Reef Check California: Citizen Science MPA Monitoring

Decadal Management Review Partner Report

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Introduction

In this report, we will highlight some of the findings and achievements of Reef Check that have come out of the program's engagement in marine protected area (MPA) monitoring and go far beyond the data collection to inform MPA management.

Organizational Background

Founded in 1996, the Reef Check Foundation is a California based 501(c)(3) non-profit organization dedicated to the conservation of the world's reef ecosystems. Reef Check's mission is to empower local communities to protect and rehabilitate reefs worldwide. The Reef Check Foundation works to protect and improve the health and sustainability of the world's reefs through the use of citizen science and community-based conservation – effective and innovative approaches to integrating scientific research, public education and ocean conservation [1-3]. The Reef Check California (RCCA) program is a community-based reef monitoring network focused on California kelp forest ecosystems. RCCA's goal is to improve marine management in California in multiple ways: by collecting needed data on California's near-shore rocky reef ecosystems through the use of volunteer scuba divers and then making it available to resource managers, universities, researchers and the general public; and by educating and empowering the public to become active stewards of their marine environment. RCCA does this by engaging Californians to participate in scientific monitoring of kelp forests and MPAs. Reef Check California started in 2006, and is focused on two of the four MPA Management Program pillars: Monitoring and Research, and Education and Outreach.

MPA Monitoring

The RCCA program was developed at the same time that the Marine Life Protection Act Initiative (MLPA Initiative) began designing the MPA network and implementing the first MPAs in the MLPA Central Coast Region. From the beginning, it was intended to meet the need for a long-term monitoring program and public participation in the implementation and management of California's MPA network [4]. Reef Check thus designed its underwater monitoring program to maximize the usefulness of citizen scientist collected data for MPA management. Key steps during program design strove to ensure the usefulness and longevity of data. For example, the monitoring program was modeled off of an existing kelp forest monitoring protocol used for MPA monitoring; the intended user of the data, the California Department of Fish and Wildlife, was engaged early on in program development; and strict data management and quality control procedures were put into place from the beginning (for more details on this approach see [5]). Since its beginning, RCCA has contributed to the baseline monitoring in all of the MLPA regions and contributed data to the statewide long-term monitoring program since its inception [6-9].

Outreach and Education

The RCCA citizen science program was also developed as a program to educate stakeholders – in particular scuba divers – about MPAs and California's nearshore marine ecosystems. Beyond data collection, RCCA's citizen science approach, in which research methods are designed by scientists and data is collected by volunteers, involves the public in authentic research used to inform marine management [10]. This collaborative effort ensures high data quality and scientific oversight while also generating considerable public participation in MPA monitoring. RCCA creates a link between local stakeholders and the management community. This collaboration allows the statewide 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. Now the term has become widespread and there are many alternative terms 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.

Since its inception, RCCA's outreach and education components have grown beyond its initial constituency of well-trained SCUBA divers and its monitoring data have been used for management and conservation approaches beyond MPAs. We will highlight some of these achievements below.

Highlights and Key Findings

Monitoring

Citizen science training

Reef Check's citizen science training program has gone through many iterations over 15 years of its existence. It has always been targeted at experienced scuba divers and prerequisites for participation have become stricter over the years as a focus on skill and safety has increased with expanded monitoring along remote sections of the California coast. Nevertheless, the basic structure and content have remained the same. Participants are taught about the ecology and management of California's nearshore ecosystem and are trained in the skills required to collect scientific data on kelp forest species inside and outside of MPAs. The training is structured around 16 hours of classroom and at home study, and six to eight scuba dives to learn and practice the survey skills. Recently due to COVID, the classroom section of the training has been redeveloped and move to an online format. Detailed information on the training can be found in RCCA's training manual (Reef Check California Instruction Manual: A Guide to Monitoring California's Kelp Forests).

