical and biological characteristics than fully sheltered reefs. Record whether the site you are surveying is always sheltered, sometimes sheltered or exposed. An example of a reef that is sometimes sheltered would be one that is only exposed to swells and/or storms a certain time of year (i.e. exposed to winter swells out of the north but sheltered from summer swells out of the south). Recent storms provide additional insight into recent physical disturbances that may have affected your survey site. Recent is defined as within the previous 4 weeks and is a storm that was accompanied by significant wind, waves and/or rain.

Dive Team Information: Please record the full name of the team member who submitted the data (usually the team leader/data captain), the name of the team member who checked the data and list the full names of all team members. Also, please be consistent with first name usage (i.e. use full legal name, no nicknames). It is extremely important that team member names are recorded and entered consistently and correctly. If not, the names will not match the names of certified divers in our database and it will make it difficult to enter the data.

Transects completed: Ideally, all transects should be completed for each survey and all errors corrected by repeating the transect. You can mark off each transect as it is completed throughout the survey day. If for some reason your team is unable to complete all the required transects or there are errors in the data that could not be corrected, then they should be noted in the “Notes:” space (see Figure 59).

Other information: On the Site Description Form, you can indicate whether an urchin size frequency survey was completed, whether juvenile, adult, or reproductive bull kelp individuals were encountered (for North and Central Coast surveys), and the percentage of purple and/or red urchins that were determined to be diseased. As a surveyor, if you are to do an urchin size frequency survey or look for bull kelp or urchin disease, the data captain or survey leader will tell you.



Site Otter Cove | Start Date: 6/7/2019 | End Date: 6/7/2019

Team Member	Certifications
Seth Melanops	IAUF
Hailey Rufescens	IAUF
Mack Pyrifera	IAUF
Perry Clathratus	IAU
Patricia Miniata	IAUF
Meg Undosa	IA
Annie Davidsoni	IAUF
Gary Nigricans	IU

Figure 59: RCCA Site Description Form example.

Assign Team Members to Survey Tasks

There are many acceptable ways to divide up the survey tasks depending on the skills of the team members and team size. Not all team members will be qualified to complete all types of transects. Some team members will feel more comfortable recording fish or invertebrates and others will just want to serve as buddies. Because each team will be different, the data collection strategy should be adjusted to match the ability and experience of the team. The best quality data will be obtained by having an experienced team leader/data captain assign tasks appropriate for each team member's skill level. The team leader/data captain must ensure that every team member is certified for the assigned transect types, understands their assignment and can perform it properly. We recommend pairing up experienced Reef Checkers with those with less experience. Team leaders assign survey tasks to buddy pairs, including transect numbers, potential location, predetermined depth ranges and compass headings.

Each team member must record on their datasheet, as well as notify the team leader, when reliability of data from a transect is in question. When this occurs, the Regional Manager will review the data and consult with the survey team to ensure the validity of the data before including them in the database or deciding to re-do the transect in question.

Buddy Pairs

Because fish are easily perturbed, the fish transect is the first survey conducted. Reef Check California divers will swim the fish surveys as a buddy team. However, only the diver laying out the transect (primary) will be conducting the fish survey count.

Teams can elect to split up the species being counted – for example, one buddy would count giant kelp individuals and stipes while the other buddy would count all the other kelp species. After the dive, the buddy team would reconcile their datasheets, so all the data are on one sheet and the other sheet is voided. Divers are not allowed to each count one side of the transect. Additionally, when splitting kelp or invertebrate surveys, divers must pay special attention to ensure subsampling is done correctly.

Recording Data and Ensuring Quality

You are becoming part of a unique and dedicated group of individuals. Once you are certified as a Reef Check California diver you will have become a citizen scientist. The most important things you do as a citizen scientist is to collect and record data. We have talked about the potential biases that we mitigate through training, practice and standardization and you will be entrusted with the quality of the data you collect. The quality of the data is the foundation of the RCCA program and must be ensured from start to finish. It is your responsibility to not only record accurate data but to record data in a way that ensures that it is entered in the database correctly. Therefore, data must be recorded completely and in a legible fashion so that others can enter it into the database. It is good practice to have someone else at the survey read your datasheet to ensure that all entries are clear and unambiguous. This will be discussed in detail in the next chapter.

Before you get in the water, it is critical that you fill out ALL the descriptive fields on your datasheet below:

- Date
- Site name
- Transect number
- Both the first and last names of the Diver (you) and your Buddy

When conducting your transects, remember to always write down each transect's start and end times. All surveys should be performed any time 2 hours after sunrise through 2 hours before sunset. If you are using your dive timer instead of a watch, indicate the approximate time of day the transect took place on your datasheet after you surface.

Disturbance and Diving Hazards

Despite good intentions, the number of people visiting a habitat, coupled with lack of education, can lead to environmental degradation. Two obvious examples that you may have experienced in California are smog and gridlock in Yosemite and trampled tide pools in Southern California.

People love to visit the Sierras and the tide pools, but even if they don't take anything, their presence can have a major impact. One of the goals of your training is to practice responsible diving in order to minimize disturbances to the rocky reef habitats we are studying.

The divers that cause the least disturbance are those that are the most familiar with their gear and their bodies. They minimize loose or dangling equipment, have excellent buoyancy control and pay close attention to where they place their fins. We strongly recommend that you attach extra clips and buckles for holding your research gear to prevent getting tangled in kelp or dragging it across the substrate. If you find yourself hung up in kelp, know that there are several tricks to help you free yourself from the situation:

- Do not panic! This only makes things worse.
- Gently reverse your trajectory and find where on your body/equipment you are hung up in the kelp. Then disengage your body or equipment from the kelp or part of the substrate you have become tangled with.
- If you find that your fin is caught, do not jerk or pull against the kelp, but gently shake it free.
- If you see your buddy struggling or notice that they are about to be trapped, help them out!
- Remember, if all else fails, giant kelp is easy to break apart. Although we try not to disturb anything in the environment we are sampling, this kelp grows quickly and breaking a few stipes is acceptable.

When conducting invertebrate or UPC transects, we do try to leave the reef (and all of its occupants) as we found it. However, sometimes to determine if what we are counting is alive, it may be necessary to gently tap or move an organism. For example, when counting snails, a wave of your hand in the water, or a tap on the shell, can determine if it is an empty shell, a hermit crab, or true owner of the shell. If the wave or tap techniques still fail to enlighten you on the true owner of the shell, it is acceptable to remove the shell, check its contents, and replace it in the place you found it. We are striving for minimal disturbance, but also want to gather accurate data. A conscious, educated approach is key to sampling the reef.

Fortunately, in California, there are very few organisms that can cause us, as divers, harm. We do want to try and follow the rule "look but don't touch" as much as possible, but here are some possible dangers:

- Urchins – Unlike many urchins found in other parts of the world, the urchins found in California, when you have somehow landed on them (with your hand or, most frequently, your knee), do not have poisonous spines. However, if you do find yourself with a spine in your skin, make sure to get the spine out and treat it with a topical antibiotic.
- Fish – Again, we have very few fish that can cause us any harm. Rockfish do have sharp spines, but divers are rarely in contact with them. Sheephead have large teeth, but are rarely aggressive in any way, unless you find yourself in an MPA where divers have been feeding them. They might mistake the finger poking out of the hole at the end of your glove for something to eat. Garibaldi can be territorial and charge you as you approach, but all of this bravado is mainly for show. The only real danger are the sharp teeth found in the mouth of the California Moray Eel. These fish are not aggressive but have been known to bite if you choose to stick your hand in their hole. Therefore, do not stick your hand in holes!

- Marine Mammals – Some of our favorite encounters as California divers are with the amazing number of marine mammals found in our waters. Again, remember the rule: look, but don't touch. These curious creatures (e.g., sea lions, otters, harbor seals, etc.) have very sharp teeth and their bites can be serious. Divers rarely find themselves threatened by these mammals but if you are uncomfortable at all, leave the water immediately. If you are bitten by any marine mammal, seek medical attention immediately.

