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COLLABORATING WITH INDIGENOUS CITIZEN SCIENTISTS TOWARDS SUSTAINABLE CORAL REEF MANAGEMENT IN A CHANGING WORLD

The One People One Reef program

Nicole L. Crane, John B. Rulmal Jr., Peter A. Nelson, Michelle J. Paddack, and Giacomo Bernardi

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Introduction

Citizen scientists have gathered data and informed lines of inquiry for the scientific community for at least the last century (Cohn, 2008; Silvertown, 2009; Miller-Rushing et al., 2012), but acceptance and increasing application of this approach by professional scientists have accelerated dramatically in the last 10 years (Couvet et al., 2008; Follett and Strezov, 2015). Museums such as the Field Museum in Chicago,[1] the California Academy of Sciences,[2] and the Smithsonian Institution[3] have involved citizens in their scientific endeavors, including the use of photographs, notes, and even specimens. More recently, organizations such as the Oceanic Society,[4] Earthwatch,[5] Reef Check,[6] and others have successfully involved citizen scientists directly in data collection to support scientific endeavors.

Long before the term *citizen science* became well-known, there was a long history of professional, "Western," or conventional scientists[7] working with indigenous peoples, utilizing local knowledge to support ~~conventional~~ science, for example by ethnobotanists to understand healing practices and uses for local plants (Heckler, 2009; Ugulu, 2011). This is also true in the marine sciences and fisheries management (Johannes, 1981; Berkes et al., 2000; Drew, 2005; Thurstan et al., 2015). The concept of traditional ecological knowledge (TEK) has become more widely recognized and accepted by the scientific community, including the marine and coastal scientific communities, particularly in instances where indigenous people are seeking to reconnect with their traditional management (Pitcher, 2001; Williams et al., 2008; Kittinger et al., 2012, 2015; Friedlander et al., 2014; Crane et al., 2017). But an often less recognized relationship is that between indigenous people and professional scientists as true collaborators.

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In our experience, the recovery and re-application of TEK for management and conservation, combined with citizen science, can be a powerful approach. It has particular relevance to communities that are often marginalized economically, socially, and governmentally. Combining citizen science with TEK offers an effective and meaningful way for conventional science to engage with these communities and assist with implementing lasting and effective conservation and management programs. These efforts, however, require a two-way exchange of knowledge to develop research agendas and management plans for the best chance for success. Despite increasing recognition of TEK as a valuable resource for conventional science, and its relevance to conservation and management, indigenous people are often asked for information but are not included in either the research agenda or management planning. Not surprisingly, this incomplete form of collaboration can lead to skepticism and even resentment by local communities (Berkes et al., 2000; Christie, 2004; see also Chapter 13).

While many global conservation and management strategies are producing good results (e.g. Marine Protected Areas; Abelson et al., 2016; Chapter 7), ~~and~~ some ~~Marine Protected Areas~~ are leading to social challenges and cultural clashes (Christie, 2004), locally driven approaches, especially in autonomously governed regions, may be the most effective strategy (McClanahan et al., 2006; Wamukota et al., 2012; Crane et al., 2017). Involving local people directly in the entire spectrum of the scientific-management process, from data collection to planning and implementation, not only empowers individuals and communities, but it also enhances local capacity and reduces the need for external resources (Drew, 2005; Hilborn, 2007; Braschler, 2009; Kittinger et al., 2012, 2015; Wamukota et al., 2012). Indigenous people can benefit in significant ways from conventional science, especially during this time of rapid environmental change where their familiar ecological context may be shifting. Conventional science, similarly, is greatly enhanced by data collected by local science teams (citizen scientists) who hold valuable TEK and can help inform the science process, especially in regions that are hard to access on a regular basis. (Braschler, 2009; Bourgoin, et al., 2013; Friedlander et al., 2014; Crane et al., 2017). Finally, if a shared goal of the professional science team and the local communities is conservation and management, then local communities need to be leading the efforts, and view them as endemic to their needs rather than an outside idea, for the best chances of long-term success (Christie, 2004; Berkes et al., 2006; see also Chapter 13).

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Collaborative approaches to conservation planning and program implementation are now the standard among many agencies and organizations facilitating ecosystem and resource protection and management (Hilborn, 2007; Couvet et al., 2008; Wendt and Starr, 2009; Wilson et al., 2010; Goring et al., 2014). Collaboration can take many forms, however, and there has not yet been a standard applied to the process of involving stakeholders (Berkes et al., 2000; Couvet et al., 2008; Dickinson et al., 2012). In addition, many conservation efforts are focused on the "protection" and "conservation" of sensitive ecosystems such as coral reefs. These are words that have important connotations, and often have the effect of leaving out

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FIGURE 10.1 Clockwise from upper left: researcher Nicole Crane collecting benthic data, a local catch, a young woman from the island of Ifaluk.

the key stakeholders themselves – namely the people who rely on the areas being conserved for their livelihoods, and their need to extract resources.

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Indigenous people, despite their pivotal roles in linking knowledge with contemporary needs and economies, have not always been acknowledged for their input. Professionally trained scientists and conservationists, rather than working with local people as key collaborators and data collectors, often attempt to enlist the support of local people to implement plans the scientists have already developed – not always a successful or sustainable approach (Berkes et al., 2000; Christie, 2004; Cinner et al., 2009; Wamukota et al., 2012; Chapter 13; see also Chapter 3 for an example of a successful citizen science project that includes indigenous communities). With the rapid onset of climate change and the associated perturbations to ecological systems, it is a critical time to develop authentic collaborations and incorporate historical data to understand and manage marine systems in a culturally and ecologically sustainable way (Kittinger et al., 2012; 2015; Thurstan et al., 2015).