The number of volunteers participating in RCCA monitoring surreys has stayed relatively consistent over the years with between 150 to 200 volunteers participating annually (Figure 1). The only exception was 2020 when volunteer numbers were substantially lower due to the COVID pandemic. In contrast, the number of days that volunteers contribute over a year has increased substantially over time, and in recent years volunteers have donated around 1000 volunteer days per year (Figure 1). While many of the volunteers contribute a few days throughout the year, some have contributed over 100 days during their time with Reef Check and a few have been volunteering since the beginning. In total, over 1,200 volunteers have contributed over 10,000 volunteer days to monitoring MPAs and California's kelp forest ecosystems.

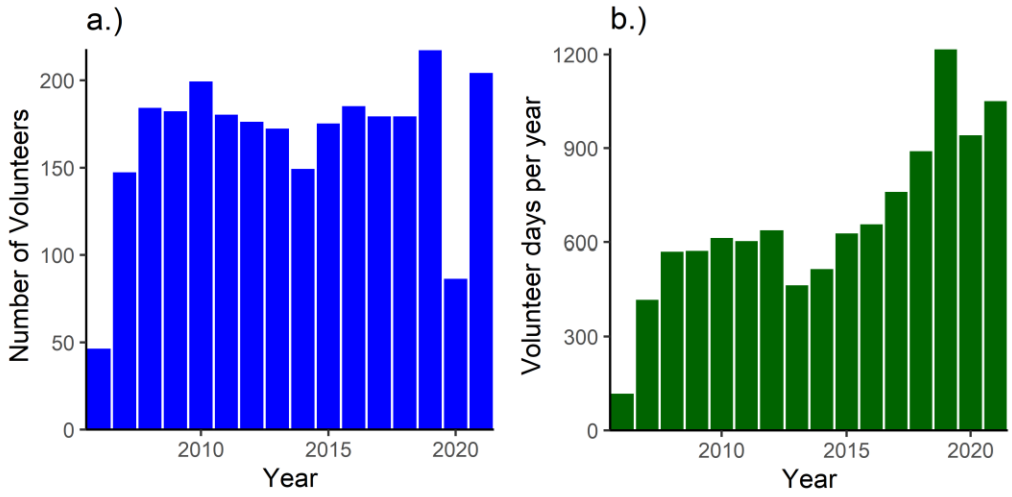

Figure 1.a.) Number of volunteers participating in Reef Check California surveys annually. b) Number of volunteer days donated by volunteers annually.

Figure 2. Map of Reef Check monitoring sites in California.

Surveys

Reef Check's monitoring network has grown as MPAs were established in each MLPA region, consecutively. Apart from the central coast region where RCCA's participation was more informal, the program was part of the state-funded baseline monitoring program in each MLPA region. After the baseline programs, RCCA continued to survey its monitoring sites and has been part of the long-term MPA monitoring program since its beginning. Overall, RCCA has conducted 1,342 surveys from 2006 to 2021 at over 100 sites from San Diego to the Oregon border (Figure 2). In recent years, RCCA has conducted about 115 surveys per year (Figure 3). Survey data from these sites have been used in many contexts beyond the MLPA process.

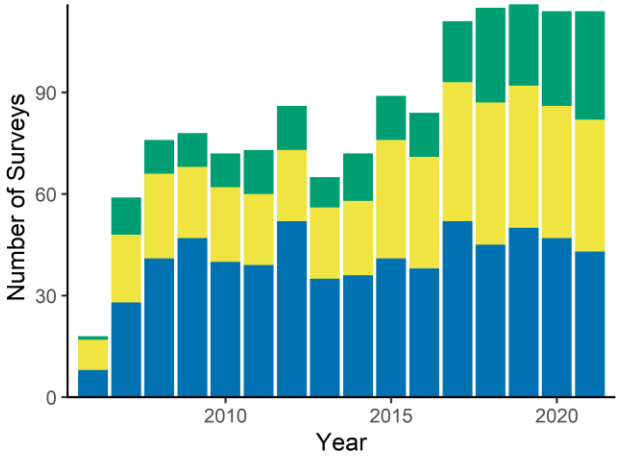

Figure 3. Number of surveys conducted by Reef Check in each region. The Northern region (green) ranges from the Golden Gate to the Oregon border. The Central region (yellow) from the Golden Gate to Point Conception and Southern region (blue) from Point Conception to the Mexican border.