Safety

Safety is the number one priority of Reef Check California. One of the most common errors divers make when completing specific tasks underwater is to be too liberal with their dive plan. It is much easier to lose track of time, your surroundings and your buddy when concentrating on data collection than when diving without a specific purpose. Carrying out any tasks underwater can increase susceptibility to decompression sickness. Hence, it is important that you plan dives more conservatively when collecting data and remain aware of air, bottom time and your buddy. A good rule of thumb for research diving is to use the next deeper depth level when calculating your dive tables and maximum allowable bottom time or adjust your dive computer to the most conservative setting. Additionally, check your air more frequently than you would on a recreational dive. When you are focusing on any task underwater, you tend to lose track of time, and therefore, air. A good rule of thumb is to check your air at every 5 m along your transect.

Buddy System

Although you may have heard it a thousand times, it doesn't make it any less essential to maintain the buddy system. At no point in any dive is it acceptable to lose contact with your buddy. As with all dives, you and your buddy should agree on lost buddy procedures prior to entering the water and follow them accordingly. Unlike a recreational dive, when you and your buddy are conducting transects along a meter tape, you can use that meter tape as a direct line to your buddy. If you finish your transect(s) you were assigned and/or are leaving the transect line (for any reason), communicate that information to your buddy. If, at any time, you lose your buddy, swim along the meter tape until you find them. If they cannot be found, you do not need to perform the typical bottom search, but safely surface. If there is no sign of your buddy at the surface, notify the boat, nearby divers, or the shore for help.

Your Safety is the Most Important Thing

Please remember, the data are not worth getting injured or risking your life! You can always come back another day to complete a survey or retrieve a meter tape. Under no circumstance should you conduct a survey if you are not completely confident in your ability to safely complete the dive. If at any time you do not feel comfortable with the proposed dive, your dive buddy, your equipment, their equipment, or for any reason, let your dive leader/dive captain know. Remember, you are responsible for your own safety, and by being cautious, you can prevent injuries to yourself and others.

Dive Gear

One of the most important and often neglected factors in dive safety is gear maintenance. Gear maintenance is your responsibility and is a necessary part of your duty as a diver for Reef Check California. For example, if you have not had your regulator serviced and/or checked for a few years, you are conducting a survey dive (collecting the best invertebrate transect data ever), and that regulator stops working, you have now put your and your dive buddy's life in jeopardy. Please remember that the number one rule in Reef Check is safety and that begins with you (and that includes your equipment).

Chapter 8

Data Entry & Quality Control

Data Submission

Accurate data entry is one of the most critical components of the monitoring process. As discussed in the previous chapter, it is critical that consistency be maintained within and among individuals. The Data Captain is responsible for data checking and submission of data for entry. All team members should assist with this activity.

The first level of data quality control is performed at the site, by the diver immediately following the dive either on the boat or on the beach. Each dive team member must ensure that all data are complete and totaled correctly and that all writing is legible. For fish divers, the fish datasheet is then checked by someone other than the person that collected the data for the same. The Data Captain then collects and reviews all data to ensure the datasheets are legible and ask any questions while the data are fresh in everyone's minds. This is a crucial step!

Within 24 hours of returning ashore, all datasheets should be washed, dried, photographed in color, and emailed to the Regional Manager who will upload them to a cloud storage service where they can be easily accessed by staff and volunteers. The original data sheets should be given or mailed to the Regional Manager at the soonest opportunity.

Every datasheet is then checked by Reef Check staff, who may follow up with the original diver if there are data that look questionable. Once the datasheets from a completed site are uploaded, the data can be entered into the database by Data Captains, RCCA staff members, interns, or trained volunteers. Final data checks are completed by Reef Check staff and then all data are made publicly available in Reef Check's Global Reef Tracker at: data.reefcheck.org. The interested public, resource managers and scientists can view, explore and download Reef Check California's data from this site through an interactive and intuitive map-based interface.

Quality Assurance Procedures

Quality assurance (QA) is a system for ensuring that data collection, entry and reporting follow a defined written plan and that if a mistake is made, it can be promptly detected, traced and corrected. This section defines the procedures for ensuring that data collected at a Reef Check California survey are correctly recorded, logged and entered in the Reef Check database. Data quality assurance and quality control steps are built into the program beginning with the training all the way through to the final data submission to the public database. Key steps are:

1. RCCA's four-day training course
2. Annual recertification of volunteers
3. Standardized data collection methods and datasheets
4. Field data verification
5. Data entry interface that minimizes user error
6. Automated data checks programmed into database
7. Data verification after data entry
8. Final data review by RCCA staff

Training

All participants are required to successfully complete the RCCA training course under the direct supervision of a certified RCCA instructor to be eligible to submit data to the RCCA database. Divers who complete the course and pass certification levels sufficient to conduct surveys continue to increase their knowledge by actively participating in underwater surveys. Only divers who have completed the required training and testing in each transect type and have demonstrated proficiency in data collection activities are allowed to contribute data for the transect types for which they are certified. This tiered approach allows volunteers to collect data for certain taxa once they complete testing and enables volunteers with differing abilities to participate in the program without adversely affecting data quality. Participants with extensive prior monitoring experience can opt out of the training course but must demonstrate proficiency in all components of the RCCA protocol under the supervision of a certified RCCA instructor before they can submit data to the RCCA database.

Requisite components of the RCCA training course are:

1. Completed reading of the Reef Check California Training Manual
2. Attendance and participation at all classroom sessions (10 hours)
3. Attendance and participation at the pool session (3 hours)
4. Attendance and participation at all field sessions (6 dives)
5. Successfully pass the written multiple-choice test (85% passing score)
6. Successfully pass the species identification tests (85% passing scores)
7. Successfully complete the methods and species identification field testing

After the initial training, all volunteers are required to complete a one-day recertification in each subsequent year before being allowed to collect data in that survey season. This recertification includes species identification tests and a field day during which volunteers are tested in all transect types before being certified for data collection.

Data Collection

Data collection methods have been designed to promote the safety of the surveyor as the primary goal followed by the accuracy and precision of all data collected. All surveyors must follow the methods outlined in the Reef Check California Training Manual. The following items have been included in the survey protocol to increase the precision and accuracy of all surveys by reducing sampler error and bias:

1. Standardized site selection and transect deployment procedures
2. Standardized time requirements, search image and use of flashlights for all invertebrate and fish surveys
3. Minimum size requirements for all invertebrate and algal species to focus on emergent organisms only
4. Grouping of species with similar morphological traits to reduce the likelihood of misidentification
5. Employment of standardized data notation procedures on the underwater datasheets
6. High level of replication within a site (eighteen 30 m x 2 m x 2 m transects)

Field Data Verification

Immediately following each dive, each team member must review their datasheet for completeness and legibility. The Data Captain verifies this prior to collection of each sheet and discusses any potential outliers with the team member. If a consensus on any data cannot be reached, the team leader will flag the datasheet for further review by the Regional Manager.

Finalizing Data

Upon receipt of the datasheets, all data will be reviewed by the Regional Manager and erroneous data are removed before data are submitted into the final database. The finalized data will be displayed via Reef Check's Global Reef Tracker on the web at data.reefcheck.org. All datasheets will be archived in digital and hard copy formats.

Chapter 9

Volunteer Expectations and Rewards

Volunteering for Reef Check California

As an RCCA volunteer, we ask that you donate at least 6 days per year to the program. One of the most important things you can do after your rigorous training is to get out there and do some surveys! This will bring all of that information you learned in the training together and you will become more confident and efficient with each survey you perform. Volunteer participation is vital to our monitoring efforts and without you, this work cannot be done.

As an RCCA volunteer, you will receive discounts and free air fills (for Reef Check dives) at several dive shops across California. These dive shops participate in our "Buddy Breathing" program and a list of those shops and what discounts they offer to our volunteers can be found on our website at: reefcheck.org/california/buddy-breathing.

If you volunteer for at least 6 days during the year, you will be eligible for our amazing ProDeals we receive from several companies. These ProDeals offer up to 40% off dive gear, lights, wetsuits, dry suits, clothing, and even sunscreen. Details about these amazing offers will be sent to qualified volunteers at the end of each survey season. Additionally, by volunteering for 6 days or more, your recertification costs for the next season will be waived. These days can be acquired through survey dives, giving a talk, entering data, manning a table at one of our outreach events, and many more activities. Feel free to contact your Regional Manager for more volunteering opportunities.