Here, we present the One People One Reef program, which operates in the Federated States of Micronesia and is aimed at strengthening community capacity to manage their marine resources using adaptive frameworks and input from both conventional and local (citizen) science teams (Figure 10.1).

Case study: One People One Reef

Authors Crane (Cabrillo College) and Nelson (H.T. Harvey & Associates) ~~are professional scientists, and~~ partner with colleagues Giacomo Bernardi (University of California, Santa Cruz), Michelle Paddack (Santa Barbara City College), and author Rulmal (Ulithi Falalop Community Action Program) and ~~his~~ local science teams.

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Together they comprise One People One Reef – a collaborative approach to reef management.

The One People One Reef program was initiated by the people of Falalop Island, Ulithi Atoll, Federated States of Micronesia, and a team of scientists from Santa Cruz, California, USA, and has now expanded to the communities of all four inhabited islands of the atoll: Falalop, Asor, Mogmog, and Federai (Figure 10.2). The communities recognized that their subsistence fisheries were declining and some of their reefs were degraded, causing concern. In 2009, our professional science team was contacted to help address these declines. Scientists met with local chiefs, leaders, and fishers to assess the scope of the problems. The professional science team asked the Falalop community to identify the major problems, describe historical trends in reef degradation and changes in resource management, fishing methods, and other potentially contributory factors. Collectively, the professional science team and the local community representatives began to understand the nature of the problem, and recognized the need for a local science team to help collect data. The Falalop community was to lead the development of a management plan, based on the science produced by the local and professional science teams, and rooted in traditional management frameworks – *a true collaboration*. The professional science team did not present the plans, rather they worked with the local teams to support locally derived plans. Thus, the One People One Reef program was born.

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Regional geography and the geo-political context

The Federated States of Micronesia (FSM) is an island nation of four states (Yap, Chuuk, Pohnpei, Kosrae) in the Western Pacific with autonomous governance by individual island communities, and is a part of the US Compact of Free Association. This agreement provides for US economic assistance, defense of the FSM, and other benefits in exchange for operating rights in the FSM (and other agreements). The geopolitical context is important as it recognizes autonomous governance – built into the constitution. The autonomous nature of governance and traditional land and ocean tenure rights make this a region particularly well-suited for locally driven management and conservation. Decisions can be made quickly, and communities can adopt unique approaches and take a leadership role, with professional scientists taking a supportive role.

Yap State consists of 138 islands and atolls, 22 of which are populated, extending approximately 800 km (500 miles) eastward into the tropical western Pacific Ocean (Figure 10.2). Although the Yap outer islands encompass over 259,000 km^2 of ocean, the state consists of only 117 km^2 of land, much of which barely rises above sea level (the main island of Yap is a "high" island). The 2010 census estimated a population of 11,376 people in Yap State.

Although Yap State is a collection of islands, "outer islanders" (people from islands other than the largest main islands of Yap proper) often have a strong sense of cultural identity, and in many cases, they differ significantly from communities on the main islands, including their language and leadership structure. Ulithi is the

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largest atoll in the Yap outer islands, and by some records the fourth largest atoll in the world (Figure 10.2). Communities on Ulithi often ~~serve as leaders~~ for the outer islands. If collaborative management can work here, it sets the stage for a management framework that can extend across a vast area of understudied and critical coral reef habitat in the Western Pacific.

Ulithi Atoll is approximately 161 km east of the main island of Yap. The lagoon measures 36 × 24 km and encompasses over 550 km^2 (212 square miles), making it one of the largest on Earth. Ulithi consists of 40 islets and four inhabited islands, collectively making up only 4.5 km^2 of land, most barely more than a meter above sea level (Figure 10.2). The total population of Ulithi is about 1,000, depending on the time of year (it has one of the two high schools in the outer islands, to which youth come during the school year from the neighboring islands). The four inhabited islands are Falalop (which has the high school and lies just outside the main atoll), with a population of between 500–700 people; Mog Mog, the governance and spiritual center of the outer islands, with a population of approximately 150; Asor, with a population of approximately 70; and Federai to the southeast, with a population of approximately 150.

Hofagie Laamle – *One People One Reef: a collaboration*

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In the following project description, we refer to the professional science teams (of which the co-authors Crane and Nelson are members), and to the local science