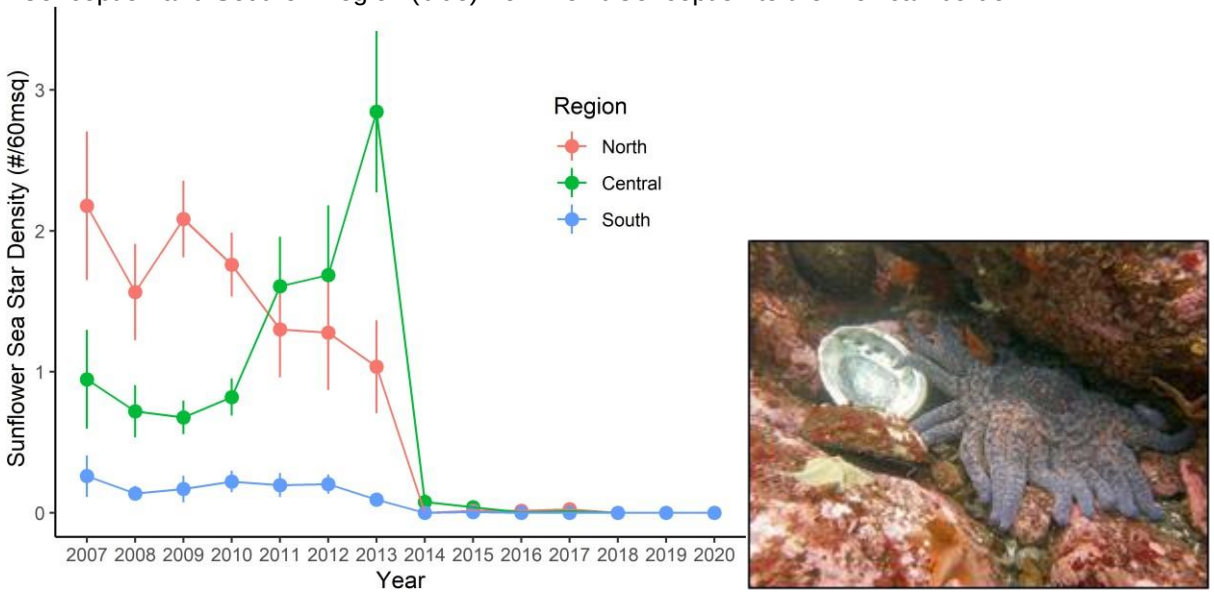

Figure 4. Sunflower sea stars declined suddenly between the 2013 and 2014 surveys due to the sea star wasting disease. Photo of sunflower sea star: Jan Freiwald.

Monitoring beyond MPA evaluation

During the 2013 and 2014 survey seasons, Reef Check, along with the other MLPA monitoring programs, documented one of the most dramatic declines of a marine species in California. As a result of the sea star wasting disease, many species of sea stars declined in those two years [11]. The sunflower sea star was hit particularly hard (Figure 4). Since 2013, the sunflower sea star has been practically extinct from California's kelp forests. Reef Check's data document the decline and lack of recovery in subsequent years and was used in the listing of the sunflower sea star as critically endangered on the IUCN Red List of Endangered Species [12, 13].

Subsequent changes to the kelp forest ecosystem along California's north coast have been documented by RCCA and others. These changes have resulted in several initiatives to save, recover or restore fisheries and ecosystems and Reef Check's data was used in the development of a kelp recovery plan by the Greater Farallones National Marine Sanctuary [14]. Following the decline of kelp and red abalone population north of the Golden Gate and the closure of the recreational red abalone fishery, RCCA collaborated with The Nature Conservancy (TNC) to expand on its MPA surveys to collect high resolution red abalone size frequency data to inform novel management approaches for the red abalone fisheries management plan that is under development. The data became part of the Management Strategy Integration Process for the Fisheries Management Plan of the recreational red abalone fishery that was directed by the California Fish and Game Commission. Several RCCA volunteers participated in this process as part of the Project Team that was engaged in developing new management approaches.