What More Can You Do?

There are many more ways in which you can get involved with Reef Check. Here are just a few ideas:

- Record additional information. For long-term monitoring, it is recommended that a full set of still photos and a video be obtained along the transect and surrounding area. Such photographs and video can be very useful in answering unexpected questions that crop up long after the survey is completed. We also recommend taking several above water photos in several directions showing the locations of the transects lined up against whatever landmarks may be available for future reference. It is generally not advisable to rely completely on video or photo monitoring for two reasons: 1) the ability to identify organisms in videos and photos is limited, and 2) analysis requires a great deal of time, even when aided by semi-automated procedures.

- Document your efforts. We strongly encourage all teams to record their travel, survey, analysis, post-dive party and any PR/media events with still photos or video.

- Photos and videos can be uploaded to the Reef Check Foundation's Facebook page or to our regional RCCA Facebook groups:

  facebook.com/reefcheckfoundation
  facebook.com/groups/NorCalReefCheck
  facebook.com/groups/SoCalReefCheck

- Tag #reefcheck to share your photos with us.

- Follow us on social media:

  Instagram: @reefcheckfoundation
  @reefcheckcalifornia
  Twitter: @reefcheck

- Participate in outreach events and presentations. We host many outreach activities throughout the year at community events and at our main office to spread the word about the work we do and to help recruit additional volunteers. We also give presentations at dive club meetings and dive shops about how to become part of the Reef Check California team. We encourage our volunteers to try to volunteer six days each year and these are great opportunities to contribute beyond completing scientific surveys of rocky reefs and kelp forests.

- Help educate youth. In July of 2017, RCCA established the marine education program, Educational Marine Biological Adventures with Reef Check, or EMBARC. Since that time, RCCA has sponsored a multitude of trips onboard the 75-foot boat, the *Matt Walsh* out of Marina del Rey, California and has provided underserved, inner-city students with this unique educational experience. The program gives middle and high school students the chance to become marine biologists for the day and the ability to observe some of the diverse marine life found in California. The curriculum for the program was designed using Next Generation Science Standards. Through this program, we hope to raise awareness about the value of ocean resources, the threats affecting ocean health and possible solutions to these problems. The ultimate goal is to create a new generation of young ocean ambassadors who will be willing to spread their newfound knowledge throughout their school, their families, and surrounding communities. We are always looking for volunteers to help us expand this program. You can help teach the students or reach out to schools and make them aware of the program so that they can send their students out on our boats.

- Get involved in our climate change monitoring project. In 2017, Reef Check California began collaborating with University of California Santa Cruz and researchers at the Monterey Bay Aquarium Research Institute (MBARI) to study climate change at locations and scales that are relevant to California's nearshore rocky reefs and kelp forests. This is a great opportunity for RCCA volunteers to get involved in climate change research. This work will improve our ability to judge the effectiveness of the state's MPA network and better track the impacts of climate change on kelp forest ecosystems and associated fisheries. Volunteers can adopt sensors and take responsibility for servicing them.

- Become a Reef Check Board Member. We're always looking for additional members to join our governing Board of Directors. Board Meetings take place every other month.

- Host a fundraising event. As a 501(c)(3) non-profit organization, based solely on grants and donations, we're always looking for opportunities to acquire supplemental funding to continue to carry out the work we do here in California and worldwide.

Sustainable Financing

As state funding for marine monitoring is extremely limited, finding new and sustainable financing for RCCA's public service of monitoring the status of California's marine environment is tremendously important. Several funding streams have been established and the involvement of RCCA's volunteers in this ongoing effort of sustaining and growing the program's funding, partnerships and sponsorships is a major part of the program's fundraising success.

Donations and Sustaining Membership

An important funding source for the California program is the donations made by volunteers and Reef Check members. By becoming a Reef Check member, you can help sustain the program with an annual contribution, or you can choose to become a Sustaining Donor with Reef Check's monthly donation program.

Grants

Grants are available from a wide range of funding sources, from hundreds of private philanthropic foundations focused on marine education, research and conservation, to State and Federal agencies interested in supporting marine monitoring and management. A major role of RCCA's development staff is to work with our teams across the state to help find grant support to start and maintain RCCA programs until such time that they can be locally self-supporting. Please let us know if you would like to work with us to search for and develop new grants or if you know of a funder that you would like to connect with us.

Corporate Sponsors

Corporate sponsorships are often the easiest type of funding for our volunteers to obtain by connecting us to their employers or other businesses in their network. These partnerships often lead to sustainable financing as corporations become long-term partners. Corporations actively seek out ways to make contributions as part of their corporate social responsibility programs. RCCA offers excellent opportunities for corporations.

Please consider helping us by connecting us to your employer or businesses and corporations within your network. We find that the highest success rate for new corporate sponsors comes from companies whose friends or employees are Reef Check volunteers. Many companies, such as dive boat operators or dive shops may also provide “in-kind” donations such as the use of facilities, boats, dive equipment and staff time.

Adopt-A-Reef

The Adopt-A-Reef program partners with companies or individuals to sponsor and support the community-based monitoring and conservation of California’s reefs. The Adopt-A-Reef program leverages the support and resources of local businesses to directly sponsor local volunteer dive teams to annually monitor the health of their marine ecosystems. By replicating this model on a statewide basis, the Adopt-A-Reef program engages California’s business community to take direct action, and a very proactive and forward-thinking stance, in moving beyond business-specific environmentally friendly practices towards actions that positively impact their local environment and community. Volunteers play a big part of helping RCCA to connect with potential Adopt-A-Reef partners through networking and, once a reef is adopted, by working with the partner to take full advantage of the sponsorship. Please let us know if you would like to help expand this program (reefcheck.org/get-involved/adopt-a-reef/).

Concluding Remarks

Reef Check California's data are contributing to our understanding of California's nearshore ocean. Our collaborative work with the California Department of Fish and Wildlife and the California Ocean Protection Council is providing a public service to the people of California by ensuring that our shared marine resources are managed and conserved based on available science as mandated by the state. As such, RCCA's data have been used to inform marine management and conservation on an ongoing basis. The data were used for the placement of the MPAs under the Marine Life Protection Act Initiative, have been integrated into the MPA baselines in all regions of the state (Freiwald & Wehrenberg 2013, Freiwald & Wisniewski 2015, Freiwald & Neumann 2017), and are now part of the ongoing long-term monitoring of California's MPAs. They have been used by federal agencies to describe the conditions of the resources in the Monterey National Marine Sanctuary (Office of National Marine Sanctuaries 2015), to make fisheries management decisions, as a baseline in case of an oil spill in Santa Barbara, for scientific research (e.g., Johnson et al. 2016, Claisse et al. 2018), and in the listing of the sunflower sea star as critically endangered on IUCN's Red List. RCCA has even been studied itself as an example of citizen science (Freitag et al. 2016, Freiwald et al. 2018).

Having trained over 1000 citizen scientists and educated many more about marine resource management and conservation issues, RCCA has created a body of well-informed citizens who have taken action to improve marine management in California. As management and conservation issues are likely to remain controversial, RCCA will help to build an educated and active constituency that can demand sound science-based management and conservation. Many of our volunteers have become vocal advocates for their marine environment, and some have started working on their own conservation projects.

Remember, we are relying on you to produce high quality data that can be used to help make informed management decisions. To achieve this, you must constantly update your skills and calibrate your sampling with other members of your team. It is critical that all RCCA surveys are standardized or else we will not be able to identify ecological trends in the data. Thank you for choosing Reef Check as a vehicle for making a difference, and above all, thank you for being concerned enough to take action!

References

Abramson, M., Gregorio, D., & Witter, M. (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.

Airamé, S., & Ugoretz, J. (2008). Channel Islands marine protected areas first 5 years of monitoring: 2003-2008 [Report produced by the California Department of Fish and Game in collaboration with the Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO), Channel Islands National Marine Sanctuary, and Channel Islands National Park].

Allen, L. G., Pondella, D. J., & Horn, M. H. (Eds.). (2006). The ecology of marine fishes: California and adjacent waters. University of California Press.