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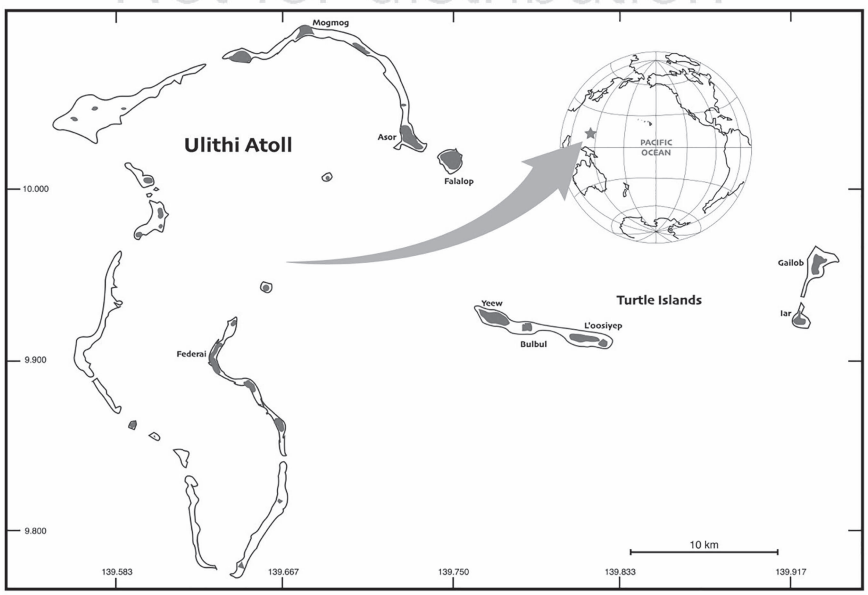

FIGURE 10.2 Case study location. Ulithi Atoll and associated islands are located in the Western Pacific Ocean.

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teams (of which co-author Rulmal is a member) to explain roles throughout the project. Though co-author Rulmal is also a member of the local community, we refer to the local community in the third person for clarity. Although referred to separately for the purposes of clarification, the teams work collaboratively.

Hofagie Laamle (translated loosely to "unite this Atoll/group of islands connected by reefs") is the name the people of Ulithi gave to this program to emphasize the importance of the reefs to their community as a whole. People of Ulithi depend on ~~the~~ reefs, and the reefs depend on the people for stewardship. The goal of the program is to build capacity within communities to manage their reefs through an understanding of the changing ecology of the system, including both their own and external impacts. With a better understanding of the system and drivers of decline, communities can plan for modifications to fishing methods and other management strategies, especially those derived from traditional practices. Local capacity to manage is enhanced by fostering collaborations between professional scientists and local citizen scientists that combine traditional knowledge with modern science.

The One People One Reef collaborative has three main goals:

1 Collect sound fishery and environmental data to better understand the ecosystems and to support management. The data are collected by professional science teams and local science teams ~~together~~.
2 Support the development of reef management plans that address ecological issues, meet community needs, and are sensitive to traditional frameworks. An important part of this goal is to collectively interpret and discuss the results and analyses of the data, and *how* they can support planning.
3 Enhance sustainable and adaptive management planning throughout the outer islands of Micronesia.

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The program approach relies on a two-way exchange of knowledge. The professional science team needs information from the community to inform their research approach, such as, what the main resource issues are, what approaches have been tried, which are failing, what the major barriers are, past and current fishing practices, and what the community sees as some of the key ecological changes on their reefs. This information helps to frame questions and develop science objectives. The community also benefits from specialized knowledge, skills, and technology from the professional science team to inform their management. For example, connectivity between reefs, fish biomass, and benthic characteristics can help inform management priorities. We facilitate knowledge transfer at community meetings, informal gatherings, cultural exchanges, and interviews and focus groups with as many different demographics as possible including leaders, men, women, elderly people, youth, and fishermen. We use a combination of informal storytelling and discussion, and more structured interview questions.

Data collection is a collaborative effort. The professional science teams collect data from the reefs including fish diversity and abundance, fish biomass, benthic composition, reef complexity, genetics, and other attributes, with a keen

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appreciation for information requested specifically by the local people. We were alerted, for example, to the presence of a "weedy" coral in Ulithi observed by local people, and so began monitoring its distribution and abundance at their request. This coral, a species of *Montipora* (Crane et al., 2016) has begun to grow abundantly, forming large areas of mono-specific coral coverage on ~~an~~ otherwise diverse reefs. Local science teams are now collecting data on the spread of *Montipora*. In addition to monitoring this *Montipora* sp., local science teams collect data on landed fish, including species, length, sex, reproductive status, location where caught, and gear used. They send these data to the professional science teams for analysis, and we share results with the community. This allows the community to assess the impact of certain gear, and the status of specific fisheries, among other things.

Our premise is that the management plans themselves and the implementation of those plans will come from the community, and our teams of professional and local scientists can facilitate this by providing information and advice as needed. We analyze the ecological and fisheries data, and inform fishers and leaders about key patterns we see that suggest overfishing, for example, or other human impacts such as eutrophication. Together we discuss these needs with the community leaders, and support the development of an effective management plan. We note that chiefs and community leaders often identify traditional methods as the best means to address management concerns, and incorporate these where possible.

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The scientists: you train us, we train you

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Our collaborative team of scientists ~~(hereafter referred to as the One People One Reef Science Team)~~ includes a core team of four to six professionally trained scientists and about eight locally trained scientists from Ulithi Atoll (Figure 10.3). Our US-based scientists, usually with undergraduate and graduate students, initially survey the reefs and provide access to technologies such as genetic tools and underwater video equipment, as well as statistical analyses to determine patterns in the data. These data, and the emerging results, are shared with the local science teams and local leaders.

On Ulithi, a local project coordinator helps assemble the local science teams, and meets regularly with them. They discuss issues specific to their island, and common issues among the islands. The professional science team trains the local science teams in several data collection techniques (see later), and data are transferred to one island where they are entered into a database. That database is transported to the main Yap island, and uploaded to a shared drive where our professional science team can analyze it and send results back to the community. We also discuss the findings directly with the community when we are on-site.