A benefit of the statewide monitoring program involving many volunteers is that it creates a knowledgeable body of divers that will detect changes in the ecosystem by being observant during dives even when not surveying. In 2016, RCCA documented a crowned sea urchin (*Centrostephanus coronates*), in the kelp forest at the breakwater in Monterey. At that time, this subtropical species had a reported distribution range from the Galapagos Islands in the south to the California Channel Islands in the north and this specimen was detected over 300 km farther north [15]. This range extension has since been confirmed and Reef Check divers have documented the occurrence of crowned urchins in the Monterey/Carmel Bay region many times since this first observation.

More recently in 2020, a Reef Check volunteer, Melanie Moreno, found the first reported occurrence of the invasive *Sargassum horneri* in the Monterey Bay (Figure 5). *S. horneri*, also known as Devil Weed, is an invasive species of seaweed native to the coasts of Japan and Korea and was first found in California in 2003 and has since spread aggressively in southern California [16]. Luckily, the specimens in Monterey could be removed, and no further individuals have been observed in the Monterey Bay since. When asked about her observation, Melanie said:

> "If I hadn't been trained and required to recertify for Reef Check every year I would not have been as focused on looking for invasive seaweeds. Not everyone who is trained goes on to complete Reef Check surveys, but the education provided puts hundreds of eyes out in the water to watch what's going on in our marine environment."

Figure 5. Invasive *Sargassum horneri* found at the breakwater in Monterey. This individual was detected by Reef Check volunteer Melanie Moreno and eventually removed. Photo: Melanie Moreno.

Figure 6. Largemouth Blenny (*Labrisomus xanti*) observed in southern California. This species is becoming more common as southern species move north with warming ocean temperatures. Photo: Selena McMillan

Another species that has become increasingly common in southern California is the Largemouth Blenny (*Labrisomus xanti*) (Figure 6). This species' historical range expanded northward into central Baja California, Mexico and it was first reported in California in 2015 near La Jolla [17]. Now it is fairly common at Santa Catalina Island and is 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.

Education

Dive into Science

Volunteering for Reef Check requires a large commitment of time and resources to participate in the trainings, supply the necessary scuba gear, travel to and from survey sites, as well as the time it takes to conduct the surveys. These high entry requirements have led to a self-selection of volunteers with a socioeconomic background that enables them to afford scuba diving, as well as an educational background (i.e. advanced science or engineering degrees) that pre-disposes them to exploring the marine environment. In a 2013 survey among volunteers, 45% had a four-year college degree and 49% a graduate degree. Reef Check has developed the "Dive into Science" program to broaden participation in marine citizen science and science in general. The program aims to provide youth from underserved and under-resourced communities with a pathway to an education in natural sciences or marine biology. This program provides scuba training and subsequent dive experience to introduce students to the marine environment and highlight the possibilities that can come with acquiring a skill such as diving. Continuing students will be mentored with the goal of introducing them to pathways to careers in diving and marine sciences (Figure 7). Two pilots of the program have been successful and interest in participation– especially by Tribal communities– is high. Unfortunately, the implementation of this program has been delayed due to the COVID pandemic in 2020 and 2021.