Behrens, D. W. (1980). Pacific Coast Nudibranchs: A Guide to the Opisthobranchs of the Northeastern Pacific. Los Osos, Calif., Sea Challengers, 5.

Bell, T. W., Allen, J. G., Cavanaugh, K. C., & Siegel, D. A. (2018). Three decades of variability in California's giant kelp forests from the Landsat satellites. Remote Sensing of Environment. doi: https://doi.org/10.1016/j.rse.2018.06.039

Breitburg, D., Levin, L. A., Oschlies, A., Grégoire, M., Chavez, F. P., Conley, D. J., . . . Zhang, J. (2018). Declining oxygen in the global ocean and coastal waters. Science, 359(6371). doi: 10.1126/science.aam7240

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

Campbell, M.L. (2006). Risk assessment (modified organism impact assessment) to update information on *Undaria pinnatifida*. All Oceans Ecology Report No. 200601. Prepared by All Oceans Ecology, Melbourne, for Biosecurity New Zealand. pp. 78.

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

Caselle, J. E., & Cabral, R. B. (2018). Monitoring California's rocky marine ecosystems across a network of MPAs: methodological comparison of multiple monitoring techniques. Technical Report to California Ocean Protection Council.

CDFW (2018). Red abalone Fisheries Management Plan. Retrieved from www.wildlife.ca.gov/conservation/marine/red-abalone-fmp.

Claisse, J. T., Blanchette, C. A., Dugan, J. E., Williams, J. P., Freiwald, J., Pondella, D. J., . . . Caselle, J. E. (2018). Biogeographic patterns of communities across diverse marine ecosystems in Southern California. Marine Ecology, 39(S1), e12453. doi:

Derby, C. D., Kicklighter, C. E., Johnson, P. M., & Zhang, X. (2007). Chemical composition of inks of diverse marine molluscs suggests convergent chemical defenses. Journal of chemical ecology, 33(5), 1105-1113.

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

Engelen, A. H., Serebryakova, A., Ang, P., Britton-Simmons, K., Mineur, F., Pedersen, M. F., ... & Pavia, H. (2015). Circumglobal invasion by the brown seaweed *Sargassum muticum*. Oceanography and Marine Biology: An Annual Review, 53, 81-126.

Eschmeyer, W. N. & Herald, E. S. (1983). A Field Guide to Pacific Coast Fishes North America (A Peterson Field Guide). Houghton Mifflin Co, Boston / New York.

Fofonoff P. W., Ruiz, G. M., Steves, B., Simkanin, C., & Carlton, J. T. (2018). National Exotic Marine and Estuarine Species Information System. http://invasions.si.edu/nemesis/. Access Date: 28-Mar-2019

Freitag, A., & Pfeffer, M. J. (2013). Process, not product: investigating recommendations for improving citizen science "success". [Research Support, Non-U.S. Gov't]. PLoS ONE, 8(5), e64079. doi: 10.1371/journal.pone.0064079

Freiwald, J., & Wehrenberg, M. (2013). Reef Check California: North Central Coast Baseline Surveys of Shallow Rocky Reef Ecosystems (pp. 64). Pacific Palisades: Reef Check Foundation.

Freiwald, J., & Wisniewski, C. (2015). Reef Check California: Citizen Scientist monitoring of rocky reefs and kelp forests: Creating a baseline for California's South Coast, Final Report South Coast MPA Baseline Monitoring 2011-2014 (pp. 244). Pacific Palisades: Reef Check Foundation.

Freiwald, J., Neumann, A., & Abbott, D. (2016a). Red abalone size frequency survey protocol. Reef Check California, Reef Check Foundation, Marina del Rey, California, USA.

Freiwald, J., Wisniewski, C., & Abbott, D. (2016b). Northward range extension of the crowned sea urchin (*Centrostephanus coronatus*) to Monterey Bay, California. California Fish and Game, 102(2), 37-40.

Freiwald, J., & Neumann, A. (2017). Reef Check California: Citizen Scientist monitoring of rocky reefs and kelp forests: Creating a baseline for California's North Coast MPAs. Marina del Rey: Reef Check Foundation.

Freiwald, J., Meyer, R., Caselle Jennifer, E., Blanchette Carol, A., Hovel, K., Neilson, D., . . . Bursek, J. (2018). Citizen science monitoring of marine protected areas: Case studies and recommendations for integration into monitoring programs. Marine Ecology, 39(S1), e12470. doi: 10.1111/maec.12470

Gillett, D. J., Pondella, D. J., Freiwald, J., Schiff, K. C., Caselle, J. E., Shuman, C., & Weisberg, S. B. (2012). Comparing volunteer and professionally collected monitoring data from the rocky subtidal reefs of Southern California, USA. Environmental monitoring and assessment, 184(5), 3239-3257.

Gotshall, D. (2005). Guide to marine invertebrates. Sea Challengers.

Gravem, S.A., W.N. Heady, V.R. Saccomanno, K.F. Alvstad, A.L.M. Gehman, T.N. Frierson and S.L. Hamilton. (2021). *Pycnopodia helianthoides*. IUCN Red List of Threatened Species 2021.

Harding, S., Lowery, C., & Oakley, S. (2000, October). Comparison between complex and simple reef survey techniques using volunteers: is the effort justified. In Proceedings of the 9th international coral reef symposium. International Coral Reef Society, Bali (pp. 883-889).

Harris, J. R., & Markl, J. (1999). Keyhole limpet hemocyanin (KLH): a biomedical review. *Micron*, *30*(6), 597-623.

Harvell, C. D., Montecino-Latorre, D., Caldwell, J. M., Burt, J. M., Bosley, K., Keller, A., . . . Gaydos, J. K. (2019). Disease epidemic and a marine heat wave are associated with the continental-scale collapse of a pivotal predator *Pycnopodia helianthoides*). Science Advances, 5(1), eaau7042. doi: 10.1126/sciadv.aau7042

Hewson, I., Button, J. B., Gudenkauf, B. M., Miner, B., Newton, A. L., Gaydos, J. K., . . . Harvell, C. D. (2014). Densovirus associated with sea-star wasting disease and mass mortality. Proc Natl Acad Sci USA. doi: 10.1073/pnas.1416625111

Hill, J., & Wilkinson, C. (2004). Methods for ecological monitoring of coral reefs. Australian Institute of Marine Science, Townsville, 117.

Hobday, A. J., & Tegner, M. J. (2000). Status review of white abalone (*Haliotis sorenseni*) throughout its range in California and Mexico. NOAA-TM-NMFS-SWR-035

Hodgson, G., Kiene, W., Mihaly, J., Liebeler, J., Shuman, C., & Maun, L. (2006). Instruction Manual A Guide to Reef Check Coral Reef Monitoring. Institute of the Environment.

Hodgson, G., Mohajerani, L., Liebeler, J., Ochavillo, D., Shuman, C.S. (2003). MAQTRAC: Marine Aquarium Trade Coral Reef Monitoring Protocol. Reef Check, Institute of the Environment, University of California, Los Angeles, Los Angeles, CA. 55 p.

Hodgson, E. E., Kaplan, I. C., Marshall, K. N., Leonard, J., Essington, T. E., Busch, D. S., . . . McElhany, P. (2018). Consequences of spatially variable ocean acidification in the California Current: Lower pH drives strongest declines in benthic species in Southern regions while greatest economic impacts occur in Northern regions. Ecological Modelling, 383, 106-117. doi: 10.1016/j.ecolmodel.2018.05.018

Humann, P. (1996). Coastal fish identification: California to Alaska. New World Publications Incorporated.

Johnson, D. W., Freiwald, J., & Bernardi, G. (2016). Genetic diversity affects the strength of population regulation in a marine fish. Ecology, 97(3), 627-639. doi: 10.1890/15-0914.1

Knudsen, S. W., & Clements, K. D. (2016). World-wide species distributions in the family Kyphosidae (Teleostei: Perciformes). *Molecular phylogenetics and evolution*, *101*, 252-266.

Hickey, B. M. 1994. Physical Oceanography. In M. Dailey, D J. Reish, and J. W. Anderson (Eds.), Ecology of the Southern California Bight: A Synthesis and Interpretation (pp 19-70). London, England. University of California Press.