The local science teams consist of two to four individuals per community, selected by the communities. These individuals are introduced as the "local scientists," and take on the important role of bridging science with management at the local level. They are self-motivated, hard-working, and respected by their communities. They work closely with fishers (and are often fishers themselves) to collect

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FIGURE 10.3 Clockwise from top left: One People One Reef local scientists (with Nicole Crane), "professional" science team, scientist Giacomo Bernardi working with fishermen and local teams to sort a catch, local scientist collecting data.

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data on landed fish. Their challenging job includes recording the catches on formal data sheets, identifying and measuring fish, determining sex and reproductive condition, and recording details of the fishing effort (e.g. habitat, gear, conditions) – all before the fishers become anxious to get their catch distributed and cooked (there is limited refrigeration). The fishers are also sometimes reluctant to talk about fishing location and even gear in some cases (necessary data), and the local scientists need to find ways to build trust. The most important drivers of success for this part of the citizen science are mutual trust, buy-in, and leadership on the part of the fishermen (see Chapter 13 on the importance of communication and building trust). The local science teams are responsible for this, and without that communication and collaboration at the local level, these data would not be available. To date, the people, leaders, and fishers of Ulithi Atoll have developed the largest database of landed fish in the entire region – over 90,000 fish, as of January 2017.

This model of a two-way exchange of information has been transformative to the professional scientists and to the local communities. We have been able to see the critical role that cultural changes and social patterns have on resources, and how an understanding of that can inform the scientific questions we ask. On a local level, One People One Reef has facilitated a change in social dynamics, and a stronger, more informed connection to the ecological systems that have sustained these communities for centuries, and probably millennia.

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Data: telling a story

Because the local communities' main concerns were declines in the size and availability of fish, and because information from landed fish can elucidate the impacts of fishing and inform future management directions, we initiated a dialog with the community on the current status of their fisheries, fishing methods, how methods differed from the recent past, and details about fish processing, storage, and distribution. We specifically sought data needed to inform local management and to compare Ulithi fisheries to other regional and national databases.

We compiled data from interviews, semi-structured interviews, and focus group meetings, and analyzed them using a coded grounded theory approach for patterns (Corbin and Strauss, 1990), as well as analysis methods similar to those used by Huntington and Cinner (Cinner et al., 2009; Huntington, 1998; Huntington, 2000). We coded these interviews and focus group comments to identify the main issues and themes that the communities ~~identified~~ as most important with respect to ~~coral reef management,~~ and found that concerns about management, community issues, loss of tradition, and resource depletion were most frequently cited (Figure 10.4).

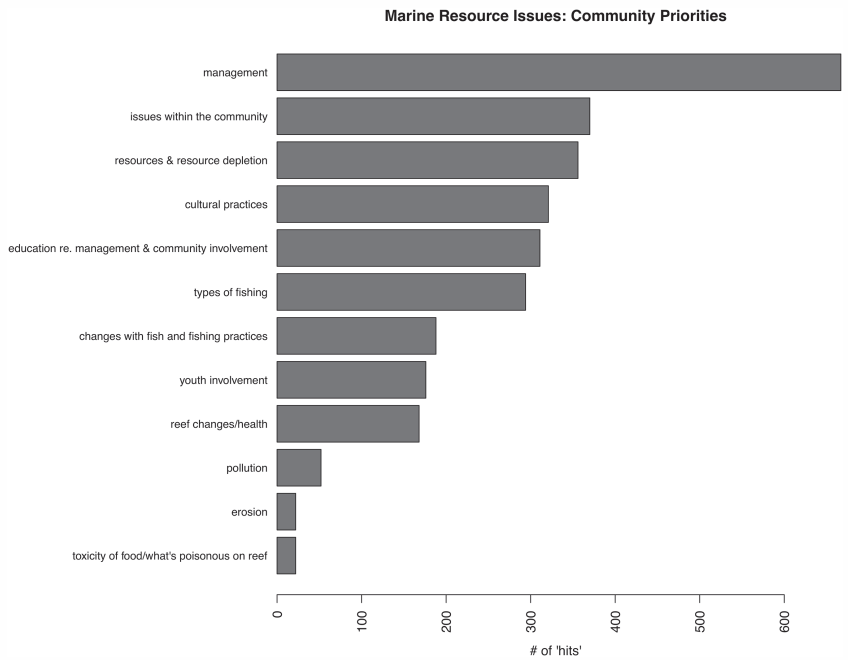

FIGURE 10.4 Priorities and concerns related to local coral reefs in Ulithi Atoll's four communities, determined by frequency of references in interviews and focus groups.

Note: Management theme included current types of fishing utilized, resource depletion, and management problems. *Community* theme included youth engagement, education about the reef and management, leadership problems, and health. *Cultural/traditions* theme included historical fishing, historical management, community taboos, and changes in traditions. *Ecosystem* theme included reef changes, toxicity in fish, erosion, pollution on reefs, new corals, and algal abundance.

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We used these priorities identified by the communities to develop ideas and questions to investigate further. For example, within "types of fishing," under the management theme, we could identify the primary types of current versus historical fishing methods. Fewer fishing methods are in common use currently (Table 10.1), likely resulting in fewer trophic guilds being caught, which we believe is having an impact on the reefs (see later and Crane et al., 2017). Local leaders and fishers have incorporated this information into management plans, some of which include restricting or banning night spearfishing (which targets parrotfish), and shallow cast nets that also target herbivorous fish, primarily surgeonfish (Figure 10.4).