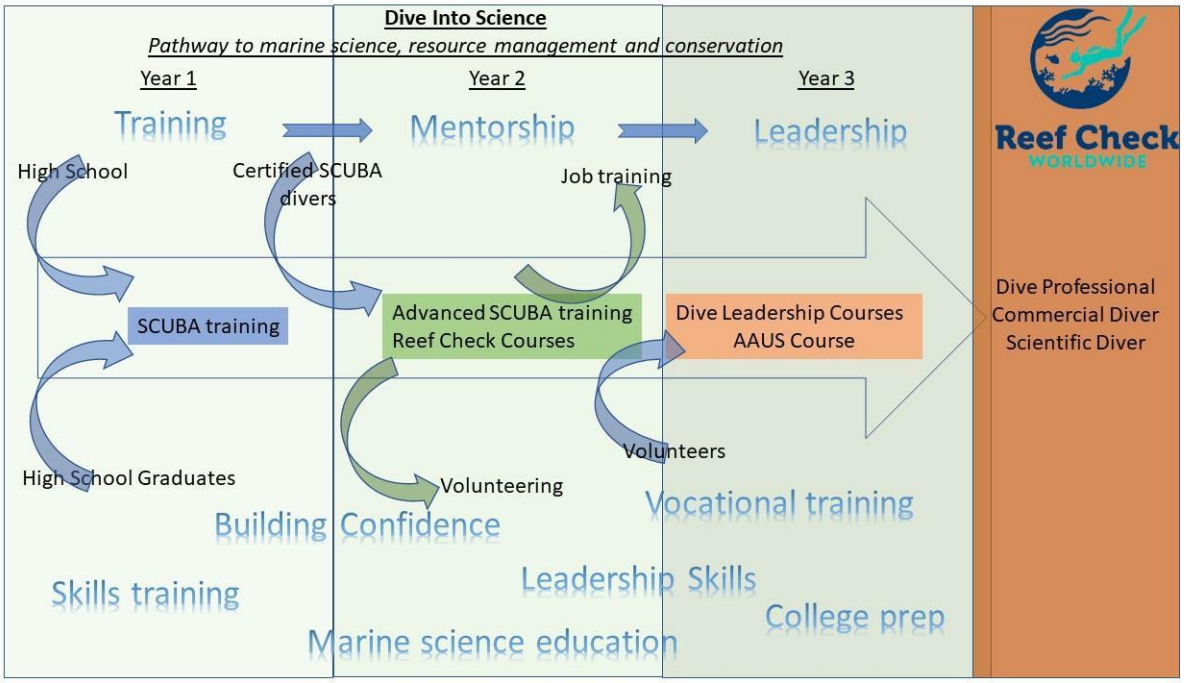

Figure 7. Conceptual framework of Dive into Science program.

Restoration

In response to the recent ecosystem changes following the decline of the sea stars and the explosion of purple sea urchin populations in central and northern California, Reef Check has begun working on several kelp restoration projects (Figure 8). These projects are the direct result of RCCA's MPA monitoring and volunteer training and have developed in several ways. In Monterey County, volunteer led projects have developed in which recreational divers are working on restoring kelp by removing overly abundant sea urchins. Reef Check works in collaboration

with the Monterey Bay National Marine Sanctuary and the California Department of Fish and Wildlife in monitoring these efforts.

Figure 8. Example of a transition from kelp forest to urchin barren in northern California. Photos: Reef Check

In northern California, the restoration efforts target two sites in Mendocino County, Noyo Harbor and Albion Cove, each approximately 10 acres in size. Reef Check is working with commercial urchin divers to remove urchins at these sites in order for kelp to have a chance to grow back naturally (Figure 9). To understand impacts of the restoration activities on the ecosystem and evaluate what effort is needed to restore kelp, RCCA surveys the restoration sites, as well as unmanipulated reference sites. These are the first kelp restoration projects in northern California and their outcomes will inform future kelp restoration plans along California's coast.

Figure 9. Commercial urchin divers working on kelp restoration in Mendocino County. Photos Tristin McHugh

Challenges

Challenges during the MPA monitoring were related to the long-term nature of the monitoring program and the significant hurdle for volunteer involvement in an activity such as scuba diving that requires high levels of training and substantial financial investments for participation. By its

nature, long-term monitoring needs long-term funding to have an impact. The short funding cycles for MPA monitoring have been a challenge for Reef Check because of the planning uncertainty this creates and the challenges it causes for hiring and retaining skilled staff. If staff cannot be hired full-time and year-round, the turnover becomes so high that it is detrimental to the program's integrity and the relationships that are built with the volunteers.