Leet, W. S. (2001). California's living marine resources: a status report. University of California, Division of Agriculture and Natural Resources; California Sea Grant.

Leising, A. W., Schroeder, I. D., Bograd, S. J., Abell, J., Durazo, R., Gaxiola-Castro, G., . . . Warybok, P. (2015). State of the California Current 2014–15: Impacts of the warm-water “Blob”. STATE OF THE CALIFORNIA CURRENT CalCOFI Rep., 56, 31-68.

Levrel, H., Fontaine, B., Henry, P. Y., Jiguet, F., Julliard, R., Kerbiriou, C., & Couvet, D. (2010). Balancing state and volunteer investment in biodiversity monitoring for the implementation of CBD indicators: A French example. Ecological economics, 69(7), 1580-1586.

Love, M. S. (1991). Probably more than you want to know about the fishes of the Pacific coast. Really Big Press.

Love, M. S. (2011). Certainly, more than you want to know about the fishes of the Pacific Coast: a postmodern experience. Really Big Press.

Love, M. S., Yoklavich, M., & Thorsteinson, L. K. (2002). The Rockfishes of the northeast Pacific. University of California Press.

Love, M. S., Passarelli, J. K., Cantrell, B., & Hastings, P. A. (2016). The Largemouth Blenny, *Labrisomus xanti*, new to the California marine fauna with a list of and key to the species of Labrisomidae, Clinidae, and Chaenopsidae found in California waters. Bulletin, Southern California Academy of Sciences, 115(3), 191-198.

Matson, P. G., & Edwards, M. S. (2007). Effects of ocean temperature on the Southern range limits of two understory kelps, *Pterygophora californica* and *Eisenia arborea*, at multiple life-stages. Marine biology, 151(5), 1941-1949.

Miller, D. J., & Lea, R. N. (1972). Guide to the coastal marine fishes of California (No. 154-158). UCANR Publications.

Mountfort, D. O., Campbell, J., & Clements, K. D. (2002). Hindgut fermentation in three species of marine herbivorous fish. *Appl. Environ. Microbiol.*, *68*(3), 1374-1380.

Neuman, M. J., Wang, S., Busch, S., Friedman, C., Gruenthal, K., Gustafson, R., ... & Wright, S. (2018). A Status Review of Pinto Abalone (*Haliotis kamtschatkana*) Along the West Coast Of North America: Interpreting Trends, Addressing Uncertainty, and Assessing Risk for a Wide-Ranging Marine Invertebrate. *Journal of Shellfish Research*, *37*(4), 869-911.

NOAA. (2009) "2009 NMFS West Coast Workshop on Abalone Species of Concern".

Office of National Marine Sanctuaries. (2015). Monterey Bay National Marine Sanctuary Condition Report Partial Update: A New Assessment of the State of Sanctuary Resources 2015. In N. O. A. A. U.S. Department of Commerce, Office of National Marine Sanctuaries, (Ed.), (pp. 133). Silver Spring, MD.

Palumbi, S. R., Sandifer, P. A., Allan, J. D., Beck, M. W., Fautin, D. G., Fogarty, M. J., . . . Wall, D. H. (2009). Managing for ocean biodiversity to sustain marine ecosystem services. Frontiers in Ecology and the Environment, 7(4), 204-211. doi: doi:10.1890/070135

Quinn, G. P., & Keough, M. J. (2002). Experimental design and data analysis for biologists. Cambridge University Press.

Schaffelke, B., Smith, J. E., & Hewitt, C. L. (2006). Introduced macroalgae–a growing concern. *Journal of applied phycology*, *18*(3-5), 529-541.

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

Shirk, J. L., Ballard, H. L., Wilderman, C. C., Phillips, T., Wiggins, A., Jordan, R., . . . Bonney, R. (2012). Public Participation in Scientific Research: a Framework for Deliberate Design. Ecology and Society, 17(2). doi: 10.5751/es-04705-170229

Sokal, R. R., & Rohlf, F. J. (1969). Biometry: the principles and practice of statistics in biological research. San Francisco: W.H. Freeman.

Snyderman, M. (1998). California Marine Life: A Guide to Common Marine Species. Roberts Rinehart Pub.

Thiel, M., Penna-Díaz, M. A., Luna-Jorquer, G., Salas, S., Sellanes, J., & Stotz, W. (2014). Citizen Scientists and Marine Research: Volunteer Participants, Their Contributions, and Projection for the Future. Oceanography and Marine Biology: An Annual Review, 52, 257-314.

Thornber, C. S., Kinlan, B. P., Graham, M. H., & Stachowicz, J. J. (2004). Population ecology of the invasive kelp *Undaria pinnatifida* in California: environmental and biological controls on demography. *Marine Ecology Progress Series*, *268*, 69-80.

Peterson, W., Robert, M., & Bond, N. (2015). The warm blob – Conditions in the northeastern Pacific Ocean. PICES Press, 23(1).

VanBlaricom, G., Neuman, M., Butler, J., DeVogelaere, A., Gustafson, R., Mobley C., Richards, D., Rumsey, S., and Taylor, B. "Status Review Report for Black Abalone." *National Marine* (2009).

Winningham, M., Eisenlord, M. E., Gaydos, J., Montecino-Latorre, D., Nichols, J., Pattengill-Semmens, C., & Harvell, C. D. (2018). A tale of two sea stars: recovery (ochre star) or endangerment (sunflower star) following the 2014 epidemic. Salish Sea Ecosystem Conference. 527.

Wernberg, T., Bennett, S., Babcock, R. C., de Bettignies, T., Cure, K., Depczynski, M., . . . Wilson, S. (2016). Climate-driven regime shift of a temperate marine ecosystem. Science, 353(6295), 169-172. doi: 10.1126/science.aad8745

Appendix A: Reef Check California Protocol Updates

In the following, we list the updates and changes that have been made to the Reef Check California protocol over the years since the program started in 2006. All of these changes are reflected in this current version of the manual. This section should serve as a reference when analyzing RCCA data so that these updates can be accounted for. All updates were made in a way that they are backwards compatible with the data collected before the respective protocol change. Therefore, they should not cause any problems in data analyses but in some cases, they have to be considered and accounted for before results are interpreted (i.e. if a species was added or a certain category of taxa was split into two).

2020 Protocol Updates

Invertebrate Transect

- California Moray Eels are recorded on both the invertebrate and fish transects.
- Sunflower stars are recorded anywhere on site.
- Leather star has been added to the invertebrate transect.

Fish Transect

- Largemouth Blennies are recorded and sized if found anywhere on site.
- Finescale Triggerfish are recorded and sized if found anywhere on site.

2019 Protocol Updates

Invertebrate Transect

Ochre Star has been added to the invertebrate transect.

2018 Protocol Updates

Fish Transect

Three fish species have been removed from the species list (because we never see them):

- Boccaccio
- Canary Rockfish, we will still count and size Vermillion Rockfish
- Rock Greenling

Four fish species have been added to the species list:

- Halfmoon
- Moray Eel*
- Finescale Triggerfish**
- Largemouth Blenny

*Moray Eels will not be sized when observed on transect.

**Finescale Triggerfish will be recorded and sized if found anywhere on site.

Invertebrate Transect

Two invertebrates added to the species list:

- California Sea Hare
- Black Sea Hare

Sunflower Sea Stars and Sun Stars have been split into separate groups and are now counted separately.

Kelp Transect

One new kelp has been added to the species list:

- Feather Boa Kelp
  - Must be at least one meter tall to count and the individual stipes get counted just like giant kelp

The Laminaria species have been split into separate groups:

- *Laminaria farlowii*
- *Laminaria setchellii*

There are now two separate size categories for Southern Sea Palm:

- Greater than 30 cm and less than 30 cm

UPC Transect

One new cover category has been added:

- Encrusting red algae (E)

2016 Protocol Updates

Abalone Protocol

Red abalone (*Haliotis rufescens*) in Northern California (Sonoma, Mendocino and Humboldt counties) will now be measured to the nearest millimeter and their density will not be sub-sampled.

For this, divers will be supplied with specialized calipers. The first 50 red abalone will be measured, then the remaining red abalone on the transect will be counted but don't need to be measured. The total number of abalone counted should be noted when tallying the datasheet after the dive.