We also worked with local families to implement a seafood consumption calendar in 2015. Local science teams went to households in the community and explained to each family how to complete the calendars with information on which meals included seafood for each day, the source of that seafood (e.g. reef fish caught by spear), and how many fish were shared. These data enabled us to tie fisheries data to consumption data, allowing us to better understand patterns in food and fishing preference, and how they could contribute to changes on the reefs. For example, the island of Mog Mog has some of the most degraded reefs, and they are among the reefs with the lowest biomass of fish (Crane et al., 2017). Families on Mog Mog tracked their seafood consumption for one month in July 2015

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TABLE 10.1 Fishing methods. Note that fish traps are being "revived" and some communities are starting to use them again today.

Fishing Method	*Historical Use (pre-WW2)*	*Current Use*
Fish traps on the sand	X	
Fish traps on drift logs	X	
Fish traps on reefs	X	* limited
Trolling with hand and line and lure	X	X
Flying fish – long line with coconut buoy	X	
Bottom fishing (hook and line)	X	X
Hook and line (reef)	X	X
Kite fishing	X	
Pole or hand line (from shore)	X	X
Pole spear (day)	X	
Torch fishing for the flying fish – open water	X	
Torch fishing – reef flat	X	
Speargun/Hawaiian sling		X
Gillnet		X
Throw net		X
Community net	X	X
Fish drive on the reef flat	X	X
Reef net	X	X
Hukilau	X	
Reef gleaning	X	X
Purse seiners (occasional commercial fishermen, not from FSM)		X

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(approximately 85% of the island inhabitants participated). Fifty-two percent of all their meals consisted of fresh seafood, with the remaining meals either consisting of no meat or canned fish. Of the fresh fish, 95% were from nearby reefs. This compares with Falalop, which is outside the Atoll, and had comparatively higher biomass of fish on their reefs (Crane et al., 2017). Falalop (with approximately 30% of inhabitants participating in the seafood consumption study) reported 53% of the meals with fresh seafood, and the remaining meals consisting of canned fish, canned meat, and no meat (Falalop has the only airport on the Atoll and residents have access to more imported meats). Seventy-six percent of their fresh fish came from reefs while 24% were caught in the open water, including the use of a local FAD (fish attracting device). The people in each community have used these data to manage their reefs differently: Mog Mog has limited or restricted some types of fishing so as not to target key fish on degraded reefs, while Falalop has closed some reefs to fishing (since they can rely on the pelagic fishes more) to recover local reefs through rotating closures.

The inconsistencies in fish naming poses one of our greatest challenges with the data on landed and consumed fish. In Ulithian, there are often several names for the same fish species, depending on color phase, sex, size, and ~~so forth.~~ This allows fishers to distinguish between phases in life history that help them better understand who should eat it (certain fish are set aside for individuals of specific status), what time of year it is best caught, and so forth. For professional scientists accustomed to using a single taxonomically based scientific name for a species and who do not speak the local language, this represents a challenge. In addition, each island can have a different naming system. So, one of the first things we did was match our scientific names with local names, using books, pictures, names, and a wide representation of fishers. This continues to be a challenge today. A local scientist, Mario Dohmai, is developing a translation document with local fish names, scientific names, and pictures to document them. This document will be critical for making the link between local knowledge and conventional science moving forward. We are also currently developing a DNA barcoding library to positively identify fish associated with local names and corresponding photographs.

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To ensure high data quality, the local project coordinator works with the local science teams to go over the data and any challenges they have encountered. The local scientist responsible for data entry goes through each record and flags any inconsistencies so s/he can check with the individual data collector or fisher. Finally, the professional science team ~~in the United States~~ checks the database, notes inconsistencies, and seeks clarification from the local teams and fishers. This process can be lengthy, and can delay analysis, but it is critical to making sure we have confidence in the data and the story they tell. When data are thoroughly analyzed, they are a powerful indicator of what is happening on the reef and can help the communities better understand the impact of certain fishing methods, which fish are being caught undersized or close to maturity, and which fish are spawning at what times of the year, among other patterns. One example of data being collected are the main types of fish (names in Ulithian) caught with different fishing methods (Figure 10.5). These data can be used to assess impact on trophic guilds.

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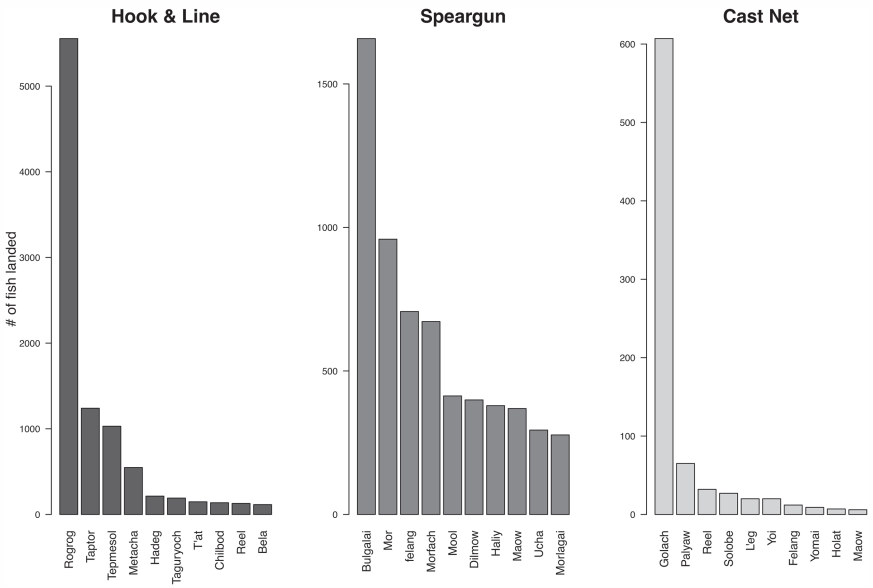

FIGURE 10.5 The most commonly reported fish (Ulithian names) from three gear types (6/27/14–19/13/15).