Another challenge is the trade-off between the need for highly trained participants in order to collect scientific data and the educational or science engagement goals of a program. Education and science engagement should be aimed at participants of all skill levels, whereas accurate data collection for management use must be done by volunteers with verified skills. This trade-off is important to consider when citizen science programs participate in ecosystem monitoring because the need for high-quality data might compromise other important program goals [18]. Reef Check has begun addressing this by building a long-term training/education program that engages students from underserved communities through the Dive into Science program with the goal of providing opportunities to acquire the skills necessary to collect scientific data.

The COVID pandemic created a challenge in 2020. Initially we feared that the travel restrictions and social distancing would make our work in 2020 impossible. However, we soon realized that our decentralized structure and engagement with local communities was well suited for operating under these restrictions. While we did not conduct any training of new volunteers in 2020, we were still able to survey most of our sites. Instead of bringing large groups of volunteers together, we started working with a small but dedicated group in each county so that people did not have to travel far and interacted with the same small group of people doing surveys. These volunteers stepped up their efforts and we completed as many surveys as in a normal year. It was amazing to see how dedicated these volunteers were in their pursuit to get the work done despite the challenges and even increase their level of investment of their time and energy over previous years. It demonstrated the phenomenal resilience of the citizen science approach to collecting monitoring data even under some of the most challenging circumstances.

Knowledge Gaps and Recommendations

Using a citizen science approach to collect monitoring data is a multifaceted endeavor when considering the complexities of subtidal data collection, the length of the California coast, and the remoteness of many MPAs. The above mentioned trade-off between the different goals of citizen science need to be considered when applying citizen science to MPA monitoring. In future MPA monitoring programs these goals should be clearly identified and all aspects, data collection and education need to be funded. The inaccurate perception that citizen science is "free or cheap science" has subsided in recent years, but nevertheless future funding needs to consider all the benefits of citizen science in order for programs to be successful in data collection and engagement. The true cost of citizen science monitoring can only be evaluated if all program benefits are considered.

Data collection for management purposes does not end when the numbers are recorded on underwater paper. The process from initial collection to analysis and reporting is just as critical to make these data useful for MPA managers. As for any long-term monitoring program, substantial resources must be allocated to this aspect. Integration of data and results from multiple monitoring programs has been a way of addressing analyses and reporting of Reef Check data in the past. Future reporting of monitoring results for management purposes would benefit from more explicitly addressing the intended use of citizen science collected data at the onset of the

monitoring program. Clear frameworks of how the data will be used to inform management would clarify the role citizen science will play in monitoring and informing management in the future. Citizen science programs and funding sources need to make the resources available to generate actionable results from citizen science data collection in order to realize the full impact of the data collected by volunteers.

Reef Check has involved a wide range of stakeholders in the MPA monitoring programs over the years, but future monitoring should aim to increase the diversity of participants in MPA monitoring. Diverse teams of people have been shown to develop more innovative ideas than homogenous teams [19, 20]. Therefore, diversity in science and management should be a focus of future programs as it not only increases opportunities for individuals from all communities, but it will also contribute to finding the creative solutions we will need in light of a rapidly changing marine environment. Citizen science is uniquely positioned to increase and foster this diversity in MPA monitoring and science in general.

Conclusion

Reef Check has built a successful citizen science program that has grown alongside the implementation of the MPAs. It has been able to provide data for the MPA management process and at the same time educate stakeholders about the MLPA process, MPAs, and the kelp forest ecosystem along California's coast. Beyond the initial objectives of MPA monitoring and citizen science, the program has expanded into areas of fisheries management by working with recreational fishers on data collection, started work on habitat restoration in northern California where we witnessed the decline of the kelp ecosystem, and expanded its educational efforts beyond its original constituency of advanced scuba divers. The program has also grown geographically by expanding monitoring into the states of Oregon and Washington. Initially developed to provide data for MPA management, Reef Check now works on many aspects of marine management and conservation and is well suited to contribute to future management and conservation of California's marine habitats.