2015 Protocol Updates

Invasive algae *Sargassum horneri* added to transect

To date, we have been recording the presence or absence of *S. horneri* at each of our monitoring sites. Starting in 2015, we will add *S. horneri* to the species that we count along our algae transects. On each algae transect, we will count the number of holdfasts of *S. horneri* within the 30x2 meter transect area. This is done in the same way as we count the other species of algae along the transect.

We will continue to record the presence or absence of both invasive *Sargassum* species, *S. horneri* and *S. muticum*, at monitoring sites as we have done in the past by checking 'yes' or 'no' on the algae datasheet. We are continuing to do this despite recording *S. horneri* on transects to maintain consistency in our data and monitor the presence of this species even if it is not found on one of our algae transects. Often *S. horneri* is found as small recruits (i.e. juvenile stage) during our main survey season in the summer. These recruits can be very abundant at times, but if they are less than 30 cm in height they will not be recorded during the algae transect, but *S. horneri* will be recorded as present at the site in the Yes/No checkbox on the datasheet.

During the UPC transect we will continue to record *S. horneri* as "Other Brown" (OB) algae. Therefore, nothing has changed in the UPC protocol and we are still recording all invasive species as "Other Brown". This keeps the UPC data compatible with what we have done in the past because we are not modifying the existing UPC categories.

2013 Protocol Updates

Fish sizing

Starting in 2013, RCCA began sizing individual fish to the nearest centimeter. The goal is to estimate the size of each individual to the nearest centimeter, but often this can be challenging, especially if schools of fish are present. In this case, it is possible to bracket the size of a group of fish and write down the largest and smallest size and the number of individuals in the group. Young-of-the-year rockfish (YOYs) are not sized but their number is recorded under "YOY" on your datasheet.

Fishing gear and trash observations

We will count any fishing gear and debris that falls within our 2-meter swath on all fish transects (18 transects). If any part of this gear or trash is within your swath (i.e. the edge of a lobster trap or a piece of monofilament line), it will be counted. Fishing gear that is attached to fish that are recorded on transect (i.e. hook in mouth, trailing line) will also be recorded. Fishing gear and other objects will be broken down into four categories:

- Hook and line (recreational) fishing tackle - includes hooks, lures, bobbers, sinkers, fishing rods and fishing line, etc. This category also encompasses spearfishing gear including spears, tips and guns (spearfishing gear seems to be uncommon and it should be noted in the comments if spearfishing gear is found to differentiate it from other gear).
- Traps - includes both abandoned (recorded as ‘lost’) and active (recorded as ‘active’) traps. Broken and deteriorated traps (i.e. parts of traps) will also be counted. Lobster hoop nets will fall into this category since they serve the same purpose as a trap.
- Nets - includes full nets or pieces of net material.
- Trash - includes anything man made that was lost or tossed into the ocean and that doesn’t fall into one of the fishing gear categories such as plastics, bottles, cans, metal, anchors, ropes, etc.

Each item from the above categories that is encountered on a fish transect will be recorded on the fish datasheet as a tick mark in its respective category.

2011 Protocol Updates

This year we have implemented some updates to our protocol and datasheets, which include both changes and clarifications. Please take the time to review these prior to coming out to your Recertification. We will discuss and clarify any questions about the changes when we meet for the Recert. The updates are as follows:

All Transects

1. 10 meters or more of sand

If you are deploying a transect on a predetermined bearing and encounter > 10 m of sand, alter your bearing to get back on to rocky reef substrate. As we have done in the past, if you do not pass any kelp and/or rocky substrate (bedrock or boulders) coming up through the sand in < 10 m, void the transect and redeploy once you have found the reef again. On the other hand, if you encounter algae emerging from the sand, frequently this suggests you are surveying recently covered rocky reef habitat and you should continue your transect according to your heading.

2. Time guidelines

Fish transects are to be completed in 5-10 min. Invertebrate and seaweed transects should be done with a 10-minute goal in mind, but there is no cut-off time. Due to the differences in complexity of the reef habitat and abundance of certain organisms, transects might deviate from this goal. UPC has no time limit but remember to write down start and end time.

3. Counting organisms in cracks

If your transect passes over a crack/crevice that is too small to swim into, count organisms in the entire area of the crevice within the 2-meter width of the swath. If the transect is placed under a ledge that creates a ceiling above the diver, do not count invertebrates on the ceiling.

<u>Fish Transect</u>

1. "Unknown rockfish" and "YOY rockfish" categories

In addition to all the species of rockfishes on our indicator organism list, RCCA also counts "young-of-the-year" (YOY) rockfishes, which are juveniles that are less than a year old. It is very difficult to identify YOY rockfishes to species when they are < 10 cm. As an RCCA certified diver, you will count small individuals (greater than 2.5 cm) that clearly have a Rockfish body shape but with coloration and/or markings that differ from adults and record them in the "YOY rockfish" category on your datasheet. Even if you have been trained to identify YOYs to species, do not record them under the respective species but record them in the "YOY rockfish" category on the datasheet. There is only one size category since YOYs are < 10 cm. It is not uncommon to see 100 or more YOYs on one transect during certain times of year (mainly the northern part of the state). It is important therefore to do your best to count all YOYs seen on transect (we DO NOT subsample any fishes) by coming up with a helpful technique, such as counting in groups of 5 or 10. We have removed the "unknown rockfish" category from the datasheet. If you encounter an individual (other than YOYs) that you cannot identify to species, take notes on your datasheet and discuss these with the team after the dive.

*Note: In the past, we have recorded juvenile Blue Rockfish separately from the others. We will not be doing that anymore and group all YOYs together.

2. Kelp Greenling

We have added a juvenile category for Kelp Greenling to the datasheet. Individuals that are less than 20 cm and cannot be clearly identified either as female or male (nondescript markings) should be recorded in this category.

<u>Invertebrate Transect</u>

1. Black abalone now treated like white abalone

Due to their endangered statuses, white and black abalones should be recorded if they are observed anywhere during the survey (on or off transect). As such, note that black abalone has now been moved to the bottom of the datasheet, where you can mark 'yes' if you see one. If you believe you see a black or white abalone, do as much of the following as possible: confirm with your buddy; record whether or not it is on transect; take a photo including the respiratory holes, shell and mantle; and mark the location with a SMB so GPS coordinates can be recorded from the surface.

UPC Transect

1. COVER: How to record algae

There are two categories for brown seaweed, Brown Seaweed (B) and Other Brown Seaweed (OB) on the UPC datasheet. Category B is used to describe only the five kelps that are counted during an algae transect. The OB category describes any other brown seaweed, including the brown invasives, *Undaria pinnatifida* and *Sargassum* spp. If your UPC point falls upon ANY PART (blade, stipe, holdfast) of any color alga, it should be recorded. This rule applies to all algae categories except Brown Seaweed (B), which should only be recorded if the point falls directly on its HOLDFAST. Non-attached algae, or drift algae, should be moved when encountered to determine what is below. When long blades of algae are encountered, it is important to determine if they are attached to the reef (accomplished by giving a gentle tug). If they are, they will be recorded and if they are not, they will not be recorded.

2. COVER: New categories

Mobile Invert (MI) - Invertebrates that can change location including urchins, sea cucumbers, sea stars, abalone, limpets, etc.

Sessile Invert (SI) - Invertebrates that cannot change location including sponges, tunicates, scallops, barnacles, sandcastle worms, anemones, etc.

Seagrass (SG) - Seagrasses, including surf grass and eelgrass.

4. How to record sandcastle worms

Sandcastle worms are recorded in the cover category as sessile invertebrate (SI) no matter if they are growing in sand or on rock, or even if there is anything growing on the colony (e.g., algae).

2007 Protocol Updates

Fish Transects

Two new species of fish have been added: Brown Rockfish (*Sebastes auriculatus*) and China Rockfish (*Sebastes nebulosus*).

Invertebrate transects

We have added a few species to ensure we are getting a representative sample of the invertebrate community on California’s rocky reefs and have changed the minimum size requirement for all gorgonians (sea fans).

We have added two new abalone species: Flat abalone (*Haliotis walallensis*) and Pinto abalone (*Haliotis kamtschatkana*). We also added Masking crab (*Loxorhynchus crispatus*).