Note that Rogrog *and* Taptor *are emperors,* Bulgalai, Mor, Felang. Morfach *and* Golach *are acanthurids (surgeonfish). Speargun and castnet are therefore mostly targeting herbivorous fishes.*

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Landings data (from 2014–2015) showed that spearfishing accounted for almost 50% of the total recorded catch from Ulithi, and 61% of the catch was composed of a few species of herbivorous fish: surgeonfish including *Ctenochaetus striatus, Acanthurus lineatus, Naso lituratus, Acanthurus olivaceus*, parrotfish including *Chlorurus spilurus* and chub (*Kyphosus cinerascens*). The second most common method (just under 40% of landings) was hook and line, which targets primarily higher trophic level fish (predators) such as emperors, grouper and snapper (Figure 10.5). Cast nets again ~~target~~ herbivorous *Acanthurus triostegus*, especially on Mog Mog island.

These data show that large numbers of herbivorous fish were caught, especially by speargun. Fishermen were particularly targeting large male parrotfish (often at night). This was likely having an impact on the reproductive capacity of the population (since parrotfish are sequential hermaphrodites – and the larger, more colorful ones are mostly male). In addition, the depletion of herbivorous fish, which have a role in keeping algae from dominating coral reefs could have an impact on coral recruitment and survivorship of corals (Dulvy et al., 2004; Graham et al., 2006; Heenan and Williams, 2013; Crane et al., 2017). By sharing these ecological stories and interpreting data *with* community leaders, those managers and leaders have reported that they better understand the impacts of their fishing, and the connection between fishing and stressed reefs (such as the impacts of the removal of too many herbivorous fishes). They have utilized these data in their management, which

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includes gear restrictions to minimize impacts on herbivorous fishes, utilizing more hook and line to take pressure off the herbivorous guild, and rotating closures in some areas. Our professional science team was also able to better understand potential drivers of reef change using these data (Crane et al., 2017).

Management successes

The One People One Reef project has resulted in substantial local change to the management of fisheries and reef resources. Management includes areas closed to fishing, bans on the take of some fish, phasing out the use of gillnets and some cast nets, and bans on night spearfishing for parrotfish. Falalop, Asor, Mogmog, and Federai communities have each closed portions of the reef under their respective jurisdictions. While this is not a new practice, it is being revisited and re-implemented across the ~~atoll~~. More than half of the island of Falalop (Figure 10.6, marked in upper part of photo) has been temporarily closed to fishing. The ban on gillnets was initiated in 2013 and is in effect across much of the atoll. Some of the night spearfishing targeting parrotfish – especially large terminal males, asleep in the reef – was disallowed first in Falalop, then Asor, followed by Mogmog and finally, in 2015, Federai. Mog Mog restricts cast nets and limits spearfishing. All four islands of Ulithi Atoll have now developed or strengthened management plans. The management plans are adaptive, and change in response to a variety of factors, including natural disaster, celebrations, and decisions by community leaders.

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Fishing restrictions come at a cost, such as not being able to access needed protein, yet the communities report a general acceptance and recognition that the changes will recover fish populations and ensure long-term food security. Unsolicited reports from the community of Falalop claim rapid, positive effects from their management, including (per interviews) species they have not seen in many years, increased abundance, and spillover effects into the fished areas. We interpret these reports and the communities' acceptance as evidence of substantial conservation success. Nonetheless, it will only be through the data, and especially the landings data collected by local scientists, that we – the professional science team and the communities – will be able to determine if these management measures have had the desired effect. We attribute this success in part to the autonomous nature of governance and the ability of communities to make rapid decisions, and in part to the collaborative science approach that relies on training local scientists and the partnership between these communities and professional scientists. We are currently analyzing data to determine the effects of management on biomass of fishes on reefs.

Being a part of One People One Reef: from the local perspective

Like anywhere in the world, trust and credibility are key to a successful partnership (see Chapter 13), and the outer islands of Yap are no exception. Bringing