Literature Cited

1. Thiel, M., et al., *Citizen Scientists and Marine Research: Volunteer Participants, Their Contributions, and Projection for the Future.* Oceanography and Marine Biology: An Annual Review, 2014. **52**: p. 257-314.
2. Theobald, E.J., et al., *Global change and local solutions: Tapping the unrealized potential of citizen science for biodiversity research.* Biological Conservation, 2015. **181**: p. 236-244.
3. Freitag, A. and M.J. Pfeffer, *Process, not product: investigating recommendations for improving citizen science "success".* PLoS ONE, 2013. **8**(5): p. e64079.
4. Sayce, K., et al., *Beyond traditional stakeholder engagement: Public participation roles in California's statewide marine protected area planning process.* Ocean & Coastal Management, 2013. **74**: p. 57-66.
5. Freiwald, J. and A. Beahrs, *Reef Check California: SCUBA-diving citizen scientist monitor rock reef ecosystems*, in *Handbook of citizen science in ecology and conservation*, C.A. Lepczyk, O.D. Boyle, and T.L.V. Vargo, Editors. 2020, University of Califorina Press: Oakland, Califorina. p. 313.
6. Freiwald, J. and A. Neumann, *Reef Check California: Citizen Scientist monitoring of rocky reefs and kelp forests: Creating a baseline for California's North Coast MPAs*. 2017, Reef Check Foundation: Marina del Rey.
7. Freiwald, J. and C. Wisniewski, *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*. 2015, Reef Check Foundation: Pacific Palisades. p. 244.
8. Freiwald, J. and M. Wehrenberg, *Reef Check California: North Central Coast Baseline Surveys of Shallow Rocky Reef Ecosystems*. 2013, Reef Check Foundation: Pacific Palisades. p. 64.
9. Ocean Science Trust and California Department of Fish and Wildlife, *State of the California Central Coast: Results from Baseline Monitoring of Marine Protected Areas 2007-2012.* , in*.* . 2013, California Ocean Science Trust and California Department of Fish and Wildlife: California, USA.
10. Shirk, J.L., et al., *Public Participation in Scientific Research: a Framework for Deliberate Design.* Ecology and Society, 2012. **17**(2).
11. Hewson, I., et al., *Densovirus associated with sea-star wasting disease and mass mortality.* Proc Natl Acad Sci U S A, 2014.
12. Hamilton, S.L., et al., *Disease-driven mass mortality event leads to widespread extirpation and variable recovery potential of a marine predator across the eastern Pacific.* Proceedings of the Royal Society B: Biological Sciences, 2021. **288**(1957): p. 20211195.
13. Gravem, S.A., et al., *Pycnopodia helianthoides. IUCN Red List of Threatened Species 2021.* 2021.
14. Hohman, R., et al., *Sonoma-Mendocino Bull Kelp Recovery Plan. Plan for the Greater Farallones National Marine Sanctuary and the California Department of Fish and Wildlife*. 2019: San Francisco, CA. p. 166.
15. Freiwald, J., C. Wisniewski, and D. Abbott, *Northward range extension of the crowned sea urchin (Centrostephanus coronatus) to Monterey Bay, California.* California Fish and Game, 2016. **102**(2): p. 37-40.
16. Marks, L., et al., *Range expansion of a non-native, invasive macroalga Sargassum horneri (Turner) C. Agardh, 1820 in the eastern Pacific.* BioInvasions Records, 2015. **4**(4): p. 243-248.
17. Love, M.S., et al., *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.* Bull. Southern California Acad. Sci, 2016. **115**(3): p. 191-197.
18. Freiwald, J., et al., *Citizen science monitoring of marine protected areas: Case studies and recommendations for integration into monitoring programs.* Marine Ecology, 2018. **39**(S1): p. e12470.
19. Hermoso, M.I., et al., *Exploring diversity and engagement of divers in citizen science: Insights for marine management and conservation.* Marine Policy, 2021. **124**.
20. Powell, K., *The power of diversity.* Nature, 2018. **558**.