Lastly, we added a group of species as "Large anemone". This group includes a group of anemones that are all members of the Order Actiniaria. Any anemone that is > 10 cm in diameter is in this category. You should not count small < 10 cm colonial anemones in this category.

We have made one additional change to the survey method for all gorgonians and switched the minimum size to count from 15 cm to 10 cm.

Glossary

Abundance: the number of individuals per species.

Accuracy: the closeness of an estimated value to its true value.

Adopt-A-Reef: Reef Check program that partners with companies or individuals to sponsor and support the community-based monitoring and conservation of California's reefs. The program leverages the support and resources of local businesses to directly sponsor local volunteer dive teams to annually monitor the health of their marine ecosystems.

Alga (*plural: algae*): a collective term for the photosynthetic organisms lacking distinct cellular differentiation and elaborate reproductive systems. Includes seaweeds.

Alginate: the main carbohydrate in giant kelp that is used to make food and household products "smoother", like toothpaste, ice cream, jelly, shampoo/conditioner and salad dressing. It is also harvested in several places to feed abalone in an increasing number of abalone farms along the coast.

American Academy of Underwater Sciences (AAUS): a non-profit, self-regulating body dedicated to the establishment and maintenance of standards of practice for scientific diving with a mission of advancing and facilitating safe and productive scientific diving.

Anal fin (*fish*): the unpaired fin located posterior of the anus.

Anemone: carnivorous marine animals that come in a variety of shapes, sizes and colors. They are usually sessile, securing themselves to the sea floor.

Benthic: associated with the seafloor.

Bias: tendency of a statistic to overestimate or underestimate a parameter. Most samplers are going to introduce a certain amount of biases into the overall data set.

Biodiversity: the variety of life in a particular habitat or ecosystem.

Bivalve: a mollusk that has a compressed body enclosed within a hinged shell, such as oysters, clams, mussels, and scallops.

Blade (*algae*): leaf-like structures on macroalgae that are used to produce energy via photosynthesis.

Boulder: area of substrate that is between 15 cm - 1 m in size.

Bracketing: surveying technique where the observer records the largest and smallest size and the number of individuals while sizing fish.

California Current: current that generally flows from north to south throughout the year, but its intensity varies with the season. This current follows the coastline of Northern and Central California during winter and spring.

California Department of Fish and Wildlife (CDFW): a state agency under the California Natural Resources Agency. The Department of Fish and Wildlife manages and protects the state's fish, wildlife, wildflowers, trees, mushrooms, algae (kelp) and native habitats (ecosystems). The Department is responsible for regulatory enforcement and management of related recreational, commercial, scientific, and educational uses. The Department also works to prevent illegal poaching. Formerly known as the California Department of Fish and Game (CDFG).

Caudal fin (*fish*): the tail fin of a fish.

Caudal peduncle (*fish*): the narrow part of the body to which the caudal fin is attached.

Cirri (*fish*): a hair-like, often branched structure often located on a fish's head.

Citizen science: the collection and analysis of data relating to the natural world by members of the public, typically as part of a collaborative project with professional scientists.

Climate change: a change in global or regional climate patterns, in particular a change apparent from the mid to late 20th century onwards and attributed largely to the increased levels of atmospheric carbon dioxide produced by the use of fossil fuels.

Cnidarians: phylum Cnidaria of mostly marine animals that include jellyfish, corals, hydroids and anemones. There are over 11,000 species of cnidarians and they have two basic body forms: swimming medusa (think sea jellies) and sessile polyps.

Cobble: substrate that is in between 0.5 cm - 15 cm in size.

Common name: a name of an organism that is based on the normal language of everyday life.

Cooperative Research and Assessment of Nearshore Ecosystems (CRANE): observational organization who monitored a large section of the California coast from Monterey to San Diego.

Core transect: transects that include an invertebrate, kelp, UPC and fish transect all conducted along the same 30 m transect line.

Cover: describes the physical structure of the seafloor and is largely based on the size of the rocky material your point is on.

Crustaceans: the subphylum Crustacea are bilaterally symmetrical organisms that have exoskeletons, segmented bodies and paired appendages. Crustaceans form a subphylum that contains over 67,000 species and includes animals such as crabs, lobsters, crayfish, shrimp, krill and barnacles.

Data Captain: volunteer who coordinates with regional RCCA staff and is responsible for logistics (e.g., checking weather conditions, parking permits, setting times, etc.), making sure the team has enough blank datasheets to complete a survey, team survey assignments, including transect locations, collection and review of datasheets after each dive and ensuring all data are entered into the online database and the original datasheets are submitted to the Regional Manager. Data Captains usually have at least 1 year of RCCA survey experience before moving into this role.

Davidson Current: northerly flowing current that occurs between November and February and is accompanied by southwest winds and warmer waters.

Detritivore: an animal that breaks down organic matter.

Dissolved oxygen (DO): a measure of how much oxygen is dissolved in the water.

Dorsal fin (*fish*): The fin(s) located on the fish's back.

Echinoderms: The phylum Echinodermata includes sea stars, urchins, sand dollars, sea cucumbers, and sea lilies. These animals have radial symmetry and are found at most depths, including the intertidal, throughout the world's oceans.

Ecosystem service: the conditions and processes through which natural ecosystems, and the species that comprise them, sustain and fulfill human life. Marine ecosystems provide a constellation of services: they produce food, receive and assimilate wastes, protect shorelines from storms, regulate the climate and atmosphere, generate tourism income, and provide recreational opportunities.

Educational Marine Biological Adventures with Reef Check (EMBARC): Reef Check's interactive marine education program that gives underserved middle and high school students a chance to experience the ocean environment first hand.

El Niño: an irregularly occurring and complex series of climatic changes affecting the equatorial Pacific region and beyond every few years, characterized by the appearance of unusually warm, nutrient-poor water off Northern Peru and Ecuador, typically in late December.

Endangered Species Act (ESA): the primary law that provides protection for imperiled species in the United States.

Epipodium (*abalone*): frilly tissue that can be seen when the abalone lifts its shell up.

Error (*statistics*): difference between the retained value and the true value.

Fish-only transect: transects on either side of a "core transect" where divers search for and record numbers and sizes of the 35 target fish species observed along 30 meter long, 2 meter wide and 2 meter high transect.

Foot (*mollusk*): The underside of a mollusk, which is used for locomotion and anchorage, and varies in shape and function, depending on the type of mollusk.

Gill raker (*fish*): small, bony processes located on the anterior part of the gill arch. They are used by rockfish to restrain prey from escaping past the gills.

Gorgonians: Also known as sea fans and sea whips; include over 500 species found throughout the world's oceans. They are sessile colonial cnidarians that can create structures of various colors, shapes and sizes. These organisms are filter feeders and collect plankton and detritus from the water around them.

Haphazard deployment: deployments as close to random as possible.

Holdfast (*algae*): root-like structures of algae that function as anchors to the substrate but do not play a role in uptake of nutrients or water.

Hook and line: hooks, lures, bobbers, sinkers, fishing rods and fishing line, etc.

In situ: to examine the phenomenon exactly in the place where it occurs (e.g., a kelp forest, tidepools, estuary, etc.).

Indicator species: key species that Reef Check surveys that are either commonly observed, exploited by recreational or commercial fisheries, ecologically important, or are a species of interest.

Intertidal zone: the area where the ocean meets the land between high and low tides.

Invasive species: A species that has spread from its native regions into new areas that strongly affect the local communities. These species are not native and have entered their new environment by human influences via boats and/or the aquarium industry.

Invertebrate: an animal lacking a backbone.

Kelp: the common name for several large species of brown algae found across the world's oceans and can be a primary habitat and food source for many marine species. Sometimes called seaweed, these species of brown marine algae belong to a type or order called Laminariales. This order of algae is typically found in temperate and arctic regions, including both the Atlantic and Pacific oceans.

Kelp forests: underwater areas with high densities of kelp that are often on areas of rocky reefs.

La Niña: a coupled ocean-atmosphere phenomenon that is the colder counterpart of El Niño, as part of the broader El Niño–Southern Oscillation (ENSO). During a La Niña period, the sea surface temperature across the eastern equatorial part of the Central Pacific Ocean will be lower than normal by 3 to 5 °C (5.4 to 9 °F). An appearance of La Niña persists for at least five months.