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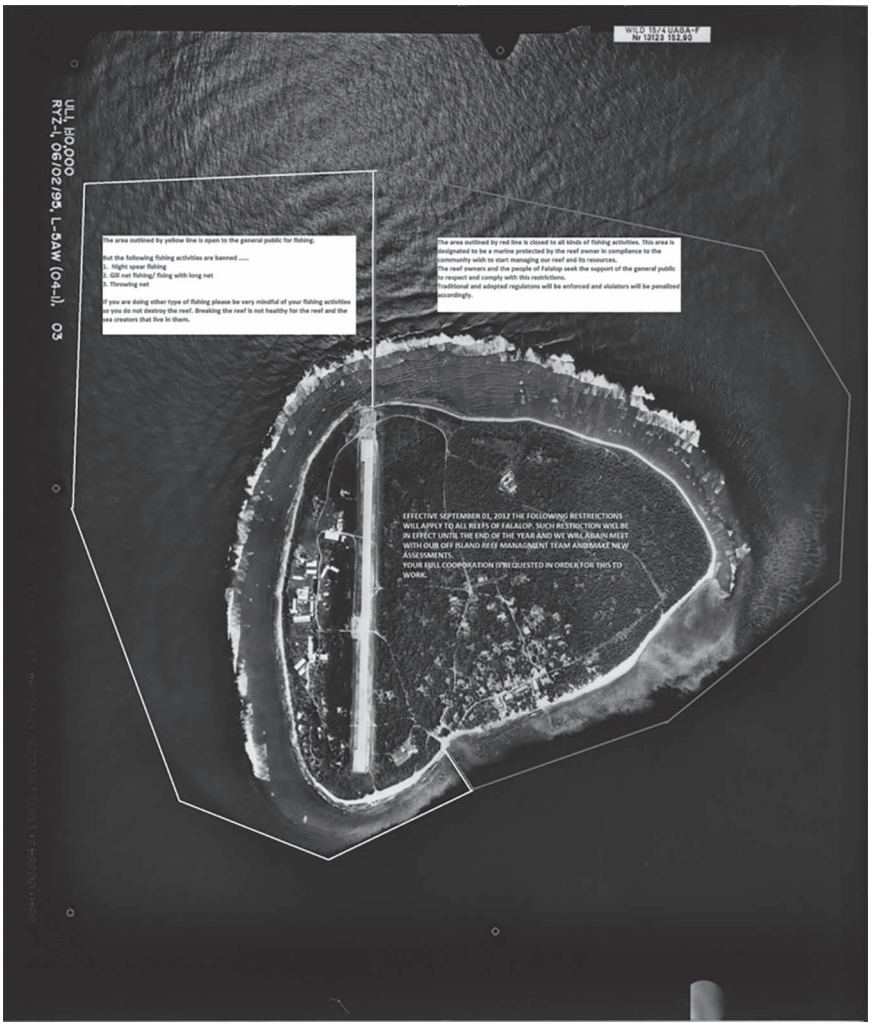

FIGURE 10.6 Marine protected area designated by the Falalop community in fall 2012. The area marked in the upper part of the photo is a no-fishing zone (except for shore fishing and community fishing), and the area marked in the lower part of the photo restricts some fishing, while allowing some fishing.

professional science teams into these communities may be met with mistrust and opposition; clear goals, consistent with local needs and interests, and a real partnership likely offer the best way towards a successful long-term effort. Recognition of the body of traditional knowledge and its relevance to conservation validates the important role that local communities play in these efforts. Without that recognition, however, local knowledge may not be readily shared unless the use and value of that knowledge is understood. For example, people may be reluctant to share

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information with professional teams about reefs, management, jurisdiction, and traditions because they question the value of sharing, and may not fully trust what will be done with the information.

Obtaining accurate local information and data from local participants depends not only on how it is collected, but also who is asking for it, and how the community is approached. In small, tight-knit communities like those of the outer islands, people are clearly capable of working together to achieve common goals effectively, but may be reluctant to expend energy on an endeavor whose outcome might have little apparent local benefit. It is critical that the outcomes be clear, and that they be articulated by the communities themselves. "People will often hear what you have to say, but more importantly they will remember and respect what you *do*" (John Rulmal, Jr.).

The One People One Reef professional science team came to the outer islands by invitation, and listened to what the people had to say. We were clear from the beginning that management would be difficult, that it would depend on the active participation of local science teams, and that plan development and implementation were up to the local community. We provided modern scientific knowledge and data analyses to help outer islanders understand the nature and extent of the problems, and made ourselves available for questions. We shared all the data collected, returned regularly, and worked closely with the local people. This helped build trust, and most importantly empowered communities on Ulithi to be leaders in management. These reefs are their reefs. Citizen scientists in this context need to be more than data collectors; they need to be co-leaders in the program, helping to determine goals and objectives (e.g. co-created projects [Shirk et al., 2012] or extreme citizen science [Haklay, 2013]).

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Navigating local social networks can be difficult, and "outside" teams are best served by being open, honest, and transparent. Decisions about local science team composition and who should be involved are best left up to a process decided by the community leaders. There are examples of conservation and management projects that come into a community and suggest teams (an "outreach and education" committee, an "enforcement" committee, etc.). These constructs can lead to tensions in communities. Governance and oversight, transfer of knowledge, and even training programs should be led by local leaders who understand social and political protocols.

Building capacity for future citizen science-based management

In addition to the management and conservation successes, there have been significant positive ancillary benefits for the Ulithi communities from the One People One Reef program. The effort to discuss management among the islands (an issue they all have in common) has led to increased dialog among leaders, and a revival of open communication channels. During this time of rapid environmental and cultural change, improved communication is critical to maintain consistent policies and to make the most effective use of a growing database to refine management and

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conservation. Although the exact management plans are difficult to document, all four inhabited islands of the atoll now have established policies in place – a testament to their dedication. In theory, a reef manager or owner may choose to close (or not) an area or parts of an area for whatever reason they choose, but the reality is that they need community support. Scientific data gathered by the local science teams since 2012 have helped local leaders re-establish their roles and responsibilities. There has been a renewed interest in traditions and cultural history around fishing and management. The community is coming together around the conservation and improved management of a critically important ecosystem, and a shared understanding of its interconnectivity.

Another spin-off, articulated by many in the community, is the interest shown by the youth, many of whom have become disconnected from their communities. Some of the youth have expressed interest in reconnecting with traditional ways and better understanding how these traditions fit with the modern world. There is a growing interest among the youth around marine work, conservation, and the merging of science and tradition. The One People One Reef program involved youth from all four islands in 2015, 2016, and 2017, with strong community support. Because people from all the islands are measuring fish for a common database, they are talking about and remembering traditional names – bringing them back. Traditional boundaries and fishing jurisdictions, which are often neglected by the youth, are being talked about and enforced again.

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Youth are motivated by seeing local leadership with the program, and particularly the active participation of their peers. This experience encourages them to come back and do more in their own communities. In one youth's words, "We are not doomed to destruction after all."

Reviving and understanding traditional practices

One People One Reef is leading to a rediscovery of traditions, and understanding how modern science can complement traditional practices. It is providing a venue to talk about these traditions and management.

Examples

- *Mol igil bong*: The first fish caught. Fishing rights belong to certain clans. They can open and close a fishing area. *Mol igil bong* is when someone from the clan (manager or owner) fishes, gets a good first catch of the season, and decides to open the area to fishing by the rest of his clan. When someone from outside of that clan is granted permission to fish there, they practice *Fa'ad elbong* ("string from the *ibong*") – two fish strung with bellies together are given to the clan that owns the area (an elder of the clan). This practice had become increasingly rare, but our interviews indicate a resurgence, apparently stimulated by the communities' increased involvement in data collection and management decisions. The practice ensures tenure over fishing grounds.

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- People are paying renewed attention to where their fish are caught. "We used to know this, [but] don't so much anymore. We are beginning to talk about it more" (Fisherman). Community members said that some elders could identify the source reef for emperors (*rogrog*), based on their coloration. This used to help reef owners know where people were fishing, and served as a check to ensure that fishers were not fishing in a closed area.
- Local scientists measuring others' fish was not welcomed initially. Now it is acceptable. Historically, catches were checked by chiefs as the canoes came to shore. That practice was largely lost, but people are paying attention now that the local science teams are checking – similar in many ways to the traditional practice.
- Certain fish species were reserved for chiefs. Larger grouper, for example, were taboo for others. Men eat certain fish away from the main island – in the boat, on an island, or at beach canoe house – such as barracuda and groupers. These taboos provide an additional means of conservation, as well as protecting the greater community from potential toxins such as ciguatera.
- Turtle harvesting seasons. Historically, people didn't harvest turtles in the water (they do sometimes now). They used to take all turtles to Mog Mog for approval and blessing before slaughtering and distributing. This limits the take as it requires a long trip to the Island. People are talking about this again, and why it is they used to do those things (it was *management*!).

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Best practices

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Some reasons the One People One Reef program has met with great local support and participation in the Yap outer islands, and specifically on Ulithi Atoll, include:

- The program recognizes the importance and sensitivity of the local community perspective and needs first, before the professional science team's goals.
- Reports (including scientific results) are written, presented, and *discussed* in a way that local people can understand them and apply the results to their management needs.
- Communities are respected. One People One Reef makes locals true partners in the conservation effort.
- There are no documents, agreements, or contracts, such as commitments to no-take reserves or spatial closures required by the professional scientists. The community decides what it wants to contribute in terms of written commitments.
- The professional science team follows through on commitments, maintains effective communications with the community (to the extent that technology allows), and provides analytical support and advice on request.

The future

Ulithi has been the trendsetter for the outer island chain in the recent past (since the building of landing strip in World War II, and the establishment of the high

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school in 1964) and these trends often make their way to the rest of the neighboring (outer) island chain. The One People One Reef collaborative program is a model that is beginning to expand through these islands, with the initial leadership of Ulithi. Its success will depend on the collaboration, mutual understanding, and commitment of all involved.

> To me, we have a moral responsibility here to set positive trends for the rest of our neighbors. I have seen divisions arise between islands, and it is time to unify around the management of a system that unites us all. *Hofagie Laamle* (*One People One Reef*).
>
> *(John Rulmal, Jr.)*

The combination of shared knowledge to understand and manage a complex human-natural coupled system leads to planning that is woven into the cultural and governance structure of the communities. That integration is the framework for sustainable management and conservation, led by local communities, and supported, rather than driven, by conventional science. This has the greatest potential for success in the long-term.

> We need to have a common understanding around management, so that everyone agrees and supports it. Understanding the old ways, and the impacts of the new ways, can help us protect the ocean for our children, and their children.
>
> *(Isaac "Ike" Chief, Asor Island, Ulithi Atoll)*

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Web resources

1 www.fieldmuseum.org/science/citizen-science.
2 www.calacademy.org/citizen-science.
3 www.si.edu/volunteer/citizenscience.
4 www.oceanicsociety.org/.
5 www.earthwatch.org/.
6 www.reefcheck.org.
7 We use the term "professional scientist" throughout this chapter to refer to university-trained people who practice science as their full-time professional job, and "conventional science" to refer to ways of generating knowledge using the classic Newtonian "scientific method" (Ballard and Huntsinger, 2006; Berkes and Turnaer, 2006). We prefer these terms instead of "Western science and scientists" because there are many ways of knowing in the "Western world," and professional scientists conduct conventional science globally beyond the Western world.

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