Laminariales: order of brown marine algae, often called seaweed.

Lateral line (*fish*): the line formed by a series of pores located on a fish's body or head.

Mantle (*mollusk*): area that encloses the mollusk's visceral mass, which is its internal organs, including the heart, stomach, intestines, and gonads.

Marine Life Protection Act (MLPA): law requiring the state of California to design, implement, and enforce a network of marine protected areas throughout the state.

Marine Protected Area (MPA): protected areas of seas, oceans and estuaries within the United States.

Mobile invertebrate: invertebrates that move around on the ocean floor.

Mollusk: an invertebrate of a large phylum (Mollusca) which includes snails, slugs, mussels, and octopuses. They have a soft unsegmented body and live in aquatic or damp habitats, and most kinds have an external calcareous shell.

Monterey Bay Aquarium Research Institute (MBARI): a private, non-profit oceanographic research center in Moss Landing, California.

No-Take State Marine Conservation Area: an area following the same guidelines outlined by a SMCA, however, agencies are permitted to conduct incidental take and specified activities (example: infrastructure maintenance). No-Take SMCAs currently constitute 0.64% of all Coastal State Waters.

Ocean acidification (OA): a reduction in the pH of the ocean over an extended period of time, caused primarily by uptake of carbon dioxide (CO_2) from the atmosphere.

Operculum (*fish*): a series of bones found in bony fish that serves as a facial support structure and a protective covering for the gills.

Partnership of Interdisciplinary Studies of Coastal Oceans (PISCO): an academic consortium that conducts research to advance understanding of the coastal ocean within the California Current Large Marine Ecosystem and inform management and policy.

Pectoral fin (*fish*): paired fins located behind the fish's head on the flanks.

Pelvic fin (*fish*): paired fins located on the underside of a fish's body.

pH: quantitative measure of the acidity or basicity of aqueous or other liquid solutions.

Photosynthesis: the use of energy from light and the process of converting it into organic compounds necessary to growth and maintenance.

Pneumatocyst: gas-filled structure on kelp that allows them to grow towards the surface.

Precision: the closeness of different replicates to each other.

Quadrats: small areas of habitat, typically selected randomly or haphazardly, to act as samples for assessing the local distribution of organisms or habitat characteristics. Tools are often used to standardize measurements.

Quality assurance: a system for ensuring that data collection, entry and reporting follow a defined written plan and that if a mistake is made, it can be promptly detected, traced and corrected.

Range expansion: the spread of species from their native regions into new areas that could have an effect on the local ecosystems.

Reef: UPC category; substrate that is greater than one meter in size.

Reef Check California EcoDiver Specialty Certification: NAUI certification that is designed to provide participants with the skills required to precisely monitor shallow kelp forests with the Reef Check California survey protocol.

Reef Check Volunteer Tool (RCVT): website that is designed to allow volunteers to sign up for surveys and find information about specific dive days. It is divided into three calendars, North, Central and South. http://calendar.reefcheck.org

Relief: describes the rugosity or vertical relief of the reef around your point.

Replication: In statistics, replication means having replicate observations of the same condition. Replication is essential because biological systems are inherently variable, and replication adds information about the reliability of the conclusions or estimates to be drawn from the data.

Respiratory pore (*abalone*): holes on the top of the shell of abalone that are used for respiration, excretion and reproduction.

Salinity: the amount of salt in a body of water.

Sand: substrate that is smaller than 0.5 cm in size.

Scientific name: a name used by scientists, especially the taxonomic name of an organism that consists of the genus and species. Scientific names usually come from Latin or Greek.

Sea Star Wasting Disease: a condition affecting sea stars that resulted in a significant Northeastern Pacific population decline following a mass mortality event in 2013.

Seagrass: actual vascular flowering plants that can be distinguished from marine algae by the presence of plant-like shape and structure like grasses on land.

Sebastes: (Genus containing Rockfish); this genus of fish has over 72 species that are found in the northeast Pacific. Rockfish can be found from the intertidal zone to thousands of meters below the ocean’s surface. The name, *Sebastes*, means “magnificent” in Greek.

Sessile invertebrate: invertebrates that are physically attached to the substrate.

Sexual dimorphism: distinct difference in size or appearance between the sexes of an animal, in addition to the difference between the sexual organs themselves.

Site description: anecdotal, observational, historical, geographical and other data that provide details about a dive site.

Site map: GPS or map that is used to verify the position of the survey site and locations of transects.

Size frequency: surveys that are conducted to measure the sizes of different organisms.

Snapshot technique: surveying technique where divers look up and count, identify, and size all the fish that are in the volume of water 2 m wide, 2 m high and roughly 3 m forward.

Snell's Law of Refraction: the magnification effect of water that is caused by the reflection of light moving from one medium (water) to another (air inside a mask).

Southern California Bight: the area between Pt. Conception, California and Punta Colonet in Baja California.

Southern California Countercurrent: current occurring in the Southern California Bight and may be thought of as a very large-scale eddy in the California Current.

Spatial variability: Variability based on differences observed by location.

Special Closure: an area where human access to ecologically important sites (such as marine mammal and seabird rookeries) are restricted or prohibited. Special Closures are often seasonal as they follow the annual cycle of marine organisms that utilize the beaches at certain times of the year. Special Closures currently constitute 0.06% of state waters of all Coastal State Waters.

Spine (*fish*): unsegmented elements of a fin or the sharp projections found on the head or gill cover.

Sponge: multicellular organisms from the phylum Porifera that have bodies full of pores and channels allowing water to circulate through them, consisting of jelly-like mesophyll sandwiched between two thin layers of cells.

Standard fish length: length of a fish measured from the tip of the snout to the posterior end of the last vertebra.

State Marine Conservation Area (SMCA): an area where special restrictions apply (see CDFW regulations on their website) to the commercial and recreational take of marine resources. SMCAs currently constitute 6.52% of all Coastal State Waters.

State Marine Recreational Management Area (SMRMA): an area where restrictions vary on the take of marine resources; for example, hunting waterfowl is permitted, but restrictions apply to the take of other marine life beneath the sea. SMRMAs currently constitute 0.08% of all Coastal State Waters.

State Marine Reserve (SMR): an area that does not allow commercial take but allows some recreational take. SMPs currently constitute 0.12% of all Coastal State Waters.

Stipe (*algae*): a stem like structure that bears the blades of seaweeds.

Subsample: a sample drawn from a larger sample.

Substrate: the earthy material that exists in the bottom of a marine habitat, such as sand, cobble, boulders, or reef.

Subtidal zone: a region below the intertidal zone that is continuously covered by water and is much more stable than the intertidal zone.

Surface Marker Buoy (SMB): dive float used by scuba divers, at the end of a line from the diver, intended to indicate the diver's position to people at the surface while the diver is underwater.

Swell: a series of mechanical or surface gravity waves generated by distant weather systems that propagate thousands of miles across oceans and seas.

Taxa: any unit used in the science of biological classification, or taxonomy.

Temporal variability: variability based on differences observed over time.

Total fish length: length of fish measured from mouth to tip of tail.

Transect: a line or strip across a surface along which a survey is conducted.

Traps: both abandoned (recorded as ‘lost’) and active (recorded as ‘active’) traps.

Trash: anything man made that was lost or tossed into the ocean and that doesn’t fall into one of the fishing gear categories, such as plastics, bottles, cans, metal, ropes, etc.

Uniform Point Contact (UPC): points at uniformly spaced intervals that provide estimates of benthic relief, substrate and cover.

Upwelling: process by which offshore winds push surface waters away from shore and allow for deeper, nutrient-rich waters to rise to the surface.

Urchin barren: rocky reefs that are denuded of kelp and other algae and overcrowded with urchins.

Variability: how spread out or closely clustered a set of data is.

Warm Blob (2015): a large mass of relatively warm water in the Pacific Ocean off the coast of North America that was first detected in late 2013 and continued to spread throughout 2014 and 2015. It is an example of a marine heatwave.

YOY: "Young-of-the-year", a term for newly hatched rockfish. Also called "recruits".

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